Granddad's Wonderful Book of Electricity

By Kurt Saxon

Cigar-Box Tesla Coil

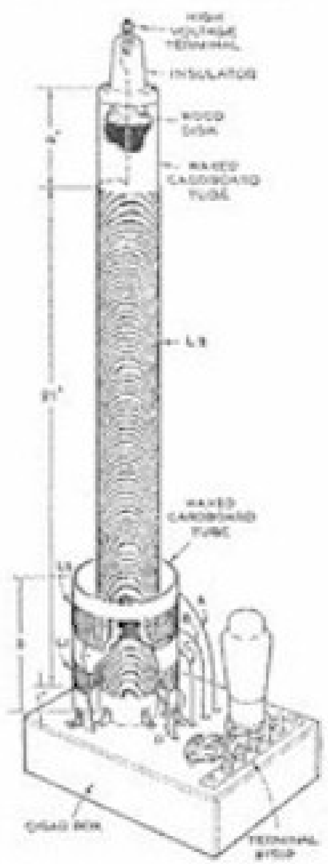
WORKS WEIRD WONDERS

POPULAR SCIENCE JANUARY 1946

By Tracy Dierrs

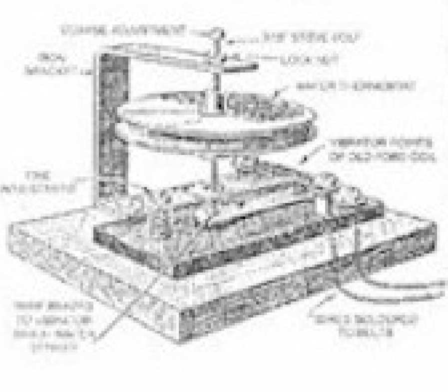
WINNING SCIENCE FAIR PROJECTS • 428 PROJECTS, EQUIPMENT, GADGETS AND CLEVER IDEAS

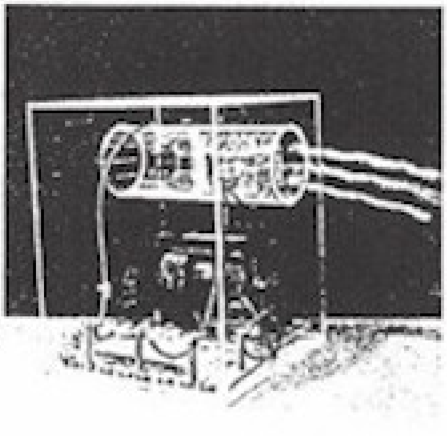
• ALARMS, ALL KINDS • AMMETER • ELECTRIC ANAETHESIS • ANEMOMETER • ANNUNCIATOR • ARC FURNACES • ARMATURES • BATTERIES • CONDENSERS • ELECTRIC GUN • APPLIANCE REPAIR • ELECTRO-MAGNETS • ELECTROPLATING • ELECTROSCOPE • ELECTROTYPING COURSE • GALVANOMETERS • GALVANOSCOPE • GEIGER COUNTER •HYDROGEN GENERATOR • HYGROMETER • INTERRUPTERS • MAGNETOS, OSCILLTING • MAGNETS • POTENTIOMETER • POWER PLANT • RECTIFIER • RELAYS • RHEOSTATS • REVERSERS • SEISOGRAPH • SILVER PLATING OUTFIT • SNOOPERSCOPE • SWITCHES • TELEGRAPH SETS • TEST EQUIPMENT • TRANSFORMERS • VARIAC • VARIOMETER • VOLTAGE REGULATOR • VOLTAMMETER • VOLTMETER • VIBRATOR • WIMHURST MACHINE

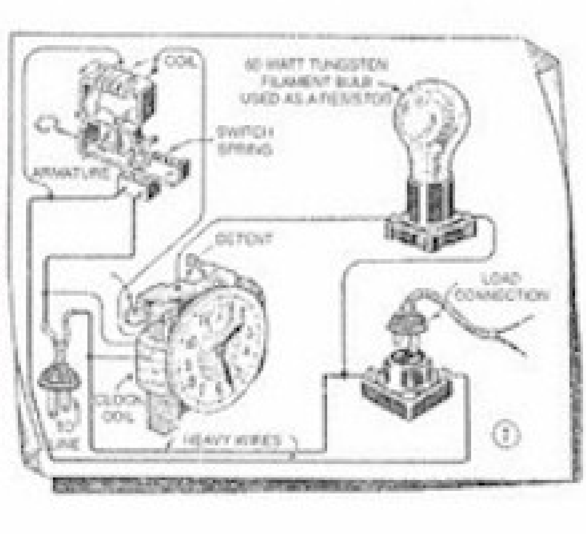


A Science Fair Project

Build a Fan with No Moving Parts







Cigar-Box Tesla Coil

WORKS WEIRD WONDERS

POPULAR SCIENCE JANUARY, 1946

By Tracy Diers

"IS THERE, I ask, can there be a more interesting study than that of alternating currents?"

With this question, put to a group of outstanding engineers and scholars more than half a century ago, Nikola Tesla opened an address and an epoch. These words ushered the leading scientists of two continents into a veritable fairyland of crackling brush discharges, indescribably beautiful gaseous glows, and space-spanning energy that wires could not confine.

On that historic night, young Tesla brought into public view the wonders of high-frequency, high-voltage alternating current (H.F.H.V.A.C.). Its source was the now famous Tesla coi'

A Tesla coil is a transformer used for stepping up medium-high voltage, H.F.A.C., to fantastically high voltages. By following the instructions given on the next page, you will be able to construct a coil capable of producing all the effects described in this article. When your coil is complete, close the filament switch. Ten seconds later, close the high-voltage switch. Immediately a 2½" arc will leap from the high-voltage terminal into the surrounding air. If it doesn't, the primary coils are probably bucking, and either one should have its connections reversed.

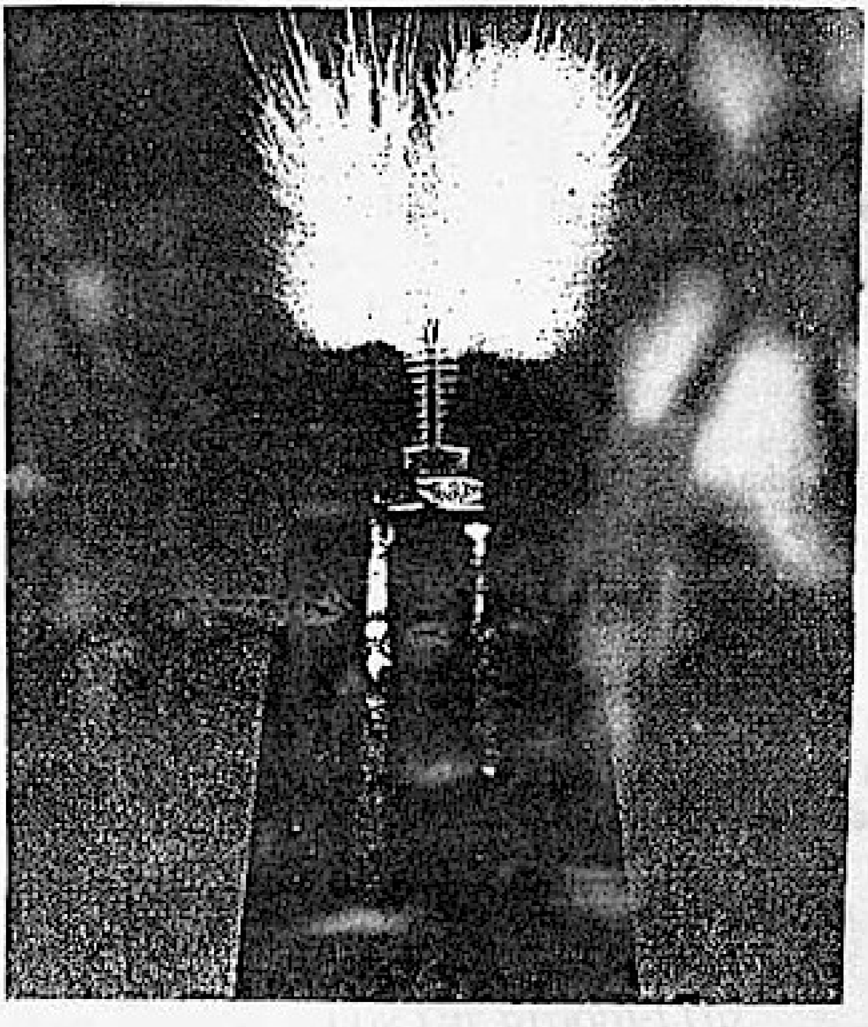
The things that this corona can and will do are legion. Two of them are illustrated by the four photos on page 193. For experiment No. 1, your equipment consists of a stiff horizontal wire supported on a free-moving metal spinner. If the wire is coated with shellac along its entire length so that the corona can discharge only at the tips, then when the H.F.A.C. rushes into the wire, it will drive it merrily—and luminously—around.

Experiment No. 2 demonstrates the ineffectiveness of glass to resist the hot electrical energy that bursts forth from the Tesla coil. One of the two metal rods of the spark gap goes to the high-voltage outlet; the other returns to ground. Both are shielded from any mid-point contacts. When the gap operates smoothly, insert a sheet of ¼" plate glass—and watch the spark continue right through.

Notwithstanding these facts and its terrifying appearance, the corona is quite harmless. If you hold a copper rod in your hand and bring its free end close to the discharge, the current will jump to the rod, and race via your body back to ground. But you won't even feel it!

Not enough current? Don't kid yourself! While it is true that the power output of this coil is not very high, 50,000 volts at the current you have here would normally ferry you into another world. Safety lies in the frequency of the current, which is well above a million cycles a second. All high-frequency currents travel on the surface of conductors; when you are the conductor, your skin carries the current and your internal organs aren't affected.

A much more strikingly visual proof of this phenomena is shown at bottom right on the facing page. Since H.F.A.C. insists on traveling only on the surface of conductors, these conductors may be hollow pipes instead of wires, but they must have

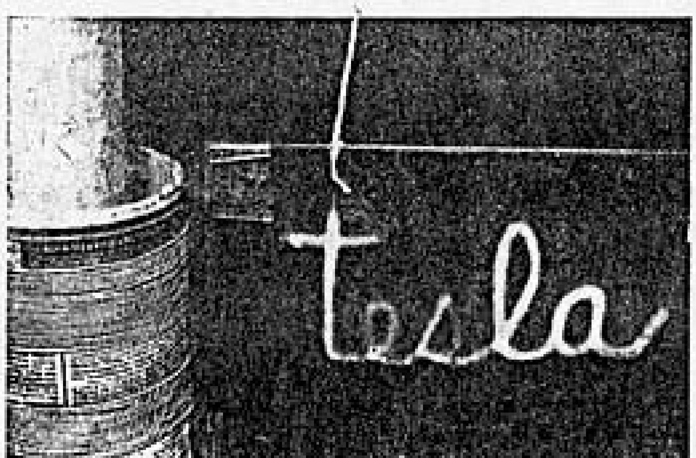


High voltages don't like to be fenced in. It's a serious problem for engineers, but for Tesla-coil experimenters the corona, right, is a welcome sign.

Radiant power is only part of the wonder of a Tesla coil. When brought within the field of the energized coil, an ordinary bulb glows with a strange violet light as rosy streamers shoot out from the filament.

Is this the lighting of the future? The young lady's reading light consists of a fluorescent tube without wired connections. The Tesla coil that powers the tube is located in another room, but plain walls are no obstacle to its energy.

Wires of small diameter can't confine the high-frequency currents generated by the Tesla coil. Current leaps out of the wire sandwiched between the glass plates, making it glow in the dark.

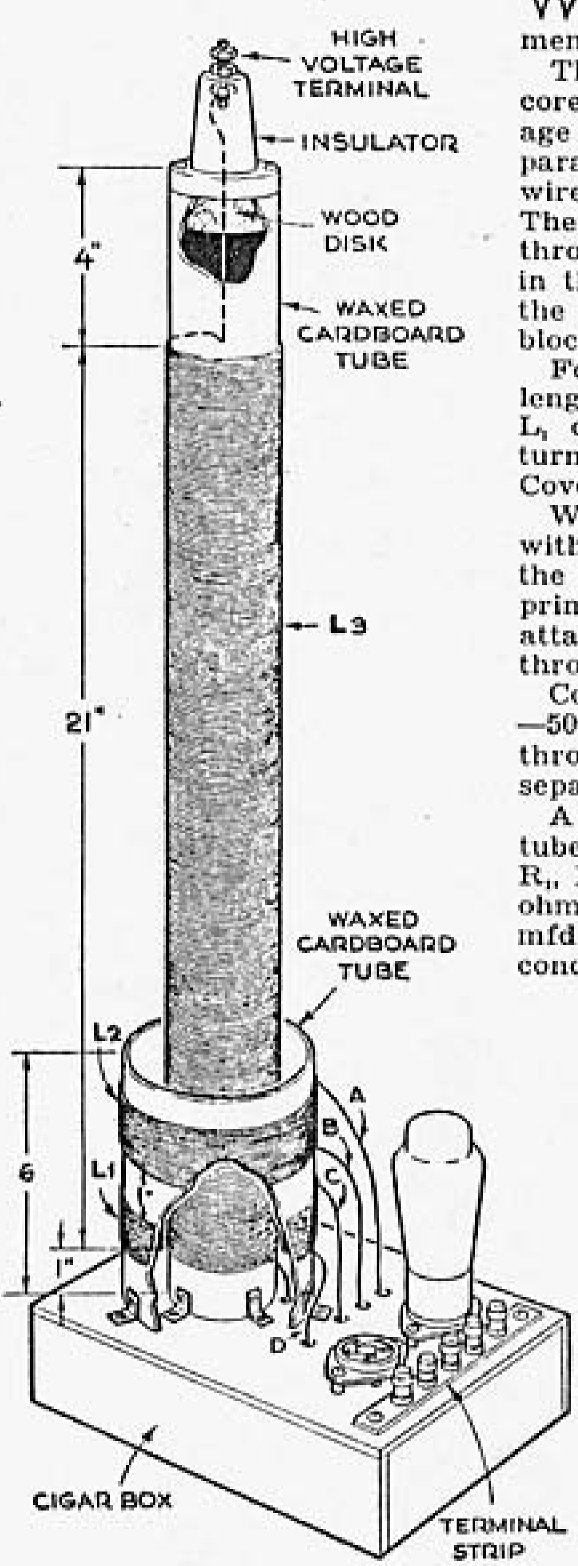


 GRANDDAD'S ELCTRICITY BOOK

surface area—lots of it. If you try to conduct high-frequency currents through fine wires without enough surface area, the current will leap clear into the surrounding air, causing the inadequate wire to glow with a ghostly light. If you spell out a word with a continuous piece of 30- or 32-gauge bare copper wire, connect one end to the high-voltage terminal, and sandwich it between glass, the word will light up.

One of Tesla's great dreams concerned the transmission of power without wires. He didn't quite make the idea practicable, but he came close enough to enable you to amaze your friends and amuse yourself with these stunts based on wireless power transmission. Connect a metal plate to the high-tension terminal. This power transmission plate must be well insulated from the ground. A short distance away, arrange another in-

Induction Coil Replaced by Vacuum Tubes in Cigar-Box Tesla Coil



WITH a Tesla coil built from a few familiar radio parts you can try for yourself the fascinating experiments described in this article.

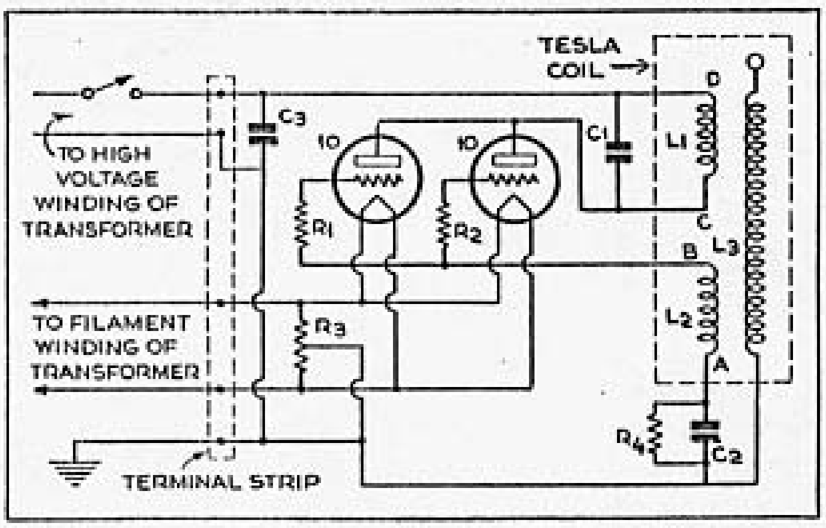
The coils are wound on ordinary cardboard tubes. A core 2½" in diameter by 26" long is used for the high-voltage secondary. Coat the outside of the tube with hot paraffin, and, when dry, wind a 21" coil of 30-gauge D.C.C. wire evenly and smoothly, starting 1" from the bottom. The end of this wire is brought up inside the tube through a wood block and insulator. Drill a ¾" hole in the round block, boil it in paraffin, and glue it into the top of the tube. Screw the insulator directly to the block.

For the other coils, cut an oatmeal box down to 6" in length and use 16-gauge D.C.C. wire for both windings. L_1 can start 1" from the bottom and extend for 15 turns. Leave another 1" space and wind 20 turns for L_2. Cover all the coils with a good shellac.

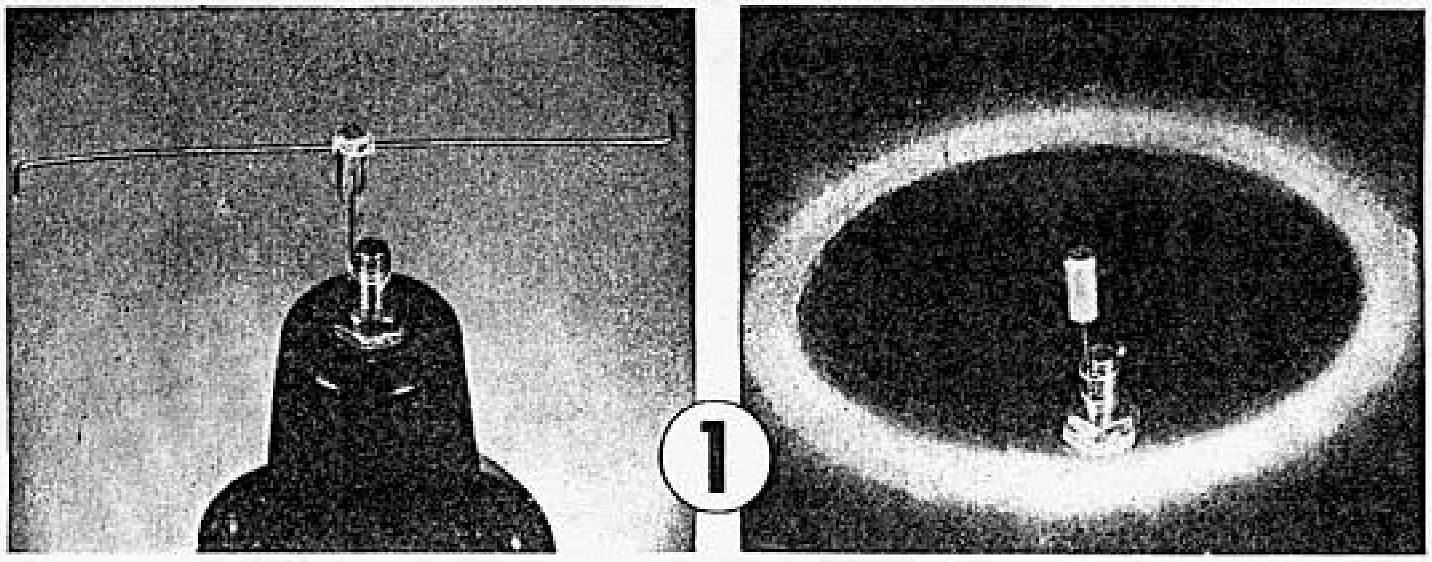
When dry, attach the secondary coil to the cigar box with small metal brackets. Bring the ground lead inside the box, making sure that it does not come near the primary. Then slip the larger form over the other and attach it in the same way. Carry the leads into the box through four small holes and fill the holes with shellac.

Connect the high-voltage side of a power transformer —500 volts or more—to the input of the Tesla coil through a single-pole, single-throw switch, and use a separate switch for the filament leads.

A pair of four-prong sockets is needed for the type-10 tubes; other parts shown in the wiring diagram are: R_1, R_2: 2,700 ohms, 10-watt wire-wound resistors; R_3: 40 ohms, centertapped; R_4: 5,000 ohms, 10 watt; C_1: .001 mfd., 1,000-volt mica; C_2, C_3: .0005 mfd., 1,000-volt mica condensers.

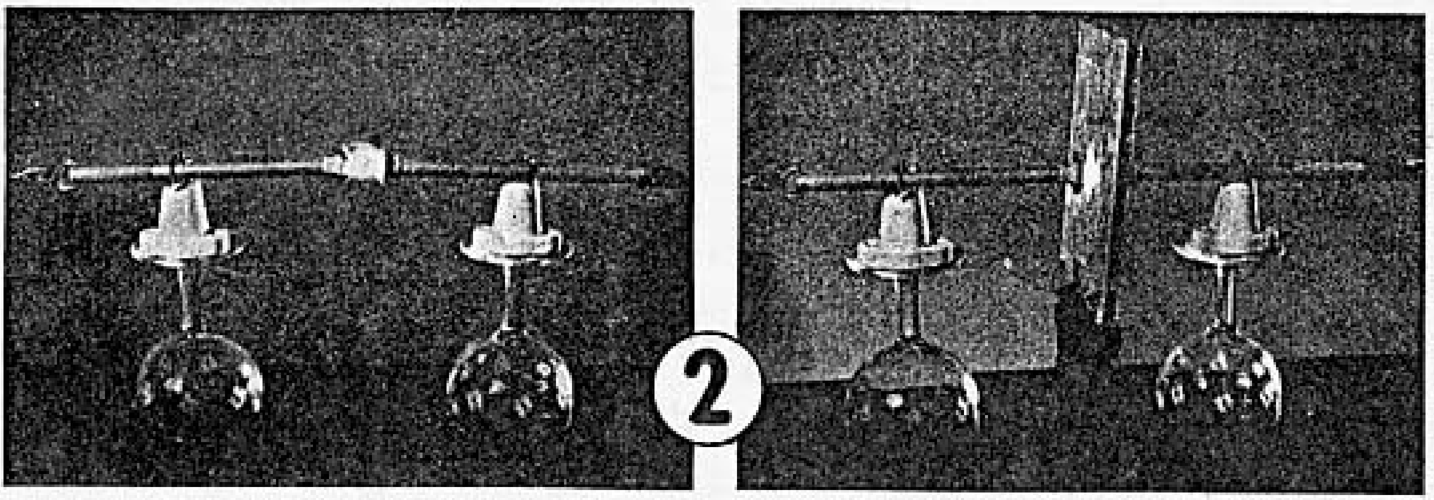


 GRANDDAD'S ELCTRICITY BOOK



The spinner used in this experiment can be made of any light wire. Drill a small hole so that the metal will pivot on a pin attached to the high-voltage terminal. Shellac all but the tips of the horizontal wire.

If you've always had high respect for glass as an insulator, make the test shown below. The spark seems to jump the gap despite the ¼" glass plate. You may have to shorten the gap a bit after inserting the glass.



sulated plate so that its face is parallel with that of the first. If you touch this power-receiving plate with a screwdriver, you will draw sparks from it even though it has no wired connection with any source of electrical energy. At still greater distances—say 8' to 10'—you should be able to light a neon tube by bringing it close to the receiving plate. Small nails scattered on the table between the two plates will also throw sparks at your screwdriver.

Now for the public part of your demonstration. Place the Tesla coil in one room and locate the power-transmitting plate close to a wall that connects with another room. Draw a chair up to the adjoining wall in the second room—preferably darkened—and begin to read a book. Do you need light? Easiest thing in the world! Just pick up a 20- or 30-watt fluorescent tube. As long as you keep your hand on the tube, it will stay lit. This works well as far as 12'. Perhaps it even presages the day when we will carry our lamps from room to room without wires.

Are you tempted to do just that with your homemade Tesla coil? Well, don't! In the first place the system would prove relatively inefficient. Even more important, it will reduce your neighbors to a state of frenzied hair pulling. This is a point well worth bearing in mind when conducting your experiments. All high-voltage devices generate some static, causing interference with radio and other electrical equipment in the vicinity. Out of consideration for your neighbors, you should avoid using your Tesla coil at those hours when you know that most people are listening to their radios.

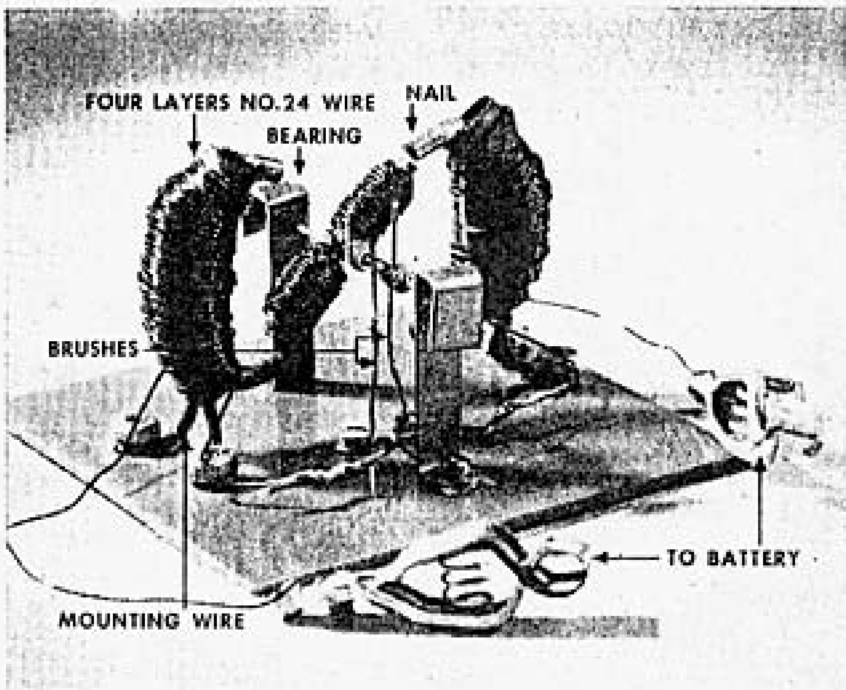
Clearly, a good deal of electrical energy is popping out of your Tesla coil. As you might expect, it packs a lot of heat. Hold the end of a cigar or cigarette close to the output tap, and it will readily light up. If you pass the cigarette through the corona, a large number of tiny holes will appear in the paper. An alcohol-soaked cloth will also burst into flames on being brought into contact with the corona.

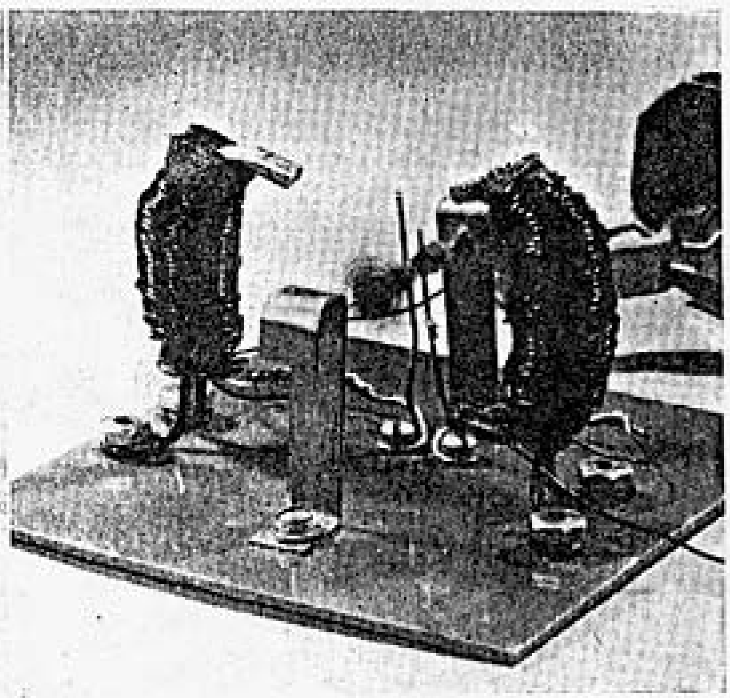
Fine metal wire, such as steel wool, provides a fine fireworks display. Arrange a

The stiff wire shown at the right carries the high voltage from the coil output to a wad of steel wool spread out on the loop. Can the steel wool take it? See above.

stiff wire structure, as shown at right, so one end will make contact with the terminal and the rest is well insulated from ground. Spread some steel wool across the wire loop and close the Tesla-coil switch. The steel wool will carry the current for a moment only—then it becomes white hot and disintegrates. That's a picture of what's left of the stuff right above.

 GRANDDAD'S ELCTRICITY BOOK





Crate-nail special runs on 3 to 6 volts, AC or DC. Although it has four field poles, construction is simplified by having only two of them act on the armature. Bearings are strips of tin plate bent over at top to retain shaft against end play. Because of dead area on the commutator, armature must be in a favorable position in order to start by itself.

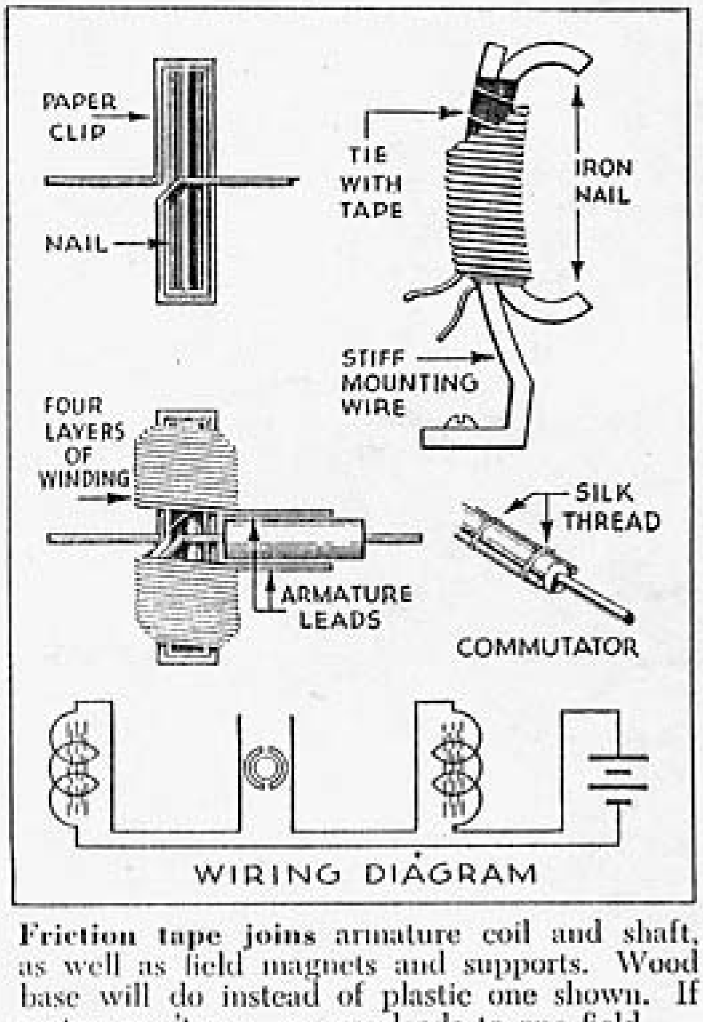
POPULAR SCIENCE, Oct. 1848

Nails Form Magnets of Midget Motor

A HANDFUL of shop scrap, plus an hour or two, are the chief ingredients of this little homemade motor. Showing in capsule form how the big ones work, it'll buzz furiously on three or four dry cells.

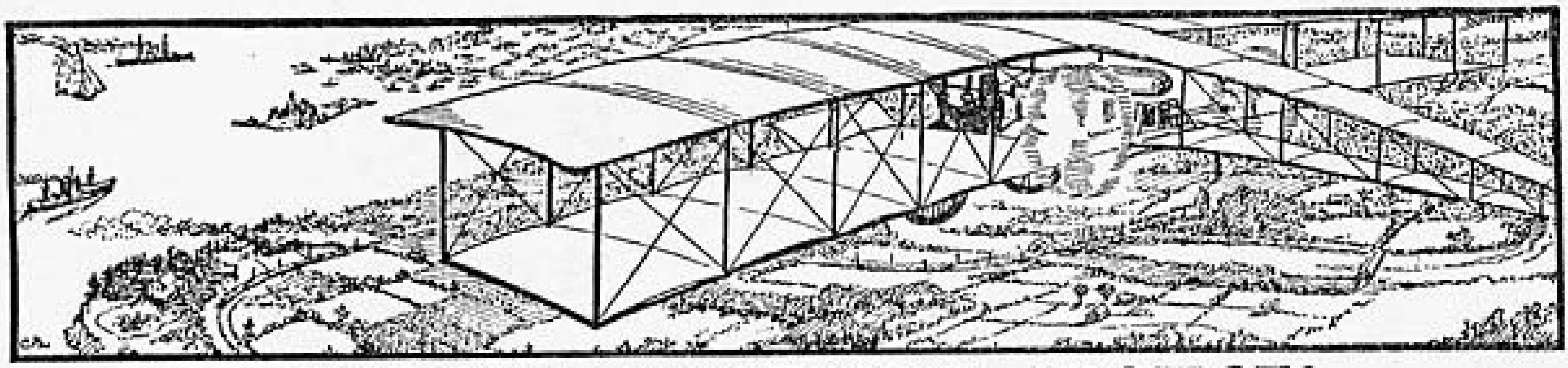
Cut off 1½" from a husky nail, and around it bend a straightened paper clip as shown at right. Be sure the extending shaft parts are aligned. Bind with a layer of friction tape. Starting near the shaft, wind half the armature with four layers of No. 24 insulated copper wire. Continue with the same wire, crossing the shaft to wind the second half in the same direction, finishing at the shaft. Slip on a bit of radio spaghetti tubing, scrape the ends, and bind them on.

Shape field magnets from two thick nails, and bend heavy copper or brass wire into supports. Bind with tape; then wind on four layers of wire, starting and ending at the bottom. Mount so the armature clears the field poles by 1/16". Attach two bare wires to bear on opposite sides of the commutator.—*Kenneth Rogers, Chicago.*



Friction tape joins armature coil and shaft, as well as field magnets and supports. Wood base will do instead of plastic one shown. If motor won't run, reverse leads to one field.

 GRANDDAD'S ELCTRICITY BOOK



MODERN ELECTRICAL PROJECTS

AMATEUR CRAFTSMAN, 1914

SOME boys (and some girls) seem to be foreordained electricians. They love batteries and wires and signals from the start. If you are one of these, the working out of the two projects here given will be "as easy as rolling off a log."

THE TELEGRAPH SET

You will enjoy making it from start to finish, the operations are varied but simple, and you will value the instrument when it is completed. Making the instrument involves woodwork, metal work, and electrical work, and when it is completed it "goes," and gives a good, loud sound.

BASE. A nice piece of wood should be selected for an instrument of this kind, and it should be carefully planed and finished. Mahogany is usually too expensive, but gum wood is cheap and makes a very good base. For a good method of planing the base, see the note at the close of this description (page 370).

The bevel around the upper edge is marked off with a pencil, 1/8" in on the top, and the same measurement down on the edge. There is an advantage in planing the bevel on the ends first.

KEY. The telegraph set has two parts, the key and sounder. The key is operated to send a message, and the sounder receives it. With the key is a switch. Now for a little metal work. A strip of sheet iron No. 24 gauge (about the thickness used in making stovepipes), 12" long and 1/2" wide, will supply all of the iron required for one set. A piece of this iron 1/2" wide, cut 4" long, will make the key, another piece 3" long will make the switch, and another piece 1 1/2" long will make the contact piece for the switch. This leaves 3 1/2" of the 12" strip to be used on the sounder.

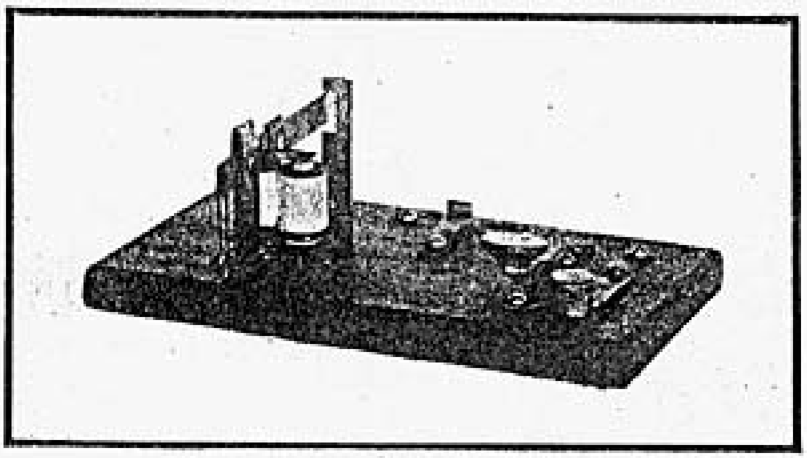
When the pieces for the key, switch, and contact piece are cut to length, the places for the holes are laid off on them and they are then punched. A nail-set and a piece of hardwood, with the end grain up, are satisfactory tools for punching. The drawing shows just where the holes are located. All of these holes may be punched just large enough to fit the No. 4 1/2" round-head blue screws that will be used. The second hole on the key, and the hole on the contact piece, may afterward be enlarged to 3/16" diameter with a 3/16" drill bit in a brace, or a drill that may be at hand. For neatness the corners of each strip may be either snipped off or filed off 1/16" each way. It is well to mark these corners off with a sharp point before cutting them off.

The knob on the switch is a piece of 1/2" round wood 1/2" long. A piece of dowel is good for this. The knob on the key is made from round wood or dowel 1" diameter and 3/8" long with the under side whittled to a concave, as the drawing shows. The switch and key knobs are fastened to the iron strips with No. 3 3/8" screws. The key, switch, and contact piece each have bends, made with flat-nosed pliers. When these pieces are finished, they may be located on the base. A light center line is drawn for the key 2 1/4" from the end of the base, and the two bolt holes and the screw hole located on it. The center line for the switch is 1 1/4" in from the end, and one screw hole and one bolt hole are placed where the drawing indicates.

SOUNDER. How it works: The ticks of the sounder are made by the hammer striking the anvil. The magnet pulls or attracts the iron armature that is fastened to the hammer. This armature should be of soft iron (a 2 1/4" piece of sheet iron 1/2" wide), so that when

 GRANDDAD'S ELCTRICITY BOOK'

the current of electricity goes through the magnet the armature is attracted downward, and as soon as the current stops the magnet lets go. The hammer cannot be iron or steel, as the magnetism would travel along it. One strip of brass 1/16″ thick, ½″ wide, and 4½″ long will make an excellent hammer. A hole ⅛″ in diameter is bored where the armature is fastened, and another ⅛″ hole at the end of the hammer, where it is to be pivoted. The armature is fastened to the hammer by riveting. A piece of a nail will do



for a rivet. The anvil is a straight piece of brass 1/16″ × ½″ × 3″. A notch is filed on one edge ⅝″ wide, ¼″ deep, beginning ¼″ from the top end. The lower end is bent at a right angle ¾″ from the end, making the base. Two holes for No. 4 ½″ round-head blue screws are bored in the base end. The yoke carries the pivoted end of the hammer. It is made something like a letter A, out of the same 1/16″ × ½″ brass strip. A piece 5½″ long is doubled in the center, leaving a full 1/16″ between each half, and then ½″ is turned outward at each end for the base. One screw hole is put in each part of the base. A hole ⅛″ in diameter is bored ½″ from the top, or doubled end, where a piece of a nail, or a rivet, goes through to hold the hammer, and is riveted loosely.

The magnet may be secured by purchasing small cheap bell magnets from an electrical supply house at ten or twelve cents each, or they may be secured from a discarded electric bell, or they may be made by winding two stove bolts 3/16″ × 1¼″ each with about twelve feet of No. 24 magnet wire. The lower ends of the bolts should be connected by a strip of sheet iron ½″ wide, 1½″ long, with a 3/16″ hole at each end, that the threaded end of the bolt may pass through, and then the nuts put on.

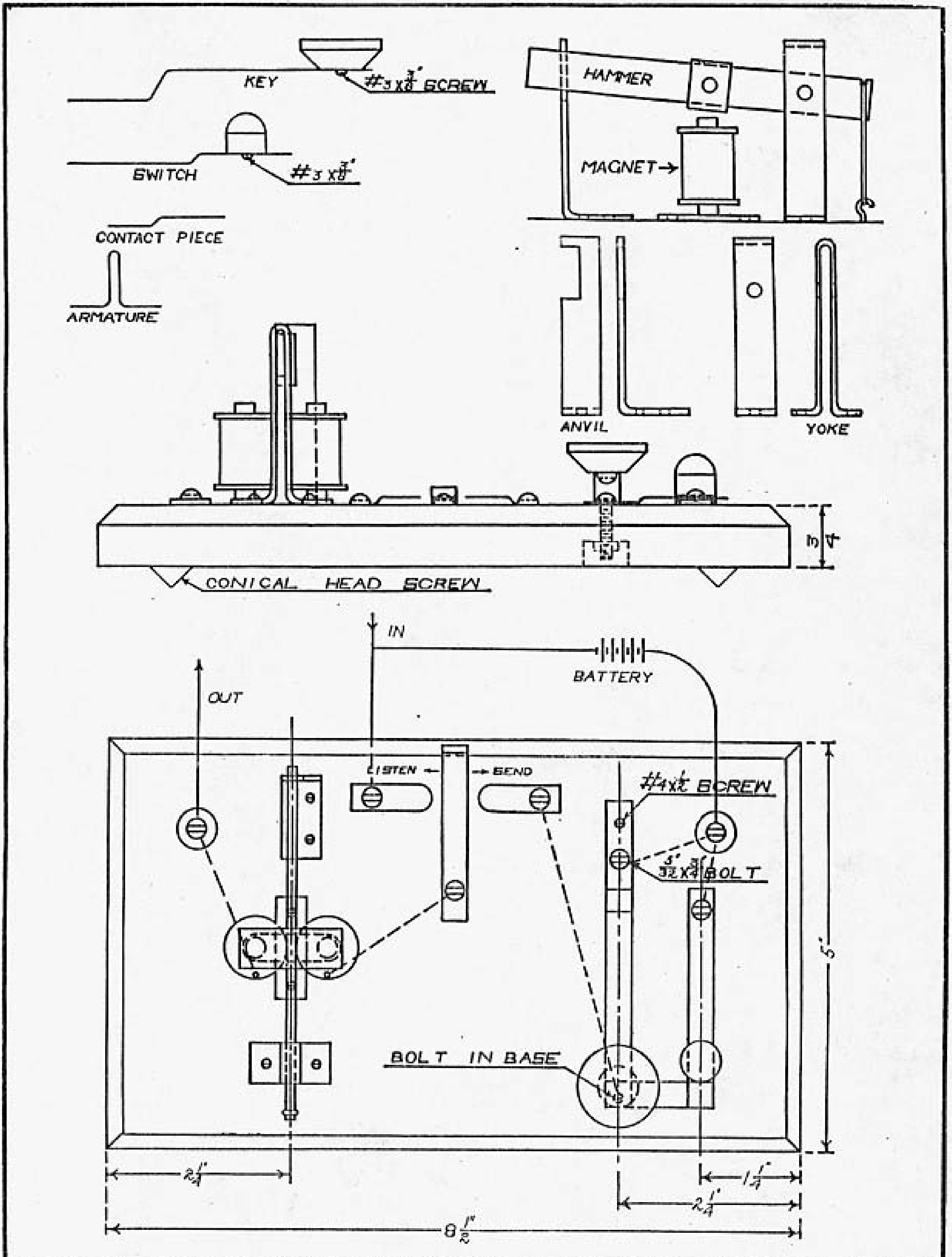
The wire should be wound in the same direction on each bolt, and the two inner ends of the wires should be scraped naked and twisted together. In most cases it is preferable to purchase the small bell magnets.

All of the sounder is located on the base, on a center line, as was the key. It is convenient to mount the magnet first. A handy way to fasten it is to take a strip of sheet iron 1¼″ long with a screw hole at each end, slip it in over the connecting bar of the magnets, and fasten the strip with two No. 4 ½″ screws, one in front of the magnet and one in back. The yoke, with the hammer connected, may then be placed, and last the anvil is screwed down. .

Two stove bolts are used for binding posts, and are placed near the corners at the back of the instrument, as indicated in the drawing. To understand the connecting of the wires on the under side of the base, trace out the path of the electricity, beginning with the right-hand binding post near the key. We will assume that the current comes in from the battery to this binding post, then along a wire to the key, along the key itself, when pressed down, down through the bolt under the handle of the key through a wire to the magnets, from the magnets to the left binding post. Also, when we are listening, the key is not pressed down but the circuit is "closed" by the switch. There is a short wire from the right-hand binding post to the bolt that holds the switch. The switch, when closed, is in contact with the short contact strip under the knob of the key. Now, then, when we are "sending," the switch is open and the current is interrupted by the pressing and rising of the key, so that the magnet in the sounder attracts the armature and lets it go each time the key is pressed down and rises. If we are listening, the switch is closed, the interrupted currents sent by the operator at the other end come in through the switch to the contact bolt under the key, then to the magnets, and on out to the other binding post.

The commercial telegraph systems are supplied by electricity either from dynamos or from "gravity" batteries. The amateur

 GRANDDAD'S ELCTRICITY BOOK



DIAGRAMS FOR TELEGRAPH APPARATUS

generally uses dry cells, which operate satisfactorily in sending signals, but will run out in a short while if the current is left on continuously. The drawing shows a little cut-out switch arranged at the back of the instrument, between the key and the sounder. When the operator is using his own batteries in sending, he pushes his cut-out switch toward the key; but if he should want to listen without using his batteries, he may leave his circuit closed by pushing the cut-out switch to the left or toward the sounder.

TELEGRAPH CODES

LETTERS	MORSE	CONTINENTAL	NAVY
A	. —	. —	— —
B	— . . .	— . . .	— . . —
C	. . .	— . — .	. — .
D	— . .	— . .	— — —
E	.	.	. —
F	. — .	. . — .	— — — .
G	— — .	— — .	— — . .
H	. . . .	. . . .	. — —
I	. .	. .	.
J	— . — .	. — — —	. — — —
K	— . —	— . —	— . — .
L	⸺	. — . .	— — .
M	— —	— —	. — — .
N	— .	— .	. .
O	. .	— — —	— .
P	. . . . .	. — — .	. — . —
Q	. . — .	— — . —	. — . .
R	. . .	. — .	— . .
S	. . .	. . .	— . —
T	—	—	—
U	. . —	. . —	. . —
V	. . . —	. . . —	. — — —
W	. — —	. — —	. . — .
X	. — . .	— . . —	— . . —
Y	. . . .	— . — —	. . .
Z	. . . .	— — . .	— — — —
&	. . . .		
1	. — — .	. — — — —	. . . .
2	. . — . .	. . — — —	— — . —
3	. . . — .	. . . — —	. . . —
4	. . . . —	. . . . —	— — — .
5	— — —	. . . . .	. . — —
6	. . . . . .	—	— — . .
7	— — . .	— — . . .	. — — —
8	—	— — — . .	— . . .
9	— . . —	— — — — .	. — — .
0	⸺	— — — — —	— . . —
.	. . — — . .	. . . . . .	
,	. — . —	. — . — . —	
:	— . — . .	— — — . . .	
;	. . . . .	— . — . — .	
?	— . . — .	. . — — . .	

1 . —   2 . . —   3 . . . —   4 . . . . —   5 —
6 — . . . .   7 — — . . .   8 — . .   9 — .   10 ⸺

Most boys know that they can buy discarded cells at automobile garages. These batteries will last quite awhile for the telegraph work. In connecting them, they should be arranged, as the electrician calls it, "in series"; this means that the carbon of the first battery is connected to the zinc of the second, and the carbon of the second to the zinc of the third, and so on until the carbon of the last battery is connected to the binding post on the right of the instrument.

While we are making our instrument, we should be getting acquainted with the codes, which are given here. Telegraph operators generally use the Morse; wireless operators are apt to use either. The advantage of the Continental code is in the fact that it does not depend on spaces, but substitutes dots.

Boys living near each other may have considerable fun if each of them makes an instrument and connects his home with wires.

The following notes give the necessary details for completing the apparatus.

STEPS FOR PLANING. (1) Plane one broad surface smooth and true, mark one. (2) Plane one edge square to one, mark two. (3) Score a knife line close to one end, square to surfaces one and two, block plane end. (4) Measure length from finished end and repeat No. 3 on the second end. (5) Gauge width from No. 2 and plane to gauge line. (6) Gauge thickness from No. 1 all around on edges and ends, and plane the last surface down to this line.

THE HARDWARE needed for one telegraph set includes: seven No. 4 ½″ round-head blue screws; eight $\frac{5}{32}$″ × ¾″ round-head stove bolts; four conical head brass tacks; one small screw hook; two No. 3 ⅜″ round-head blue screws; one piece of brass $\frac{1}{16}$″ thick, ½″ wide, 10″ long; 1 piece of stovepipe iron (No. 24 will do) ½″ wide, 12″ long; some bell wire. In boring the wood base for the bolts, bore through with a $\frac{3}{16}$″ bit, and then make a recess $\frac{5}{16}$″ deep for the nut on the under side with a ½″ or $\frac{9}{16}$″ bit.

FINISH. After all of the parts have been assembled, and before wiring, it is well to take the parts off of the base and lightly clean the wood with a fine piece of sandpaper wrapped tightly around a block. Sandpaper *with* the grain, not across it. Be very careful not to round off the bevels. All the dust should be wiped off, and two coats of white shellac put on. When doing this, handle the brush lightly; don't press it down hard. Lay the coat on with a *few light* strokes. As soon as the shellac is dry, the parts may be put back, the wires put on the under side, and the conical tacks put on for feet.

THE WIRELESS TELEGRAPH STATION

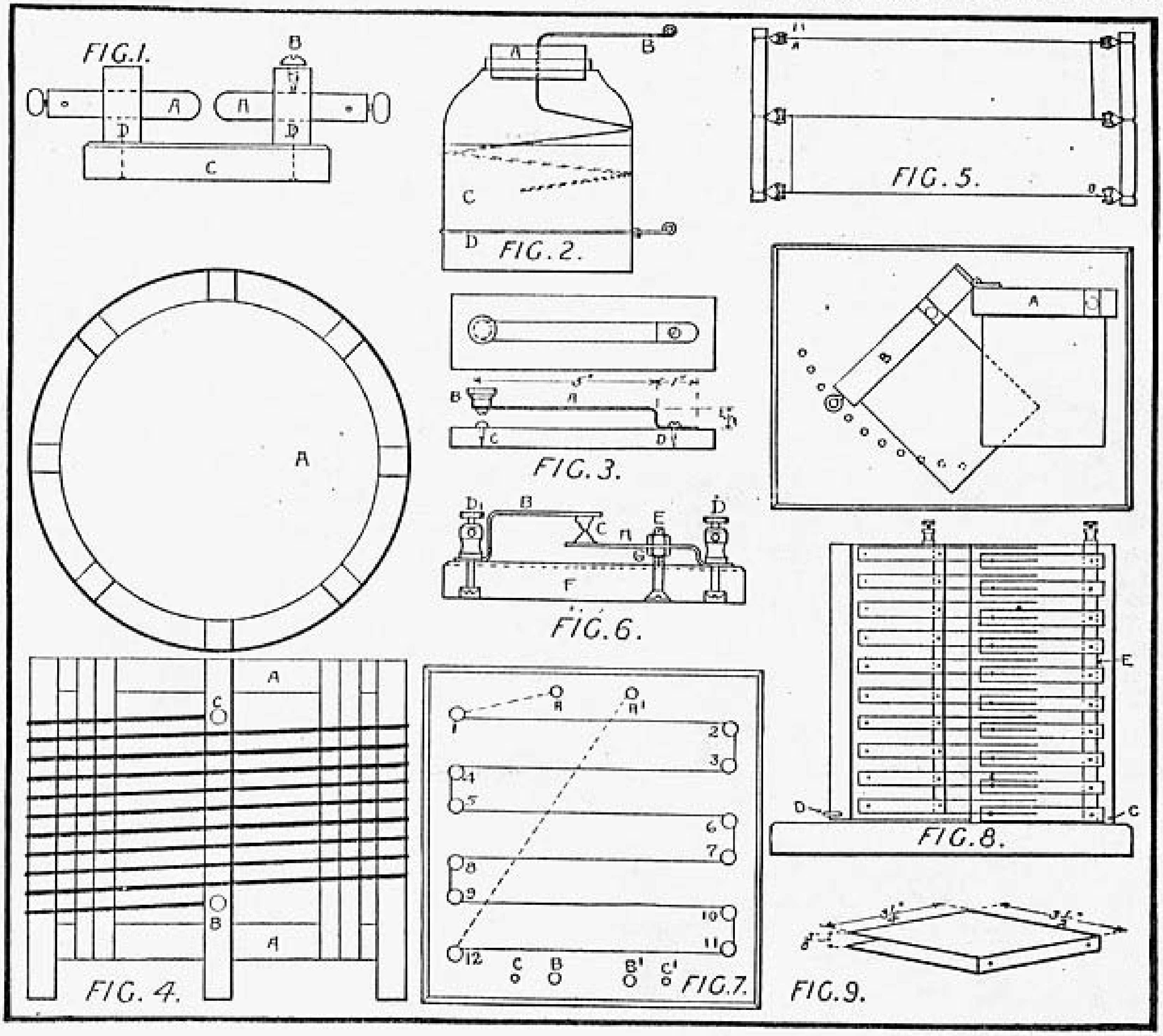
The station to be described is a small one, and in some localities can doubtless be operated without a license from the Federal government; but the amateur who builds it should write to the inspector in charge of his district, describing the station, before he attempts to do much sending. He may receive, however, without a license. Before starting construction read carefully all the directions for any given piece.

The apparatus commonly found in a wireless station consists of a spark coil, spark gap, key, fixed condenser or Leyden jar, sending coil, aërial, detector, receiver, variable condenser, tuning coil, and potentiometer. The amateur had much better buy the spark coil, of ½″ spark, from some dealer in wireless supplies, and also purchase the receiver.

THE SPARK COIL having been obtained, let us make the SPARK GAP for it. Get two old zinc rods from a used-up battery and break them off about 2″ long. File the end opposite the screw until it is round as at A, A, Fig. 1. Make a wood base, C, about 3″ × ½″ × 2″, and on it mount two uprights, D, D, 1″ high, to hold the zincs. Bore holes through and put a small brass screw, B, through one of them to hold one zinc at any place. Make this zinc to slide, but have the other tight. The uprights may be nailed on from the bottom. Now find a wide-mouth glass jar, such as a preserve jar, and clean it carefully. Line it on the inside and outside with tinfoil to within one inch of the top, as in Fig. 2, C. Make a wooden bung for the jar, A, and pass a stout copper wire, B, through it, coiling it so as to make a good contact with the inside coating and forming the outer end into a terminal. Tightly twist a second wire, D, around the outside coating near the bottom. This jar is known as a LEYDEN JAR or FIXED CONDENSER. THE KEY is for the purpose of controlling the current of the spark coil so as to make signals. To make a key, get a piece of spring brass 6½″ long and ¾″ wide and bend it into the shape shown in Fig. 3, and with the dimensions there shown. Drill screw holes near each end. Cut an empty thread spool in half, and, plugging the hole, screw it to one end of the brass strip for a handle, as at B, using a round-head brass screw. Make a wood base ½″ thick, 3″ wide, 7″ long. Make two small screw holes at C and D so as to take small brass screws. Screw on brass strip so that B is directly over C, touching it when the key is pressed down.

THE SENDING COIL is shown in Fig. 4. Cut out, or, if you have a lathe, turn out, two wood discs ⅞″ thick and 10″ diameter, as at A. Plane up four sticks ¾″ square and 8″ long and four more ¾″ square and 9″ long. With brass screws fasten these sticks to the discs as in the figure, alternating the long and short ones, so as to make four legs for the piece to stand on. On one of the longer sticks drill a hole for a binding post 2½″ up from the bottom, and a second hole 1½″ from the other end, as at B and C. Get some stout bare copper wire, about No. 8, and wind on ten turns, keeping the wire tight enough to keep from slipping, but also keeping the turns nicely rounded. Two pieces of flexible conductor (lamp cord will do) about a yard long can be used for connections by attaching to them small spring clips such as come on some makes of suspenders. These clips may be clipped on the wire at any place. THE AËRIAL must next be made. This is simply a wire held in an elevated position and connected to the spark coil. You will need to look around your back yard, or consider whether you can have the use of the roof of your house, before you decide how long to make the aërial wire. Get two pieces of wood about 24″ × 3″ × ⅞″. Cut notches in them as in Fig. 5. Tie porcelain knobs or glass bottle necks at these notches and string through them some stout copper wire, making the space between the two wood bars as long as your space will permit. Twist connecting wires across the first wires at the places shown in the figure and attach wires at A and B, twisting them into a single wire to lead into the house to your wireless station. The wires must not touch anything, if possible, till you get them into the house. Make a hole in the window glass, or put a porcelain tube through the wall of the house to carry the wire inside. The aërial may be set up on the roof by making two masts properly guyed. We have now completed the sending part of our station.

THE DETECTOR, Fig. 6, consists of some crystals held between brass clips. Various substances are used, such as carborundum, galena,



pericon, and silicon. As it will be interesting to try different ones, this holder has been made to take any of them. To make it, get some spring brass ½″ wide and 6″ long, rather stiff. Cut it into two pieces 3″ long and bend one into the shape shown at A and the other like B. The two pieces should be about ½″ apart when set on a flat surface. Drill a binding post hole in the end of each piece, and in A drill a second $\frac{3}{16}$″ hole for a stove bolt, about 1¼″ from the straight end, as at E. Make a small wood base, F, about 4″ long × 1″ wide × ½″ thick, and on it mount the two brass springs by means of the two binding posts. Directly below the $\frac{3}{16}$″ hole in A drill a hole for the stove bolt at E, making it a tight fit for the bolt. Insert the bolt from beneath the base and put on it a nut just below the spring. Screw the nut down and force the bolt through the spring and put a nut on the top of the bolt, so there will be a nut on each side of the spring. By means of these two nuts you can change the pressure on the crystals held between the brass springs. At C place your crystals. A good pair to try is this: from some dealer in wireless supplies buy a little zincite and chalcopyrite. Crack them into small pieces and test them against each other in the detector, while you are listening for signals when the station is ready for work.

To change the working of the detector we need to provide a means of varying the current through it, and this can be done by making a simple piece of apparatus called a POTENTIOM-

ETER. This is shown in Fig. 7. Make a baseboard 9″ square and ⅞″ thick. Mount on it brass round-head screws about 1½″ long at the places marked 1 to 12 on the figure. Let the screws project about ¾″, and around them wind tightly a piece of bare German silver wire, about No. 30. Connect one end of this wire underneath the base to a binding post at A and the other to A′. On the other side of the apparatus mount two more binding posts and drill small holes near them, as at C, C′ near B, B′. Fasten pieces of lamp cord about a yard long down through the two holes and to the bottoms of the binding posts. To the loose ends of the lamp cords fasten spring clips as used on the sending coil. These clips are to enable you to connect to any part of the German silver wire.

To help in receiving long distances, the operator makes use of an instrument called a VARIABLE CONDENSER, shown in Fig. 8. Make a board 7½″ long, 4″ wide, and ¾″ thick, as at A, top view in the figure. Make a second board 7½″ × 4½″ × ¾″, as at B. Hinge these together by small brass hinges, as in the figure. Now cut twenty pieces of tin, rather stiff, each 3¼″ × 7⅜″, which we will call the "plates" of the condenser. Cut also two tin strips ½″ × 8″ for connectors, as at E. Bend each one of the large plates into the shape shown in Fig. 9, keeping the sides exactly ⅜″ apart and not getting any buckled places in the plates. Place each sheet saddle fashion over a piece of hardwood and punch two small tack holes in the sheet, as in the figure. Lay one of the ½″ strips, E, on A and flush with one end of it, as at C. Tack ten of the plates or "saddles" on the strip A, starting flush with the first one at C. By using a piece of ⅜″ hardwood for a driver you can tack them on easily. Space them exactly ⅜″ apart. In like manner, put a strip on B and tack over it the remaining ten saddles, arranging them to come just between those on A, when A and B are closed up to form a square corner. There should then be 3/16″ between metal everywhere. Be sure there are no places that come near touching. Bend over the ends of the strips and fasten them by two binding posts. Mount the whole on a base 9½″ × 7″ × ⅞″. Fasten only the piece A, with end C down. Cut off the bottom of B, so that B will just swing clear of the base, and fasten to it a small screw eye, D. By looking at the top view you will see a simple scheme for holding A in any position. When the plates are all sandwiched together, the condenser has its greatest effect.

To assist in receiving from a distant station, the operator will have need of a piece of apparatus called a TUNING COIL, shown in Fig. 10. Make a wood base of ½″ wood, 15″ × 5¼″, as at A, Fig. 10. Make two pieces 4¾″ square out of ½″ stock, as at B, B′, and draw a line across the middle of each. Measure 2¼″ in from one side on this line and make a dot. On B drill a ⅜″ hole halfway through at this dot. On B′ mark a circle 3½″ diameter and cut it out, saving the squared part to use. Turn or cut out two discs ¼″ thick and 3⅜″ diameter, with ⅜″ holes through them, at their centers. Glue one of them on B, as shown at C. On a round roller 3⅜″ diameter, roll up a paper tube with walls 1/16″ thick and 6″ long, as at D. Make a pair of small holes at E, 1″ from one end of the tube, and two more at F, ½″ from the other end. Mount the paper tube temporarily on something so you can revolve it, and wind on it one layer closely of No. 20 single cotton-covered copper wire, leaving a 6″ terminal at E and just enough to fasten at F. Slip this tube over C and tack it firmly in place with copper tacks. Now slip B′ over the tube and tack as before. Be sure the two wood squares stand firmly on a flat surface. Get a piece of ⅜″ dowel rod or other round rod and cut it 13½″ long, put glue on one end and drive it into C and B. Let the other end be supported with the center 2½″ above the base till all is set. Screw B and B′ neatly to the base from below and nail across their tops a strip of wood, G, ¼″ thick, 1″ wide, and 6½″ long. Fasten a binding post at each end, connecting one to E and the other to an 8″ piece of lamp cord, H. Wrap eight turns of stout bare copper wire around G at IJ to make a slider. Fasten the lamp cord at I and make J rub along the wire on the cylinder, sandpapering a path for it. Call this the primary winding of the tuning coil. To make the secondary winding for it, roll a paper tube, K, 6″ long with walls 1/16″ thick and outside diameter 3″. Make a wood disc, L, ⅜″ thick and 2⅞″ diameter, and another like it at M. Bore a 7/16″ hole through L in the center and a hole in the center of M that will be a loose fit on the dowel rod. Now make a piece $\frac{1}{2}''$ thick, $3\frac{15}{16}''$ long, and $3\frac{1}{2}''$ wide, N. Dot it $1\frac{3}{4}''$ from one side and $1\frac{3}{4}''$ from one end.

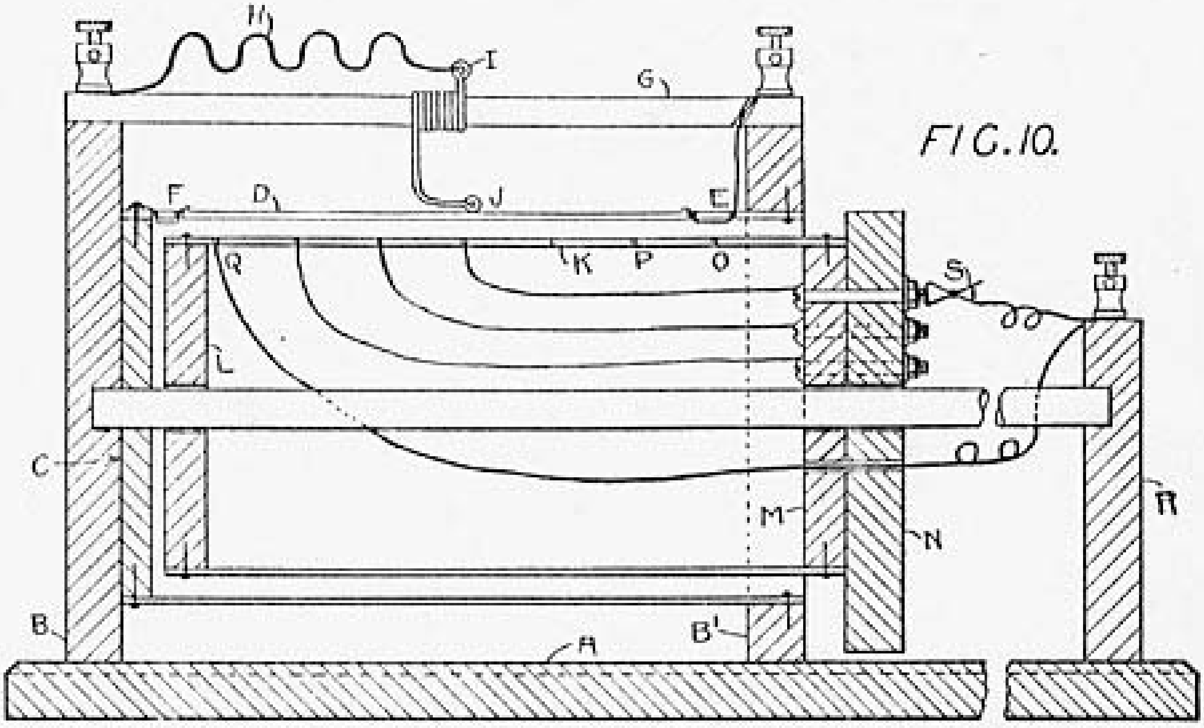


FIG. 10.

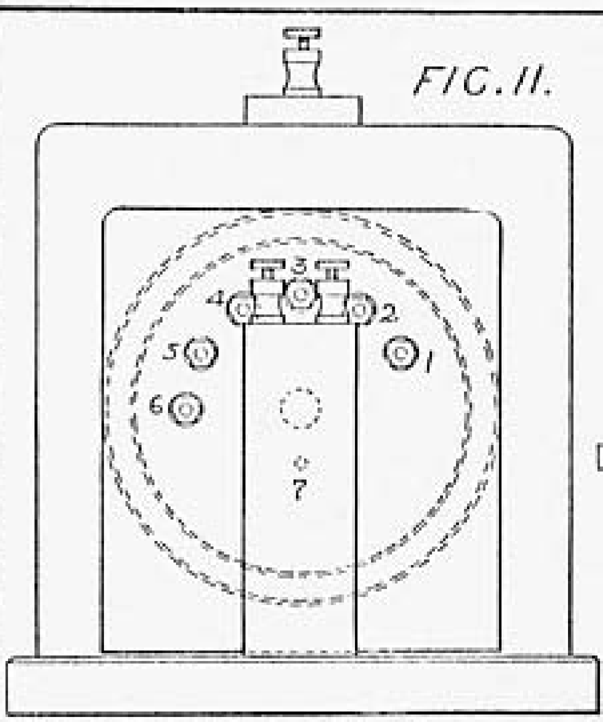


FIG. 11.

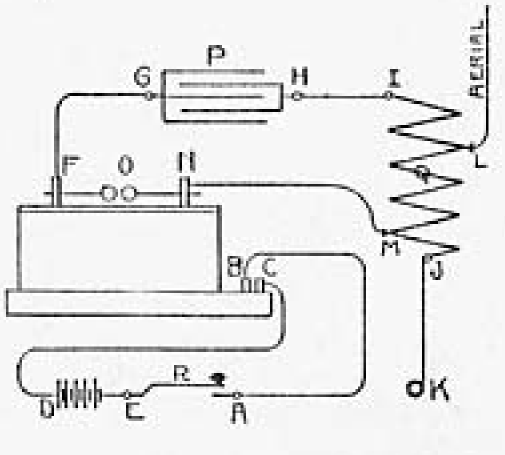


FIG. 12.

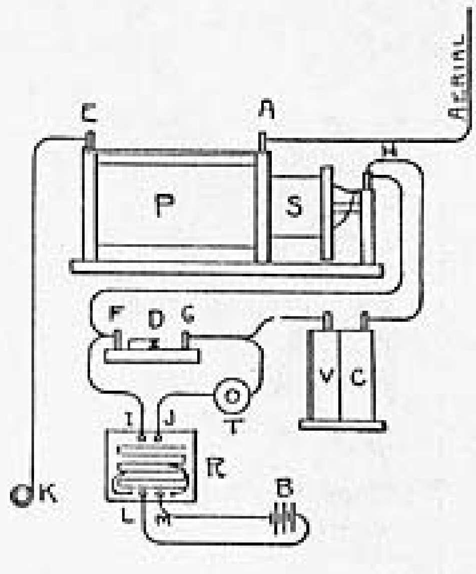
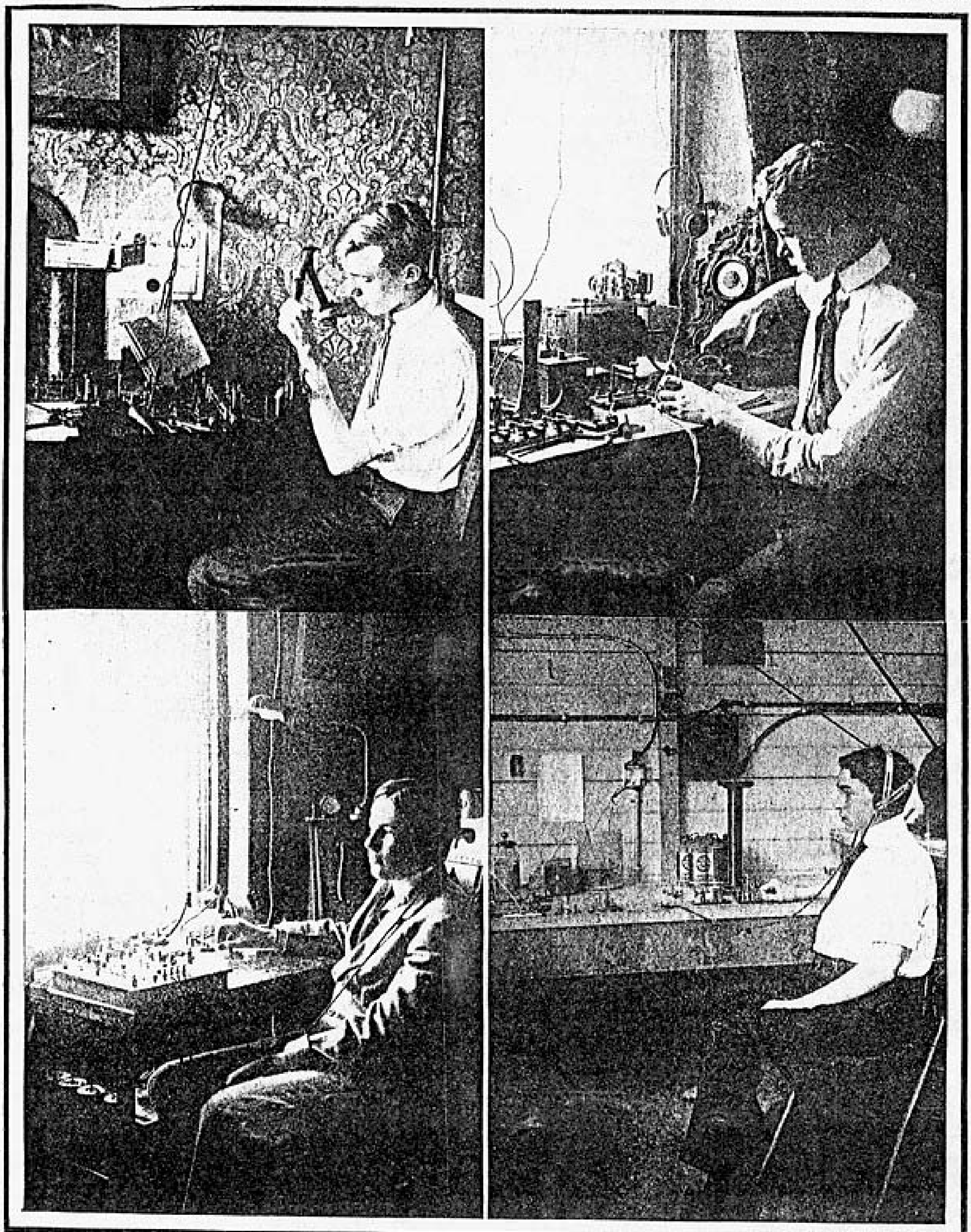


FIG. 13.

Bore a hole through it for a loose fit on the dowel. Fasten it to M with the holes in line. Referring to Fig. 11, lay out on M a circular row of holes, No. 1–6, each to be $\frac{3}{16}''$ diameter. Bore hole No. 7 also for a piece of lamp cord to pass. Pass six little bolts (stove bolts are good) through the six holes from the inside, as in Fig. 10. They should project about $\frac{1}{8}''$ beyond the washers and nuts. Wind on the paper tube one close layer of No. 22 single cotton-covered copper wire, starting $1\frac{1}{8}''$ from the right-hand end, by passing the wire through hole O for a 4″ terminal and then plugging the hole. Wind on closely till you have $\frac{3}{4}''$ wound on. Then pass



AMATEUR WIRELESS OPERATORS AT WORK

Top: A home-made machine that sent 300 miles; tuning up his wireless. Bottom: Sending on his wireless; listening for the press.

the wire in a loop down through a hole, P, plug the hole, and continue winding. The loop should reach to the end of the tube, as at M. Continue winding and looping till you have five loops. End the winding ½″ from the left end of the tube and pass the end down through hole Q, then through hole No. 7, and leave 12″ extra. Plug hole Q. Fasten the disc M inside the tube with copper tacks and fasten the wire through O to bolt No. 1, first loop to No. 2, etc., then put in the disc L, and tack in place. Slip the completed coil over the dowel rod and into D, with hole No. 7 down. Make an upright, R, ½″ thick, 1″ wide, and 3″ high, bore a ⅜″ hole halfway through one side 2¼″ from the bottom, and then fasten the dowel rod into it with glue, making sure it stands upright on the base. Screw the upright to the base. Put two binding posts on the top of this upright, as in Fig. 11. Connect one post by a piece of lamp cord 8″ long with a spring clip, S, making a firm contact, and connect the other post with a piece of lamp cord twisted to the wire through hole No. 7. Push the excess wire and part of the cord back into this hole.

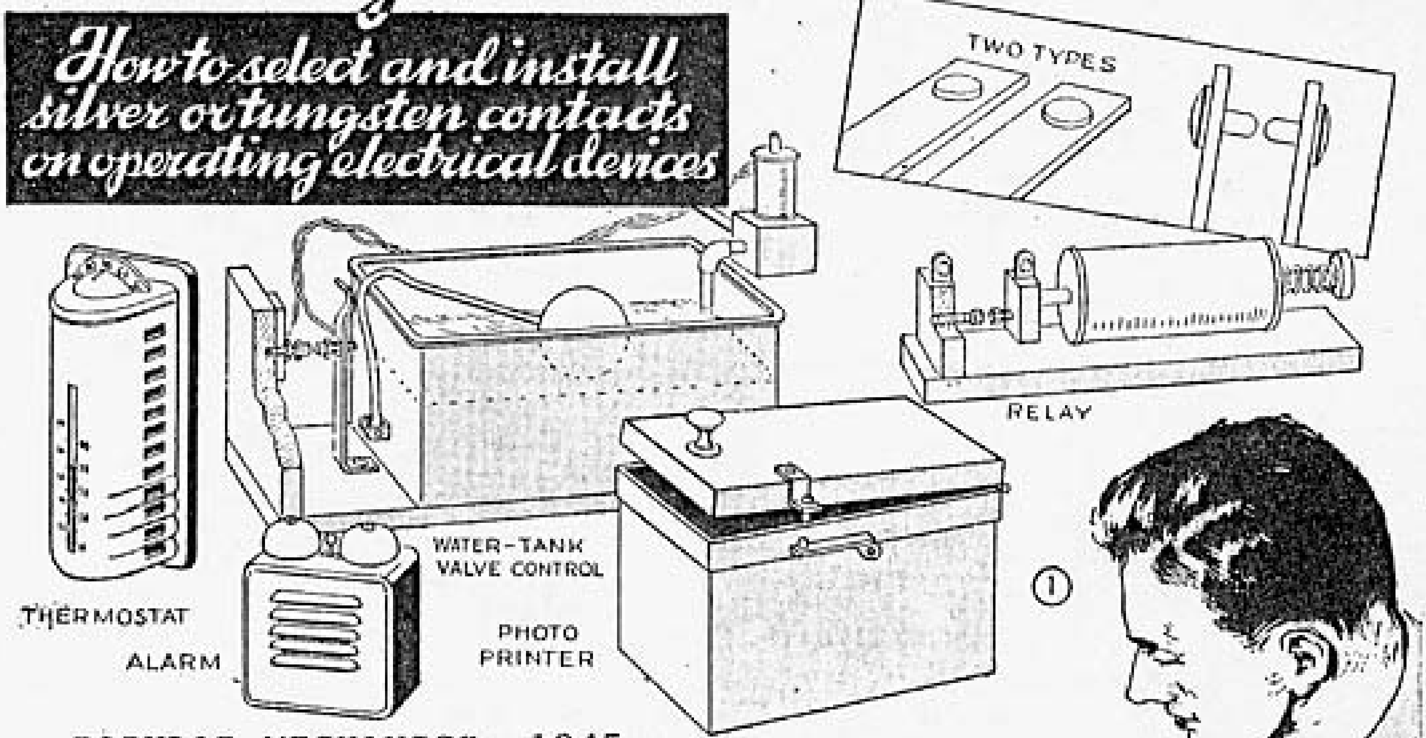
We are now ready to install our apparatus and connect up the station. First look at Figs. 12 and 13. In Fig. 12 connect with stout copper wire one end of the key, R, to a battery of five dry cells. To do this loosen the screw on the key and put the bare copper wire under it, screwing down again firmly, then connect the other screw of the key to B. Connect the remaining terminal of the battery to C on the primary of the spark coil. If you buy the spark coil, the primary posts, B, C, are those closest together, generally at one end of it. Pressing the key will now send current into the spark coil. Connect the two other posts, F, N, of the spark coil, one each to the two sides of the zinc spark gap, O, and set the gap at ⅛″. The key should now send sparks across the gap when pressed down. Connect also one side of the spark gap to one side, G, of the Leyden jar, P. Connect the other terminal, H, of the jar to post I on the sending coil. Now connect the other post of the sending coil to a water pipe for a "ground," as it is called. Do this by filing a bright place on the pipe and winding several turns tightly around it, as at K. Connect N to a clip to be placed on M, and connect your wire from the aërial by means of a clip to the sending coil at L. The receiving set, Fig. 13, has the aërial connected to one post of the primary of the tuning coil at A. The other post of the tuning coil, E, is to be connected to a water pipe, K. Connect one post of the secondary to one side of the detector at F, and connect the other side of D to a high-resistance receiver, T, which you were advised to buy. The terminal G is connected also to one side of the variable condenser, VC. The other side of the condenser, VC, goes to the second post on the tuning coil at H. Fasten a wire also from the side of the detector at F to I on the potentiometer, R. Connect J to the remaining side of the receiver, T. Attach a battery of three dry cells to L and M of the potentiometer, R, and snap on the two spring clips at any two places on the German silver wire. You must arrange to disconnect the aërial from the sending set when you are listening, and *vice versa*. This can be done by a double-throw switch, or by simply removing the wire on the binding post, A. To listen, connect aërial to the tuning coil as shown, place the receiver at your ear, then slowly slide in the tuning coil secondary, or run the slider along the primary, or try changing the pressure on the crystals in the detector, till you catch the distant signals. They may sound like a faint high-pitch note. By experimenting with your apparatus, you will find the best adjustment.

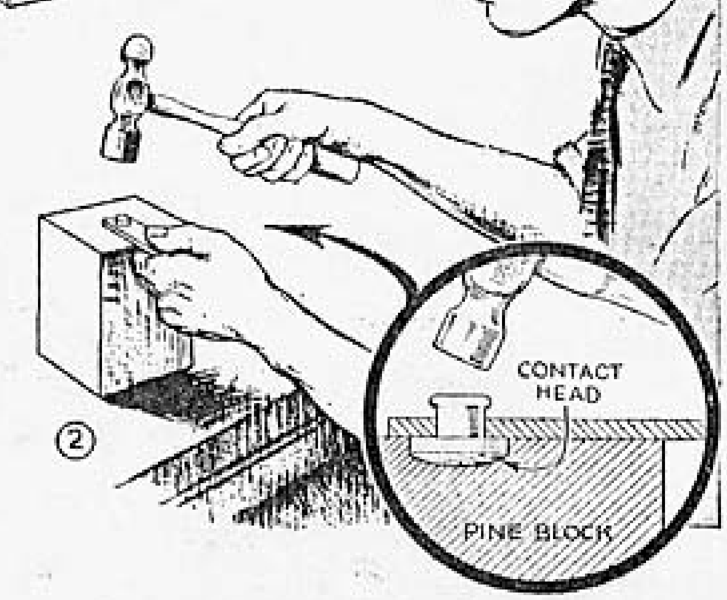
The descriptions of apparatus for these telegraph and wireless sets are technical, but the machinery is not too complicated for you to study out and make. Mr. Hall, who writes the directions for the wireless apparatus, is a teacher of high school boys. He says that he has acted as "consulting engineer" more than once to boys who were setting up wireless stations. The telegraph set is described by Mr. MacNary, principal of the Vocational School, Springfield, Massachusetts.

To make and use this apparatus with any satisfaction, you must have not only mechanical skill but a knowledge of the principles of electricity. Read the chapter on "Electricity" in Volume II, where the story of these two inventions is told, but do not be content with this. Read everything you see on the subject, and learn all you can about this mysterious force which you are making your servant to enable you to talk across space.

Making GOOD CONTACTS

How to select and install silver or tungsten contacts on operating electrical devices





POPULAR MECHANICS, 1945

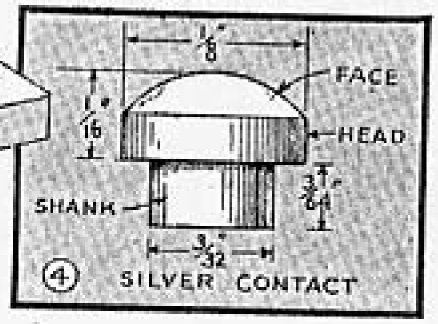
By C. A. CROWLEY

AS THE satisfactory operation of many electrical appliances and devices depends on the flow of electricity across a pair of closed movable contacts, as in thermostats, relays, etc., Fig. 1, it is important that they be kept clean, and that the proper type be used for the particular job. No matter what type or style contacts are used they get dirty or pitted and require occasional cleaning. Emery paper or cloth should not be used to clean contacts. Fuzz or grit is liable to be left between the faces, leaving the contacts little better, or even worse, than before. Carefully drawing a thin, flat file between the faces will remove the scale and pits. The filings and accumulated greasy dirt should be wiped off with a piece of chamois moistened in cleaning fluid. The capacity of condensers across a pair of contacts, when this method is used to prevent sparking on d.c. circuits, should not be so high as to eliminate the spark altogether. A little sparking burns away the accumulations of greasy dirt resulting in better performance. Where contacts carry a heavy load, a resistance coil of about 1 ohm per volt in the circuit should be connected in series with the condenser to prevent the contacts from overheating during the break or when they chatter slightly as often may be the case. Although many metals and alloys are used, contacts of silver or tungsten are best usually.

Simple Tester for Short Circuits

If a lamp or some appliance in the home is blowing fuses, you can make a tester to locate the trouble. Just take a short electric cord with a plug on one end and a socket on the other. Remove the insulation in the center and connect a socket containing a fuse to one of the wires. To use the tester, remove all appliance wires and then plug in the tester to each one in turn. When the faulty appliance or connection is found the fuse in the tester will blow.

③ THERMOSTAT WITH SILVER CONTACTS



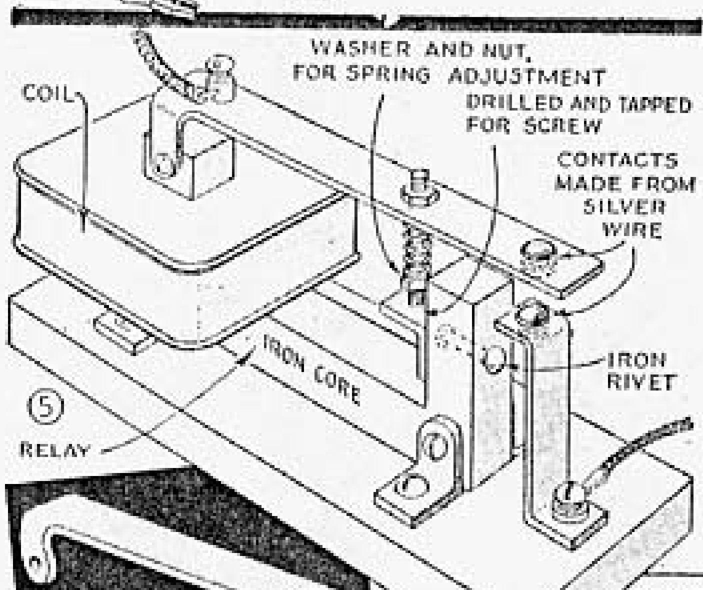
④ SILVER CONTACT

Silver contacts: Pure silver has the lowest electrical resistance of any metal, and makes the best contacts where the voltage and the mechanical pressure holding the contacts together are both low. Relays, thermostats and other devices operating with a voltage not greater than 6 volts, perform better if the contacts are of silver.

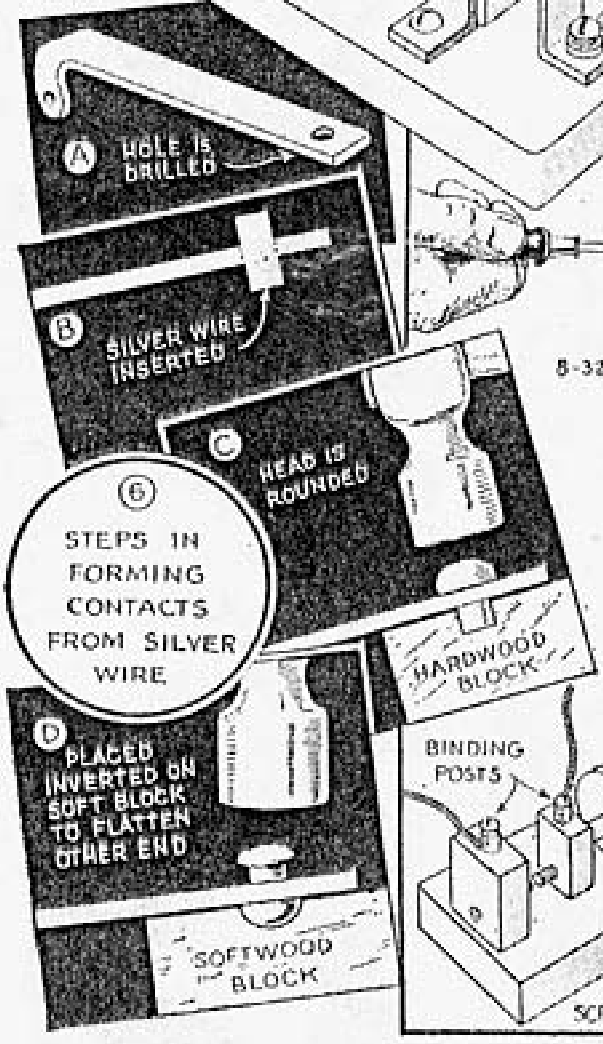
Silver rivet contacts: Silver contacts are made in the form of rivets for convenience, as the metal is soft and malleable. Due to the mechanical impossibility of perfectly aligning two flat surfaces, silver contacts are provided with radius faces as in Fig. 4. To illustrate the use of this type of contact, a thermostat of the type shown in Fig. 3 which closes and opens a low-voltage electrical circuit with a rise or fall in air temperature, is used as an example. Using a block of soft white pine as a base for the contacts, Fig. 2, will prevent deformation of the face when mounting. The mounting assembly also shows how the contact face is pressed into the soft wood by the force of the hammer blows in heading over the shank. In those cases where a vise must be used to press-fit the contacts into a mounting thicker than the length of the contact shank, the soft pine block will protect the head from deformation by the jaws.

Silver wire contact points: Contacts for small assemblies like the relay shown in Fig. 5 can be made easily from silver wire and formed right on the mounting. Fig. 6 illustrates the method used, which is nothing more than forming the head or face of the contact with a hammer.

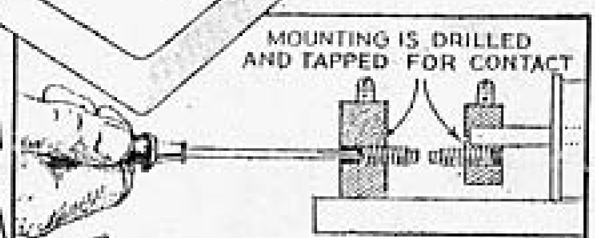
Tungsten contacts: In building large relays, automatic switches, buzzers,

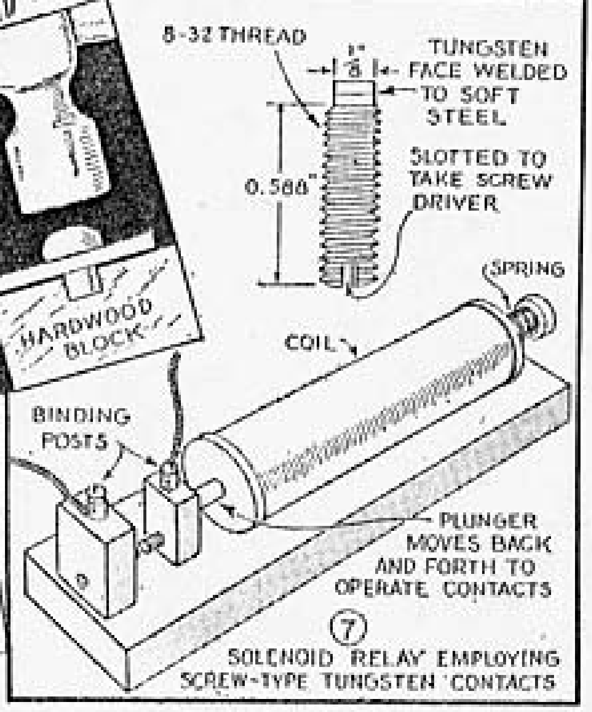


⑤ RELAY



⑥ STEPS IN FORMING CONTACTS FROM SILVER WIRE





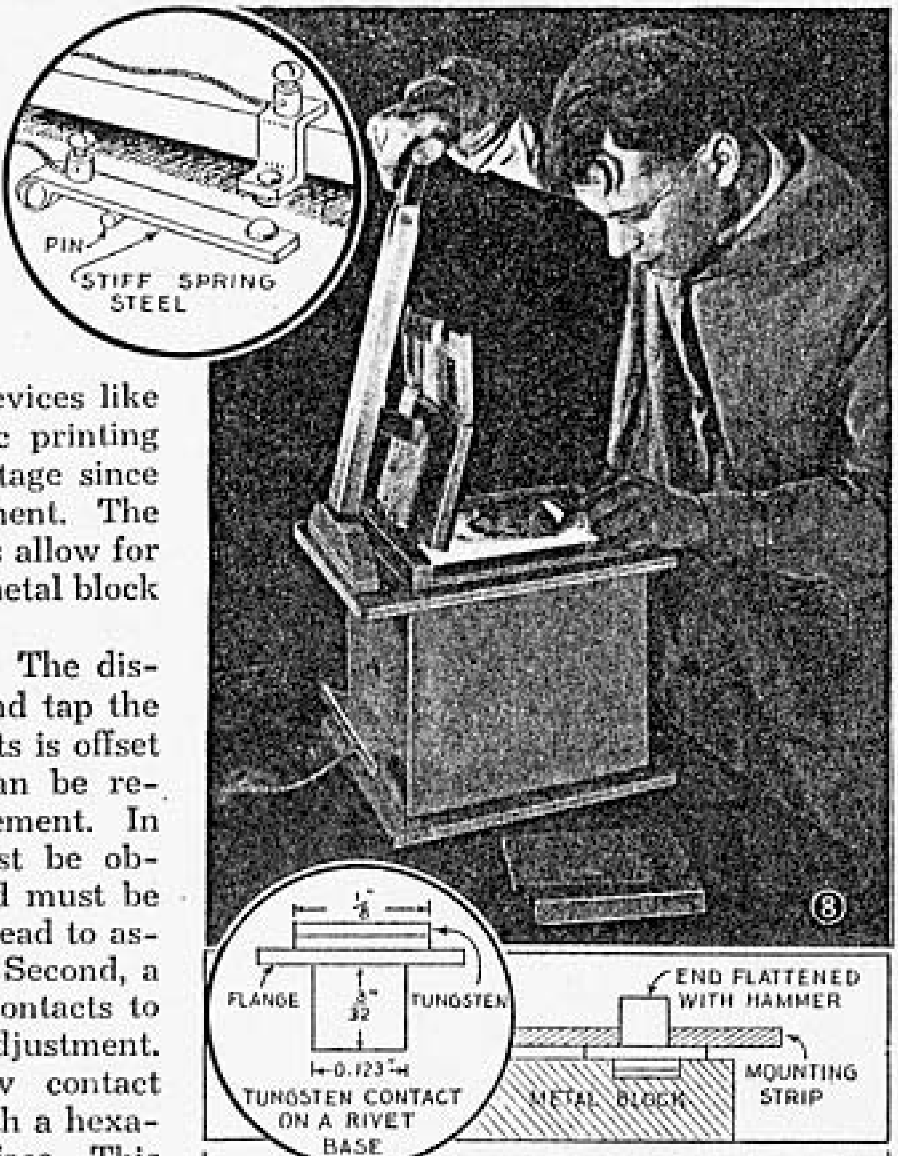
⑦ SOLENOID RELAY EMPLOYING SCREW-TYPE TUNGSTEN CONTACTS and similar devices with voltages ranging from 6 to 135 volts, it is best to use tungsten contacts. Tungsten is very hard, so contacts of this metal are always furnished welded to a soft steel base screw or rivet.

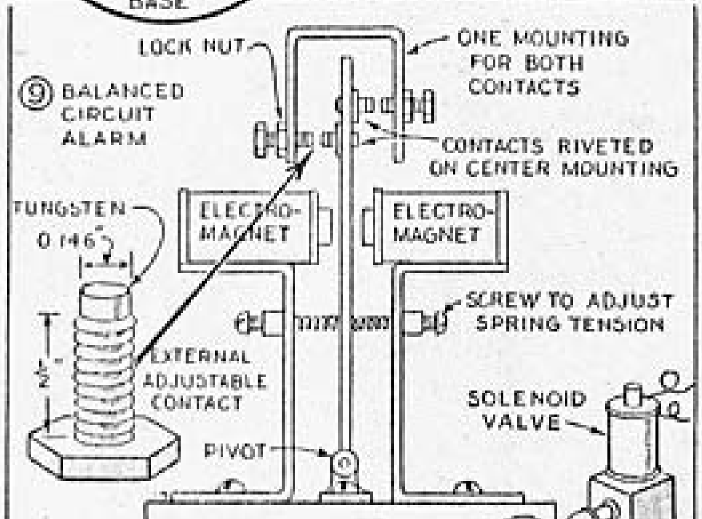
Tungsten rivet contacts: Rivet contacts like the one shown in the circular detail of Fig. 8 are the easiest to install. On devices like the switch on the photographic printing box they can be used to advantage since they need little or no adjustment. The flange on tungsten rivet contacts allow for a firm support of the head on a metal block when mounting them.

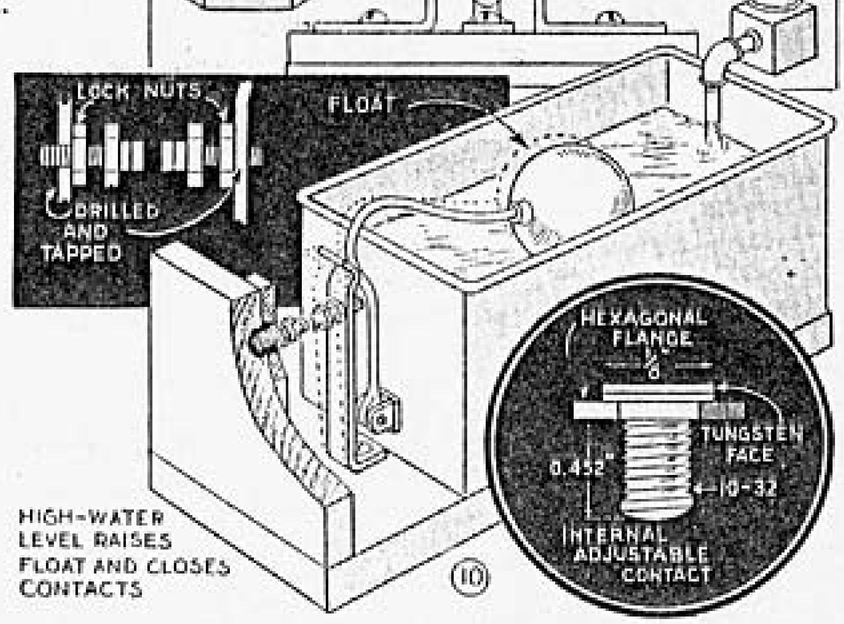
Internal adjustment contacts: The disadvantages of having to drill and tap the mounting for screw-type contacts is offset by their adjustability. They can be removed for cleaning or replacement. In mounting, two precautions must be observed. First, the tap drill used must be exactly the right size for the thread to assure a tight fit to the contacts. Second, a lock nut must be used on the contacts to tighten them in place after adjustment. The internal adjustment-screw contact shown in Fig. 10 is provided with a hexagonal flange just back of the face. This type of screw contact is used where installation and adjustment must be done from between the two mountings. The electrical overflow control for water tanks is a good example of this.

Headless contact: Useful on very thick mountings is the headless, slotted, tungsten contact screw shown in Fig. 7. It is installed from the outside of the mounting with a screwdriver. The solenoid relay is just one example of a device using heavy mountings with this type of contact.

External adjusting contact: On some devices adjustment and installation of the contacts can only be accomplished from the outside of the mountings. In Fig. 9 is shown a tungsten screw-contact unit designed to meet these conditions. The hexagonal adjustment head is on the end opposite the face. Two of these contacts, installed with lock nuts from the outside on the stationary mounting of the alarm control, oppose two rivet-type contacts installed on the movable mounting.





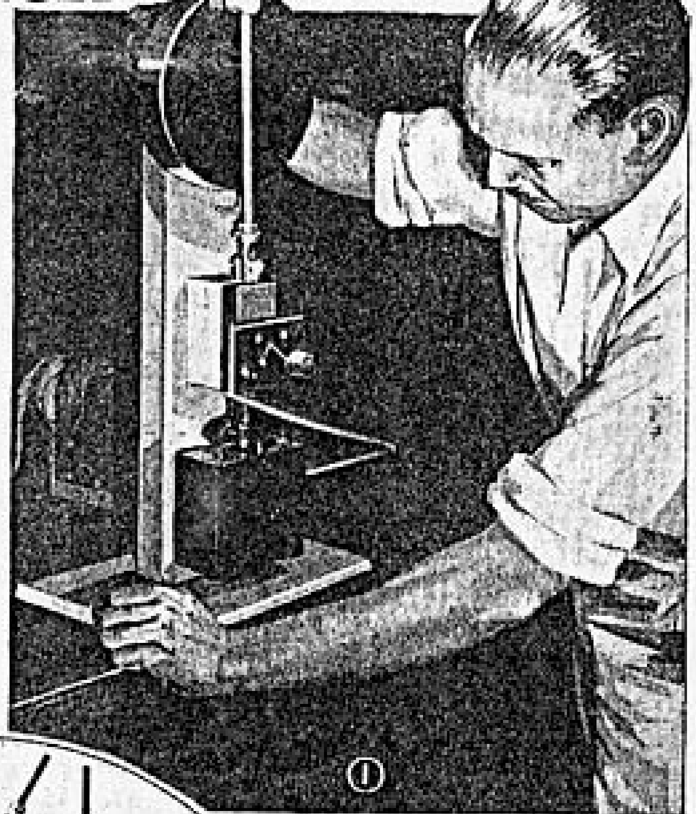


Oscillating-type MAGNETOS

EASILY TESTED AND SERVICED

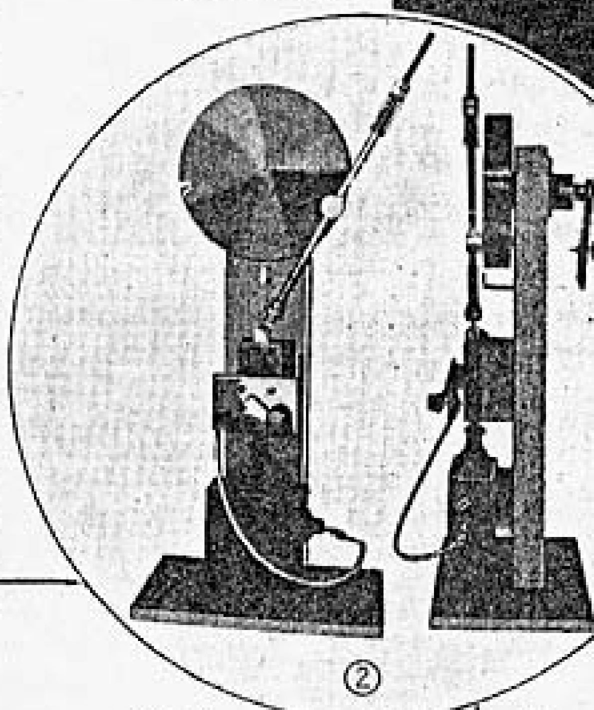
POPULAR MECHANICS, 1945

By JACK BEATER

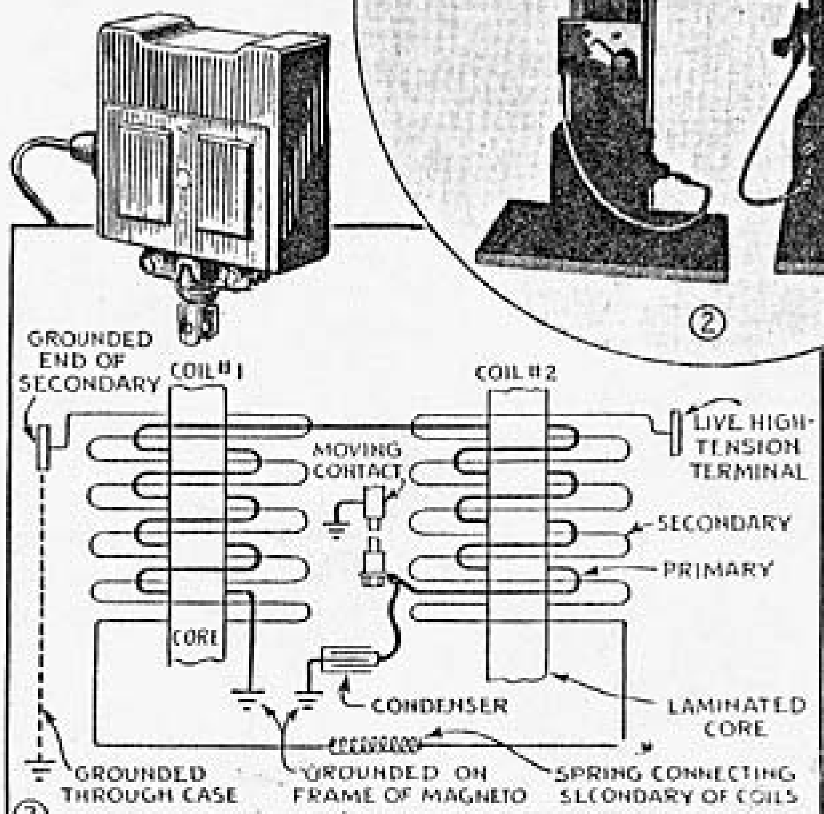


①

ONE of the most popular types of oscillating magnetos, which is used extensively on small one-cylinder gas engines supplying power for boats, lighting plants, light machinery and pumps, cannot be tested on any ordinary type of generator or magneto test bench as the magneto has no rotating parts. The crossbar or "armature" of this magneto is "kicked" up and down on the pole ends to make and break the magnetic field, and to open and close the primary circuit. It is a simple high-tension magneto, consisting mainly of two laminated pole pieces, eight plain-bar magnets, two coils containing both the primary and secondary windings, points, condenser, and laminated armature. The operating principle is easily understood. The bar magnets, clamped between the pole pieces, supply the initial energy and make one pole piece a north pole and the other a south pole. The coils are hollow and slip over the pole pieces. The laminated crossbar, or armature, rests upon the tops of the pole pieces and provides a path for the magnetism to travel from the north to the south pole. When the engine mechanism moves the crossbar from the tops of the pole pieces, the flow of magnetism is interrupted. This action creates an electrical current that flows through the primary windings of the two coils. An instant after the crossbar has left the pole tops the continued movement of the crossbar opens the points, and the current flow in the primary is suddenly interrupted. This inter-

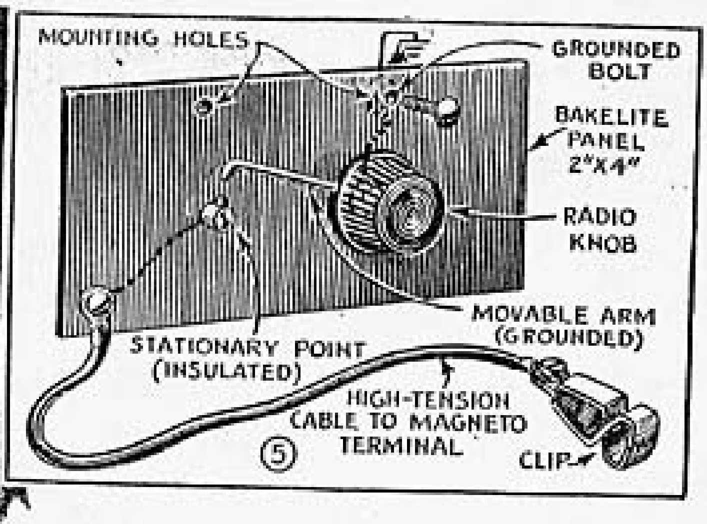


②

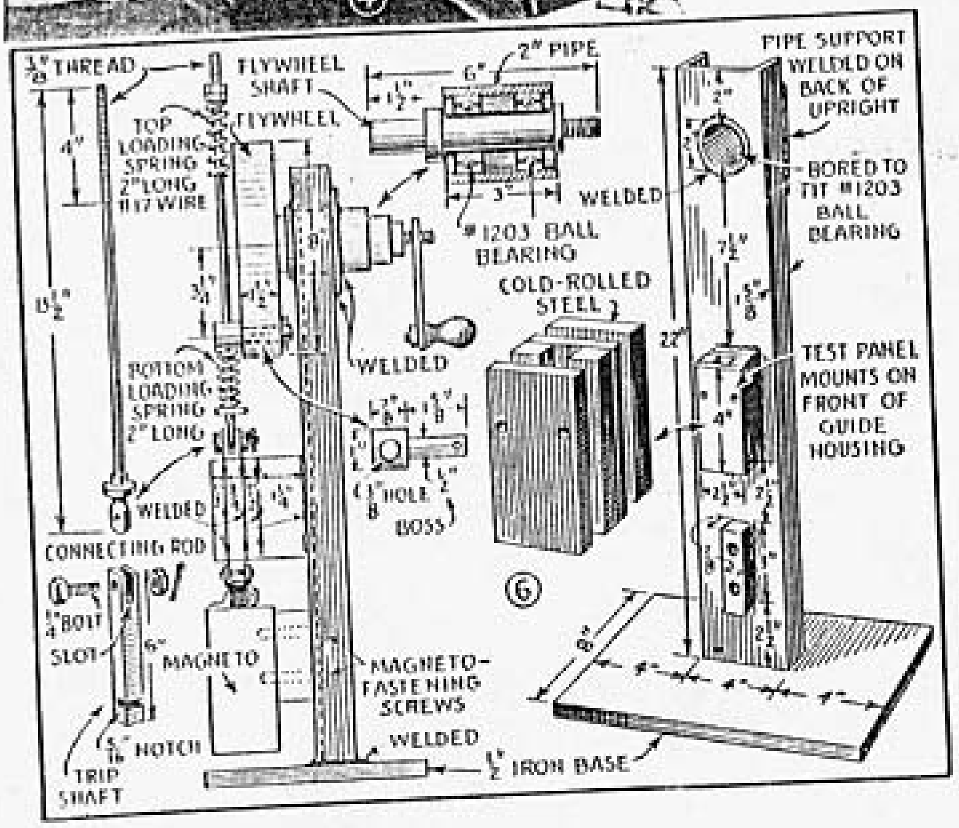


③ CIRCUIT DIAGRAM OF OSCILLATING-TYPE MAGNETO

④



⑤



⑥

ruption induces a high-voltage current in the secondary windings of the coils that passes out of the magneto terminal and to the spark plug. The engine mechanism then returns the crossbar to its original position on the ends of the pole pieces, completing the cycle.

The coils of this magneto are quite rugged but occasionally become defective due to excessive moisture or other causes. The high-tension terminal of each coil consists of a small brass button, and the high-tension connection between the two coils is made by a short coil spring insulated with varnished tubing. The terminal button on one coil is always grounded to the outer cover, while the other button connects through a small coil spring to the high-tension terminal of the magneto. The paths of the primary and secondary circuits are shown in the circuit diagram, Fig. 3. The coils can be tested on one of the standard magneto coil testers such as that shown in Fig. 4.

The construction of a test stand for this magneto is shown in detail, in Figs. 5 and 6. The channel-steel upright is welded to the steel base plate. Above this a small steel block is welded to the upright to hold the magneto in the right position for testing with the crossbar down, Fig. 1. Immediately above the magneto, the trip-shaft guide block is welded to the frame. The guide block is assembled from ordinary square and flat steel stock and spot welded together. Near the top of the upright a 3-in. length of 2-in. pipe is welded through and at right angle to the frame. Before welding into place, this pipe is machined inside to take the two ball bearings used to support the flywheel shaft. The flywheel can be of cast iron or steel and is a press fit on the shaft. A floating boss is mounted in a drilled hole near the rim of the wheel and controls the action of the spring-loaded connecting rod.

The latter is made of 3/8-in. cold-rolled steel rod, threaded at one end and heated and flattened at the other. A turned collar at the bearing end supports the bottom loading spring, while the tension of the top loading spring is adjusted by means of a nut and lock nut. The loading springs are of the coiled-wire type.

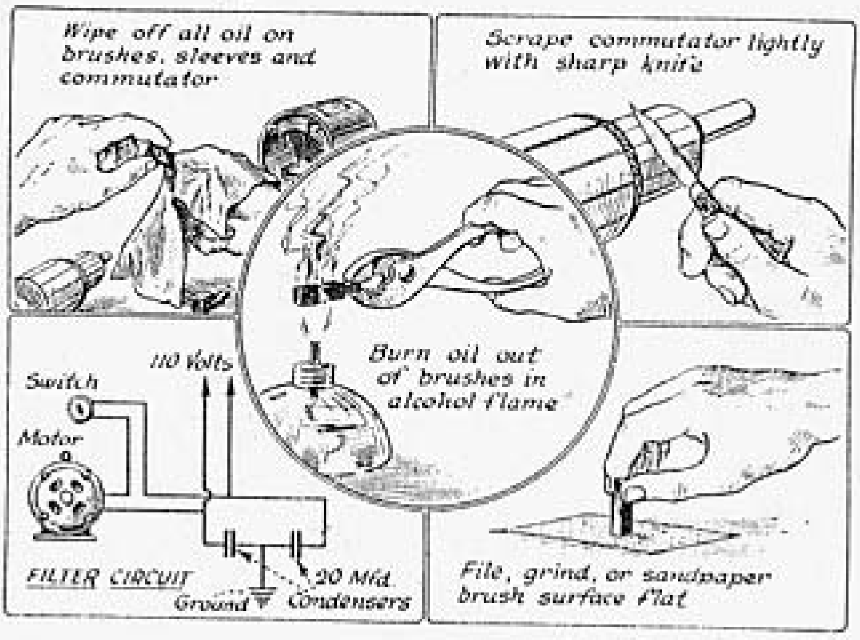
The trip shaft is easily made from ¾-in. square steel bar. It must be notched at both ends as shown and must slide freely in the guide. A crank handle can be provided on the flywheel shaft for manual operation, or a pulley for motor drive.

Now, in operation the floating boss compresses the top spring as it moves upward. Slightly before top dead center the coil spring is fully loaded and the continued movement of the boss "bumps" the connecting rod upward. The latter being engaged with the lifter pin of the crossbar on the magneto, snaps the armature from the pole tips and pulls it upward as the spring unloads tension. The bump of the flywheel boss on the fully compressed loading spring causes the initial separation of the armature from the pole tips but the balance of the snappy upward movement of the armature is caused by the unloading of the top coil spring. On the downward half of the cycle the flywheel boss loads the lower coil spring and re-engages the armature with the pole tips. Unless the armature makes a good contact with the pole tips after each spark the magneto will miss on the next revolution. Hence the lower loading spring is important but not critical in adjustment.

A small Bakelite panel is mounted above the magneto on the front of the trip-shaft guide housing, Figs. 2 and 5. The panel is fitted with an adjustable spark gap for checking the condition of the spark. A high-tension cable and clip are permanently attached to the panel for connection to the magneto high-tension terminal.

When operated by hand the magneto can be tested at any speed, from one revolution per minute up to several hundred or more. Because it duplicates the tripping action as found on all engines using this type of magneto, the tester can be depended upon to prove the condition of the magneto before it is put back into service. The tester shown here was designed and built in a magneto repair shop, where it has given splendid results.

How to Care for the Household Utility Motor



Oil in the wrong place is an enemy of small motors. Wipe off the commutator—keep it clean. Radio noises can be eliminated by grounding a 20 m.f.d. condenser across the circuit. Brushes are important. This shows how they are cleaned.

"GIVE that little mill a break," says Esten Moen, a Packmag reader. "Nothing about the household is so abused and so given to neglect." And then in these words he tells how to service the little fellows:

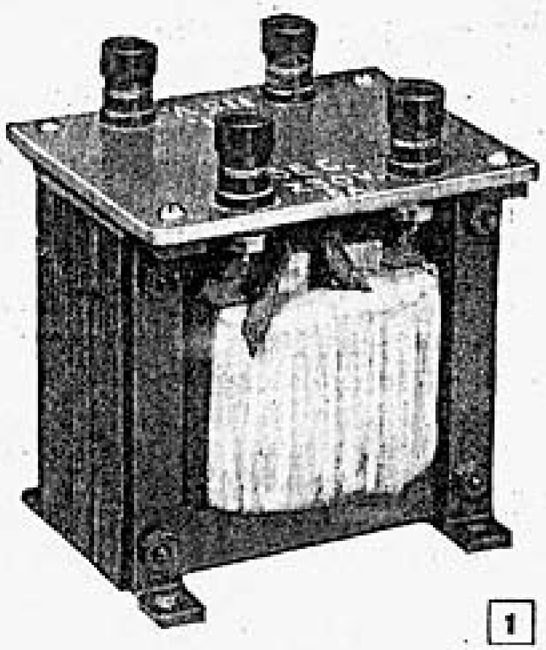
Usually the midget utility motor, developing only from 1/20 to ¼ h.p., is subjected to loads and lack of attention (through ignorance) more than any other piece of machinery on the face of the earth. When they get worn and growly, they affect the radio, and cause no end of dissatisfaction that is really no fault of their own but of the gentleman who runs them. Clean them up and watch the difference.

Take the end plates off. Clean the commutator by scraping lightly with a sharp knife. Do not scrape so hard that the copper comes off, just remove the scum from the burned oil. No emery or sandpaper should be used unless the commutator is badly scored. Even then it might be best to put the armature in a lathe and face it off a little.

Oil is never to be allowed on the commutator. Through ignorance sometimes people oil the whole works. Oil should be used only on the bearings. When the commutator is clean, next attack the brushes. See that they are square on the ends. When worn they are hollow and cover more segments than they should.

YOU CAN BUILD YOUR OWN TRANSFORMER

POPULAR MECHANICS, 1951

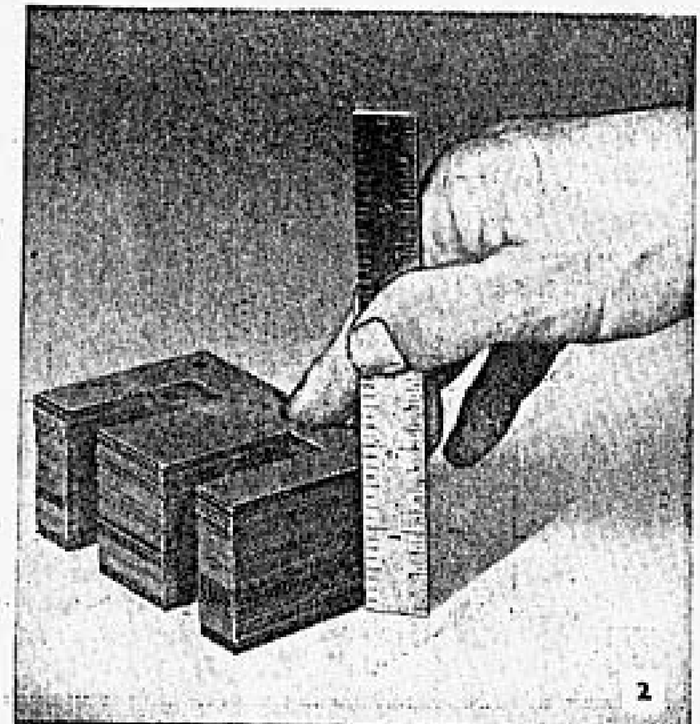


1

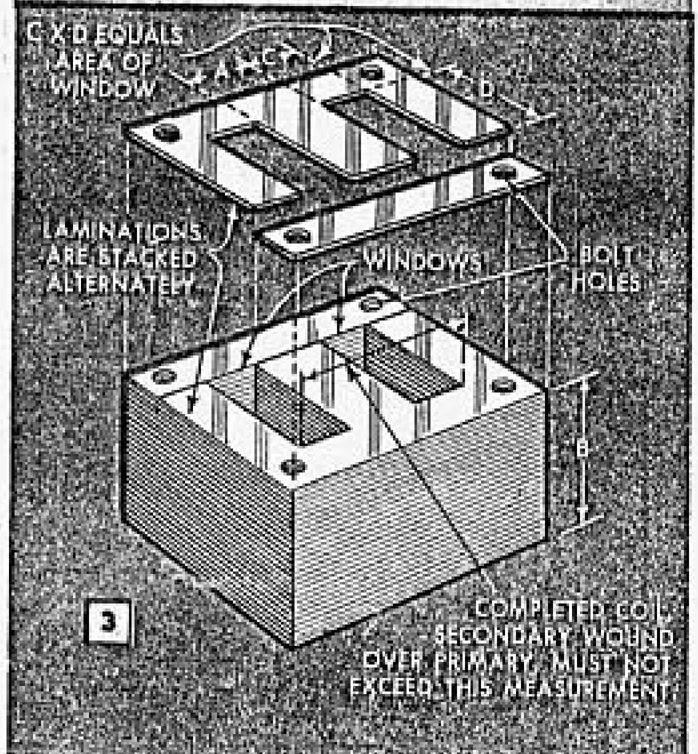
By Harold P. Strand

DESIGNING and making small single-phase transformers, such as the electrical experimenter and radio technician require, is an interesting and educational project. Although transformers of standard voltage rating can be purchased, it is often necessary to obtain special voltages for experimental work or new apparatus. It is far more economical to make the transformer yourself than to have one built to order.

An elementary transformer consists of a laminated iron core on which a coil of insulated wire is wound. The coil may be a single winding with taps, such as an auto transformer, or one with two separate coils as in Figs. 1 and 5. The latter, being the most widely used, will be discussed in this article. As indicated in Fig. 5, one of the coils is called the primary and is connected to the current input. The other coil, from which current is taken, may have more or fewer turns than the primary and is called the secondary. The core must be built up, or laminated, from thin sheets of silicon steel, because the constant reversal of the alternating-current flux sets up eddy currents in a solid-iron core. Therefore, the use of a solid core would result in excessive heating of the transformer. Laminating tends to break up these eddy currents.



2

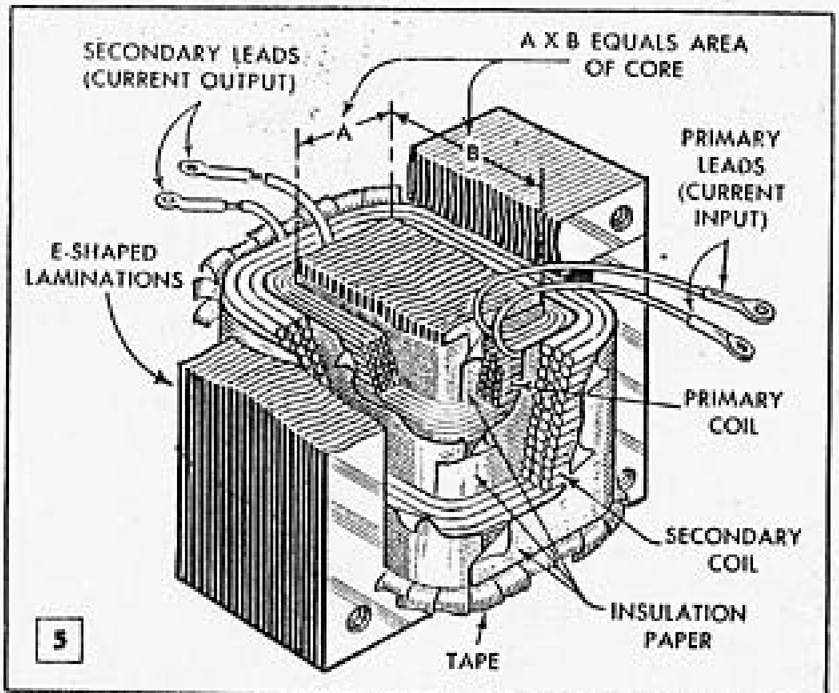


3

4 **AVERAGE TRANSFORMER CORE RATINGS**

Volt-ampere Output	Cross-sectional area in square inches		
	25 cycles	50 cycles	60 cycles
5	0.6	0.3	0.25
10	0.8	0.4	0.3
20	1.2	0.6	0.5
25	1.4	0.7	0.6
50	2.5	1.25	1.0
75	3.5	1.75	1.5
100	4.2	2.1	1.8
125	4.6	2.3	2.18
150	5.0	2.5	2.2
200	5.6	2.8	2.4
250	6.0	3.0	2.6
300	6.6	3.3	2.8
400	7.0	3.5	3.0
500	7.6	3.8	3.4
750	8.8	4.4	4.0
1000	10.8	5.4	4.8

For transformer-grade, silicon steel sheet metal 26 to 29 gauge.



6 FORMULA FOR FIGURING PRIMARY TURNS

$$\frac{10^8 \times E}{4.44 \times f \times A \times Bm} = \text{TURNS}$$

E—PRIMARY VOLTAGE
4.44—FOUR TIMES THE FORM FACTOR
f—FREQUENCY, CYCLES PER SECOND
A—AREA OF THE CORE IN SQUARE INCHES
B—FLUX DENSITY IN LINES PER SQUARE INCH

7 WIRE TABLE

Gauge	Cross-Sectional Area (bare) Circular mils	Turns per Square Inch (with insulation)
8	16510.	56
9	13090.	72
10	10380.	90
11	8230.	112
12	6530.	140
13	5178.	177
14	4107.	220
15	3257.	276
16	2583.	346
17	2048.	428
18	1624.	534
19	1288.	665
20	1022.	835
21	810.	1042
22	642.	1310
23	509.	1600
24	404.	1980
25	320.	2470
26	254.	3090
27	202.	3870
28	160.	4830
29	126.7	5920
30	100.5	7430
31	79.7	9120
32	63.2	10,000
33	50.1	13,900
34	39.7	17,700
35	31.5	22,200
36	25.0	27,700

Turns per square inch have been calculated from the mil dia. of each size and are close enough to use in estimating size of finished coils.

Briefly, the theory of transformer operation is as follows: The line voltage sends a current through the primary coil, setting up a magnetic flux—invisible lines of force —in the iron core. As the core also encircles the secondary coil, the flux, which rises and falls in step with the alternating current, cuts through the turns of the secondary and, by the laws of magnetic induction, induces a voltage in this winding. If the secondary circuit is closed by adding a load, a current will flow in the secondary. The voltage induced in the secondary is in direct proportion to the number of turns in that winding as compared to the number of turns in the primary, except for a slight loss which will be explained later. For example, with 100 turns in the primary coil and 200 in the secondary and with 100 volts applied to the primary, 200 volts are delivered at the secondary. The transformer also automatically controls itself. When the line voltage is applied to the primary, a counter E.M.F. (electro-motive force), or voltage, is induced in that winding, which is practically equal to the line voltage at no load. With the secondary open, this back voltage prevents all but a very small amount of current from flowing in the primary. Thus, at no load a properly designed transformer draws practically nothing from the line. This current is called the exciting current and serves to produce the flux in the core.

When a load is placed on the secondary, the current flowing in that coil must, in accordance with Lenz's law, flow in such a direction as to oppose the flux in the core. This opposition tends to reduce the value of the flux which, in turn, causes the back E.M.F. to be reduced. As it is due to the latter that the current is held in check, it is obvious that more current will be allowed to flow in the primary to satisfy the demands of increased load on the secondary. Thus, a transformer acts much like an automatic regulating valve.

The first step to consider when designing a transformer is the core size and its relation to some value of volt-amperes or size rating. For the benefit of the amateur designer, the table, Fig. 4, can be used as a general guide. This does not mean that the table must be followed to an exact degree because, when less iron is used in the core, more primary turns are put on to offset it. Note in the formula, Fig. 6, that the relationship of core area to turns is maintained so that a safe flux density is kept in the core. However, it is not good practice to use an excessive amount of either iron or copper, if losses and efficiency are to be considered. Although transformer cores can be made from straight strips of silicon steel, standard E-type laminations, Fig. 3, which may be purchased or salvaged from a discarded power transformer, are more convenient to use. The principal core dimensions important to any transformer design are the height of the stacked laminations, measured as in Fig. 2; the width of the center leg, A, Fig. 3, and the area of the window space.

The problem that usually confronts the amateur is the number of turns and size of wire required for use with a core on hand to produce a certain voltage output. Suppose, for example, that the width of the center leg of the laminations on hand measures 1¼ in., a window opening to one side of this leg measures ⅝ x 1⅞ in. and also that there are enough laminations to stack tightly to a height of 1¾ in. The area of the core is the width of the center leg (1.25 in.) multiplied by the height of the stack of laminations (1.75 in.), A and B, Figs. 3 and 5, which equals 2.19 sq. in. Using the table, Fig. 4, we find that this falls in a class of about 125 volt-amperes at 60 cycles, the current input required. Were the transformer to be used on a 115-volt line and required to deliver 230 volts at .5 amperes at the secondary leads, we would multiply 230 x .5. This gives 115 volt-amperes which is well within the range of the 125 volt-ampere rating for the core.

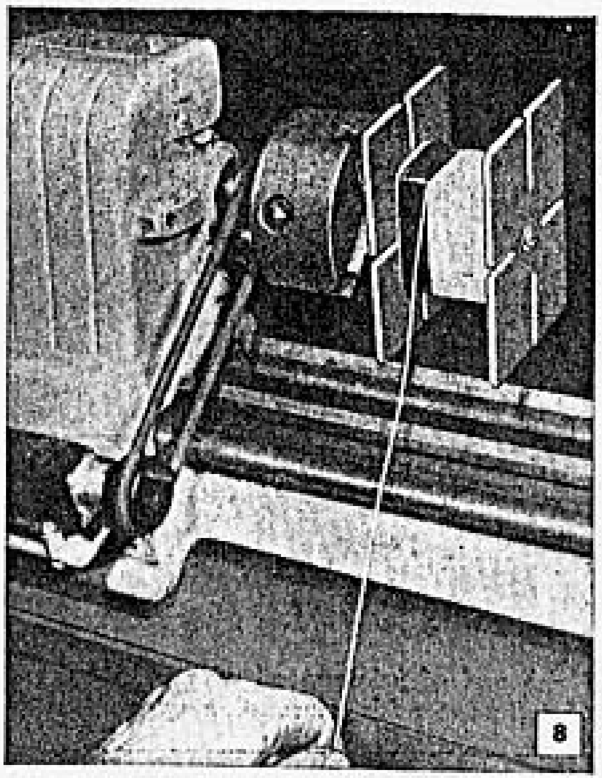
To find the correct number of turns for the primary winding, the formula, Fig. 6, is used. Substituting the proper values, the problem condenses to:

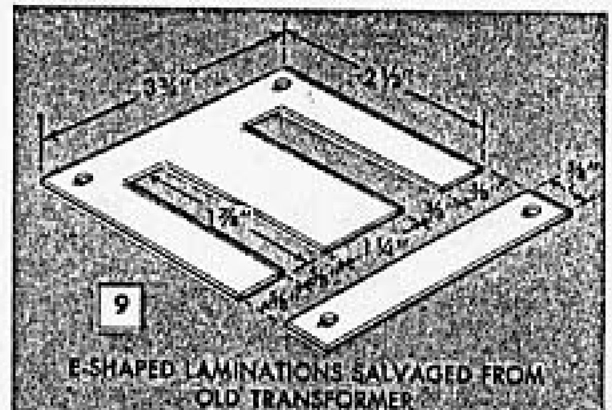
$$\frac{10^8 \times 115}{4.44 \times 60 \times 2.19 \times 65{,}000} = 303 \text{ turns}$$

In the above, 10^8 is taken for 100,000,000
115 is the primary voltage
4.44 is a factor
60 is the frequency
2.19 is the core area
65,000 is lines per sq. in. of flux density

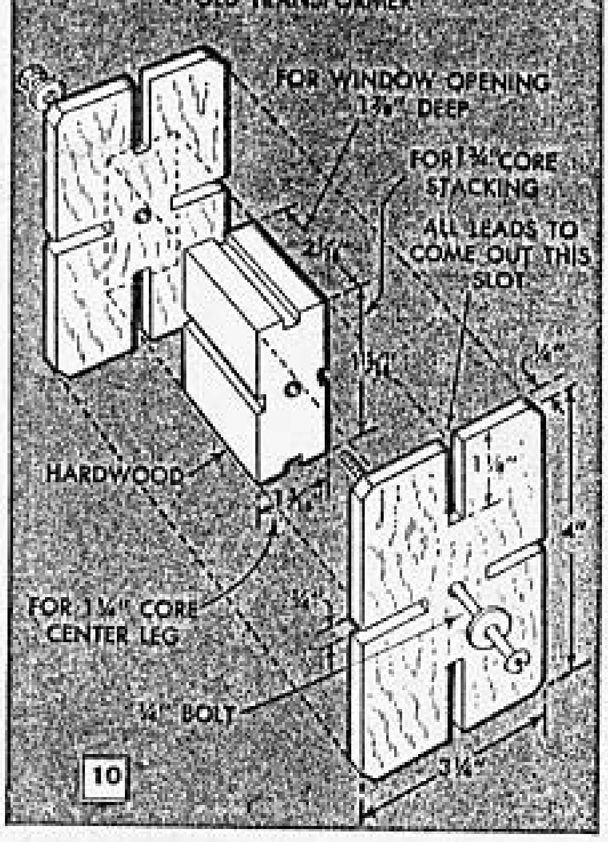
The result, 303 turns, can be made an even 300. The next step is to divide 300 by the line volts (115) to get the turns per volt. This will be about 2.61. The secondary turns for any output voltage desired are figured by multiplying 2.61 by the desired voltage. In this case, 230 volts are wanted, so 230 × 2.61 = 600 turns.

Iron and copper losses both enter the picture, but the addition of about 4 percent in turns will take care of them. Regulation, or the condition which affects output voltage from no load to full load must also be considered. Usually, about 2 percent more in turns will take care of this condition. So, by adding 6 percent to the 600 turns calculated or a total of 636 turns, the full 230 volts should be obtainable with a .5-ampere load.


8

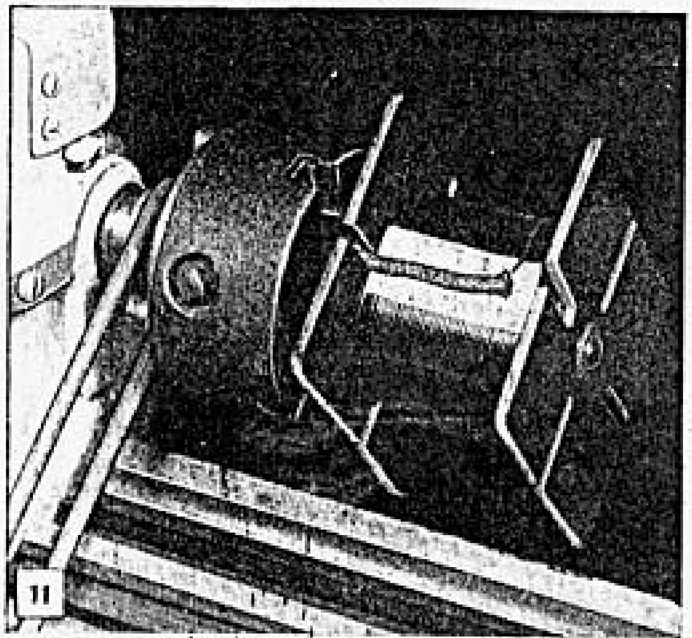


9

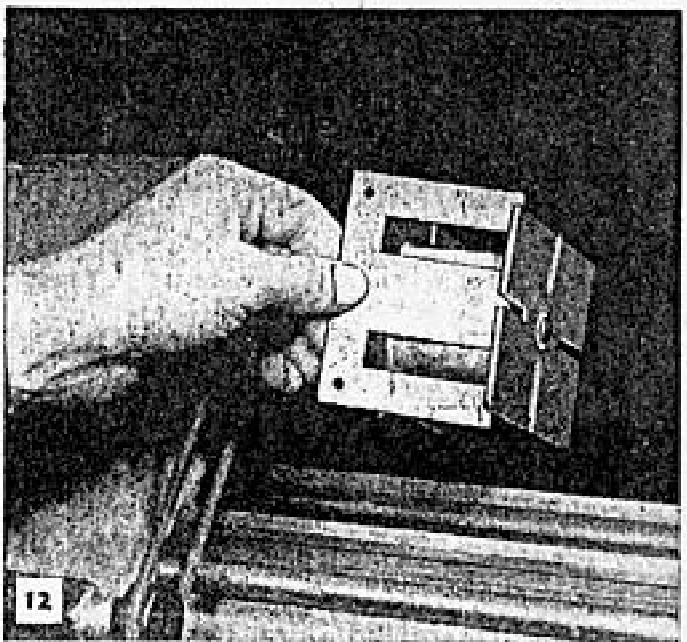


10

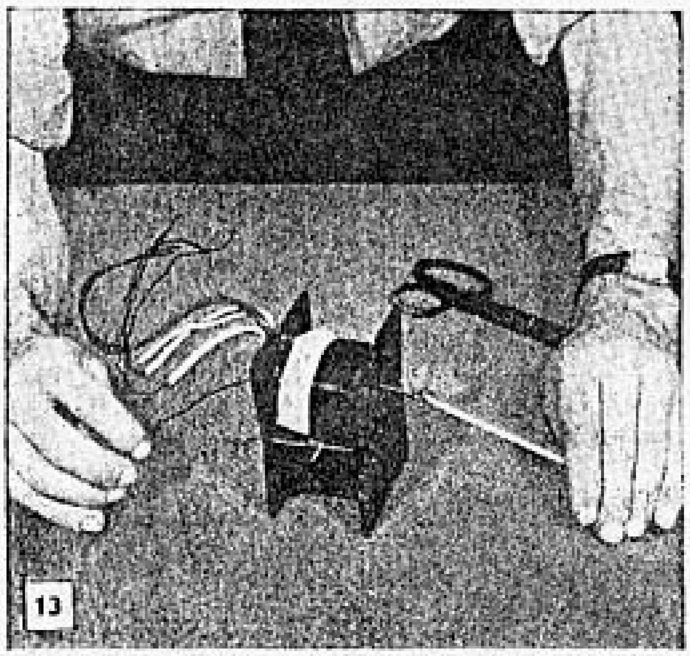
The table, Fig. 7, shows the cross-sectional area of copper wires. If the decimal point in the column of circular mils is moved three places to the left, it is possible to quickly determine the ampere capacity of each size. The secondary is to carry .5 amperes and from the table, No. 23 wire at 509 circular mils is the nearest size. To determine the current in the primary, divide the volt-ampere rating, 115, by the primary volts, 115, which gives 1 ampere. Since transformers never run at 100



Finish end of primary-coil wire is laid over a piece of tape for added insulation where it crosses coil



For a quick check to determine how much room is left for secondary coil, hold a lamination against coil



Use a piece of wire with small hook bent on one end to draw coil-tying string through slots in form

percent efficiency, an addition of 10 percent or a total of 1.1 amperes is a good estimate. No. 19 wire at 1288 circular mils is the nearest larger size.

The first step in building a transformer is the selection or making of the laminated iron core. Standard E-shaped pieces of iron for this purpose may be purchased or the iron from a burned-out transformer may be used. The core can also be made of sheet-metal strips. In either case, the estimated size of the finished coil must be known, so the window openings of the core can be checked for sufficient clearance. The coil will consist of primary and secondary windings of wire, several layers of insulating paper and a wrapping of white cotton tape applied around the completed coil.

To calculate the cross-sectional area of the wire coils, refer to the table, Fig. 7 on page 158. The No. 19 wire to be used for the primary is listed as having 665 turns per sq. in. Dividing the 300 turns needed by 665 gives .451 sq. in. The No. 23 wire is listed as having 1600 turns per sq. in. Dividing 636 by 1600 gives .397 sq. in. Adding these two figures makes a total of .848 sq. in. required for the wire coils. An additional 25 percent of the area needed for the wires (in this case, .212 sq. in.) will take care of the space required for insulating material. This will give a grand total of 1.06 sq. in. of window space needed for the completed coil. Since the window openings of the core iron selected for this transformer, Fig. 9, are ⅝ x 1⅞ in. or 1.17 sq. in., the coil should just fit, provided the turns of wire are wrapped tightly and are close together.

To wind the coil, a form as shown in Fig. 10 will be needed. The dimensions of the form should be carefully figured in relation to the size of the laminations. The dimensions given are suitable for the laminations shown in Fig. 9. The coil can be wound by hand or with a hand drill clamped in a vise. However, considerable time can be saved if the form is mounted in a lathe equipped with a turn counter. The counter, shown mounted on the lathe bed, Fig. 8, is driven by a tight-fitting rubber vacuum-cleaner belt which fits over a 1-in.-dia. wooden pulley on the counter shaft and a groove turned in the hub of the lathe chuck. Both pulley diameters must be the same size to assure an accurate turn count. The center block of the form is first wrapped with one turn of flexible armature paper of .010-in. to .015-in. thickness. The start end of the wire coil, which should be about 6 in. long, is fitted with a sleeve of cotton insulating material.

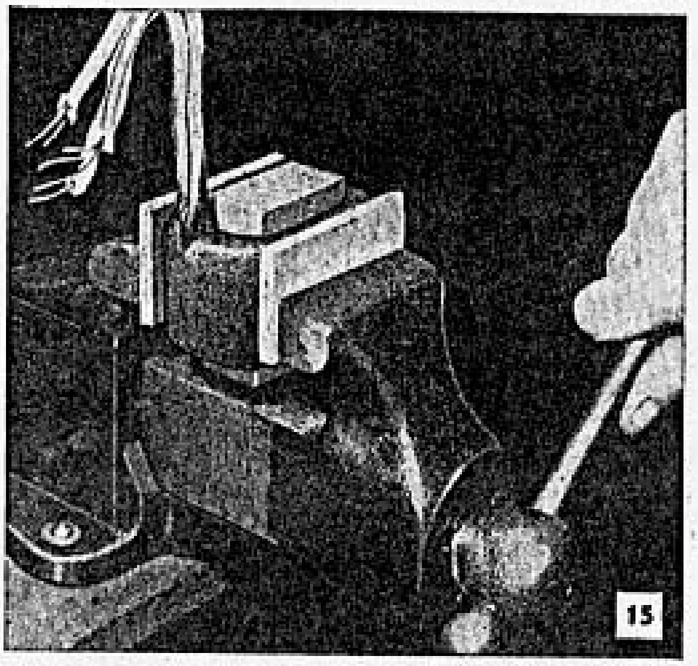
After winding on the 300 turns of the primary coil, snip off the wire, allowing about 6 in. for a lead. Cover this with cotton sleeving and run it out from the coil through a slot in the narrow side of the form as indicated in Fig. 10. A piece of tape is then placed across the top layer of wire and under the lead wire, Fig. 11, for added insulation. A quick check can be made at this time by holding one of the E-shaped laminations against the coil as in Fig. 12, noting the diameter of the coil in relation to the window openings of the core. Next, place one turn of insulating paper around the primary windings, and over this the 636 turns of the No. 23 wire for the secondary coil. A piece of cotton sleeving should be used around both leads of the secondary coil and carried out through the slot in the narrow side of the form. Some transformer designs call for a fairly heavy wire with only a few turns involved. If the wire is too heavy to wind easily, two wires having a cross-sectional area equal to that of the single wire may be paralleled or wound side by side for easier winding. A neater and more uniform winding will result if a hammer and a block of wood are used to tap the turns in place after winding each layer. Another block of wood placed under the form and resting on the lathe bed will offer a support while tapping the turns of wire.

After both coils are wound, the form and coils are removed from the lathe and four lengths of string drawn through the four slots and grooves of the form with a wire as shown in Fig. 13. The coils are then tied tightly together and the form separated. Care must be taken when knocking out the center block to avoid disrupting the shape of the coils. After this, the coils are wrapped with ¾-in. white cotton coil tape as in Fig. 14. Cut and remove the strings one at a time as the strings are approached with the tape and secure the end of the tape with a needle and thread. Dipping the coils in insulating varnish is the next step. Use air-dry varnish and allow the coil to remain submerged for about five minutes so that it is thoroughly impregnated. Then hang it up to dry for several days in a hot, dry place. If the coil, after drying, is too large to fit the window openings of the laminations, reinsert the center block of the winding form and compress the coil in a vise between two pieces of wood, as in Fig. 15. Before assembling the core laminations, place thin pieces of fiber on the sides and edges of the coil that will be covered by the core.

The laminations are stacked around the coil in alternate positions. This is done by placing the center portion of an E-shaped lamination in the core opening, as in Fig. 16. A straight lamination is then butted against the edges of the E-shaped lamination on the opposite side of the coil. Then, the center portion of the second lamina-

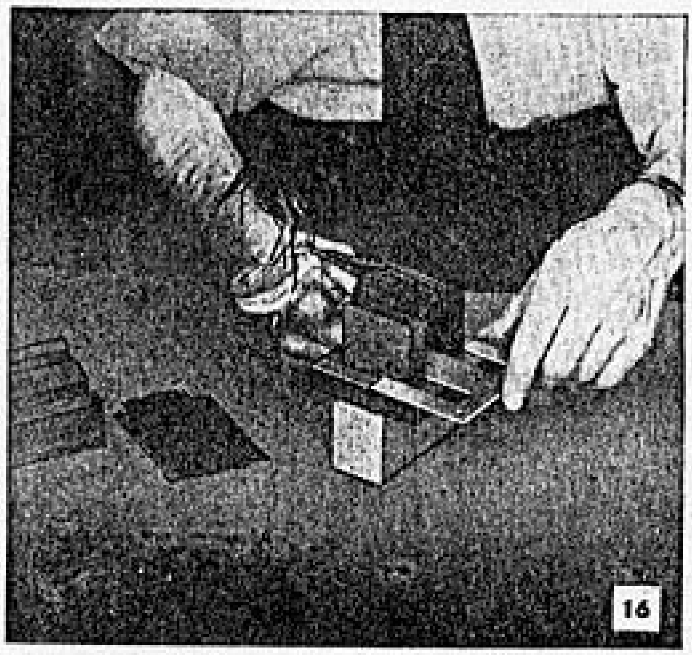
14

Completed coils are taped together with white cotton tape. Remove the tie strings as tape approaches them



15

If outside of coil is too large to fit window openings of laminations, compress between jaws of a vise



16

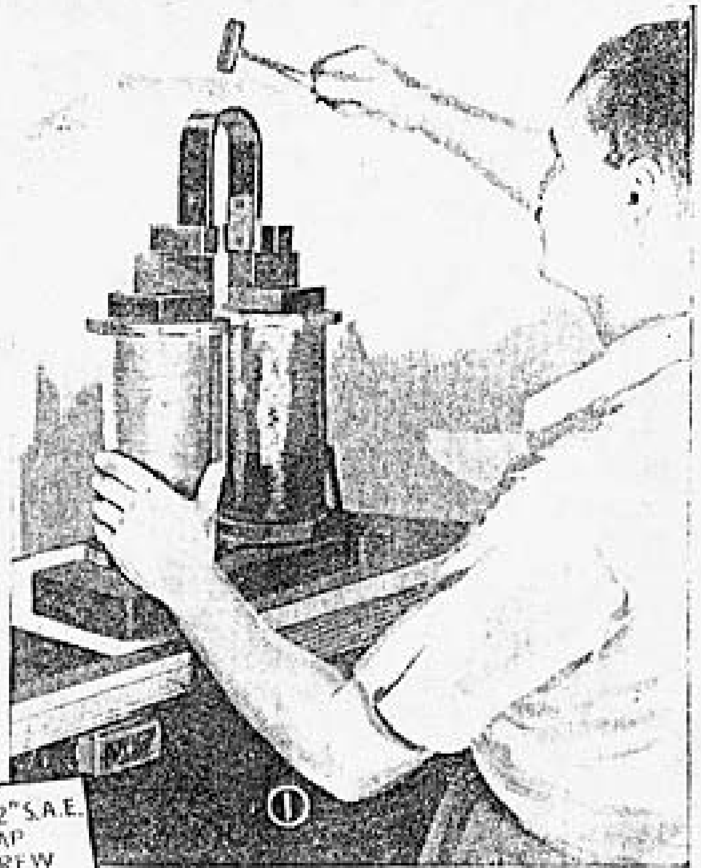
In assembling core and coil, alternate positions of the straight and E-shaped laminations from side to side

Pepping up "TIRED" MAGNETS

Electromagnet to charge bar or horseshoe magnets such as used in truck and tractor magnetos, outboard motors, small gas engines and radio speakers

By JACK BEATER

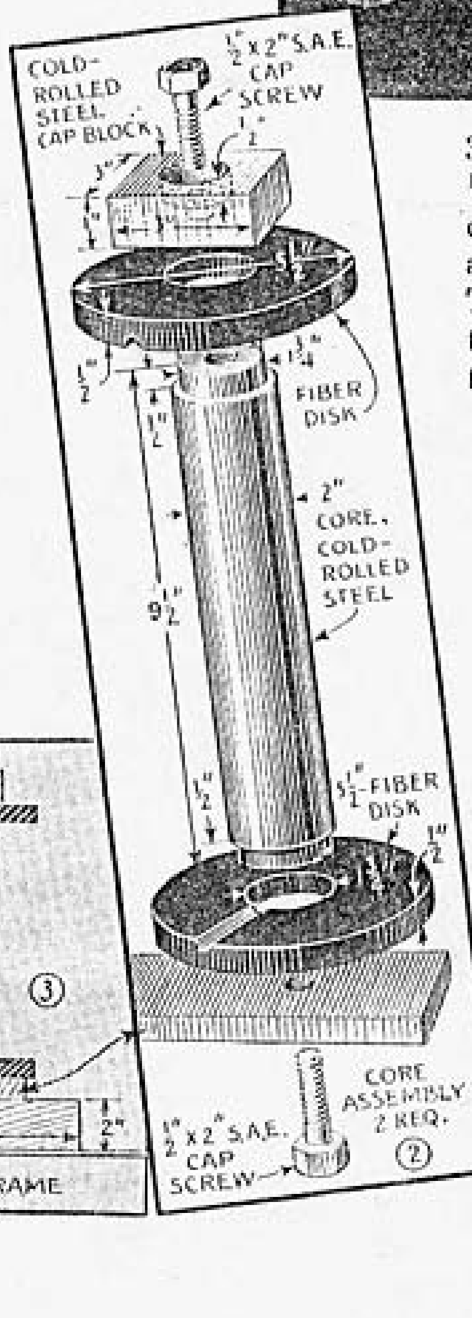
POPULAR MECHANICS, 1940

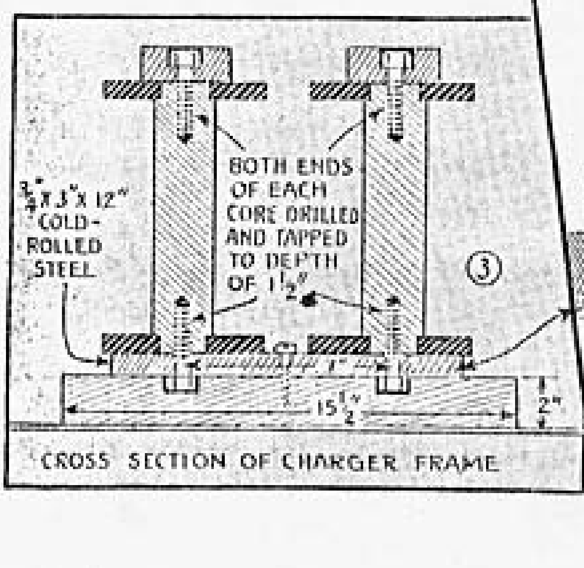


THIS magnet charger was designed for heavy-duty use in the shop, and is made of materials readily available. The three separate circuits in each of the charger coils allow great flexibility for handling magnets of various sizes on the one hand, and make for greater current flow on the other. For very small magnets, such as are used in some speedometers, one winding will develop all the strength required, while for very large magnets all three windings can be used.

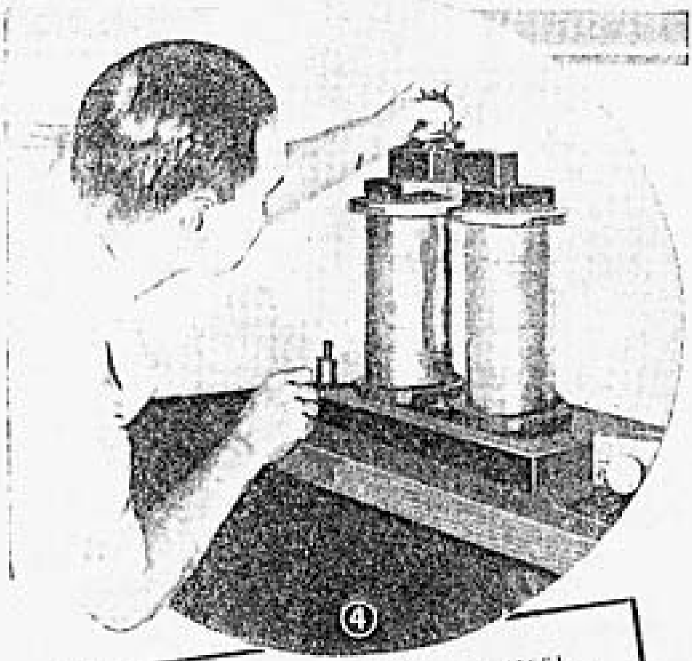
The cores upon which the two coils are to be wound are cut from cold-rolled steel 2 in. in diameter, and each piece is 9½ in. long, Figs. 2 and 3. Each end is turned down ½ in. to 1¾ in. diameter as in Fig. 2 and the end of each core is drilled and tapped to a depth of 1½ in. to receive a ½-in. cap screw. The base consists of a 12-in. length of cold-rolled steel, 3 in. wide by ¾ in. thick. Two ½-in. holes are bored on the centerline of the base, 7 in. apart and 2½ in. from each end. Two pole caps of the same material, each 3 in. square by 1 in. thick are made up before the winding of the coils is started. A ½-in. hole is drilled in the center of each of these blocks, after which the holes should be counterbored to house the cap screws.

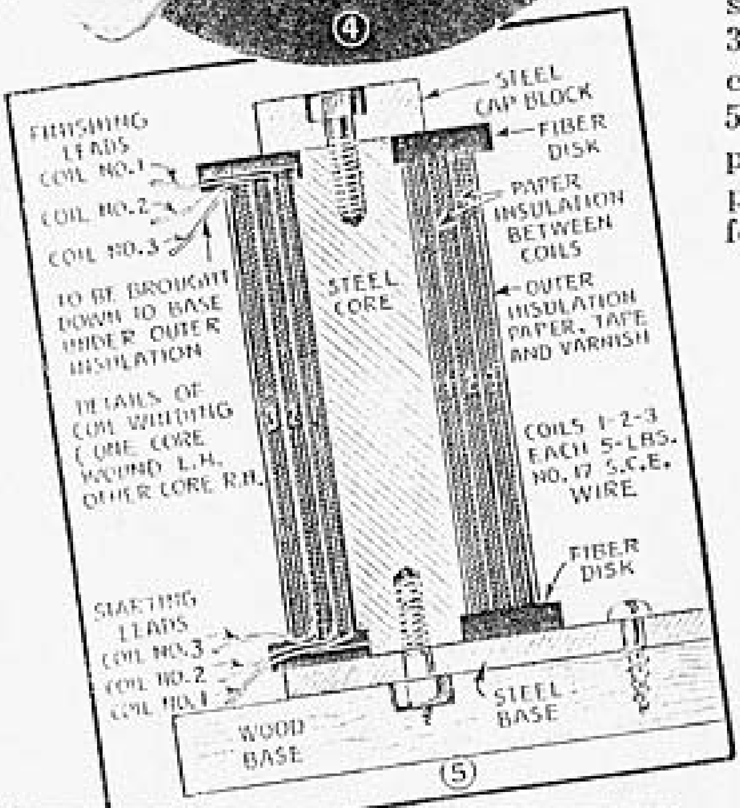
The four ½-in. fiber disks that fit over the ends of the cores to form the winding spools have an outside diameter of 5½ in. and a bore of 1¾ in. Make a ⅛ by 3/16-in. V-cut in each disk from the center hole to the edge as in Fig. 2. The cores must be insulated with tough wrapping paper. Cut sheets wide enough to cover the width of the core, and long enough to go around about five turns. Lay the

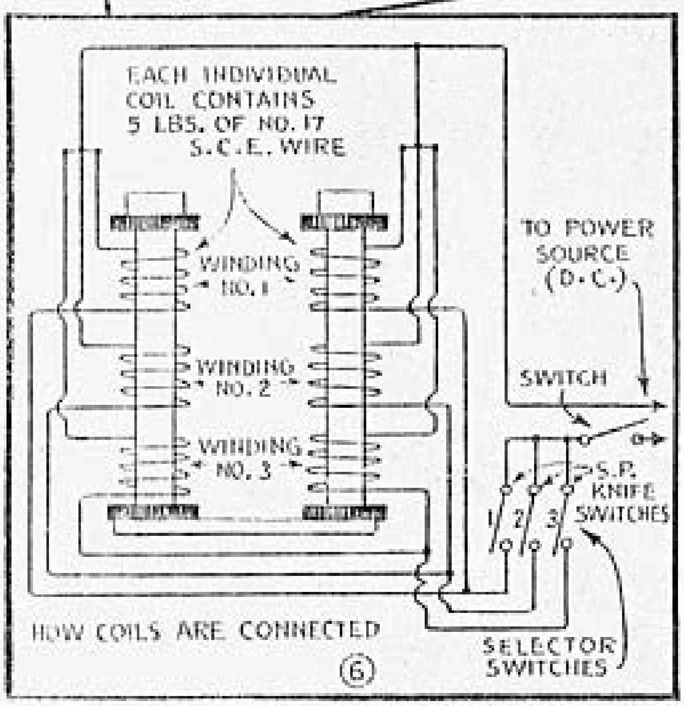




CROSS SECTION OF CHARGER FRAME







paper out flat, coat it with shellac, and wrap it around the core, using rubber bands or string to hold it until the shellac has set. The round disks are now pressed over the ends of the cores, and the cap block of each core is screwed in place to hold the upper disks. Counterbore two blocks of hardwood, duplicates of the steel cap blocks, to hold the lower disk in place on each core while winding. The best way to wind the coils is in a lathe where a steady, moderate speed can be maintained. The head of the lower cap screw can be chucked in the lathe headstock, while a center hole drilled in the head of the upper cap screw supports the core on the tail-stock center. The cores are wound with 30 lbs. of No. 17 single cotton-covered, enameled wire, 15 lbs. to each core, and 5 lbs. for each of the three windings per pole. This winding will take the full amperage of a generator at 15 to 18 volts. Before starting the winding, place a protective layer of tape or cotton sleeving over that part of the wire that will reach from the outer edge of the lower disk to the core. Place the wire in the V-groove, then wind on the first half dozen turns by hand. Start up the lathe in slow speed and feed the wire evenly along the core, then back and forth across the core until 5 lbs. have been wound. Bring the finishing end out at the top of the coil—the end opposite from the start. Tape the part of the finishing end that will be covered by the second and third windings. The second and third coils are wound in the same manner as the first, except that the starting end of each coil is cut a little shorter than the first for later identification. A layer of heavy paper is wrapped around the coil between windings 1, 2 and 3, Fig. 5. The outer insulation of the completed coils consists of another wrapping of heavy paper, then a tight banding with cotton tape and an application of shellac. For a final trim the coils can be painted or enameled in color. The second core is wound exactly like the first except that the winding is done in the opposite direction. In other words, one coil is wound right hand, the other left hand. In this way all the starting ends will come out at the bottoms of the coils and the finishing ends at the tops. Before assembling the coils to the base plate each of the three windings on each coil should be tested with a 6-volt battery and an accurate ammeter. Each individual winding should show a current flow of approximately 2.67 amperes. A slight variation is permissible but if a full five pounds of wire have been used on each winding the readings should be within close limits. A high reading shows that a number of turns or layers are short-circuited.

The two coils are bolted to the steel base before being connected together. This assembly is then screwed to a wooden sub-base in the manner shown in Figs. 3 and 5.

Connections are made as shown in Fig. 6. Each pair of windings is connected in parallel, as this allows double the amperes to flow. All six starting ends are soldered together to form a common connection to the battery or other source of d.c. current. The two starting ends of the two No. 1 coils are soldered together and carried to a single-pole knife switch. The starting ends of the No. 2 windings are joined together and connected to No. 2 knife switch, while the starting ends of the two No. 3 windings are connected to switch No. 3, Fig. 6. With this arrangement it is possible to connect either one, two or three of the charger windings into the circuit, depending upon the magnet being charged.

The charger can be operated on from one to three or more 6-volt batteries, or from an automobile generator capable of delivering 15 or more amperes. The charger described here is connected to such a generator; the output to the charger is 26 amperes and 18 volts at 1,800 r.p.m. This overload results in no harm because the generator is used for only a minute or so at a time. In charging a magnet the north pole of the magnet must always be against the south pole of the charger. Small magnets can be spun above the charger, Fig. 4, and allowed to assume the right position of their own accord, but for the bulky magnets a pocket compass should be used to identify the proper polar relationship. Tapping on a magnet with a non-metallic mallet during the charging process aids somewhat in magnetizing, Fig. 1.

To complete the magnet charger outfit an assortment of steel blocks, Fig. 1, will be needed. These are used to make a firm contact with various shaped magnets.

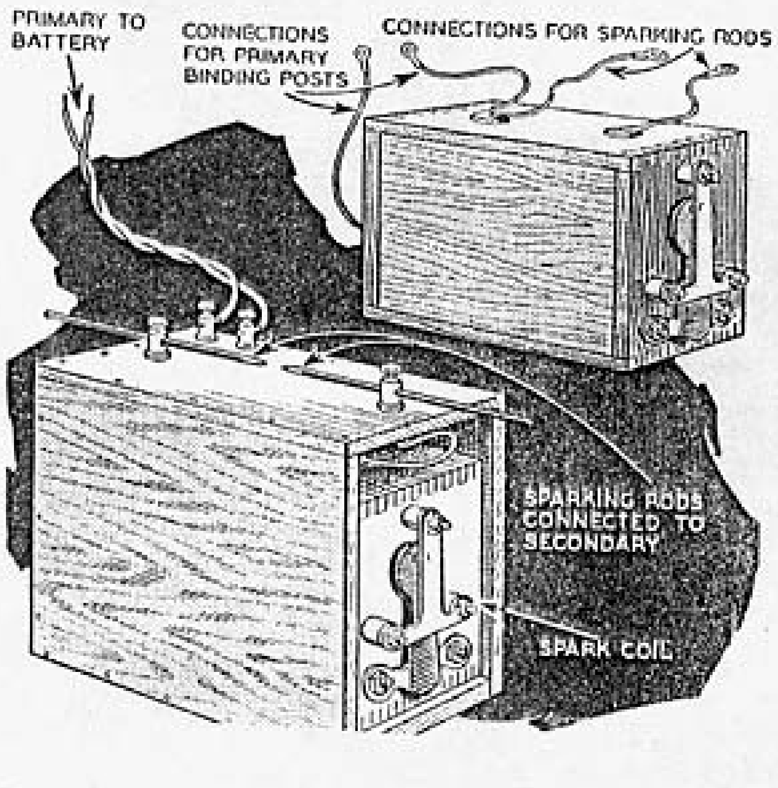
MODERN MECHANIX, 1934

Induction Coil for Experimenters

AN OLD Ford spark coil will make a very satisfactory induction coil for experimental purposes. Nail together a wooden box to house the spark coil snugly as shown in the diagram below.

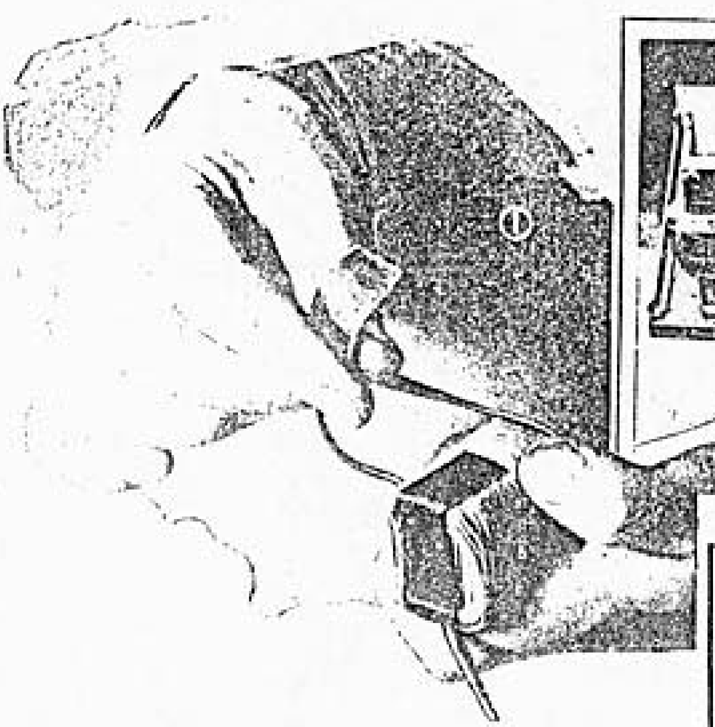
Next, solder insulated wires, as illustrated, to the spark coil to provide connections to be fastened inside the box to the binding posts. Use radio binding posts for the primary connections. Select two large brass binding posts to hold the sparking rods. The sparking rods also should be brass. Suitable material can be purchased at a well stocked hardware store for a few cents. Use a rod having a diameter of approximately one eighth of an inch. Redrill the holes in the two binding posts if the holes are not large enough to accommodate the rods.

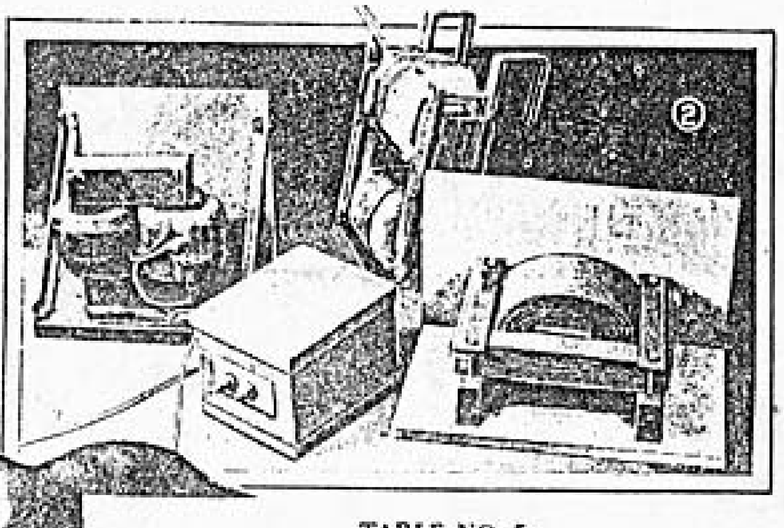
Two dry cells connected in series with the primary connections on the box will operate the coil very satisfactorily, or it may be operated from a toy train transformer.—George Smith.



 GRANDDAD'S ELCTRICITY BOOK

TRANSFORMER





TRANSFORMERS to suit any requirement can easily be built by carefully following the instructions contained in this article. There are two types of this apparatus, the shell and the core type, both shown in Fig. 2. They differ in that the former has its windings on a center crosspiece of the core and takes less copper, while the latter has the primary coil on one and the secondary on the other leg of the core. Cores may be built up from standard silicon-steel E and I-punchings, obtainable in many sizes, or assembled from strips of No. 26-gauge silicon steel, cut to size with tinners' shears.

The starting point in transformer design is the exact determination of the output required in watts, which is the product of amperes and volts. For example, a 6-volt transformer delivering 20 amp. has an output of 120 watts. Let us assume that we are going to build a shell-type transformer and that the frequency of our 110-volt supply circuit is 60 cycles. Referring to table No. 1, does not give the exact size of transformer desired, one of 120 watts, and therefore the next larger size is selected, which is 150 watts. The turns of wire required for the secondary coil is found by multiplying the turns per volt as given in table No. 1, by the volts required, which in this case is 6 volts times 1.96, or

TABLE NO. 5

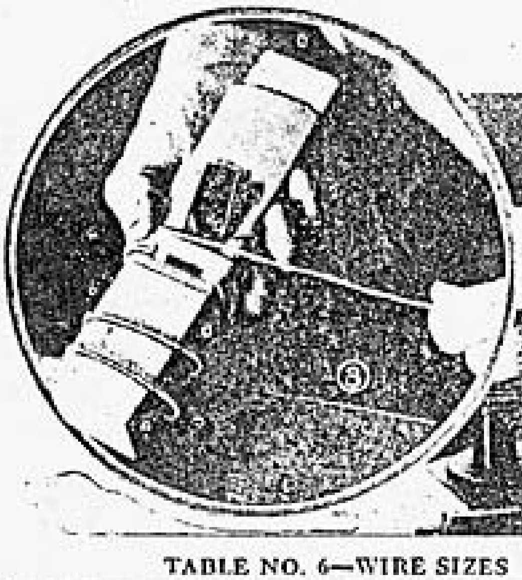
Size in Watts	Design No. For Use in Figuring Transformers of Sizes Not Listed in Tables 1, 2, 3 and 4	Fuse for Line		Wire Size for Primary Coil			
				Shell Type		Core Type	
		110 Volts	220 Volts	110 Volts	220 Volts	110 Volts	220 Volts
5	2.21	1	1	34	36	32	35
10	3.16	1	1	31	34	30	33
15	3.87	1	1	29	32	28	31
20	4.47	1	1	27	31	27	30
30	5.48	1	1	26	29	25	28
40	6.33	1	1	25	28	24	27
50	7.07	1	1	24	27	23	26
75	8.65	1	1	22	25	21	24
100	10.00	1	1	21	24	20	23
125	11.19	6	1	20	23	19	22
150	12.22	6	1	19	22	18	21
175	13.21	6	1	19	21	17	20
200	14.12	6	1	18	21	17	20
225	15.00	6	6	18	20	16	19
250	15.81	6	6	17	20	16	19
275	16.59	6	6	17	19	15	18
300	17.31	6	6	16	19	15	18
350	18.70	6	6	16	18	14	17
400	20.00	6	6	15	18	14	17
450	21.20	6	6	14	17	13	16
500	22.35	6	6	14	17	13	16
600	24.45	6	6	13	16	12	15
700	26.45	10	6	12	15	11	14
800	28.30	10	6	12	14	11	14
900	30.00	10	6	11	14	10	13
1000	31.60	10	6	11	14	10	13
1100	33.20	15	6	11	14	9	12
1200	34.60	15	10	10	13	9	12
1250	35.40	15	10	10	13	9	12
1300	36.00	15	10	10	13	9	12
1400	37.40	15	10	10	12	8	11
1500	38.70	15	10	9	12	8	11
1600	40.00	20	10	9	12	8	10
1700	41.20	20	10	9	12	8	10
1800	42.40	20	10	9	11	2 #10*	10
1900	43.60	20	10	8	11	2 #10*	10
2000	44.70	20	10	8	11	2 #10*	10

*Wind two #10 wires at the same time and use as 1 wire by connecting the starting ends together and the finish ends together.

11.76 turns. The next higher even number, or 12 turns, should be used.

Next, we should determine the size of wire needed for the secondary, which depends on the current to be passed, already known to be 20 amp. Multiply the amperes by 750 for the shell type, or by 1,000 for the core type to find the cross-sectional area of the wire in circular mils. In the example, this would be 15,000. Table No. 6 gives the wire sizes corresponding to the circular-mil area. As the figure 15,000 is not given, take the next one above it,

CONSTRUCTION



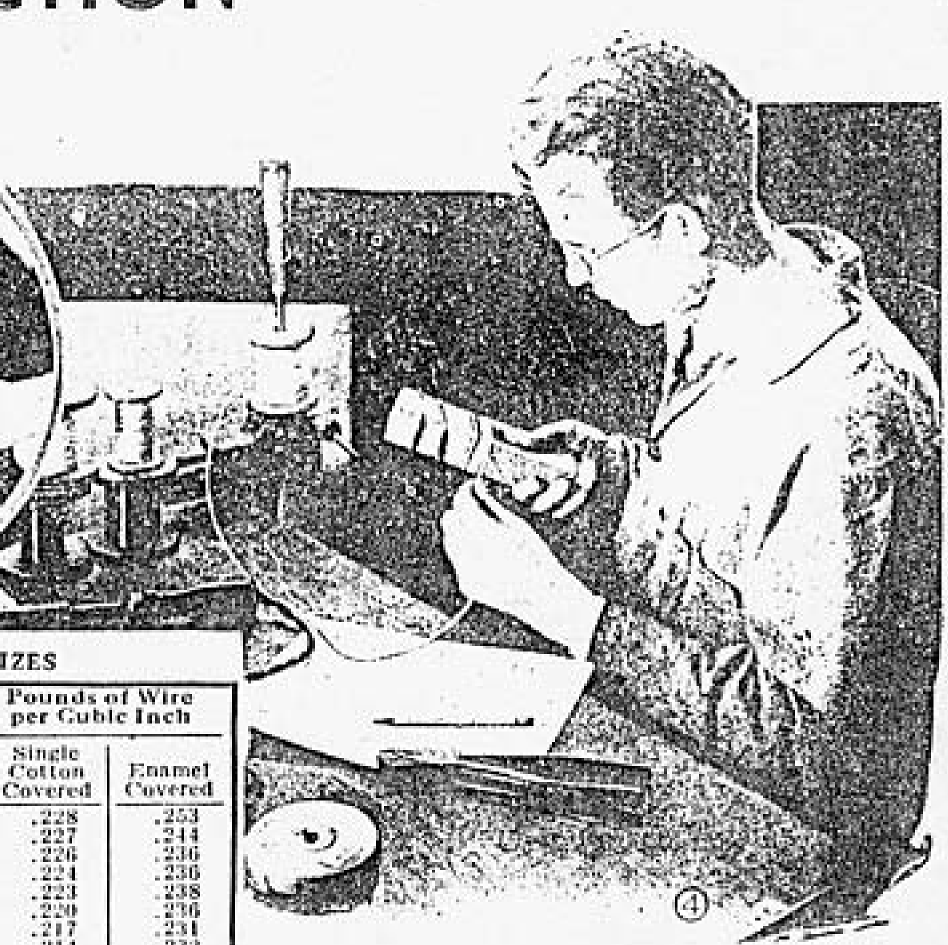


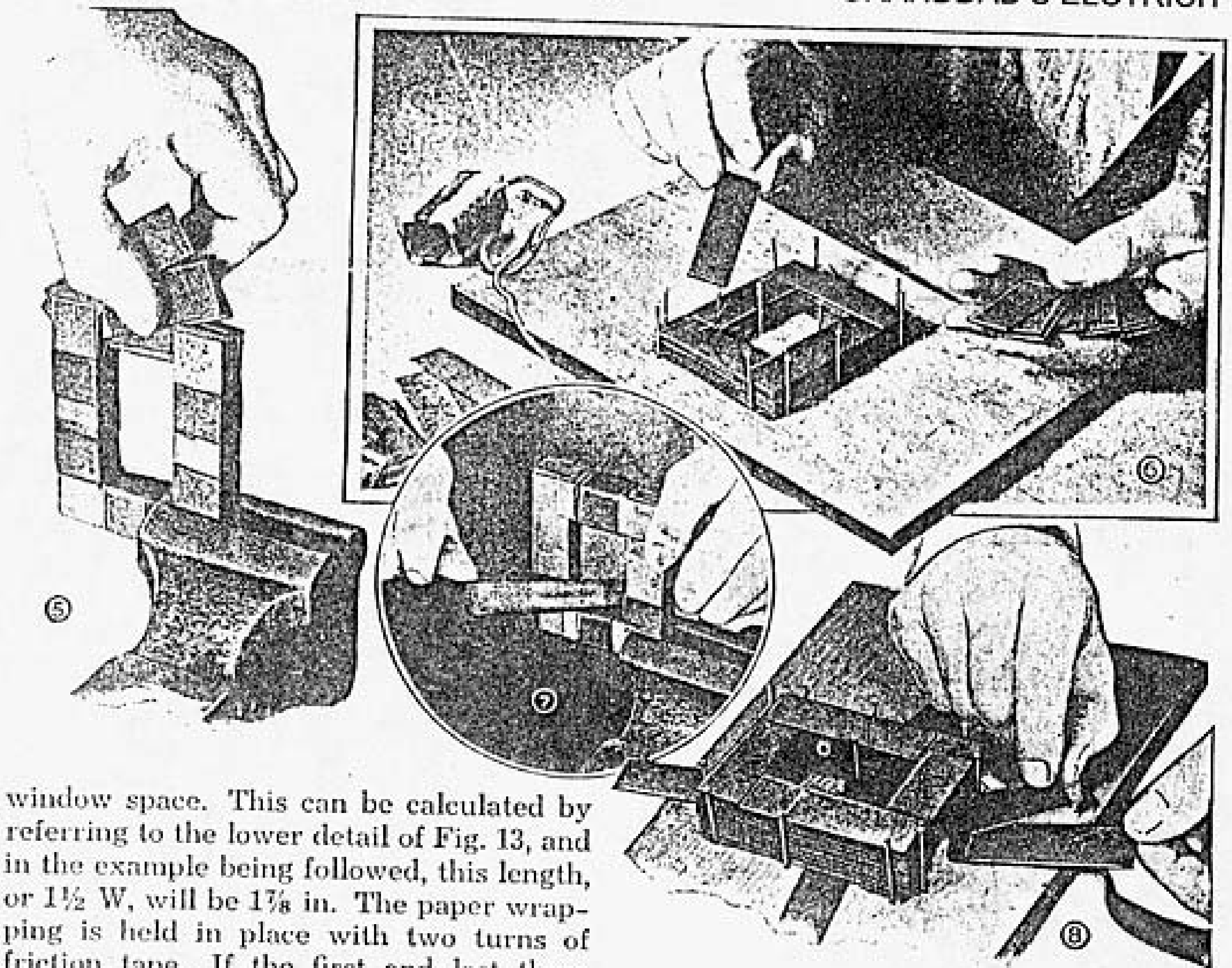
TABLE NO. 6—WIRE SIZES

B & S Gauge No.	Circular Mils	Turns per Square Inch		Pounds of Wire per Cubic Inch	
		Single Cotton Covered	Enamel Covered	Single Cotton Covered	Enamel Covered
8	16510	55	53	.228	.253
9	13090	71	66	.227	.244
10	10380	87	83	.226	.236
11	8234	104	106	.224	.236
12	6530	138	135	.223	.238
13	5178	172	168	.220	.236
14	4107	196	215	.217	.231
15	3257	265	271	.214	.232
16	2583	331	345	.210	.226
17	2048	407	433	.207	.227
18	1624	493	545	.204	.227
19	1288	618	681	.200	.225
20	1022	719	852	195	.223
21	810	836	1065	190	.221
22	642	1064	1340	183	.220
23	509	1362	1665	177	.217
24	404	1615	2100	170	.217
25	320.	1946	2630	164	.217
26	254	2385	3320	157	.216
27	201	2830	4145	150	.215
28	159	3462	5250	143	.215
29	126	3760	6510	135	.213
30	100	4713	8175	128	.212
31	79	5535	10200	120	.210
32	63	6137	12650	110	.207
33	50	6920	16200	101	.200
34	39	7960	19950	093	.205
35	31	9243	25000	.083	.205
36	25	9723	31700	.075	.205

which is 16,510, corresponding to No. 8 wire, which is the correct size to use. How much wire is needed for the secondary coil depends on the size of the core on which it is to be wound, the number of turns already being known. To estimate the weight of wire needed, consult table No. 6, where we find that No. 8 s.c.c. wire will wind 55 turns per square inch. Dividing our turns, or 12, by this number we get .218 sq. in. as the cross-sectional area of the wire on the coil. Multiplying this number by the distance around the core, as found in table No. 1, we get 8⅛ times .218, or 1.8, which is the number of cubic inches of wire needed for the coil. Table No. 6 also gives the number of pounds of No. 8 s.c.c. wire per cubic inch as .228. By multiplying this number by 1.8 cu. in. we get .46 lb., or the approximate weight of wire for the secondary coil.

The next step is to find the size of the core and its weight. From table No. 1 we find that the width of the core leg on which the coil is wound should be 1¼ in. This table also gives the thickness of the core as 2^13^/16 in. and the approximate weight of silicon steel required as 5.8 lb. Fig. 13 shows how all the core dimensions are based on the width of the core leg which is indicated by W. It only remains to determine the turns, wire size and weight of wire required for the primary or input coil. Referring again to table No. 1 you will find that there are to be 212 turns, and that the winding will weigh about .9 lb. Refer to table No. 5 to find the size of wire needed, which in this case is No. 19.

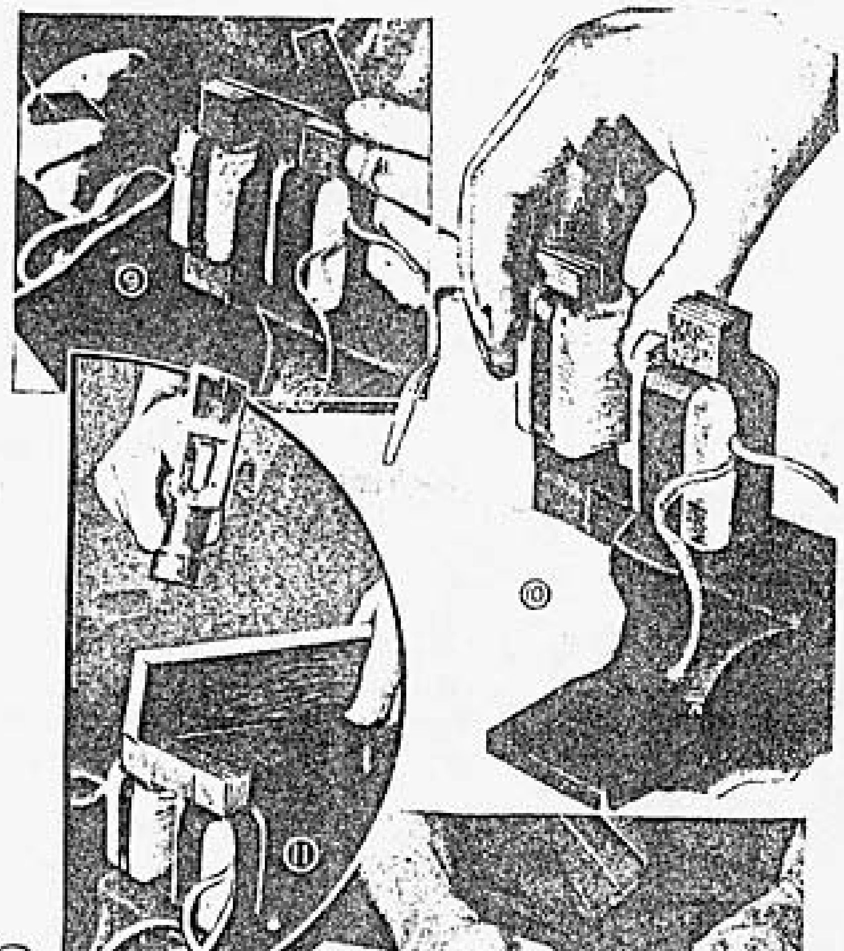
The coils are wound on a wooden form, as in Fig. 4. The primary is wound first. The form is cut to a width and thickness slightly greater than the dimensions of the core, which in this case is 1¼ by 2 13/16 in., and is covered with two or three layers of heavy brown paper for a distance equal to the length of the coil, which in turn is made ¼ in. less than the length of the

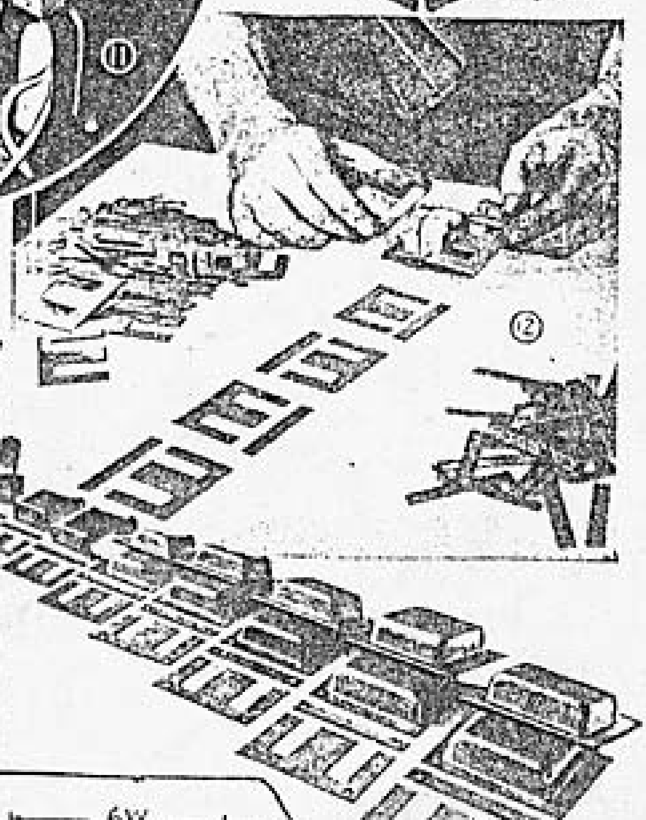


window space. This can be calculated by referring to the lower detail of Fig. 13, and in the example being followed, this length, or 1½ W, will be 1⅞ in. The paper wrapping is held in place with two turns of friction tape. If the first and last three turns of each layer of wire are wound over a length of friction tape, and this is doubled back over the coil, as shown in Fig. 3, the end turns will be securely held in place. A thin sheet of tough paper should be wound between layers of wire if space permits. If there is not room for this, use a sheet between every other, or every third layer. When the primary coil has been completed, cover it with two layers of heavy brown paper and wind on the secondary coil. Great care should be taken to prevent contact between the two coils. When completed, they are slipped off the form and bound with tape, as in Fig. 1. The core is then slipped into the coils, as shown in Fig. 12. After the core and coil have been assembled, they should be impregnated with orange shellac or electrical-coil varnish. If orange shellac is used, dilute it with an equal volume of alcohol. A large can will serve as a dipping tank. Allow the assembly to soak for about 12 hours, after which it is left to dry thoroughly for an equal period. To complete the drying, bake the transformer at a low heat for 2 or 3 hours. Shell-type transformers may be completed by bolting on a pair of standard pressed-steel end plates obtainable in various sizes corresponding to the core punchings shown in Fig. 12.

Core-type transformers are easily assembled in a jig, as in Fig. 6, the strips being piled alternately, as shown in the detail above table No. 7. The cores must be bound together and securely taped while held in a vise to avoid hum. Figs. 7 and 8 show the steps for binding a core of this type. The coils are wound separately and slipped on each leg of the core, as in Fig. 10. To do this, remove the laminations from one side of the core, as shown in Fig. 5, replacing these, as in Fig. 9, after the coils have been placed in position. A mallet or block is used, as in Fig. 11, to force the laminations down evenly, after which they are taped securely. The transformer may be clamped with channel iron or angle-iron brackets, as shown in Fig. 14, and mounted in a metal box, as in Fig. 16. The cord, which connects the transformer to the supply circuit should be brought into the can through a porcelain bushing. Low-voltage secondary connections are made to brass screws or binding posts mounted on a fiber or Bakelite strip, as in Figs. 16 and 18. Then the can is filled with melted insulating tar, Fig. 17, obtainable at battery-service stations.

If you need a size of transformer not covered in the tables, refer to table No. 5. Locate the desired size, or the nearest one of higher value, in the first column. Opposite this size is a design number needed for figuring the other values. This table also gives the wire size to be used for the primary coil. Let us assume that you want to build a core-type transformer to convert 110 volts to 220 volts on a 60-cycle circuit, and that you will need 5 amp. from the secondary. The watts will be 5 times 220 or 1,1000. Consulting table No. 5,





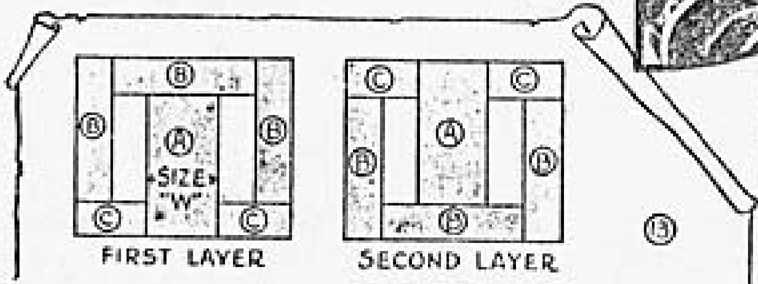
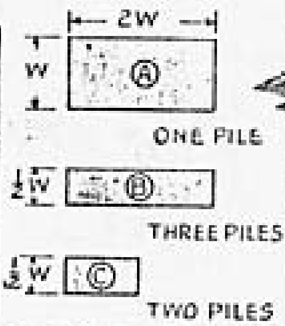


TABLE NO. 7

DIMENSIONS FOR SHELL TYPE OF TRANSFORMER STEEL		
Size "W"	Area of 1 Window In Sq. In.	Weight of Core 1" Thick Lb.
⅝	.29	.50
¾	.42	.73
⅞	.57	.99
1	.75	1.30
1⅛	.92	1.65
1¼	1.10	2.03
1⅜	1.41	2.46
1½	1.68	2.92
1⅝	1.97	3.44
1¾	2.27	3.96
1⅞	2.62	4.58
2	3.00	5.20
2¼	4.22	6.63
2½	4.70	8.25
2¾	5.60	9.90
3	6.70	11.70
3½	9.20	15.90
4	12.00	20.80
4½	15.20	26.40



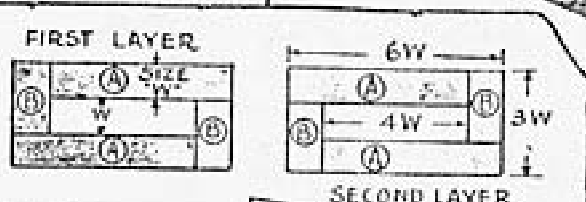
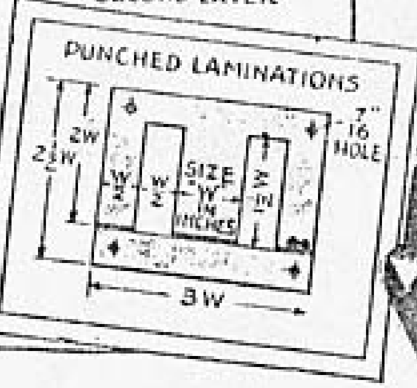
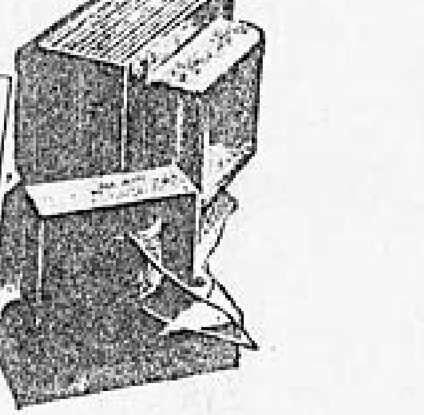


TABLE NO. 8

DIMENSIONS FOR CORE TYPE TRANSFORMER STEEL				
Size "W"	Dimensions of Core A	Dimensions of Core B	Area of Window Sq. In.	Wt. of 1" Thick Core
⅞	⅞ x 4⅜	⅞ x 1¾	3.06	2.9
1.0	1 x 5	1 x 2	4.00	3.8
1⅛	1⅛ x 5⅝	1⅛ x 2¼	5.06	4.8
1¼	1¼ x 6¼	1¼ x 2½	6.25	5.9
1⅜	1⅜ x 6⅞	1⅜ x 2¾	7.55	7.2
1½	1½ x 7½	1½ x 3	9.00	8.6
1⅝	1⅝ x 8⅛	1⅝ x 3¼	10.60	10.1
1¾	1¾ x 8¾	1¾ x 3½	12.5	11.8
1⅞	1⅞ x 9⅜	1⅞ x 3¾	14.1	13.3
2	2 x 10	2 x 4	16.0	15.2
2¼	2¼ x 11¼	2¼ x 4½	20.25	19.1





GRANDDAD'S ELCTRICITY BOOK

SHELL-TYPE TRANSFORMERS, TABLE No. 1—50 TO 133 CYCLES

Size of Transformer in Watts	Primary Coil — For 110 Volts: Turns of Wire	Approximate Wt. of Wire in Pounds	For 220 Volts: Turns of Wire	Approximate Wt. of Wire in Pounds	Turns per Volt for Secondary Coil	Dimensions for Silicon-Steel Core — Cross-Sectional Area of Core in Sq. In.	Core Size (See Core Table No. 7 for Dimensions)	Thickness of Compressed Core	Approximate Wt. of Core	Sq. In. of Window Left for Sec. and Insulation
50	368	0.4	736	0.4	3.40	2.0	1	2	2.6	.45
100	260	0.7	520	0.6	2.40	2.9	1¼	2⅜	4.3	.60
150	212	0.9	424	0.9	1.96	3.5	1¼	2¹¹⁄₁₆	5.8	.75
200	184	1.0	368	1.0	1.70	4.1	1¼	3¹⁄₁₆	6.7	.75
250	164	1.3	328	1.2	1.52	4.6	1⅜	3⁵⁄₁₆	8.2	.95
300	150	1.5	300	1.4	1.38	5.0	1⅜	3¹¹⁄₁₆	9.0	.92
400	130	1.7	260	1.6	1.20	5.8	1⅜	4¹⁄₁₆	10.4	.86
500	116	2.1	232	2.0	1.08	6.5	1½	4⅜	12.6	1.00
600	106	2.6	212	2.5	.98	7.1	1½	4¾	15.0	1.32
700	98	2.3	196	2.2	.91	7.7	1⅝	4¾	18.9	1.87
800	92	3.3	184	3.2	.85	8.2	1¾	4⅞	20.0	1.92
900	87	3.4	174	3.3	.80	8.7	2	4¾	22.8	2.10
1000	82	3.3	164	3.2	.76	9.2	2	4⅝	24.2	2.15
1250	75	3.5	150	3.5	.70	10.0	2	5.0	26.0	2.15
1500	67	4.2	134	4.1	.62	11.2	2	5⅝	29.4	2.00
EASY METHOD OF FIGURING VALUES FOR OTHER SIZES										
Select Size to Suit Purpose	2,600 / Design No.	See Table No. 6 for Pounds per Cubic Inch	5,200 / Design No.	See Table No. 6 for Pounds per Cubic Inch	24 / Design No.	29 × Design No.	Select Core Size with Window Large Enough for Windings	Cross-Sectional Area / Core Size	Weight = Thickness of Core × Wt. per Inch. See Table No. 7	Check to See if Your Coils Will Fit Space

SHELL-TYPE TRANSFORMERS, TABLE No. 2—25 TO 40 CYCLES

Size of Transformer in Watts	Primary Coil — For 110 Volts: Turns of Wire	Approximate Wt. of Wire in Pounds	For 220 Volts: Turns of Wire	Approximate Wt. of Wire in Pounds	Turns per Volt for Secondary Coil	Dimensions for Silicon-Steel Core — Cross-Sectional Area of Core in Sq. In.	Core Size (See Core Table No. 7 for Dimensions)	Thickness of Compressed Core	Approximate Wt. of Core	Sq. In. of Window Left for Sec. and Insulation
50	565	0.8	1130	0.7	5.23	3.2	1¼	2⅞	5.8	.90
100	400	1.2	800	1.0	3.70	4.5	1½	3	8.8	1.18
150	327	1.7	654	1.6	3.02	5.5	1½	3⁵⁄₁₆	11.7	1.35
200	283	2.0	566	1.9	2.62	6.3	1½	3⅞	14.5	1.39
250	253	2.2	506	2.1	2.34	7.1	1⅝	4¼	16.0	1.56
300	231	2.6	462	2.4	2.14	7.8	1⅝	4¼	17.6	1.52
400	200	3.0	400	2.9	1.85	9.0	1¾	4¹¹⁄₁₆	22.4	1.81
500	179	3.6	358	3.4	1.66	10.0	1⅞	5¹¹⁄₁₆	24.4	1.74
600	164	4.2	328	4.0	1.52	11.0	2	5½	29.6	2.01
700	151	4.6	302	4.4	1.40	11.9	2¼	5½	29.8	2.05
800	141	4.6	282	4.4	1.30	12.7	2¼	5¾	31.6	3.16
900	134	6.4	268	6.2	1.23	13.5	2½	5¹³⁄₁₆	44.5	3.37
1000	127	6.2	254	6.0	1.17	14.2	2½	5¹¹⁄₁₆	47.0	3.40
1250	117	7.0	234	6.9	1.08	15.5	2⅝	6⅜	50.1	3.33
1500	104	8.3	208	8.1	.96	17.4	2¾	6¹¹⁄₁₆	57.5	3.19
EASY METHOD OF FIGURING VALUES FOR OTHER SIZES										
Select Size to Suit Purpose	4,000 / Design No.	See Table No. 6 for Pounds per Cubic Inch	8,000 / Design No.	See Table No. 6 for Pounds per Cubic Inch	37 / Design No.	45 × Design No.	Select Core Size with Window Large Enough for Windings	Cross-Sectional Area / Core Size	Weight = Thickness of Core × Wt. per Inch. See Table No. 7	Check to See if Your Coils Will Fit Space

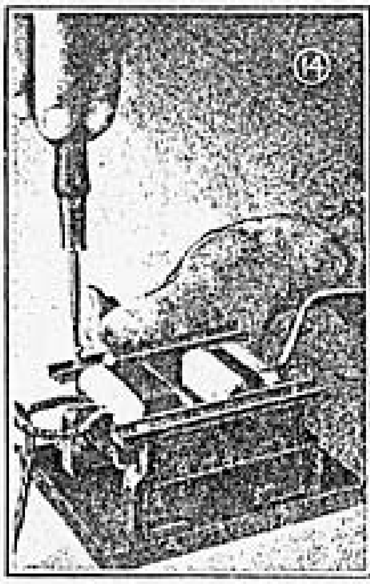
CORE-TYPE TRANSFORMERS, TABLE No. 3—50 TO 133 CYCLES

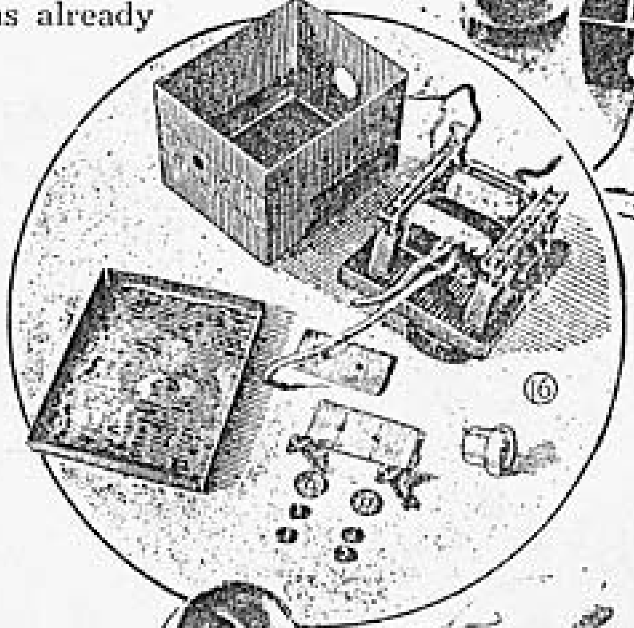
Size of Transformer in Watts	Primary Coil — For 110 Volts: Turns of Wire	Approximate Wt. of Wire in Pounds	For 220 Volts: Turns of Wire	Approximate Wt. of Wire in Pounds	Turns per Volt for Secondary Coil	Dimensions for Silicon-Steel Core — Cross-Sectional Area of Core in Sq. In.	Core Size (See Core Table No. 8 for Dimensions)	Thickness of Compressed Core	Approximate Wt. of Core	Sq. In. of Window Left for Sec. and Insulation
50	1160	1.3	2320	1.2	10.60	.657	⅞	¾	2.2	2.06
100	820	2.0	1640	1.8	7.50	.93	1.0	¹⁵⁄₁₆	3.6	3.00
150	670	3.2	1340	2.9	6.13	1.14	1⅛	1.0	4.8	3.46
200	580	3.6	1160	3.4	5.30	1.32	1⅛	1⅛	5.7	3.36
250	518	3.7	1036	3.5	4.74	1.47	1⅛	1¼	6.3	3.36
300	473	4.5	946	4.3	4.33	1.62	1¼	1¼	7.8	4.25
400	410	4.9	820	4.7	3.75	1.86	1¼	1½	8.9	4.25
500	368	5.7	736	5.5	3.36	2.08	1⅜	1½	10.9	5.35
600	335	7.3	670	7.0	3.06	2.28	1⅜	1⅝	13.0	6.40
700	310	9.7	620	9.4	2.84	2.46	1⅜	1⅝	15.2	7.40
800	290	9.2	580	8.9	2.65	2.63	1⅜	1¾	16.4	7.60
900	273	10.2	546	9.9	2.50	2.79	1⅜	1⅞	17.7	7.40
1000	260	9.9	520	9.7	2.38	2.94	1⅜	1¹⁵⁄₁₆	18.3	7.50
1250	239	11.8	478	11.6	2.18	3.20	1½	2.0	20.5	7.10
1500	212	15.7	424	15.5	1.94	3.60	1¾	2¼	24.0	8.40
EASY METHOD OF FIGURING VALUES FOR OTHER SIZES										
Select Size to Suit Purpose	8,200 / Design No.	See Table No. 6 for Pounds per Cubic Inch	16,400 / Design No.	See Table No. 6 for Pounds per Cubic Inch	75 / Design No.	.093 × Design No.	Select Core Size with Window Large Enough for Windings	Cross-Sectional Area / Core Size	Weight = Thickness of Core × Wt. per Inch. See Table No. 8	Check to See if Your Coils Will Fit Space

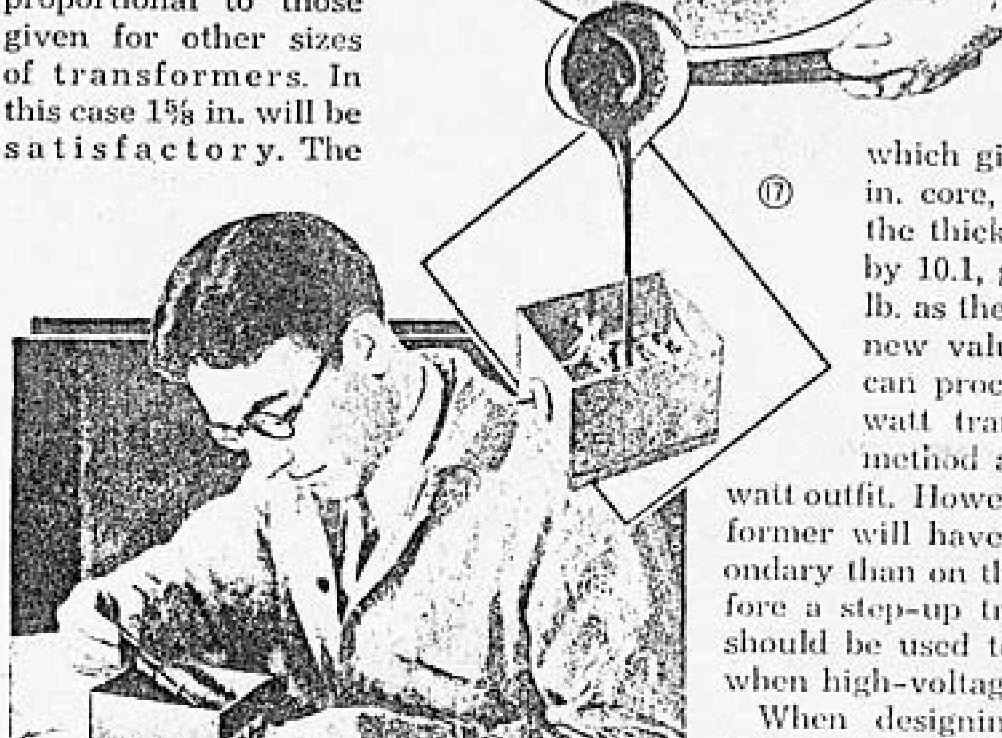
CORE-TYPE TRANSFORMERS, TABLE No. 4—25 TO 40 CYCLES

Size of Transformer in Watts	Primary Coil — For 110 Volts: Turns of Wire	Approximate Wt. of Wire in Pounds	For 220 Volts: Turns of Wire	Approximate Wt. of Wire in Pounds	Turns per Volt for Secondary Coil	Dimensions for Silicon-Steel Core — Cross-Sectional Area of Core in Sq. In.	Core Size (See Core Table No. 8 for Dimensions)	Thickness of Compressed Core	Approximate Wt. of Core	Sq. In. of Window Left for Sec. and Insulation
50	1795	2.5	3590	2.1	16.40	1.01	1	1	3.8	2.5
100	1270	3.8	2540	3.5	11.60	1.44	1¼	1⅛	5.4	3.1
150	1036	5.9	2072	5.5	9.50	1.76	1⅜	1¼	8.1	5.0
200	898	6.4	1796	6.0	8.20	2.19	1⅜	1⁵⁄₁₆	11.2	5.0
250	802	6.9	1604	6.6	7.33	2.28	1⅜	1⁹⁄₁₆	12.1	4.9
300	733	8.6	1466	8.2	6.69	2.50	1½	1¹¹⁄₁₆	14.5	6.0
400	634	9.4	1268	8.9	5.80	2.83	1½	1¹³⁄₁₆	16.6	5.9
500	568	11.5	1136	10.9	5.20	3.22	1⅝	2.0	20.5	7.1
600	519	13.5	1038	13.0	4.75	3.52	1⅝	2.0	23.2	8.6
700	479	18.3	958	17.7	4.38	3.81	1⅝	2.0	26.6	9.2
800	448	17.3	896	16.7	4.10	4.07	1¾	2⅜	29.1	9.5
900	423	19.2	846	15.7	3.87	4.33	1¾	2⅜	30.8	9.2
1000	402	18.7	804	18.2	3.67	4.55	1¾	2⅜	32.4	9.6
1250	369	22.4	738	22.0	3.37	4.95	2.0	2½	38.0	10.6
1500	328	36.0	656	35.4	3.00	5.57	2¼	2½	48.0	13.9
EASY METHOD OF FIGURING VALUES FOR OTHER SIZES										
Select Size to Suit Purpose	12,700 / Design No.	See Table No. 6 for Pounds per Cubic Inch	25,400 / Design No.	See Table No. 6 for Pounds per Cubic Inch	116 / Design No.	144 × Design No.	Select Core Size with Window Large Enough for Windings	Cross-Sectional Area / Core Size	Weight = Thickness of Core × Wt. per Inch. See Table No. 8	Check to See if Your Coils Will Fit Space

you find the design number for 1,100 watts to be 33.20, and that the primary coil should be wound with No. 9 wire. Remembering this, you turn to table No. 3, which contains formulas for calculating 60-cycle, core-type transformers. In the space under the first column listing the size in watts, write 1,100, which you have already found. For the second column divide the design number, or 33.20, as found in table No. 5, into 8,200 and you will get 247 for the number of primary turns. The weight of primary wire for the next column, and the weight of secondary wire may be calculated later by the same method as has already been outlined. The secondary turns per volt is next determined by dividing 75 by the design number, in this case 33.20, which gives 2.25. Likewise, multiplying .093 of the next column by 33.20 gives 3.08 for the cross-sectional area of the core. To decide on a core size, look up the column and select a size proportional to those given for other sizes of transformers. In this case $1\frac{5}{8}$ in. will be satisfactory. The thickness of core needed can now be figured by dividing the area already found, or 3.08, by the core size, or $1\frac{5}{8}$ in., which gives 1.89, although we can use a $1\frac{15}{16}$-in. core to make it even. The weight of steel needed can be found by referring to table No. 8, which gives the weight of a $1\frac{5}{8}$-in. core, 1 in. thick. Multiplying the thickness of the core, or $1\frac{15}{16}$ by 10.1, gives approximately $19\frac{1}{2}$ lb. as the core weight. With these new values for table No. 3, you can proceed to design the 1,100-watt transformer by the same method as was used for the 150-watt outfit. However, the 1,100-watt transformer will have more turns on the secondary than on the primary, and is therefore a step-up transformer. Special care should be used to assure good insulation when high-voltage coils are built.





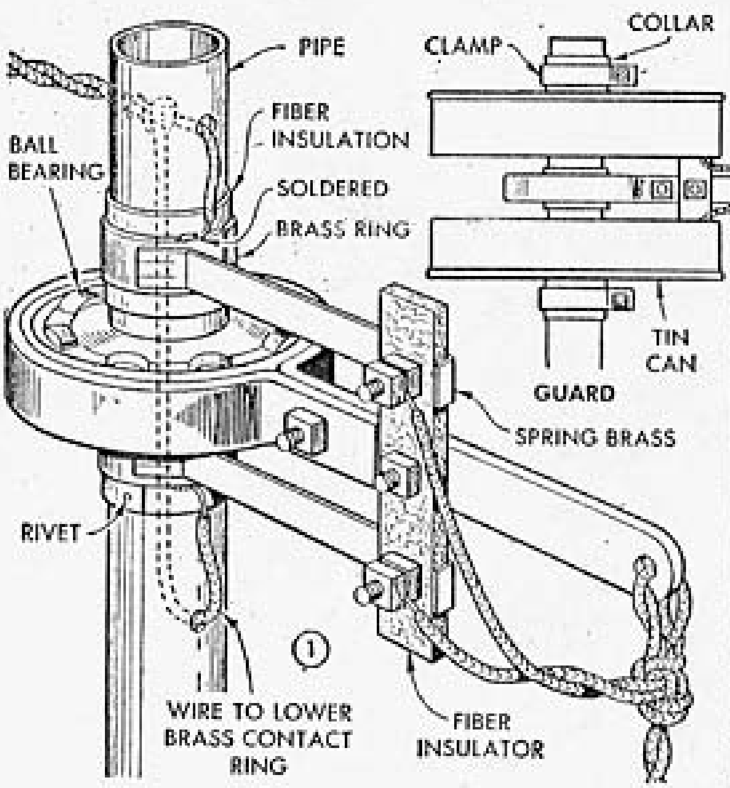


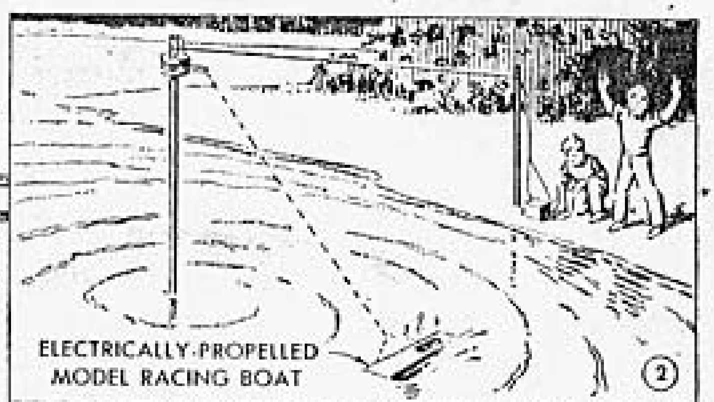
When designing transformers, one should always check the window space of the core to make sure that it is large enough. If the coil requires more space, select a core of the next larger size. In changing the core size, divide the cross-sectional area of the core, as given in tables No. 1 to 4, by the width of the new core, to find the proper thickness to use. For low-voltage transformers, where the amperage is high, it is best practice to wind several small wires side by side at the same time, connecting them together at each end, instead of using a single large wire. The total circular-mil area of the small wires must be equal to that of the single wire for which they are substituted.

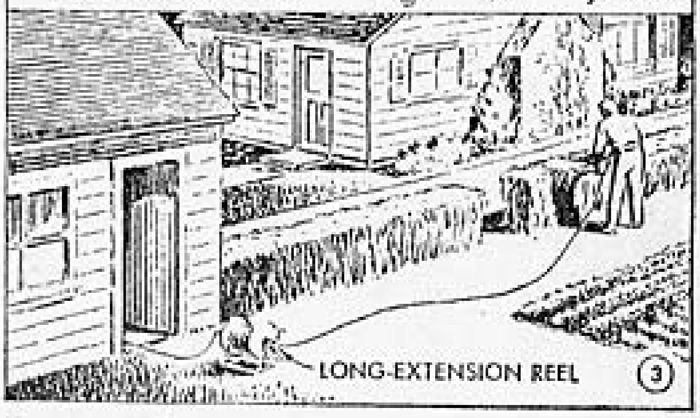
Welding transformers, passing several hundred amperes, should have secondary windings of heavy copper ribbon or strips of sheet copper. To figure the number of amperes a strip of copper can carry safely, multiply the width by the thickness to get the cross-sectional area in square inches, and multiply this product by 1,275. Copper ribbon or strips of sheet copper are insulated before winding by wrapping them with plain linen tape or strips of varnished cloth. Splices must be soldered.

POPULAR MECHANICS, 1948

Rotating Electrical Contact Has Numerous Uses







Current can be passed through this rotating contact unit to operate model speedboats, small machines that must be moved about to the work, lawn mowers, power-driven hedge shears and any other equipment of a similar type which must operate at a considerable distance from the power source. No dimensions are given in Fig. 1 as the unit can be made any convenient size. It is necessary, however, that the spring-brass contacts have a cross-sectional area equal to or greater than that of the line which supplies the current. Another important point in the construction is adjustment of the spring contacts so that they bear uniformly and yet lightly on the contact rings, thus avoiding any undue drag when the unit is rotating. Surfaces of the contact rings should be polished glass-smooth and the ends of the spring-contact arms must be slit with a hacksaw as indicated. This helps to prevent arcing. For use on 110-volt current a guard made from a tin can is a good safety precaution. Fig. 2 shows the unit in use delivering current to a model speedboat running a circular course. Fig. 3 suggests another use, that of delivering current to electrically driven hedge shears through a long extension reel.

C. L. Meehan, Lakeview, Ont., Can.

ELECTRICITY

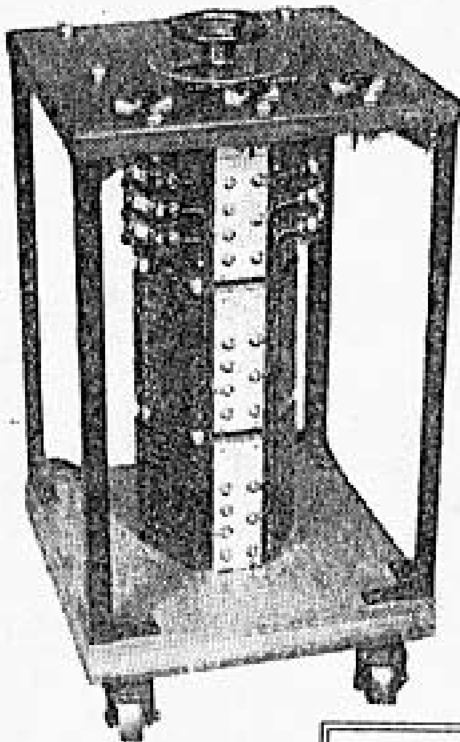
SCIENCE AND MECHANICS APRIL, 1950

Three-Phase Variac

This variable transformer controls voltage to three-phase motors

By HAROLD P. STRAND
Electricity Editor

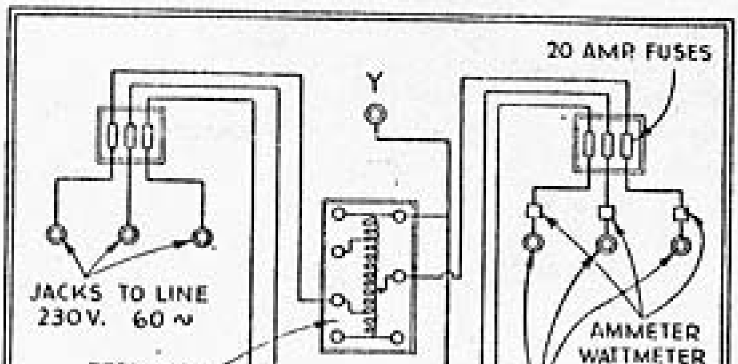
IN THE testing of electric motors, you need to be able to obtain exact voltages, according to the case at hand. This is especially required when taking ammeter and wattmeter readings both under no load and various load conditions, where a few volts high or low in the line would make readings inaccurate. Watts increase as the square of the applied voltage, while amperes increase directly as the voltage. It is therefore very necessary to be able to control the voltage supply when testing.

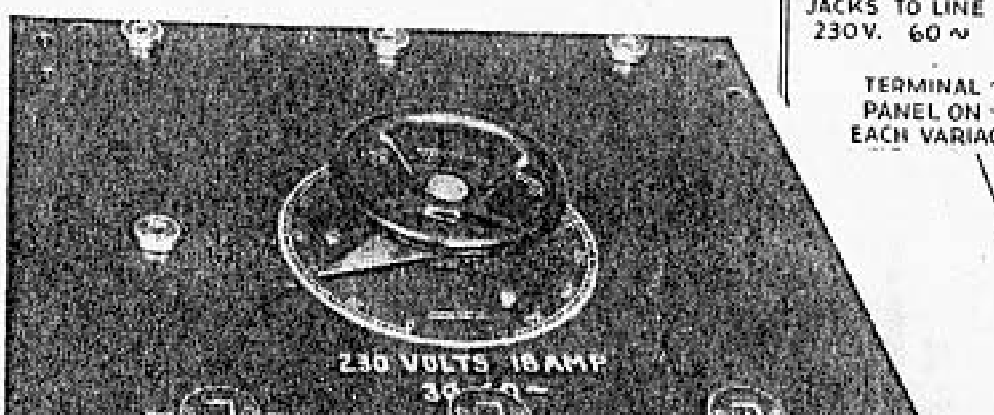


With single-phase motors a simple variable transformer, known as a "Variac," which is made by General Radio Co., Cambridge, Mass., is a useful instrument to use for the purpose. Three-phase motors, on the other hand, require a special three-phase variable transformer to do the job. While such a device can be purchased, they are quite expensive and not always easy to obtain. A very satisfactory one can be built in the electrical shop, as detailed in this article, in which three single-phase Variacs are built into a convenient caster-equipped stand and connected into "Y" to form a three-phase voltage regulator. Jacks allow connection to the line and others to the load, while special jacks (shown in drawing) make it easy to connect ammeter and wattmeter in the circuit while motor is running if desired.

Note in drawing, that wooden base is made of three thicknesses of ¾ in. maple or birch, which are laid in alternate grain positions similar to plywood. A frame is made from 1 in. angle iron to dimensions shown, with short pieces welded on top and bottom to allow bolts in drilled holes to secure frame in place. Top panel is 1 in. slate, fiber board or Bakelite, and drilled as shown. Four heavy commercial type casters attached to underside of wooden base make it easy to move unit around.

Discard original ¾ in. steel shaft furnished with each Variac and cut a new length of ¾ in. cold rolled steel 23¾ in. long. This shaft passes through the three Variacs and rotat-

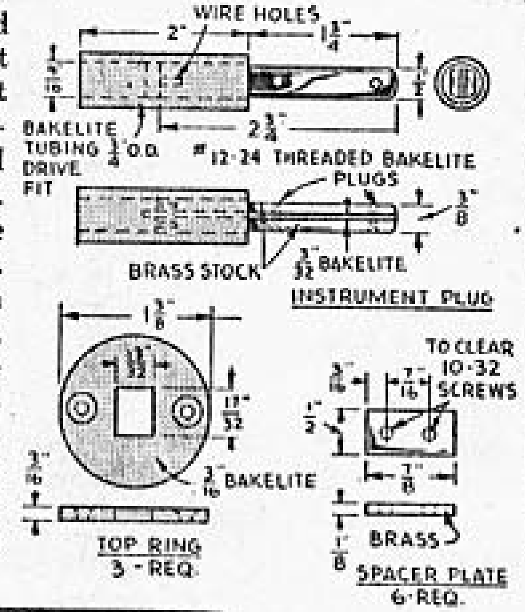


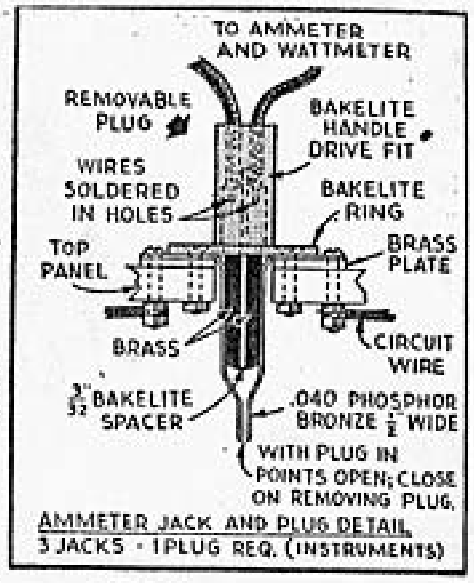


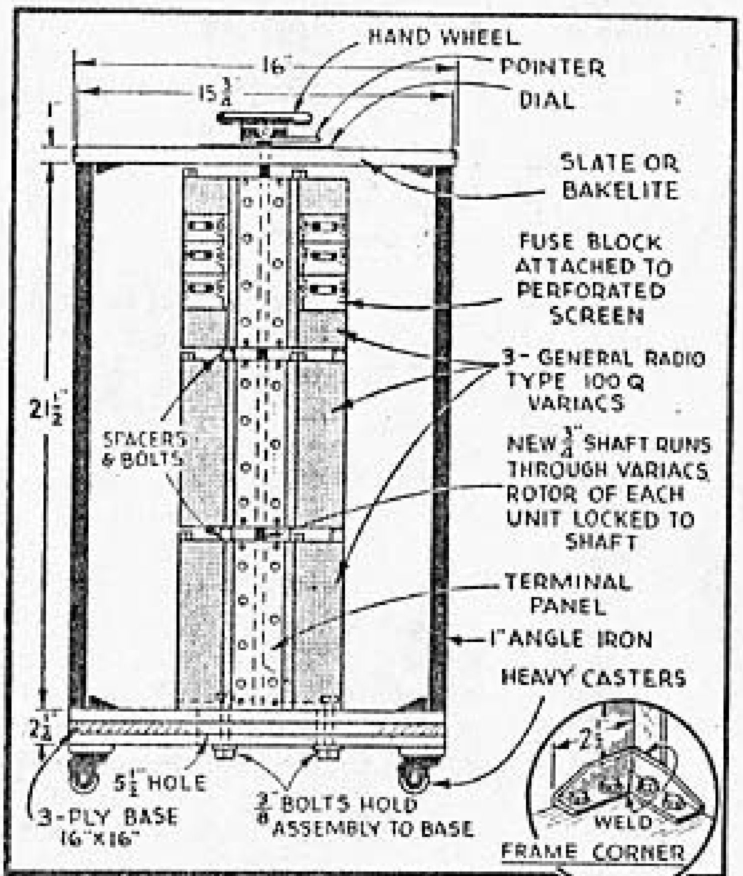
Left, close-up of top of Variac showing 0-260 dial plate and jack connecting points.

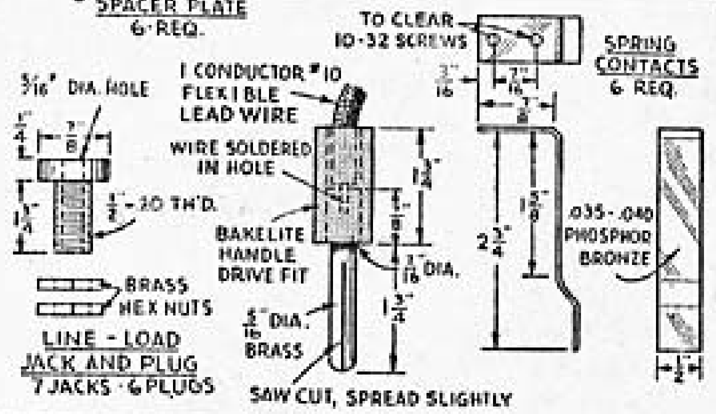
 GRANDDAD'S ELCTRICITY BOOK

ing element of each is moved to its extreme left hand position and then locked to shaft with set screws. In this way, movement of shaft rotates three rotors together. The three units are held together by using ¾ in. dia. spacer sleeves or risers, which are ⅝ in. high, with at least a ⅜ in. I.D. These can easily be cut from pipe, and 3 are used between each unit, or 6 are required in all. Place them at the 3 corners of the hexagonal frame, which leaves original clamping bolts at the other 3 corners. Use short ⅜ in. bolts through spacers to secure units









together. At the base end, use ⅜ in. bolts, about 3¼ in. long through holes in lower frame and drilled holes in base; these hold assembly in a rigid position.

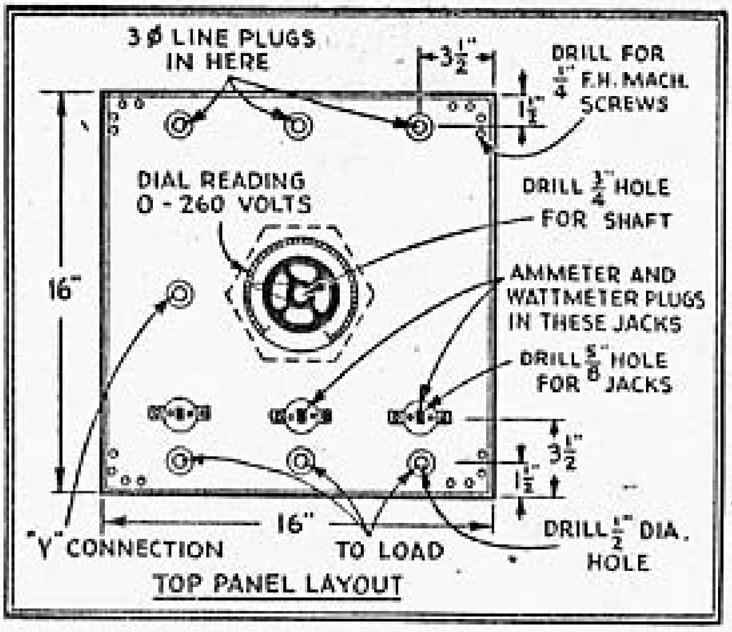
This unit was designed to be used on a 230 volt, 3-phase line and voltages from 0 to about 260 volts can be obtained from it in very gradual steps. Dial plate furnished with each Model 100 Q Variac, used in this project, is stamped 0 to 130, which is not suitable for this job. Therefore, a plate can be obtained from the manufacturer which reads 0 to 260 as required; this stamping is sometimes found on the reverse side on the original plates which are furnished. Or you can make one up, using stamping dies for the numerals. One of the original hand wheels is used at top end of shaft as shown. Make up the jacks and plugs used with the transformer from brass stock (see drawings). Three round jacks receive plugs from the line and 3 others of the same type

MATERIALS LIST—3-PHASE VARIAC
BASIC UNITS AND FITTINGS

3 model 100 Q, single-phase "Variacs", scale 0-130 volts (General Radio Co., Cambridge, Mass.).
1 dial plate to use with same, 0-260 volts (General Radio Co., Cambridge, Mass.).
1 pc. C. R. S. shaft 23¾" long x ¾" dia. (steel supply house).
1 pc., panel slate or Bakelite, 1" x 16" x 16" (large elec. supply house).
3 layers smooth stock birch or maple joined and glued to ¾" x 16" x 16". Alternate grain direction and glue together for base. ¾" plywood may be substituted.
4 commercial type casters, 2½" wheels (mill and heavy hardware store).
2 3 pole 250 volt cutout blocks (electrical supply store).
6 20 amperes cartridge fuses.
6 steel pipe spacer sleeves, ⅝" long x ¾" O.D. x ⅜" I.D.
4 pcs. 1" angle iron 21½" lg. (steel supply house).
16 pcs. 1" angle iron 2½" lg. for corner braces.

BRASS, BRONZE AND BAKELITE STOCK

6 pcs. Bakelite tubing (line and load plugs), 7/16" I.D., ⅝" O.D., 1¾" lg.
6 pcs. brass stock (line and load plugs), 7/16" dia., 2⅝" lg.
7 pcs. brass stock (line and load jacks), ⅞" dia., 2" lg.
14 hex. brass nuts 5/16" thick, ½"—20 thread, can be made and threaded in shop.
1 pc. Bakelite tubing (instrument plug), 5/16" I.D., 13/16" O.D., 2" lg.
1 pc. brass stock (instrument plug), 5/16" dia., 2¾" lg.
1 pc. Bakelite sheet stock (insulation between halves of plug), 3/32" x ½" x 3" long.
2 pcs. Bakelite rod (for locking plugs), 7/32" dia. x 2" long, turned to .210 and threaded 12-24. Cut off flush with plug flats after installing in holes.
3 pcs. Bakelite sheet stock (insulating discs top of jacks), 3/16" thick x 1½" square. Cut to circular discs 1⅜" in diameter with center hole and screw holes, see drawing.
6 pcs. phosphor bronze sheet stock (instrument jack contacts), .035-.040 thick x ½" x 3⅞" long.
6 pcs. brass stock (instrument jack spacers), ⅛" x ½" x ⅞".
Misc. screws, bolts, nuts, wire.



TOP PANEL LAYOUT

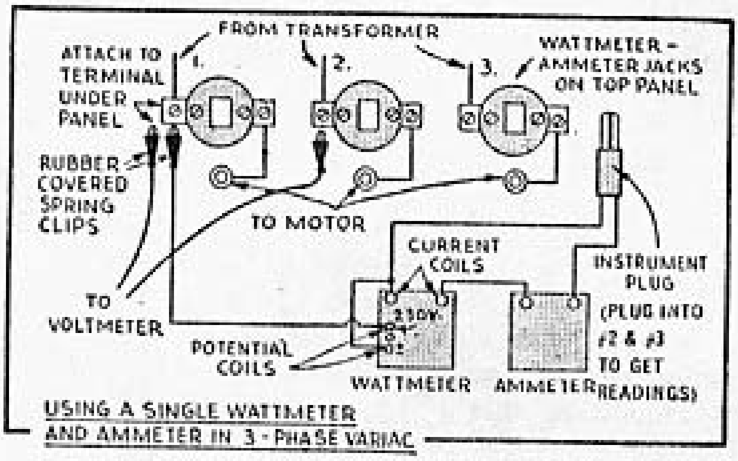
are used at the load side. An additional one is used for the "Y" connection which, for special testing, may be useful to have out at the panel.

Jacks for the instruments are also made up as shown. Note that with instrument plug out of its jack, lower spring contacts will be closed and thus circuit is closed to the load. Insertion of plug separates points and current is diverted through instruments so readings can be taken. The line and load jacks are turned on the lathe from ⅞ in. dia. brass stock to ½ in., leaving a shoulder as shown. This is threaded ½ in. by 20 threads and two thin brass nuts are used for clamping and connection of wires. For the plugs turn 7/16 in. dia. brass stock to 5/16 in., leaving a shoulder as shown. A saw cut in the end, a small hole drilled at top end for the lead wire and a piece of Bakelite tubing for a handle, complete this job. Wires for leads should be extra-flexible #10 rubber-covered, single conductor cable. Heavy spring battery type clips with rubber protectors are useful at the ends for attachment to line and to motors.

Follow details for making instrument jacks and plugs closely, as they must work right in the circuit. Note that phosphor bronze strips are bent up to shape, so when secured in ⅝ in. hole in panel, their ends are tightly held together. Small brass plates used as spacers and a top Bakelite ring with a rectangular center hole, make up assembly of the jacks. Turn plugs from 9/16 in. dia. brass stock to ½ in. dia., with a shoulder as shown. Mill or file two sides flat and split piece length-wise, removing 3/32 in. of stock. Then place a piece of 3/32 in. Bakelite between the two halves and place assembly in a vise for drilling. Drill and tap two holes for 12-24 thread at points indicated and thread pieces of Bakelite rod or similar insulating material for the holes. When dressed off, assembly will be tightly held together and yet two halves of plug will be insulated from each other. A piece of Bakelite tubing pressed on the top end, after wires have been soldered in drilled holes of plug, serves as a handle and also holds top ends of split plug together.

Wiring of transformer is simple (see diagram of connections). Attach two 3-pole cutout blocks to the perforated cage of top Variac and use 20 ampere fuses protection against overloads. Wire with ordinary #12 solid rubber-covered wire, placed neatly as shown. Drawing shows which terminals to use at each terminal board.

In 3-phase motor testing, use a single wattmeter and ammeter and connections as shown in drawing. Always leave instrument plug out of its jack when starting motor, to protect instruments from the usual heavy motor starting current. After reaching full speed insert plug in jacks 2 and 3 in turn. Note that wattmeter potential lead with its spring clip is attached to line under panel at #1 jack, which will not be used in this test. At no load, it will be found that with meter plug inserted in jacks the same way, unit will give one up-scale or positive reading and the other will tend to read down-scale or negative. Turn plug over or reverse wattmeter, if it is equipped with reversing switch, so as to get a reading on this negative value. The true no load watts result from subtracting low reading from the higher one. At full load, both readings will be up-scale, with plug placed in jacks the same way (they are simply added for the watt value).



USING A SINGLE WATTMETER AND AMMETER IN 3-PHASE VARIAC

If desired and instruments are available, two wattmeters and ammeters, each group equipped with one of the instrument plugs, will be found more convenient. This saves switching from one jack to the other. Potential leads of both wattmeters are clipped to same line terminal at #1 jack. Readings can be taken in two legs of circuit at the same time, which is preferable. Ammeter readings of current can be taken by plugging instruments into all three jacks. You can average the readings to get the current value.

Brace on Miter Box

• A strip of wood bracing top of a miter box keeps sides more rigid and insures more perfect cuts.—M. Ligocki.

Electric Temperature

HOW TO MAKE THERMOCOUPLE PYROMETERS TEMPERATURES OF MOLTEN METALS, ETC., AS

by C.A.Crowley

POPULAR MECHANICS 1934

①

TWO pieces of wire of different metals or alloys, welded or brazed together at one end, and connected to a d.c. millivoltmeter at the other end form a thermocouple pyrometer. The welded end is inserted where temperature is to be measured. Heat at this end causes a difference in electric potential which is shown on the millivoltmeter, the scale of the instrument having been calibrated in degrees. The millivoltmeter is simply a voltmeter which is sufficiently sensitive to read as low as .001 of a volt, or less in certain cases. These are available from instrument manufacturers and, unless the pyrometer is to be used for extremely accurate work, the inexpensive kind will serve the purpose admirably.

In designing a thermocouple, it is first of all necessary to decide upon the type of metals which should be used in the couple itself. Fig. 2 shows the maximum working temperature which can be used with seven different types of thermocouples. The first type of couple shown in Fig. 2, Chromel-Alumel, can be used for measuring temperatures as high as 2,500° F. It is impractical to build thermocouples

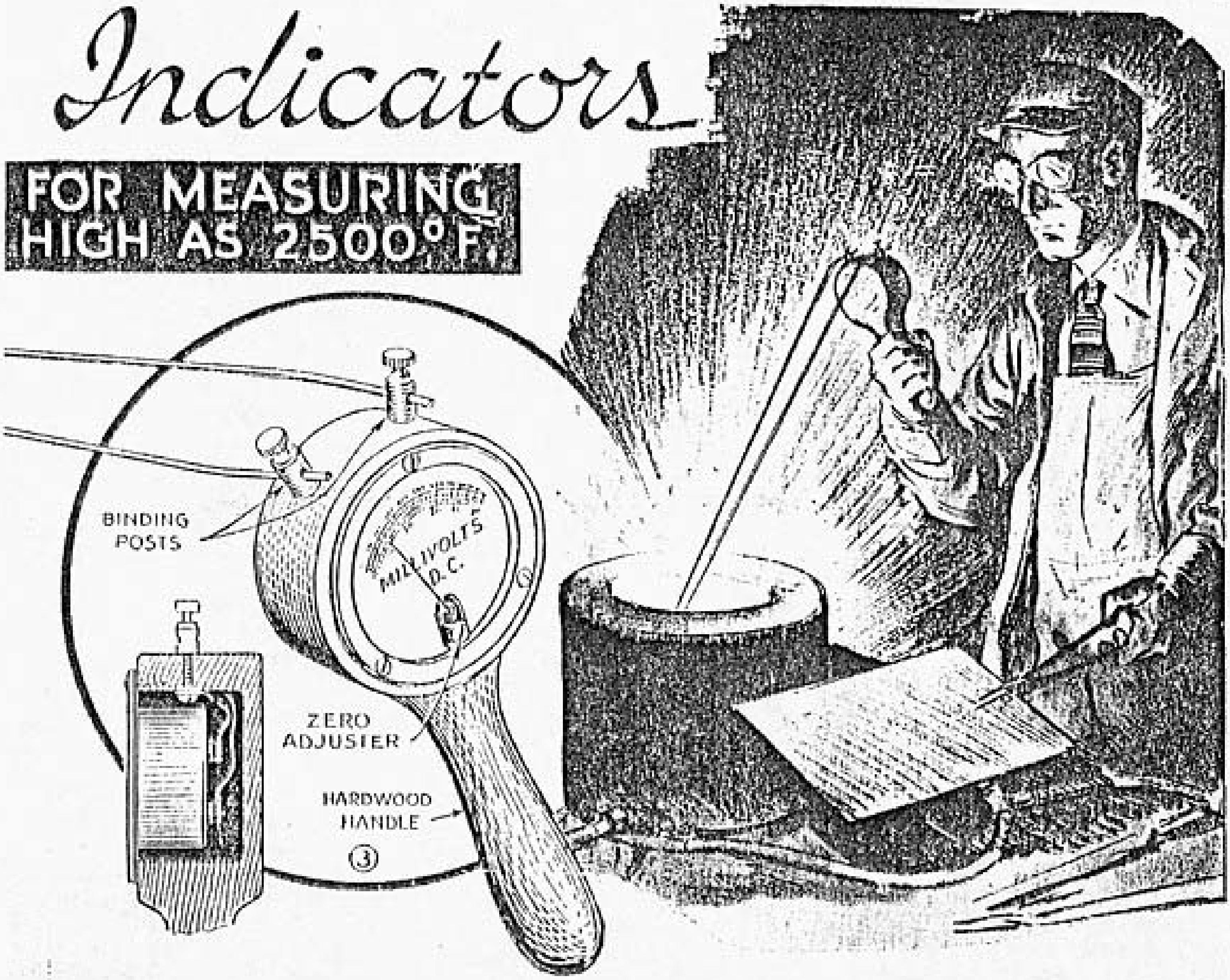
MILLIVOLTS CORRESPONDING TO TEMPERATURES

②

	Chromel-Alumel	Nichrome IV-Nickel	Nichrome-Nickel	Nichrome-Advance	Nichrome IV-Advance	Iron-Advance	Copper-Advance
2500°F.	54.85						
2400°	52.95						
2300°	51.00						
2200°	49.01						
2100°	46.97	48.72					
2000°	44.89	46.40					
1900°	42.77	44.08					
1800°	40.62	41.76	29.52				
1700°	38.43	39.44	27.88				
1600°	36.20	37.12	26.24	54.40	65.44	47.52	
1500°	33.94	34.80	24.60	51.00	61.35	44.55	
1400°	31.65	32.48	22.96	47.60	57.26	41.58	
1300°	29.33	30.16	21.32	44.20	53.17	38.61	
1200°	26.98	27.84	19.68	40.80	49.08	35.64	
1100°	24.62	25.52	18.04	37.40	44.99	32.67	
1000°	22.25	23.20	16.40	34.00	40.90	29.70	
900°	19.88	20.88	14.76	30.60	36.81	26.73	
800°	17.52	18.56	13.12	27.20	32.72	23.76	
700°	15.18	16.24	11.48	23.80	28.63	20.79	
600°	12.85	13.92	9.84	20.40	24.54	17.82	13.38
500°	10.56	11.60	8.20	17.00	20.45	14.85	11.15
400°	8.31	9.28	6.56	13.60	16.36	11.88	8.92
300°	6.09	6.96	4.92	10.20	12.27	8.91	6.69
200°	3.87	4.64	3.28	6.80	8.18	5.94	4.46
100°	1.52	2.32	1.64	3.40	4.09	2.97	2.23
TO METER	0-60	0-50	0-30	0-60	0-70	0-50	0-15

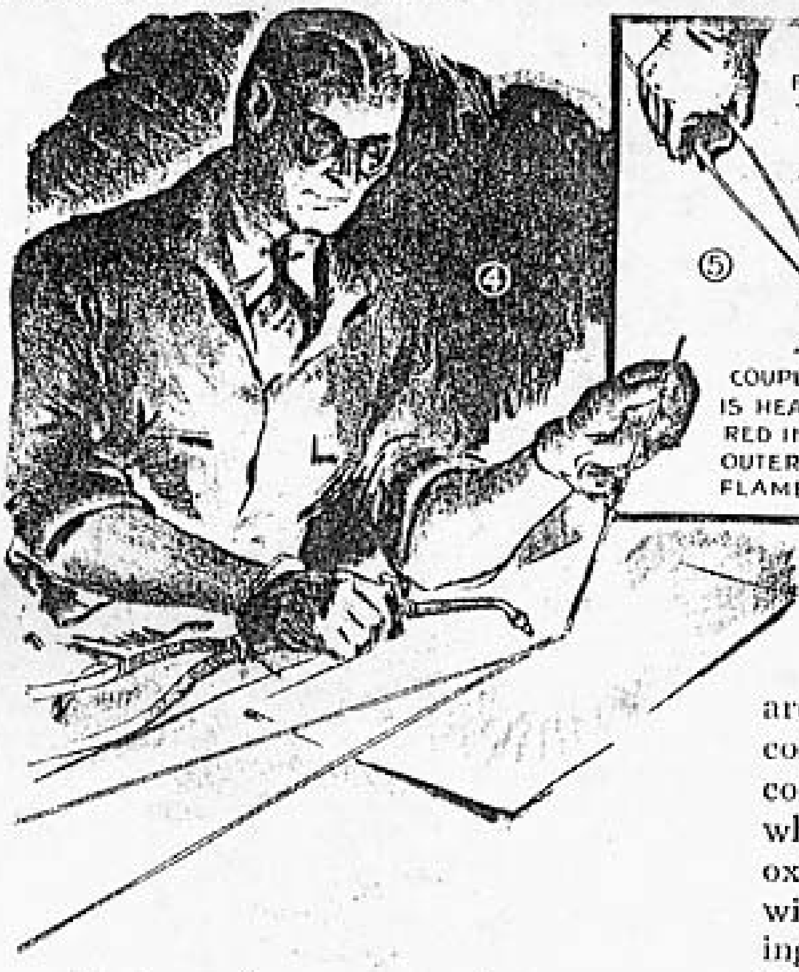
Indicators

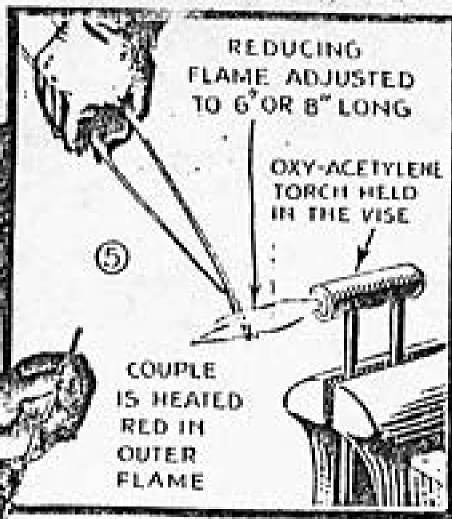
FOR MEASURING HIGH AS 2500° F.

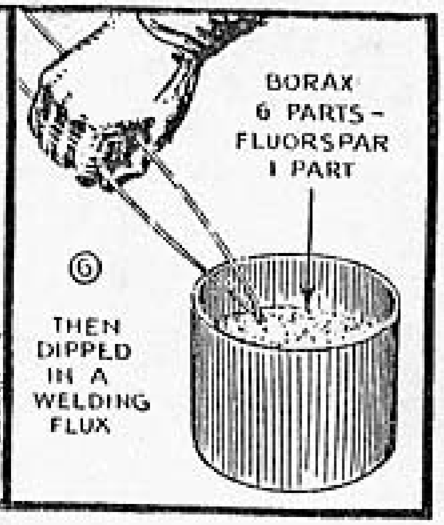


for measuring temperatures higher than 2,500° F. because all thermocouple metals, with the exception of platinum and extremely expensive alloys, melt or cease to be sensitive at about this temperature. If it is not necessary to measure temperatures this high, one of the other couples shown in Fig. 2 may be selected for the job. A couple made from Nichrome IV and Advance wires, is the most sensitive of all of the couples described. Thermocouples made from these metals may be used up to 1,600° F.

After deciding which metals will serve the purpose at hand, it will be necessary next to decide upon the form of couple and pyrometer which are to be constructed. If the couple is to be used for measuring the temperature of molten metals in a crucible, the design shown in Fig. 3 is extremely practical. This type of pyrometer consists of a millivoltmeter mounted in a handle turned from wood. The ends of the thermocouple wires are attached to the binding posts of the millivoltmeter as shown. If rigid No. 8 or 10-ga. wire is used, this arrangement is quite handy around the shop. If the thermocouple required must be permanently installed for indicating the temperature inside a furnace or other inaccessible place, a unit such as shown in Figs. 8 and 9 is more satisfactory. With this type of installation, the millivoltmeter is mounted on the wall as in Fig. 8, at a suitable location where it can be read easily and the wires run to the thermocouple which is permanently installed in the furnace or other equipment as in Fig. 9. If you wish a rugged portable pyrometer, Fig. 10 shows the most convenient method of construction. In this case, a section of steel tubing is welded closed at one end and the thermocouple junction inserted and sealed in place. The lead wires from the couple to the instrument should be well insulated and may be made as long as required, provided a sufficiently large size of wire is used. To

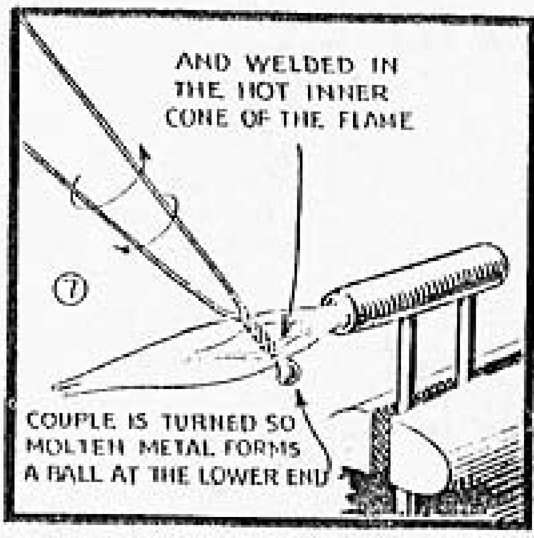


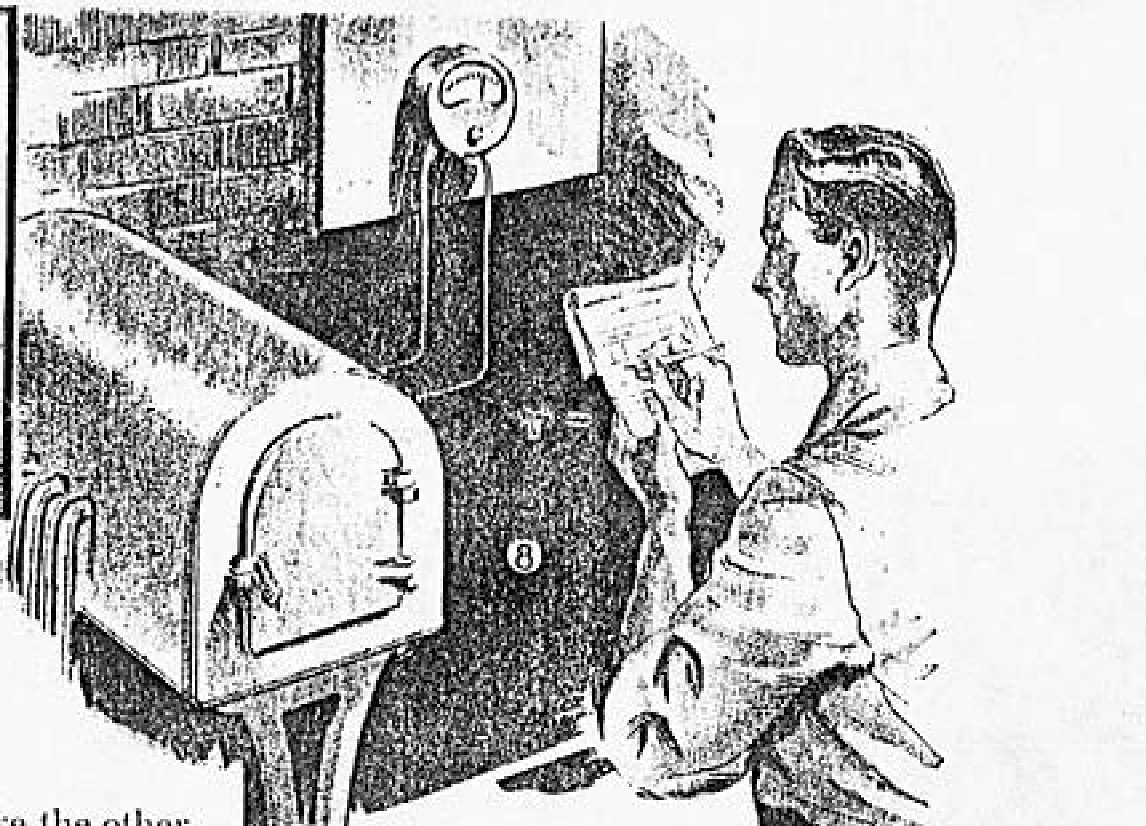




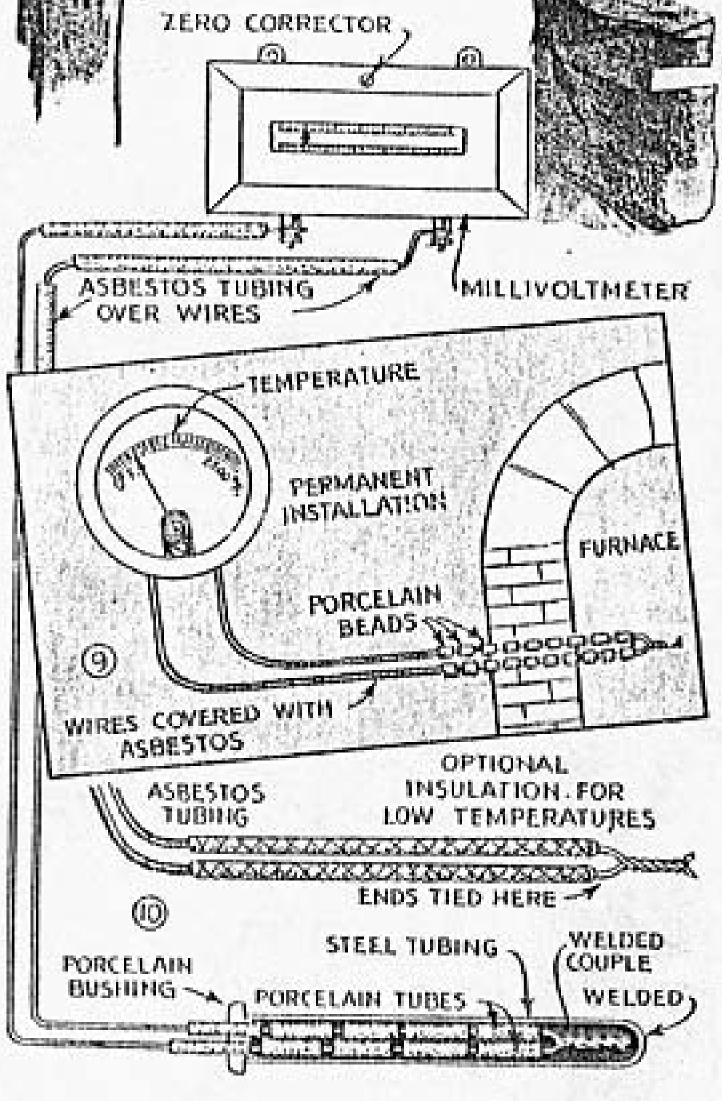
use this type of pyrometer, the instrument is set at any convenient location and the thermocouple tube inserted into the furnace or other location at which it is desired to read the temperature. This type of pyrometer is particularly desirable when the unit is to be used for metallurgical work. Many metals and alloys when in contact with thermocouples, will alloy with them and therefore change the instrument reading.

After selecting the particular thermocouple metals, which will operate at the maximum temperature which the unit is to be used on, from Fig. 2, and after you have decided upon the form of unit which will be the most serviceable for your purposes, the next step is to procure the material needed and start construction. In the case of all of the instruments, it is desirable to use as large a wire size as possible for the construction of the couple in order to prevent losses and to make the instrument as accurate as possible. Thermocouples which are to be operated at high temperatures particularly, should be constructed of at least No. 10-ga. wire. For intermittent use and when short leads are used, No. 12, 14 or even 18-ga. wire may be selected. The exact length of thermocouple wire required to reach from the couple location to the instrument is measured and this exact length is cut from both kinds of wire. Many of the alloy wires used in making thermocouples are difficult to cut and, accordingly, the corner of a grinding wheel will be found convenient for this purpose. The grinding wheel is also handy to use in removing oxide or corrosion from the surface of the wires to insure a good contact with binding posts. Next, the ends of the wire are fastened side by side in the jaws of a vise as shown in Fig. 1. The ends of the wires should protrude above the vise jaws about an inch. They are then twisted together as shown, with a pair of pliers. The twists should be made regular and firm to insure good contact. If the thermocouple is to be operated at a temperature below the melting point of silver solder or brazing spelter, the junction may be brazed neatly by heating it in the torch, Fig. 4, sprinkling with borax and applying just enough silver solder or brazing spelter to flow into the junction and insure good contact. For high-temperature work where brazing would not be satisfactory, an oxyacetylene torch should be used to weld the ends of the wires together. In making thermocouple welds, it is convenient to hold the torch in the vise so that the flame will be horizontal, as in Fig. 5. The gas valves are then adjusted to produce a slightly reducing flame about 6 or 8 in. long and so that the inner cone is between 1¼ and 1½ in. long. A reducing flame is produced when a slight excess of acetylene is being fed to the flame. Now, the twisted junction is held in the flame until both wires become red hot. The junction is then withdrawn and dipped into a good welding flux as in Fig. 6. The flux will stick to the wire due to its being melted by the heat.



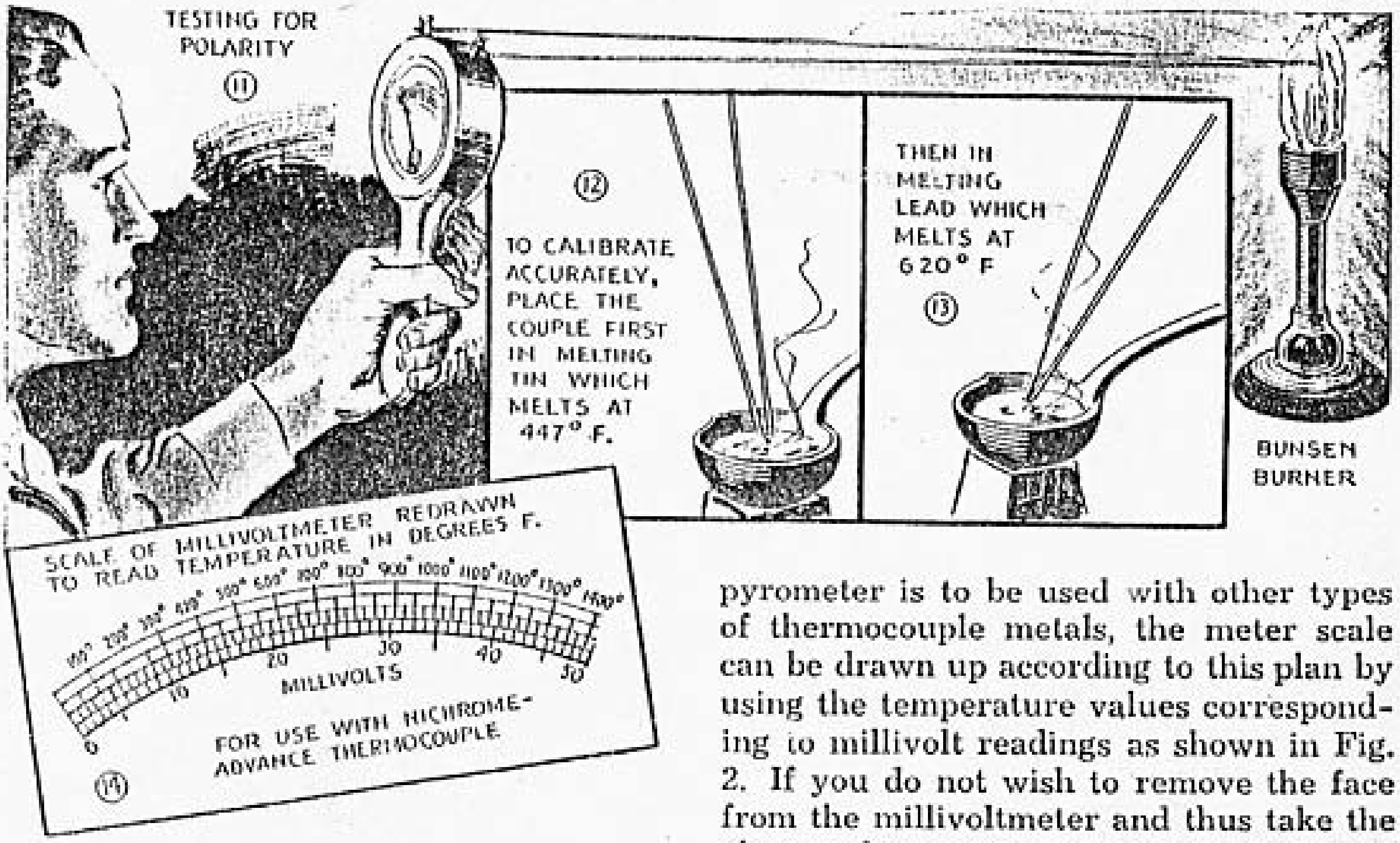


The wire junction is now returned to the hottest part of the flame and kept moving to insure even heating as in Fig. 7. In all cases, one of the wires making up the junction will tend to melt before the other and some care will be required to prevent it from flowing before the other wire comes to its melting temperature. Careful manipulation in the flame will easily overcome this and insure a good neat weld. When both wires have just reached their melting points, rotate the couple carefully so that the metal from both wires flows together and forms a ball of molten metal at the tip. If the job has been handled satisfactorily, this ball of metal which will flow to the end of the couple will consist of an intimate mixture of both metals. In welding a thermocouple by this method, care should be taken to avoid overheating and burning. A burned junction will be weak and in addition will not give accurate temperature readings when connected to the millivoltmeter. It is important that the weld be completed at the first attempt, inasmuch as repeated heating and cooling is likely to bring about certain changes in the alloys which would prevent them from functioning properly. If the first weld is unsuccessful, the joint should be cut off and a new junction prepared. After a little practice, the job can be handled quite easily.



Having completed the junction, the other ends of the thermocouple wires are filed or ground clean and bright to insure good contact and connected to the terminals of the millivoltmeter. To test the instrument for polarity, and also to check the effectiveness of the weld, the thermocouple may be placed in the flame of a burner while watching the voltmeter needle as in Fig. 11. If the needle tends to move in the wrong direction, this indicates that the couple was connected wrong and then, the connections to the instrument should be reversed at the meter terminals. If heating in the flame produces a regular de-

 GRANDDAD'S ELCTRICITY BOOK



flection of the millivoltmeter, you are ready to assemble the pyrometer according to the plan which has been decided upon. If the unit is to be built according to the plan shown in Fig. 3 the wires will need to be bent carefully to the proper shape so that the ends can be fastened tightly in the binding posts of the millivoltmeter. After this, the wires may be formed so that they are of convenient shape for inserting into the furnace while holding the handle of the instrument in such a position as to facilitate reading. If the unit is being built along the lines indicated in Figs. 9 and 10, porcelain beads or glass beads, if the temperature to which the pyrometer is to be exposed is not high enough to melt them, should be slipped over the wires as shown to prevent their coming in contact with each other and with the metal case. If bare thermocouple wire is used, it may be insulated by slipping sections of asbestos tubing over the entire length of each wire. A convenient plan which produces a neat job is to place asbestos tubing over the wires and to encase the two jointly in a length of rubber tubing. This will effectively prevent contact between the wires.

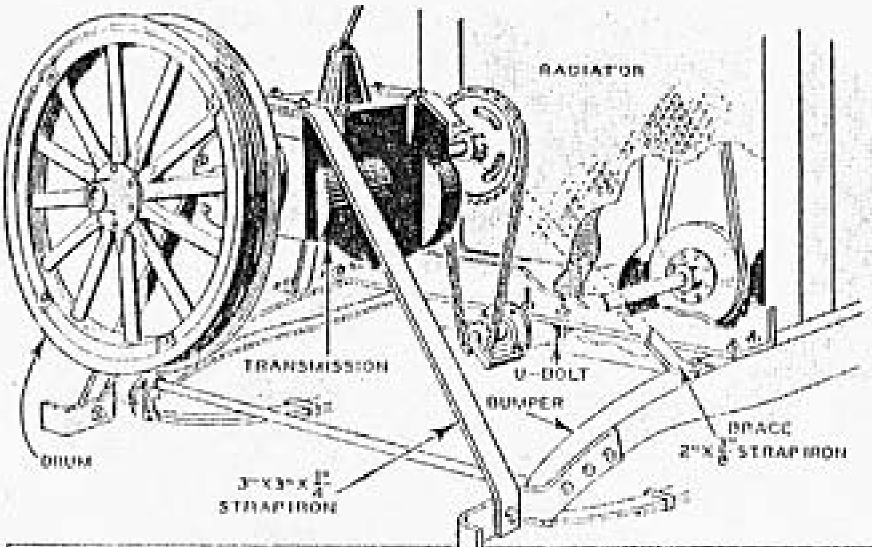
Fig. 14 shows a millivoltmeter scale to which has been added figures giving corresponding temperatures for use with a Nichrome Advance thermocouple. If the pyrometer is to be used with other types of thermocouple metals, the meter scale can be drawn up according to this plan by using the temperature values corresponding to millivolt readings as shown in Fig. 2. If you do not wish to remove the face from the millivoltmeter and thus take the chance of impairing its accuracy, it is quite satisfactory simply to prepare a chart which gives temperatures corresponding to millivolt readings. A chart of this type can be placed on the wall near the pyrometer for instant reference.

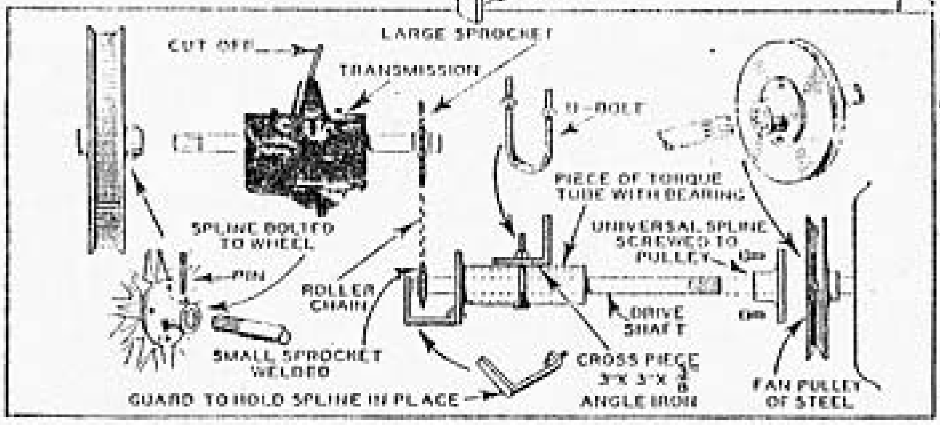
To use the pyrometer thus altered, adjust the zero adjuster on the millivoltmeter until the needle points to the millivolt reading corresponding to room temperature. This should be done with the couple out of the heat. Upon inserting the couple into the furnace the needle will then read correctly. For more accurate work the couple should be calibrated by placing it in melting tin and then in melting lead, Figs. 12 and 13. As the metals are heated the millivolt reading will rise gradually until the melting point is reached, then the reading will hold constant for a few seconds. The reading at which the temperature holds constant is the melting point. To check this value let the hot molten metal cool while watching the millivoltmeter. Here again the needle will hold at the melting point.

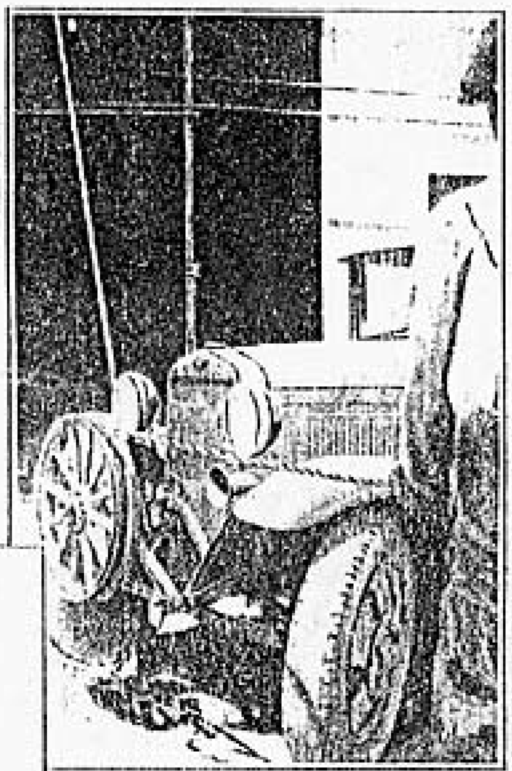
¶When mixing paints, an accurate method of assuring that each batch will be identical in color, is to put a sample of each one on a clean paddle and let them run together by inclining the paddle. If a blend is noticeable when the two samples mix, the colors are not identical.

MODERN MECHANIX, 1934

AUTO Motor Powers this UTILITY HOIST







Hoist is employed to snub rope as illustrated above. Details of assembly are seen at left. No dimensions are given as they vary with materials available and make of truck to be equipped.

UTILIZING parts picked up in auto wrecking lots a very useful and efficient hoist may be cheaply constructed on the front of a truck or auto with a few tools suitable for doing some heavy boring.

The steel fan pulley, shown in the drawings above, has to be turned out at a machine shop. It was found by experience that the stock cast iron pulley would not stand up under the strain imposed on it. To the front of this steel pulley is attached one of the spline plates by means of ⅜ in. machine screws. The male spline is on the end of the section of drive shaft which extends through the front of the radiator by about six inches. Total length will be about one foot.

Holes are bored in the frame just in front of the radiator and a piece of angle iron is bolted across on which the piece of torque tube, which acts as a bearing for the short shaft, is attached. Note that this bearing is held in place by a U-bolt flattened in the middle. Then onto the end of the drive shaft is welded a small sprocket wheel taken from the timing system of an old Studebaker.

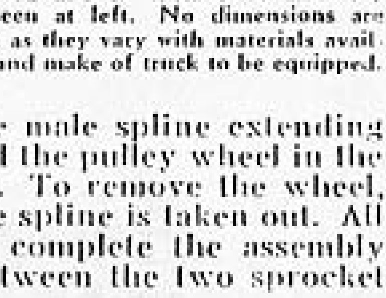
Next bore a hole in the frame on either side about six inches in front of the cross piece already in place. This is to hold the angle iron which is to support the rear end of the transmission. The transmission is supported in front by a piece of strap iron bolted onto the top and bent so as to fasten onto the bumper bars.

Onto the shaft extending out the back of the transmission is welded the large sprocket. Onto the male spline extending out in front is fitted the pulley wheel in the manner illustrated. To remove the wheel, the pin through the spline is taken out. All that is needed to complete the assembly now is a chain between the two sprocket wheels.

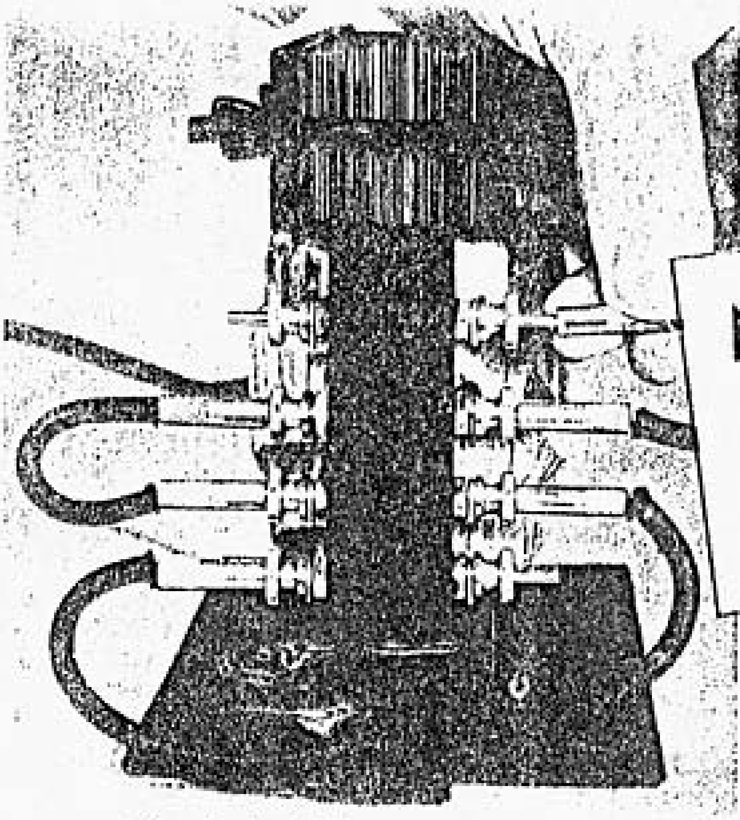
The transmission gives one his choice of three different speeds or power with a constant engine speed. It also provides a means of disengaging the drum wheel when necessary. When moving, if desired, the spline fitting onto the fan pulley may be pulled out by moving the guard, thus completely disconnecting the unit. No dimensions are given as length and sizes will vary according to the materials available and the make of the truck to be equipped.

Restoring Life to Old Magnets

OLD magnets may be rejuvenated by winding a piece of No. 12 wire on them, connecting the ends to a storage battery. Five-second applications of juice repeated several times in hour will restore magnetism. Ten or 12 turns of wire will suffice.



Restore life to magnet by winding on ten or twelve turns of No. 12 insulated wire, hooking ends to a 6-volt battery. Give three 5-second charges an hour.



Quick-change leads and coils are its secrets (left).

Multi-Voltage Transformer FOR THE HOME WORKSHOP

by Walter B. Ford

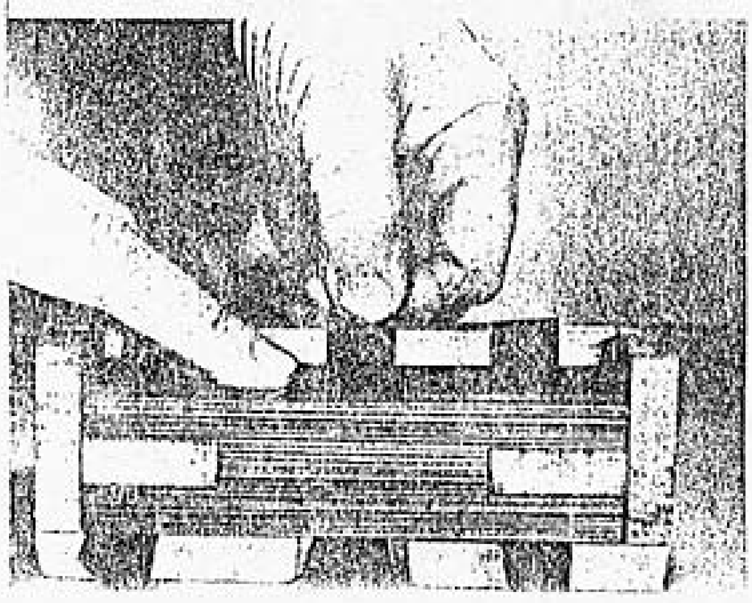
In your shop work, have you had occasion to use a voltage lower than your power supply? This transformer has 37 different step-down voltages to fill your needs.

Mechanix Illustrated August, 1944

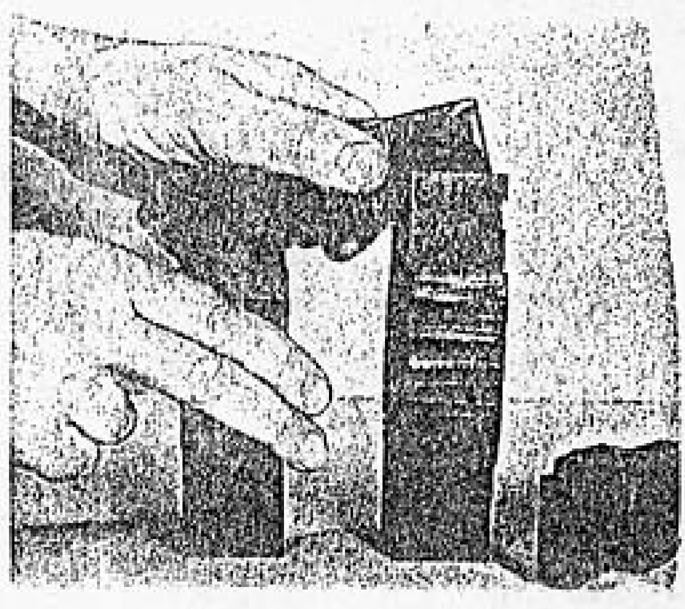
HAVE you ever wanted a particular voltage lower than that supplied by the light line and found it unavailable? This easily built transformer will supply an almost unlimited range of separate voltages without switches or taps, and with a minimum outlay for wire and other constructional materials. The number of separate voltages at the disposal of the builder will be limited only by the number of secondary coils he wishes to wind. For instance, with secondary coils wound for 3 volts, 4 volts, 6 volts, and 8 volts, the builder will have 18 separate voltages available. By adding only one more coil wound for 20 volts, the number of separate voltages will have increased by 19, making 37 voltages available by the use of only 5 secondary coils.

The secret of the transformer's usefulness lies in the application of a principle that is generally overlooked in small transformer construction. That principle is that when a current flows through two adjacent secondary coils in opposite directions, with these coils connected in series, the voltage available at the two terminals of the coils will be the difference of the voltages that would be set up in the coils when the current flows through them in the same direction. For example, when we connect the 3-volt coil and the 4-volt coil in series with the current flowing through each coil in the same direction, the total voltage available will be the sum of the individual coil voltages, or 7 volts. If we connect the two coils so that the current flowing in one coil is in the opposite direction to the current flowing in the other, the voltage available will be the difference of the individual voltages, or one volt. By means of quick-change leads and terminals, coil con-

Tape laminations together before removing the form.



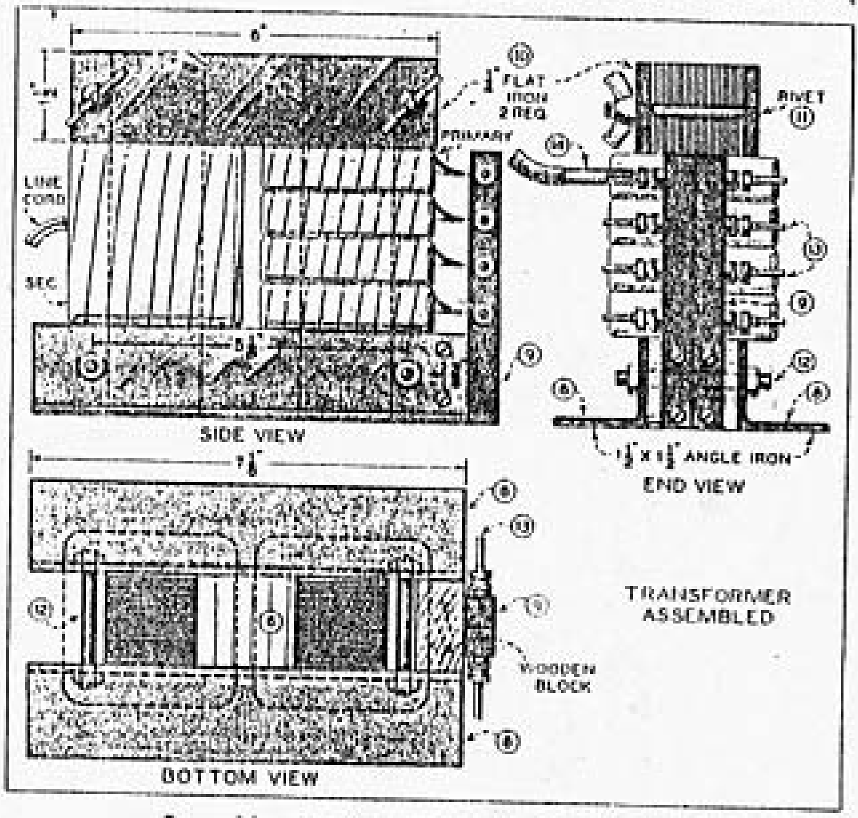
Sections of the core are assembled as shown below.



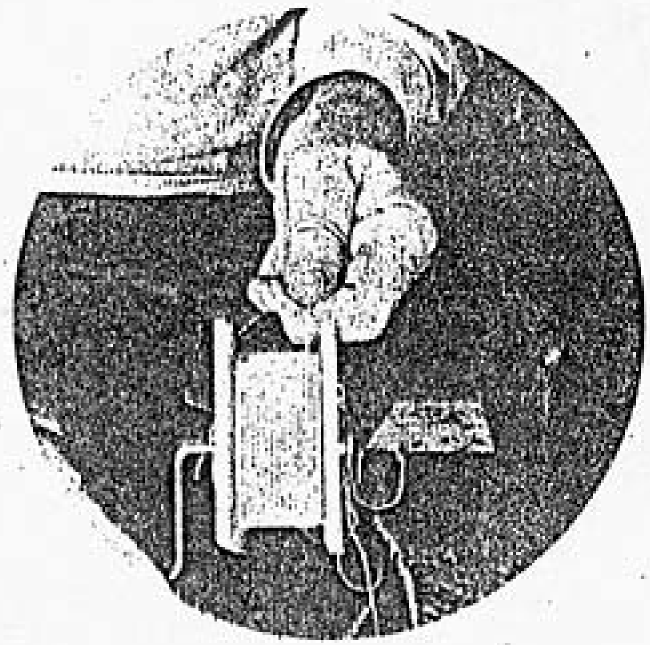
nections may be changed within a few seconds. When it is necessary to remove a coil from the transformer and replace it with another, the removable core section makes it possible to complete that operation within less than two minutes.

The transformer is designed for operation on 120 volts, 60 cycles, and has a conservative output rating of 100 watts. Since the output voltage requirements will vary with each individual builder, data for winding secondary coils with definite voltage output will not be given. Instead the builder may wind coils to meet his particular needs.

The first step in building the transformer is to cut the core laminations to the sizes shown at figures 1, 2, 3, and 4. The steel sheets for the laminations may be obtained from the salvage stock of power companies. If that is not obtainable, stove-pipe iron of 26 or 28 gauge may be substituted. Cut enough pieces of each size to make stacks as follows: Fig. 1, 1" high; Fig. 2, 2" high; Fig. 3, 1" high; Fig. 4, 2". Make two wood forms for forming the core sections, as shown at figure 5. One form should have an inside length of 4⅝" and the other form an inside length of 6". Cut four wood blocks, ½" thick, 1½" square, for holding core laminations in place before they are taped. The method of forming the core sections is shown at figure 5. Strips of friction tape are placed in the wood form to facilitate removing the laminations from the form. Wrap the tape around the wood blocks and the laminations, place the whole assembly in a vise and wrap the center section tightly with friction tape. The com-

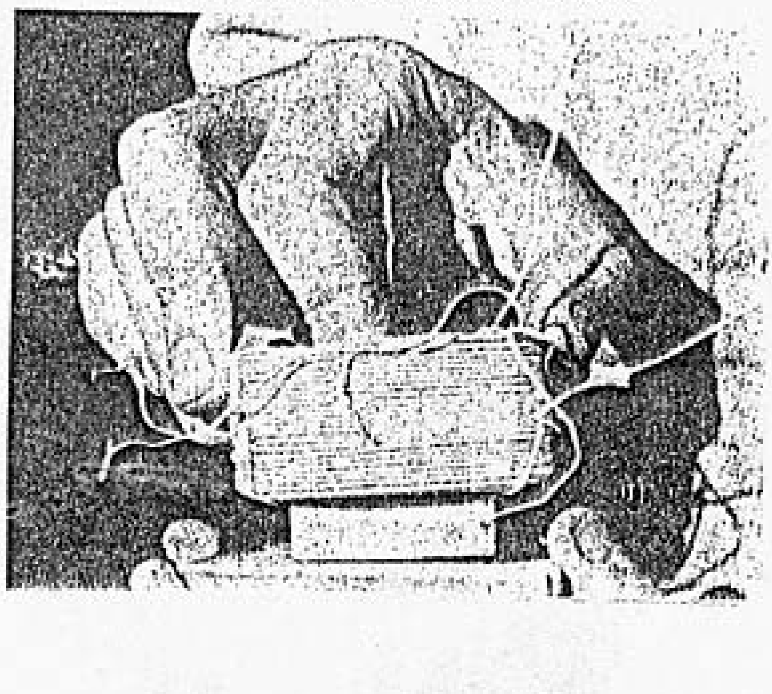


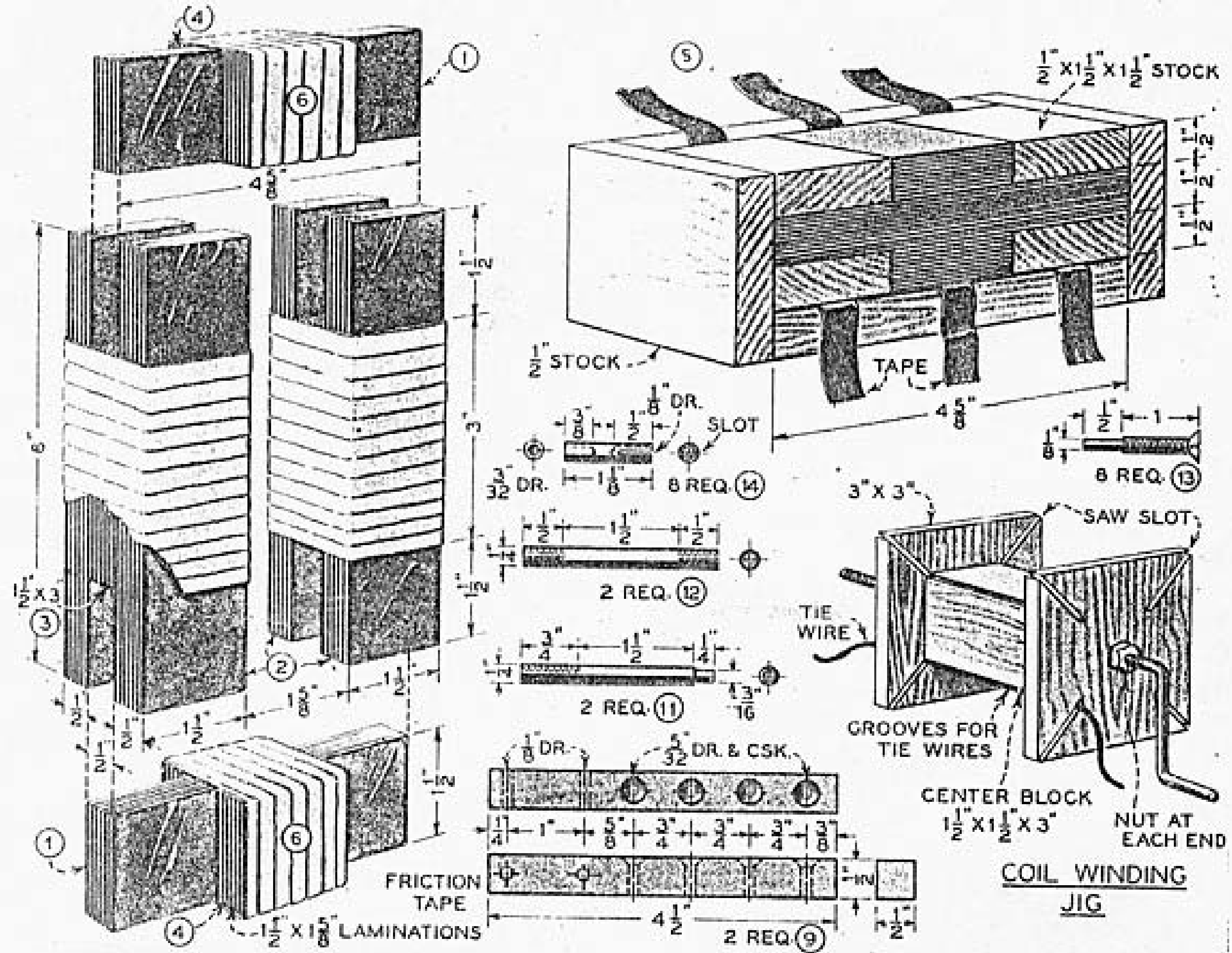
Assembly detail; numbers are referred to in text.



Each coil should be wrapped firmly with cotton tape.

Winding with jig (above); removing wire coil (below).





These are details of the coils and winding jig. Cut the steel sheets for laminations to the sizes shown.

pleted core section is shown at figure 6. When assembling the core section which will be removable, paint each lamination with shellac or varnish as they are assembled. This will bind the laminations into a solid section. The longer sections of core then are assembled in a similar manner in the larger wood form, with the exception that only two wood blocks will be required. The wood blocks are placed in the form on top of a ½" stack of laminations, figure 2. The center laminations, figure 3, next are placed in the form between the wood blocks, followed by another stack of long laminations.

Assemble the core with a short section on the bottom and the two long sections in an upright position. Drill the two pieces of angle iron as shown on the side-view drawing. The holes for clamping the two pieces together should be ¼". Drill 5/32" holes in the ends of the angle irons to hold the wood block. Thread the ends of the ¼" round rods, figure 11, and clamp the angle irons to the core with hexagon nuts. Insert a wood block between the ends of the angle irons to hold the terminal strips in place, as shown on the side and end-view drawings.

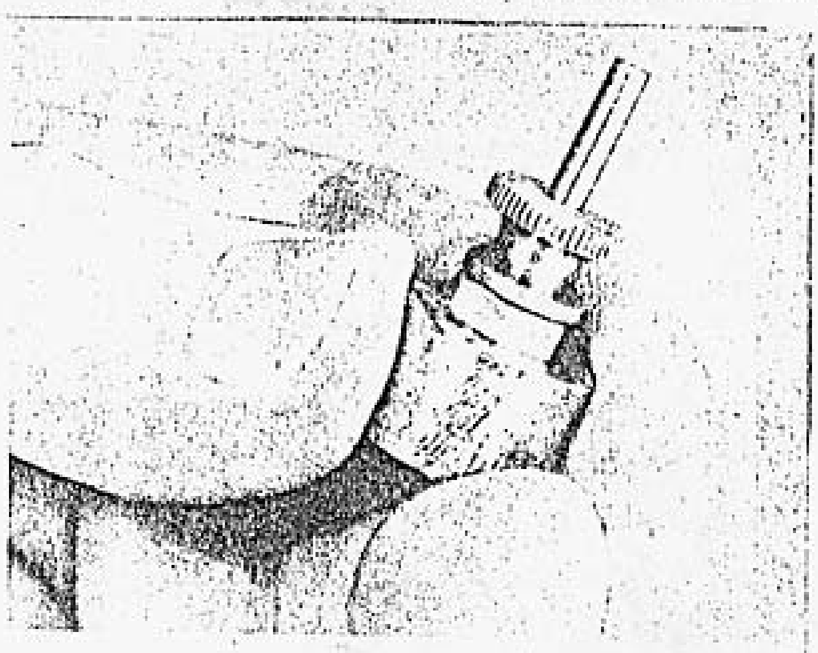
Drill the wood terminal strips as shown at figure 9. Turn the ends of the 8-32 brass machine screws as shown at figure 13. Insert the machine screws in the wood terminal strips so that the heads of the screws rest in the countersunk holes. The heads of the screws should be below the surface of the wood strips so that they will not make contact with adjacent screw heads. Secure the wood terminal strips to the wood block and join the two strips together at the top with a wood screw.

A winding jig for winding the primary coil is shown in the drawing. Jig consists of two square wood sides and a wood center block, held together with a threaded crank. Slots are provided in the sides and center block for the insertion of tie wires which will hold the completed coil together while it is being removed from the jig. Before starting the winding of the primary coil, place a piece of scrap wire about 9" long in each slot. Wrap a piece of thin 3"x12" cardboard around the center block of the winding jig. Drill a 3/16" hole in a piece of wood to serve as a support for the threaded end of the winding jig, place the coil support in a vise and wind 360 turns of No. 20 D. C. C. wire evenly on the jig over the cardboard center. Before starting the winding, allow an end of the wire about 6" long to extend through one of the slots in the side of the winding jig. Twist the ends of the tie wires together around the coil and remove the coil from the jig. Connect a piece of lamp cord to the two ends of the coil, solder and tape the connections, then tape the whole coil with cotton tape, in and out through the center of the coil and parallel with its length. Be sure to remove the tie wires when they are no longer needed.

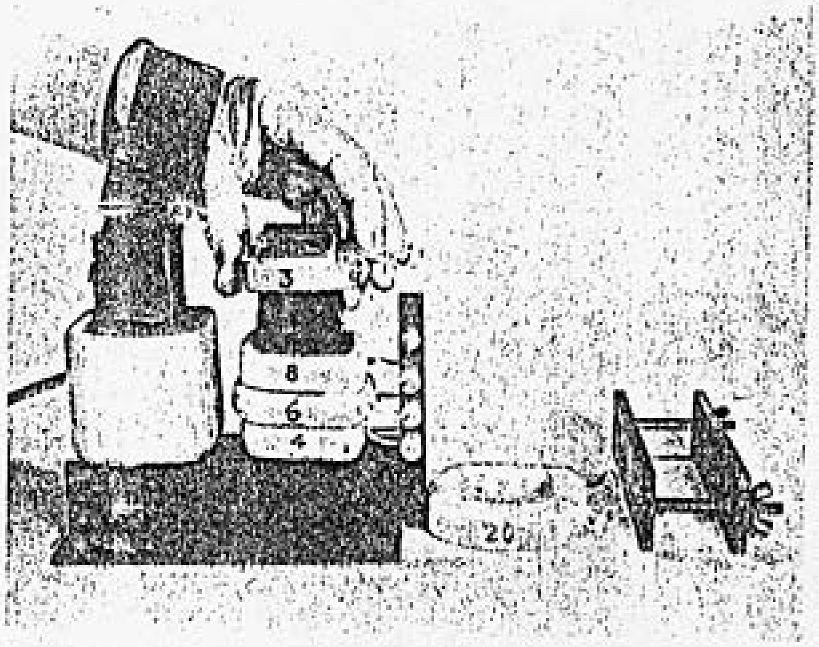
Dip completed coil in shellac or varnish and allow it to dry. The secondary coils are wound in a similar manner, with the exception that the center block of the winding jig should be only ¾" long. Since the builder will undoubtedly wish to select voltages best suited to his needs, no data for winding particular secondary coils will be given. By allowing 3.3 turns of wire for each volt that he requires, he may wind his coils accordingly. Each coil should be wound in the same direction and after each coil is completed, the starting end should be painted or marked to make identification easy. The size of wire used in the secondary coils will depend upon the amount of current required at the particular voltage for the finished coil.

Total current in amperes which will be available from any secondary coil may be found by dividing the wattage of the transformer, 100 watts, by the voltage of the secondary coil. For example, the total current available at 6 volts would be 16⅔ amperes, but there are few applications where that amount of current would be required. By allowing a cross-sectional area of 1,000 circular mils for each ampere of current required and referring to a wire table for the nearest corresponding size, the numerical size of the wire may be determined easily. Mark the voltage on each secondary coil to permit a quick selection.

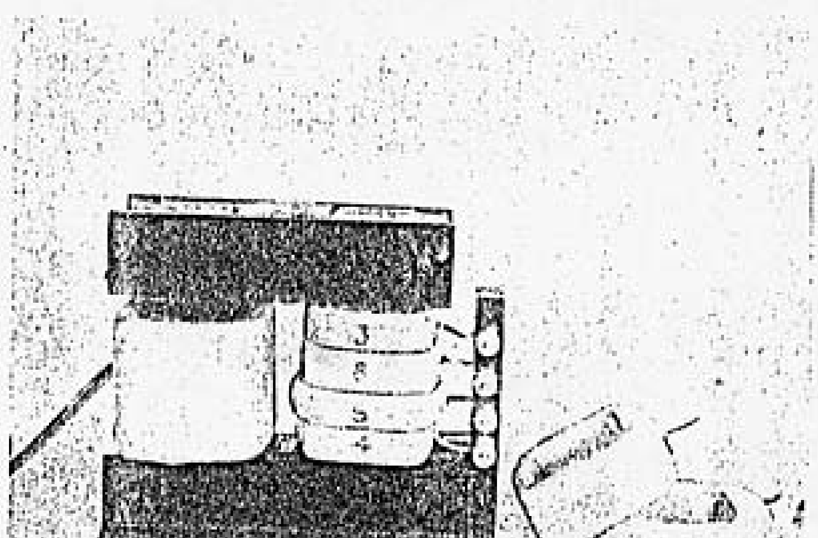
Drill the two pieces of band iron as indicated at figure 10. The holes in one piece should be



Make a jig for pins of the coil terminals as above.



Changing coils: their voltages are marked on sides.



Completed transformer with leads and extra coils.

¼", and those in the other piece 3/16". Cut a shoulder on the two pieces of ¼" round steel and thread the opposite end as shown at figure 11. Rivet the ends of the threaded rods in the 3/16" holes in the piece of band steel. Place the two pieces over the upper section of the core and clamp in place with two wing nuts. To change secondary coils it will be necessary only to loosen the clamp and remove the upper section of the core.

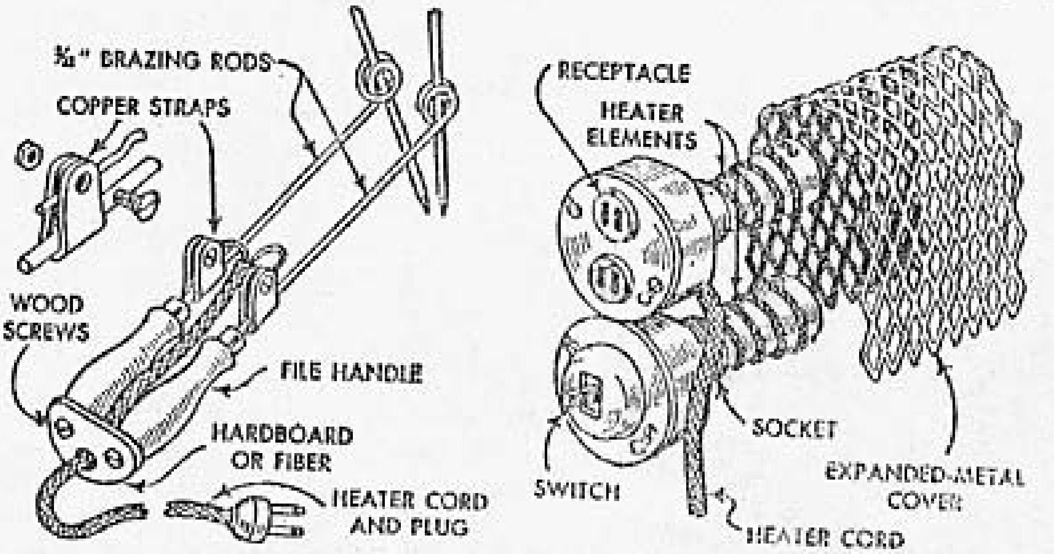
The sockets for the coil-connecting leads are made for pieces of ¼" round brass rod, as shown at figure 14. A ⅛" hole is drilled in one end of the brass piece, after which it is slotted to make a tight fit on the end of the terminal screw, figure 13. A 3/32" hole is drilled in the opposite end, in which the connecting wire is soldered. Four connecting leads will be required; two short leads to connect between adjacent terminal screws and two long leads to connect between terminals on opposite sides of the terminal strips. The connecting leads should be of flexible wire as large as the largest size used in the secondary coils.

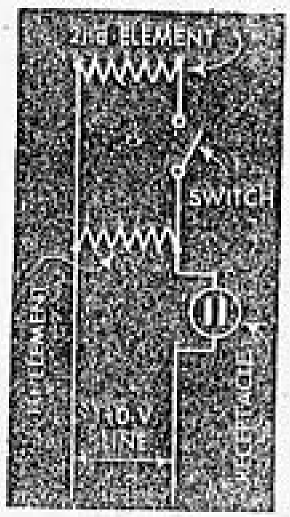
LIST OF MATERIALS

9 lbs. transformer steel
1¼ lbs. magnet wire, No. 20, D. C. C.
Wire for secondary coils (see text)
6-ft. lamp cord, No. 18, rubber covered
1 attachment plug cap
2 pieces angle iron, 1½" x 1½" x 8"
2 pieces band iron, ¼" x 1½" x 6"
4 pieces round steel rod, ¼" diameter, 2½" long
4 steel nuts, hexagon, ¼"
2 steel nuts, wing, ¼"
8 machine screws, F. H. brass, 8-32, 1½" long
8 M. S. nuts, hexagon, brass 8-32
8 knurled nuts, brass, 8-32
2 pieces wood, ½" x ½" x 4½"
1 piece wood, ⅝" x 1½" x 1½"
4 wood screws, F. H. bright, ½", No. 6
5 wood screws, F. H. bright, ¾", No. 6
8 pieces round brass rod, ¼" wide, 1⅛" long
Winding jig (see text)
2 ft. Stranded wire, rubber covered, for terminal connections (see text)

ELECTRIC TORCH

Electric Torch Made From 600-Watt Heater Elements





Two outlet boxes, a duplex receptacle, two porcelain sockets, a toggle switch and two 600-watt heater elements provide the parts for the resistance unit of this homemade electric torch, which is designed to handle both light brazing and hard soldering. The sockets are screwed to the bottoms of the outlet boxes and wired according to the diagram with asbestos heater cord. With the switch in the "off" (low-heat) position, only a little current passes through the torch, whereas in the "on" (high-heat) position, both heater elements operate to send full amperage through the torch. *Caution:* Plugged in, the torch becomes electrically "hot" and should be treated as such to avoid a shock from touching the exposed parts. In use the tips of the two carbons are brought together by squeezing the handles. The carbons are held together momentarily and then slowly spread apart. This produces an arclike flame which is directed at the work and controlled by varying the pressure on the handles. The arc will form better with the switch at high heat, after which the current is cut to low heat. Use only cored carbons made especially for electric torches and readjust carbons as they burn away.

When brazing, silver soldering or hard soldering, be sure that the parts to be treated are clean and covered with a good flux before beginning. Use an asbestos board for a base when doing extensive work.

ELECTRICITY

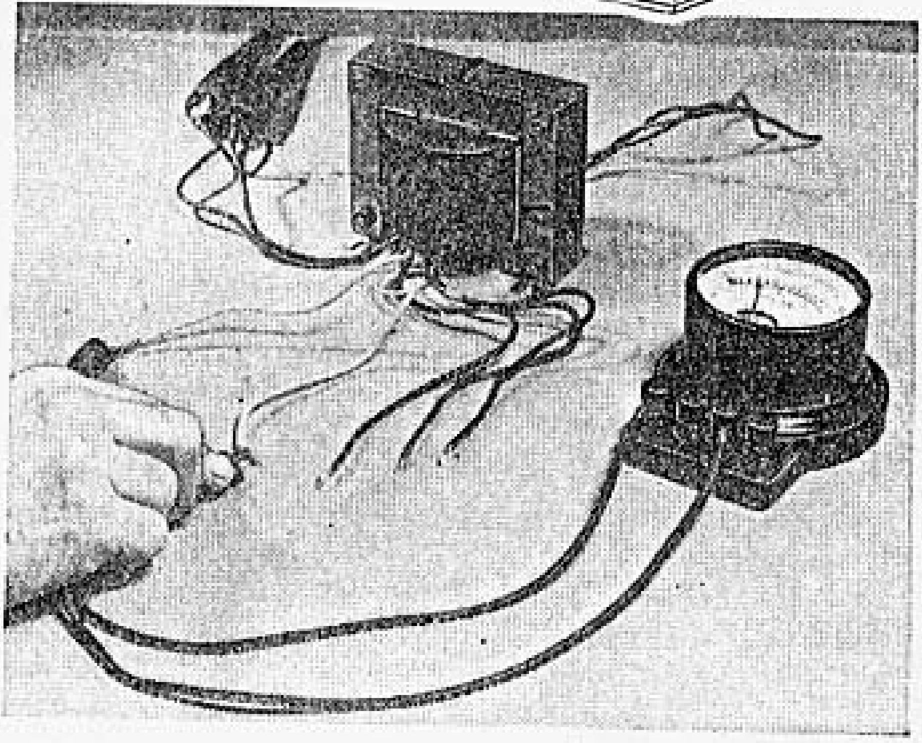


Fig. 1. The completed transformer is being tested at the low voltage leads. This one registers 5.2 volts.

Complete step-by-step instructions for building a transformer for 115 volt, 60 cycle input, with three secondary voltages.

By HAROLD P. STRAND

Building a POWER TRANSFORMER

SCIENCE AND MECHANICS April-May 1948

YOU can easily build a very serviceable power transformer which will do excellent duty in a radio or the amplifier of a record player. First, you will need to have a means of winding a coil with a suitable turn counter attached. By studying the design procedure given in previous SCIENCE AND MECHANICS articles and substituting other factors as required, you can design and build a transformer for any voltage, current output or frequency desired. Our problem in this example, however, is the building of a transformer for 115 volt, 60 cycle input and with three secondary voltages—600 volts, 50 ma., 5 volts, 2 amp., and 6.3 volts, 2.5 amp. The 600 volt and the 6.3 volt windings are to have center taps.

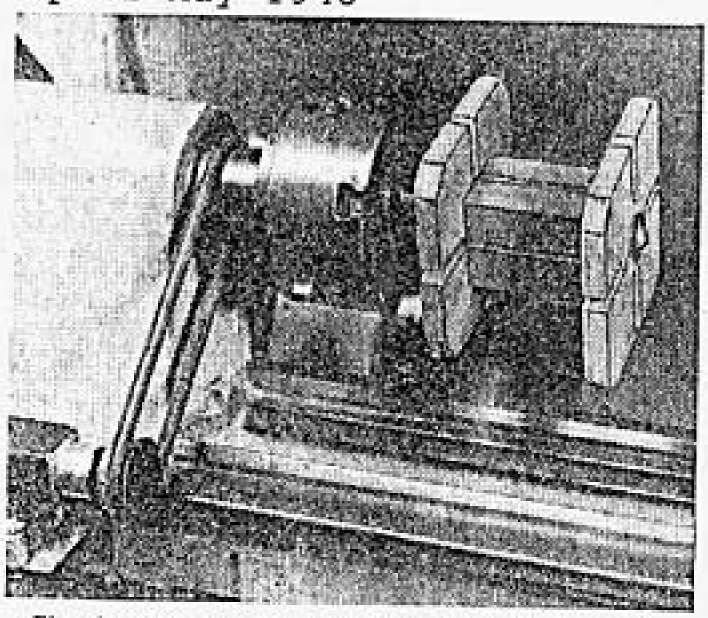


Fig. 2. Coil form is held together with a 1/4 in. bolt which is clamped in the lathe chuck. Grooves in the block and slots in the side pieces allow strings to be passed through for tying.

The first step is to determine the total wattage or volt-ampere capacity of the transformer. To do this, add the outputs of the separate windings: $600 \times .050 = 30$ watts. $5 \times 2 = 10$ watts. $6.3 \times 2.5 = 15.7$ watts. Adding these gives a total of 55.7 watts. So we will design the transformer for 60 volt-amperes to be on the safe side. Referring to the table on suggested core areas, the nearest size listed is 75 watts (nearest larger size). This calls for a cross-section of 1.5 sq. in. Some laminations were on hand from a transformer formerly used in a motor control unit and the old coil was removed and the iron cleaned up. The center leg of the E sections measures 1½ in. wide, so a stacking of 1 in. would give us 1.5 sq. in. Ordinarily this would be done, but in our case there are several factors which will result in quite a large sized coil, including the large number of secondary turns and extra insulation between the windings. With additional iron, however, fewer turns will be required and thus the coil will be smaller and more liable to fit in the lamination space. Let us take the figure 1.8 for cross-section and see how many turns are necessary, using about 60,000 line as a reasonable flux density. The formula which should be used and the solution to the problem are as follows:

$$N = \frac{10^8 \times E}{4.44 \times f \times A \times B_m} = \text{Turns} —$$

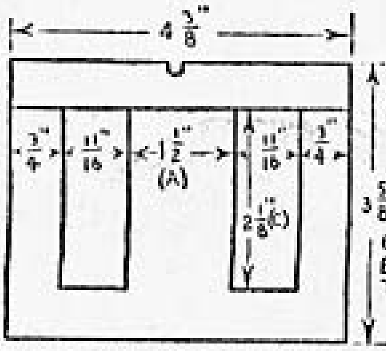
$$\frac{100{,}000{,}000 \times 115}{4.44 \times 60 \times 1.8 \times 60{,}000} = 400$$

With 400 primary turns established, the wire size is found by first dividing watts capacity by line volts: 60 ÷ 115 = .52 amp. Adding about 10% for loss in efficiency a total expected current draw in the primary will be .57 amperes. Consulting the wire table, No. 22 is the nearest larger wire size, allowing 1000 circular mils per ampere.

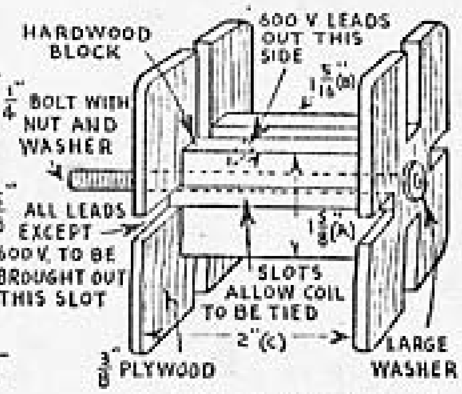
The turns per volt can then be found by dividing 400 by 115 = 3.48. Multiplying the desired secondary voltages by this factor gives the necessary turns for each winding, plus an allowance for losses. The first voltage to consider is 5 volts or 5 × 3.48 = 17.4 turns (18). This gives slightly over 5 v., using 18 turns at no load. Because of few turns involved, losses will be slight and if but a light load is to be connected, the turns can stand at 18. However, under full load, there will be a drop of about 4% (regulation) in voltage and if 5 volts at full load is desired, another turn should be added.

The 6.3 volt winding is figured the same way: 6.3 × 3.48 = 21.9 turns (22). This will give close to 6.3 volts, no load. If full voltage at full load is desired, add another turn to make 23. This winding has to be center tapped. In order to tap the winding exactly in the middle (11.5 turns), tap the coil on the half turn or on the other side from the start. If 22 turns are used, it will be tapped at the 11th turn. The 600 volt winding will be 600 × 3.45 + 5% (for copper losses because of the large number of turns of fine wire), which will be 2173 turns. As this voltage is not critical like the other two voltages discussed, we can safely make this a round figure of 2200 turns. The center tap will be on the 1100th turn. With a load of .050 amperes, the wire table lists No. 33 as suitable. The author did not happen to have this size on hand but had No. 29 and as substituting a larger size wire is usually good practice when necessary, this was used.

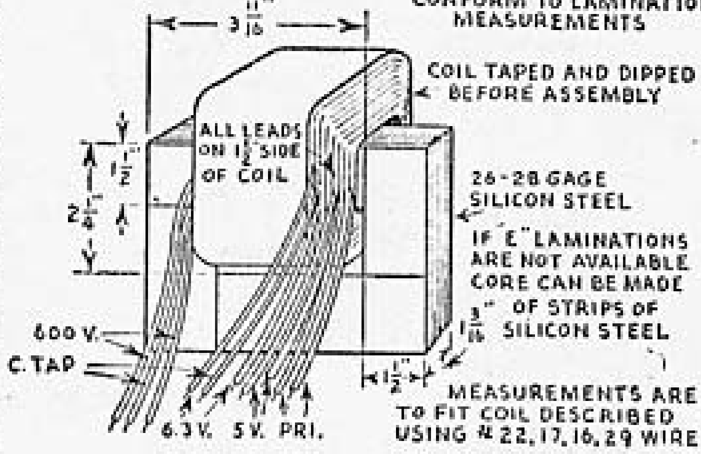
Before beginning building, you must estimate size of completed coil to see if it will fit in the lamination opening. The wire table lists No. 22 at 1070 turns per sq. in. Thus 400 ÷ 1070 = .37 sq. in.; No. 17 runs 372 turns per sq. in. and 18 ÷ 372 = .05 sq. in.; No. 16 is 306 turns per sq. in. and 22 ÷ 306 = .07 sq. in.; No. 29 lists at 3900 turns per sq. in. and 2200 ÷ 3900 = .56 sq. in. The total of this area is 1.05 sq. in. Measuring



MEASUREMENTS OF LAMINATIONS TO BE STACKED 1 3/16" HIGH (B)



HOW COIL FORM IS BUILT TO CONFORM TO LAMINATION MEASUREMENTS



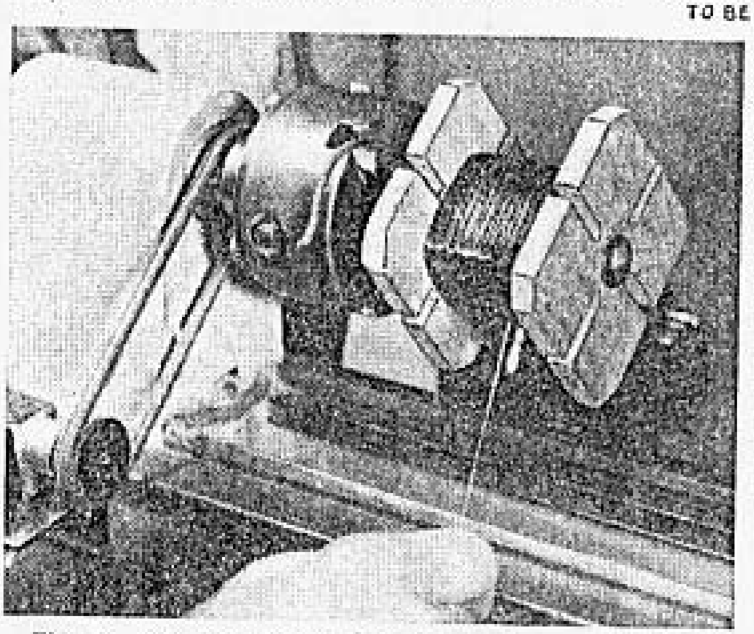


Fig. 3. Primary shown here is partly wound. Lay the turns as flatly and evenly as possible and keep reasonable tension on the wire during winding.

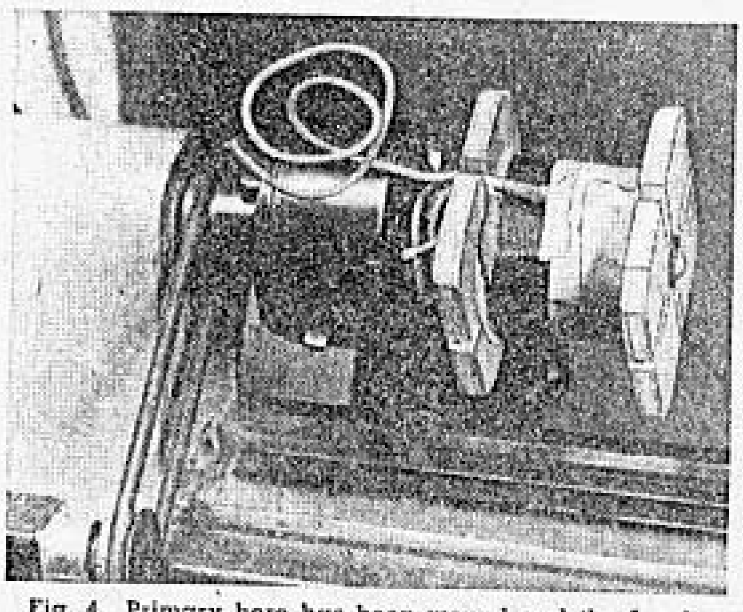


Fig. 4. Primary here has been wound and the 5 volt winding has been placed over two turns of Duro insulation. Note soldered, taped leads. Next step is 6.3 volt winding.

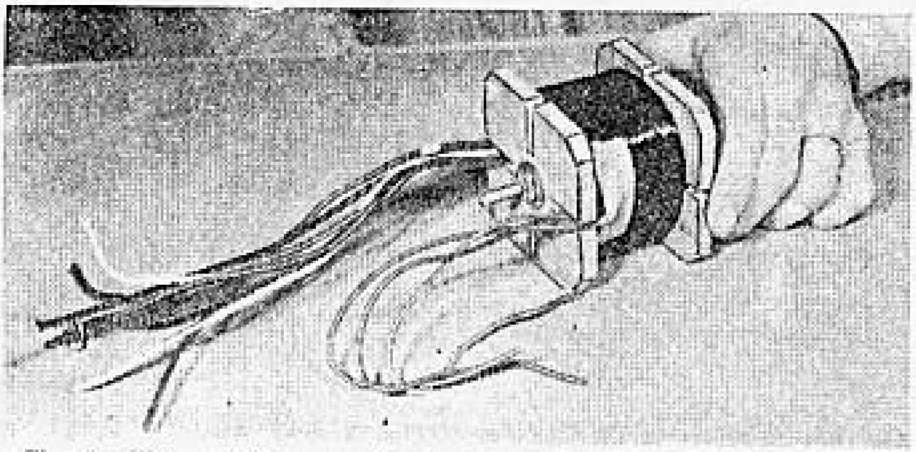


Fig. 5. With winding completed, the top form is removed from the lathe. Note carefully the positions of the leads. The 600 volt winding is the last to go on.

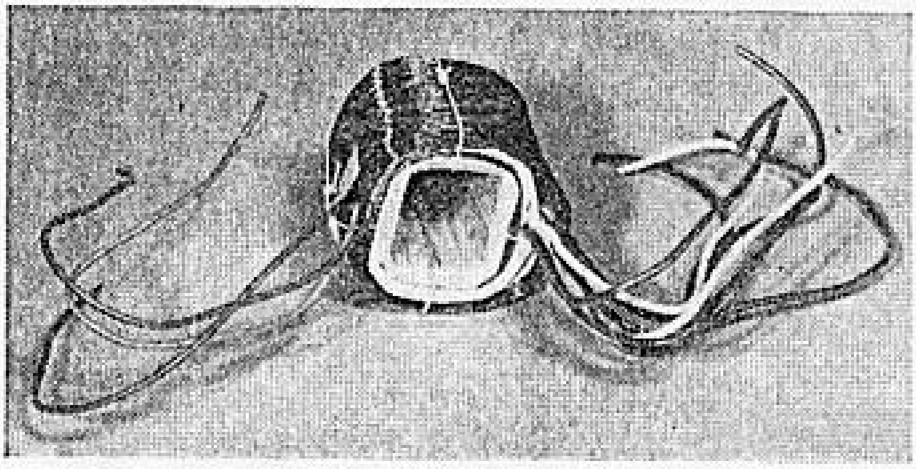


Fig. 6. After tying, the form is opened and the coil will look like this. Note how turned up edges of Duro insulation prevents the windings from contacting each other.

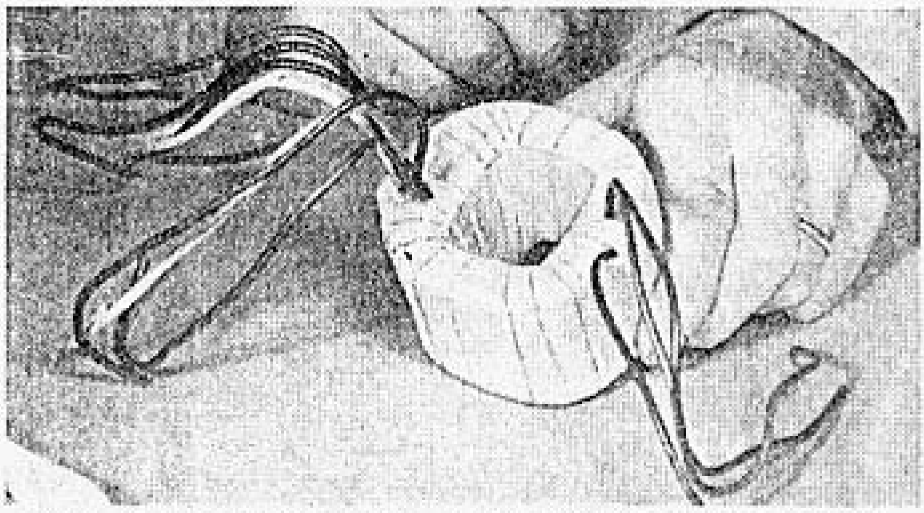


Fig. 7. Here's a well-taped coil. Cut and remove strings as they are reached in the taping operation.

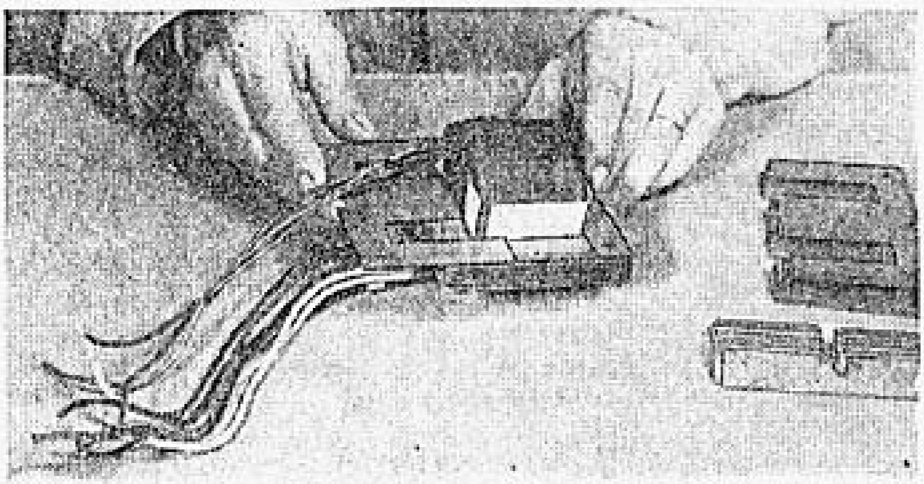


Fig. 8. Core is being built up within the coil by alternating the positions of the E and the straight pieces. Pieces of insulation protect winding against grounding.

the opening of the lamination, 11/16 x 2⅛ in., we get 1.46 s. in. Now the insulation and taping will take up probably about 20% more space so this is added to the 1.05 figure, making a 1.25 total. A coil of this size should fit in a space of 1.46 nicely if care is exercised in winding. In making these calculations, the minimum number of turns for the 5 volt and 6.3 volt windings are used. A turn or two added to cover the drop as suggested will not take up enough extra room to worry about. Figures given here were taken from a table for Enamel S. C. wire; Formex wire will take even less room.

The first step in the building is to make a wooden form for the coil as illustrated in the drawing and shown mounted in the lathe chuck (Fig. 2). Dimensions of this form will vary with laminations to be used, but the drawing shows how to figure correct measurements. The main consideration is that finished coil must be fitted over core leg without forcing it. Apply two turns of Duro or .010 thick armature paper over center block of form, allowing paper to come about ⅛ in. up the sides. Solder a piece of No. 18 flexible lead wire to the start of the No. 22 wire and wind on the primary in neat, even turns, avoiding overlapping and crossing the turns as much as possible. You don't need to layer wind it, but it will make a better job.

Solder and tape piece of lead wire to the finish end. Carry both these lead wires out a slot in the form at one of the 1⅝ in. sides, or in other words so that it represents the measurement of the width of the core center leg. Place all leads on this or the opposite 1⅝ in. side so as to prevent interference of the leads with the laminations later.

After completing the 400 turns primary, cover with two turns of the .010 Duro paper. Over this start the 18 or 19 turns of No. 17 five volt winding. Solder and tape flexible leads to start and finish as before and bring them out the same form slot. Next apply one turn of Duro paper over the last winding and wind on the 22 (or 23) turns of No. 16 for the 6.3 volts. Again solder leads to start and finish, as well as a third lead which is tapped at the center point (11th or 11.5 turn). Identify this lead with a band of tape or a different color.

Now wrap two turns of Duro over

winding after turns have been gently tapped down with a fiber hammer or block of wood to even them up. Put on the high voltage winding over this insulation, winding 2200 turns and tapping at the 1100th turn. Bring out three flexible leads in the form slot at the opposite side (see photos). When making taps or splices, do not use a knife to scrape off enamel as this might nick the wire. Use sand paper instead. Use rosin-core rather than acid core solder or paste flux. Fig. 3 shows winding of primary in progress and Fig. 4, the completion of the 5 volt winding. In Fig. 5, the 600 volt winding has been completed, binding strings passed through slots of form, and coil securely tied in shape. Now remove from the form carefully (Fig. 6). Note how ends of Duro insulation are carried up a bit to prevent adjacent windings from coming in contact. The next step is to tape the coil with white cotton taping (Fig. 7). Then dip taped coil in a good insulating varnish and bake it or hang it up over a hot stove for 4 hours to dry.

To assemble laminations and coil, alternate placement of E sections and straight pieces so that joints are covered by each succeeding layer. If core is to be made up with all cut pieces as shown as an alternate method in the drawing, these are also laid in alternate form in the usual transformer stacking. Figure 8 shows core partly in place. Note that pieces of insulating paper are used between the core and the coil at top, bottom, and sides; this eliminates the chances of winding grounding to core. After completion of stacking, pieces of 1/16 in. fiber are driven in as wedges between the center core leg and the coil, so as to tighten the center section, which prevents an unnecessary hum from loose laminations.

Before proceeding further, make a ground check. If a hypo transformer has been built from the plans given in a previous article, this is a good chance to try it. Apply 1100 volts between the core and the bared ends of all leads. The pilot lamp should not blink or go out. Otherwise, use at least a series lamp on 115 volts as a ground test. The finishing touches include making four side brackets, which with four bolts serve to clamp the laminations tightly and also allow mounting to the chassis. Use a low reading voltmeter on the two low voltage windings as a test (Fig. 1). In the example illustrated, 22 turns were put on for the 6.3 volts and 18 turns for the 5 volts, because the transformer is to be used on a small three-tube amplifier and the load will be light. The test showed 6.4 volts and 5.2 volts, which is satisfactory for this application. Without a voltmeter with a 600 volt scale it is not possible to test the other winding. But the exact voltage is not critical and from the turns figured, there is no doubt but you have at least 600 volts.

Improving Fleece Quality

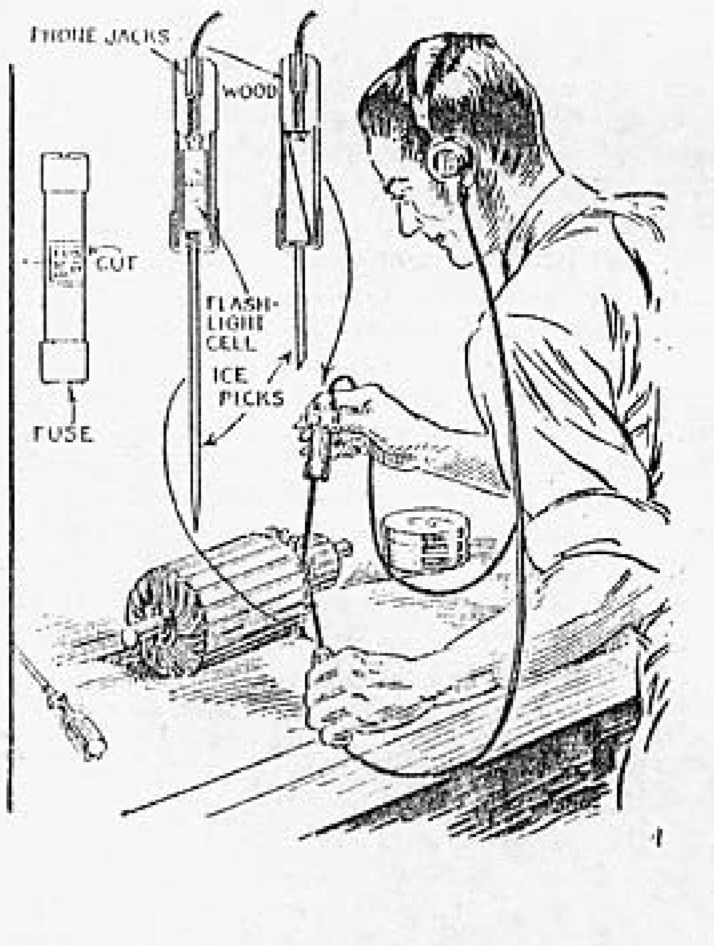
• Stockmen report that wool sheared with electric shears nets as much as 30 per cent more cash because of improved fleece quality.

POPULAR MECHANICS, 1941

Test Prods Have Self-Contained Current Supply

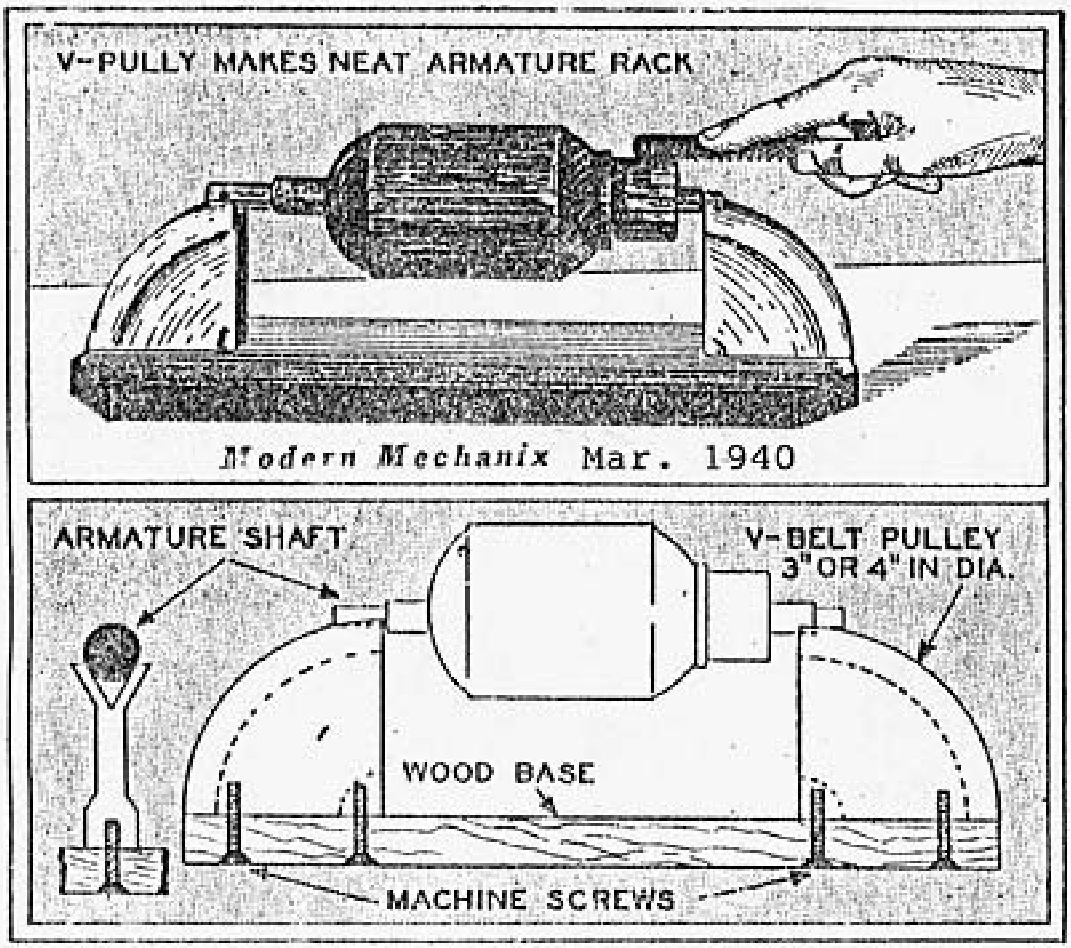
These test prods are unusual in that a flashlight cell is contained in one of them to supply the electric current when used in conjunction with a pair of headphones, thus dispensing with the usual connecting wires. The bodies of the prods are made from a 5-in. screw-cap fuse cut in half, and the points are made from ice picks. The wood handles in the open ends of the fuse halves are pieces of broomstick whittled down to size. Jacks in the handles of the prods permit quick attachment of the phones. As shown, one jack is connected to the dry cell, which is in turn connected to the prod point by means of a coil spring. The jack in the other prod is connected to the point by means of a metal strip.

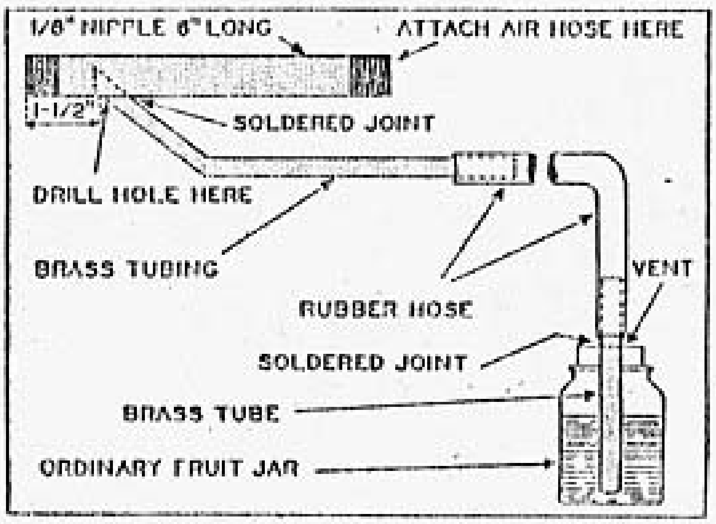
—Theodore Kropushek, St. Louis, Mo.



V Pulley Makes Armature Rack

AN ARMATURE rack that will dress up an electrical bench without destroying utility can be made easily from a wooden base and a discarded V belt pulley of 3 or 4-in. diameter. Saw the pulley into 4 equal sections and mount two of these on the base at the proper distance apart. When set on the base and enameled a contrasting color the resultant rack lends an extremely neat appearance to any test or repair bench.—*W. C. W.*



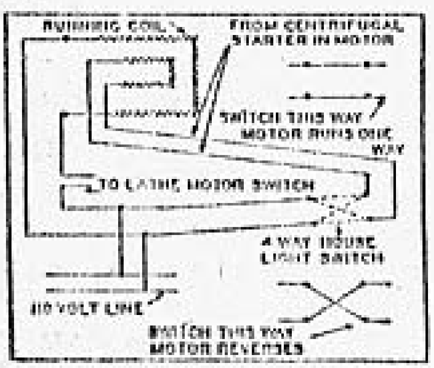


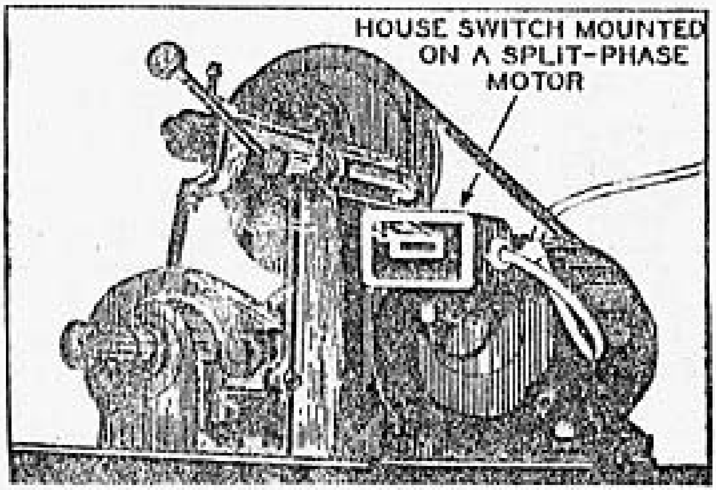
Homemade Spray Gun

THIS homemade spray gun can be used for spraying oil, solvents, paint or insecticides in a wide variety of uses. Use an ⅛-in. nipple about 6-in. long and drill a hole in it about 1½-in. from one end, the exact size of an ordinary brass tube. Saw one end of the tube at an angle of about 60° and insert it in the pipe, as shown. Attach a rubber hose to the brass tube and insert the end in the material you want to spray with. The longer end of the nipple is attached to the air hose.—*J. L.*

Making A Motor Reversible

ONE workshop fan wanted a reversible motor for his metal turning lathe. He was using a ⅓ h.p. split phase motor which he converted with the help of an ordinary four-way house switch. He inserted the switch in the line, then took two leads from the coil of the starting motor and ran them to the other two terminals of the switch. To reverse the motor he merely throws this switch the way he wants motor to run, then starts it with regular lathe switch.



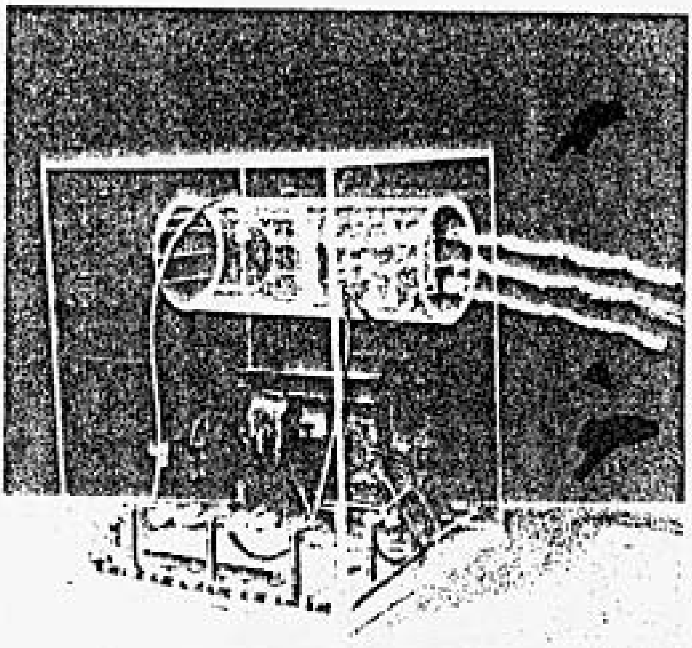


 GRANDDAD'S ELCTRICITY BOOK

ELECTRONICS

A Science Fair Project:

Build a Fan with No Moving Parts



OUR fan with no moving parts works on electrostatic principles (which we'll explain in a minute) and can make a dramatic project for a Science Fair or science class. But it is for demonstration only and not meant to cool a sweating brow. In fact, it even has some dangers (which we'll also explain in a minute).

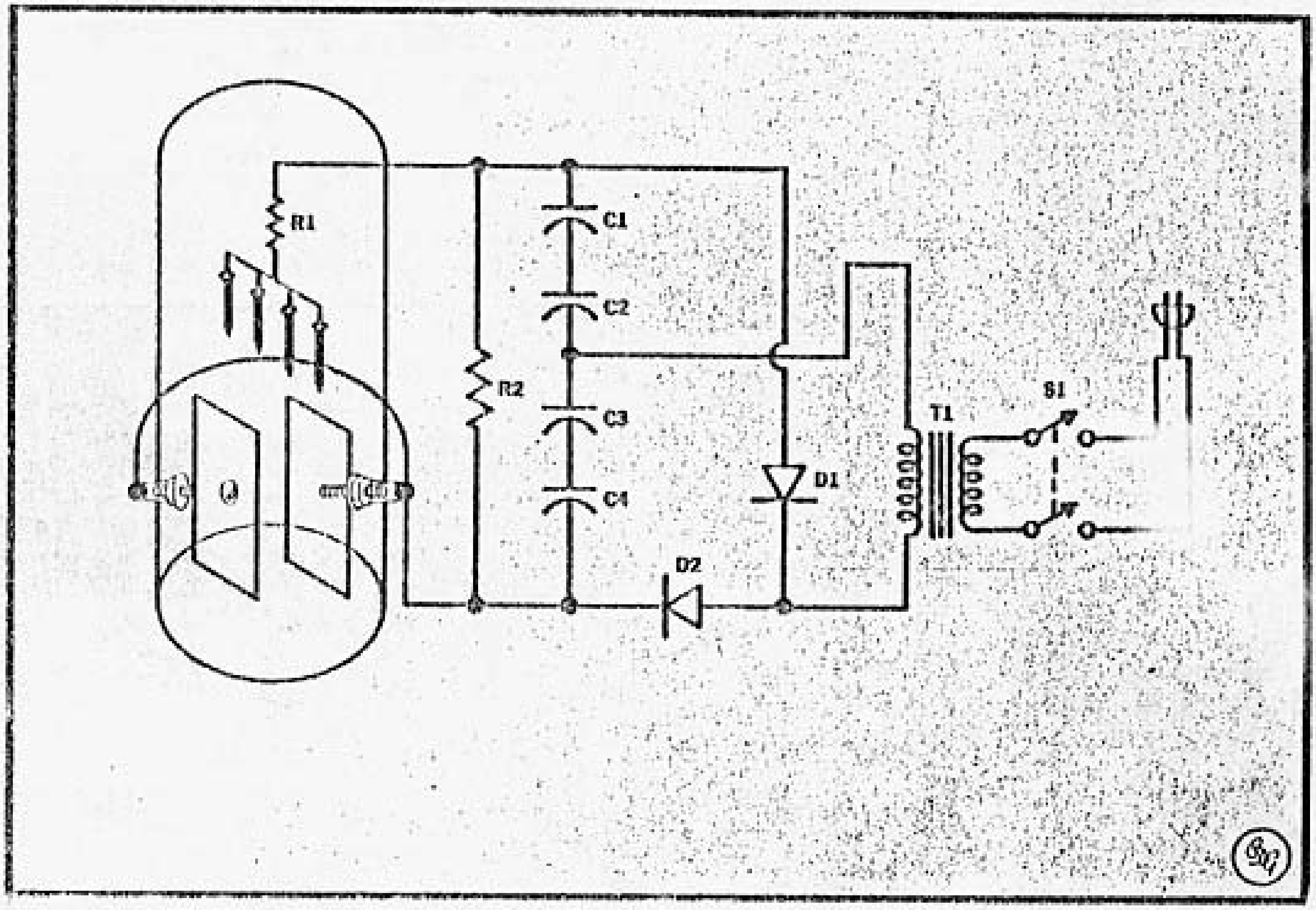
The term *electrostatics* has to do with electrical charges, which can be positive, negative or neutral. Our fan generates a current of air because positive or negative charges are forever trying to balance themselves by hooking up with charges of the opposite sign.

Ben Franklin experimented with electrostatics as early as 1780 but after the battery came along the subject went into decline. The phenomenon remained, to be sure, but nobody talked about it.

An electrostatic device that would move air is one of the oldest ideas in the field. Though not as efficient as a mechanical fan (our electrostatic rig is only 1 per cent efficient), it still can move 100 cu. ft. of air per minute.

The secret behind the electrostatic fan lies in the electric field between anode and cathode. A charge amounting to 14,000 volts is put on these plates (the

MECHANIX ILLUSTRATED, Jan. 1973



WIRE EXACTLY as shown. Lethal voltages are present when fan is plugged in.

anode is positive). The intensity of the field between the two is not necessarily uniform and tends to become especially intense if one plate has points (such as the points of nails we use for the cathode).

The electrostat'? charge around the cathode eventually rises high enough to cause electrons (negative charges) to stream off the nail points and head for the positive anode, which now has a tremendous attraction. Along the way, the electrons bump into atoms of oxygen, which normally have two electrons, and join up. The result is 0_3 (three atoms), or ozone. All this bumping gets the ozone and other atoms in the air to moving toward the anode so fast that the mass goes right on by the anode and shoots out as a stream of air (with ozone added). Ergo, one has a fan

The electrostatic fan is not difficult to build. But be aware of two dangers. The power supply generates 14,000 volts—more than enough to kill you. And ozone

PARTS LIST

C1-C4—0.0022 µf, 6,000 volt disc ceramic capacitor

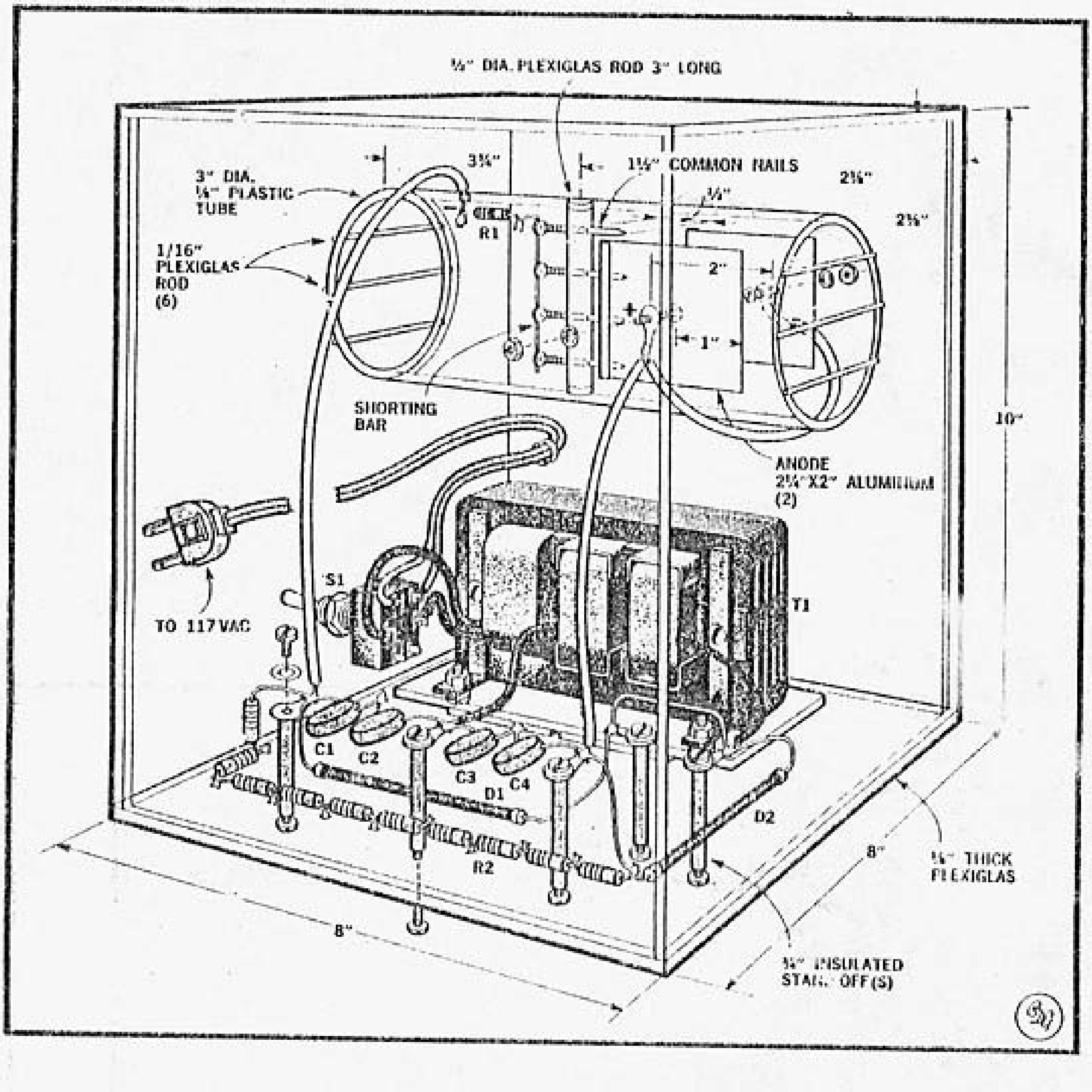
D1,D2—High voltage diode; 18,000 volts PIV @ 0.001 amps (see text)

R1—1,000,000 ohms, ½ watt carbon resistor

R2—220,000,000 ohms, 2 watt carbon resistor (see text)

S1—DPST toggle switch

T1—Power transformer; primary: 117 VAC, secondary: 5,000 VAC (see text)



is harmful. It should be breathed only in exceptionally small doses and for short periods. In other words, demonstration of your electrostatic machine should be of short duration.

Fan circuitry is housed in a ⅛-in.-thick Plexiglas box measuring 8x8x10 in. Follow our drawing exactly to prevent arc-over.

Mount filter capacitors and rectifiers on ¾-in. insulated stand-offs. Use GC Electronics' part No. 6778C or equivalent. Screw the power transformer to a separate Plexiglas plate cemented to the bottom of the box. All hookup wire should be able to withstand voltages greater than 20 kilovolts. We used Belden type 8866.

House the fan assembly, a set of cathodes and anodes, in a 3-in.-dia. plastic tube. Fit this assembly into the matching holes in the box.

Space the anodes, consisting of two rectangular pieces of aluminum measuring 2¼ in. long by 2 in. high, 2 in. apart and parallel to each other inside the tube. Bend the ends closest to the cathodes over so no sharp edges face the cathodes. Screw the anodes to the sides of the tube and solder a jumper across them. Connect to the positive side of the power supply.

The cathode consists of four 1½-in. common nails inserted in a 3 x ½-in.-dia. piece of Plexiglas rod. Space the nails ¾ in. apart in the rod and push through the rod halfway. Solder a shorting bar across the nail heads. Then solder one lead of R1 to the shorting bar.

The transformer (T1) is available from Electret Corp., 159 West End Ave., New York, N.Y. 10023 for $17.50. The diodes are GC Electronics No. 16-506. Component R2 is a string of ten 22-megohm, 2-watt carbon resistors soldered together. This resistance discharges capacitors C1-C4 when power is removed.

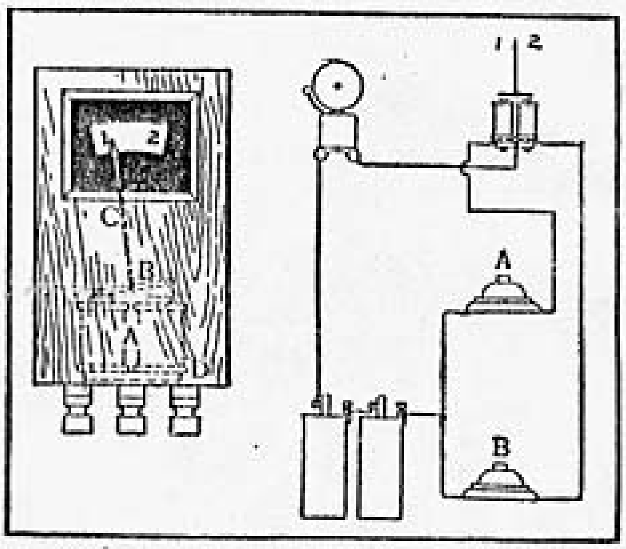
The negative side of the power supply is connected to the nails through resistor R1. This resistor protects the power supply in case the air between the anode and cathode assembly breaks down and energy arcs from one assembly to the other.—*Herb Cohen*

POPULAR MECHANICS, 1913

Homemade Annunciator

When one electric bell is operated from two push-buttons it is impossible to tell which of the two push-buttons is being operated unless an annunciator or similar device is used. A very simple annunciator for indicating two numbers can be made from a small box, Fig. 1, with an electric-bell magnet, A, fastened in the bottom. The armature, B, is pivoted in the center by means of a small piece of wire and has an indicator or hand, C, which moves to either right or left, depending on which half of the magnet is magnetized. If the back armature, D, of the magnet is removed the moving armature will work better, as this will prevent the magnetism from acting on both ends of the armature.

The wiring diagram, Fig. 2, shows how the connections are to be made. If the push-button A is closed, the bell will ring and the pointer will point at



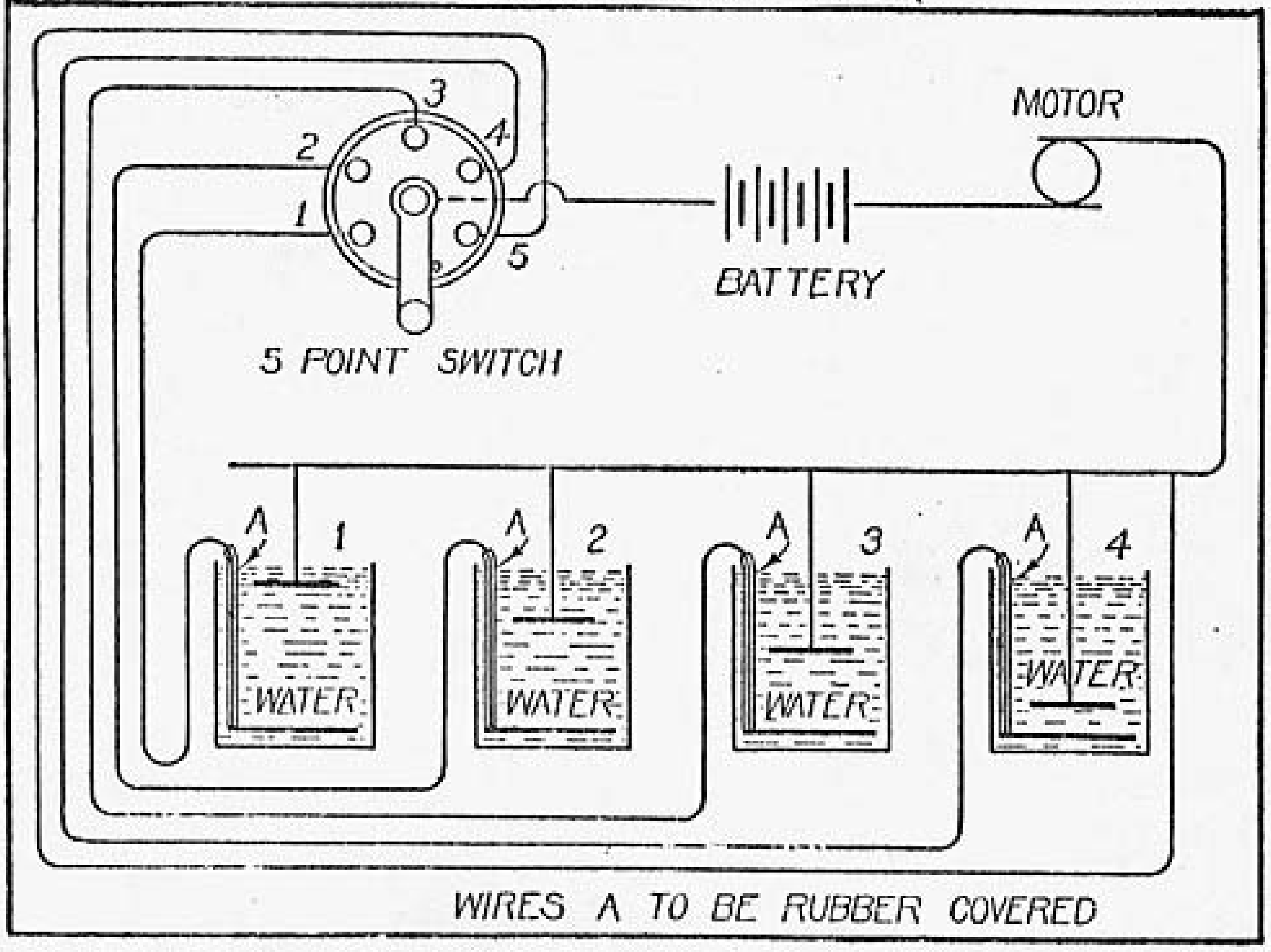
Annunciator and Wiring Diagram

1, while the closing of the push-button B will ring the bell and move the pointer to 2.—Contributed by H. S. Bott, Beverly, N. J.

¶ When drilling spring steel with a regular carbon steel drill, place a piece of flat iron under the work, instead of the usual wood block, and you will be less likely to break the drill.

How to Make a Simple Water Rheostat

POPULAR MECHANICS, 1913



Wiring Plan for Water Rheostat

The materials necessary are: One 5-point wood-base switch, 4 jars, some sheet copper or brass for plates, about 5 ft. of rubber-covered wire, and some No. 18 gauge wire for the wiring.

The size of the jars depends on the voltage. If you are going to use a current of low tension, as from batteries, the jars need not be very large, but if you intend to use the electric-light current of 110 voltage it will be necessary to use large jars or wooden boxes made watertight, which will hold about 6 or 7 gal. Each jar to be filled with 20 parts water to 1 part sulphuric acid. Jars are set in a row in some convenient place out of the way.

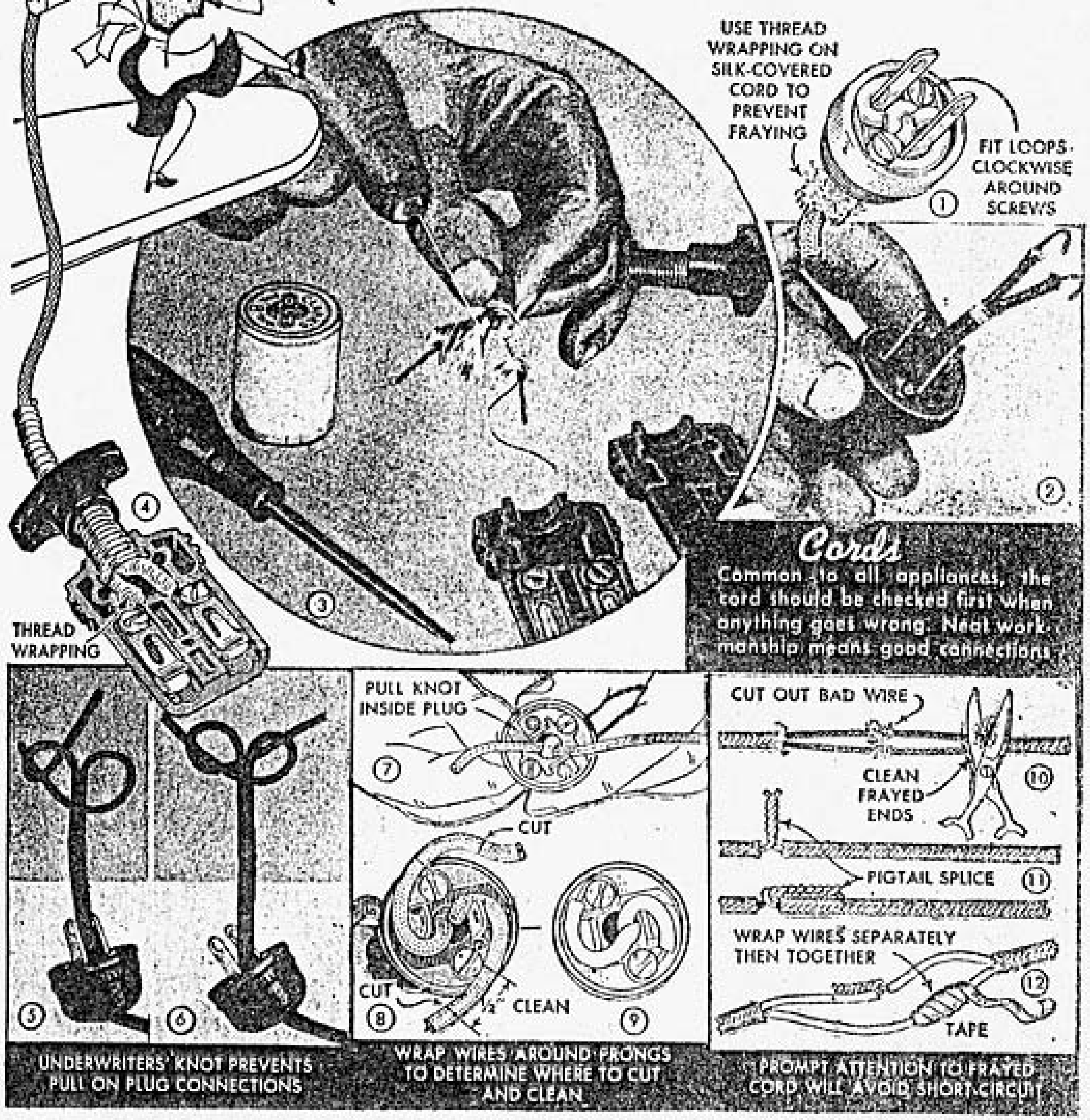
Next cut out eight copper or brass disks, two for each jar. Their size also depends on the voltage. The disks that are placed in the lower part of the jars are connected with a rubber-covered wire extending a little above the top of the jar.

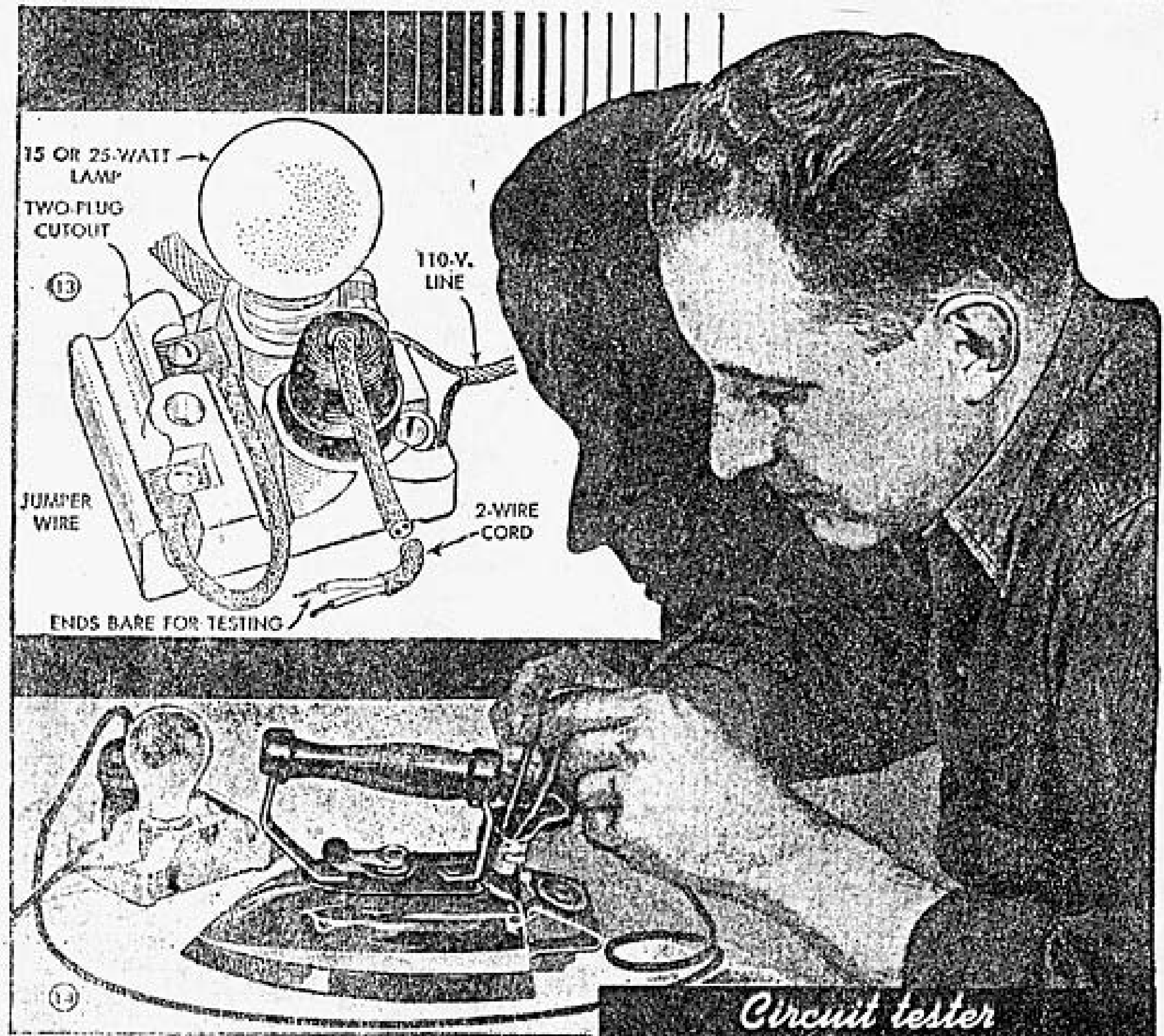
To wire the apparatus, refer to the sketch and you will see that jar No. 1 is connected to point No. 1 on switch; No. 2, on No. 2, and so on until all is complete and we have one remaining point on switch. Above the jars place a wire to suspend the other or top disks in the solution. This wire is also connected to one terminal on the motor and to remaining point on switch. The arm of the switch is connected to one terminal of battery, or source of current, and the other terminal connected direct to remaining terminal of motor.

Put arm of switch on point No. 1 and lower one of the top disks in jar No. 1 and make contact with wire above jars. The current then will flow through the motor. The speed for each point can be determined by lowering top disks in jars. The top disk in jar No. 2 is lower down than in No. 1 and so on for No. 3 and No. 4. The connection between point No. 5 on switch, direct to wire across jars, gives full current and full speed.

ELECTRIC IRON REPAIR

Cords and plugs: Cords and plugs are basic and apply to all electrical equipment. Most persons know how to make necessary repairs, but the few ideas pictured on this page may serve as a "refresher" course. Silk-cov-

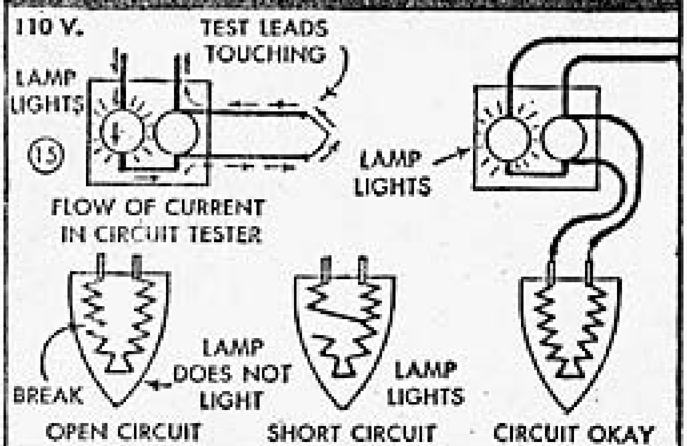


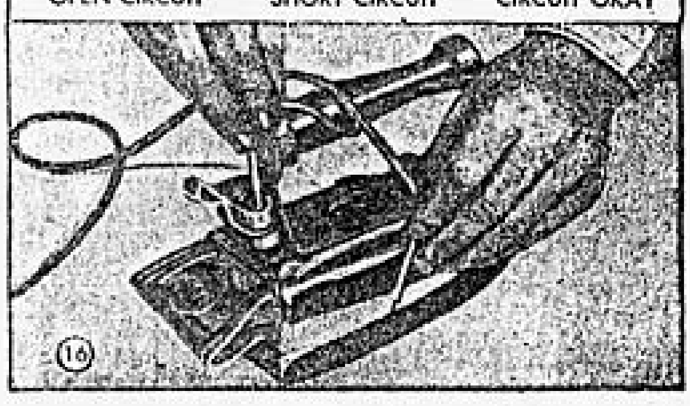


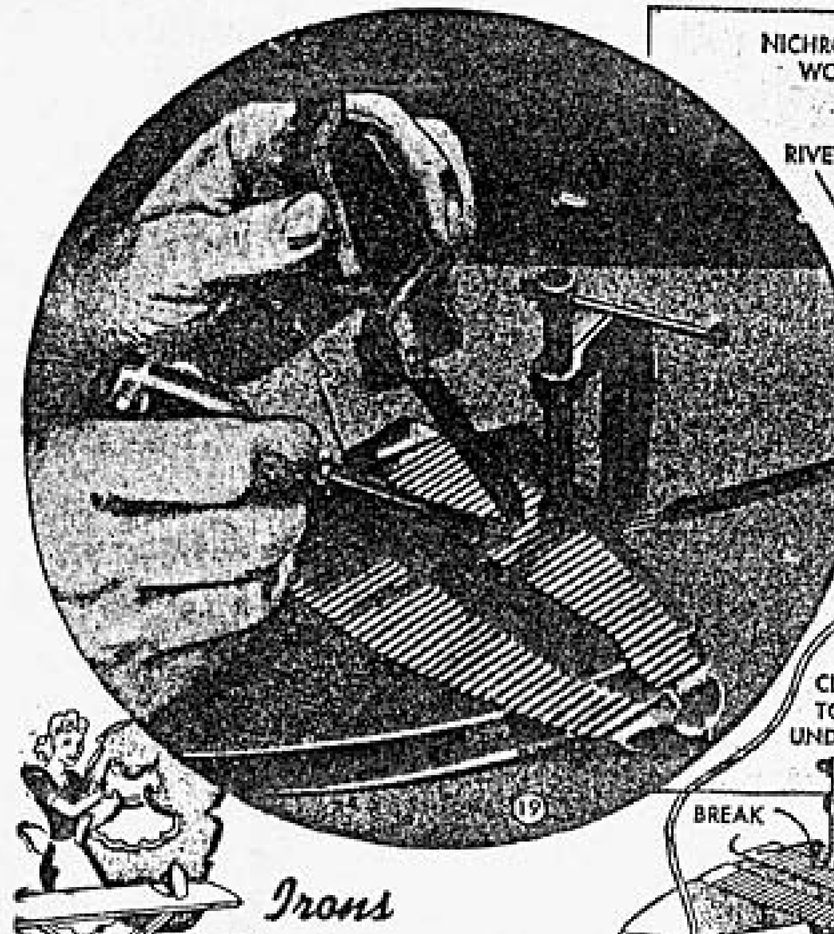
ered cords and asbestos-insulated cords should always be wrapped with thread when making plug connections to prevent fraying, as shown in Figs. 1, 2 and 3. The insulation should be intact right up to the point of contact, Fig. 4. The underwriter's knot for plugs as shown in Figs. 5 and 6 takes the strain of pulling on the cord and prevents strain on the connections. It is especially good with the popular parallel-wire rubber cord. Steps in making plug connections after tying the knot are shown in Figs. 7 and 8. The best practice is to leave the wire long and the insulation intact until actual fitting. Fig. 8 shows where to cut and clean. Fig. 9 shows a plug properly connected—the wire is pulled around the prongs and fitted clockwise under the screw heads. A frayed weak spot in a cord should be spliced promptly instead of waiting until the wire or fuse burns out due to a short circuit. The common splice joint is best made with pigtail splices, as shown in Figs. 10, 11 and 12. Each joint is wrapped separately with friction tape; then the two wires are wrapped together.

Circuit tester

Best method of checking circuits in any appliance is to use the simple circuit tester shown—costs little and is useful on dozens of jobs

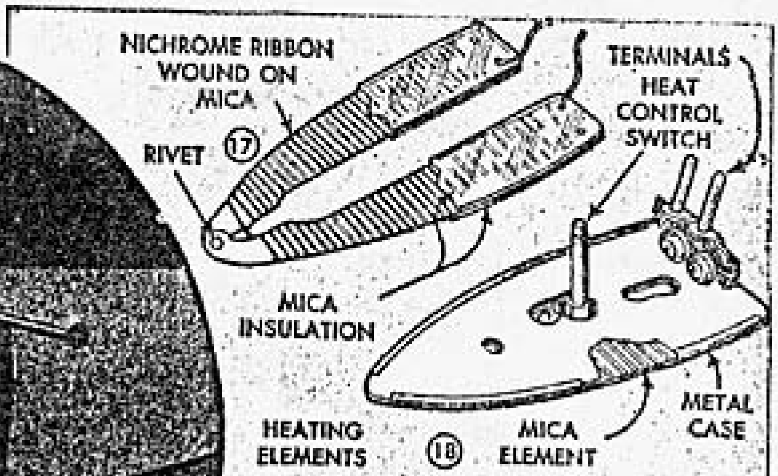


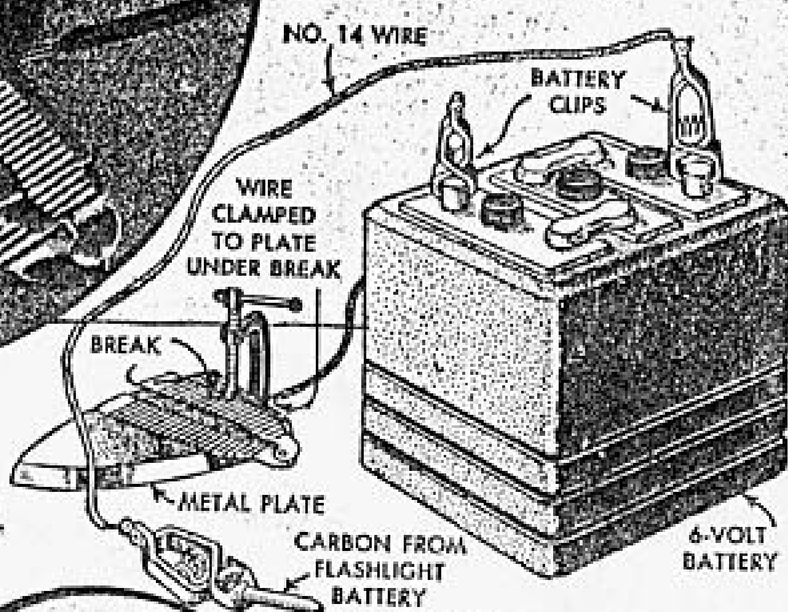




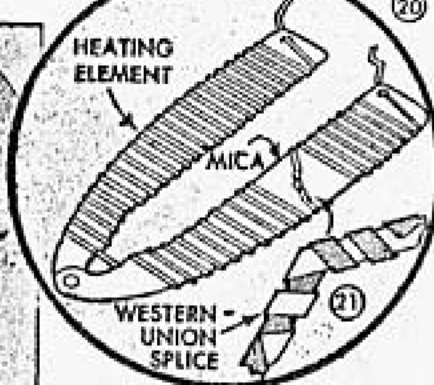
Irons

Usual fault is break in heating element, which can be repaired by splicing or arc-welding the severed ends

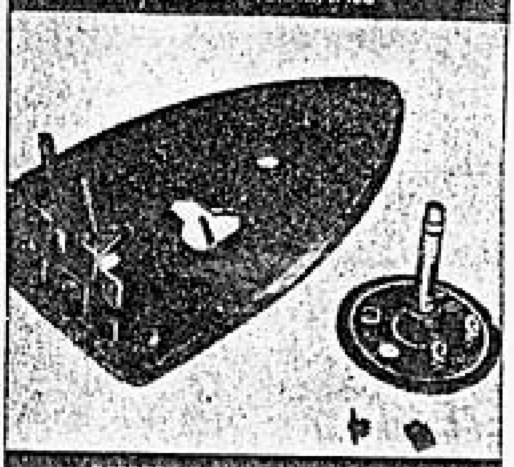




(20) SET-UP FOR ARC WELDING BROKEN WIRE



(22) LAMP SHOULD LIGHT WHEN TEST LEADS ARE TOUCHED TO SWITCH TERMINALS



(23) DEFECTIVE SWITCH CAN BE DISCARDED. ELEMENT WILL WORK WHEN WIRES ARE SPLICED

Circuit tester: While breaks in an electrical circuit usually can be traced visually, it is quicker and better to use a circuit tester. This is made up as shown in Fig. 13 and costs less than fifty cents. How it works is shown in Fig. 15—if you touch the two test leads together you make a complete circuit, causing the lamp to light. Likewise if you apply the test leads to any circuit, such as a flatiron, as shown in Figs. 14 and 15, the lamp will light if the circuit in the iron is not broken. Also, it should be noted that the lamp will light if a short circuit exists, Fig. 15, but positively cannot light when the circuit is broken. The current passed by the bare wires of the circuit tester is limited to the size of the bulb used, and is not sufficient to actually heat the iron, run a motor, or do anything else which the straight 110-volt line would do. This doesn't mean that you shouldn't be careful—play safe and treat the two test leads as "hot."

Checking electric iron: Using the circuit tester, apply the leads to the prong terminals, as shown in Fig. 14. If the heating element is all right, the lamp will light. Apply one lead to the prong terminal and the other to the sole plate, Fig. 16. The lamp should not light. If it does the circuit is grounded, that is, some part of the wiring is bare of insulation and touching the sole plate or cover. No light across the terminals shows that the circuit is broken. In this case, remove the handle, cover, and any other parts necessary to expose the heating element. The most common type of heating element is ribbon Nichrome wire wrapped on mica and insulated on either side with mica, as shown in Fig. 17. Better grade elements are covered with a metal case, Fig. 18, and it is necessary to pry off the case. Still other elements are built right into the sole plate in a solid mold; this type is not repairable except by obtaining a new replacement part.

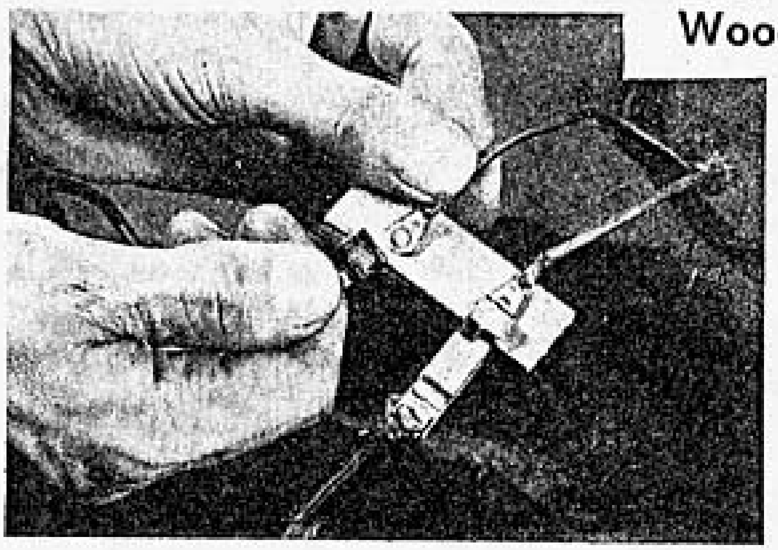
Patching Nichrome wire: A break in the Nichrome ribbon or wire can be patched by twisting the two ends together, as shown in Fig. 21. A better method is to fuse the broken ends together with a small makeshift arc-welding outfit, as in Figs. 19 and 20. In use, the pointed carbon should be touched to the break delicately and only for an instant. You will get a flash of white hot wire and the two ends will fuse together. Prolonged contact generates too much heat and burns the wire completely. No flux is needed although borax can be used if desired. Sometimes the break is within a few turns of the post terminals, and in this case it is practical simply to unwind the broken section and make a new connection.

Electric-iron switch: If the iron has a heat-control switch, test it across the terminals, as shown in Fig. 22, to determine if the fault is in the heating element or the switch. If the switch is defective and a replacement not available, the iron can be made usable by twisting or welding the two ends together, as indicated in Fig. 23. There is little that can be done with a defective switch; make certain, however, that the thermostatic disk is not jammed open (saucer shape). Try mild pressure with your fingers in manipulating the disk—it should have a curved bell shape when the iron is cold.

Other heater-type appliances: Apply the same general tests as described. Always check the cord first (use test lamp and run current through both wires separately), and then proceed systematically until the fault is discovered. Some appliances, such as inexpensive toasters, can be checked visually since the heating element is in full view. Breaks in round Nichrome wire can be spliced much the same as described for ribbon wire. In all cases, press the splice flat and make it as tight as possible—any slight amount of arcing from a loose joint will immediately burn the wire.

POPULAR SCIENCE *JANUARY, 1944*

Wood Strip Prevents Short Circuits



SHORT circuits sometimes do much damage to costly apparatus when a test cord attached to spring clips is used to connect electrical equipment. Such mishaps can be effectively guarded against by clipping the equipment leads upon a thin piece of wood, or other non-conductor, as in the photograph. This will keep the clips from accidentally swinging against each other and thus causing a short circuit which might do irreparable damage to the electrical equipment. Little time and effort are required for this simple precaution.—W. E. B.

Lubricating an Electric Clock

An excessively noisy electric-clock motor usually indicates a lack of oil, which can be applied to most motors without opening the case. To do this turn the motor so that the exposed pinion is at the top and, while warming it with the heat of a 60-watt bulb, apply a few drops of light household oil to the pinion. During the operation small bubbles will appear. As soon as the bubbling ceases remove the heat but continue to apply oil that will be drawn in around the pinion as the motor cools.

ELECTRICITY

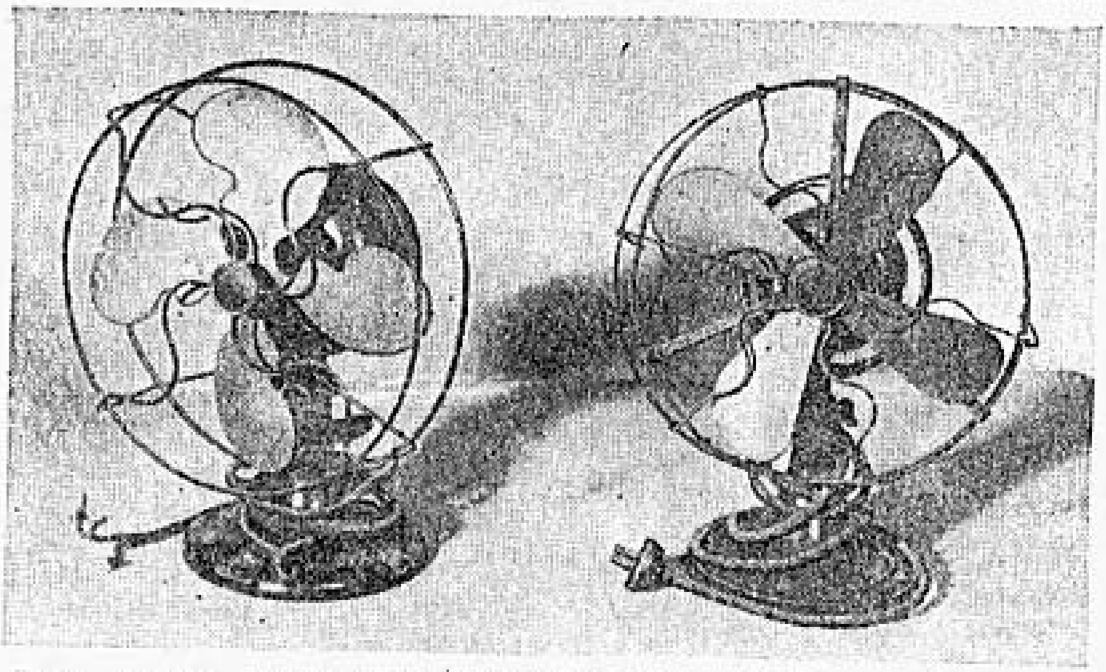


Fig. 1. Two 8-inch fans, one stationary and the other oscillating, are about to be overhauled. Put away without covering, they are dusty and dirty.

SCIENCE AND MECHANICS April-may 1948

Servicing Household ELECTRIC FANS

Get set for the hot summer days by overhauling your fans now. Here's how it's done

By HAROLD P. STRAND

WITH the coming of warm weather, thoughts naturally turn to cooling aids, such as the electric fan. This useful appliance, however, is often neglected and abused, but is expected to be ready to run on a moment's notice. Two examples of neglect are shown in Fig. 1, which illustrates two old-model fans which were photographed just as they were taken down from a top shelf in the storage closet. Dust and dirt has settled on them during their stay over the winter months and no doubt it has found its way into the motors where it mixes with oily deposits to cause overheating, wear in the bearings and generally poor efficiency. It would be a mistake to put fans in such condition into service, without first giving them an overhauling.

Proper care for all fans would eliminate such a condition. Motors should be blown out in the Fall when through using them. Air pressure, hand bellows or the pressure outlet of a vacuum cleaner, can be used for this purpose. This removes all dust and dirt drawn in during use. Then wipe the surface off and apply a protective covering, tied at the bottom, as illustrated in Fig. 2. Fans put away

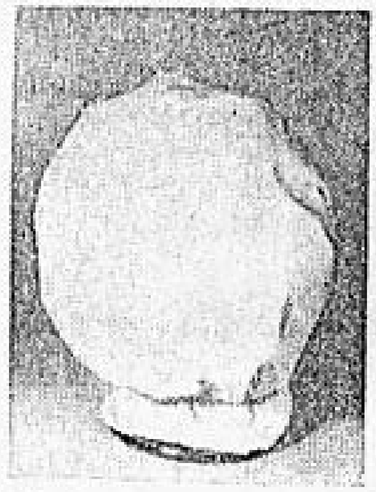


Fig. 2. The proper way to store fans is to cover them with a protective covering, tied at the bottom like the one shown above.

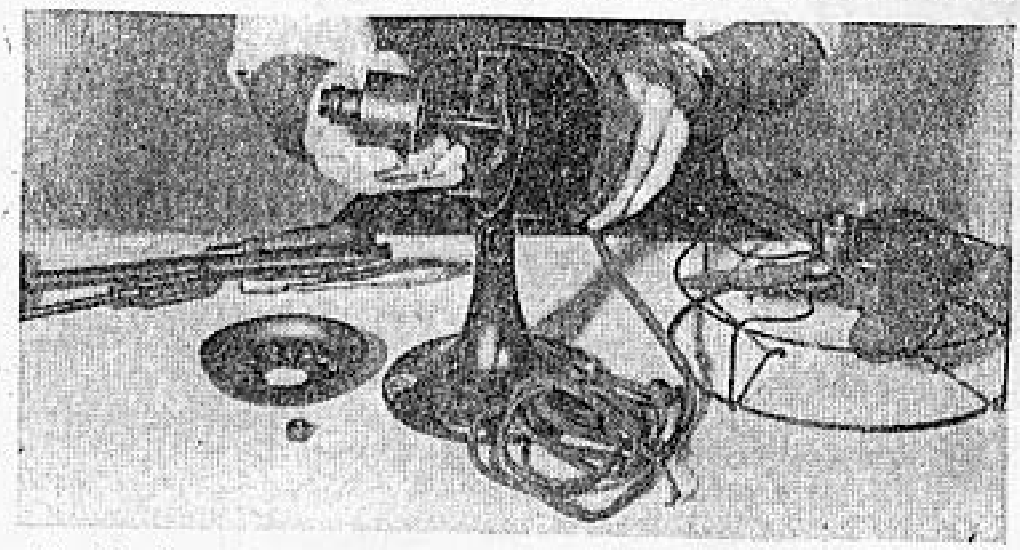


Fig. 3. Here the fan is being taken apart for cleaning and inspection. The rotor turns on a hollow fixed shaft.

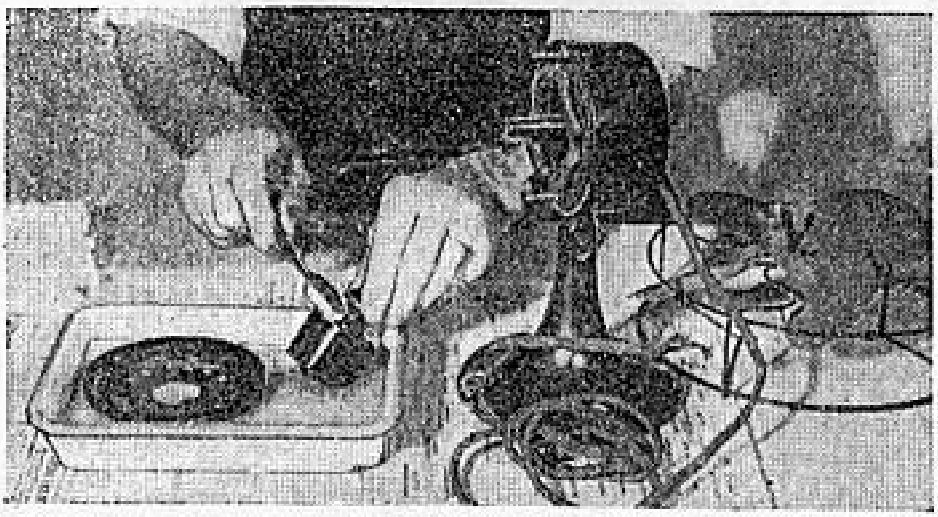


Fig. 4. All removed parts are thoroughly cleaned, using either carbon tetrachloride or kerosene.

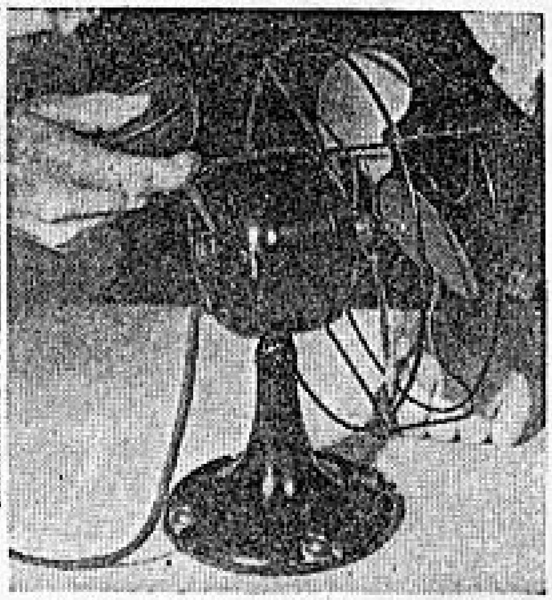
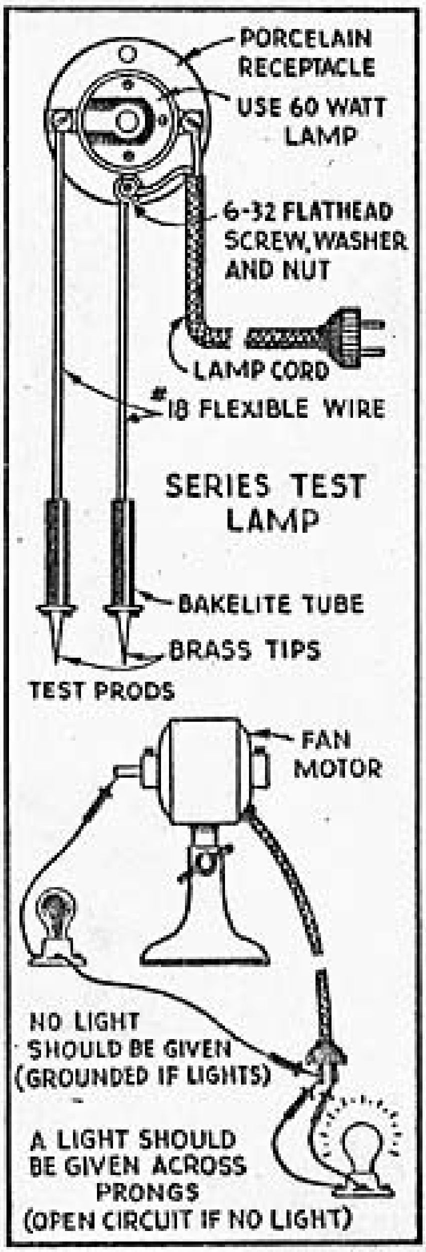


Fig. 5. The fan has been reassembled and some oil is being applied to the oil cup, prior to starting the fan.

in this manner will keep clean indefinitely and when the time comes to use them, all that is usually necessary is to apply some fresh lubricant to the bearings and gear box (if one exists), wipe them off, and start them up.

The fans illustrated in Fig. 1 are both 8-inch models; one is fixed for direction while the other oscillates. Let us start first with the stationary one and see how it looks inside. Remove the guard first by loosening the retaining nuts. Then remove the four-bladed fan unit. With most fans this is done by loosening a set screw on the hub, but in the fan illustrated, rather novel construction has been employed. The motor has a fixed, hollow shaft on which the rotor turns and the fan unit screws on an extended hub of the rotor, so it will turn with the rotor. To disassemble such a fan, the motor end cap is removed as far as possible to allow a pair of gas pliers or other suitable tool to be passed so that it can grip the hub of the rotor. The fan unit can then be unscrewed; you may find this a *left hand* thread. The end cap can then be entirely removed and after unscrewing a special locking nut on the end of the shaft, the rotor can be slipped off as in Fig. 3. Take care to note the number of and location of the washers on each end of the rotor and replace them exectly as they were. They serve the double purpose of lining up the rotor iron properly with the stator iron and they will also take up excessive end play.

With other types of fans, it may be merely necessary to remove the motor screws found at



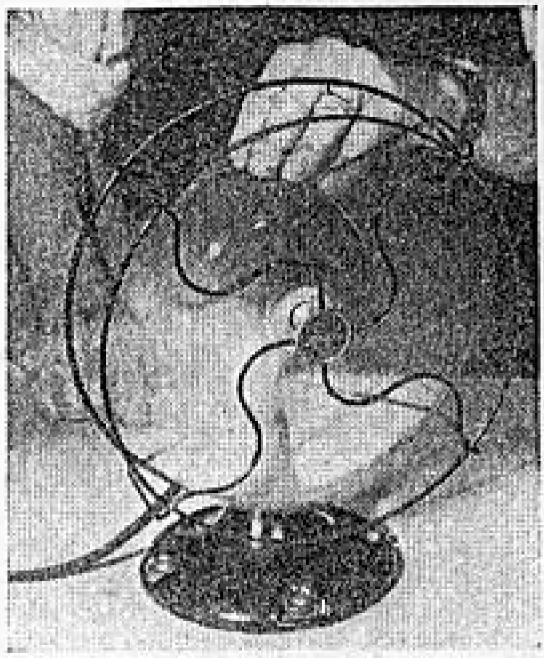


Fig. 6. Testing the fan for unbalance by placing a hand on the motor.

the end caps and after tapping the caps off, the rotor can be withdrawn. Sometimes, however, only one end cap is removable. When doing any of this work, use a plastic or fibre hammer. Do not use a metal hammer on the parts. Secure a shallow tray with some carbon tetrachloride or kerosene and an old tooth brush. Place the removed parts in this bath and clean them well (Fig. 4). Then dry them with a clean cloth. The stator can be cleaned with a dry brush, together with a cloth dampened in carbon tet. Check oil passages to bearing surfaces and see that they are clear. The cleaned parts are then examined for wear and the rotor is tested on its shaft for looseness. Other fans using conventional design should have the shaft tested in its bushings for the same reason. Wear over about 2 or 3 thousandths will cause noisy operation and in cases of excessive bearing looseness, new bushings should be installed. These can either be ob-

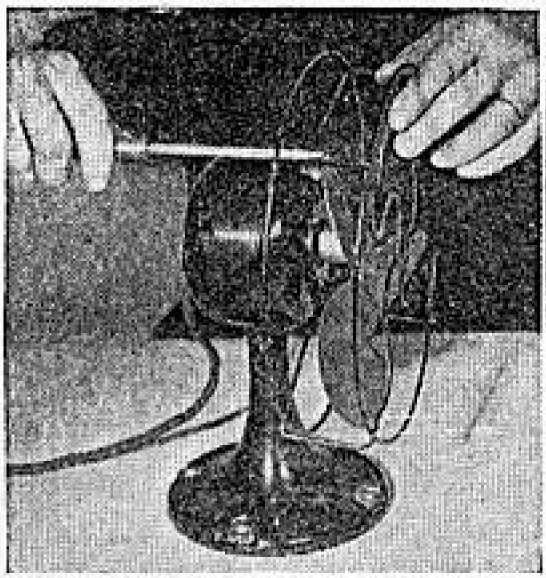


Fig. 7. Checking and correcting the alignment of the fan blades may help to cut down vibration.

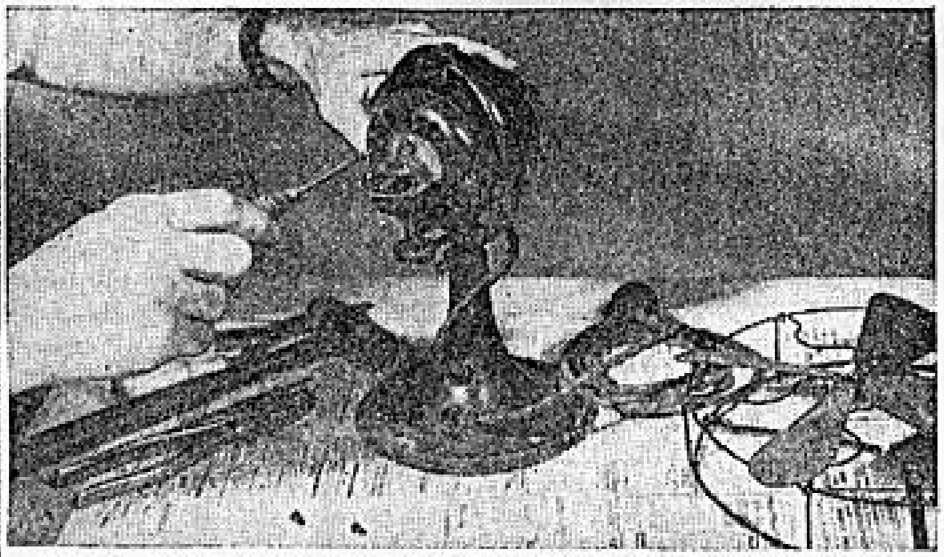


Fig. 9. After removing the guard and fan unit, disconnecting the operating lever at the bottom of the motor, and dropping the jack shaft in the gear box down, the motor can be opened up and the rotor removed.

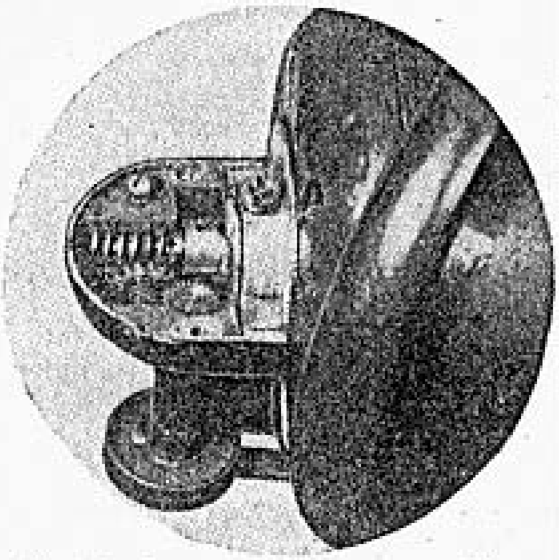


Fig. 8. On removing the cover of the gear box on the oscillating fan we discovered that the gears had been running dry.

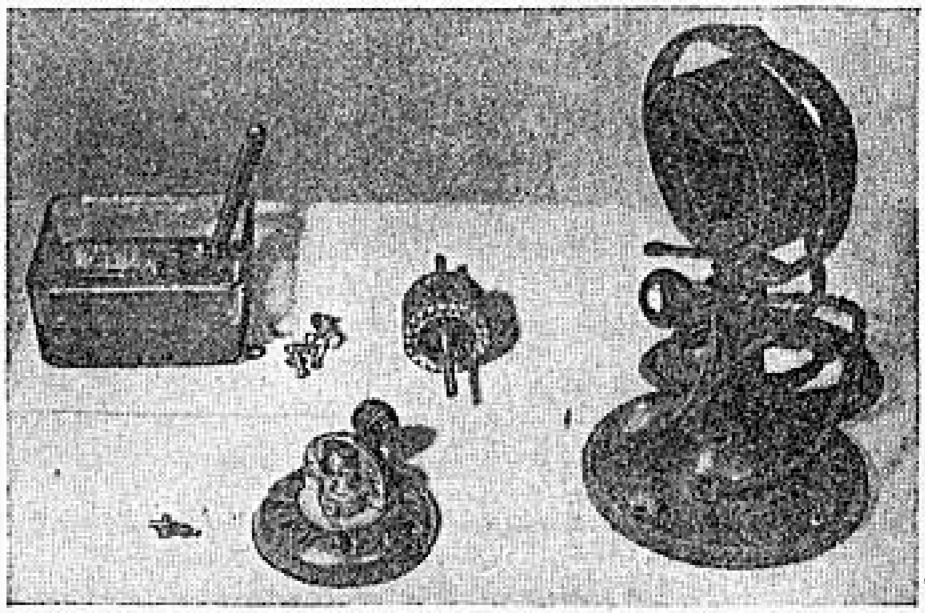


Fig. 10. After a thorough cleaning, the parts are laid out on the bench for inspection.

tained from the manufacturer or made in the lathe. After pressing in new bushings, use a hand reamer to get a perfect fit for the shaft.

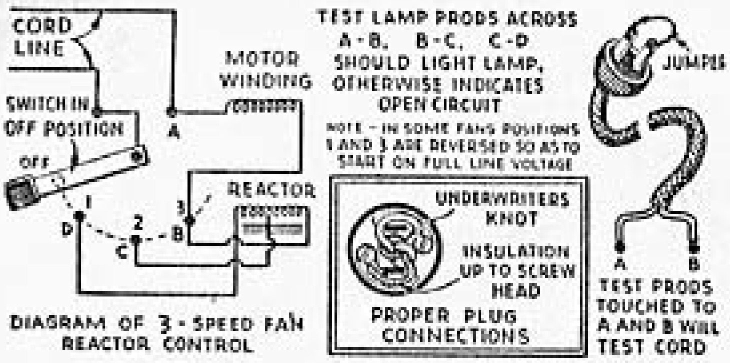
The windings should receive a simple test at this time. Using a series test lamp, equipped with a pair of test prods (Feb.-Mar. '48 S. & M.), test for a ground to frame and also for open circuit. The drawing gives details of this job. Also examine the line cord for damaged insulation and check the plug, replacing them if questionable. A grounded motor should be rewound, unless the damaged place in the insulation can be found and fixed. If an open circuit is indicated, check the cord carefully. If the splices where the cord joins the winding can be reached easily, open these joints so the cord and winding can be tested separately. An open winding usually means a rewind job.

With the fan illustrated, everything tested O.K., removal of dirt and old oil mixture being the most important factor in this case. After wiping the fan blades clean, as well as the guard, it was ready for assembly. A few drops of oil placed on the shaft before inserting the rotor will assure lubrication at the start. In Fig. 5, the fan has been put together and a little oil is being added to the one oil cup provided. With many other fans, a second oil cup will be found at the other end of the motor. Grease lubricated fans usually have a grease cup at each end which require filling.

After starting the fan (as in Fig. 6) a test is made for unbalance by placing a hand on top of the motor. It should run smoothly and quietly with very little vibration. Unbalance is generally caused by the fan blades being out of line. To check for this, hold a screwdriver tightly against the guard, as in Fig. 7, with the end just touching the edge of a blade. Pull the other blades around in turn and if they do not touch the tool as the first one did, bend them until all are the same. If the guard has become bent in use, it can be straightened with a pair of pliers, adjusting it to clear the blades.

The second fan, which is of the oscillating type, involves further thought in overhauling. The cover of the gear box is first removed (Fig. 8) and the first thing noted is that the gears have been running practically dry, while they should have been well supplied with grease.

It will also be seen that a worm is cut on the end of the motor shaft, which engages a gear on a short jack shaft. This shaft has a worm on the other end, which runs with a gear on a vertical shaft. A disc attached to the lower end of the latter rotates at a very slow speed, and by means of a short lever attached to the disc with a screw and, at the other end, to the motor, the latter is caused to rotate back and forth. This principle is employed in most oscillating fans. In some models, a vertical shaft with a knob on top is built into the gear mechanism with a sort of clutch. This allows the fan to be used either as a stationary or oscillating model. Failure to oscillate is usually caused by the stripping of worm or gear teeth and most frequently this occurs in the short shaft piece. A new part is the only remedy in such a case. It might also be



caused by wear in the clutch end of the control shaft, if this type of mechanism is involved.

The next step is to remove the guard and fan unit, and also disconnect the lever from the driving disc. Then loosen the motor clamping screws in the end cap, but before the rotor can be withdrawn, it is usually necessary to drop the short shaft in the gear box down, so its gear is out of mesh with worm on the rotor shaft. Loosening a set screw and pulling out a sleeve will allow this to be done. The end cap can then be tapped off and the rotor removed. Figure 9 shows the removal of the motor screws. The removed parts are cleaned well, as was done with the first fan. In Fig. 10, the parts have been laid out for inspection. Carefully examine

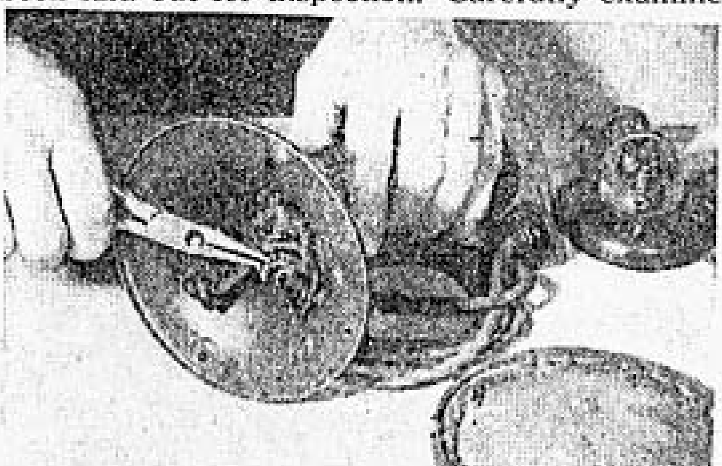


Fig. 11. Adjusting the switch contacts in the base in order to obtain better contact.

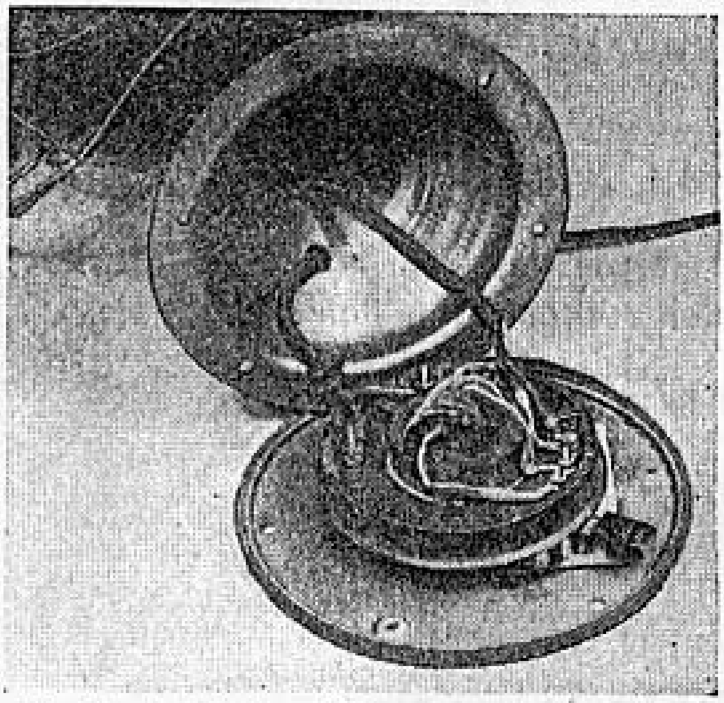


Fig. 12. A 12-inch oscillating fan with three speed control, with the base opened for inspection of the reactor.

each part for wear, checking among other things the fit of the motor shaft in its sleeve bearings, and the condition of the gears.

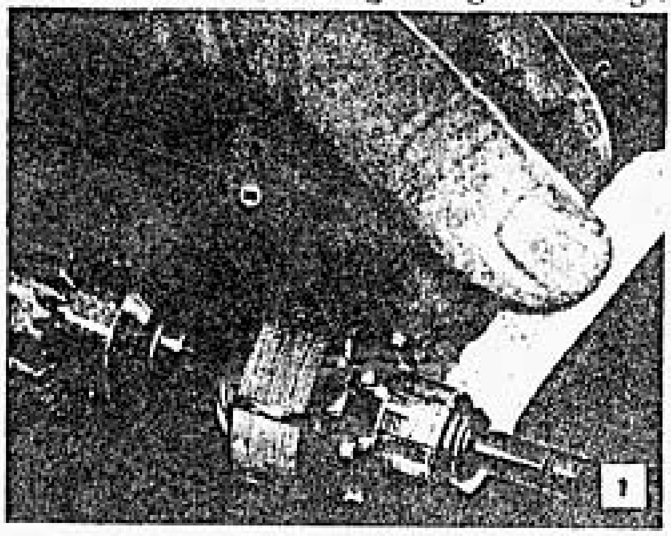
This fan has a small toggle switch in its base for controlling its operation. This had been giving trouble with intermittent contact. This happened to be an open type switch and with a pair of long nosed pliers (Fig. 11) it was possible to bend the spring contacts together to correct this difficulty. If this had been a closed type of switch, a new switch would have to be installed. As with the other fan, the cord and plug should be examined and replaced if required. The test lamp can be used to test the winding for ground and open circuit, as shown in the drawing. One frequent trouble with oscillating fans is that the short cord connecting the motor with the base receives a lot of bending in operation. This eventually breaks the conductors, causing an open circuit. This condition can be checked with the test lamp and if it shows open, the piece of cord can be replaced.

After all tests and inspection have been made, assembly of the fan is quite simple. Fill the gear box with medium grease and also refill the grease cup at the other end of the motor. Apply a drop of oil to each of the pivot screws in the main outer ring, and adjust these screws so there is no lost motion, yet the motor is allowed to swing freely. Also apply a drop of oil to the operating lever at each of its screws.

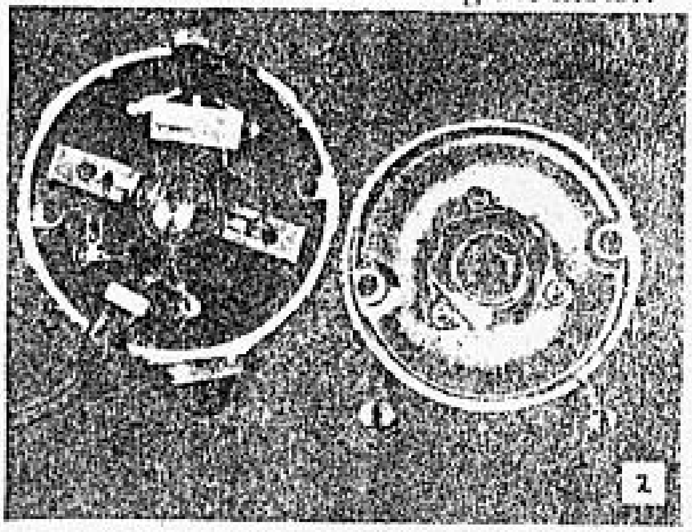
Some fans, especially in the larger sizes, are equipped with three speed control through a lever switch in the base. This is usually done with a tapped reactor built in the base space. The opened base of such a fan is shown in Fig. 12 and a diagram of a typical circuit is given in the drawing. Trouble here is usually due to either burning out of the reactor winding or an open circuit. The test lamp can be employed to check this condition. A defective reactor must be either rewound or replaced.

ELECTRIC FAN REPAIR

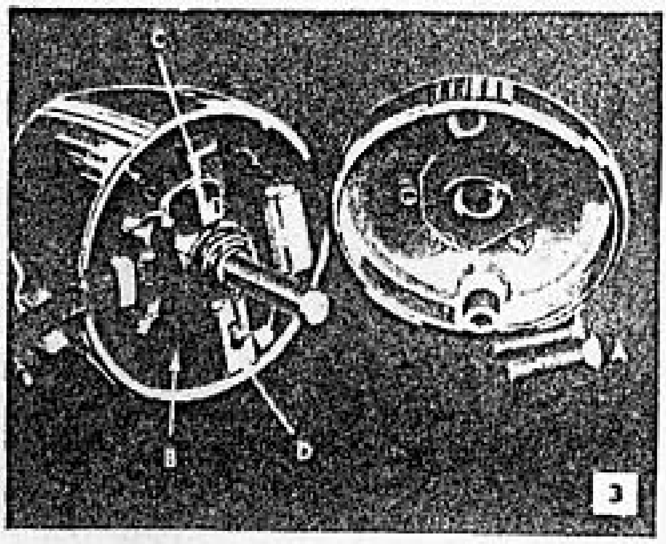
FAILURE of small electric-fan motors usually is due to four common causes—lubricant hardened or dried, bearings clogged with dust, brushes worn short and a loose connection. Any one of these can put the motor temporarily out of service. Most small fan motors can be dismantled quite easily by first removing the wire guard, the fan unit and the motor end shield. On some fan motors, it will be necessary to unsolder wire leads before the brush-holder plate can be removed. On others, this is not necessary. Fig. 2 shows a common arrangement of parts on the brush-holder plate. After removing the two screws, A in Fig. 3, work carefully in removing the end shield or damage may result. Removing the end shield generally exposes the brush-holder plate, B, the brush holders, C and D, and the resistance unit, R. Excessive wear of the brushes frequently causes the brush pigtails to jam in the holders, thus interfering with proper brush contact on the commutator. If the brushes are so badly worn that the pigtails jam or the follower springs no longer bear on the top ends, then they should be replaced. If new brushes are not readily available, replacements can be made from common generator brushes. Mike the old brush as in Fig. 5 to get the exact size. Then cut the generator brush to these dimensions and drill for the pigtail as in Fig. 6. Drill another hole at right angles through the first one and anchor the pigtail with solder. If the commutator brush track is badly carboned, it must be cleaned. Remove the holder plate, Fig. 4, and also the armature. Then mount the armature in a drill chuck, and clean and true the commutator with a piece of fine sandpaper as in Fig. 1. Clean the armature bearings with a solvent, such as kerosene, and apply new lubricant before reassembling the motor.



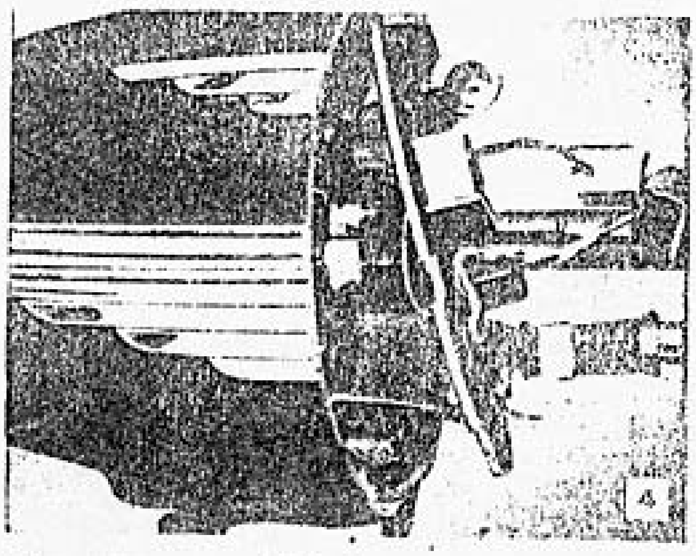
If the brush track on the commutator is badly carboned, it can be cleaned with ordinary fine sandpaper. Do not use any other abrasive for this work



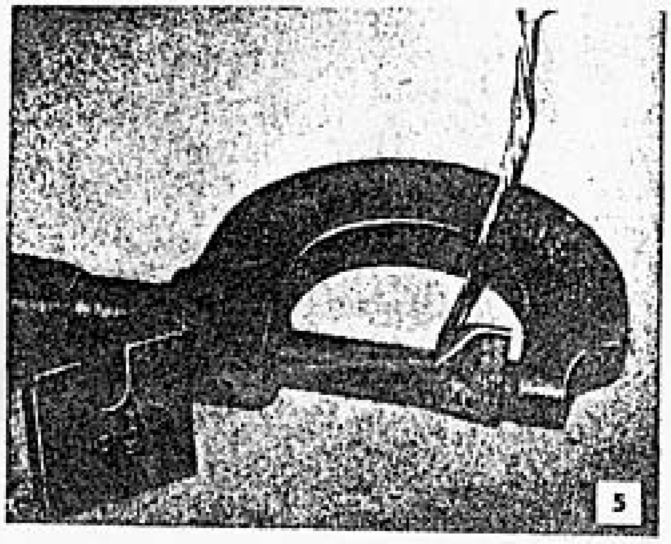
This is what you'll find inside a typical electric-fan motor when the end shield is removed. On some motors, wires are unsoldered to free the brush plate

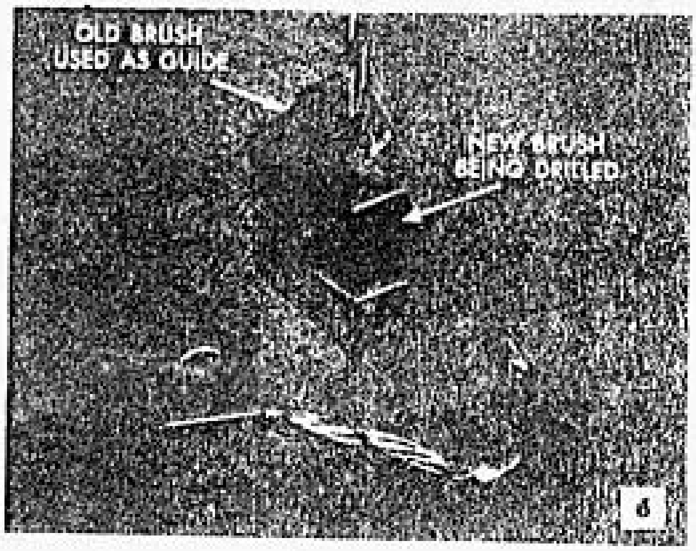


Above, a common cause of motor failure is jamming of the brush pigtails in the holders when brushes become worn. Below, replacement brushes can be made from generator brushes. Measure brush for size

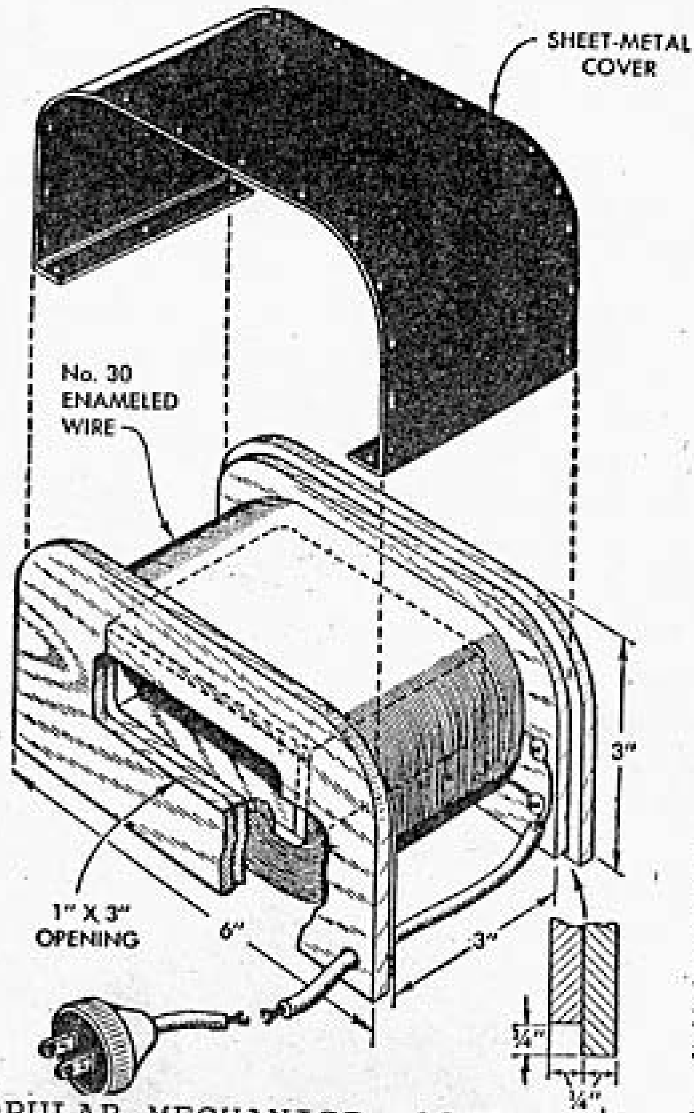


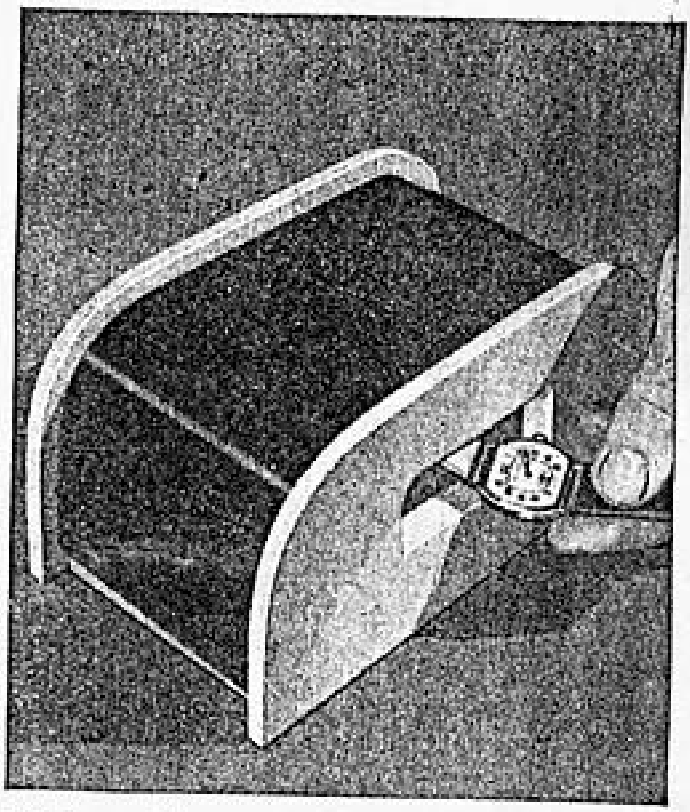
Above, in most small fan motors, the brush-holder plate must be removed to free the armature. Below, attach the pigtail to replacement brush by drilling holes at right angles and then anchoring with solder





Coil Demagnetizes Watches and Tools Quickly



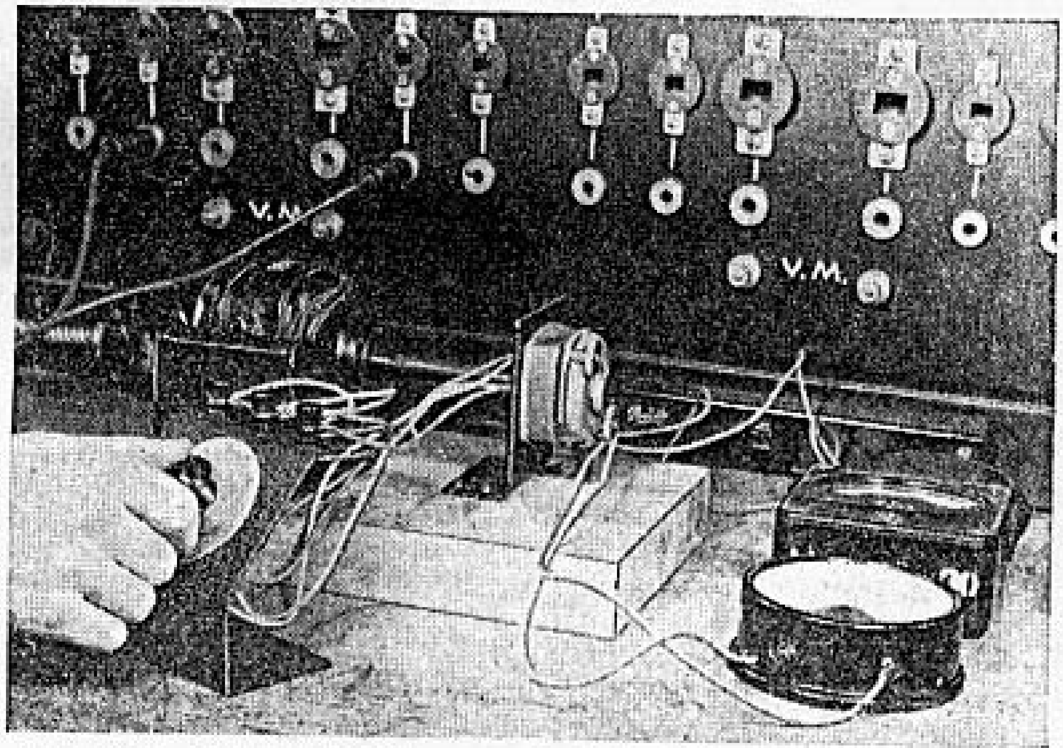


POPULAR MECHANICS, 1948

As most watches are exposed to stray magnetic fields in common everyday use, a pocket or wrist watch often will fail to keep time accurately due to a partially magnetized hairspring. Or, you may have a screwdriver or pliers that has become magnetized. If so, you can demagnetize them quickly with this little "demag" box. To use, simply plug it into a current source, place the watch inside the core and then withdraw the watch slowly after approximately 10 seconds. In using the demagnetizer, always turn off the current after withdrawing the watch to prevent burning out the coil. To determine when the watch is demagnetized, hold a compass over it and note if there is any attraction.

The demagnetizer consists of a hollow wooden core or spacer fitted between two sides and wound with 3500 ft. (1.1 lbs.) of No. 30 enamel-covered wire. Wire salvaged from the field coil of an old radio speaker can be used if the insulation is not worn. Two roundhead screws provide terminals for the coil leads and for attaching a lamp cord. The coil is neatly enclosed by a sheet-metal cover which is attached with small screws to the rabbetted edges of the case.

Dan W. Damrow, Chicago.



A setup in a special laboratory experiment in which the potentiometer described in this article is being used in the circuit of a small Alnico type generator to vary the generator's output.

POTENTIOMETER
for the Electrical Lab

Here's just the thing for your radio and electrical testing work

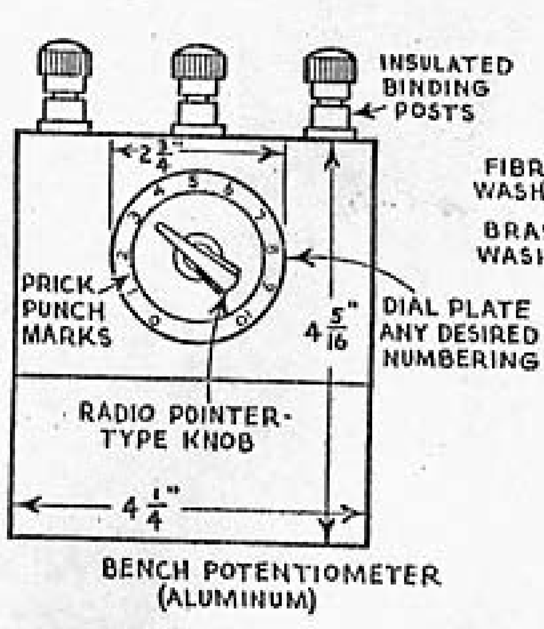
By HAROLD P. STRAND
Electrical Editor

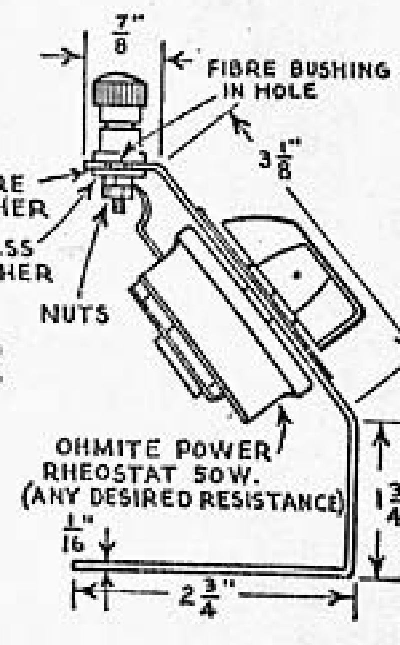
SCIENCE AND MECHANICS APRIL, 1949

ELECTRICAL experimenters and radio technicians have constant need of variable resistors for many purposes. These should be in such form that they are handy to use on the bench and are easily adjusted. One type of home built adjustable slide wire resistor, described in SCIENCE AND MECHANICS (Aug. '47 issue), was built around a resistance tube commonly sold in radio stores. Another and more versatile type can be built from a power rheostat, a piece of 1/16 in. aluminum sheet, a knob, a dial and three binding posts. This device is shown in use in a circuit of a special piece of electrical apparatus under test, where a certain resistance value is necessary. The handy stand takes but little space on the bench and offers suitable support. The pointer type knob is easily adjusted to give any value within the range of the unit. Insulated binding posts at the back permit easy connections. Several of these units should be made up, using various rheostats, both in respect to resistance and capacity, so as to be able to cover any reasonable condition.

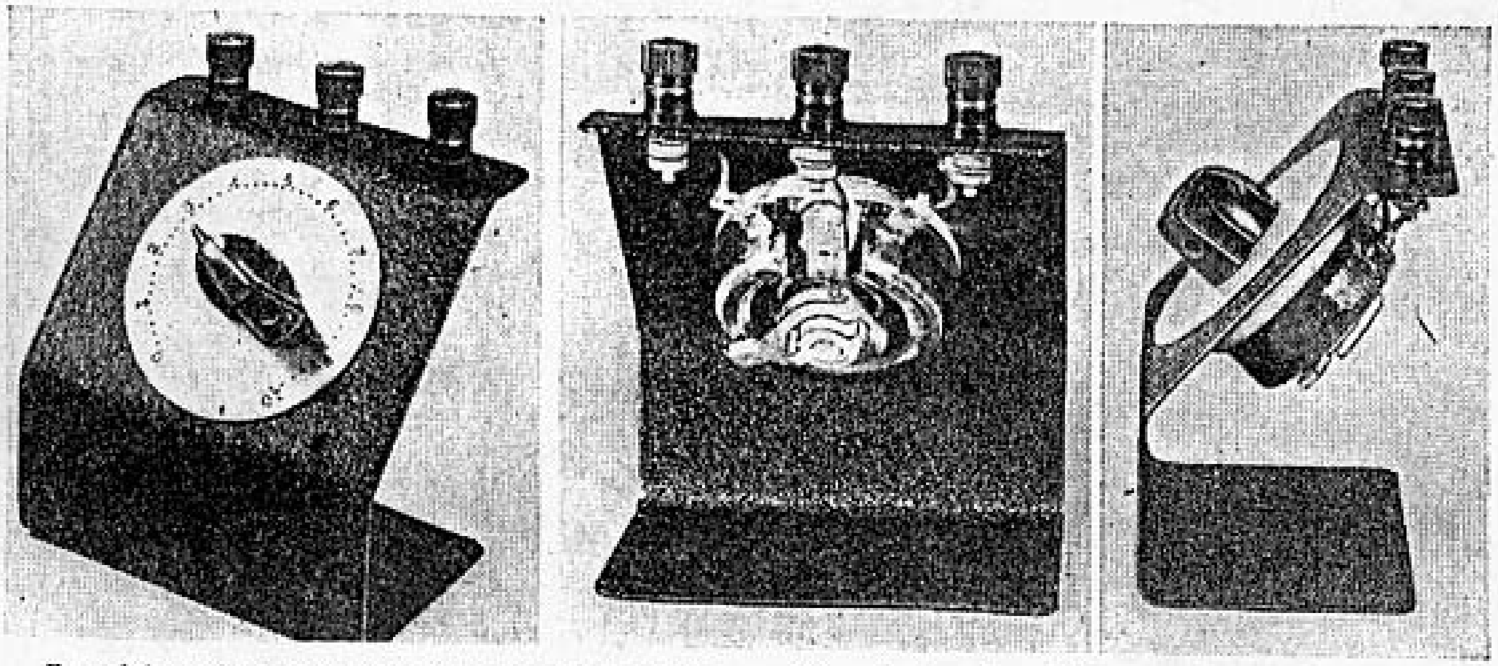
Begin building by bending up the stand from some 1/16 in. sheet aluminum (thinner gage steel can be used). Dimensions given will accommodate 50 watt Ohmite power rheostats, which have three terminals so they can be used as potentiometers or as straight series resistance if desired. These 2 5/16 in. dia. rheostats can be obtained in values ranging from .5 ohm 10 amperes up to 10,000 ohms .070 ampere.

In the center of inclined





 GRANDDAD'S ELCTRICITY BOOK



From left to right, front, rear and side views of the versatile potentiometer, which was built from a power rheostat, a knob, a dial, and three binding posts. Note connections on rear view.

surface of the stand, drill a hole to clear threaded end of rheostat, so it can be locked in place with the nut provided. Before securing it in place, however, make up a dial from some .015 or .020 thick sheet brass. Cut this out in the form of a $2\frac{3}{4}$ in. dia. circle. Then scribe a $2\frac{5}{16}$ in. dia. circle on the disc and lay out your scale on this line. The figures 0 and 10 should be extreme stop positions of the pointer knob, which should be marked first by testing knob for its two positions. Between these two points, lay out 10 even divisions on the circular line. Divide each division into 5 equal parts, which will be the subdivisions. With a set of number stamping dies, stamp numbers from 0 to 10 on the main divisions just above the line. Use a prick punch to make markers for each sub-division. Should stamping the numbers result in warping the disc as it often does, anneal metal by heating over a flame and when cool it can be flattened easily. When completed, clean and polish dial and finish it with a coat of clear lacquer.

Now place dial in position over hole in stand, and push rheostat stud through; locknut holds the assembly in place. Keep numbers 0 and 10 in a level position at the bottom and terminals of rheostat at the top. In addition to hole for rheostat mentioned, drill three additional $\frac{1}{4}$ in. dia. holes at the back level surface for the Bakelite binding posts. Since metal stand would short-circuit posts if they were placed directly in the holes, provide insulating sleeves and washers in position, to insulate the posts from the stand. Bakelite tubing, $\frac{1}{4}$ in. O.D. (with a hole to clear the 6-32 threaded studs of the posts) and $\frac{5}{16}$ in. long, serves to insulate studs in the holes. A fiber washer, together with a brass washer and a nut complete assembly of the posts. At the back side solder three short pieces of No. 18 lead wire to the three rheostat terminals and connect these to binding posts. If you have the facilities, apply a black crackle finish; put this durable, attractive finish on before any assembly work is done but after all four holes had been drilled. If crackle finish is not available, paint metal with dull black lacquer or any other finish selected.

Potentiometers are used in many ways in electrical circuts. They are often connected with the outside terminals across the line, (provided resistance value is suitable) and load is taken from center terminal and one side of the line. Thus a method is provided for getting reduced voltage control. Another use is for voltage dividers in circuits. They can also be used as simple series resistance by using one outside terminal and the center one. When using any form of resistance in circuits make sure that both resistance value and capacity of resistor in amperes are suitable. Otherwise, it is easy to burn out a resistor quickly.

 GRANDDAD'S ELCTRICITY BOO

Cigar Box MULTI-TESTER

A combination voltmeter and ammeter that takes the place of ten different instruments. Invaluable to the experimenter.

BY TRACY DIERS

Mechanix Illustrated March, 1946

THE coming of age of every electrical experimenter is symptomized by his increased passion for greater accuracy. But he may find his desire to buy good measuring instruments frustrated by high prices.

Fortunately it is possible to make a good combination voltmeter-ammeter having many voltage and current ranges. The cigar box multi-tester described in this article will take the place of 10 different instruments. This is accomplished by converting a 0-1 mil DC milliammeter into both a DC voltmeter and ammeter.

This cigar box multi-tester has the following ranges:

DC Volts 0 to 10
DC Volts 0 to 50
DC Volts 0 to 250
DC Volts 0 to 1000
DC Volts 0 to 5000

DC Amperes 0 to 1 mil (1/1000 of an ampere)
DC Amperes 0 to 10 mils
DC Amperes 0 to 100 mils
DC Amperes 0 to 500 mils
DC Amperes 0 to 1 ampere
DC Amperes 0 to 10 amperes

You will need the following items to construct this versatile instrument:

A cigar box, preferably wood.
One 0 to 1 mil DC milliammeter.

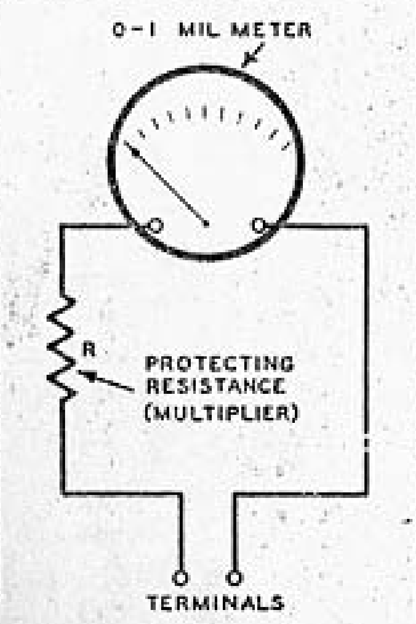


FIG. 1 CONVERTED INTO A VOLTMETER

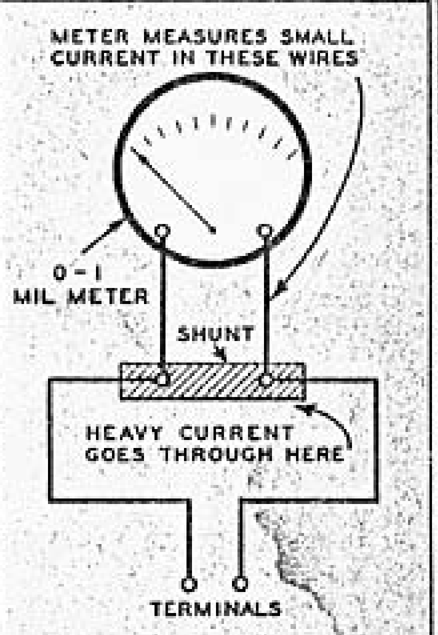
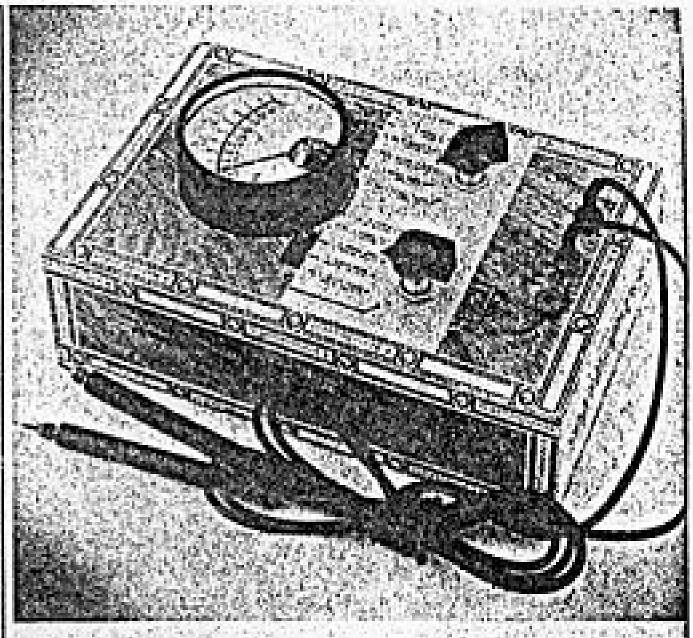


FIG. 2 CONVERTED INTO AN AMMETER



The completed cigar box tester with the test prods. Finish with shellac.

 GRANDDAD'S ELCTRICITY BOOK

Some copper wire Nos. 30, 24, 22, 20, and 16.
Some fixed resistors (described later).
2 single pole, 6-point rotary selector switches.
A pair of test leads fitted with prods.
3 Bakelite insulated tip jacks, 2 red and one black.
1 piece of masonite.

The 0 to 1 mil meter can be bought in many large cities. After you have obtained this meter write to the manufacturer and find out what the resistance of the moving coil is. In this article we shall use a meter whose moving coil has a resistance of 27 ohms. If your meter has a different coil resistance simply substitute that value in the calculations.

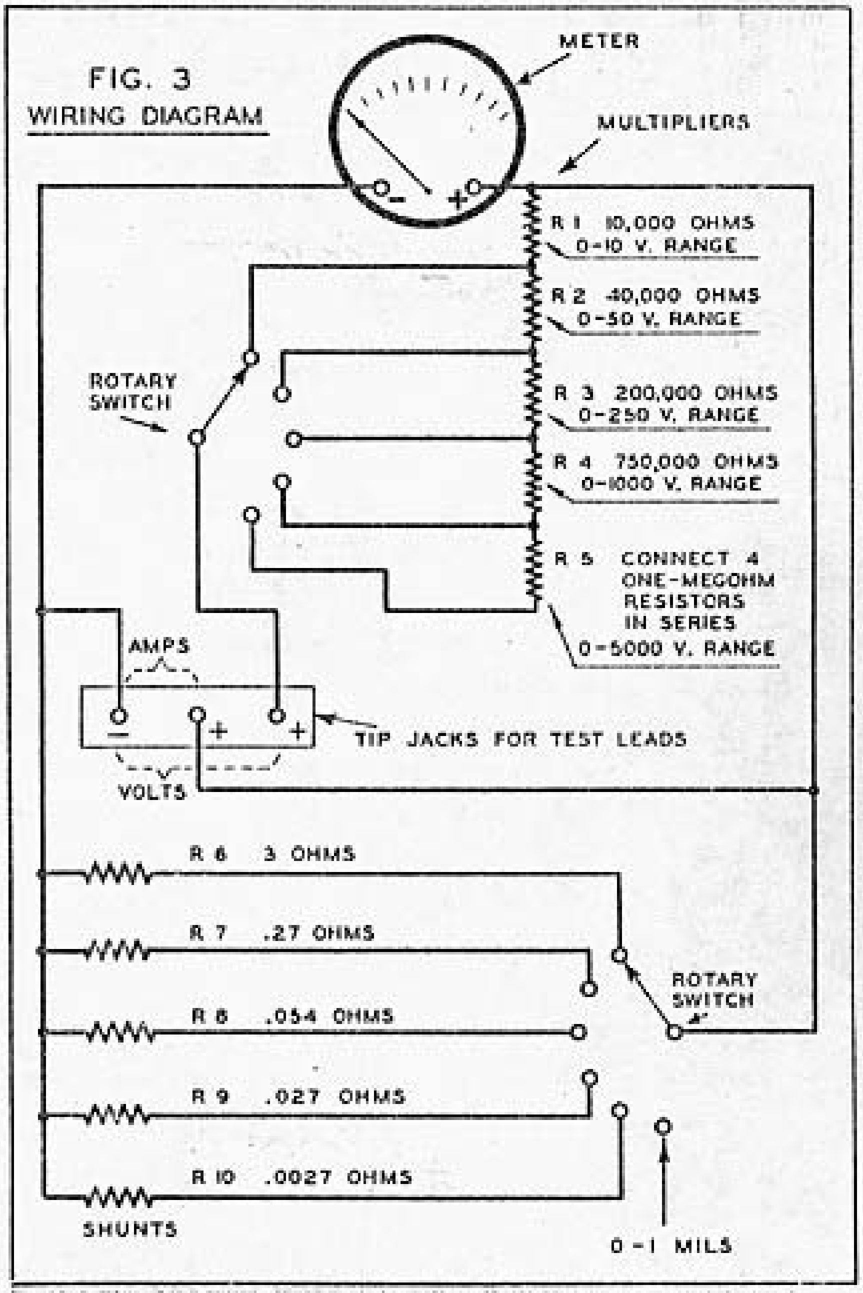
To understand how a 0 to 1 mil meter is converted into a voltmeter see figure 1. The resistance R is a protecting resistance called a multiplier. This multiplier prevents the moving coil in the meter from receiving more than the one mil for which it was designed. By using different sizes of multipliers we can make the meter read various voltage ranges.

Figure 2 shows how the meter can be made to act as an ammeter. In this case we connect a heavy conductor across the poles of the meter. This is called the shunt, and as before, varying the size of the shunt makes it possible to read different amperage ranges.

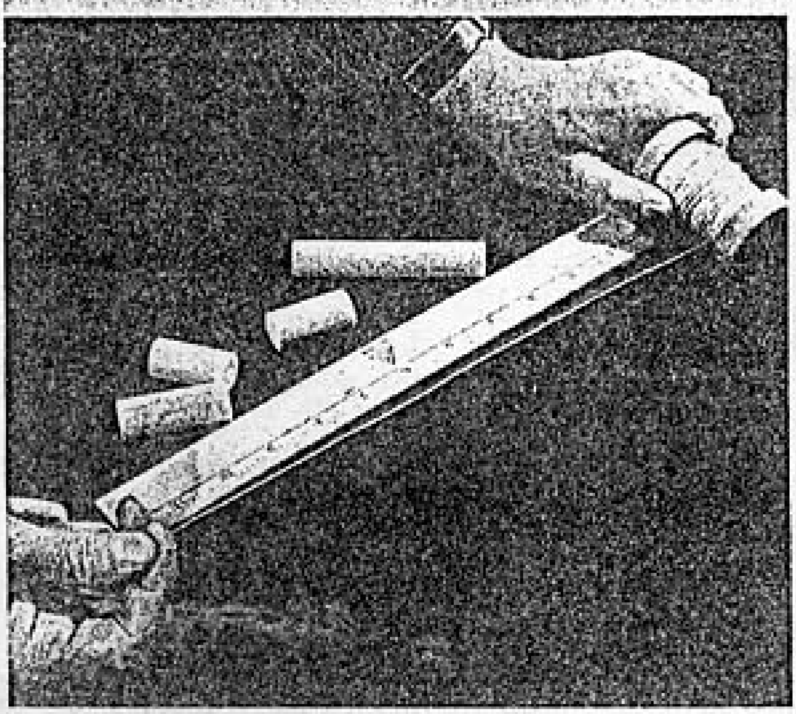
The rotary selector switches make it possible to quickly switch from one shunt or multiplier to another.

The actual resistance of the 0 to 1 mil meter is not important in the construction of the voltmeter section of the multitester. If your meter resistance falls anywhere between 20 to 75 ohms then the following will be the correct multiplier resistances:

The 0 to 10 volt range 10,000 ohms
The 0 to 50 volt range 40,000 ohms
The 0 to 250 volt range 200,000 ohms
The 0 to 1000 volt range 750,000 ohms
The 0 to 5000 volt range four, one megohm resistors in series.
All one watt. The one megohm resistors may be ½ watt.



Measuring off wire for the shunts. Don't stretch. This should be done very accurately and carefully.



 GRANDDAD'S ELCTRICITY BOOK

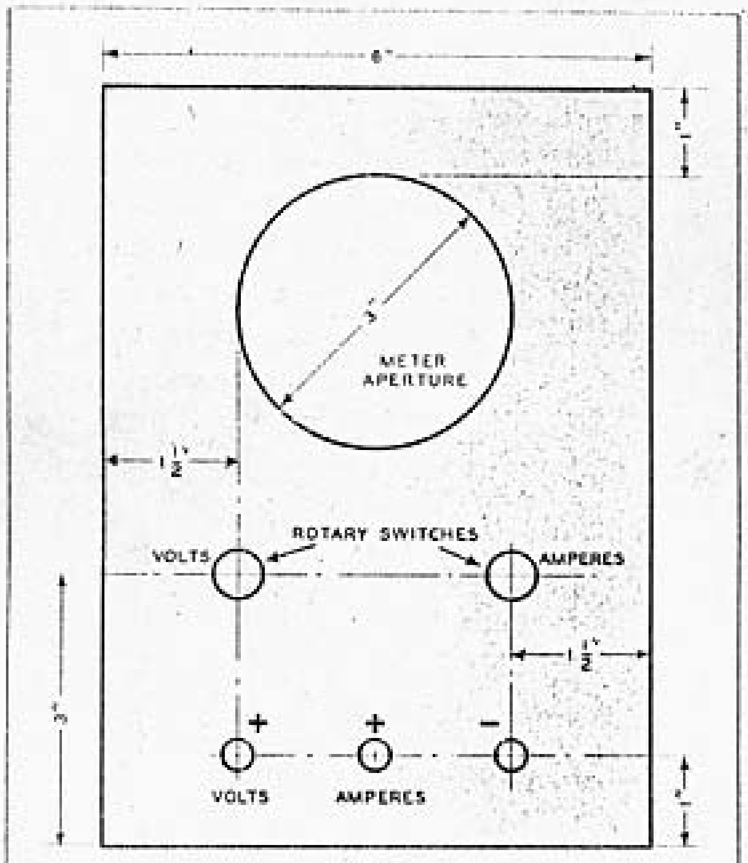
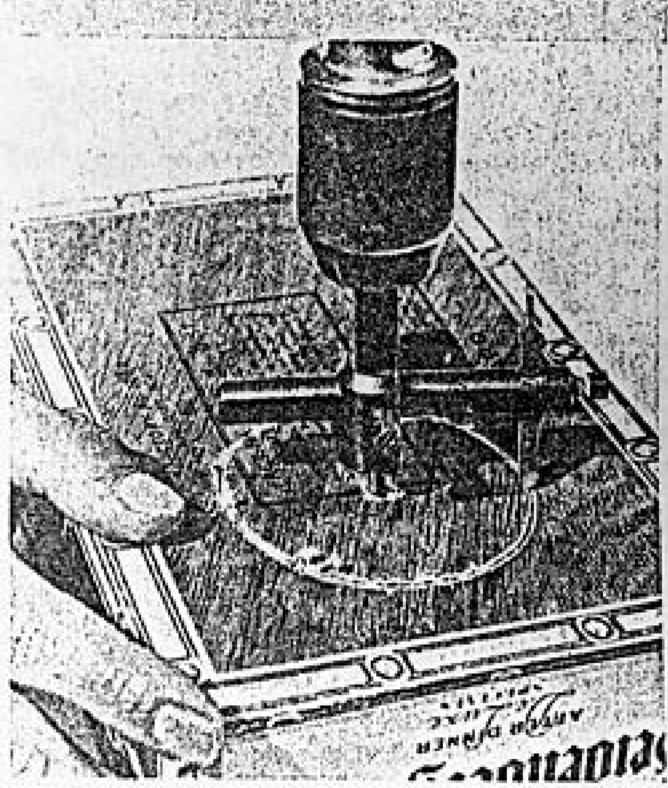


FIG. 4


Use a circle cutter for meter hole in box and back the wood up so that it will not split.

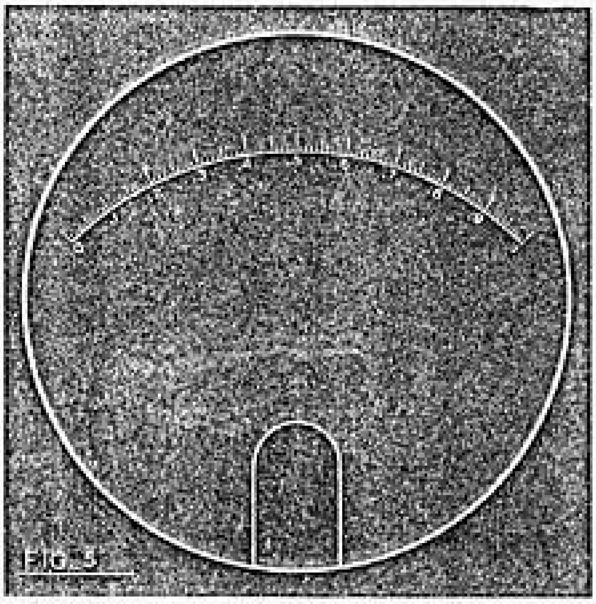


FIG. 5

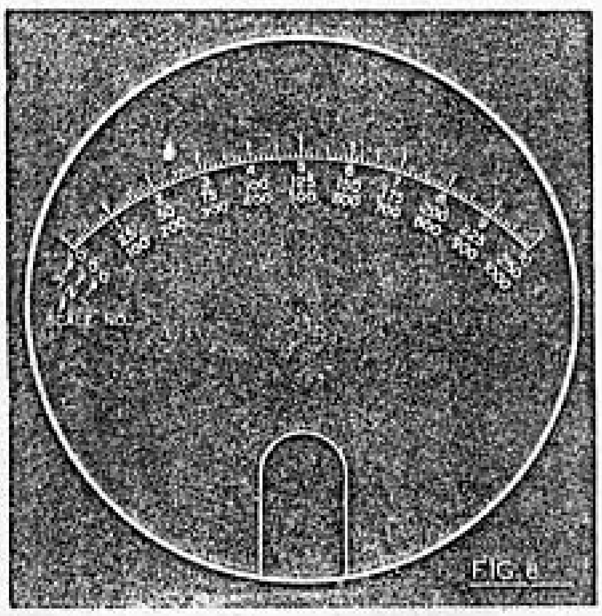


FIG. 6

The best multiplier resistances are, of course, wire wound but the cost is high. As a compromise, use wire wound for the 0 to 10 volt range and for the 0 to 50 volt range. Good metallized resistances may be used for the other ranges. Any metallized resistance having a tolerance of ±5% will be satisfactory. These resistances may be obtained in any large radio store.

The shunts come next. As stated before if your meter has a 27 ohm coil you will not need to perform any calculations but if it has any other resistance you will need to use this formula to calculate your own shunts.

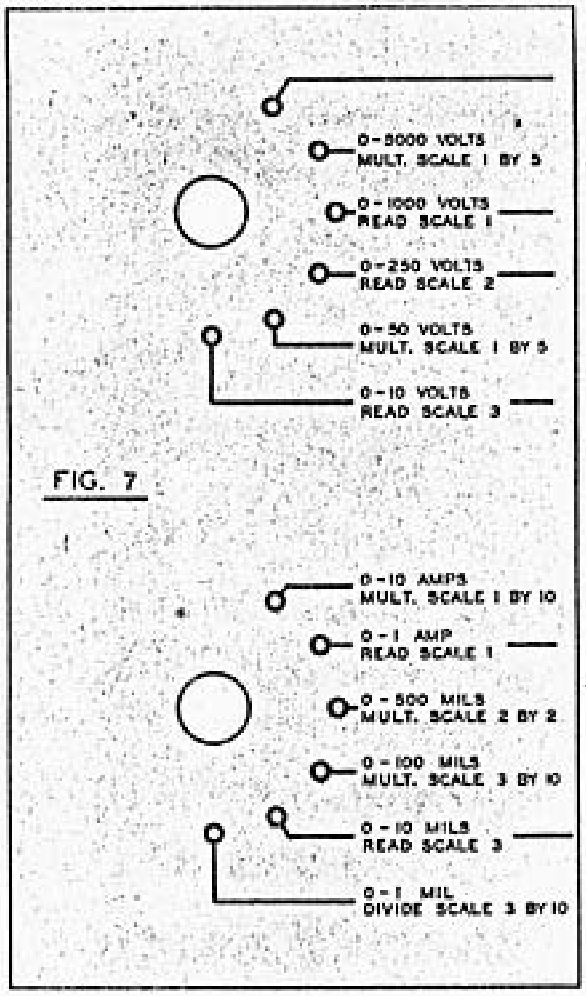
$$\text{Resistance of Shunt} = \frac{\text{Resistance of Your Meter.}}{X}$$

The values of X are:

For the 0 to	10	mil scale use	9
For the 0 to	100	mil scale use	99
For the 0 to	500	mil scale use	499
For the 0 to	1	amp scale use	999
For the 0 to	10	amps scale use	9999

When these figures are substituted for X then you will obtain the resistances necessary to make the shunts. When this formula is used for the 27 ohm meter we get these resistances:

0 to 1	mil range, resistance of shunt	(none)
0 to 10	mil range, resistance of shunt	(3 ohms)
0 to 100	mil range, resistance of shunt	(.27 ohms)
0 to 500	mil range, resistance of shunt	(.054 ohms)
0 to 1	amp range, resistance of shunt	(.027 ohms)
0 to 10	amps range, resistance of shunt	(.0027 ohms)



The shunts are all made of copper wire and for the 27 ohm meter have the following lengths:

Resistance of shunt	Length and size of wire
3 ohms	28½ ft. No. 30 DCC
.27 ohms	10 ft. 3½ in. No. 24 DCC
.054 ohms	40½ in. No. 22 DCC
.027 ohms	32½ in. No. 20 DCC
.0027 ohms	8 in. No. 16 DCC

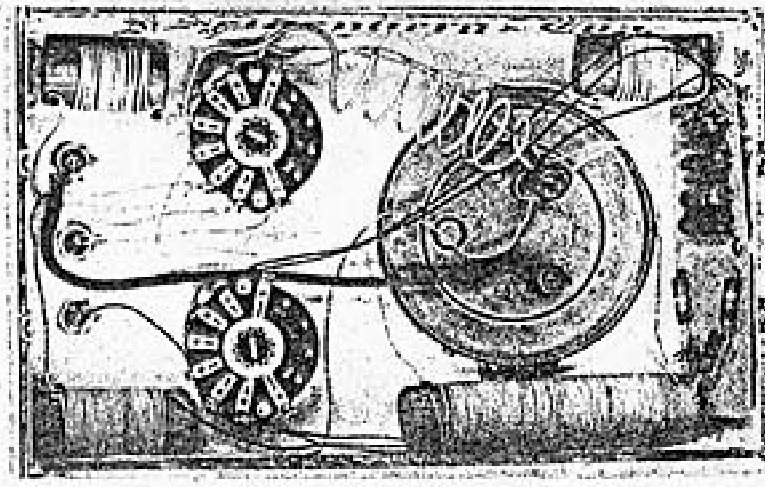
If you do not have a 27 ohm coil then you will have to use different lengths of the above wires. Use only those sizes, *no substitutions.*

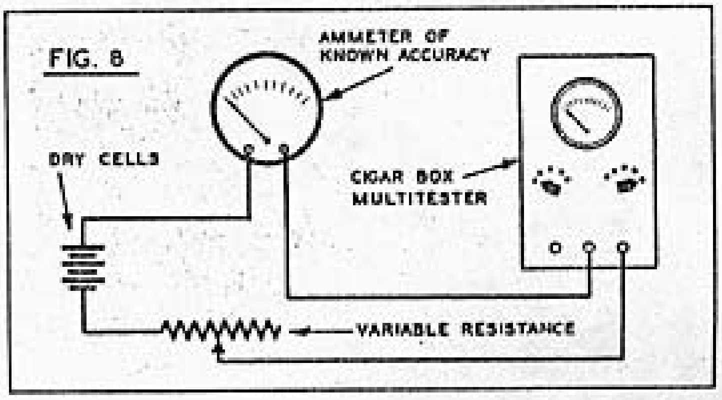
First calculate the resistance of your shunts, then from this table figure out the amount of wire you will need for each shunt:

Size of wire	Resistance in ohms per ft.
No. 30	.105 ohms
No. 20	.01 ohms
No. 24	.026 ohms
No. 16	.004 ohms
No. 22	.016 ohms

When measuring off the proper amount of wire from the spool

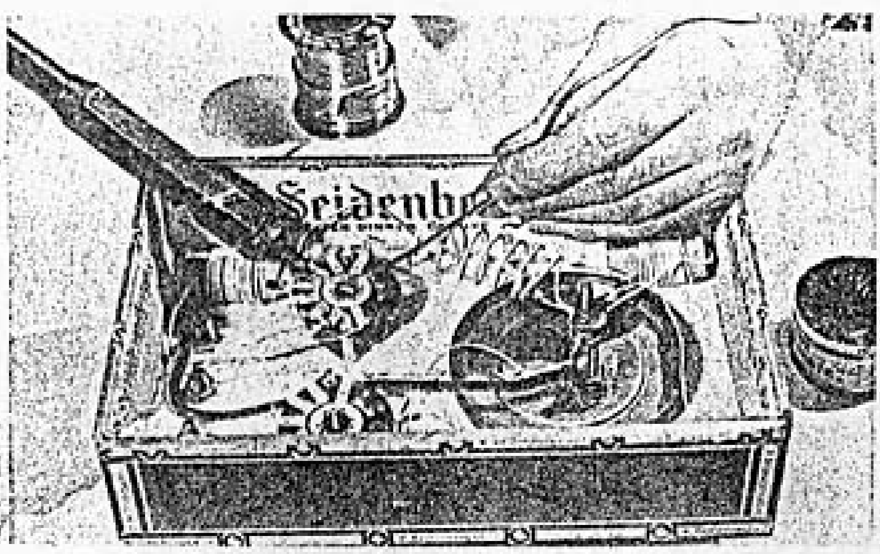
Bottom view of the wiring of the multi-tester. All windings should be shellacked in place.



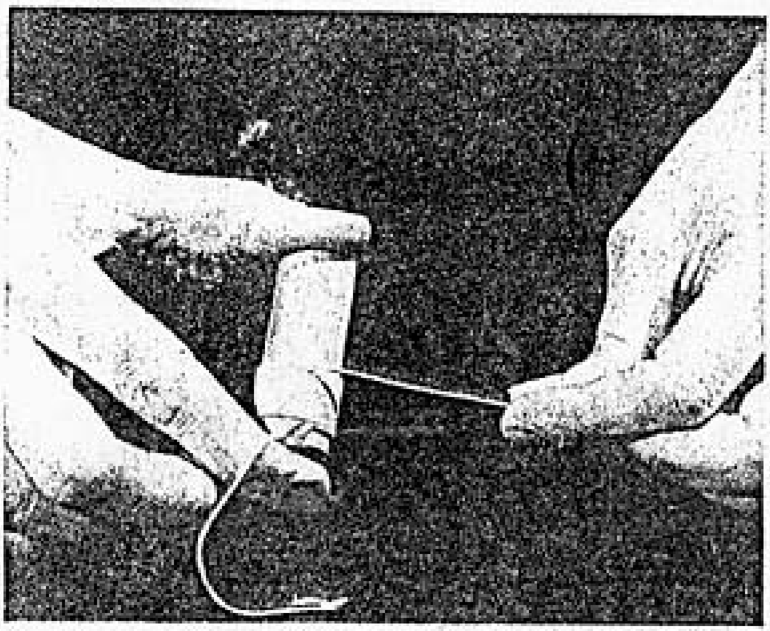


pull tightly but do not stretch. The shunts are made by winding the wire on small pieces of wooden dowel ⅝ in. in diameter. A piece 4 in. long should be used for the No. 30 wire, 2 in. long for the No. 24, and the numbers 22 and 20 can be wound on 1½ in. pieces. The No. 16 wire does not need to be wound on a dowel support since it is very short. The wire must be wound neatly and when necessary more than one layer may be used. Allow end pieces for connections and shellac the windings in place.

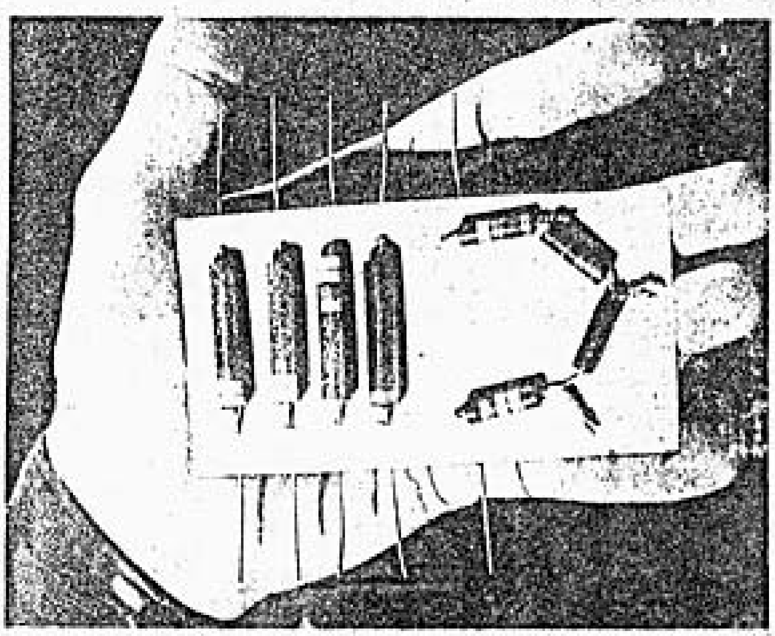
The cigar box in which the multi-tester



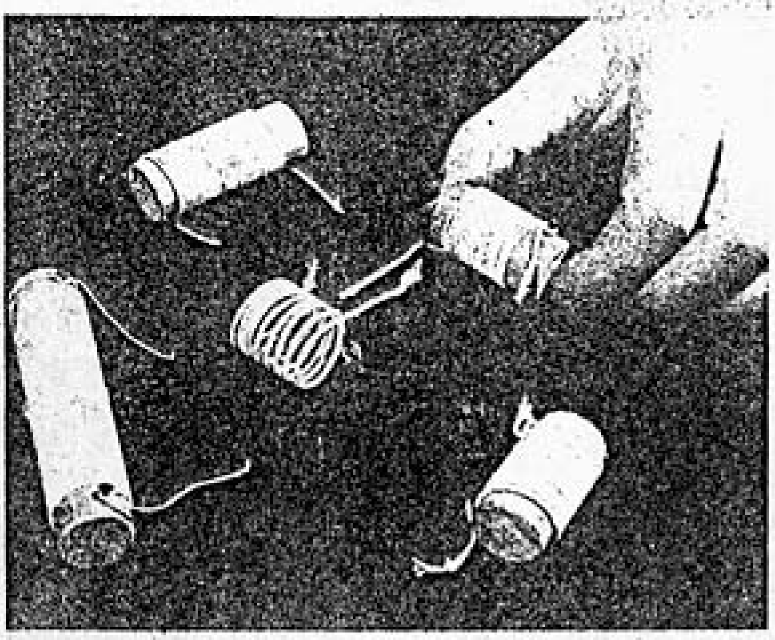
Good soldering is most important: test your connections by pulling.



Leave end pieces on shunts for connections so that no extra soldering will be required.



The multiplier resistances mounted on masonite. If you use cardboard or plywood, shellac it well.



Finished shunts. 10 amp shunt needs no dowel. Note the leads left over for making connections.

is to be constructed may now be prepared. The hole for the meter is cut with a circle cutter. Bolt the two selector switches in place and also attach the jacks for the test prods. The shunts may be glued to the inside of the cigar box.

The face of the 0 to 1 mil meter should now be removed and the new scale made. Most meters have a scale composed of 50 divisions. Either letter the new values on the face of this scale or remove it and cut a new one out of thin white cardboard.

The old scale is shown in figure 5 and the new one appears in figure 6. The 50 divisions of the old scale should be copied on the new scale in exactly the same place. If you photograph the old scale on process film and make a print on double weight paper you will have an exact reproduction. The unwanted numbers can be blocked out on the negative with opaque. The new numbers can be inked in on the print with India ink.

If the original scale on your meter had more or less than 50 divisions then it will be necessary to assign different values to each division but the sum totals for scales 1, 2, and 3 should still be 10, 250, and 1000.

A scale should now be made for both the voltmeter selector switch and the ammeter switch. These are cut out of white cardboard and pasted on the cigar box.

The multipliers and shunts may now be hooked up (figure 3). When making connections to the shunts do not attach extra pieces of wire but make the connections with the end pieces of which the shunt is wound. All connections must be well soldered, especially the shunts. The points on the selector switch should be correctly connected to correspond with the labels on the switches.

Your multitester is now ready for service. Plug one of the test leads into the black tip jack. This is always negative. To read volts plug the other test lead into the red voltage tip jack. This connection is positive. If your meter reads backwards reverse the connections. Always set the selector switch at the next higher reading which you expect to test, if too high you can then switch to the next lower.

To read current remove the positive lead from the voltage tip jack and plug it into the current jack. See Figure 8 for testing with meter of known accuracy.

Switch on Electrode Holder Decreases Line Load

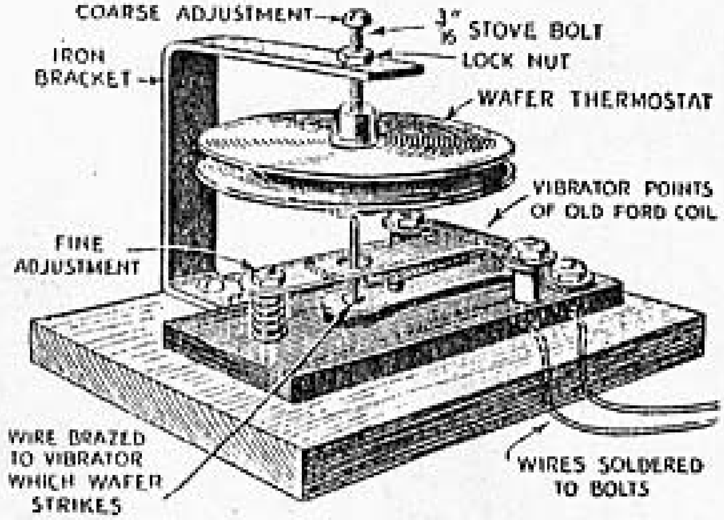
POPULAR MECHANICS, 1948

In almost any welding shop and especially on construction jobs there are intervals when the welding machine continues to run without actual welding being done. At such times the load on the primary line to the machine can be lessened considerably by breaking the excitation current to the shunt fields of the generator by means of a button or other pressure-type switch on the electrode-holder handle as shown in the detail. The saving on a 300-ampere welding machine amounts to approximately 6 amperes at 220 volts. Moreover, this arrangement renders both the holder and rod "dead" when not in the hands of the operator, thus preventing any accidental "short" which might be produced between the rod and the work or ground. On any of the self or externally excited motor-generator sets the switch may be attached by disconnecting the rheostat from one terminal and connecting a wire from the rheostat to the switch on the electrode holder. Then connect another wire of equal length to the other terminal of the switch and lead this back to the rheostat terminal as shown in the detail. Any ordinary rubber-covered wire of No. 14 ga. will do since the amperage carried in this circuit is relatively low. The wires are taped to the welding line at intervals as shown. Any type of toggle or push button switch may be used as long as it has a carrying capacity of 6 amperes at 120 volts.

Wm. R. Lewis, San Francisco, Calif.

Wafer Thermostat Control for Electrical Devices

For operating electrically heated brooders and similar devices where changes in temperature is the controlling factor, a sensitive thermostat can be made from a cheap wafer thermostat and the vibrating points from an old Ford coil. The thermostat has two adjustments, a coarse one obtained by raising or lowering the wafer with a stove bolt which attaches it to a supporting arm, and a fine one obtained by the regular adjustment on the points.

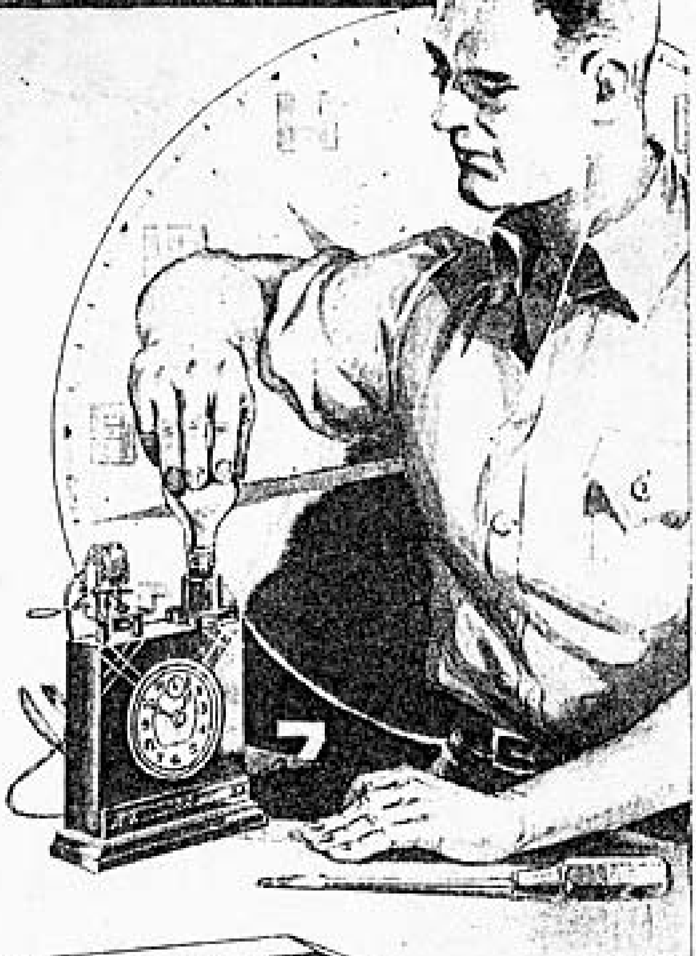


A slight change in temperature causes this thermostat to open or close an electrical circuit

Converting Electric Clocks to TIME SWITCHES

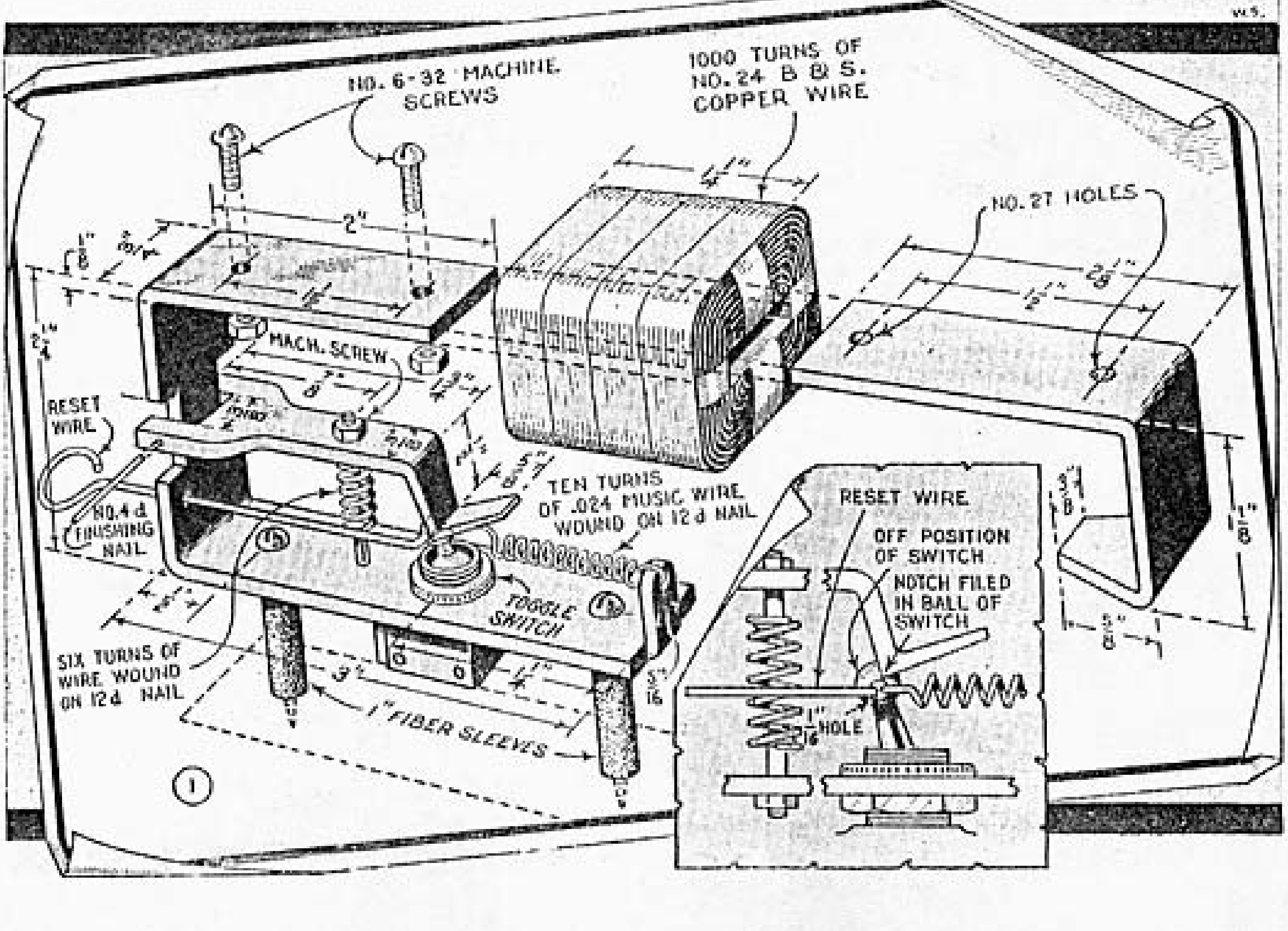
POPULAR MECHANICS, 1941

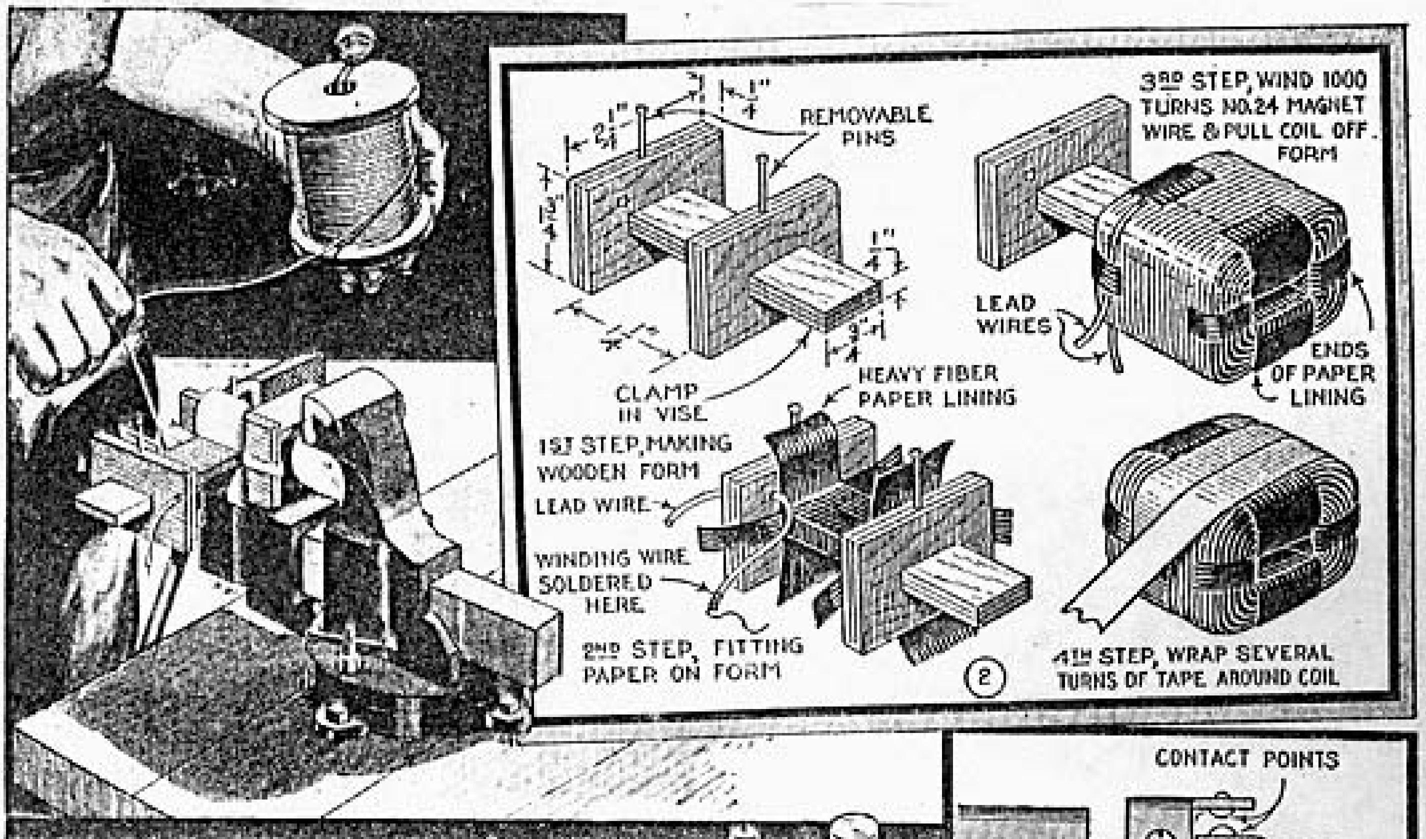
By C. A. CROWLEY

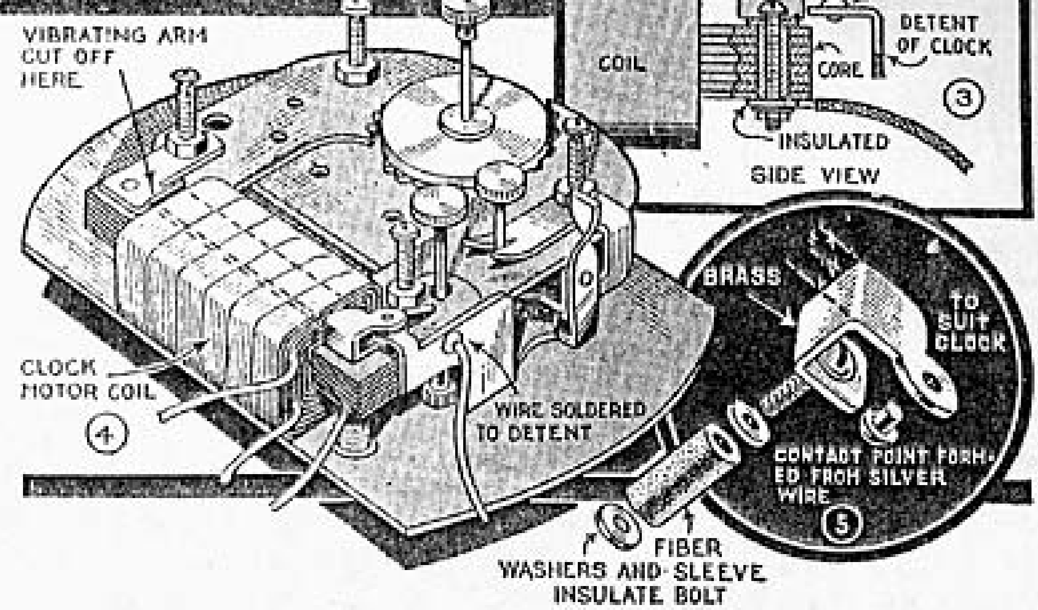


DO YOU need a time switch to turn off lights or electrical appliances at a predetermined time when no one will be there to turn the switch by hand? Perhaps your problem is to turn one circuit off and another on at the same time, or after an elapse of time. By simply making a few alterations in one or two electric alarm clocks and making relays from some scrap iron and some copper wire, you can have these automatic servants to save your time and labor. In effect you are altering them to form time switches, which turn electric circuits on and off at any time for which the clocks are set.

Three models: Three models of time switches will cover many needs. The relays used are the same but the circuit connections vary, as shown in the diagrams Figs. 7, 8 and 9. The arrangement in Fig. 7 is a straight cut-off switch. Merchants will





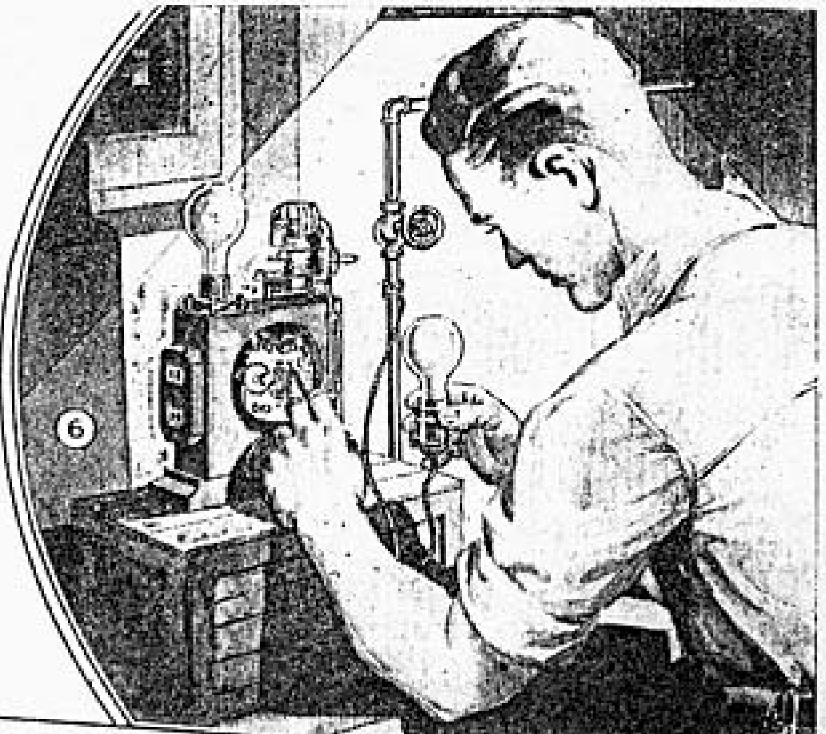


find it useful for shutting off display lights. Or, this arrangement is useful for turning off a radio, ventilating fan, outdoor lights and other appliances. A slight elaboration of the circuit, as shown in Fig. 8, enables one to turn one circuit off and another on at the same time, or either one of these functions separately. With this switch a radio can be turned on in the morning, or a solenoid-type water valve can be opened to start a sprinkler system, etc. The third model has two electric alarm clocks and two relays, Fig. 9. This one will turn a circuit on and then off after a lapse of time, such as turning hall and porch lights on early in an evening and off at a later time. As all of these time switches are designed to be portable and compact, they can be moved around wherever needed.

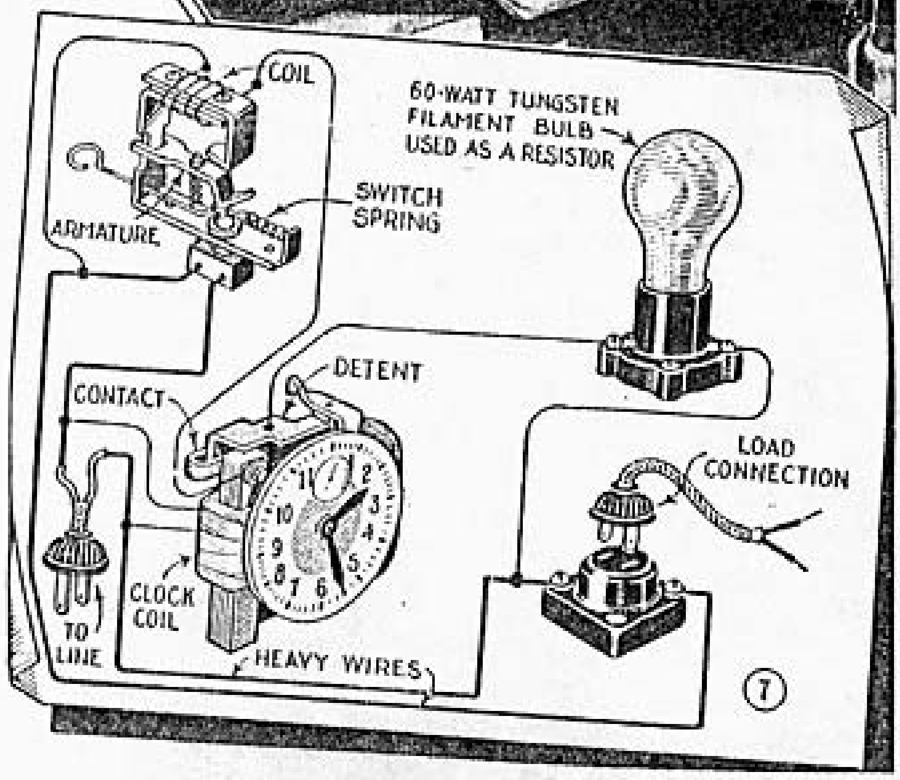
Making the relay: Fig. 1 shows the general assembly of the relay, and the parts comprising it. Flat iron ⅛ in. thick is used for the frame, pole piece and armature. It is advisable to anneal the bends from a cherry-red heat to relieve the strains set up in them. This can be done over a gas stove or even in the furnace of your heating plant. Dress up the pieces with a file and drill the holes as indicated. When drilling the holes to fasten the pole piece to the frame, it is advisable to clamp them together and drill through both pieces at once to insure a perfect matching of these holes when the relay is assembled. Drill the hinge-pin holes in the frame and armature before notching them out to fit each other. Care must be used not to allow the holes to wander off center.

To wind the armature and switch springs, a small flat is filed on the side of the nail so that the end of the music wire can be clamped to it in the vise. Wind the turns as closely together as possible. No. 24-ga. music wire is used for making both springs. See Fig. 1. In notching up the ball tip of the toggle switch do not attempt to form it by hammering. Use a file, as the toggle is usually made of hard brass and is brittle.

The notch for the switch catch is filed on the side of the toggle that is held by the relay armature when the switch is in the on position. Details of winding the coil on a form are shown step by step in Fig. 2. It is not necessary to wind the coil in layers. Single cotton-covered magnet wire, No. 24, is satisfactory, but enameled or other insulated wire may be used.

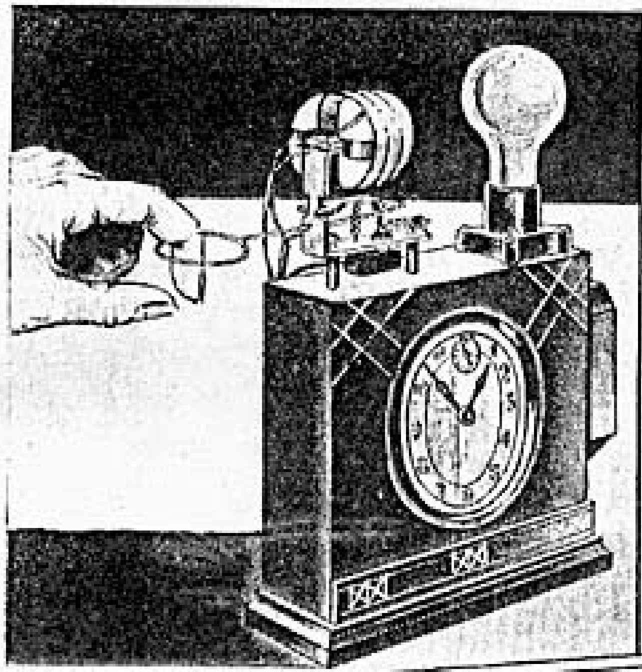


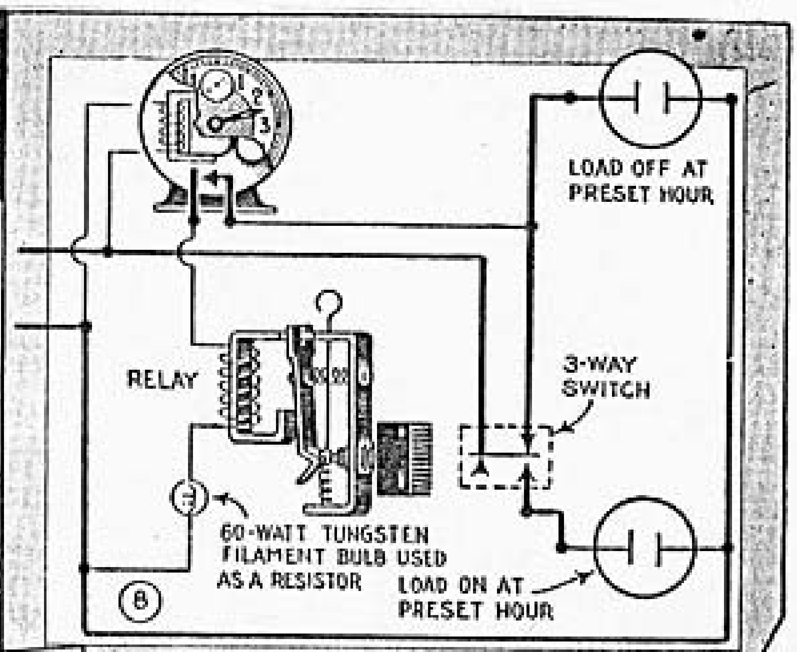
In assembling the relay, first place the mounting screws in their holes, then hinge the armature and mount the toggle switch. The armature or switch catch and the toggle switch usually have to be adjusted to each other. This can be accomplished by carefully bending the catch with a pair of pliers if necessary, and also by moving the switch up and down by means of the mounting nuts. A piece of stiff wire will serve as the reset catch when bent to shape. Slip the coil on the frame, insert the pole piece, and fasten the two together. Tighten the fastening screws securely to prevent the pole piece from chattering.



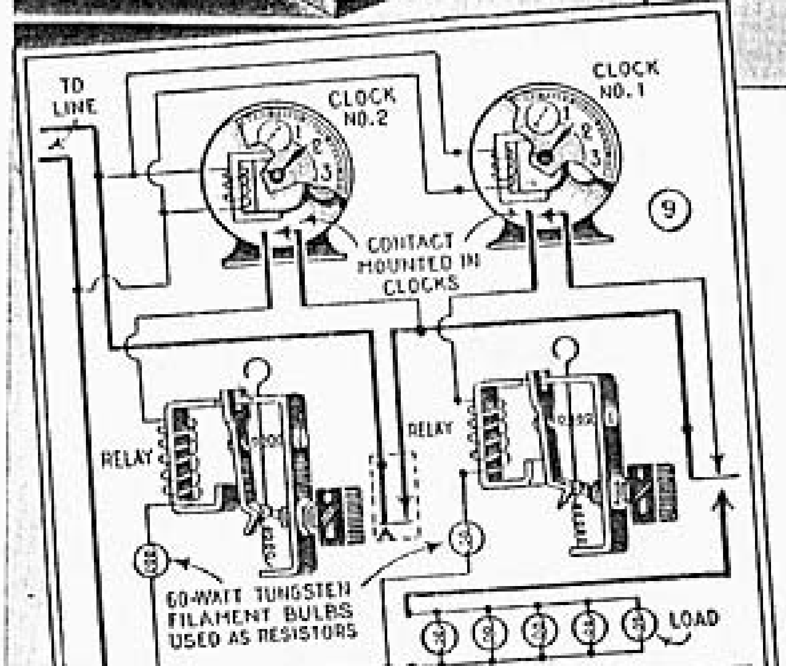
Modifying the clock: Alterations on the clock are the same for all the models and consist of installing a pair of electrical contacts in the alarm system. Where two clocks are used, the procedure is exactly the same for both clocks. The clocks do not need to be alike so long as they both have an alarm system. The alarm system of an electric clock is very simple. As shown in Fig. 4, a vibrator arm, which lies next to the motor coil, is riveted at one end to the laminated core of the clock and is held in place at the other end by a movable detent or catch, which releases the arm, allowing it to vibrate. The vibrating arm is cut off as indicated. A contact point on the detent is made by removing the detent, drilling a hole in it at the point shown, inserting a short piece of silver wire, (obtainable at jewelers) and riveting over the ends with a hammer. Use a hardwood block to back up the work while riveting the wire, to prevent excessive flattening of the contact on the other side. A second silver contact is mounted in the same way on a piece of sheet brass cut to fit your particular clock. This contact must be electrically insulated from the rest of the works when mounting it on the laminated core as shown in Figs. 3 and 5. Then the lead wires are soldered in place. Bring these wires through the cord hole in the back cover plate and close up the clock. Cut off the clock cord about 3 in. outside of the cord hole. If, by chance, you have clocks already equipped with contacts, these may be used and this part of the work omitted by simply bringing out leads from them after disconnecting them from the rest of the clock works.

Mounting the parts, wiring and testing: If the clock has a wooden frame, the relay, the lamp receptacle and the load plug-in socket can be screwed to the top and sides.





TO TURN OFF ONE CIRCUIT AND TURN ON ANOTHER AT THE SAME TIME



USING TWO CLOCKS TO TURN ON CIRCUIT AND TURN IT OFF AFTER LAPSE OF TIME

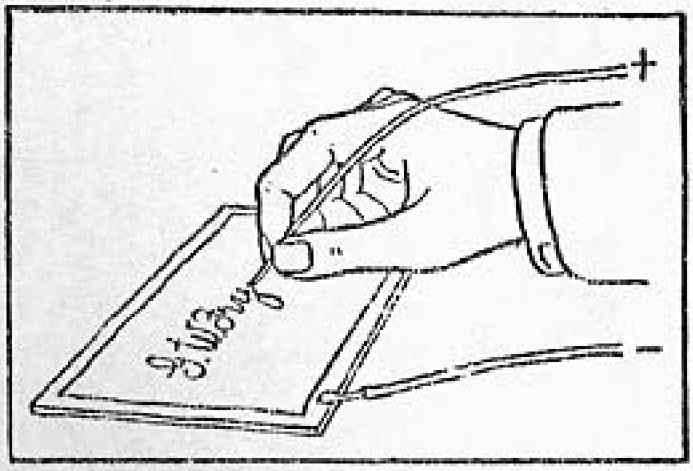
Otherwise these parts and the clock are all mounted on a wooden base of suitable size. In wiring, do not use a wire size of less than No. 14 gauge where the lines on the diagram are heavy, but No. 20 gauge wire is sufficient for the lighter wiring. In all cases, stranded wire is preferable to solid conductors.

Use a 60-watt lamp in the resistance receptacle, pull the reset back until the catch holds the switch, and plug the switch clock into the line. Do not touch anything until you have made a test to find the grounded side as in Fig. 6. This is done by touching one lead from a lamp to the metal back of the clock and the other lead to a water pipe or radiator valve to obtain a good electrical ground connection. If the lamp lights, reverse the cord plug used to connect the clock to an outlet. After this has been done, plug some convenient test load such as a desk lamp into the load receptacle. The lamp should now go off at any time to which the alarm is set. In Figs. 8 and 9, three-way switches are used. In the diagrams, connections are made to the switch as indicated in the dotted portion although the switch itself is shown attached to the relay without any connections.

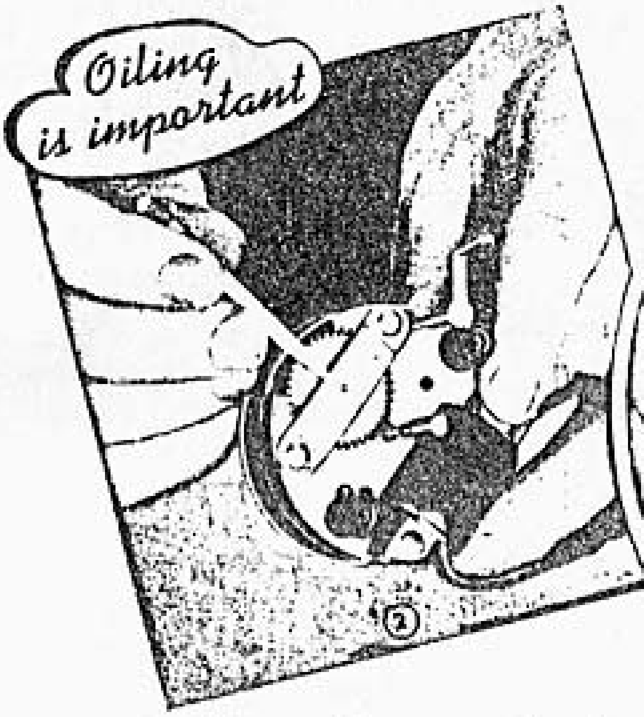
Writing with Electricity

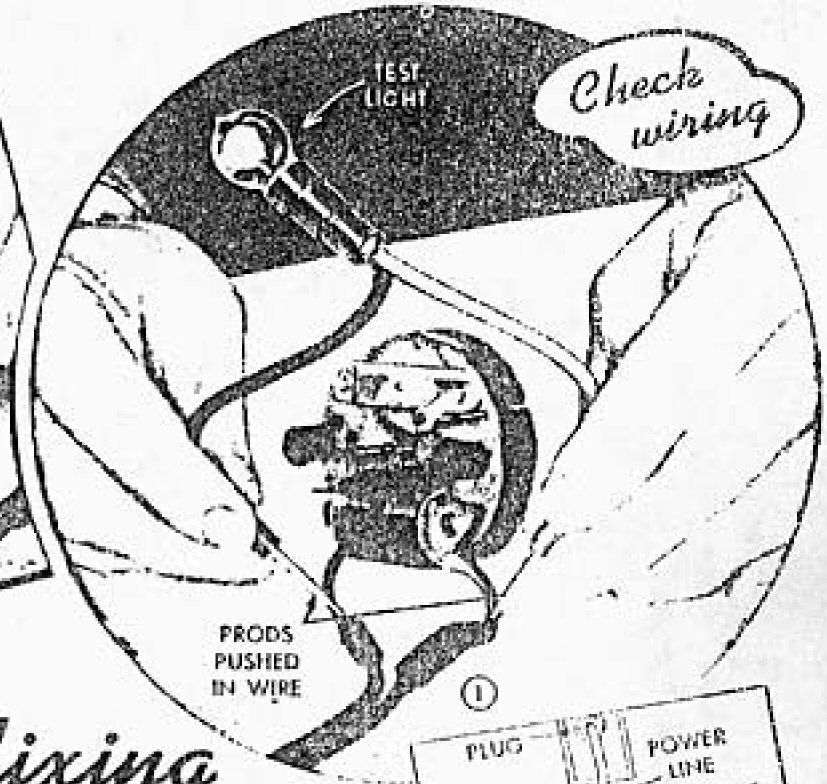
THE BOY MECHANIC – 1913

Soak a piece of white paper in a solution of potassium iodide and water for about a minute and then lay it on a piece of sheet metal. Connect the sheet metal with the negative or zinc side of a battery and then, using the positive wire as a pen, write your name or other inscription on the wet paper. The result will be brown lines on a white background.

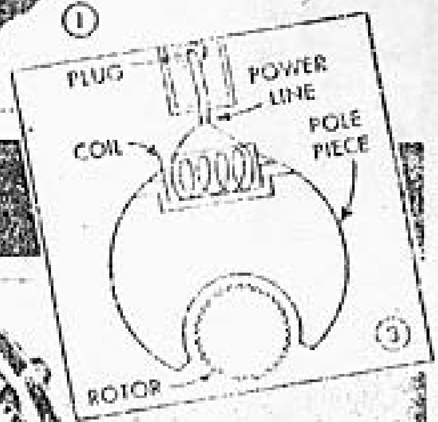


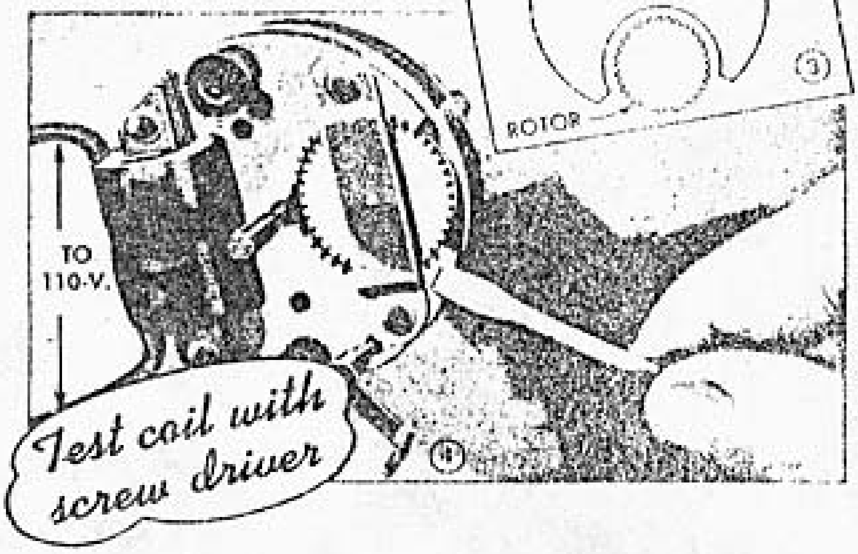
Electrolytic Writing





Tricks of fixing ELECTRIC CLOCKS

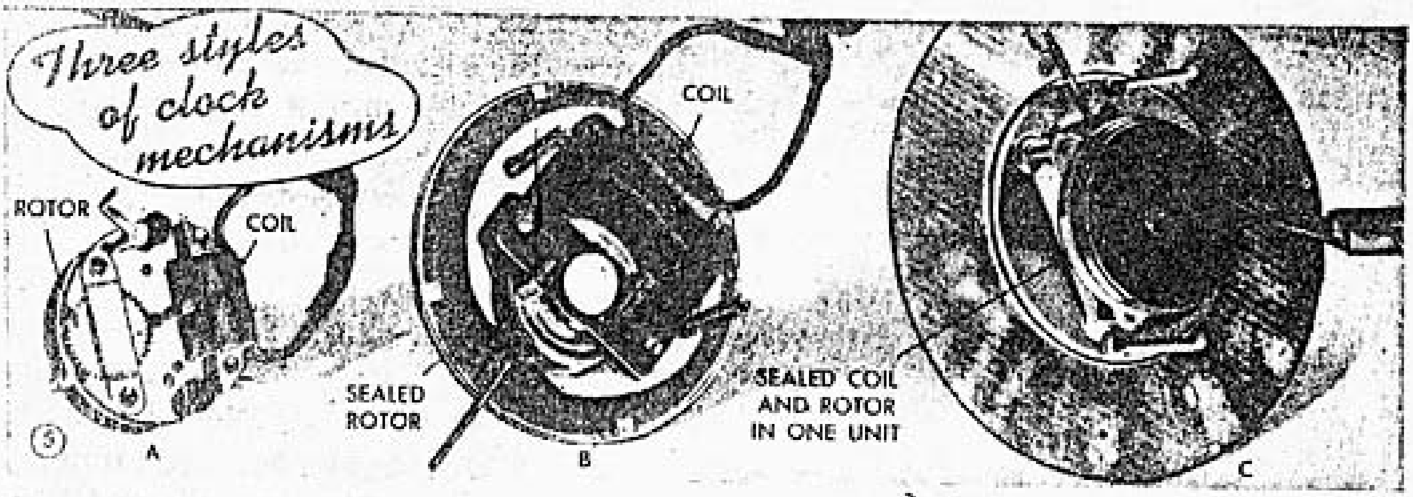


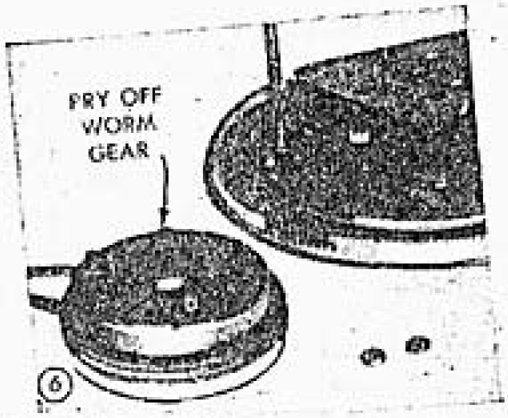


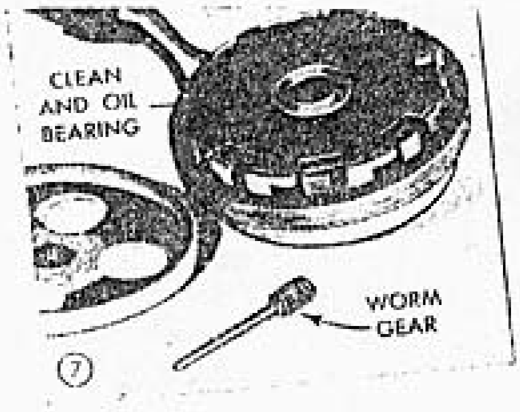
DO YOU have an electric clock that won't run? Just follow these simple steps and it's ten to one you can start the hands going again. First, dismantle the clock. This is a simple procedure, which involves taking out a couple of screws to remove the clock back or the entire mechanism from the case. It may be a simple unit like the one shown in Figs. 1 and 3, or the driving mechanism may be sealed, as those shown in details B and C of Fig. 5. At any rate, the actual operation is the same as diagramed in Fig. 3—the current flows through the coil, setting up a magnetic field in the pole piece that causes the rotor to revolve.

Obviously, the first thing to check is the coil. Plug in at power source, then hold the clock to your ear. A faint hum indicates that the coil passes current. The coil hum is sometimes very faint and a more positive check is to touch a screwdriver to the pole piece near the rim of the rotor, as shown in Fig. 4. A gentle vibration indicates that the coil is in good condition. If the coil does not seem to pass current go over the wiring. Use any kind of electrical tester and test the current flow right up to the coil, which is easily done by using sharp test prods and sticking them into the wires near the coil, as shown in Fig. 1. If the line tests okay and if the coil is not dead, the trouble, then, must be at the rotor or other point of the mechanism. Perhaps something is jammed.

In many cases, a dry, gummy bearing at the rotor is the source of the trouble. Clean the clock as well as you can with a small piece of cloth wrapped around a matchstick and dampened with any kind of cleaning fluid. Then, with a pointed match, carefully oil all the bearings that you can see, and the rotor shaft, as in Fig. 2. Use any good grade of nondrying, nongumming oil, such as watch oil, gun oil, etc. After this, it's probable that the clock will run. If it doesn't, check the mounting—sometimes this is rubber tubing over studs and the rubber may have deteriorated, letting the clock sag so that hands or other parts rub. Rubber mounting can be replaced with "spaghetti" tubing used in radio work. Spin the rotor of the clock with your finger



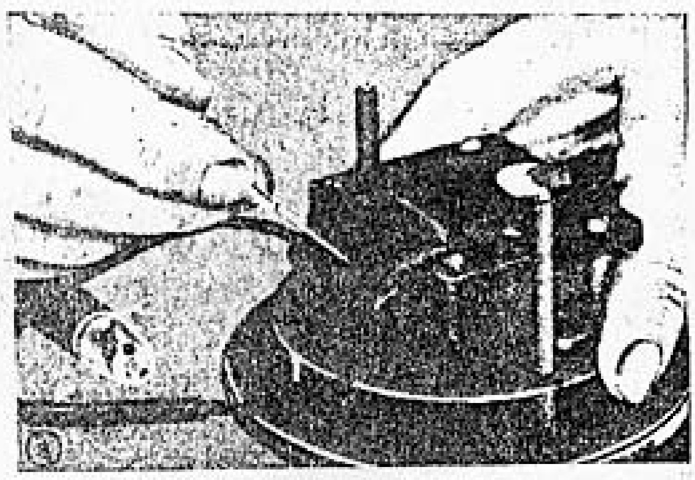




—it should revolve freely. Don't worry about end play at rotor shaft; it is made that way and centers automatically in the magnetic field when the clock is running.

If your clock has combined coil and motor like the one shown in detail C of Fig. 5, remove the whole unit by unscrewing two nuts that hold it in place. It will then look like Fig. 6. With slim pliers or other suitable tool, pry off the worm gear. The parts are shown at Fig. 7. Then the long bearing surface can be cleaned and reoiled.

Coil repairs are usually impractical and, in sealed units, impossible. However, with the open type of coil as shown in details A and B of Fig. 5, it is worth looking into as a last resort. Split the insulation, Fig. 8, and unwind the first layer of wire. If you find a break, you can fix the coil by soldering. If you don't find the break in the first layer you can stop right there because invariably the break is near one end or the other. Obviously, you can't get at the inside end. The final remedy is to write the manufacturer for a quotation on a new coil. Many manufacturers will exchange rebuilt units for defective ones at a nominal charge.

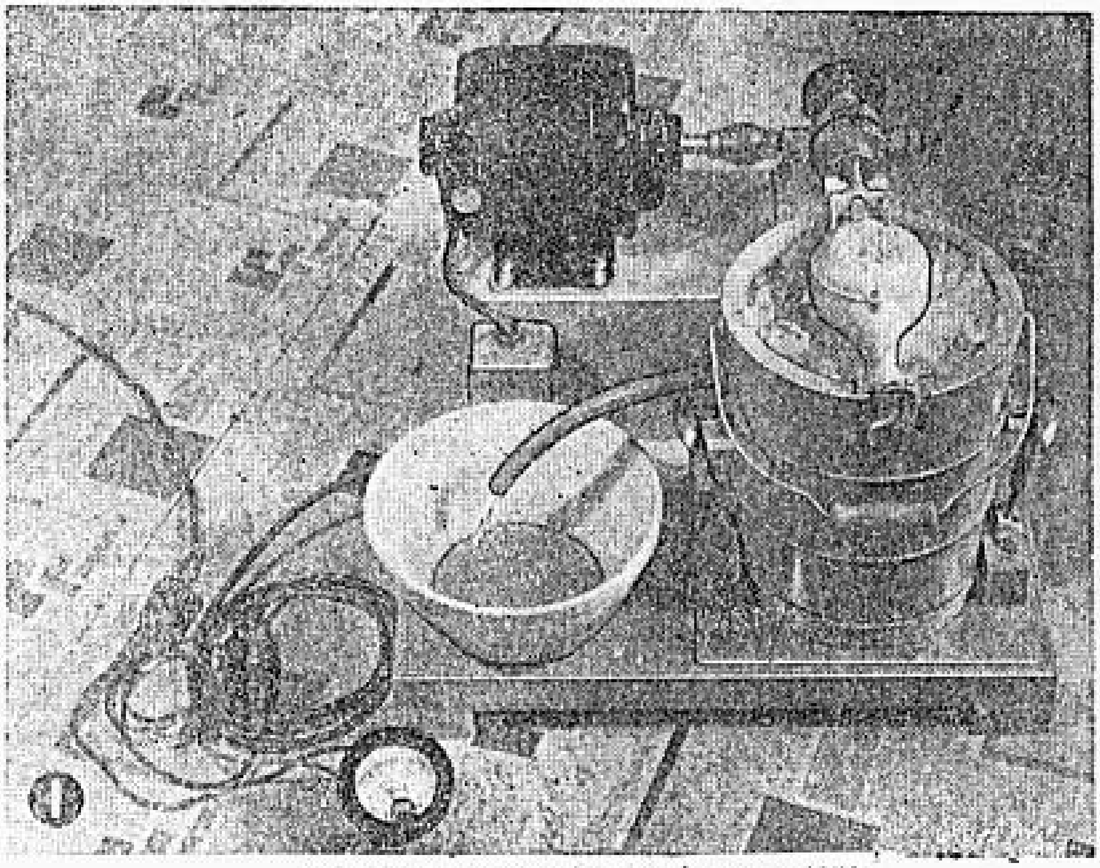


Adding Life to Electric Clock

Sometimes an electric household clock stops running because the gears are worn and do not mesh properly. If this is the case, the clock can be restored for many more years of service simply by turning the works upside down and replacing them in the case in this inverted position. Before reassembling the clock mechanism clean all visible working parts with a soft cloth slightly coated with a fine machine oil.

 GRANDDAD'S ELCTRICITY BOOK

ELECTRICITY


1

SCIENCE AND MECHANICS AUGUST, 1950

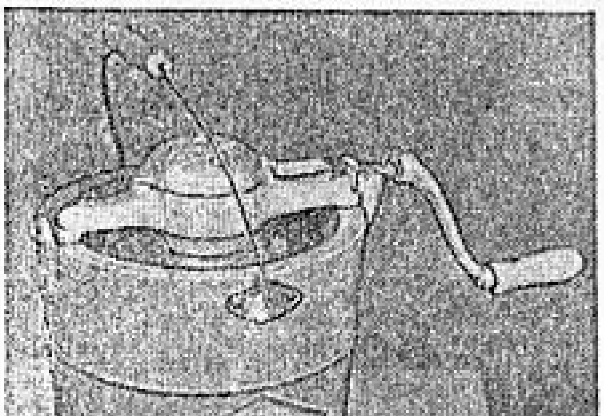
Electrify Your ICE CREAM FREEZER

Let a motor do the work while you just wait for that rich, cool goodness

By HAROLD P. STRAND
Electricity Editor

WHILE ice cream made in the freezer trays of automatic refrigerators tastes good, its quality and quantity cannot compare with that made in the old-fashioned hand-turned freezer. However, if you find the chore of turning the crank very tiresome, here's how you can convert a standard White Mountain freezer of 2-quart capacity to an electrically-operated one. Freezers of larger size can also be electrified, if you use a larger motor and worm-gear speed reducing unit than that used on this job.

For the 2-quart freezer, use a 1/4 *hp* split-phase or capacitor motor. A 48-to-1 ratio gear unit is required to reduce the 1725 *rpm* delivered by the motor to 36 *rpm*, which is an average cranking speed. This also increases the power output. While this item can be purchased new for about $20.00 to $25.00, the one illustrated was picked up in a second-hand machinery shop for $5.00. Having a 1/2 in. input and output shaft, no belts or pulleys are required. Flexible couplings are used between motor and gear unit and between gear unit and freezer. One of the features of this electrified freezer is a breaker type control switch, which carries the motor current until the frozen mixture becomes stiff. The current has then reached a value that causes a heater element in the switch to trip the switch off. This not only protects the motor against an excessive overload, but shuts off the power when the ice cream is finished. A selection of heater elements, a list of which is printed on the inside switch cover, allows the use of a heater which will be exactly suited to the particular motor current and which will trip the switch off at the desired time. Experiment until you find the right heater.


2

The freezer used for this conversion is a typical hand-operated type (Fig. 2) using a wooden tub. The rotating metal cylinder in which the ice

MATERIALS LIST—ELECTRIC ICE CREAM FREEZER

No. Req'd.	Item
1	¼ *hp* 1725 *rpm* split-phase or capacitor motor, ⅝" shaft
1	White Mountain 2 qt. ice cream freezer
1	worm gear speed reducing unit, 48 to 1 ratio, ½" shafts (or larger). Sources of supply: W. W. Grainger Co., Dept. M, 740 W. Adams, Chicago, Ill.; Boston Gear Works, Dept. S, 14 Hayward St., Boston, Mass.; Grant Gear Works, 154-M W. Second St., South Boston, Mass.
2	flexible shaft couplings: one, ⅝" to ½", other ½" to approx. 15/32" or bush as req'd to fit freezer shaft. Latter to be pull-apart variety
1	pc. sheet aluminum, brass or zinc, 10½" x 9½" x 1/16" (tub base)
2	spring hood latches from an old automobile
1	Arrow-Hart and Hegeman Load Limit Switch, Cat. 28210, with suitable heater
2	porcelain or hard rubber bushings to fit ½" knock out holes
8	ft. #18 two-wire rubber SJ cord
1	attachment cap
1	pc. ¾" rubber hose, 8 to 10" long
2	pcs. 1" x 3/16" angle iron 1½" long, shaped to fit side of tub
2	pcs. ¾" x ⅛" angle iron 7" long (securing elevated motor base)
4	*rh* stove bolts ¼" x 3" long (securing gear unit)
4	*rh* stove bolts ¼" x 1½" long (securing motor)
	WOOD
1	pc. hard pine, glued up to width, 20" x 18" x 1½" (base board)
2	pcs. hard pine 18" x 2½" (bottom cleats)
2	pcs. ¾" plywood 16" x 5¼" (sides of motor base)
2	pcs. ¾" plywood 5½" x 5¼" (ends of motor base)
1	pc. ¾" plywood 16" x 7" (top of motor base)
1	pc. maple or oak 4¼" x 4¼" x 1 5/16" (block under gear unit)
1	pc. maple or oak 5" x 2¼" x 1½" (back tub block)
2	pcs. maple or oak 4" x 1¼" x 1½" (side tub blocks)

Misc. screws, paint, etc.

cream ingredients are placed, is operated through a set of bevel gears in the top housing. It was purchased in a local department store for $7.95.

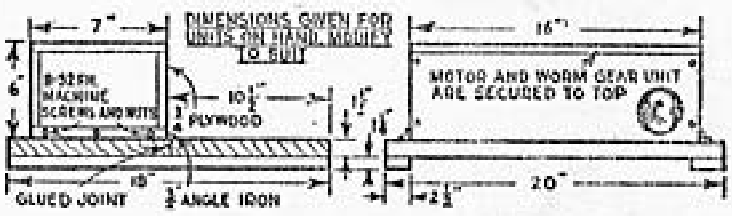
The first step is to unscrew the hand crank, which is no longer required. To do this, hold the cylinder so it can't turn or use a small Stillson on the shaft, and turn crank to left. Next mount the motor and reducing gear on a temporary wooden board, with a block under the gear unit, so the two shafts line up. Use flexible coupling to join shafts. With this set up, place board on a box or other suitable support, so that output shaft of gear unit will line up with that on freezer when placed on a level surface. Use shims or pieces of wood to get this alignment. From this, it is easy to take measurements of the necessary height of the permanent base for the motor and gear unit, as well as dimensions of the baseboard. Place a piece of 1/16 in. aluminum, brass or zinc under tub of freezer, including it in the height of latter. This piece of metal is used in the finished job to take the wear of sliding the tub into place, so enamel finish of baseboard is not worn off.

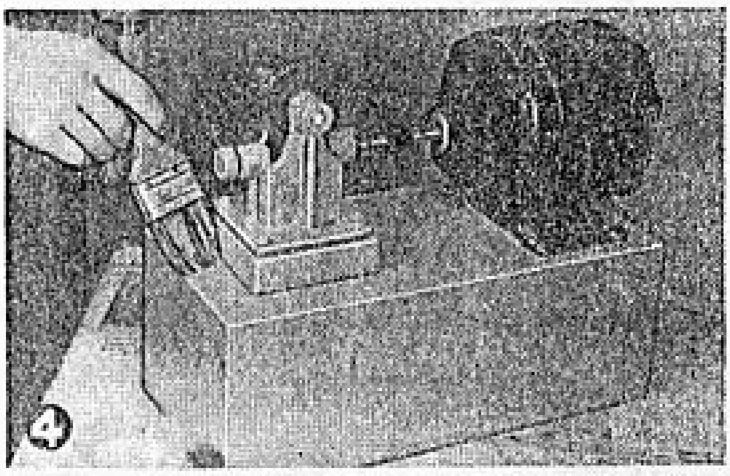
Make elevated motor base (Fig. 3) from ¾ in. plywood, firmly glued and screwed together, and give it a coat of light grey enamel (Fig. 4), a finish selected for the entire job. Use ¼ in. stove bolts to secure units to base and leave bottom side of base open (Fig. 5).

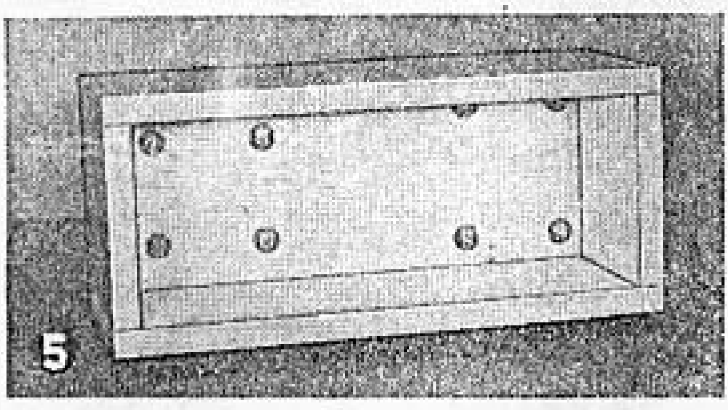
Make baseboard of 1½ in. thick hard pine with two cleats on the under side. If you cannot obtain a piece of plank of the required width, joint and glue two pieces of 10 in. width. After clamping and drying, put the piece through a thickness planer to smooth up the board and get the required thickness. Attach cleats with heavy *fh* (flat head) screws (Fig. 6), countersinking for screw heads, to make a solid, non-warping base for the job. This is necessary to maintain perfect alignment of driven shaft with gear unit.

Give a coat of paint to baseboard and allow time for drying, then secure motor base in place with 2 pieces of ¾ in. angle iron (Fig. 7). Use 3/16 in. stove bolts through ends of motor base and 1 in. #9 *fh* screws into base board, countersinking for the heads in the angle iron. To locate base properly, put freezer in position (Fig. 7), with freezer coupling in place on shafts (Fig. 8). Coupling must separate by pulling apart, so that freezer can be slipped back to remove it. This uses 2 leather discs with 4 holes to fit 4 studs in coupling flanges.

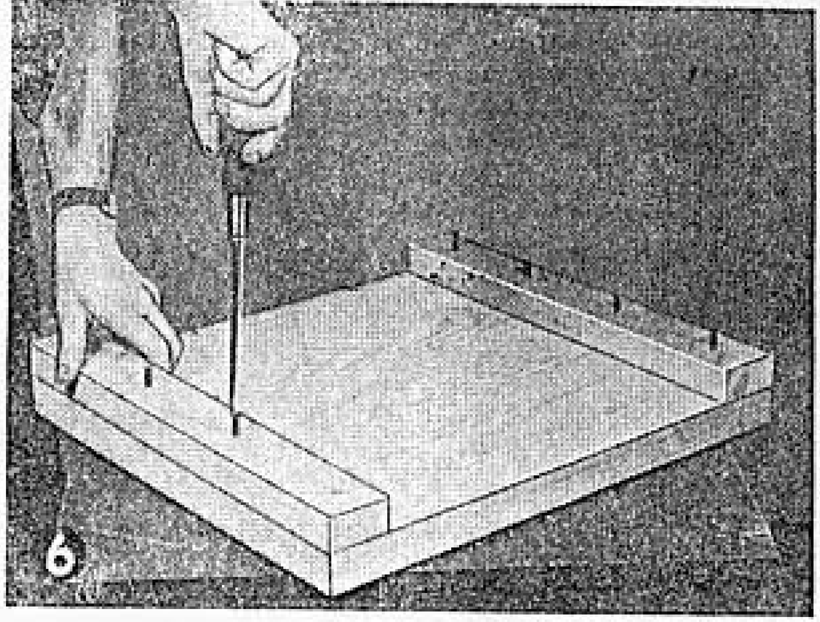
Cut back block or stop for freezer from hardwood such as maple or oak (Fig. 9). Cut a groove in concave side for lower hoop to fit in, with a Dumore Duplex motor tool equipped with a routing burr (Fig. 10). Attach side blocks also with a groove for hoop, to base and through alumi-

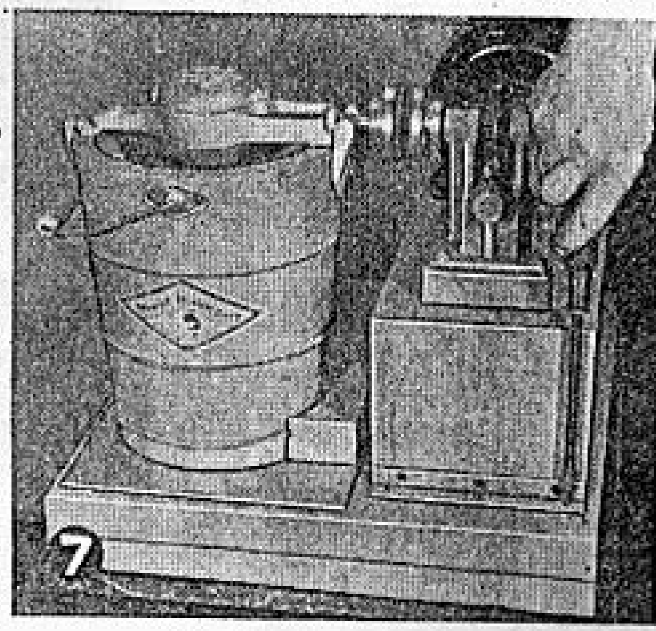



4

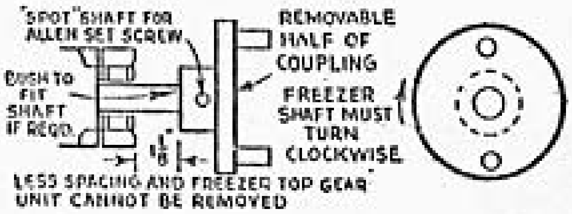

5

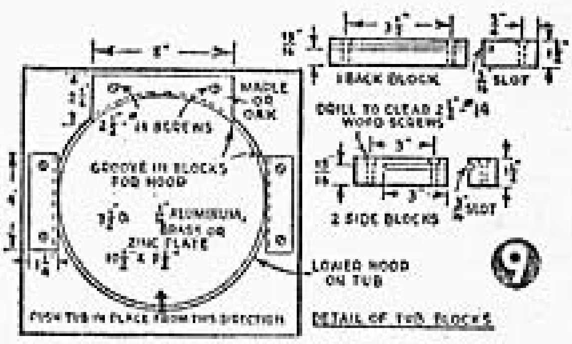
 GRANDDAD'S ELCTRICITY BOOK

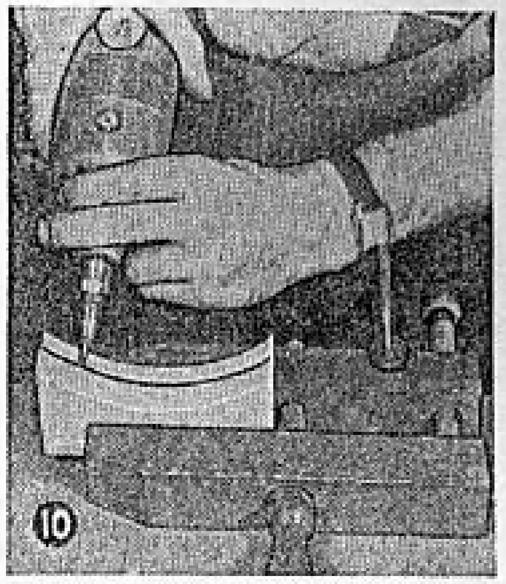




num plate with 2½ in. #14 *fh* wood screws, placing them so tub will slide easily in place (Fig. 11).

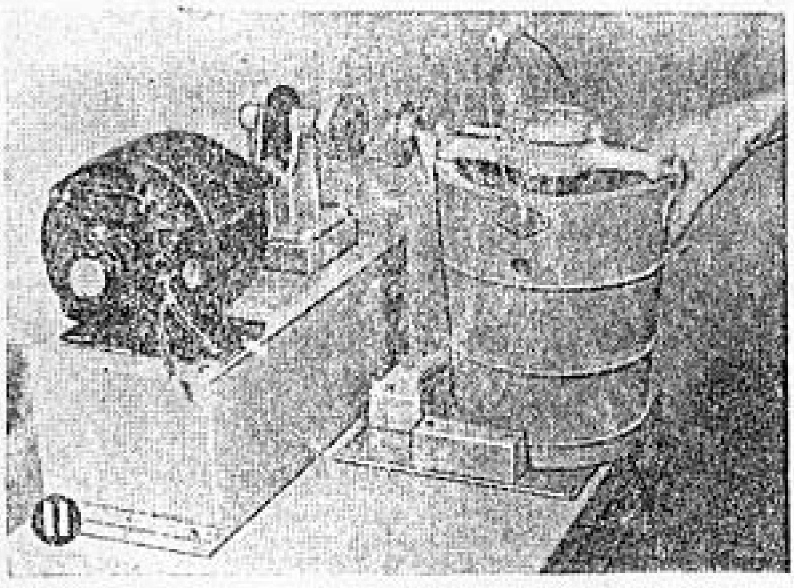


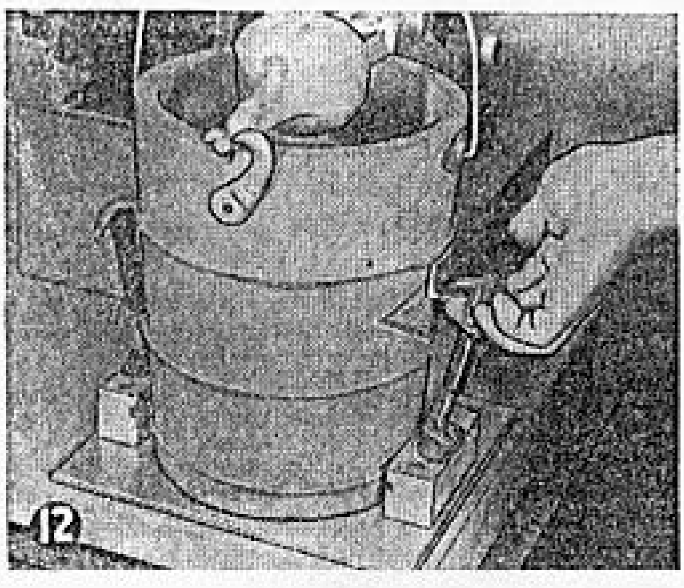




Two hood fasteners from an old automobile can be used to hold freezer firmly in place during churning operation (Fig. 12). Obtain a pair alike with good spring tension. Attach lower ends to side blocks with 1 in. #9 wood screws and hook top ends in holes in angle brackets secured to tub. Make brackets (Fig. 13) from short pieces of 1 in. angle iron, curving surface to fit against rounded tub, by hammering in the vise. Use 10-32 *rh* (round head) brass machine screws, washers and nuts to hold brackets to tub at required height.

Now make the electrical connections (Fig. 14). Mount the breaker type switch box to side of motor base with short screws and rubber grommets or porcelain bushings used in knocked out holes in the 2 ends of switch box. A short piece of rubber cord runs from top end of box to motor and the line cord of the same material comes in the lower end. Since this switch is of the single pole variety, one soldered and taped splice is made between the 2 cords, the remaining free ends being attached to switch terminals (Fig. 15). After making connections to switch and securing latter to box, put heater in position and tighten its 2 screws (Fig. 16). In action, coiled heater increases in temperature with added load, until this is sufficient to cause a bimetallic spring piece





to bend and trip the switch. A piece of rubber hose is fitted into hole in side of tub, to allow water from melting ice to run out into a bowl or pan (Fig. 1).

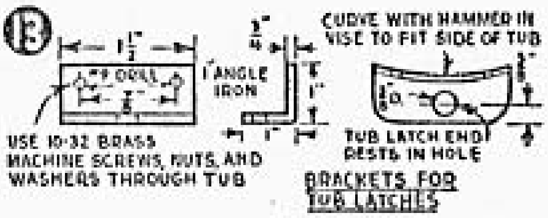
Before placing the machine in operation, lubricate all working parts. Place a few drops of oil in each motor oil cup, the oil holes at the bearings of gear unit, and apply a little light grease to worm gear, unless it is of enclosed self-lubricating type. The manufacturer of the freezer advises applying 2 or 3 drops of light oil in the hole of top gear housing of freezer and a like amount to the shaft bearings. Avoid too much oil, as it may work into the ice cream.

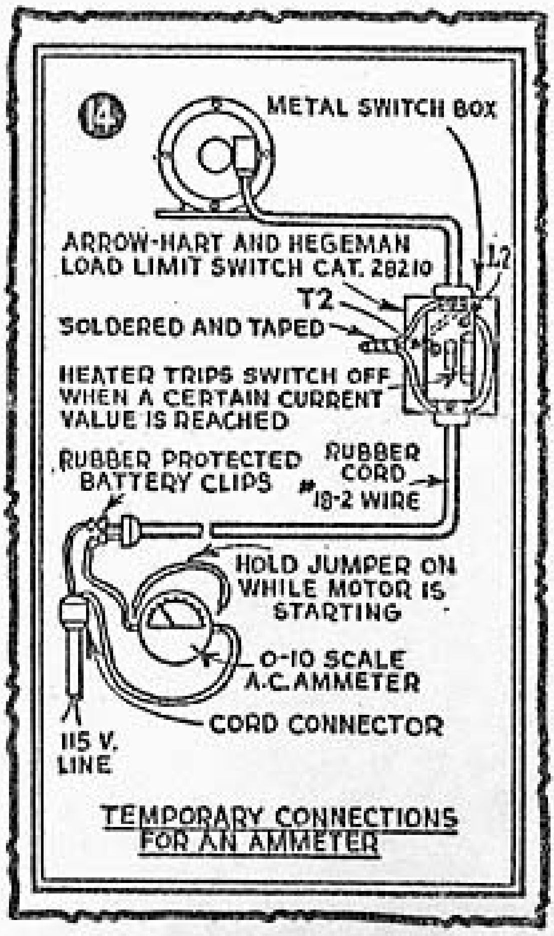
Scald in double boiler, 2 cups of milk. Combine 2 beaten eggs, 1 cup of sugar, 1 tablespoon of flour, ¼ teaspoon salt. Stir constantly until it thickens somewhat. Cool, then add 1 pint of light cream. Allow this mixture to thoroughly cool and keep in the refrigerator or on ice until ready to use. At that time, add about 1 pint of crushed fresh or frozen strawberries. If some other flavor is desired, omit the berries but add 2 teaspoons of vanilla when adding the cream, for plain vanilla ice cream.

How to Operate the Freezer

To use the freezer, obtain some rock salt and ice, together with 2 wooden boxes or metal containers. Use one box to crush the ice and the other to mix the ice and salt. The finer the ice is crushed or chipped, the quicker the freezing action. A White Mountain ice chipper accessory can be purchased cheaply and reduces the amount of work necessary. Salt has a great attraction for water and causes the ice to melt. The melting ice absorbs heat from the mixture in the can, reducing its temperature. The correct proportion of salt to crushed ice is one part salt to five parts ice.

Prepare the ice cream mixture before mixing the salt and ice. A recipe for strawberry ice cream is as follows:

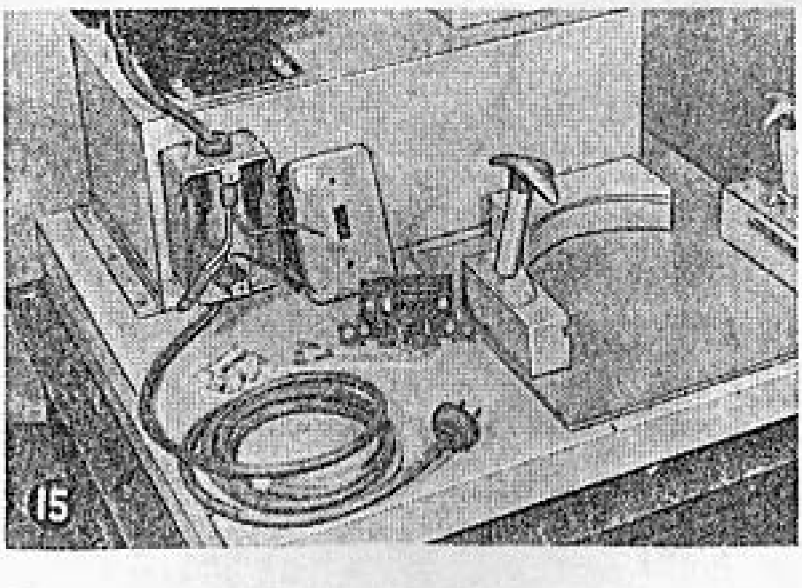


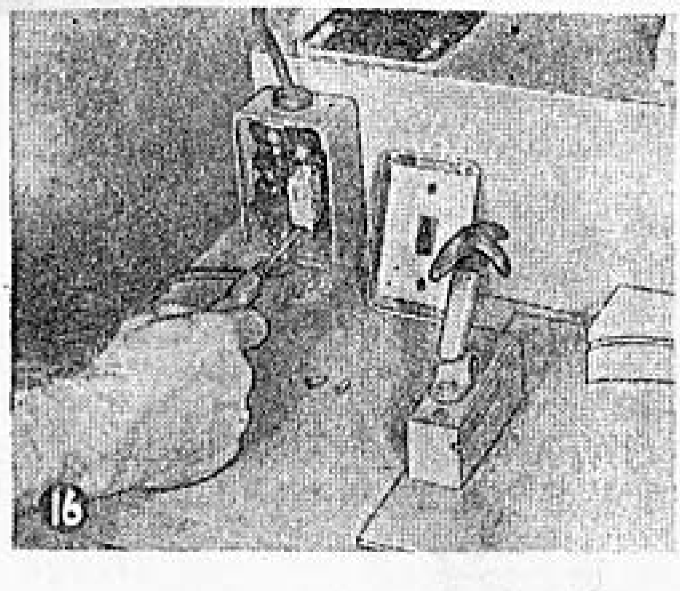


When ready for the freezing job, fit the beaters in the can and place can in position on center point in tub. Pour in mixture, filling the can not over three-quarters full. Put cover on and fit top gear unit in place. Line up studs of coupling with their holes and slide tub into position. Use side spring latches to hold tub.

Pack the ice and salt mixture around can, tamping it down well so that all surfaces of can will be in contact with freezing mixture. Keep can completely covered during freezing, adding ice as required. Turn motor coupling by hand for a few revolutions, to make sure can turns freely and all parts are in place. Allow freezer to stand fully packed for a few minutes, then throw on the switch. Rotation of freezer shaft should be clockwise, or the same way as the crank would be normally turned. This is important and should be checked during building of freezer, reversing motor rotation if necessary.

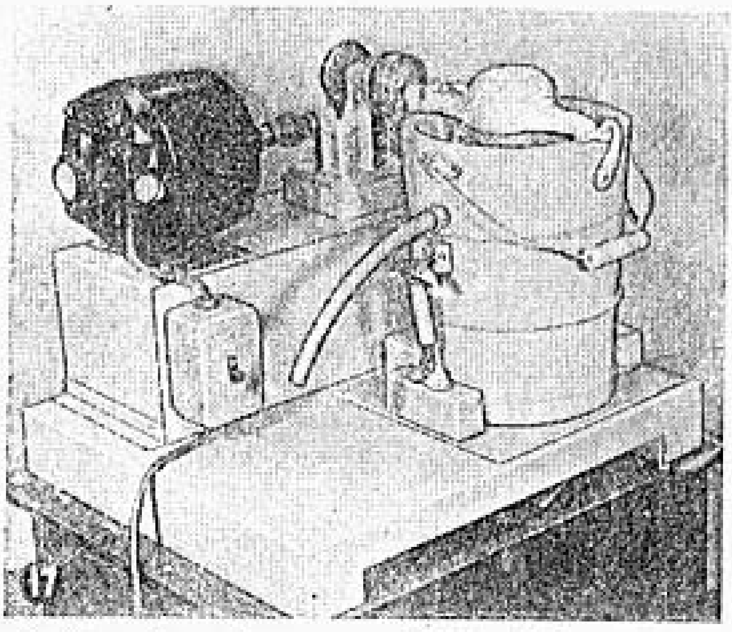
Generally speaking, split-phase motors with 2 leads are not reversible outside the motor. One end of the main winding and one end of the starting winding are tied together in a splice, which





connects to one side of the line (Fig. 18A). Since reversing is accomplished only by interchanging the starting winding with respect to the main winding, it is necessary in this case to disassemble the motor and open this splice, so the 2 ends of the starting winding can be reversed. The starting winding is usually of much smaller wire than the other winding and is located in the top of the slots. Then too, it can be traced as one side going to the centrifugal starting switch.

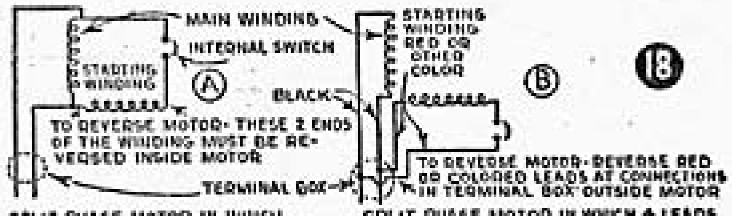
Some of the binding tape may have to be cut and later replaced, in order to trace out this common splice in the winding and effect the change suggested. It is a good plan, once the 2



windings have been separated, to bring out separate leads, 2 black ones for the main winding and 2 red ones for the starting winding. In this way, the motor is easily reversible in the terminal box (Fig. 18B). Some motors are already wound as reversible type, in which case it is very easy to reverse them by simply interchanging the 2 starting leads in the terminal box. Some 4-lead motors are for 115 and 230 volts, the leads being connected in parallel for 115 volts and in series for 230 volts. Such motors cannot be reversed outside the motor as suggested with the other 4-lead motor. To make sure, examine nameplate; if it states a single voltage, such as 115 volts and you have 4 leads, the chances are that it is a reversible motor. If both 115 and 230 volts are mentioned, it is not, unless additional leads are also present.

Should all 4 leads of single voltage motor be of the same color and no identification is given otherwise, use an ohmmeter to test the windings. Obtain a circuit across one pair of leads, with no connection to the other two; this must be one winding. Testing across the other pair should also show a circuit, with no connection to the first two. Now read resistance of each pair. The one showing higher resistance is the starting winding, and connections can be made for either direction as shown in B of Fig. 18.

An ammeter can be temporarily connected in series with one side of the line to record motor current at start and at final period (Fig. 19). In this way it is possible to determine how much current is involved, so as to select the right heater for the switch. At the start, the cream is comparatively thin and the load on the motor will be light. But after freezing has taken place, it begins to get very stiff and the motor will



SPLIT PHASE MOTOR IN WHICH ONLY 2 LEADS HAVE BEEN BROUGHT OUT FOR THE LINE

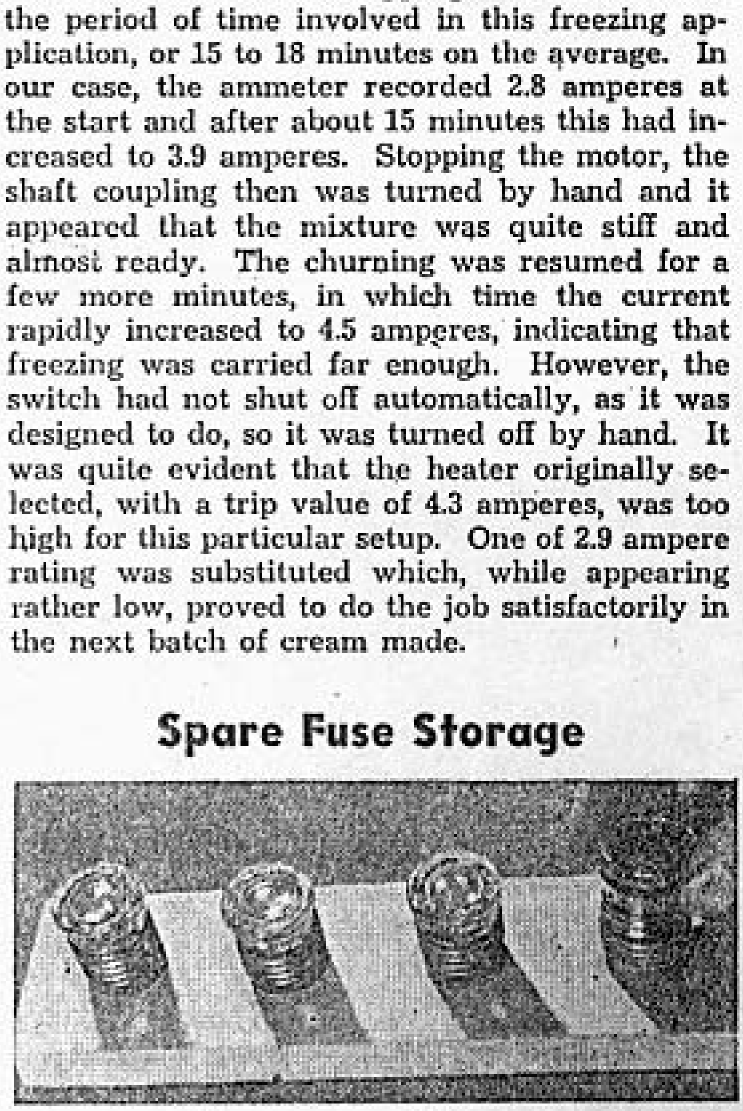
SPLIT PHASE MOTOR IN WHICH 4 LEADS HAVE BEEN BROUGHT OUT FOR EASY REVERSAL

have to operate at near its full load, in which case the current will rise. It is important to open the switch before an excessive load is placed on the motor or its driven units, to avoid damage. Therefore, the heater tripping value must be carefully selected.

Time Delay for Thermal Types

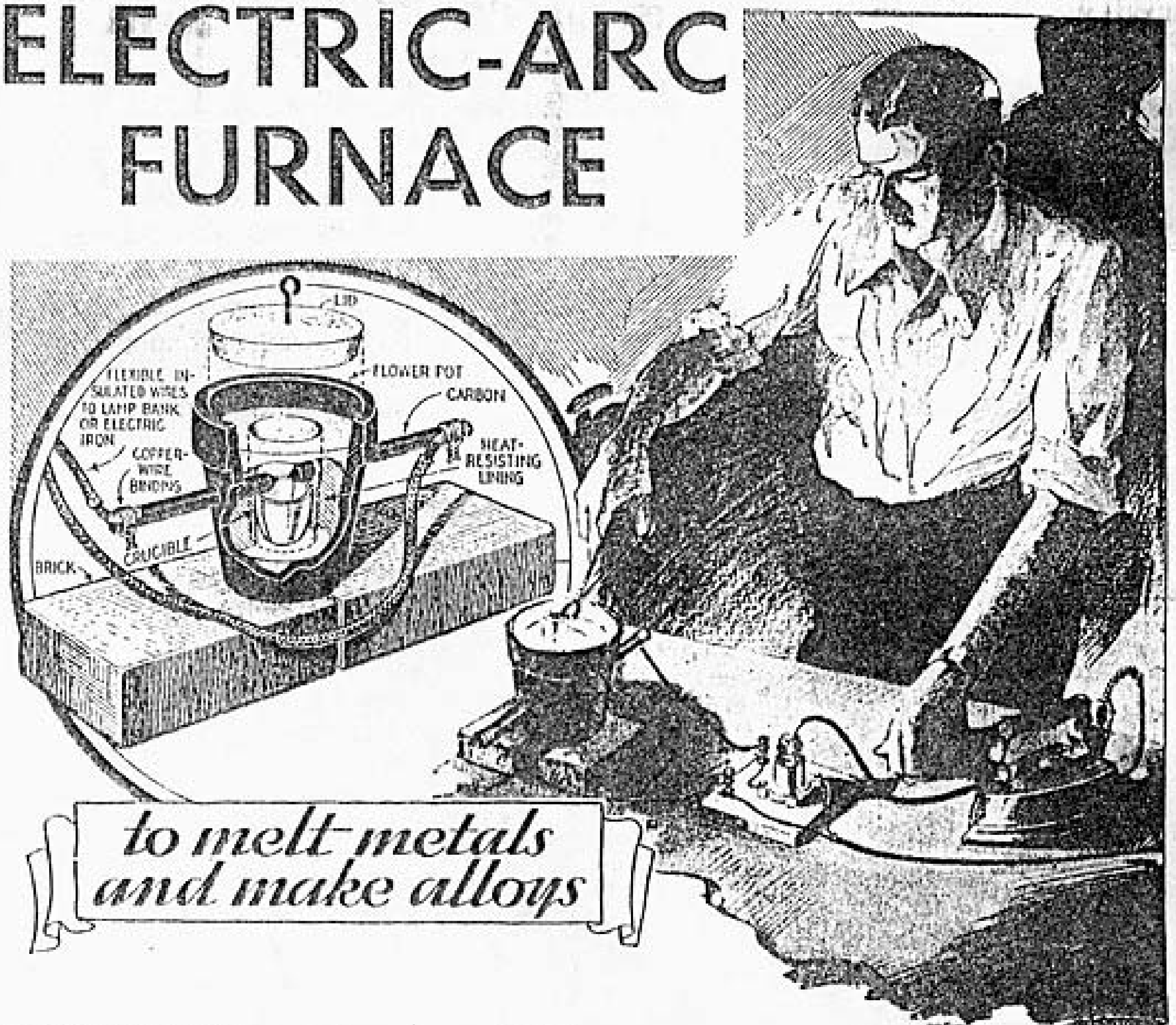
All thermal type heaters have a time delay, before they will actually trip the switch. The author also found that their ratings seem to be much lower than their tripping current value for the period of time involved in this freezing application, or 15 to 18 minutes on the average. In our case, the ammeter recorded 2.8 amperes at the start and after about 15 minutes this had increased to 3.9 amperes. Stopping the motor, the shaft coupling then was turned by hand and it appeared that the mixture was quite stiff and almost ready. The churning was resumed for a few more minutes, in which time the current rapidly increased to 4.5 amperes, indicating that freezing was carried far enough. However, the switch had not shut off automatically, as it was designed to do, so it was turned off by hand. It was quite evident that the heater originally selected, with a trip value of 4.3 amperes, was too high for this particular setup. One of 2.9 ampere rating was substituted which, while appearing rather low, proved to do the job satisfactorily in the next batch of cream made.

Spare Fuse Storage



• Threaded shells removed from discarded electric-light sockets are ideal receptacles for spare fuses. Fasten several shells to a wooden panel and mount near fuse box.—WM. SWALLOW.

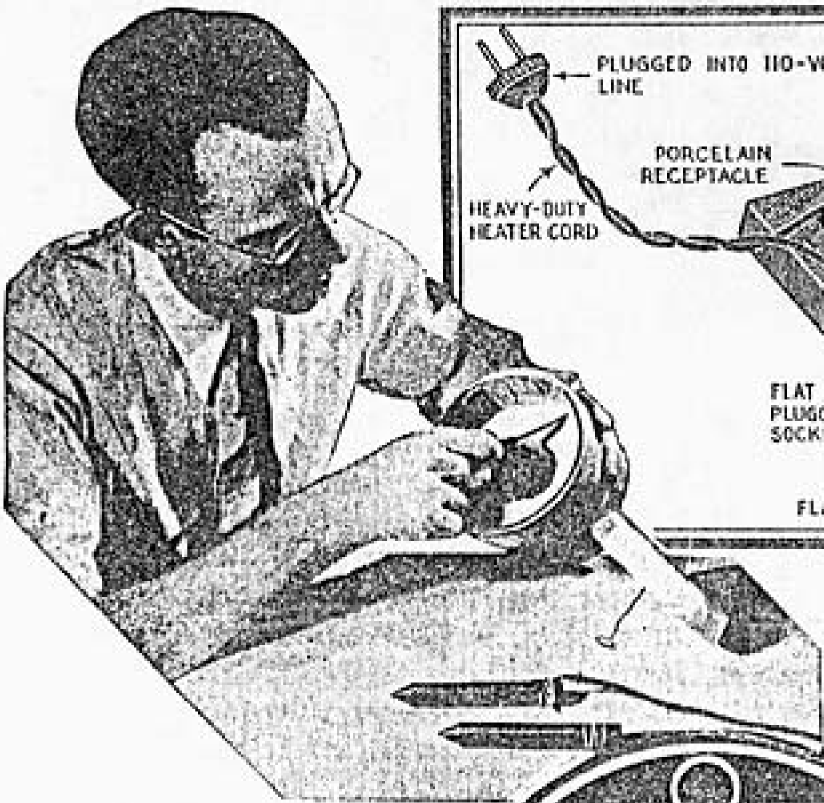
ELECTRIC-ARC FURNACE

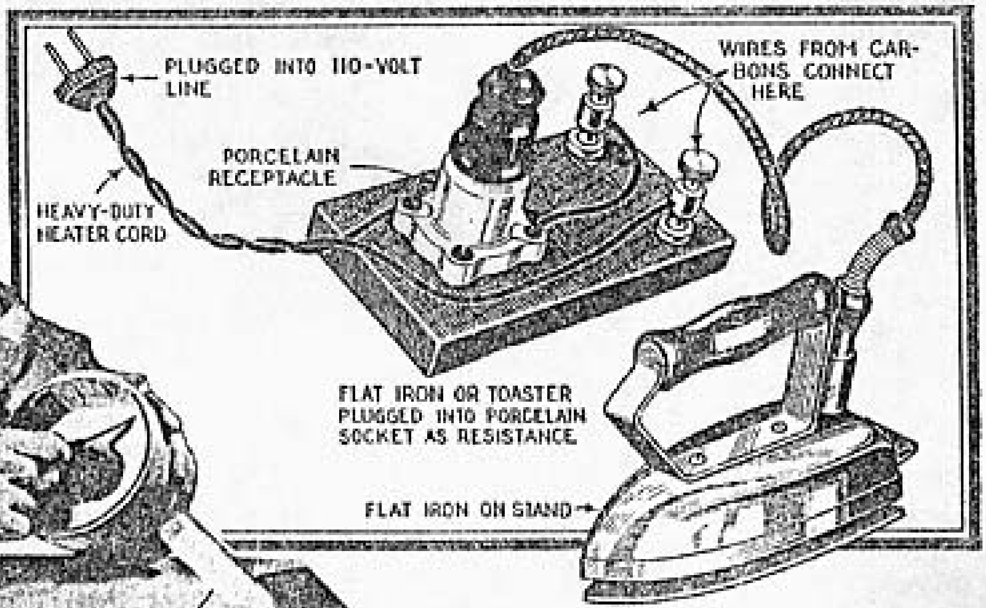


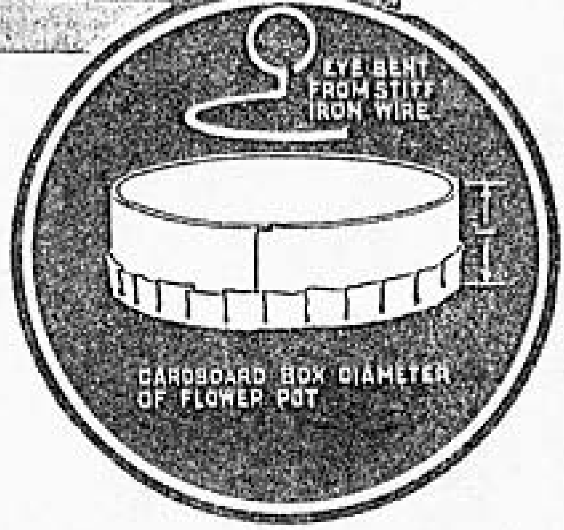
to melt metals and make alloys

WHERE high temperatures are needed for melting small quantities of metals, making alloys, or performing chemical experiments requiring intense heat, a small electric-arc furnace, which is easy to make and costs little, will often be found indispensable in the home workshop or laboratory. It is built in a flowerpot, as shown above. Holes for two electric arc-light carbons are cut into opposite sides of the pot about three-fourths of the height of the pot above the bottom. The holes should be just a fraction larger in diameter than the carbons. They are best made by slowly drilling through with a small drill, after which they can then be carefully reamed to the proper size with a coarse rat-tail file.

A good refractory lining for this furnace is made by mixing while dry, equal parts of fire clay and ground asbestos. This filling material is worked to a thick, even, putty-like cement with a small quantity of water glass. Only the amounts to be immediately used should be made up, as when allowed to stand, this cement gets stone hard and becomes useless. The bottom of the flowerpot is covered with the refractory cement to a depth of about 1½ in. It should be pressed firmly in place and tamped level and even with a flat-ended stick. A smooth drinking glass whose sides taper slightly is now set upright on the center of this bottom lining to serve as a mold for the side lining. The arc carbons are next wrapped with a layer of asbestos paper, which may be secured in place with a short length of thread. They are then inserted through the holes in the pot and their ends pushed square against the drinking glass. The asbestos is used to prevent cement from sticking to the carbons and thus making it impossible to remove them, after the lining has hardened. The space between the glass and







the pot is next filled to within 1½ in. of the top with the lining cement. It should be applied in small quantities, packing thoroughly to eliminate air pockets. The drinking glass should be carefully removed immediately after the packing is complete, otherwise it may permanently stick to the cement and have to be broken away after the lining has hardened. If the glass is to be saved it should be immediately washed in water to remove the water glass. The carbons should next be carefully turned in their asbestos wrappers to make certain that they are not stuck. They should not be removed, however, until the lining has dried for a couple of days. The lining may be dried out in an oven in about 5 hrs., although a better job will be had if it is allowed to dry in the air for a week.

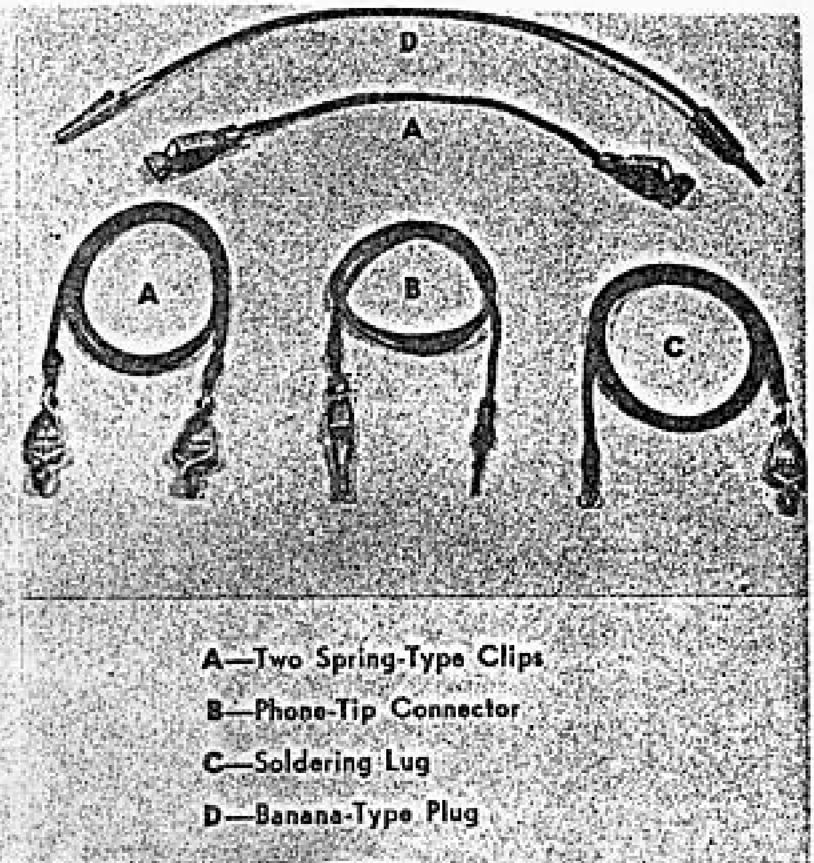
To make a lid for the furnace, get a round cardboard carton of the same diameter as the inside of the flowerpot, and cut it to a depth of about 2 in. to serve as a mold. Before pressing cement into the box a piece of stiff iron wire is bent to the form of an eye at one end. The other end should be buried in the cement cover so that only the eye projects to serve as a handle for removing the cover from the furnace with a pair of tongs. The cover should be allowed to dry in the mold and the cardboard is torn away after the cement has hardened.

When the lining has dried the carbons may be removed. A 3-ft. length of heavy-duty heater cord is connected to each carbon at its unpointed end. The strands of fine wire in the heater cord may be held in good contact with the carbons by binding with wire as shown, or if a more permanent job is wanted, brass clamps may be made to hold the wires. The other ends of these wires are connected to the binding posts on a small block as shown. An electric-arc furnace cannot be connected directly across the lighting circuit without blowing fuses, so the family electric flatiron comes into play as a limiting resistance. The iron is plugged into the socket also mounted on the board. With this arrangement the iron is connected in series with the carbons. To start the arc, push the carbons together with their points about in the center of the furnace. This should be done with a pair of pliers having taped handles to avoid shock and burns after the furnace has been running for a few minutes. After the carbons have been in contact for a few seconds they will become hot on the ends, and then one of them may be carefully pulled away

 GRANDDAD'S ELCTRICITY BOOK

from the other for a distance of about ¼ in. A little practice will enable you to draw an arc without difficulty. The cored-type of carbons are the easiest to use. The arc should not be viewed with the naked eye but a pair of goggles should be worn and with these you will be enabled to see the condition of the arc without danger to the eyes.

Copper wires held in the arc are immediately melted and burned. Almost all common substances undergo similar chemical change when they are exposed to the high temperature of the arc. If a few scraps of fine copper wire are cut into short lengths, placed in a small crucible and sprinkled with borax to prevent the formation of the black powder, or copper oxide, which was formed when the wire was held directly in the arc, they may be melted in 10 or 15 minutes. The lid should be kept on during the melting of copper as a great amount of heat will be required. The copper will glow red and finally white, and you may think that it is not going to melt at all, but do not give up, for the wires will presently and unexpectedly lose their shape and form a molten pool of mirror-like brilliancy in the bottom of the crucible. If you add to the molten copper about half its weight of zinc and then turn off the arc, the zinc will melt and mix with the copper to form the common but very valuable alloy known as brass. Brasses have varying proportions of zinc and copper, depending upon their purposes. Similarly, if tin is added to molten copper an alloy known as bronze is formed. There are hundreds of interesting and valuable experiments in this magic of metals known as alloying, which may be performed with this arc furnace. New alloys are discovered or invented almost every day.



MECHANIX ILLUSTRATED, Sept. 1949

Keep Test Equipment such as meters, on a short shelf over the workbench where it is accessible yet out of the way of tools. Two brass fingers screwed to the shelf will prevent pulling the equipment off accidentally.

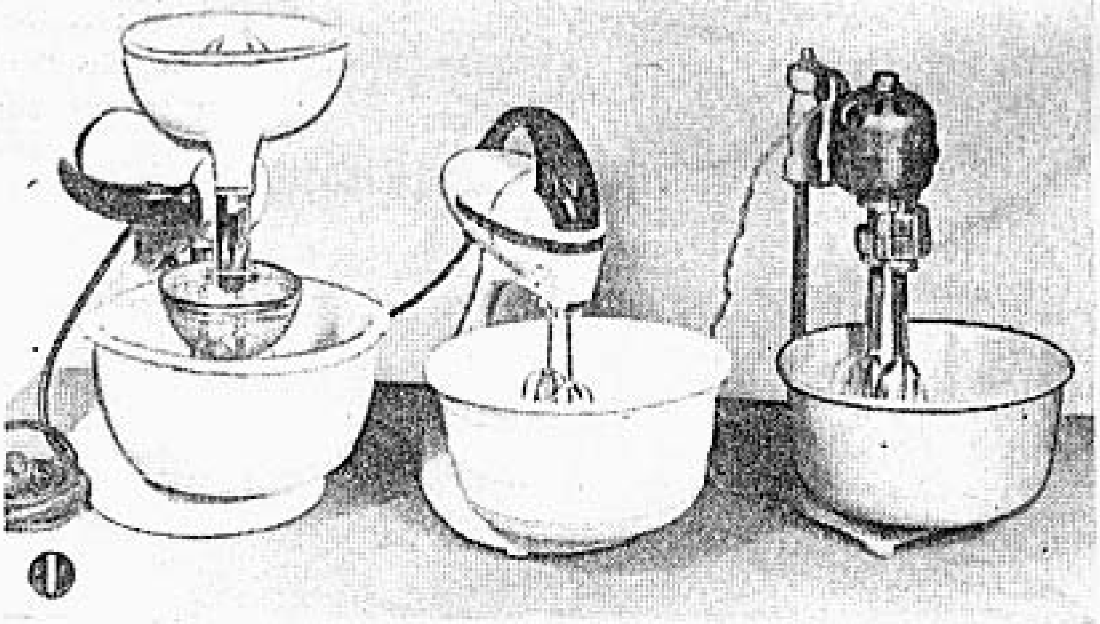
Flexible Leads fitted with clips and other connectors are invaluable for making test connections. Use random lengths of insulated flexible wire and wrap with tape close to each connector to prevent insulation from unraveling.

Servicing ELECTRIC MIXERS

If the mixer didn't do a good job on your favorite cake last time, here is how you can repair it

By HAROLD P. STRAND

SCIENCE AND MECHANICS Dec. 1948



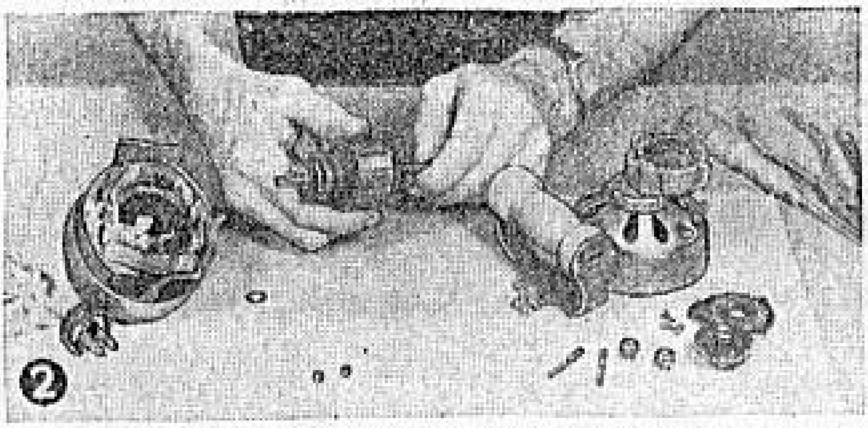
MIXMASTER KNAPP-MONARCH MAGIC MAID

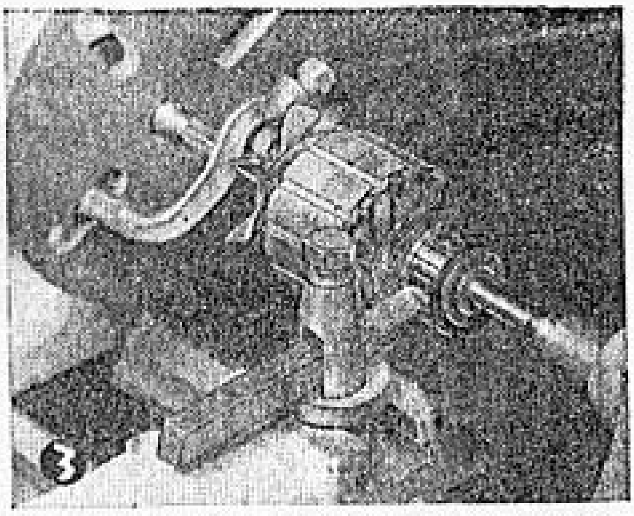
Fig. 1. Three mixers that are typical of those in general use.

SMALL electrical motor-driven appliances such as mixers, portable drills, vacuum cleaners, hair dryers, and hand power tools, all use a universal motor in their design. This type can be distinguished from an induction motor, from the fact that they have a commutator and carbon brushes like a dc motor. In fact, they will run satisfactorily on either ac or dc; hence their name. All iron in the magnetic circuit must be laminated in a universal motor, or else when being operated on ac eddy currents will quickly cause excessive heating. Armature and field are series connected, which gives this motor some characteristics of a dc series motor, such as high speed without load, good torque, and, in addition, easy adaptation to speed control. However, some people think that any dc shunt motor can be re-connected to series and it will run satisfactorily on ac; unfortunately, this is not usually correct. For one thing, many dc motors have a cast iron field structure instead of a laminated one. In addition, windings of a dc motor would not usually be of the correct design for universal use, as far as turns in the armature in relation to those in the field are concerned. Hence if such a motor can be made to run at all, it will likely lack desirable speed and power.

In Fig. 1, three makes of mixers are shown, which will be used as examples of mixer servicing and repair work. Many details discussed here will be found to apply to other makes of mixers, as well as other types of power equipment. So, with a few modifications, the methods described here can be taken as general procedure. Mixer on the right in photo is an old model Star-Rite Magic Maid, which has seen about 15 years' service. It will be completely overhauled to illustrate work that might be expected on machines of this age and type. The other two are modern streamlined machines—center one is a Knapp-Monarch and the left one, a Sunbeam Mixmaster. These two will require much less work than the first, but we will open them up to show their inside parts and make any necessary repairs or adjustments.

Taking the Magic Maid first, remove motor unit from stand, and remove beaters and also handle, by removing four base screws. Loosen and remove two nuts that fit on the long motor tie bolts. Next remove brushes by loosening and removing two insulated retaining plugs. Then tap outer casing apart at the center joint and pull off the half at the gear box end. This allows exposure of armature which is pulled out of its far bearing (Fig. 2). Now you are ready to inspect and clean. The armature receives first consideration. You note that, from long wear of brushes, commutator has become badly blackened and rough. Placed between centers of a small lathe, make a light cut across face of commutator (Fig. 3). Follow with fine sandpaper. Turning should be carried to the point where all roughness and blackened copper is removed, resulting in a clean smooth surface. Some commutators were originally undercut at the factory, or in other words, a slot was cut between each segment to reduce height of mica insulation between. In such a case, a tool should be used to clean out chips from turning and old carbon deposits, after the turning job. Should turning result in reaching depth of original undercutting, commutator should be undercut again. A piece of hack saw blade in which "set" of teeth have been ground off will do for a tool. Draw the blade carefully between segments, with rake of teeth towards you, until mica is down about 1/32 in. or a little less. Finish up with fine sandpaper to remove any sharp edges. In our case commu-





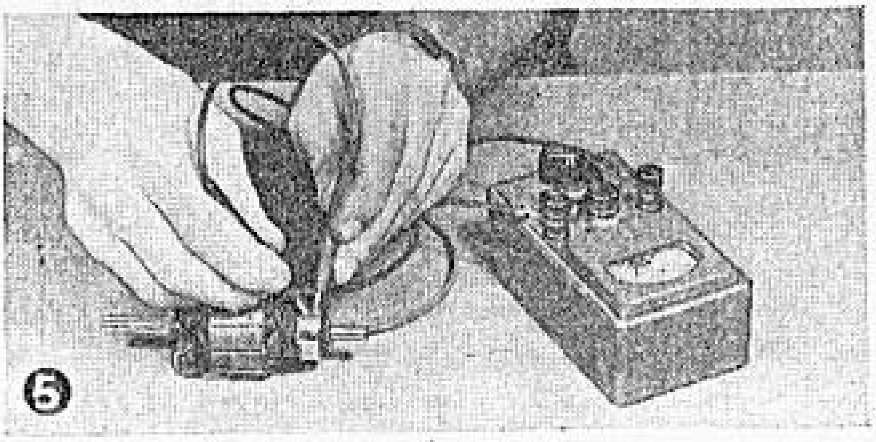
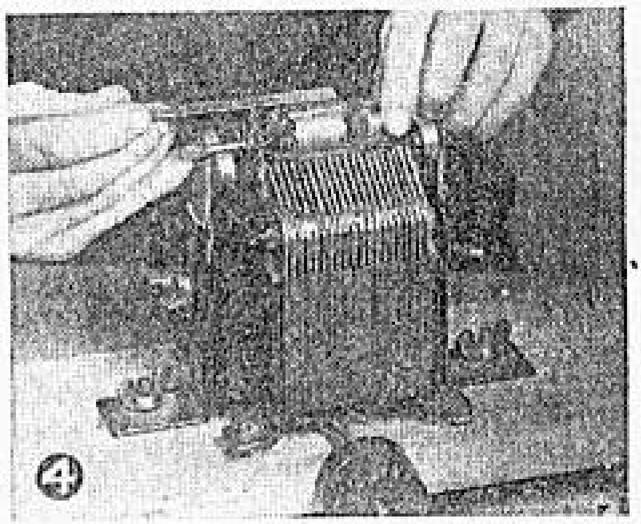
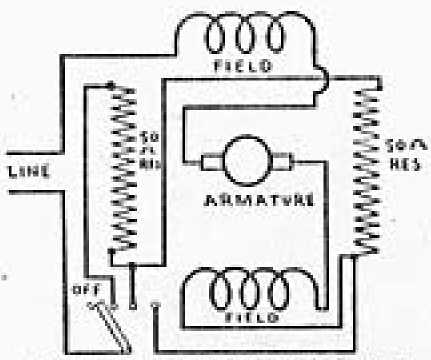


Fig. 2. Oldest mixer shown disassembled on bench for servicing.
Fig. 3. Turning the face of a commutator in a lathe.
Fig. 4. Testing the armature in a growler for shorts.
Fig. 5. An ohmmeter makes a useful instrument for testing armatures.



tator was never undercut, so we left it as it was.



Schematic diagram of Star-Rite Magic Maid' mixer, typical of Universal motor appliances with 3-speed switch.

Next test the armature winding. If a growler is at hand or can be borrowed, place it in position between the poles (Fig. 4), and use a thin piece of steel at the top, as armature is slowly rotated by hand. There should be no attraction for the steel, at any point that the armature is turned. If there is attraction a short exists. In an undercut commutator this could be due to metal particles between segments which can be cleaned out. In other cases, a shorted winding usually has to be replaced. Another useful test is with an ohmmeter (Fig. 5). Touching each pair of adjacent segments with test prods, uniform readings should be obtained all around the commutator. An open or shorted coil will usually register zero. Extremely high or low readings from some pair of segments may indicate partly shorted coil or other winding trouble. Following these tests, make a ground check, using about 500 volts from our high voltage test transformer between shaft and commutator, which should show no circuit. A series lamp on 115 volts will answer if other equipment is not available.

Field section of motor can also be tested with the ohmmeter by touching prods to bared ends of winding for a continuity test. No circuit through a coil indicates it is open and must be rewound. In this mixer a resistance wire unit was placed between each field coil and, through a four-point switch, speed control was effected. The ohmmeter can be used across the terminals of each unit as a continuity test and also to measure the resistance. In our case a reading of 50 ohms was found for each unit, which would be about right. For inspection of these resistance units and replacing cord, other half of outer casing was first removed (see photo). Check condition of four-point switch, cleaning contacts if required, and bending movable arm to increase tension if needed. With all parts cleaned up, a few drops of oil placed on each end of armature shaft, and gear box re-packed with fresh grease, motor was re-assembled. Brushes were still found to be of reasonable length, so they were replaced in their holders. On testing the finished job at the bench, it was found to operate almost as well as new.

The Knapp-Monarch mixer is taken apart by first loosening a set screw in speed control dial and removing this piece. Under this is found a nut, which is unscrewed. Next brushes are removed. On the under side of gear unit at the other end of machine, remove two screws found there, and then gear unit can be withdrawn. At extreme forward end, under this unit, three screws will be found; remove these and then you can remove the handle. It is now possible to remove housing at commutator end. Parts are then laid out for inspection. (Fig. 6). In this machine, a rheostat mounted at the end is used for speed control. Outside the rheostat is a lever type switch which is actuated by control dial, and serves as an on-and-off switch for motor. In Fig. 7, contacts of this switch are being held open for inspection. If found dirty or pitted, a small fine-cut file can be used to clean them up. After a thorough inspection, parts seemed to be in good order in this one, so further dis-assembly was unnecessary. The beaters, however, struck each other in operation, so they were placed in the lathe chuck and were found to run out ½ in. out of true. Center rods were bent (Fig. 8), but it was an easy matter to strengthen them by hand in the chuck. This mixer was assembled again and oil was applied to two oiling holes provided (Fig. 9).

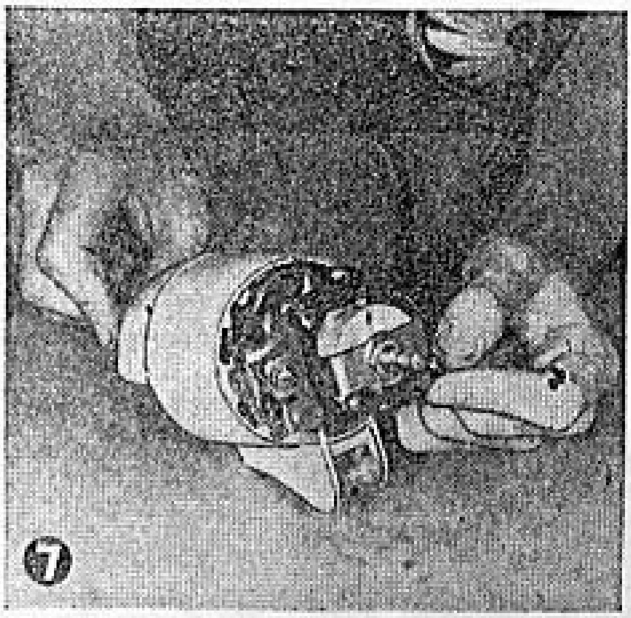
The first step in taking the Mixmaster apart is to pry out center disc in speed control dial and remove a nut, as was done in the last one. This allows dial unit to be removed. Two screws will be found in rim of next section; after removing them this part can be taken off. Next you'll find a rotating switch and two small brushes that bear on collector rings. Remove brushes and loosen the Allen set screw and then you can pull rotating switch element off the shaft. Fig. 10 shows machine in the condition described where parts can be carefully studied. In this machine, speed control is accomplished by means of a governor, the chief element being the rotating switch. Action of centrifugal force on pivoted arm causes contacts to open and close, which serves to cut a resistance in and out as required to maintain desired speed. This round resistance unit is at right of shaft (Fig. 10). The action of moving speed control dial (on end of machine) is to move a conically shaped, slotted piece in and out; this affects the contacts in their opening cycles, thus regulating speed. With this sliding piece in fully-in position, lowest speed is obtained, because contacts will be held open, thus allowing full use of resistance. With contacts held closed, on the other hand, highest speed will be delivered, since resistance will be shorted out. Further action of dial is to actuate a plunger rod, which connects with an on-and-off switch, for the off position of the dial. A condenser shown at left is also connected in parallel with the contacts, and helps to eliminate radio interference and lessen arcing at contacts. Both resistor and condenser can be replaced when defective by simply spreading brass supporting strips apart and lifting raised buttons on their ends out of

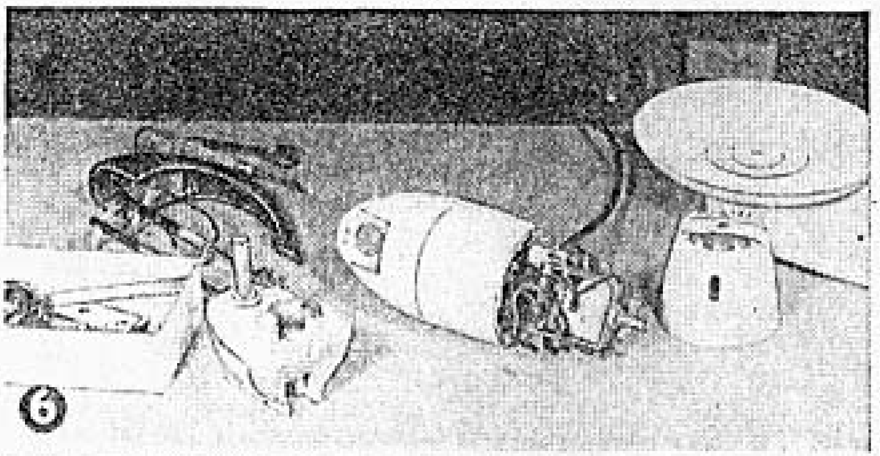
Fig. 6. The Knapp-Monarch mixer is shown disassembled for inspection and whatever service is required.

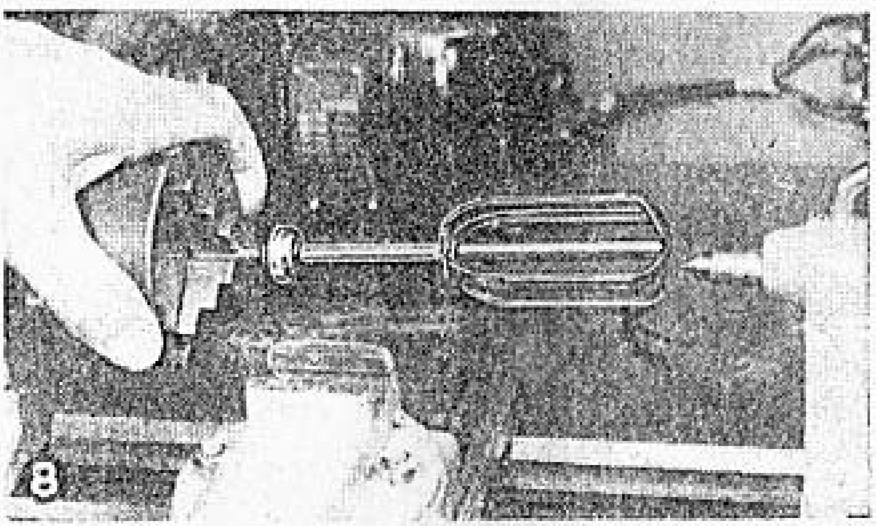
Fig. 7. The control end, showing rheostat and switch. Points are being held open to check contact surfaces.

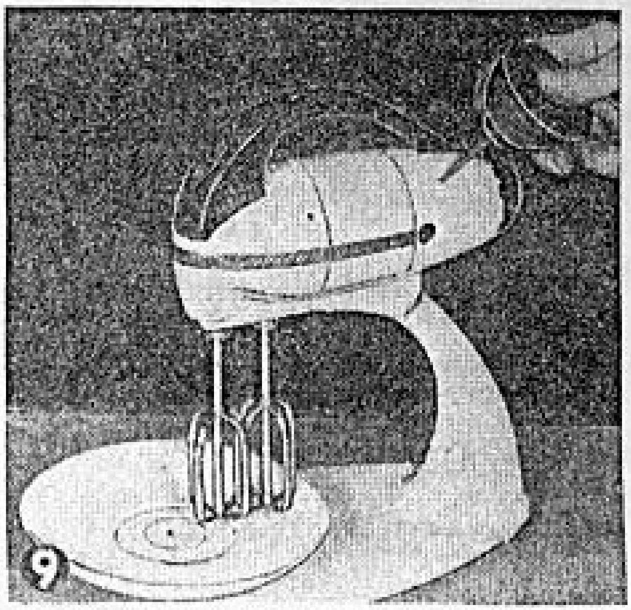
Fig. 8. Beaters can be checked and straightened in lathe chuck.

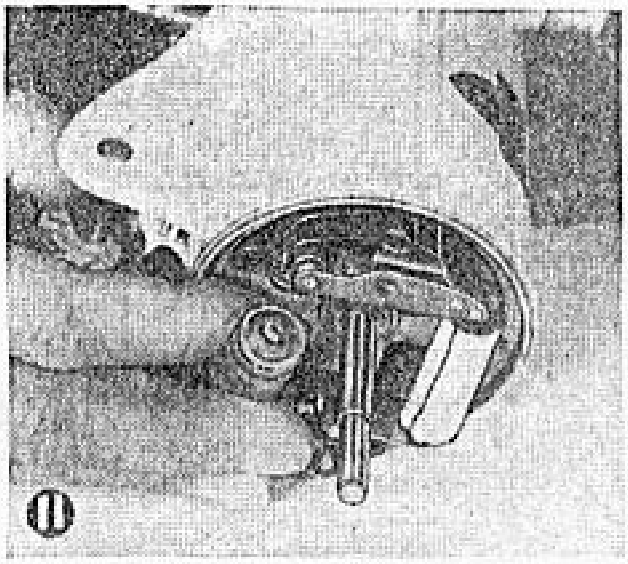
Fig. 9. Two or three drops of medium oil should be applied every two months or so to oiling holes provided on mixer.

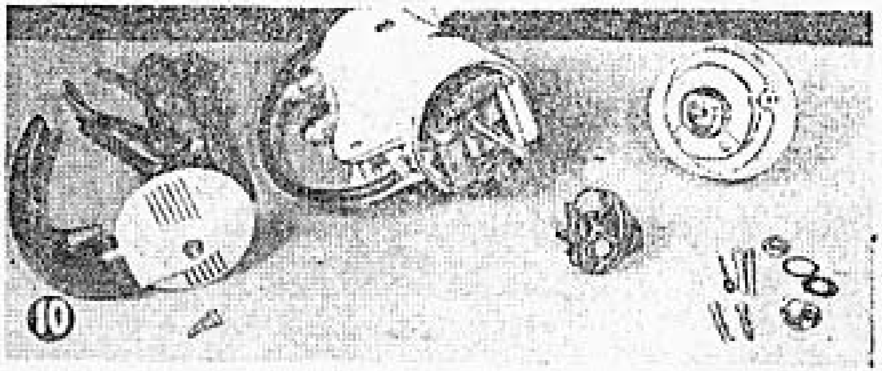

7


6


8


9





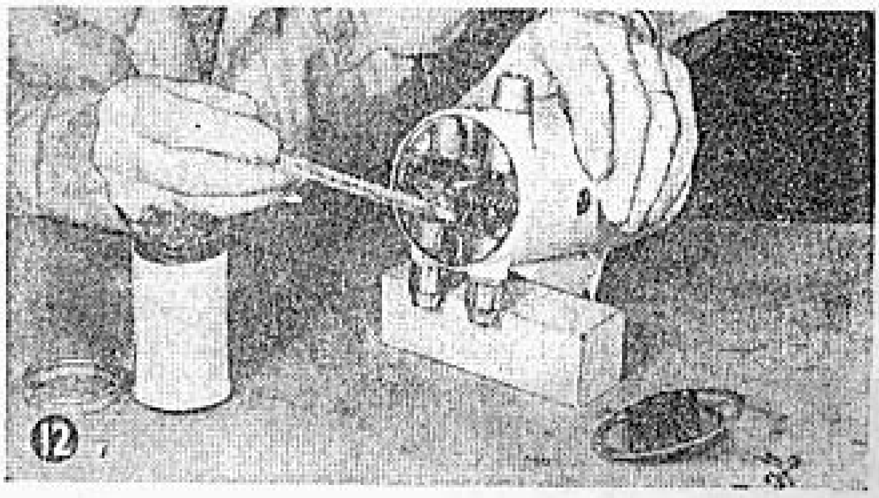


Fig. 10. The Mixmaster is shown partly disassembled on the bench..

Fig. 11. A loose contact at the condenser has caused the end of the condenser to be partly burned away from the arcing.

Fig. 12. Lubrication of the gears is accomplished by removing a cover and applying some fresh medium grease.

holes in strips.

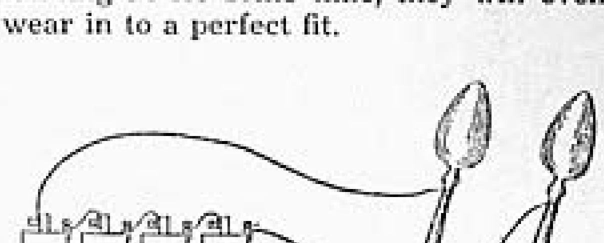
In service checking determine condition of these two units. Resistor can be tested with an ohmmeter and should read about 250 ohms. If open, this condition can be quickly noted on meter. Condenser is rated at 160 volts and .08 mfd., and can be tested by a radio technician. Check to see that good contact exists at the ends of these units; ends of strips can be adjusted for good pressure and the metal cleaned for good measure. Fig. 11 illustrates what may happen from poor contact. It was found that metal end of condenser had burned almost away from loose contact, and a new condenser was required. While contacts of both switches seldom give much trouble, it is well to check them and clean the surfaces if required. Any work necessary on motor itself can be carried out by further disassembly, testing and repairing components as described for the first mixer. Access to gear box at front of machine can be had by removing single screw holding handle in place and then removing four machine screws in the cover. In Fig. 12, some fresh grease is being added after inspection of gears. In some mixers, after considerable use, motor bearings may become worn loose. This is usually indicated by a noisy motor and, in some cases, one which will not run full speed. If bearing wear is suspected, armature shaft should be tried in sleeve bearings and if found a loose fit, new sleeves should be installed. Proper lubrication, however, should eliminate this condition to a large extent.

The Mixmaster was assembled following a thorough inspection and the minor work outlined. Take care in assembling parts at the governor end to see that they go back as they originally were. A short pin with one square end fits in a hole in metal cover piece, with its square end fitting in circular groove in inside of dial control. The long push rod also fits in a hole in this cover, with its insulated end resting in a recess in the on-and-off switch arm. When replacing this cover on end of motor, see that slotted sliding piece fits in place in grooves in center of rotating governor unit. Brushes, if worn short, should be replaced. If brushes purchased come with their ends not shaped to curvature of commutator, a piece of round stick of the same diameter, with a piece of fine sandpaper wrapped around it, can be used to shape them. After running in for some time, they will eventually wear in to a perfect fit.

Home-Made Electric Battery Massage

THE BOY MECHANIC – 1913

A simple and cheap electric massage device can be made by using three or four cells of dry battery connected to two ordinary silver tablespoons, as shown in the sketch. The handles of the spoons should be insulated or the operator can wear either kid or rubber gloves.



ELECTRICITY

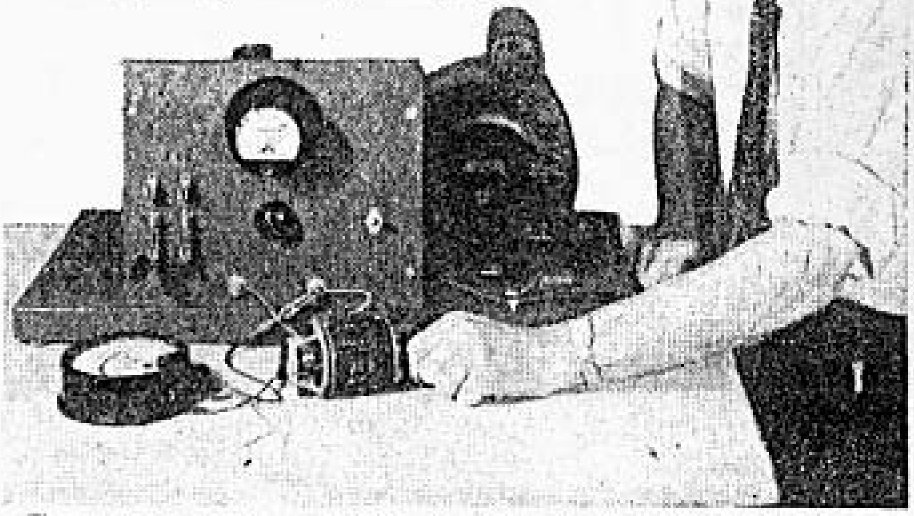
SCIENCE AND MECHANICS FEBRUARY, 1952

DC Motor-Generator Set

By HAROLD P. STRAND

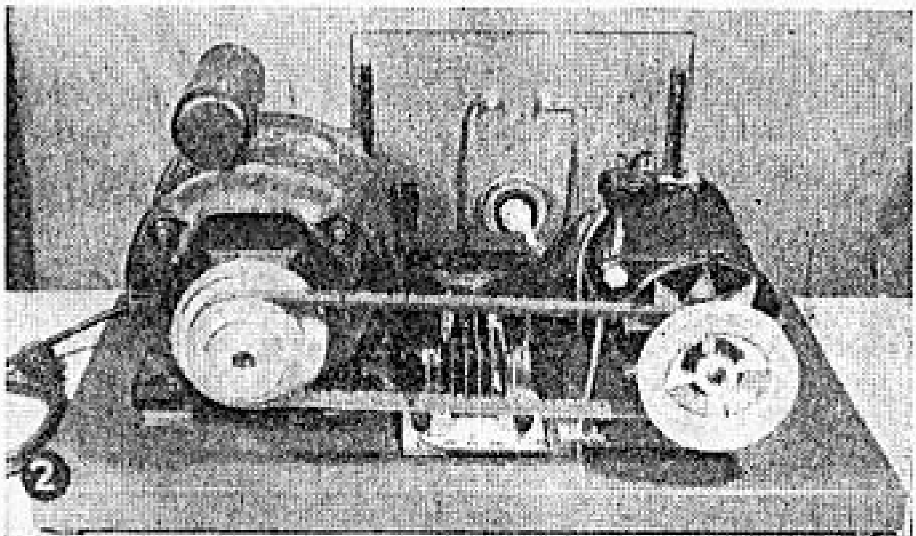
Electrical Editor

WITH an old 6 volt automobile generator and ⅓ *hp* capacitor motor as the basic units you can build a very useful motor-generator set (Fig. 1), which will deliver *dc* voltages of about 6 up to 30 or 35 v. At the lower voltage, you can do light electroplating, battery charging or test various small 6 volt automobile motors and similar experimental work. By operating the field rheostat and adjusting the driving pulley ratio, you can run the voltage to any desired value up to its maximum. A simple belt tightening rod allows either belt tension adjustment or slackening of the belt when changing pulley steps.



The motor-generator set delivering 28 volts dc to a surplus dynamotor, from which 220 volts dc can be obtained.

The generator can be self excited, or by throwing a double-throw switch the fields receive separate excitation. In the self excited condition it can be run at the lower speeds or under conditions of load where the voltage will not exceed about 8 or 10 volts. Should the voltage rise much beyond this value, the fields will receive too much current and may burn out. Therefore, separate excitation is provided from a selenium rectifier unit, which supplies a constant voltage to the fields. In this way we can increase speed to the maximum for the highest voltage value, yet keep field current normal.



The generation of 28 volts dc should find wide appeal among readers who have surplus 28 volt dc aircraft motors of small size and wish to use them. Dynamotors operating on this voltage provide dc voltages up to 600 volts or more. In fact, there is virtually no end to the uses that can be found for such a versatile power unit.

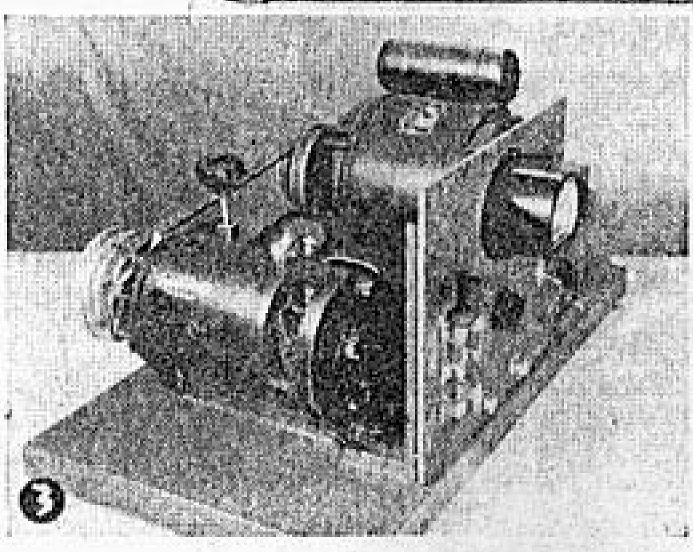
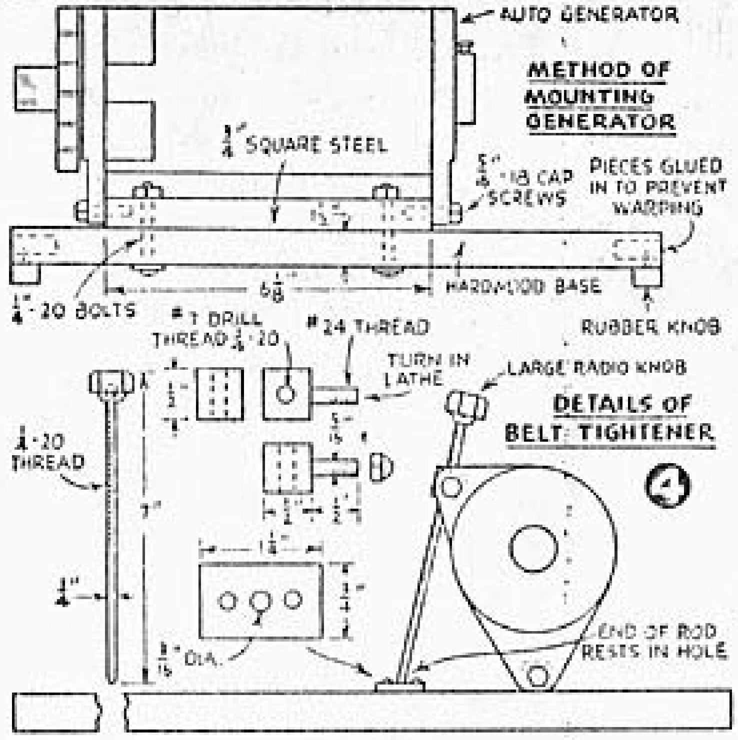
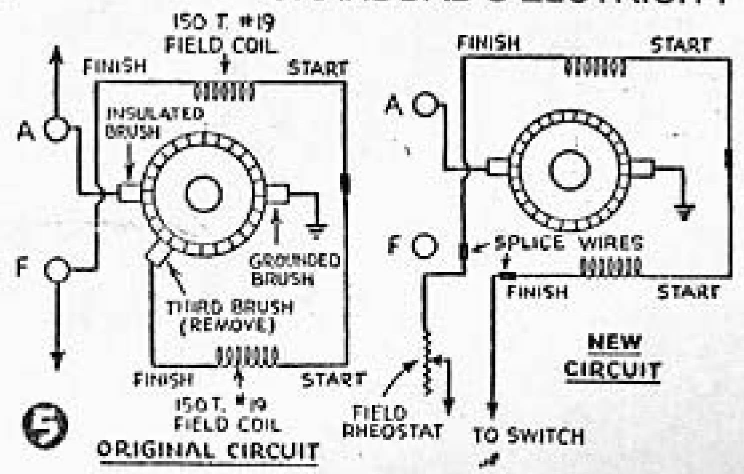


Fig. 1 shows the completed job, with its neat front panel, on which are a voltmeter, a field switch, a rheostat knob and output terminals. A switch is located at the right for turning the driving motor on and off. A small surplus dynamotor is shown being supplied with 28 volts, as one example of application; 220 volts *dc* is obtainable from this dynamotor.

A ⅓ *hp* 15 v. *ac* motor is shown, which proved satisfactory for loads within the capacity of the generator, or about 120 w. Figure the





amperes it is safe to use on any voltage by dividing the voltage into 120. The generator is mounted by its original projecting arms at the bottom by using 5/16 in. cap screws through the holes, which turn into the ends of a piece of ¾ in. sq. steel stock, placed between the arms and secured to the base board. This makes a swinging mount, and a threaded rod with a hand knob at the top (Fig. 4) permits adjustment of belt tension and loosening for changing pulley ratios. Other details are shown in Figs. 2 and 3.

First, secure a good used automobile generator. While most any type will do, a Delco-Remy Model 935X was found satisfactory and only cost $5.00. This is a third brush generator, but the movable brush is not needed, so remove it. Take the generator apart and clean it in carbon tetrachloride. Next, make the following checks, then reassemble: the fields must not be grounded to the frame; they must also test to have about 2 ohms resistance, as tested with an ohm-meter or bridge. If shorted turns are present, the resistance will be much lower and will require a rewind job. Also, a grounded winding must be replaced.

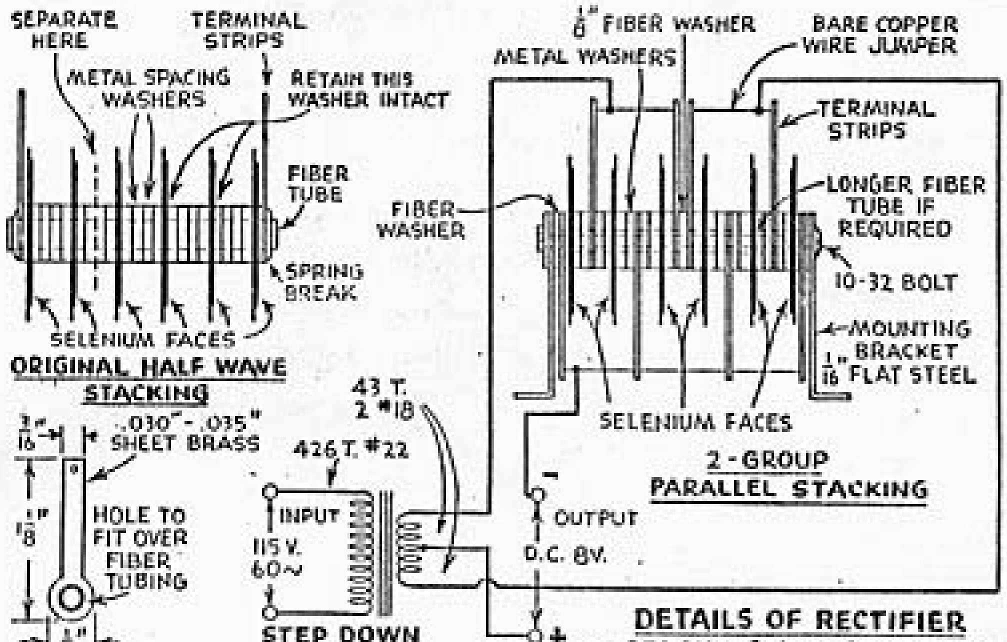
Clean the armature commutator or turn, if necessary, to provide a smooth surface. Use a thin tool to clean between segments or undercut between segments. Placed in a growler, it should test free of shorts.

If other models of automobile generators are used, some experimenting may have to be done with the values given all around, since the windings may be considerably different in various generators. To rewind field coils, remove the old winding and measure the size of the wire, the inside of the coil and the thickness of the coil (Fig. 13). Make up a wooden form to these dimensions and wind new coils on the lathe, using the same number of turns as counted on an old coil. Solder on flexible leads, tape the coils, then dip in insulating varnish. Bake for a few hours. While still warm, shape to fit in the frame.

One end of the field winding will be found connected to the third brush and the other end to the terminal post marked F (Fig. 5). Disconnect the wires at these two points and solder onto the field leads two pieces of #18 insulated lead wire, about 1 ft. long. Tape the splices. It is to these two leads that resistance measurement is taken. With the two main brushes in good condition, reassemble the generator, bringing the field leads out one of the openings at the end of the frame. Install a new step pulley on the shaft later to replace the orginal pulley and locknut. One brush will be found grounded to the frame; connect the other to the terminal post marked A.

MATERIALS LIST—DC MOTOR-GENERATOR SET

Amt. Req.	Material
1 pc.	hard pine 23 x 12½ x 1½", or
2 pcs.	¾" plywood glued together, baseboard
1 pc.	Transite board 8½ x 4 x ¼", rectifier base
1 pc.	Masonite board 11 x 9 x ¼", front panel
1	auto 6 v. generator (Delco-Remy Model 935X)
1	⅓ hp cap. type, 115 v. ac motor, ⅝" shaft
2	3-step V pulleys, 4—3—2", ⅝" bore
1	Dayton Cog-Belt, AX31—49 or plain "V" belt
1	0-50 volt dc panel voltmeter
1	D.P.D.T. battery knife switch
1	4-6 ohm, 50-75 w. power rheostat, with knob (G.E. cat. URC-2005 50 watt shown)
1	H.D., S.P. or D.P. panel tog. sw., motor control
1	Federal 500 ma. rectangular plate rectifier stack, model 43SD3428A, or equivalent
1	transformer core from old power transformer or Allegheny Ludlum Steel Corp., Pittsburgh 22, Pa., laminations EI-125H. E section 3¾" long by 2½". Center leg 1¼" wide. Window opening 1⅞ x ⅝". Laminations to stack 1¼" thick. Steel 26 gage, electrical transformer sheet. Approx. wt. 2¼ lbs. E pcs., 12½ oz. straight pcs.
½ lb. (approx.)	#18 Formex magnet wire, wound on two spools, trans. sec.
1 lb. (approx.)	#22 Formex magnet wire, trans. pri.
4 pcs.	flat cold rolled steel 3½ x ½ x 1/16", transformer brackets
1 pc.	c.r.s. 6⅛ x ¾ x ¾", gen. mounting block
1 pc.	c.r.s. ¼" round, 7" long, gen. belt tightener
1 pc.	c.r.s. 1¼ x ¾ x ⅛", base for above rod
1	large radio knob ¼" hole, tightener rod knob
1 pc.	c.r.s. 1 x ½ x ½" tight. rod swivel base in gen.
1	5/16" x 24 thrd. dome nut, swivel blk. to gen. lock
2	¼" x 20 thread 2½" long stove bolts, with washers, gen. block to base
2	5/16" x 18 thread cap screws 1" long, with washers, gen. to mtg. block
6	rubber screw-in bumper or shock mounting knobs, under base
	#10 flexible insulated lead wire
	#18 flexible insulated lead wire
	Misc. screws, paint etc.
2 pcs.	½" angle iron 10½" long. Cut and bend 90°, then weld to form angle brackets for front panel.



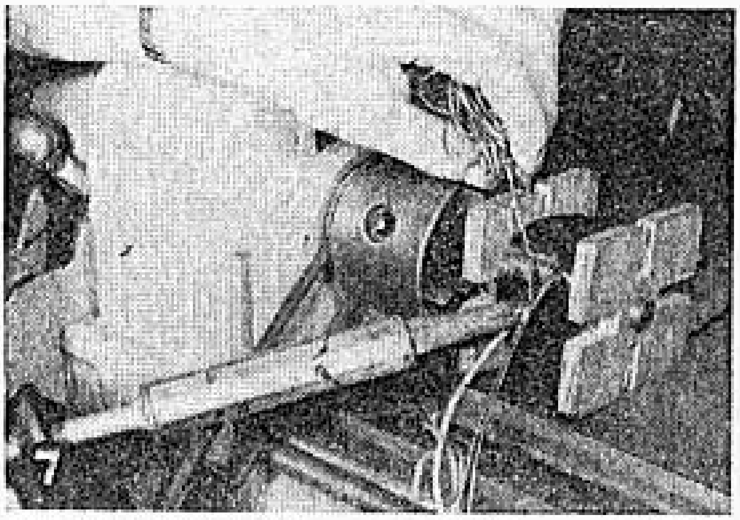
6 DETAILS OF RECTIFIER STACKING AND SCHEMATIC DIAGRAM

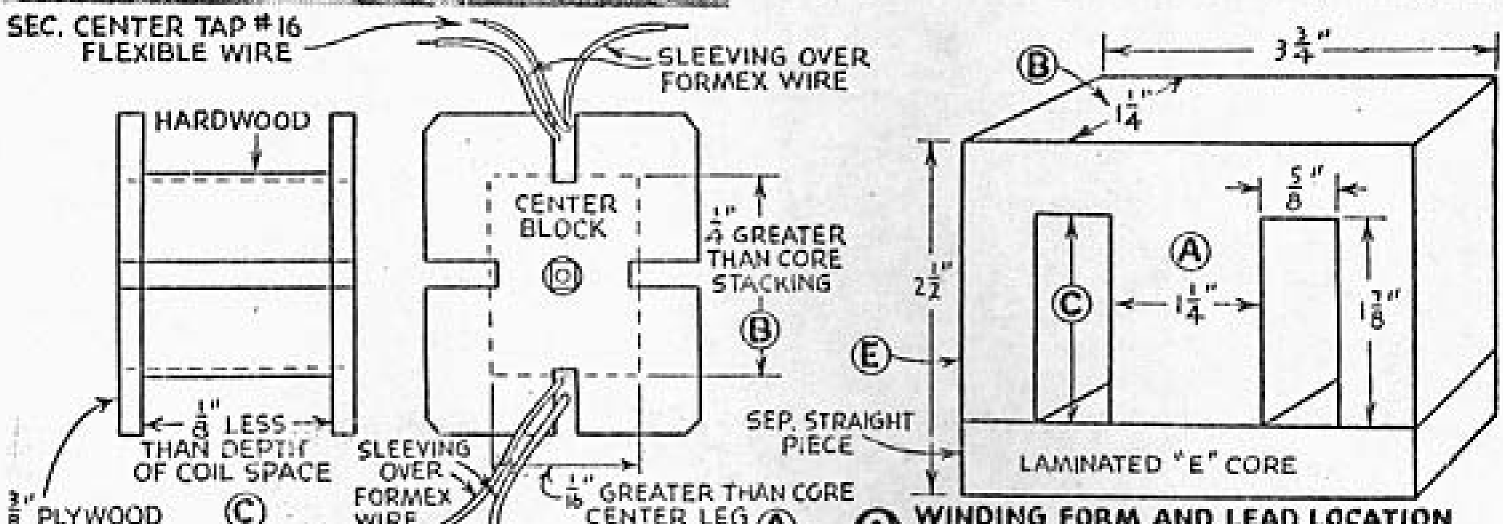
Next, make up the rectifier unit, consisting of a step-down transformer and selenium rectifier, arranged in a center tap full wave circuit (Fig. 6). This unit provides about 8 volts *dc* for the field excitation, from the 115 volt *ac* line. All winding data for the transformer to follow is based on 60 cycle operation. The transformer requires a core with a cross-sectional area of 1.56 sq. in. This means that the center leg of the E laminations can measure 1¼ in. and the core stack to 1¼ in. or any other combination which, multiplied together, gives the same area. The window or winding space, side of the center leg, should be at least 1⅞ in. long by ⅝ in. wide, in order to fit the coil to be wound. Some old radio power transformer or other electrical control transformer might fit the specifications, and its core could be salvaged for this job. Or, you can build one from pieces of sheet transformer steel.

Make a suitable wooden winding form (see past transformer articles and Fig. 8) and place a turn of .010 insulating paper around the center block. Wind the primary with 426 turns of #22 Formex wire, bringing the start and finish ends, equipped with sleeving, out one of the form slots. Place a turn of insulating paper over the closely and tightly wound primary, then wind on the secondary. This consists of two #18 Formex wires in parallel or wound together, is equivalent to one #15 wire in carrying capacity, but is easier to wind than the single heavy wire. Wind 43 turns and then scrape a small spot clean and solder a tap lead, with a piece of #16 insulated wire as the tap (Fig. 7). Insulate the tap well and continue winding for 43 more turns or 86 turns in all. Bring the start, tap and finish out the form slot (Fig. 8).

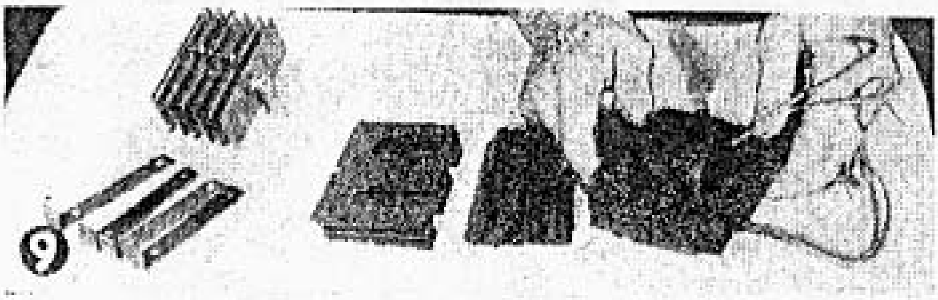
Tie the coil at four points and remove from the form, then tape with white cotton coil tape, dip in insulating varnish and thoroughly dry. Next, fit laminations in the coil, alternating the positions of the E and straight pieces, so joints will be alternated and never together (Fig. 9). Use the side brackets (shown at left) to clamp the core tightly and provide mounting feet.

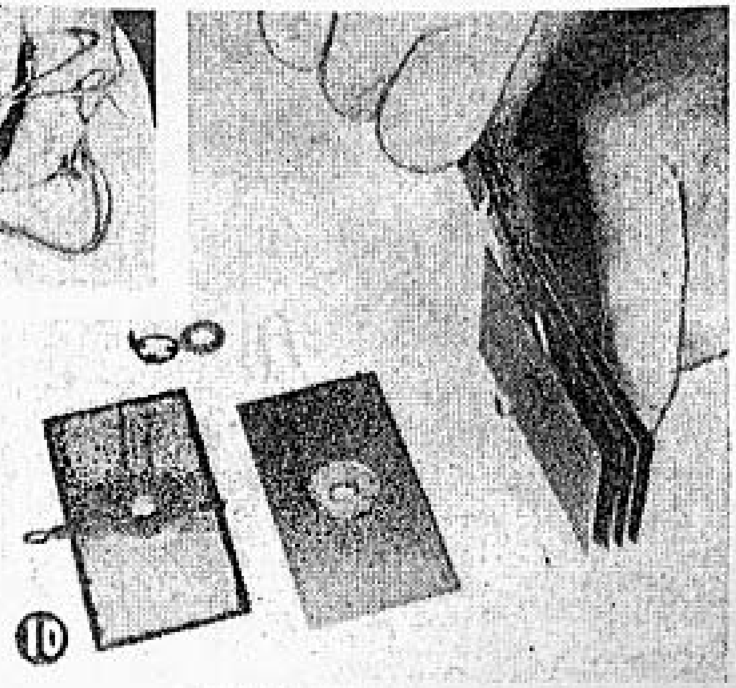
For the rectifier, secure a 500 ma. half wave unit, from a radio supply store. A Federal Telephone and Radio Model 438D3428A unit was selected, being in the form of 6 rectangular plates (Fig. 9). Take it apart and rearrange the plates





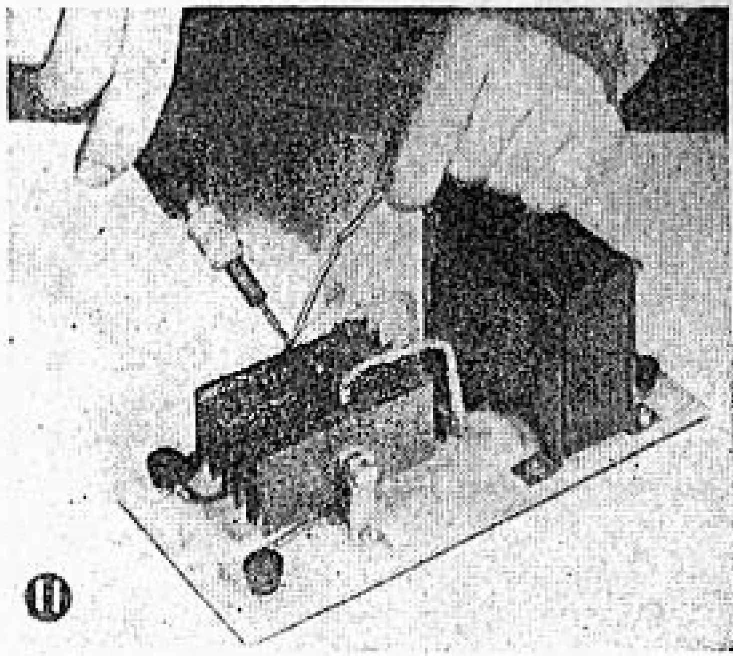
8 WINDING FORM AND LEAD LOCATION RECTIFIER TRANSFORMER



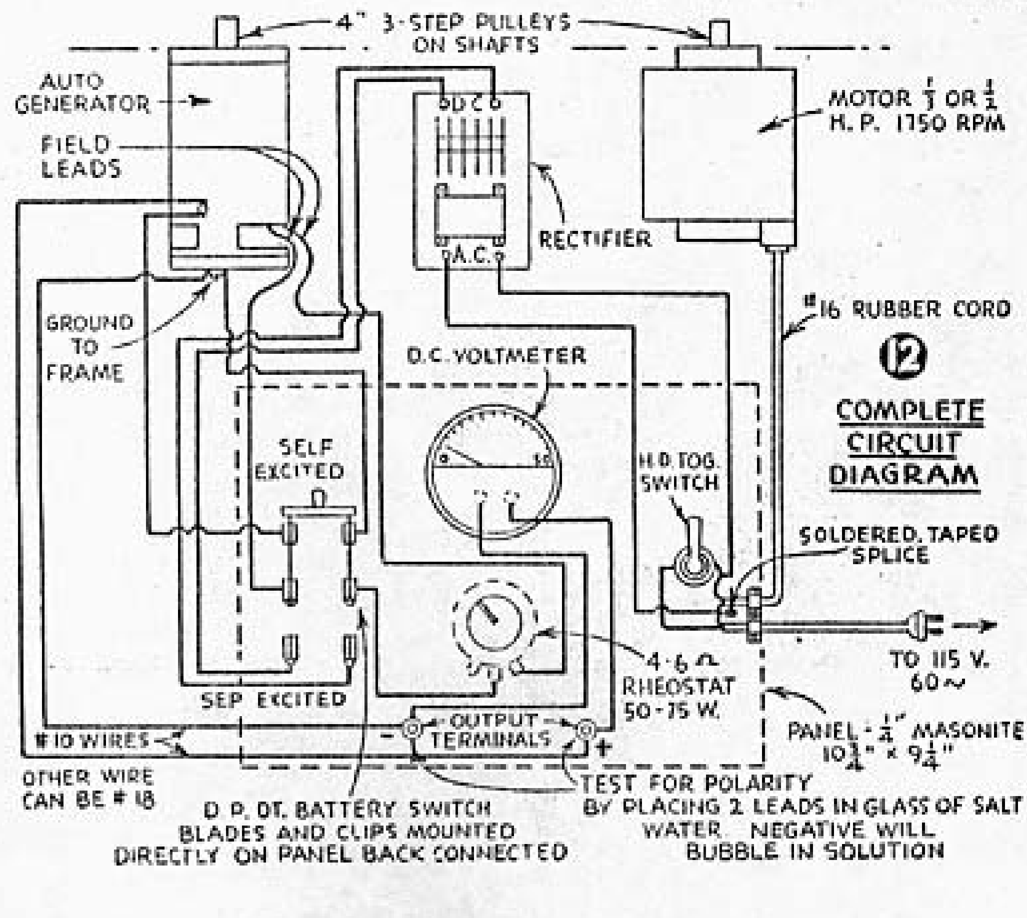


to form two groups of parallel, connected plates, three plates to a group. This will then carry the required 3 amps., when arranged in a center tap full wave circuit (Fig. 6).

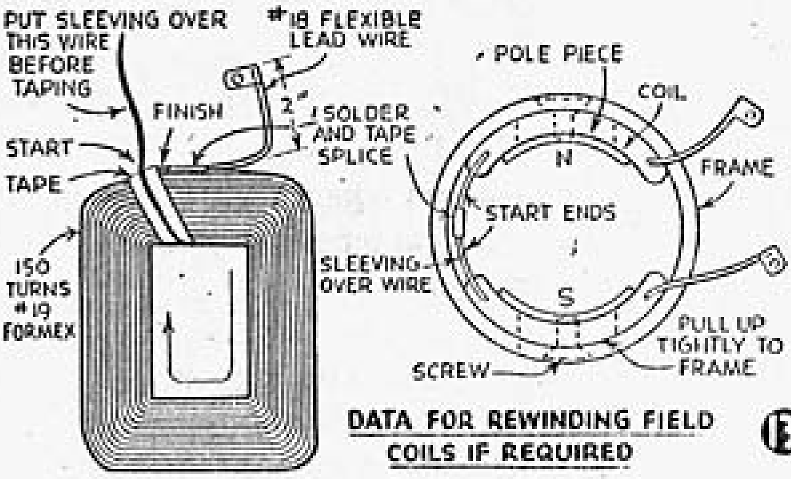
Cut one of the spring washers at the end of the stack and then use a knife blade to separate the spacer washer (Fig. 10). Separate between center washers and not next to a plate, as this original contact must be maintained. One side of the plates is plain, while the other side has a light selenium coating. Make terminal strips from sheet brass stock, with holes to slip over the fiber tubing; place them between washers. Use five washers between each two plates; it may be necessary to add a few brass washers to those supplied. This is necessary for proper ventilation. You will probably need a longer fiber tube and mounting rod. Use an insulating Bakelite washer between the two sections at the center of the stack. Make two angle mounting brackets from steel stock. Join all plain faces of the plates as a common, with a connecting jumper at the bottom (Fig. 6). Also join three of the selenium faces of each group, but separate at the center with the Bakelite washer. Test each cell with an ohmmeter before making the jumper connections; an extremely high resistance should be shown with the leads connected one way to a cell, but upon reversing the leads, the resistance should be low. Cells should test about the same; if considerable difference is noted in either direction, in one cell from the others, it indicates faulty contact, a defective assembly somewhere or possibly a defective cell.



Mount the transformer and rectifier units on a piece of 1/4 in. Transite (asbestos-cement) board, with terminals as shown. When wired, test with a dc voltmeter, with the transformer connected to the line. A voltage of around 10 volts should be recorded at no load. The *ac* input to the transformer should be quite low, or somewhere around .2 to .8 amps. since this should be only exciting current at no load. If the *ac* input to the transformer primary should be high, under no load conditions, there are shorted primary turns, wrong

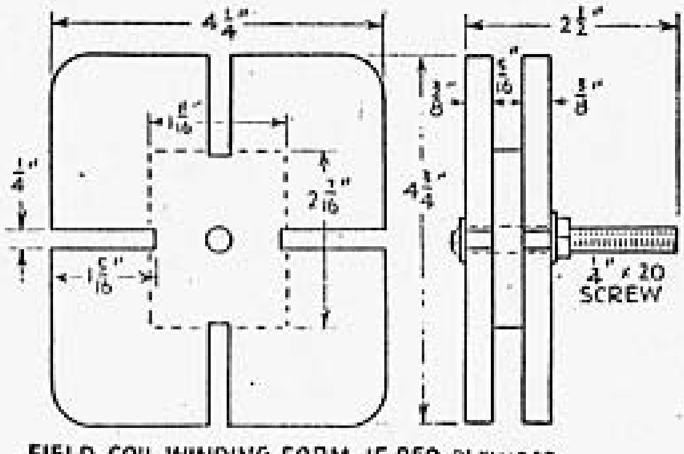


12 COMPLETE CIRCUIT DIAGRAM



DATA FOR REWINDING FIELD COILS IF REQUIRED

13



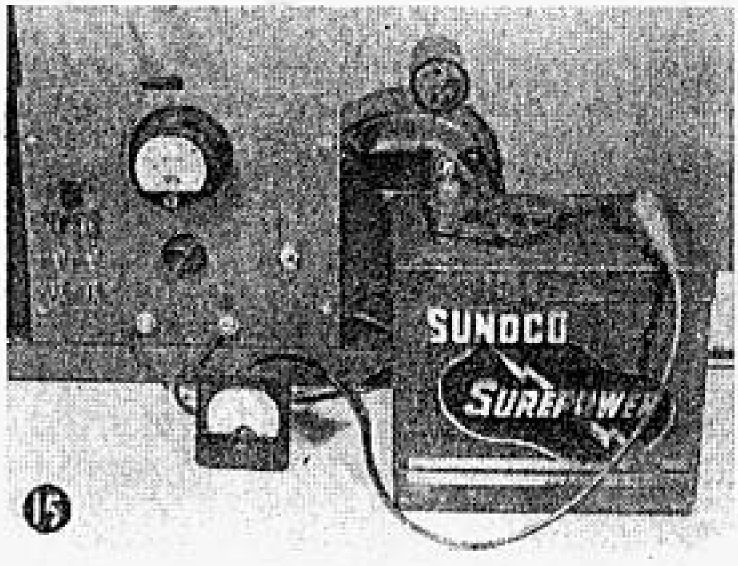
FIELD COIL WINDING FORM IF REQ. PLYWOOD

turns, or too little iron-stacking in the core. Solder the secondary leads to the rectifier (Figs. 6 and 11).

Next, assemble the components on a base of 2 in. planed hard wood, with heavy strips let in at the ends to help prevent warping (Fig. 2). The complete circuit diagram is given in Fig. 12. Lay out the motor and generator, so that pulleys fitted on their shafts will line up. The generator shaft is slightly over ⅝ in., so a ⅝ in. bore pulley will have to be bored out in the lathe. The motor will probably take a standard ⅝ in. pulley. The new generator pulley requires that the original fan be attached to one side (Fig. 14). Do as shown, drilling for machine screws. Take care to center the fan properly.

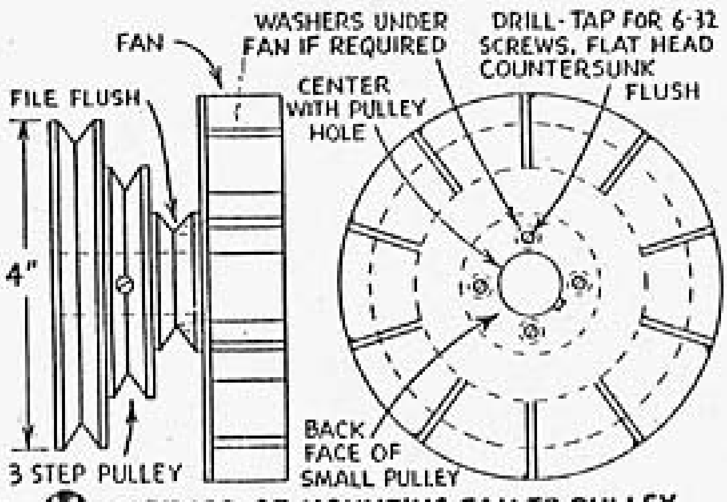
Fig. 15 shows the charging of an automobile battery with the unit. With the belt on the second pulley step, it was possible to charge at a 15 amp. rate easily, using either self-excited or separately excited position of the double throw switch. The latter is preferred, since there is less load on the generator. Don't use the self-excited position at a light or no load, where the indicated voltage is much over 10 volts, as the field current will be excessive. On the other position of the double throw switch you can drive the generator at any speed, or generate any voltage desired.

Should the generator fail to build up when first started, try the lower switch position; if it fails, try reversing the leads at the lower terminals. Then throw the switch to the upper position, and, if the voltage falls off, reverse the two top leads. When the direction of current from both sources, through the fields, is such as to aid the residual magnetism polarity, so necessary for the build up process, the machine will operate correctly.



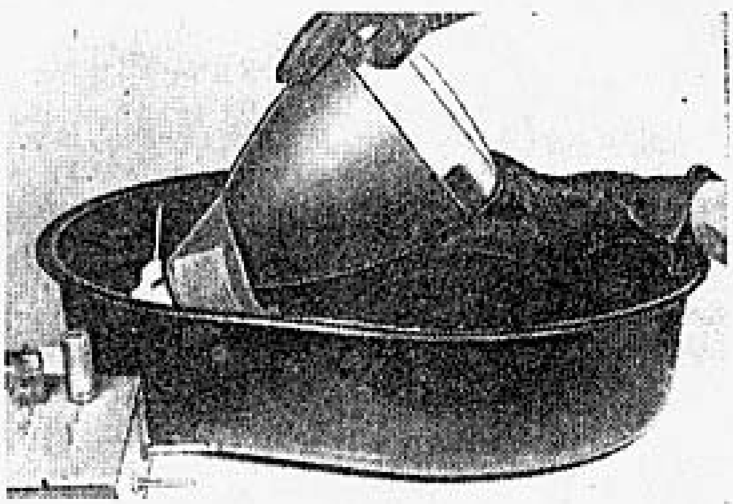
15

A 6 volt automobile being charged from the generator. With the setting of field rheostat and switch position shown the battery is being charged at a 7 amp. rate, which is better for the battery than being charged at a high rate.



14 METHOD OF MOUNTING FAN TO PULLEY

Basin Prevents TV Tube from Rolling



• Place TV tubes in hard rubber basins, available at surplus stores, for safe keeping while trying another tube or handling other repairs on the set. The hard rubber is less likely to damage the tube than metal containers.—H. Leeper.

Easy Electrical Experiments

POPULAR MECHANICS
March. 1903 L. P. DICKINSON

HOW TO MAKE AN ELECTRIC GYROSCOPE.

The gyroscope has long been known to physicists as an interesting scientific toy. In an elementary form it has been used probably by many of the young readers of this paper. The form usually sold in toy shops, consists of a lead wheel with an extremely heavy rim mounted in a pair of pivots supported on a ring. When set into extremely rapid rotation by means of a string wound around the axis, the wheel may be made to perform numerous interesting feats such as hang-

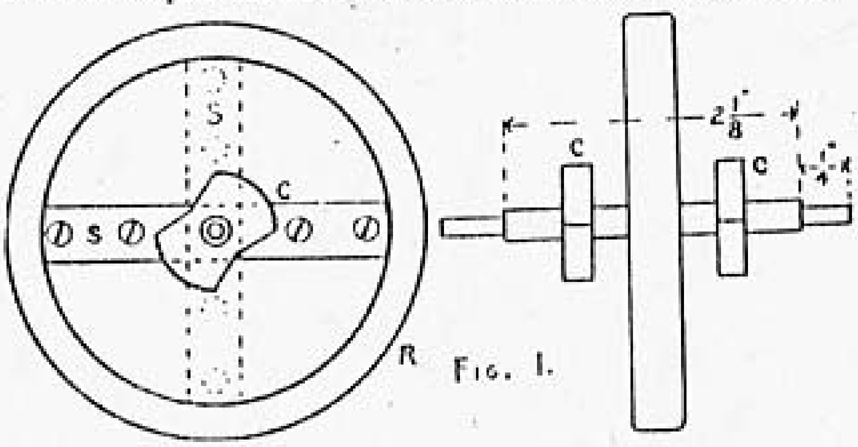


Fig. 1.

ing by one side from the edge of a table or other convenient support. The common top so dear to every boy's heart is only a special form of gyroscope. Every one knows that as a top spins rapidly it will stand upon its point in apparent defiance of the law of gravity, and if displaced from its position will tend to assume an erect position again. If we take a bicycle wheel from its frame and grasp the supporting axle in the two hands, we may tilt the wheel easily to any angle provided the wheel be at rest. If however, we set the wheel spinning quite rapidly and then try to change the direction of rotation of the wheel by grasping the axle, we shall find that it is almost impossible to suddenly wrench the wheel out of its normal position.

In all these cases, it is apparent that a body in rapid motion possesses properties which a body at rest does not possess. They are only specific illustration of the important law of motion which states that a body once set in motion cannot of itself change either the direction or the value of its own motion.

In the case cited the motion soon ceases and the effect is, therefore, only a temporary one. In the instrument to be described in this paper electrical means are employed to keep the body in constant rotation, thus making possible the demonstration of many interesting physical facts. One of these which is of especial interest is the visible demonstration of the rotation of the earth upon which we live. We ordinarily accept as true that the earth rotates on its axis; the gyroscope makes this rotation a visible fact.

We will need first of all, a heavy brass wheel such as is shown in Fig. 1. This wheel is 3 inches in external diameter and has a heavy rim ¼ inch thick, the width of this rim being ⅜ inch. The wheel may be turned from a ⅜ inch plate of brass. Especial care should be taken to accurately center and turn the wheel. The central portion of the wheel should be turned down to a thickness of ⅛ inch, the rim being of the dimensions already given.

On one face of the wheel and within the rim, is to be mounted a piece of soft iron shown at S which is 2½ inches long, 7-16 inch wide and 1-16 inch thick. It is fastened in place by four flat head iron screws counter sunk flush with the surface. On the other side of the wheel and at right angles to the first piece of iron is mounted a second piece indicated by the dotted lines.

Having done this, bore through the exact center of the wheel a hole which is a scant ¼ inch in diameter. Through this hole is to be driven very tightly a shaft whose total length is 2⅝ inches, the wheel being in the exact center of the shaft. The shaft is turned down for ¼ inch from each end to a diameter of ⅛ inch thus forming two shoulders to fit in bearings to be described later. If any doubt exists as to the shaft being exactly in the center of the wheel a test should be made at this point and the wheel turned down by taking a very light cut until both inside and outside of rim run perfectly true.

At C are shown two contact wheels made of 3-16 inch brass driven tightly upon the shaft. These contact wheels are so made that they will make contact with a brush which is to press upon them for one-fourth of a revolution, then break the contact during the next quarter revolution, then make contact during the next quarter and so on. Accordingly they have the shape shown in the left hand part of the figure, the diameter measured between circular portions being ¾ inch. They should be placed in the position indicated in the figure, the discs on opposite side of wheel being twisted around so as to be at right angles to each other. This point will be explained more fully later, after we have built the remaining parts of the machine.

(To be continued next week.)

Easy Electrical Experiments

BY L. P. DICKINSON

HOW TO MAKE A GYROSCOPE.–II.

In the last chapter the rotating part of our instrument was described consisting of a brass wheel with an extremely heavy rim supported on suitable shaft. The field magnets and supporting frames of this motor will now be described.

A view of the frame is given in Fig. 2 with two of the

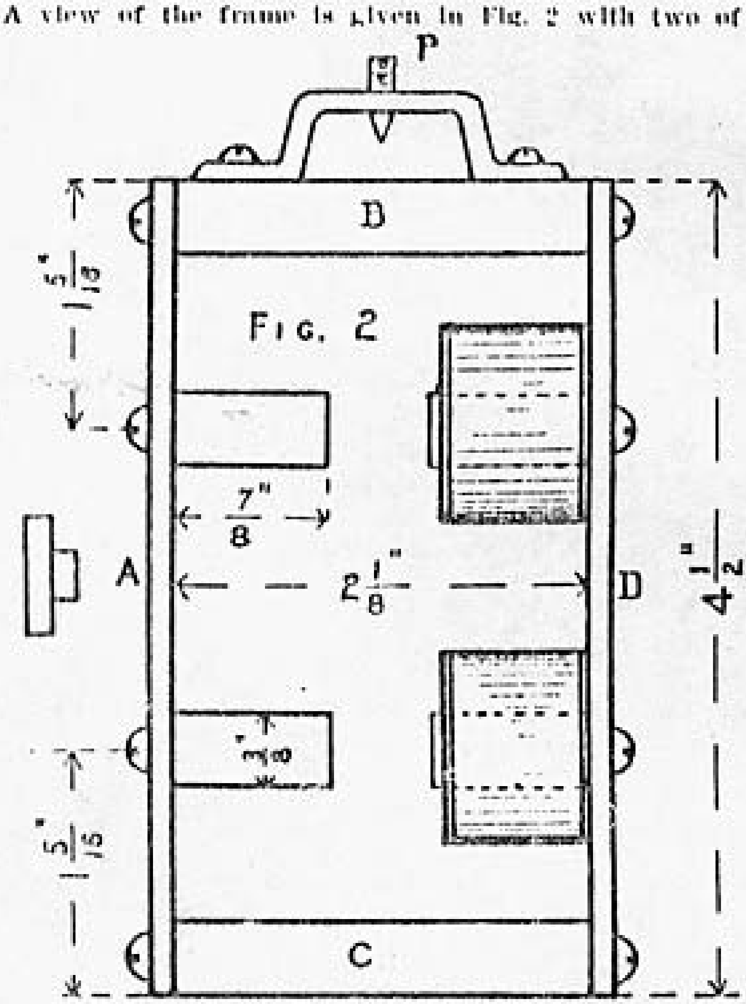


Fig. 2

four coils composing it in place. It consists of two side strips of iron marked A and D which are 4½ inches long, ⅝ inch wide and ¼ inch thick; the end pieces of the frame C and B being made of pieces of brass ⅝ inch square and 2⅛ inches long. At a distance of 1 5-16 inches from the end of the iron strips, bore two holes 3-16 inch in diameter. These are to support the circular iron cores shown at H. These circular iron cores are of the dimensions given in the figure and are drilled and tapped at one end so as to be fastened to the iron strips by round headed machine screws passing through the holes already drilled. The frame is fastened together at the end by iron screws passing through the strips of iron and into the ends of the brass strips. Extreme care must be taken to see that the frame is rigid, and perfectly balanced throughout. To secure these qualities care should be taken to finish the various strips carefully. After the frame is screwed together bore with a small drill a hole close to the end screws and passing through the iron strips into the brass strips to a depth of ¾ inch. In these small holes drive a tight fitting pin which will help to prevent racking of the frame.

Coils are next to be wound upon the four inwardly projecting cores. Two of these are shown in the figure, the other two being omitted to make the diagram clearer. Turn out from a piece of brass eight pieces 1-16 inch thick, and 15-16 inch in diameter, with a hole in the center just big enough so that the disc may be driven tightly upon the circular iron cores, to form heads to contain the wire to be wound upon the cores.

About four ounces of number 30 double silk covered magnet wire will be required. Wind each core with a layer of paper, fastened on with shellac, and cover the inside of the brass head with a paper disc, so that the wire cannot possibly come in contact with the core. Then wind the coils on the four iron cores, so as to make a coil 15-16 inch in diameter. Connect all the coils in series when they are complete, connecting them in such a manner that a north pole of one coil will be opposite to the south pole of the coil opposite.

Before fastening the cores in place to the side strips A and D, bore a hole in the exact center of the two strips A and D, the holes being ¼ inch in diameter. To these holes are to be fitted brass bushings of the shape shown at the left of the figure. These brass bushings are to form bearings for the support of the revolving wheel described in the last chapter, and accordingly must be flush with the surface of the iron on its inner face. The bushings had better be threaded into the iron and fastened by means of a set screw.

We must provide means for supporting the apparatus when it is completed. It is to be supported by being hung upon the steel pivot P. This pivot is threaded into a brass strip ⅝ inch wide bent into the shape shown. In order to exactly balance the machine it will be necessarly probably to exactly this piece of brass a little so that the screws which fasten it to the frame pass through slots cut in the brass instead of through holes.

We are now ready to put the apparatus together, but the description of this will have to be left to the following chapter.

(To be continued.)

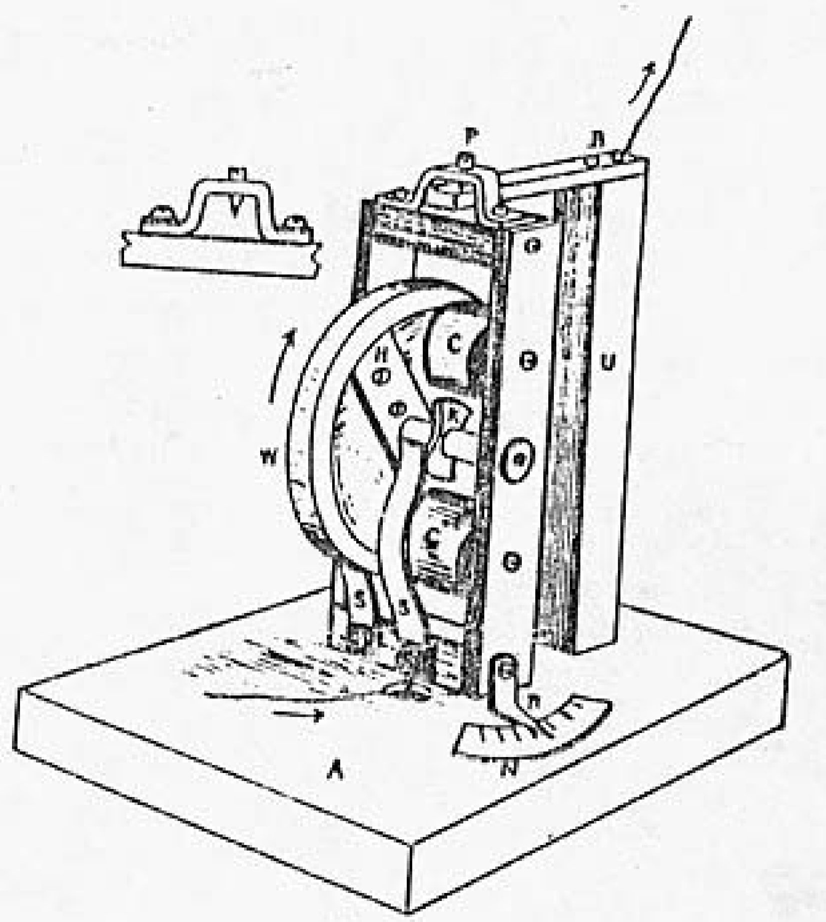
Easy Electrical Experiments

By L. P. Dickinson

HOW TO MAKE A GYROSCOPE—III.

The rotating and the fixed parts of our instrument having been completed, they can be assembled together after the manner indicated in the figure below. It will be seen that the wheel W is mounted so as to swing freely in the center of the frame, already constructed. It is essential that this wheel should run very smoothly and evenly and should be perfectly balanced. The iron armatures fastened to its sides should pass very close to the poles of the electro magnets C, of which there are two on each side of the wheel, without touching the latter. For this reason the wheel can have hardly any side motion. The strip of brass into which the pivot P is fastened must be insulated from the frame. To accomplish this strips of hard rubber are placed between it and the frame and also under the head of the screws which clamp it, the latter being provided as well with an insulating bushing.

At the bottom of the frame are attached two springs,



Gyroscope

marked S, which are also insulated from the metal frame, but are connected with each other and to a piece of wire hanging from the bottom of the frame to a distance of about one inch. The four coils are connected in series in the manner previously described, and one terminal of the wire is connected to the insulated pivot P. The other terminal of the coils is connected to some part of the metal frame.

A suitable base, shown in the figure, is provided with an upright post U, which carries at the upper end the heavy strip of brass B. The height of this post should be such as to allow the frame to swing clear of the base by about ½ inch. Directly under the middle of the frame a hole is to be bored in the base to a depth of ¼ inch, into which is to be poured a globule of mercury. The projecting wire already mentioned should dip into this mercury when the frame is suspended in position. The pivot P should be very sharp and hard and should bear upon a piece of hardened steel fastened to the brass strips B so that the gyroscope may turn with very little friction into any position.

Its action is as follows: Current is led into the lower mercury cup by a wire as indicated, thence to the insulated springs S, to the contact maker K, to the frame of the machine, through the coils C to the pivot P, and thence out of the wire shown at B. The action of the contact maker K is as follows: When the iron strip H is ⅛ of a revolution from the poles of C, K should make contact with S, closing the electric circuit through C, which causes H to be attracted. This should continue until H is exactly opposite to the poles, when the contact should be broken. Now for ⅛ of a revolution the circuit will be open, but after this interval the strip on opposite side of the wheel should be ⅛ of a revolution from the magnets on that side. The contact maker on that side should now close the circuit and act in just the manner that K acts when it comes in contact with S. If three or four strong bichromate cells be used, the wheel ought to revolve at a high rate of speed.

Its gyroscopic action—that is, its resistance to any change in the plane of its rotation—is very marked. If no force were acting on the wheel, it would be impossible for it when once started to change the plane of its rotation. If the pivot P be without friction, the base may be turned about in any direction without altering the position of the wheel H. Suppose the wheel to be started so that its plane points exactly north and south. It will continue to run in the direction in which it is pointed, even though the base A and the earth

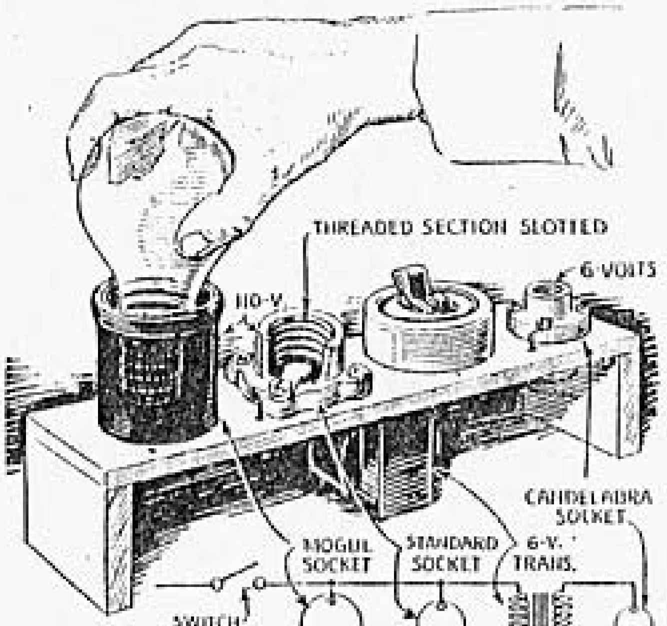
 GRANDDAD'S ELCTRICITY BOOK

under A should change their position. Now the earth is constantly rotating, and what is north for a person in one place is not north for a person in another place, for the reason that the meridians of longitude converge at the pole and are therefore not parallel. If the wheel be started to rotating in a north and south meridian at a given time, it does not mean that the wheel will continue on this same meridian, but it will always continue to rotate towards some fixed point in space. After a time, therefore, the wheel will apparently have changed its direction of motion and will no longer point north and south. It is not the wheel which has changed, however, but the earth. By making a small sphere and drawing lines upon it to represent the meridians, it will be very easy to understand this matter. Of course, it is understood that the force of gravity will make the wheel to always rotate in a plane passing through the center of the earth, but this can in no wise affect the horizontal direction in which the wheel points.

NOTE.—In Chapter 1 the contact strips were erroneously described as having an arc of contact of $\frac{1}{4}$ revolution. They should close the circuit for only $\frac{1}{8}$ of a revolution at a time.

Test Board Accommodates Lamps of Various Sizes

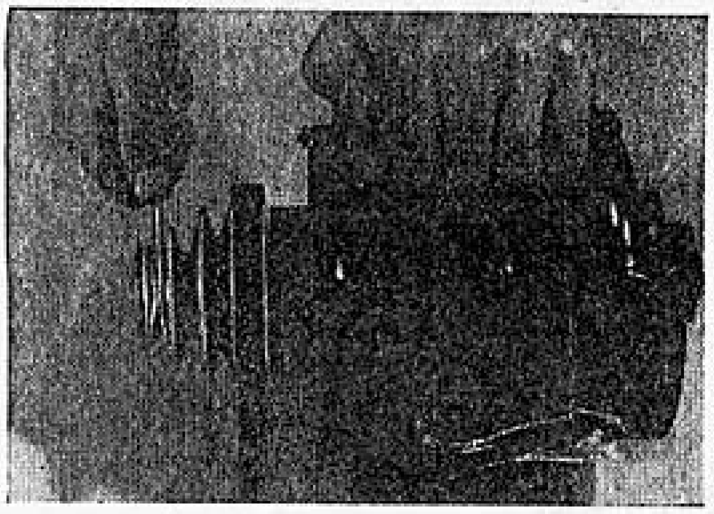
It always creates a better impression if the lamps a customer buys are tested while he is watching. By using a mogul base, the ordinary bulb can be tested in a second or two without removing it from the wrapper, and the same applies to the candelabra bulbs which are tested in an ordinary socket. Radio and flashlight bulbs are tested with a doorbell transformer. A fixed radio rheostat hooked in series with the socket will lower the current to 2½ volts or whatever needed.—Morris Katz, Aurora, Ill.



REVERSING SPLIT-PHASE MOTOR

A SPLIT-PHASE motor may be temporarily reversed to take care of work that occasionally require this.

This is done by wrapping about three feet of stout cord around the pulley in the direction the motor must run. Now give the cord a sharp yank (the way you would start an outboard

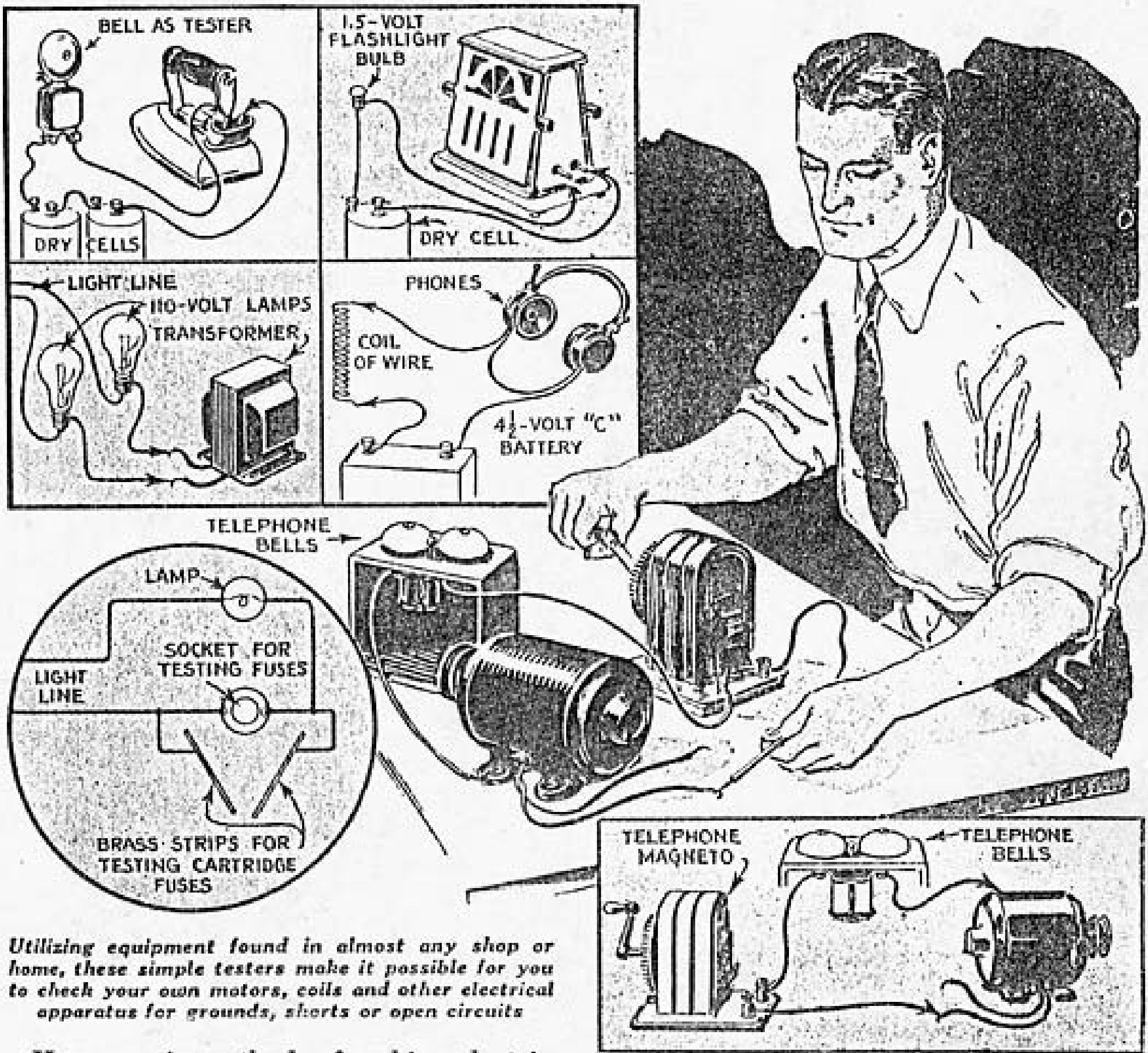


motor) and immediately turn on the switch. The motor will now continue to rotate in that direction. When the motor is stopped it will, of course, be in position to run in its normal direction or rotation.

It is important, when cord is pulled, to spin the rotor fast enough to open the starting switch which is in series with the starting winding. If connected to a load (as shown in illustration) it may be necessary, to avoid drag, to shift the motor ahead so the belt will be loose and slip; then tighten when motor is in operation.—W.J.R.

"Simplest" Test Set, consisting of earphones and a flashlight battery connected in series, will locate most of the troubles with radio parts. Touch the wires to a suspected part to find out if it is burned out or shorted.

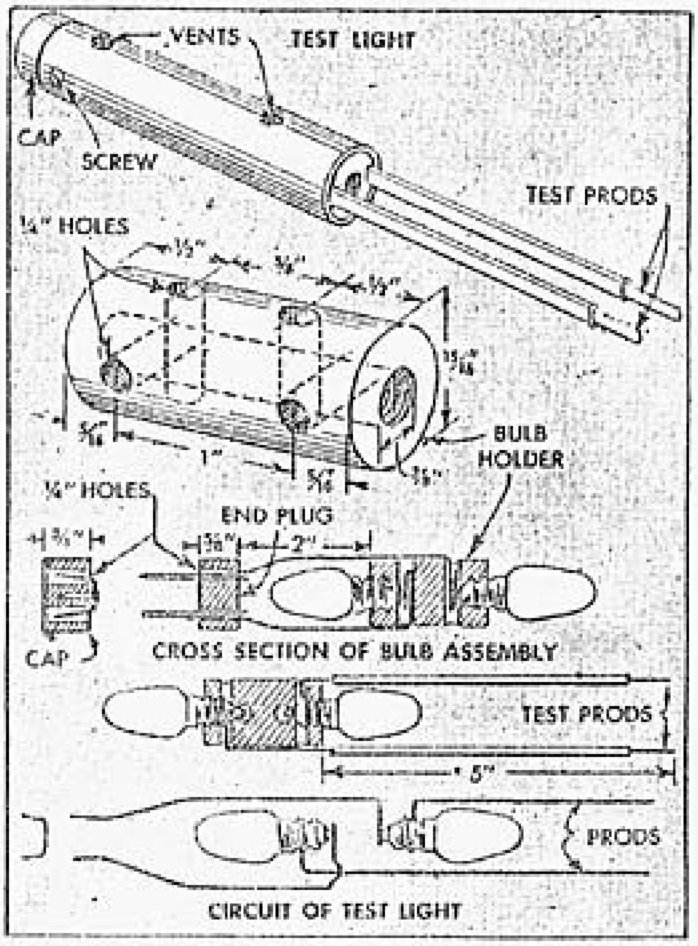
ELECTRICAL TESTER



Utilizing equipment found in almost any shop or home, these simple testers make it possible for you to check your own motors, coils and other electrical apparatus for grounds, shorts or open circuits

Here are six methods of making electrical testers from inexpensive equipment to locate grounds, short and open circuits. In the two upper details the methods are identical with the exception that the test results are audible on one and visible on the other. The bell will ring or the bulb will light when the test leads are connected together or to an unbroken circuit. The next left-hand detail shows a tester using two 110-volt lamps and operated from the lighting circuit. In this case also the lamps light when the leads are connected to a closed circuit or in case of grounds. Brilliancy of the lights is a rough measure of the resistance in the circuit being tested. The adjoining detail shows a sensitive method which makes use of a pair of radio headphones. At the instant the leads are connected to a circuit in good condition there will be a click in the phones. In the circular detail is a tester for all kinds of fuses. The porcelain socket for testing plug fuses has its core removed and a piece of brass tubing substituted so that fuses may be pushed in for testing. The brass strips mounted below the socket are for testing cartridge fuses. The most sensitive tester is shown in the lower right detail. A telephone magneto is used as the source of power, while a telephone bell serves as the indicator. This instrument is most useful for locating grounds which would not show up with other testers. It is also handy when testing circuits having very high resistance but is not very satisfactory for coils of fine wire as it sometimes rings when a circuit is open if the wires in the coil are close together.

Electrician's Test Light Built From Stock Parts



In addition to the regular flexible prods for locating defective fuses and open circuits, this test light has a novel and useful feature. A removable end cap allows the light to be plugged into a 110-volt outlet for testing fuses and locating grounds or open circuits without danger of grounding the source of power. The housing is made from a length of fiber tubing and the bulb holder is a round piece of wood cut from a shade roller. Two 110-volt candelabra-base bulbs are used. With care these can be turned into the holes in the ends of the bulb holder to form their own threads. The end plug supporting the plug prongs and cap can be cut from the same wooden stock as the bulb holder. Contact strips for the whole assembly are made from 1/32-in. spring-brass strips, ¼ in. wide. After assembling and wiring the parts, the assembly is forced into the fiber holder. Slip the end plug over the plug prongs and close the opposite end of the holder with a fiber disk notched to provide openings for the test prods. The cap is fitted with a bent strip of metal held in place with a small brad. A disk of thin fiber is glued to the outer face of the cap to cover the small holes drilled in the cap to take the ends of the strip. When the cap is in place, the metal strip closes the circuit between the two prongs so the unit may be used to locate defective fuses and open circuits in the usual manner. Removing the cap and plugging the tester into a receptacle on the end of an extension cord allows the user to test grounded motors and other equipment for open windings and circuits without danger of grounding the "live" side of the circuit, as one lamp is in each lead. With the prods touching, both lights will be on at half brilliancy. However, contact with a grounded circuit will cause one light to be extinguished while the other reaches full brilliancy.

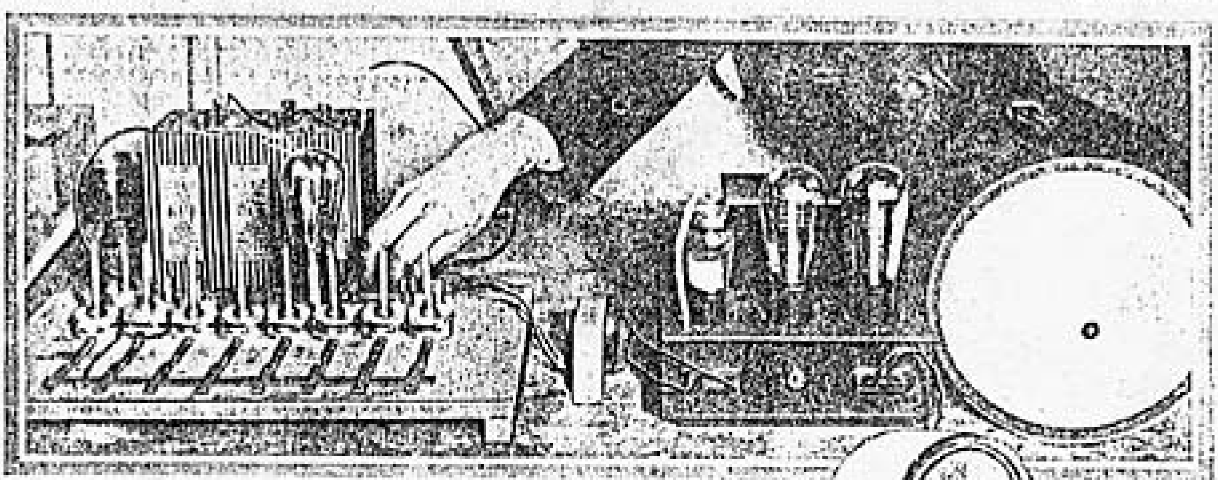
Self-Lighting Arc Searchlight

THE BOY MECHANIC – 1913

A practical and easily constructed self-lighting arc searchlight can be made in the following manner: Procure a large can, about 6 in. in diameter, and cut three holes in its side about 2 in. from the back end, and in the positions shown in the sketch. Two of the holes are cut large enough to hold a short section of a garden hose tightly, as shown at AA. A piece of porcelain tube, B, used for insulation, is fitted tightly in the third hole. The hose insulation A should hold the carbon F rigidly, while the carbon E should rest loosely in its insulation.

The inner end of the carbon E is

Continued on page 115



The simple electric organ shown at left was used in a coast-to-coast broadcast. Below, in playing this unusual instrument only one key at a time is pressed

How to Build an Electric Organ

FOR ABOUT FIVE DOLLARS

POPULAR SCIENCE, APRIL, 1933

WITH its deep, mellow notes, the electric organ is fast gaining the musical limelight.

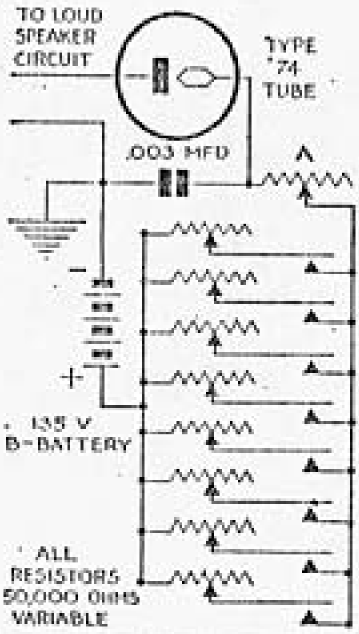
As a rule, these instruments are large and costly. Yet, for the price of a new hat, you can build a duplicate of a small organ that was featured in a recent coast-to-coast radio broadcast.

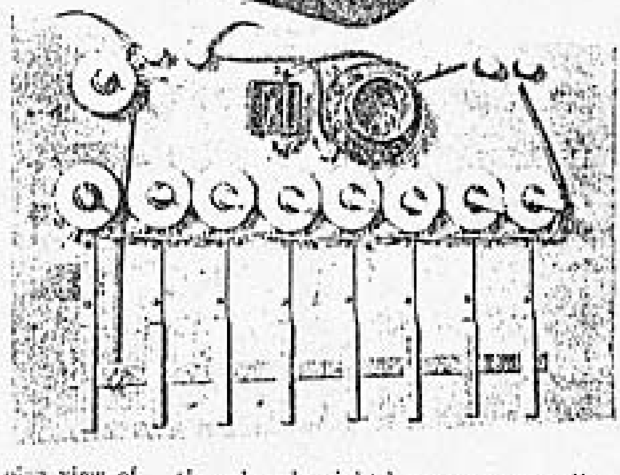
Complete, the original instrument cost its designer, Elmore B. Lyford, a New York electrical engineer, a little more than five dollars. In spite of its low cost, its rich organ-like notes delighted the well-known radio pianists that fingered its keys and its simplicity interested the engineers that examined it.

All you need to build the organ is nine 50,000-ohm variable resistances, a .003 microfarad condenser, some brass, a type '74 voltage regulator tube, a socket, and a few feet of insulated connecting wire. For power, the organ uses three forty-five-volt B-batteries.

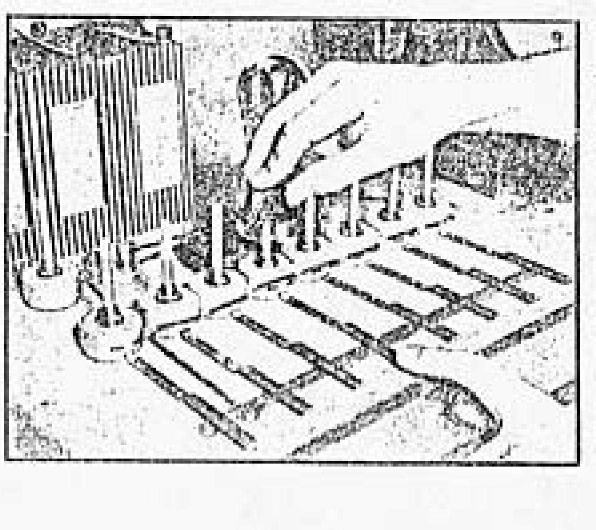
Although the organ can be connected directly to a loudspeaker, best results are obtained if an audio amplifier is used with the speaker. Of course, if you have a modern radio, you can use its amplifier and speaker by making connections to the detector tube or through the phonograph jack attachment. In the photograph, a separate amplifying unit and speaker are shown.

The keys can be bent from strips of brass or ordinary push buttons can be used for the contacts. In fact, if you are really ingenious, the keyboard of an old toy piano can be rigged as your electric console. Although only eight keys, corresponding to the scale, were used in the original, more can be added to obtain the intermediate tones.





A plan view of the organ keyboard is given above showing the nine variable resistances in place. At left, diagram to aid in building the electric organ. Below, tuning the organ by adjusting resistors



With the tube in place and the organ connected to the speaker circuit, you are ready for the simple tuning operations. As shown in the diagram, each key circuit contains a variable resistor. This resistance controls the tone of the note formed when that particular key is pressed. The resistances should be adjusted until each key, starting at the left, produces a note in the scale.

The master resistance, marked A in the diagram, controls the tone of the entire range. Increasing this resistance lowers the entire tone of the scale and decreasing it raises it.

When you play the organ press only one key at a time. In the beginning start with a simple tune, and you will be surprised how easily you can pick out the notes by ear. As each key is pressed, your loudspeaker will reproduce the notes in the rich tremolos characteristic of a fine organ.

 GRANDDAD'S ELCTRICITY BOOK

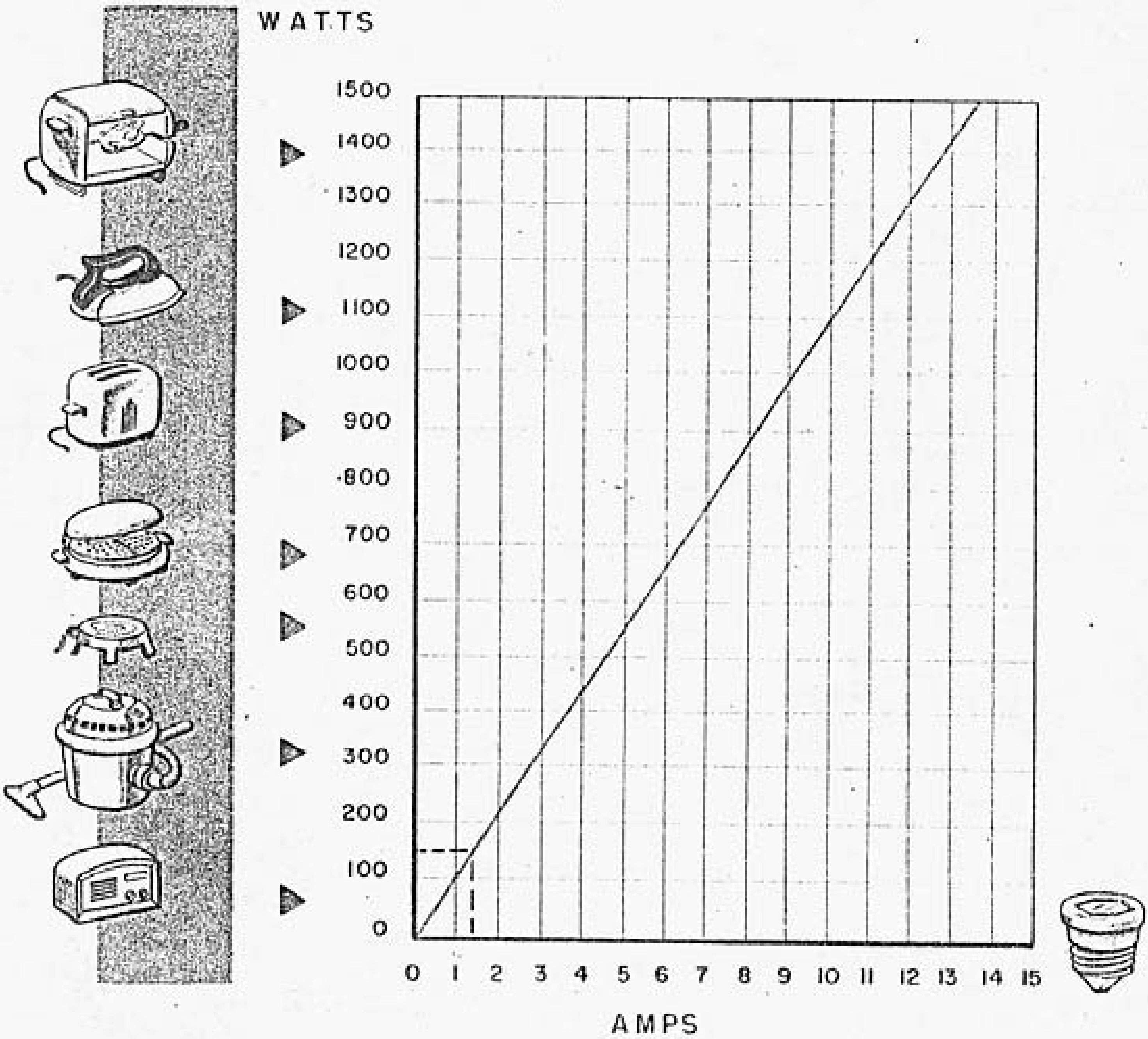
"WATCH THOSE WATTS"

How many appliances and lights can you safely use in your home at one time without risking a blown fuse? This chart provides the answer.

By Ed Bukstein

MANUFACTURERS of electrical appliances invariably rate their products in watts rather than in amperes. To the user of such appliances, this poses the problem of how many of the appliances may be used at the same time without overloading the circuit and blowing a fuse. The accompanying graph, based on a 110-volt circuit, provides a rapid solution to such problems.

To use the graph, find the wattage rating on the vertical scale, follow this line until it meets the diagonal line, and then read straight down to the amperes scale. For example, suppose you want to know how many amperes of current will be drawn by a 150-watt light bulb. Locate 150 on the watts scale, follow this line until it meets the diagonal, then read down to the amperes scale. •



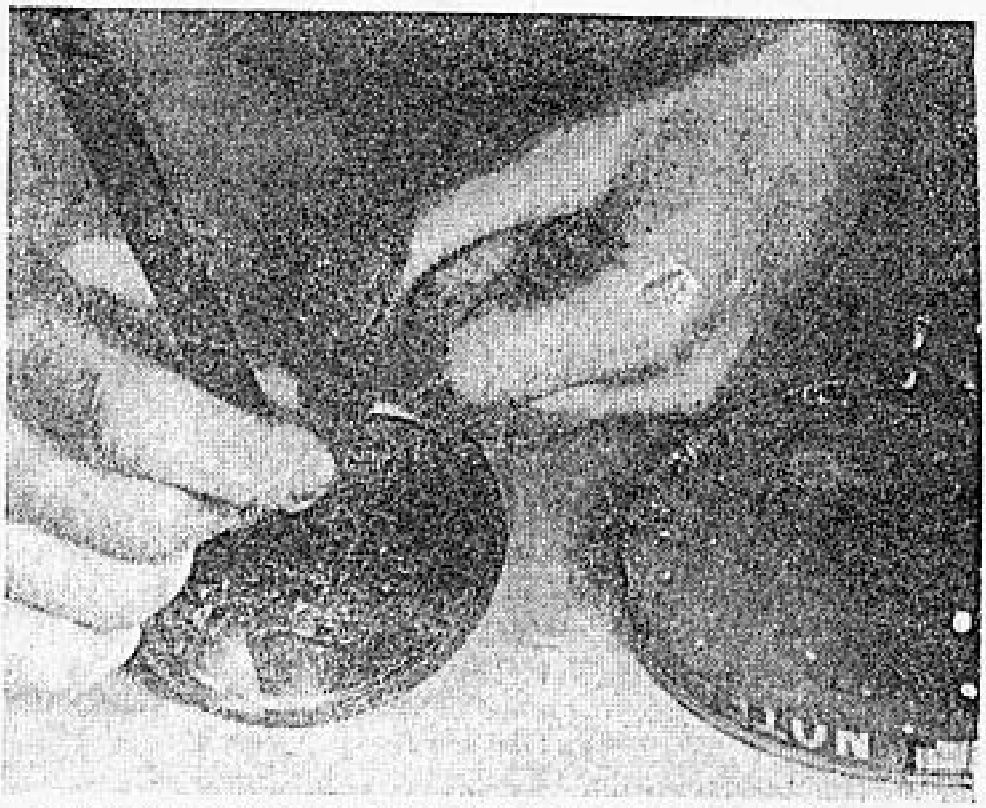
Everyday SCIENCE . . . . .

ONE'S ATTRACTIVE, THE OTHER'S FAST. MEET THE 2 TYPES OF ELECTRICITY

SCIENCE AND MECHANICS

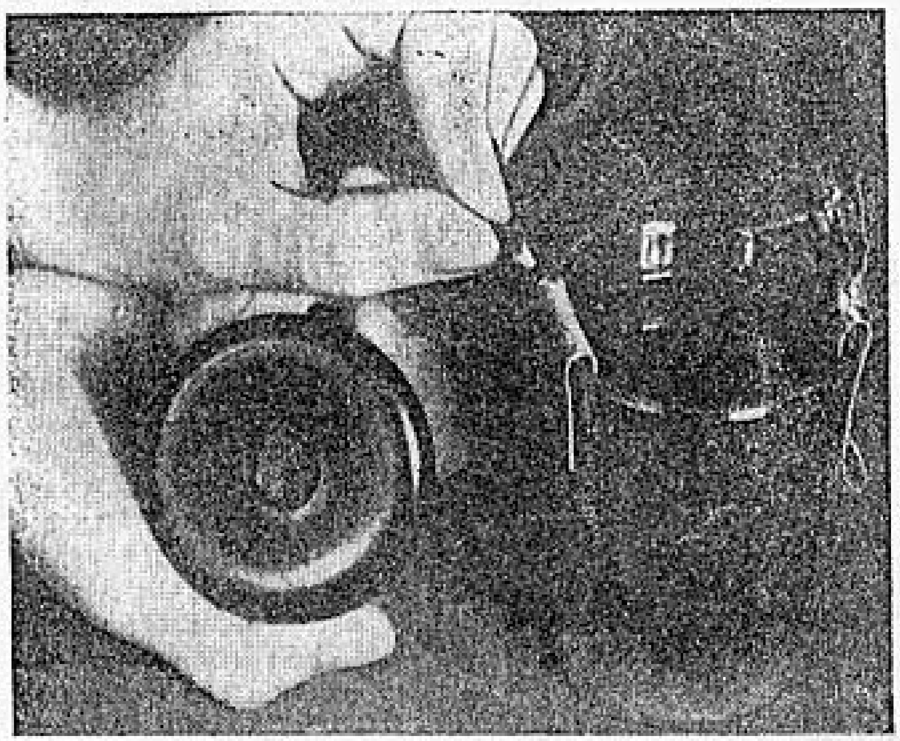
DECEMBER, 1947

An electric cell is made in a jiffy by placing pieces of copper and lead or any two dissimilar metals in vinegar solution. A telephone receiver connected to two metal pieces will emit a loud click indicating relatively powerful current.

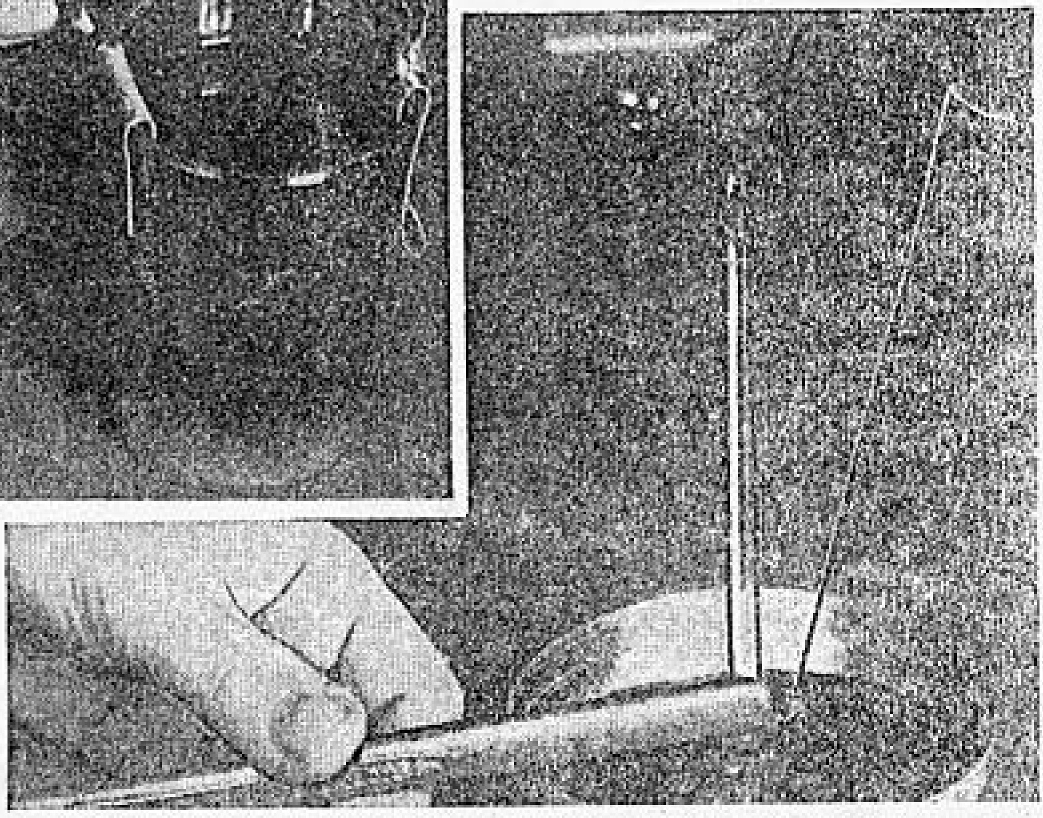


There are two kinds of electricity, current electricity which moves, and static electricity which stands still. The electrophorus or static generator is made with a cake of molten sulphur and an insulated glass or rubber handle cemented to the metal cover of a coffee can. A piece of pure, dry wool is used to briskly rub the sulphur cake after which the tin cover is placed over it, the operator making sure to use the insulated handle. After removal, a long electric spark may be drawn from the tin cover with the knuckle.

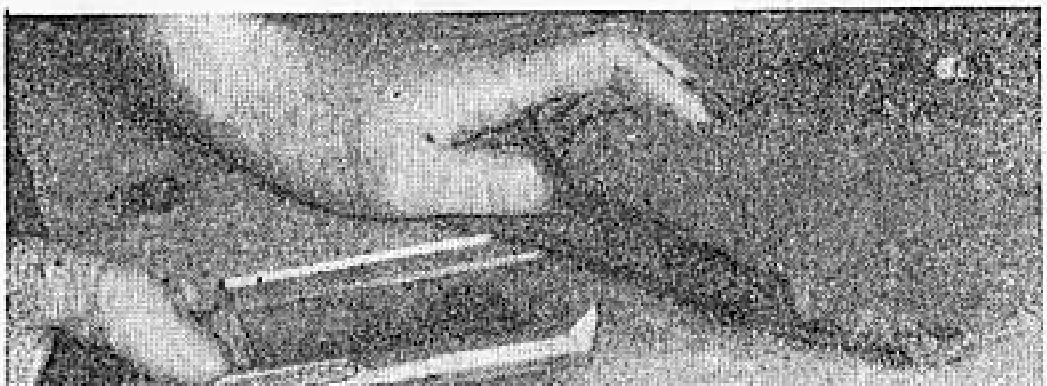
A few bits of dry paper are placed in the inverted cover of a tin can and a dry piece of glass is placed over it. When the surface of this glass is rubbed briskly with a dry piece of silk, the bits of paper will fly upward and adhere to the glass.



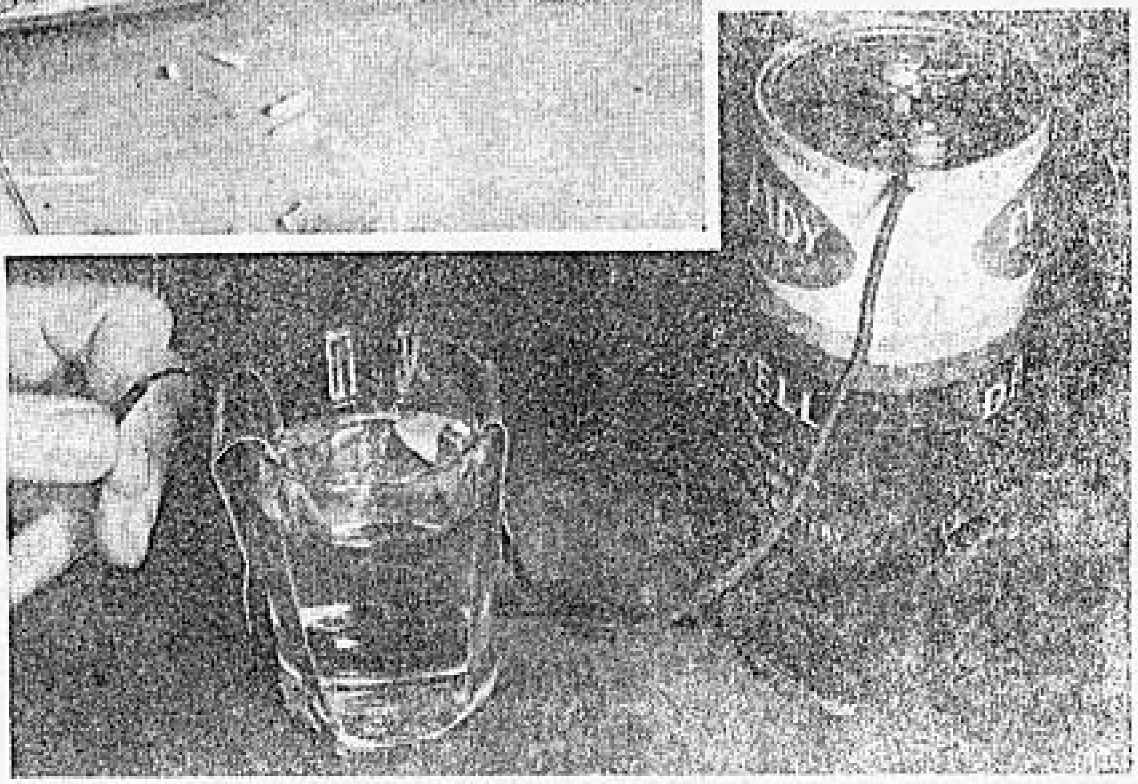
An electric cell is made in a jiffy by placing pieces of copper and lead or any two dissimilar metals in vinegar solution. A telephone receiver connected to two metal pieces will emit a loud click indicating relatively powerful current.



A piece of glass rod is held to the bottom of a tin can cover with sealing wax and provided with a copper wire arm from which is suspended a small piece of pith by means of a silk thread. Pieces of sealing wax, rubber or glass briskly rubbed with wood or silk will either attract or repel the pith balls.



Rubbing a piece of sealing wax with a piece of wool or silk will generate a strong electric charge which will greatly agitate small bits of paper on a pane of glass. All of the articles used in static experiments must be perfectly dry if good results are to be obtained.



Pure water will not conduct electric current to any great extent. Conduction comes through the presence of impurities that form electrolytes (conductors). We prove this by trying to make a spark when the dry cell shown is connected to the pieces of metal immersed in the glass of pure water. If we drop in a teaspoonful of table salt, however, the spark can be seen immediately.

FISHING for DISTANT EARTHQUAKES with a

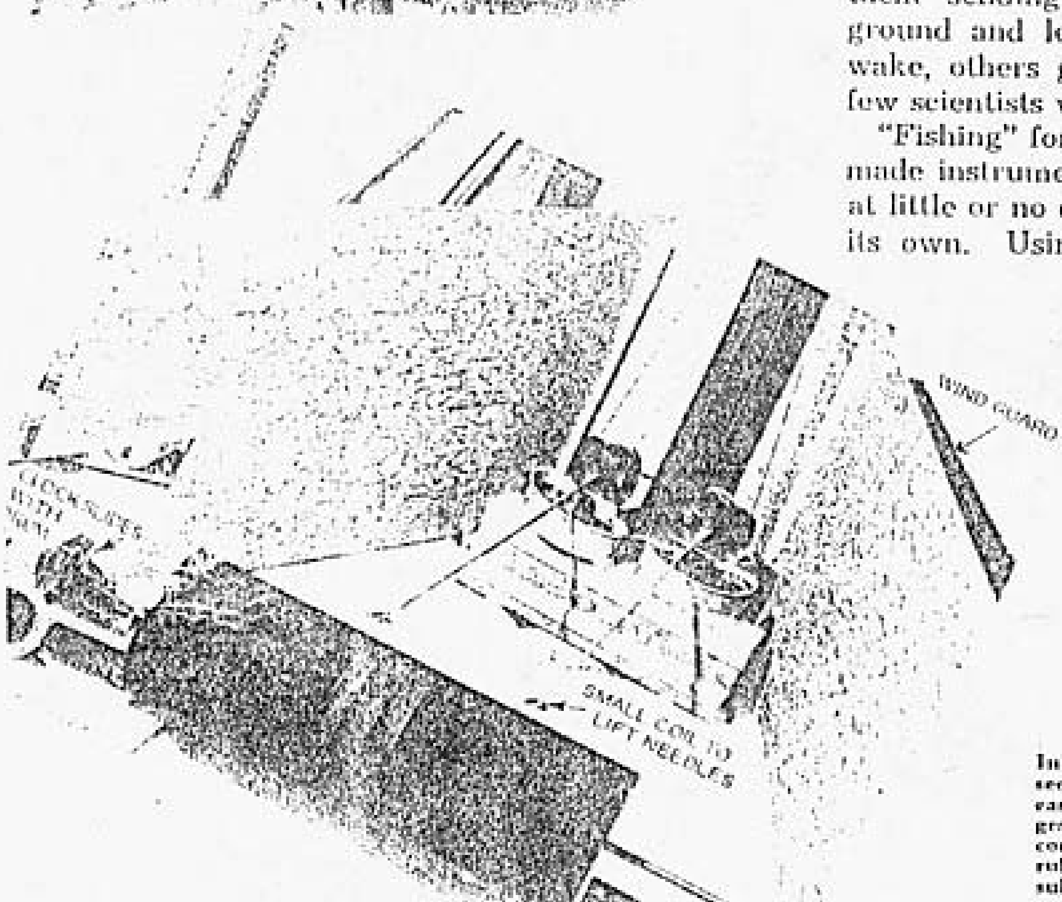
MODERN MECHANICS, Apr. 1938

Designed for the amateur scientist, this easily-built instrument records earth tremors occurring in all parts of world.

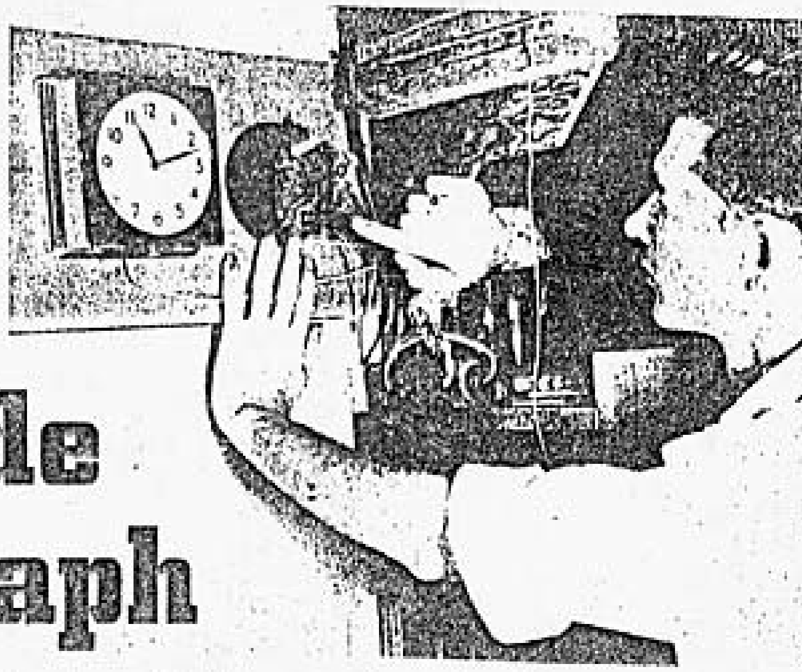
by Don Murphy

EVERY few minutes, an earthquake vibrates through old Earth's rocky crust. On an average, more than 9,000 of these shocks occur every year—some of them sending buildings crashing to the ground and leaving ruined cities in their wake, others going unnoticed except by a few scientists who specialize in this subject.

"Fishing" for these tremors with a home-made instrument, built from odds and ends at little or no cost, is a sport with thrills all its own. Using an instrument similar to that described below, Martin G. Murray, its designer, bagged complete records of the disastrous March, 1933, earthquake that devastated a whole section of southern California. So good were his 'grams that seismologists of nationally known observatories were glad to exchange records with



In the picture above, Martin G. Murray is seen examing a seismogram made on his earthquake recorder. A close-up of seismograph appears at left. Note that it incorporates such special refinements as a rubber tired drum carriage and vanes submerged in oil to dampen vibrations.



Electric magnets attached to the recording arms of the seismograph are automatically raised each hour to provide a time check on the record itself. A sweep second electric clock, with face removed, is provided with electric contacts that close magnetic circuit.

home-made seismograph

him from their big, complicated machines costing hundreds of dollars.

A seismograph is nothing but a large pendulum with a pointer which scratches a fine line on a revolving drum. Strangely, when a quake comes, it moves the drum itself —not the pendulum, which swings freely and whose inertia keeps it at rest, while the ground and everything attached rigidly to it quivers and shakes. The vibration of the earth is greatly magnified by a long arm attached to the pendulum bob, so that the record may be more easily studied. Simply by changing the length of the pendulum, the machine may be "tuned" to far-away quakes much as a piano is set to a tuning fork.

To build a simple, yet effective, seismograph, first cut a triangular piece of scrap plate ⅜ or ½-inch thick and 18 to 20 inches on the side, as shown in Fig. 1. Your local blacksmith will help you out on this for a small charge. Drill a ½-inch hole through the plate near each corner and weld a 42-inch piece of 2-inch angle iron, vertically, in the center of it.

Near the top of the angle iron, drill a ¼-inch hole through each face and fasten a ¼ by 1½-inch bolt.

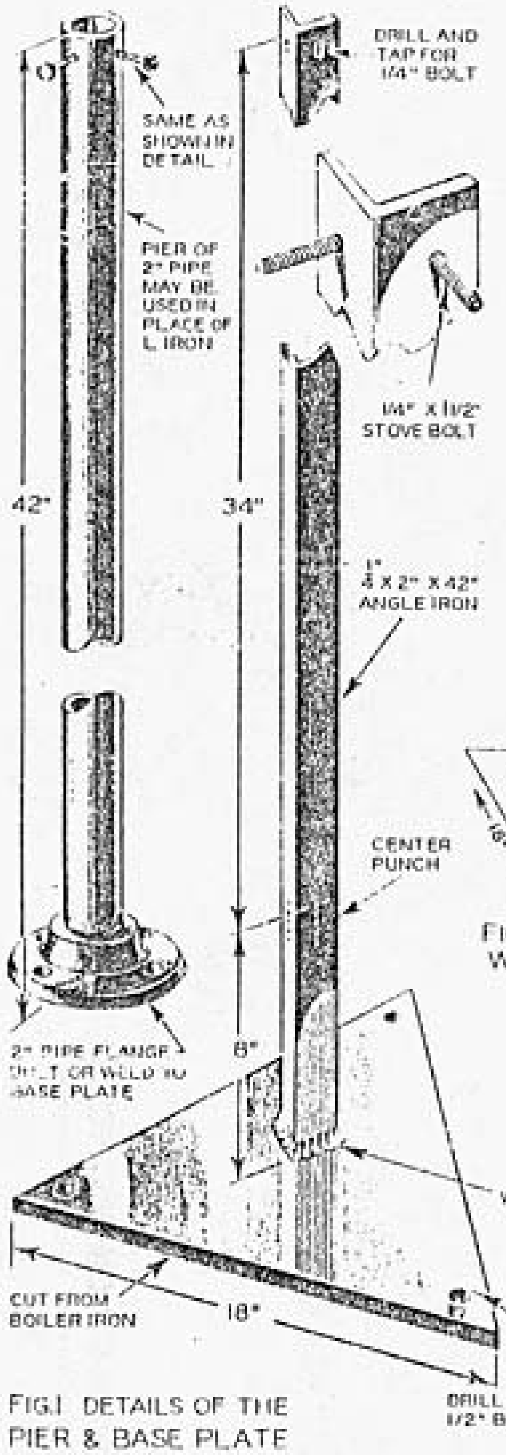


FIG.1 DETAILS OF THE PIER & BASE PLATE

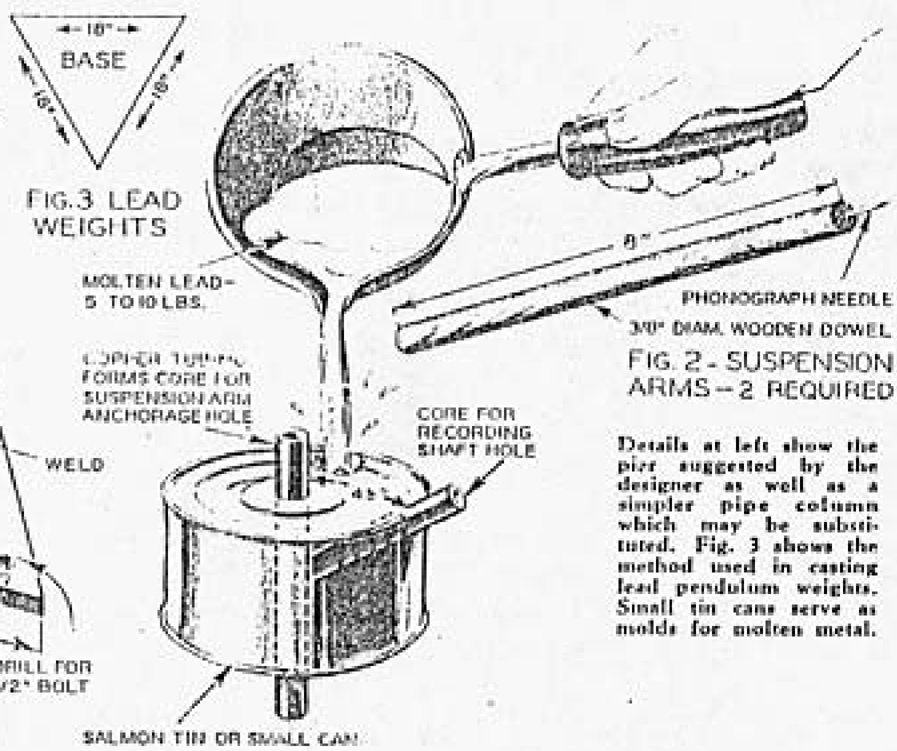
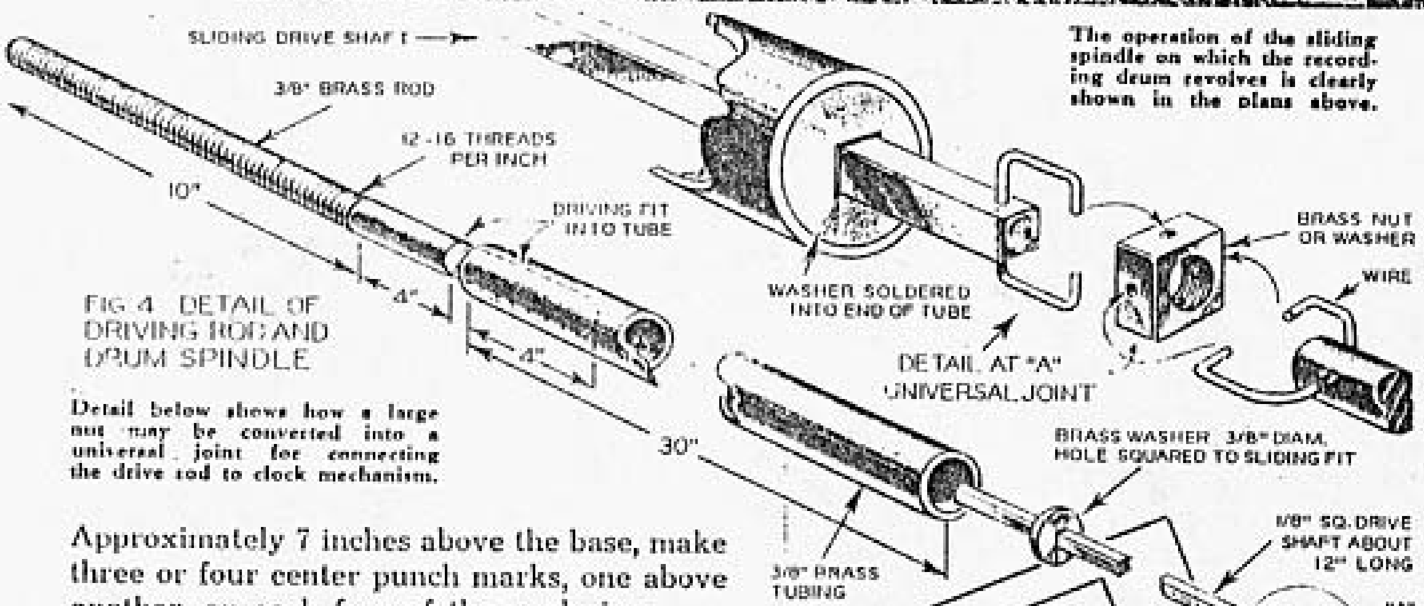


FIG.3 LEAD WEIGHTS

FIG. 2 - SUSPENSION ARMS – 2 REQUIRED

Details at left show the pier suggested by the designer as well as a simpler pipe column which may be substituted. Fig. 3 shows the method used in casting lead pendulum weights. Small tin cans serve as molds for molten metal.

The seismograph is prepared by smoking a sheet of wrapping paper, attached to the drum, with a kerosene lamp. Finished seismograph is protected by dipping it in a solution of shellac and alcohol.



The operation of the sliding spindle on which the recording drum revolves is clearly shown in the plans above.

FIG 4 DETAIL OF DRIVING ROD AND DRUM SPINDLE

Detail below shows how a large nut may be converted into a universal joint for connecting the drive rod to clock mechanism.

Approximately 7 inches above the base, make three or four center punch marks, one above another, on each face of the angle iron.

This frame comprises the pier or support for the magnifying arms. It is now ready to be bolted to some firm, stationary foundation such as the garage floor. Care should be taken in placing the base (see Fig. 6), so that the faces of the angle iron will be in a true east-west, north-south position, so that you may determine the direction of a disturbance registered by the instrument. By using double nuts on the foundation, you are able to level the base and so keep the recording arms, to be mounted later, parallel to each other.

These magnifying arms should be made of some light metal beam, thirty inches long. Strips from an old Venetian blind or other light wood may be used instead, provided cross members and wire braces are attached to stiffen them.

Fashion two wooden shafts, as indicated

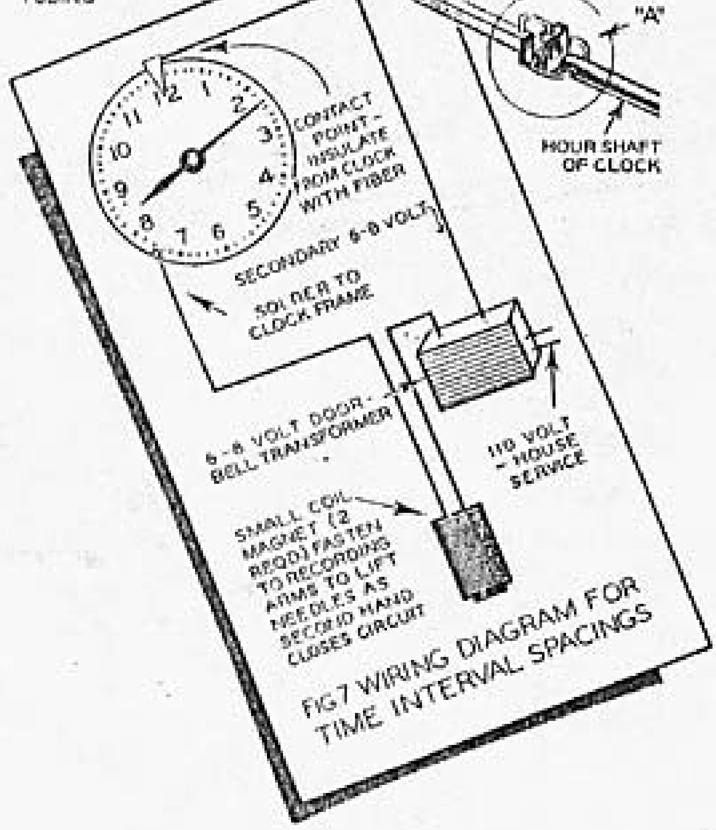
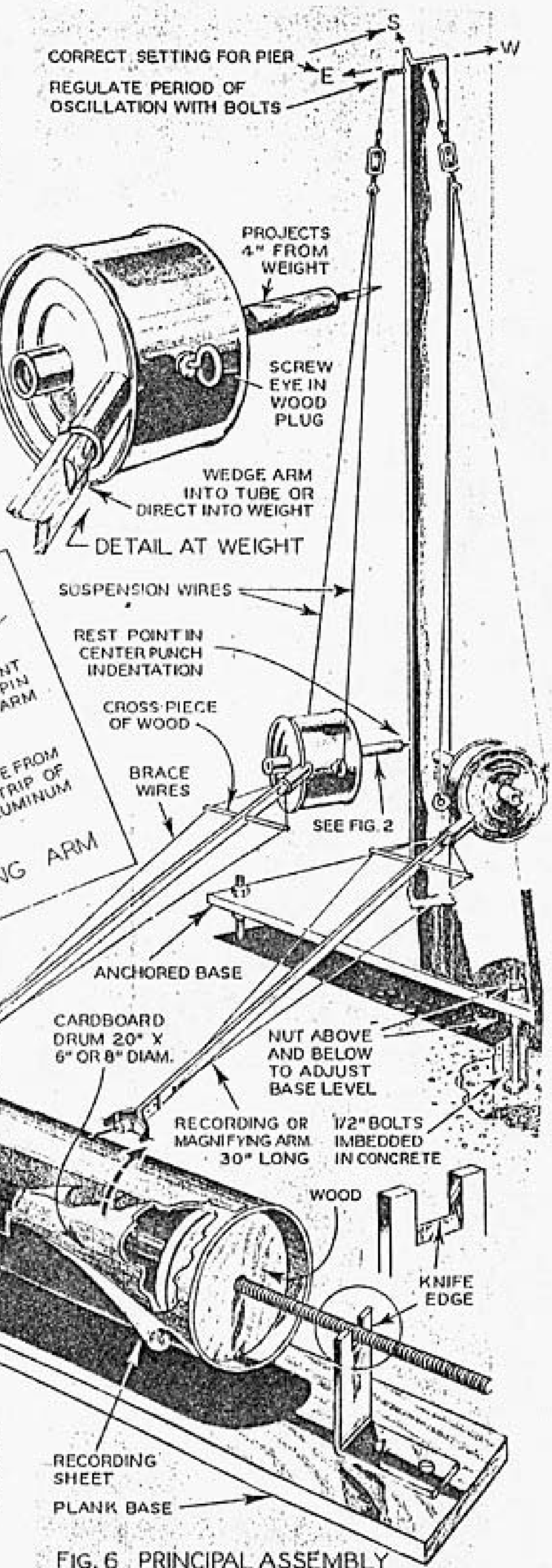
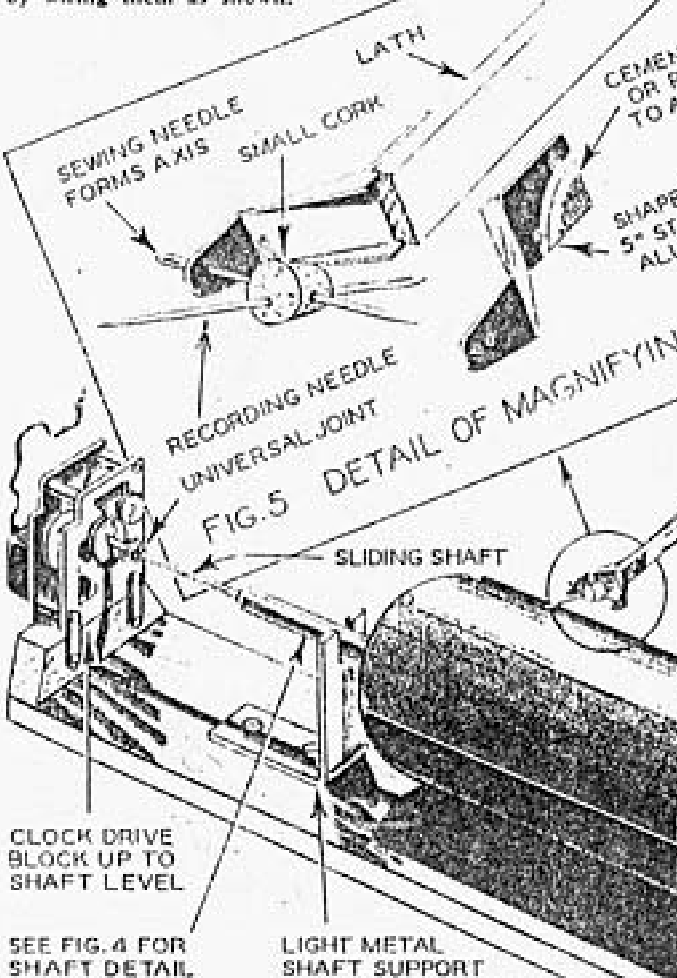


FIG 7 WIRING DIAGRAM FOR TIME INTERVAL SPACINGS

in Fig. 2, about ⅜-inch in diameter and from 4 to 8 inches in length. Into one end of each, insert an old phonograph needle, pointed end out. The other end of each shaft is later fitted with the lead weights.

Referring to Fig. 3, make two lead weights, exactly alike in heaviness, by pouring lead into two small tin cans. The weight of each should be between 5 and 10 pounds. Before pouring the lead, fasten in place two lengths of copper tubing such as used for automobile oil lines. One tube should run down the center of the tin can; the other should be run diagonally through the can, forming an angle of 45 degrees with the center tube. After the lead has cooled,

Fig. 5, below, shows assembly of the recording needles. Magnets for raising needles hourly are optional and may be installed to end of magnifying arms by wiring them as shown.

The completed seismograph is depicted above in perspective. A careful study of the details will insure the builder of an instrument of precision accuracy.

FIG. 6 PRINCIPAL ASSEMBLY

remove the tubing and insert in the resulting holes the ⅜-inch rods, leaving the needled end protruding about 4 inches. Into the diagonal hole is fitted one end of the recording arm. Now prepare the stirrups at the ends of the recording arms, folding strips of aluminum as shown in Fig. 5 and punching small holes in the sides of the stirrups to accommodate the recording needles. These needles consist simply of two ordinary sewing needles run through a piece of cork at right angles, one serving as an axis while the other traces a fine line on the recording drum.

The arm is now ready to mount on the pier. Hang the weights from the two ¼-inch bolts at the top of the pier, using light, strong wire and cutting in small turnbuckles for adjustment. Now place the points of the phonograph needles in the punch marks and adjust the wires until the magnifying arms come to rest parallel to each other. This construction is clearly detailed in Fig. 6.

If the arms and weights are exactly alike they will have the same natural "period" of vibration. Set them in motion and time each one's movements, shifting the wire on the ¼-inch bolt until they have exactly the same rate of vibration. Moving the wire toward the pier lengthens the period; away from the pier, shortens it.

The recording drum, also shown in Fig. 6, is a cardboard roll 6 to 8 inches in diameter and 20 inches long and may be secured for the asking at a furniture store. Linoleum is shipped on such rolls of various sizes. A drum of these dimensions will run a week's record without renewing the record sheet.

From your neighborhood plumber, get a brass tube about 30 inches long and a brass rod that will slip snugly into the tube for a distance of 2 or 3 inches. This brass rod should be about 14 inches in length and threaded, 12 or 16 threads per inch, for a distance of 10 inches.

A square-hole washer now should be soldered in one end of the brass tube, which forms the axis for the recording drum. Mount the drum securely on this axis, leaving the 10 inches of threaded brass rod projecting from the end of the drum. The threads run in the "V" of one of the knife-edged supports made from metal strip, so the drum will move horizontally the width of one thread for each revolution of the drum. The other support, of course, carries the opposite end of the drum, as pictured in Fig. 4.

Make a square shaft which will slide smoothly in the square hole in the washer of the drum's axis. Connect one end of this square shaft to the hour shaft of the driving clock (preferably an electric or 8-day instrument so as not to stop at inopportune moments) and insert the other end in the washer.

For connecting the driving rod to the clock a universal joint of some sort must be used to allow for friction that may develop through mis-alignment or temperature changes. Fashion this universal joint by using a square washer with holes on four sides, or a small block of rubber will suffice.

The instrument may be refined somewhat by mounting the clock on a rubber-tired toy cart which moves horizontally with the drum, thus eliminating the sliding driving rod and reducing friction.

Use a sheet of wrapping paper for a recording sheet. Wrap it smoothing around the drum and glue the edges tightly. Revolve the drum slowly as you now smoke the recording sheet black by use of a coal-oil lamp minus chimney.

With recording sheet in place, carefully check over the apparatus. See that the magnifying arms are parallel; that the instrument is protected from air currents; and that the needles rest lightly on the recording drum. When everything is ship-shape, start the clock. As the drum slowly revolves a fine line will appear on the smoked record cylinder.

To make a really accurate record it is well to provide some kind of time clock. A simple scheme is to wind two tiny coils and place one on each magnifying arm in such a position that when the coil is energized by current from the light socket, it will attract the needle and lift it momentarily, leaving a minute break in the seismogram. Fig. 7 and the accompanying photos show details of magnets.

A second clock, preferably an alarm clock with a sweep-second hand, should be fitted with contacts so that each hour the contact will be made and the magnet coil energized, producing an hour mark on the drum. A small bell-ringing transformer will step down the 110 volts from the lighting service to the right voltage.

When the drum is filled with a record, remove the sheet and slip it into a trough containing shellac diluted in 50 percent alcohol, then hang it up to dry. The alcohol not only thins the shellac, but also gives a dull finish to the record and protects it against blurring.

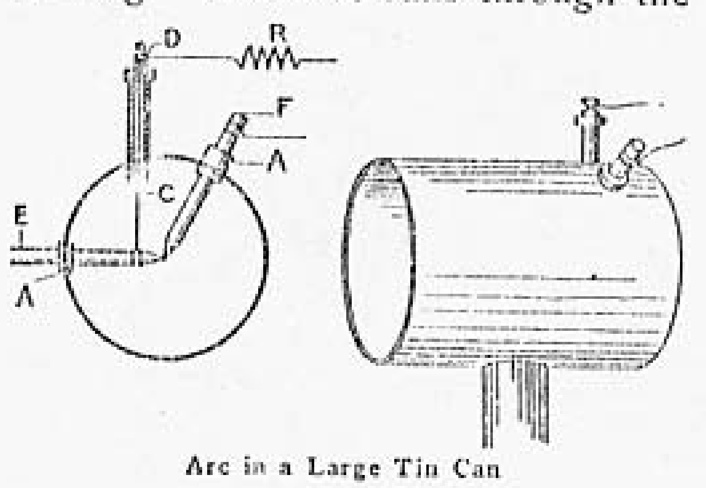
Don't expect immediate results—you may register a quake five minutes after starting the instrument, or you may have to wait several days. But on the average, there is a distinct earthquake somewhere on this earth once every hour and some of them will register on the recording drum.

When studying your first seismogram, note that the waves seem to come in bunches. That is because each quake consists of at least three distinct groups of shocks—a primary wave, a secondary wave following a little later, and a long succession of minor shocks. The spreading of the waves as they travel through the earth's crust gradually separates these groups, and for a quake 8000 miles away, they may be as far as twenty seconds apart. By noting the time between these wave groups you may form a rough idea of how far away the shock originated.

In the study of seismograms you will doubtless find of interest two booklets that can be bought from the Superintendent of Documents, Government Printing Office, Washington, D. C. The first is a 61-page booklet with a map of the U. S. and is entitled, "Earthquake History of the U. S., Exclusive of the Pacific Region"—Special Publication No. 149, and costs 15 cents. The other, "Destructive and Near Destructive Earthquakes in California and Western Nevada, 1769 to 1933,"—Special Publication No. 191—is priced at 5 cents and is a 24-page booklet.

Continued from page 106

supported by a piece of No. 25 German-silver wire, C, which is about 6 in. long. This wire runs through the



Arc in a Large Tin Can

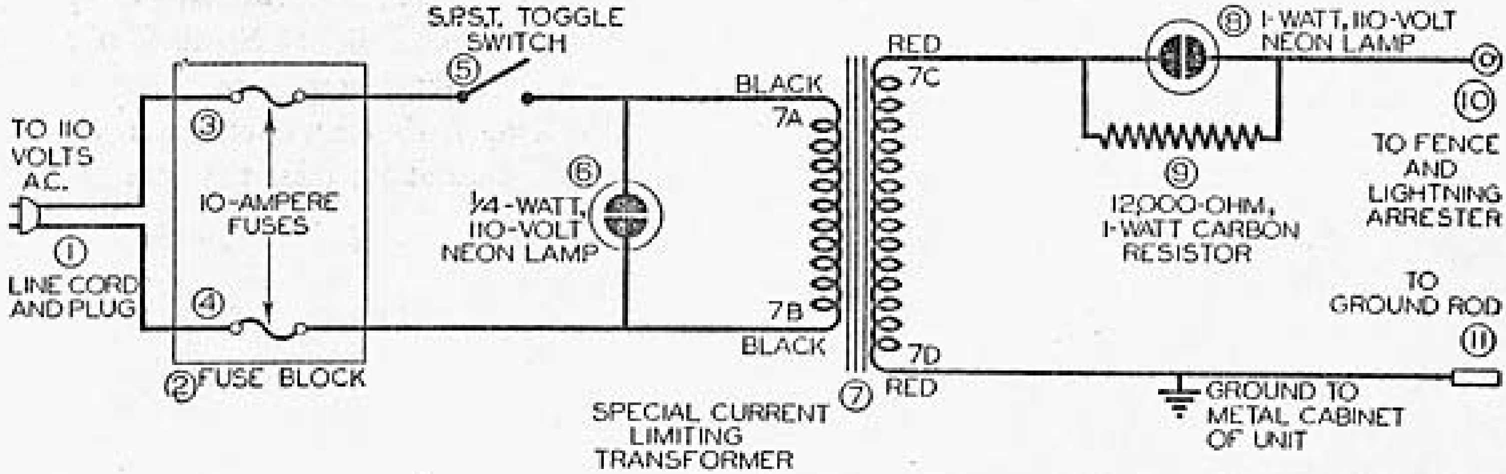
porcelain tube to the binding post D. The binding post is fastened to a wood plug in the end of the tube. The tube B is adjusted so that the end of the carbon E is pressing against the carbon F. The electric wires are connected to the carbon F and the binding post D. A resistance, R, should be in the line.

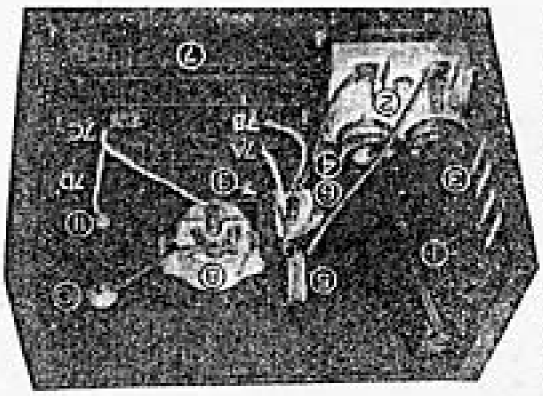
The current, in passing through the lamp, heats the strip of German-silver wire, causing it to expand. This expansion lowers the end of the carbon E, separating the points of the two carbons and thus providing a space between them for the formation of an arc. When the current is turned off, the German-silver wire contracts and draws the two carbon ends together

SCIENCE AND MECHANICS OCT.-NOV., 1938

Electric Fence Plans

Here are long-awaited plans for a low-cost, safe and effective 110-volt A.C. electric fence unit.





Circuit diagram of 110-volt A.C. electric fence unit. Plugging the line cord into a wall outlet and closing switch 5 places the unit in operation. There are no moving parts to wear.

Rear view of completed unit. It will effectively and safely charge over 25 miles of fencing.

If dogs persist in knocking over the garbage cans, just hook up your 110-volt A.C. Electric Fence unit as shown here, and in a few weeks every dog in your neighborhood will be permanently educated. Be sure to warn the garbage collector beforehand, and show him how to turn off the unit.

ELECTRIC fencing, a relatively new and unusual use for electricity, keeps animals in a defined territory not by brute force or by inflicting bodily injury, but by means of an electric charge which produces physical sensations which are so new and puzzling to the animal as to discourage further contacts with the fence wire. The fencing itself usually consists of a single strand of plain or barbed wire supported by insulators on posts spaced up to 60 feet apart. The charge is applied by an electric unit which operates from a 6-volt battery or from a 110-volt A.C. power line. It is estimated that more than 160,000 of these units are in operation today, charging over 250,000 miles of fencing.

The ideal electric fence unit must, first of all,

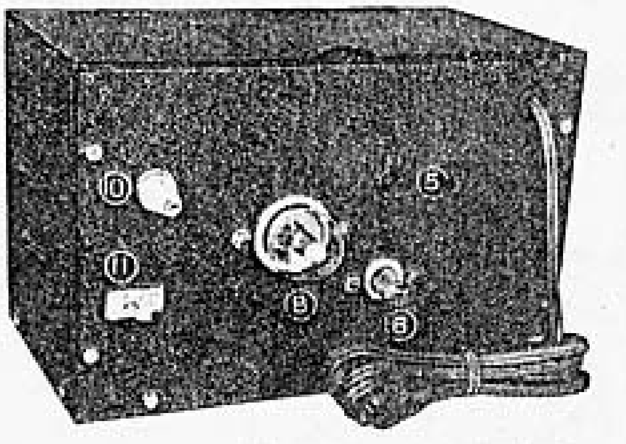
ready for lighting again. The feed can be adjusted by sliding the carbon F through its insulation.

A resistance for the arc may be made by running the current through a water rheostat or through 15 ft. of No. 25 gauge German-silver wire.—Contributed by R. H. Galbreath, Denver, Colo.

be safe to humans as well as animals under absolutely all conditions of operation. Secondly, it must deliver a strong enough shock to be effective on animals in dry as well as wet weather. Finally, the operating costs must be low.

No Interrupter Needed

The unit for which constructional plans are presented here meets all of these requirements, yet it is one of the simplest and least costly. It consists of a special constant-current or current-limiting transformer which steps up the 110-volt A.C. line voltage to approximately 600 volts A.C. and yet never delivers more than the universally accepted safe electric fence current of 8 milliamperes (.008 ampere) even under short-circuit conditions. This transformer eliminates the need for costly and oftentimes troublesome circuit-interrupting devices.



Front view of completed 110-volt A.C. electric fence unit. Numbers are the same as those on corresponding parts in the circuit diagram.

The output voltage is high enough to be effective in dry weather or in sandy regions where earth resistance is high. Operating costs are only a few cents a month. Initial erecting costs are only about one-fifth those for old-fashioned four- to six-strand fences with closely-spaced posts. All parts, except the easily replaceable neon lamps, last indefinitely. The unit is portable. It may be set up anywhere by plugging the line cord into the nearest 110-volt, 60-cycle A.C. outlet, connecting the insulated output terminal to the fence, and connecting the ground terminal to any convenient water pipe or 5-foot metal rod driven into the ground.

The other parts shown in the diagram, while not all essential, add to safety and convenience. Two 10-ampere fuses, one in each A.C. line, are protection against accidental shorts in the primary circuit. The S.P.S.T. toggle switch makes it possible to turn the unit off without pulling out the line cord.

The ¼-watt neon lamp across the primary winding of the transformer serves as a pilot lamp, glowing only when the electric fence unit is in operation. Any other 110-volt lamp which can be seen at a reasonable distance may be used.

The 1-watt neon lamp in the secondary or fence circuit, protected by a 12,000-ohm shunt resistor, glows only when the fence is grounded. That lamp and resistor also serve to protect the transformer insulation against resonance effects. If both pilot lamp and ground-indicating lamp glow when the unit is connected, the fence is grounded somewhere. This ground must be removed to restore effectiveness. A ground will have no damaging effects upon the transformer, however.

A Special Warning

Do not attempt to use a radio set transformer for this unit. Such transformers do not have the special type of iron core required to limit secondary current to a safe value. Do not attempt to wind your own transformer. It may prove to be dangerous. The current-limiting transformer required is not expensive, so there is no reason for experimenting with dangerous makeshift transformers.

Assembly of the unit is simple. Either the schematic diagram or the photographs may be used as a guide. The parts may be mounted on a single board, but a completely enclosed metal or wood cabinet will be safer and more satisfactory. If a metal cabinet is used, the 9" x 5" x 6" size shown in the photographs will be found ideal.

Mount the parts in approximately the positions shown in the photographs. One coil on the transformer will have two black leads; these identify it as the primary winding and should be connected to the terminals of the ¼-watt neon pilot lamp. The leads for the secondary winding are red. One goes directly to the ground terminal; the other connects through the ground-indicating lamp and its shunt resistor to the fence terminal.

For protection against lightning, an extra soldering lug should be placed at the back of the feed-through insulator for the fence terminal. This lug should be bent until its end is about one-sixteenth inch from the metal chassis. A standard lightning arrester of the air-gap type should be mounted outside of the unit, either on the outside of a building or on the first fence post, and connected between the charged wire and ground. In most cases fire underwriters require that an outside lightning arrester be used.

Locating the Unit

Ordinarily the cabinet used for the electric fence unit will not be water-proof. Therefore it must be located inside a building or in some other shelter. An ordinary porcelain tube, like those used in radio antenna installations and for house wiring, may be used to bring the fence wire through the building wall. The wire used to connect the unit to the fence may be either bare or insulated. For a neater looking installation insulated wire is preferable.

 GRANDDAD'S ELCTRICITY BOOK

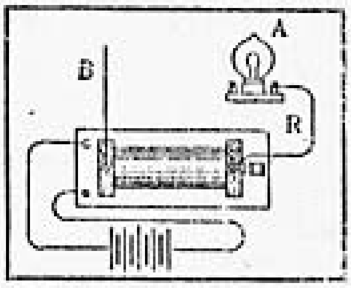
When electric fencing is used along highways, it is advisable to post small signs every few hundred feet to indicate that the fence is charged.

Detailed instructions for erecting electric fences, including types of posts, insulators, and wire to use, how to erect corner posts and gates, correct fence heights for various animals, etc., were given in the February, 1938 issue of SCIENCE AND MECHANICS. This article points out many uses for electric fence units other than on farms, such as for keeping dogs in their own yards or out of gardens, and also tells how to build a battery-operated electric fence unit which is entirely satisfactory for occasional use (not suited for continuous operation because current drain from the 6-volt battery is quite heavy).

For information as to where you may obtain the special current-limiting transformer required for this 110-volt A.C. electric fence unit, the completely-drilled metal cabinet, or a complete kit of parts including these items, send a letter or postcard to Radio Editor, SCIENCE AND MECHANICS, 800 North Clark Street, Chicago, Ill. A detailed list of the parts required for the unit will be included free of charge, for your convenience. Indicate also if you desire information as to where electric fence accessories, such as insulators and gate hooks, may be purchased.

Electric Blue-Light Experiment

Take a jump-spark coil and connect it up with a battery and start the vibrator. Then take one outlet wire, R, and connect to one side of a 2-cp. electric lamp, and the other outlet wire, B, hold in one hand, and press all fingers of the other hand on globe at point A. A bright, blue light will come from the wires in the lamp to the surface of the globe where the fingers touch. No shock will be perceptible.



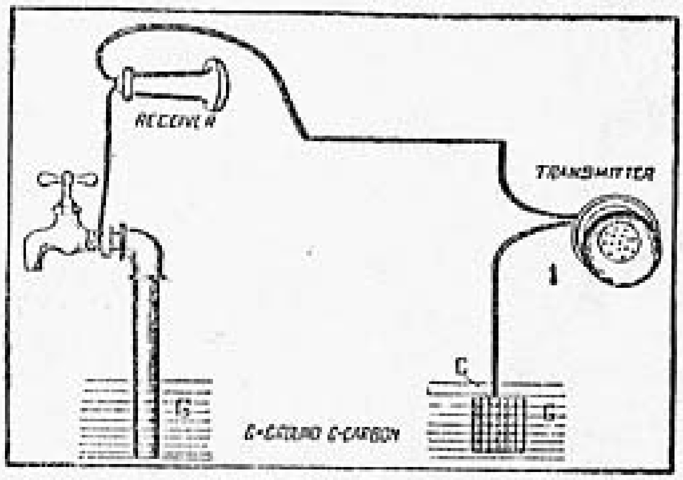
THE BOY MECHANIC – 1913

Interesting Electrical Experiment

The materials necessary for performing this experiment are: Telephone receiver, transmitter, some wire and some carbons, either the pencils for arc lamps, or ones taken from old dry batteries will do.

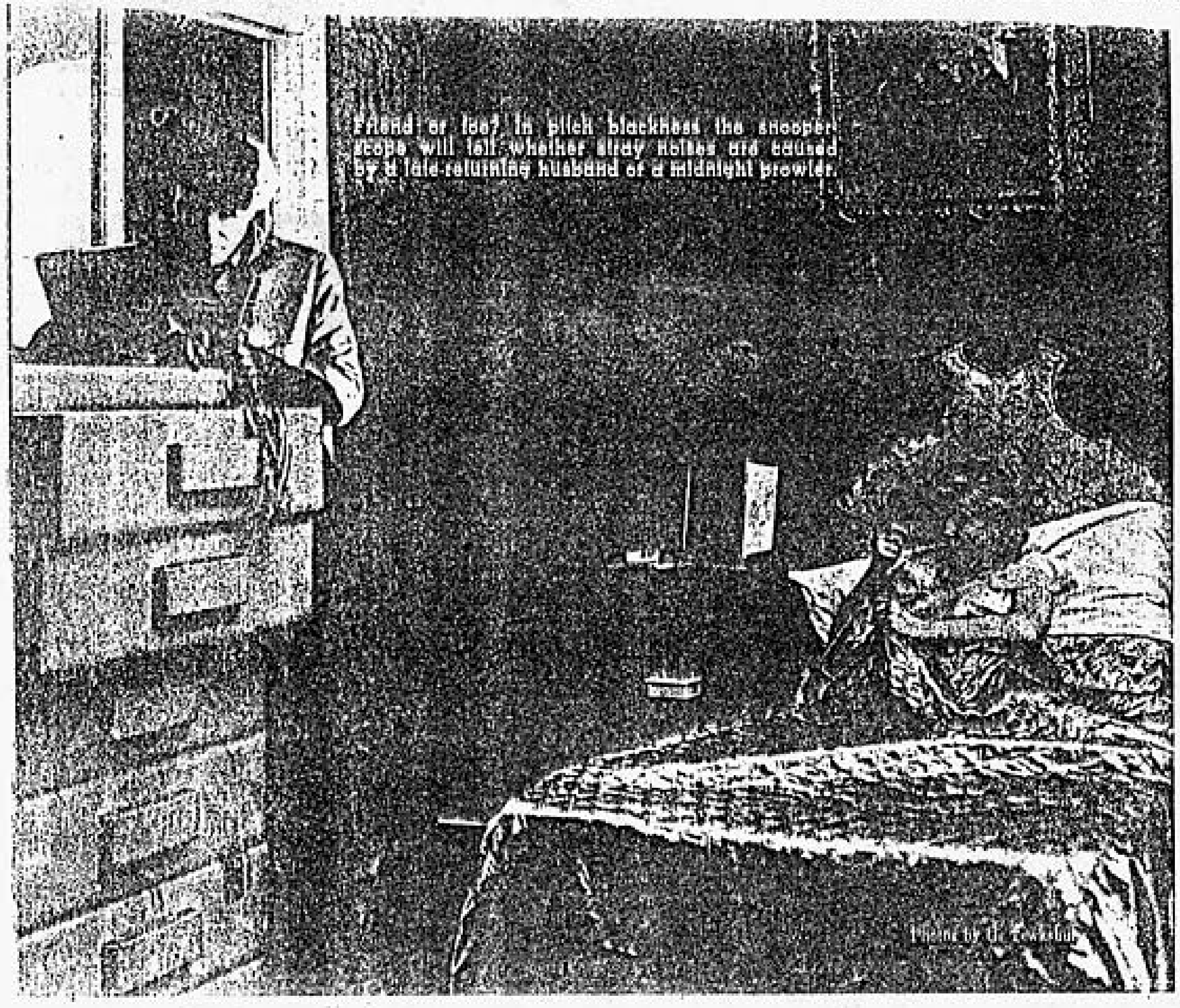
Run a line from the inside of the house to the inside of some other building and fasten it to one terminal of the receiver. To the other terminal fasten another piece of wire and ground it on the water faucet in the house. If there is no faucet in the house, ground it with a large piece of zinc.

Fasten the other end to one terminal of the transmitter and from the other terminal of the same run a wire into the ground. The ground here should consist either of a large piece of carbon, or several pieces bound tightly together.



A Unique Battery

If a person speak into the transmitter, one at the receiver can hear what is said, even though there are no batteries in the circuit. It is a well-known fact that two telephone receivers connected up in this way will transmit words between two persons, for the voice vibrating the diaphragm causes an inductive current to flow and the other receiver copies these vibrations. But in this experiment, a transmitter which induces no current is used. Do the carbon and the zinc and the moist earth form a battery?—Contributed by Wm. J. Slattery, Emsworth, Pa.

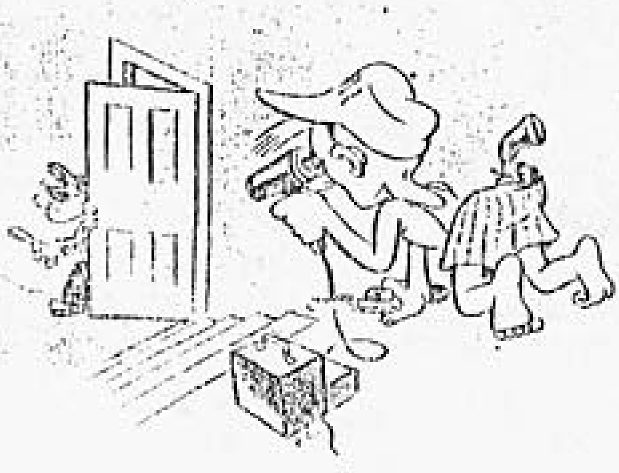


Friend or foe? In pitch blackness the snooperscope will tell whether stray noises are caused by a late-returning husband or a midnight prowler.

Mechanix Illustrated August, 1951

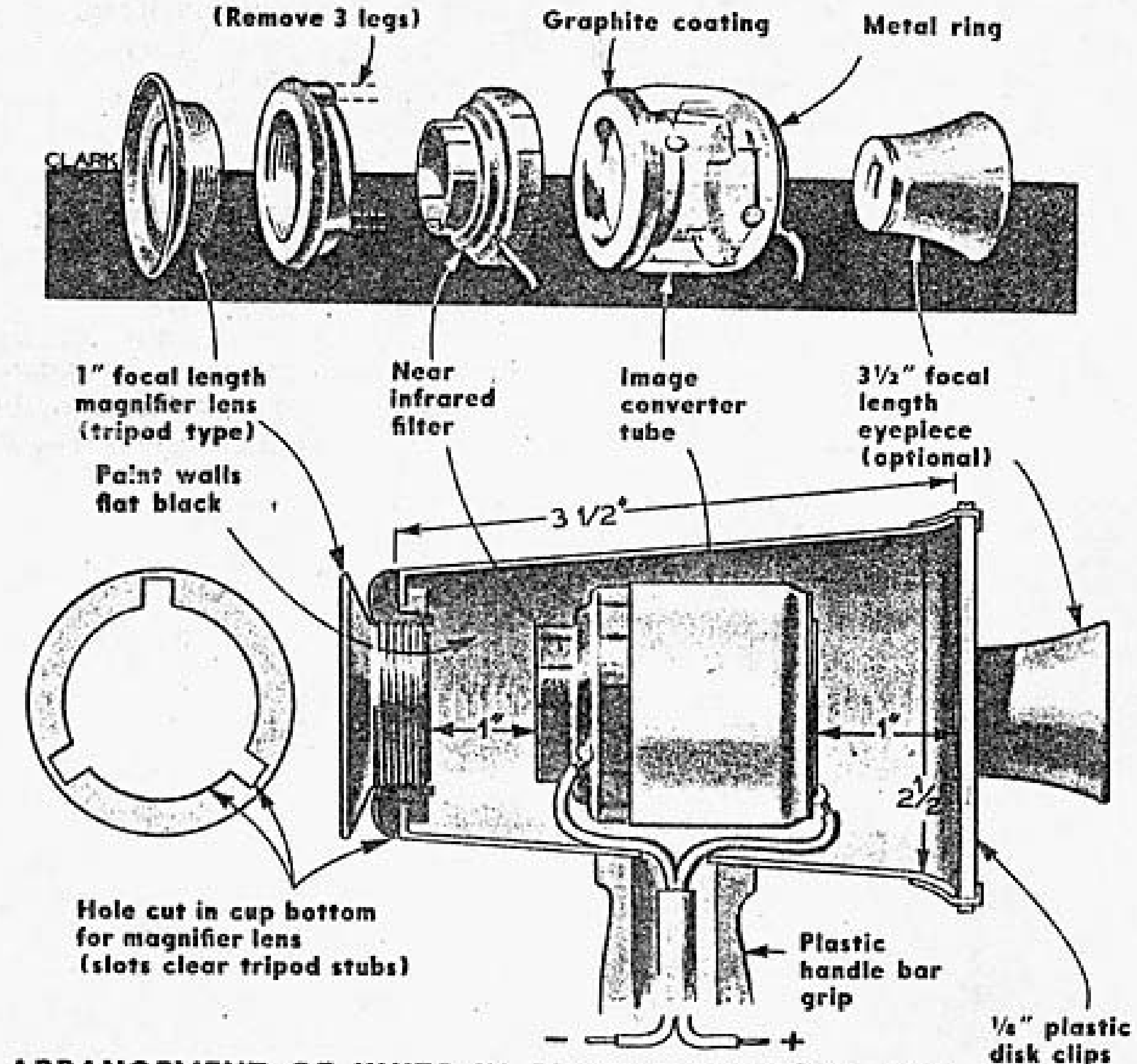
make this SNOOPERSCOPE and see in total darkness

By Harold Pallatz



PICTURED above is only one of the possible applications of the modified wartime sniperscope. This unit, called a snooperscope, is an enlarged version of the instrument used by GI riflemen to enable accurate fire power in total darkness. When the infrared light source is turned on, the user, by employing the special eyepiece, can see in the area covered by the light, although to the naked eye total darkness still prevails.

A number of more practical applications have been developed with the snooperscope because of its ability to peer through any opaque material that passes infrared rays. Crime detection laboratories are now using similar equipment for reading through certain types of material. Since the infrared reflection of pigments in paints and inks is different from that of white light, it is possible to detect forged paintings and checks by the way the colors appear. You can demonstrate this by writing a message with India ink and then painting over it with a coat of ordinary fountain pen ink. Your eye will only see the blackened spot but the snooperscope will peer through the top



ARRANGEMENT OF UNITS IN PLASTIC DRINKING CUP

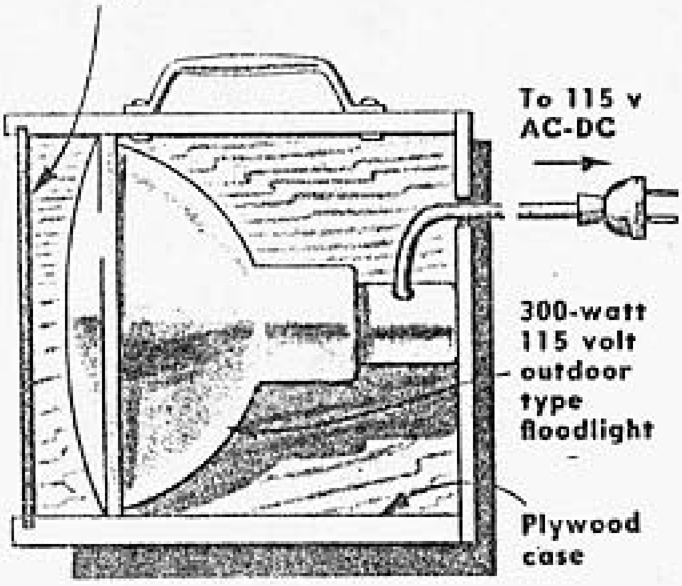
layer of ink and reveal the writing just as clearly as if there were no top coating. This type of inspection can be made photographically if infrared film is used in the camera. The electronic method permits instantaneous examination which often is a great convenience.

As you might have thought, there are several photographic applications. Using this device, you can take photographs with no visible light source. (For instructions on this type of work, see Shoot 'Em In The Dark, January, 1951, MI, pgs. 148-149.) One of the handiest uses is using the snooperscope as a darkroom viewer. Difficult operations that have to be carried out in total darkness can now be viewed clearly throughout the process. If you run into trouble loading film tanks you will appreciate a viewer when the film becomes snarled. A test for fogging should be made before the viewer is used. Within the next few years every modern darkroom may be equipped with infrared viewers.

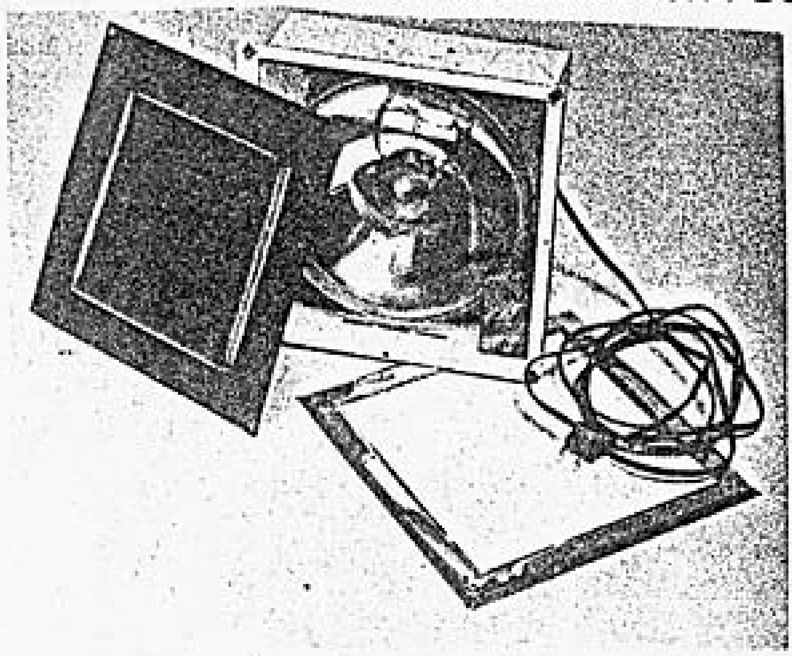
In scientific laboratories a modified unit such as this is used to study the behaviour of small nocturnal animals in total darkness. A converter tube has been used with a microscope to study bacteriological and botanical specimens under infrared rays. Certain large molecules may now be examined in a different way, since they become transparent under infrared light.

Military uses are obvious. The sniperscope has already been mentioned. The Germans used infrared-equipped tanks and trucks for driving during blackouts. Under these conditions they could travel almost as fast as during the day. Cars equipped with a snooperscope would have the advantage during fog. Certain types of fog are transparent to infrared (depending on the particle sizes) and during such weather increased safety of the road could be obtained. The experimenter is cautioned about building a unit for this purpose, as very good lenses are required as well as powerful headlights. Such specialized construction is likely to prove difficult and driving with makeshift equipment would be dangerous.

In the actual construction of your snooperscope, your best tube would be one of several British models, which are available



UNIT FOR SUPPLYING LIGHT SOURCE



Elements of the light source. Bulb employed is a standard 100 to 300-watt lamp. Although this case is of metal, you may use plywood if so desired.

on the surplus market. Two of these are type CRI 143 and CV 147. For operation at the highest voltages, the tubes should be carefully selected. Other electronic parts required are a 4,000 to 6,000-volt low current power supply (less than one milliampere), a light source and two filters.

For indoor operation a 4,000 to 5,000 volt neon sign transformer operates the tube satisfactorily. Two 1-megohm resistors are used, one in series with each lead, to limit the current. Rectification is not necessary unless the objects are in motion (objects in motion cause a strebescopic effect when AC is employed.

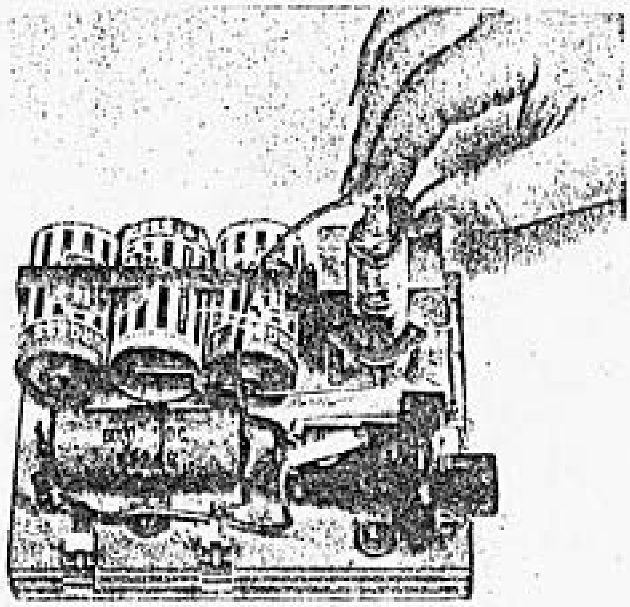
For portable use either indoors or outdoors a handy-sized power supply may be constructed that operates off three standard flashlight cells. For continuous operation leave the power supply on as long as required. Very long battery life can be obtained by switching on the power supply only momentarily to charge the condenser. The condenser will then store this energy and continue to operate the tube for some time after the unit is turned off. Place a small piece of rubber tubing over toggle switch handle to help eliminate charge pickup.

The high voltage is supplied by a model airplane ignition transformer with a vibrator to interrupt the primary current. These transformers are available on the market with the vibrator already built in. Only two wires need be attached for operation. You can make up your own vibrator coil arrangement by using the parts of an old buzzer or bell. Some types of buzzers can simply be connected in series with the primary of the transformer. Try yours to see if this is possible (1½ volt buzzers). Caution: Avoid contact; these voltages are high and while not dangerous, can give you a rather uncomfortable shock.

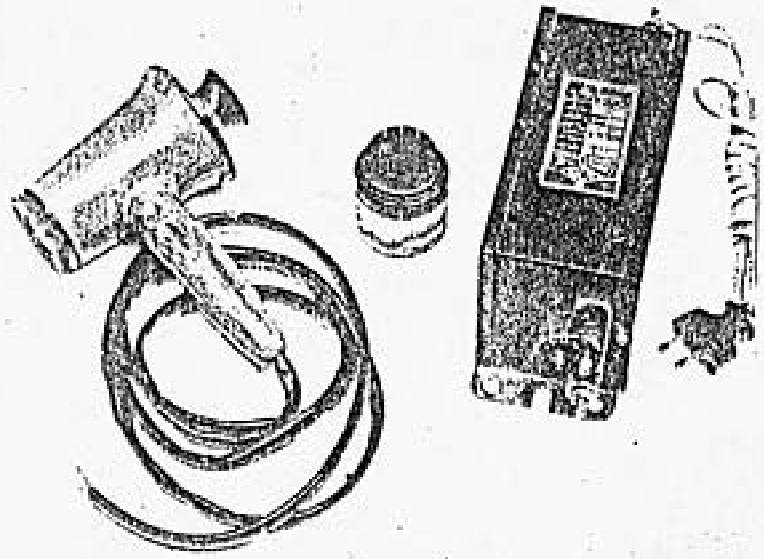
Construction of the snooperscope: The image converter tube is mounted in a plastic drinking cup 3½ in. high by 2½ in. in diameter. The optical system required depends upon your intended use. We used a small tripod type magnifier lens of 10 power (1 in. focal length) for the front lens and objects from three inches to one and a half feet can be focused. There is no reason why a greater range cannot be had with this lens by moving it closer or farther away from the tube.

After selecting the lens system mount it in a hole cut into the bottom of the cup. A jeweler's saw or coping saw is ideal for cutting the hole. Paint the *inside* of the cup with black paint. Black airplane dope works fine. No light other than that from the lens must be permitted to hit the tube. Place an infrared filter between tube and lens to reduce effects of stray white light.

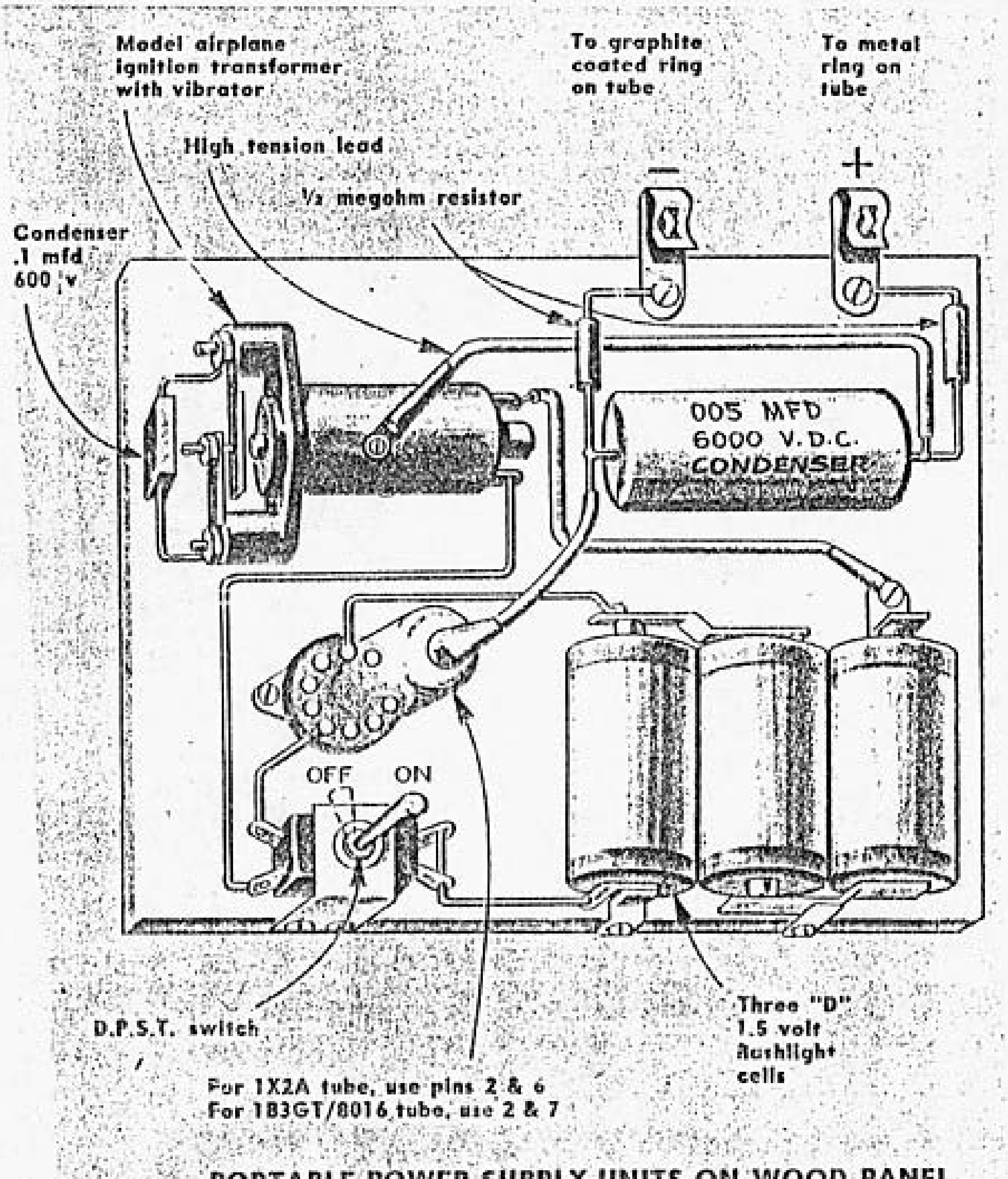
The image converter tube is inserted with the graphite side toward the front lens and the metal ring toward the mouth of the cup. A thin flexible lead from the metal ring connects to the positive side of the power supply. Some tubes were manufactured without this lead, in which case a piece of spring metal pressed against the metal ring will work just as well. The front end of the tube has a graphite ring around it. This is the end where the infrared image is to be focused. The graphite coating is the cathode or negative lead. Connect this lead to the B minus side of the power supply. A piece of spring



Top view of simplified power supply for portable use. Cells are the ordinary flashlight type. The entire unit is mounted on a ¾-in. plywood baseboard.



The snooperscope itself. For indoor use a small neon sign transformer (right) may be used to power the infrared tube within the plastic cup.



PORTABLE POWER SUPPLY UNITS ON WOOD PANEL brass or even the flat sheet metal carefully removed from a tin can should be formed with the fingers so it fits snugly around the cathode terminal.

The rear viewing lens is optional as it is only required if you wish to view the images closely with the eye. It should have about three power and a focal length between 2½ and 4 in. This lens is mounted and cemented to a piece of plastic or wood. The material should be opaque and have good insulating qualities. The handle is a plastic bicycle handlebar grip which is cemented over a hole drilled into the side of the drinking cup for the high voltage leads. The lead wire can be the plastic type of zip cord, over which is placed plastic insulating tubing.

Light source: The main limit to the viewing distance is the power and type of light source. Greater intensity means greater distance. For the direct viewing of glowing objects this imposes little difficulty. Such objects as the moon and extra bright stars may be viewed directly. A small flashlight with a plastic filter may be detected at quite a distance. Reflected light from objects requires the use of heat lamps, photofloods or standard 100 to 300-watt lamps to illuminate them. Of course these lights are filtered so that no visible light is seen. The light source shown on page 100 consists of a 300 watt sealed beam outdoor type floodlight (115 volt), a glass type infrared filter and a 10x10 in. recessed lighting box.

Outdoor applications involving greater distances require a bulb with a sharply focused reflector. Gold-plated reflectors give very good results. The sniperscope used a 30 watt, 6 volt bulb similar to the type used in auto headlights. This was operated on a small rechargeable storage battery. Good substitutes are auto spotlights of the sealed beam type such as Westinghouse type 4535 or the General Electric 4524. Standard type flashlights with small dry cells *will not* provide ample infrared for viewing by reflection. Never point your snooperscope at extremely bright light sources like the sun. Damage to the tube may result.

Infrared filters: Experimental filters can be made by sandwiching several layers of dark red and blue cellophane between two sheets of clear plastic. Both plastic and glass types are available from photographic and scientific supply houses. The latter type is to be used whenever heat is involved. Infrared filters cut out all or most of the visible radiation and allow the heat rays to pass through unobstructed. Since a tungsten lamp produces much more infrared than it does visible light, the action of a filter reduces its strength only slightly, while to our eyes it now becomes total black. Don't forget that it is possible to overheat even glass filters, so light sources should not be left on longer than necessary. •

SNOOPERSCOPE PARTS LIST

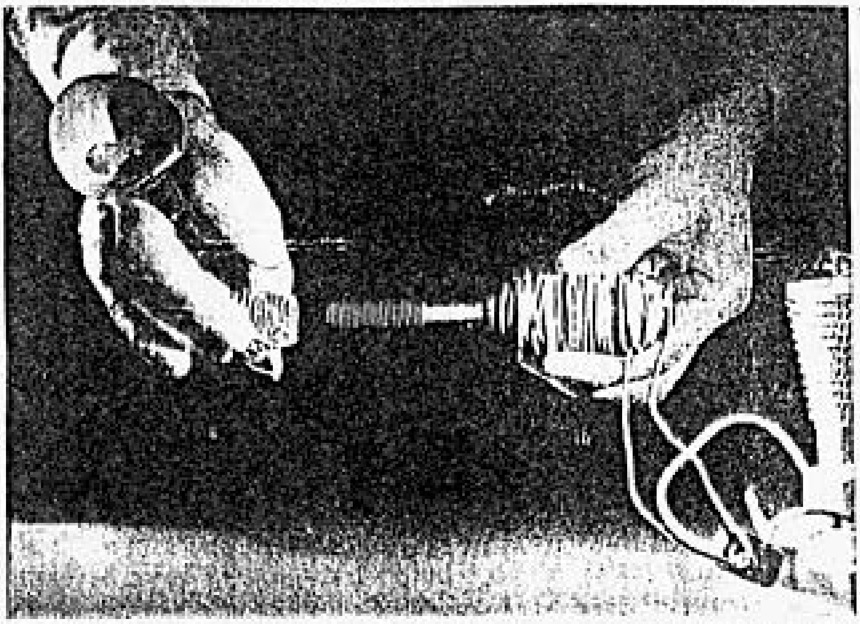
Light Source:
- Sealed beam light or standard 100 to 300-watt lamp and reflector
- Metal housing for above items
- Infrared filter

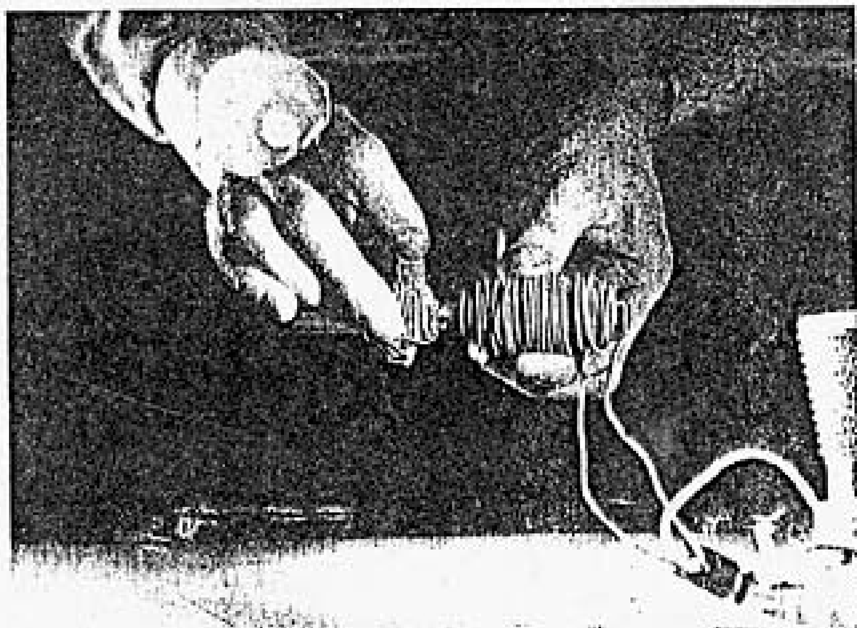
Snooperscope (Eyepiece unit):
- Image converter tube
- Plastic drinking cup
- Plastic handlebar grip
- Jeweler's eye loupe (approximately 2 to 4-in. focal length)
- Tripod magnifier, approximately 10x, 1-in. focal length
- Five ft. plastic-insulated cord (do not use cord with rubber or cloth insulation)
- Near infrared filter
- Black paint or airplane dope

Power Supply, AC:
- Neon sign transformer, 4 to 5 kilovolts at under 10 mills current rating
- Two ½-megohm resistors (may be as high as 5 meg.)

Power Supply, Portable:
- Three flashlight cells
- Model airplane ignition coil
- Small buzzer
- .005 mfd. condenser, 6,000 volts
- .1 mfd. condenser, 600 volts (if not built into vibrator coil)
- Two ½-megohm resistors
- 1x2A or 1B3GT/8016 tube
- Socket for above tube
- Wooden baseboard
- D.P.S.T. switch
- Grid cap
- Two fahnestock clips

Note: These parts may be obtained from the Precise Measurements Co., 942 Kings Highway, Brooklyn 23, N. Y.





home EXPERIMENTS

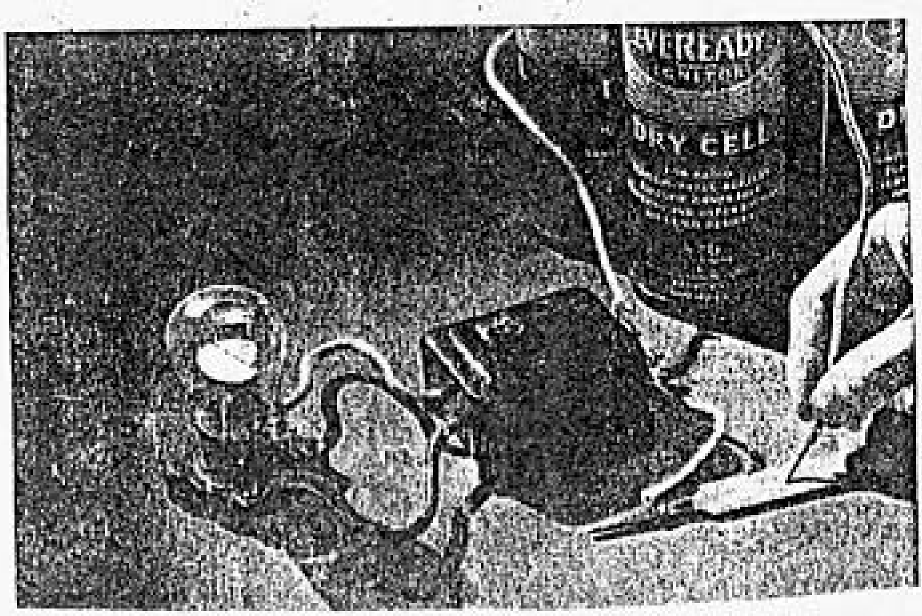
THE PRINCIPLE OF INDUCTION, which causes electric current to be transferred from one circuit to another with which it has no metallic connection, can be demonstrated with the simple equipment at the left. First, bring to a red heat an iron bolt about 5" long, and allow it to cool slowly. Then wind about 100 turns of bell wire around half the bolt nearest the head. Wind a second coil of about 200 turns of finer, insulated wire around a thick pencil or dowel of such a size that when it is removed the coil will fit loosely over the bolt. Connect a flashlight bulb and socket to the ends of this second coil, and then connect the ends of the coil on the bolt in series with a resistance such as a heater unit and to a source of 110-volt alternating current.

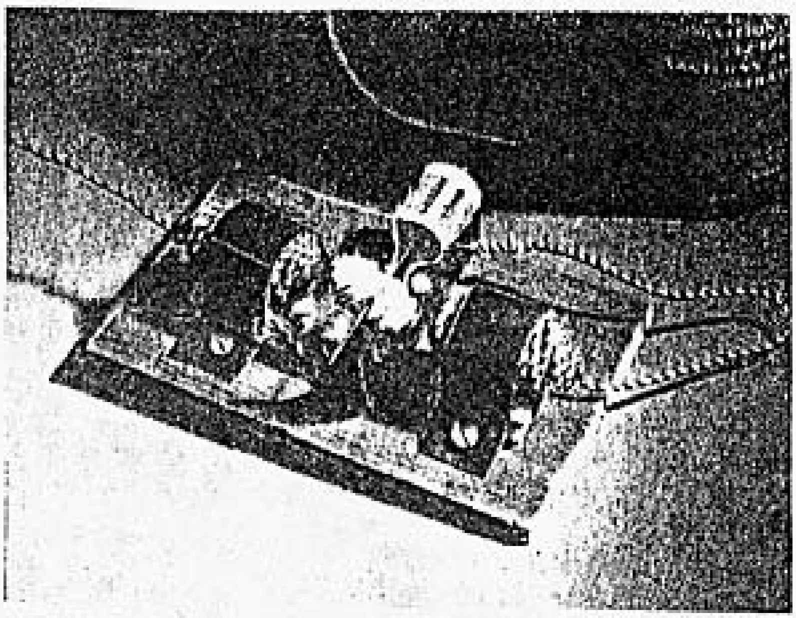
Now slide the second coil onto the bolt, and the bulb will light, increasing in brightness as the coils are brought closer together. Transformers and spark coils operate on the same principle, except that the efficiency of commercial equipment is increased by precise design of core and windings.

POPULAR SCIENCE JANUARY, 1944

IN A TRANSFORMER the voltage ratio between the two coils is almost exactly equal to the difference in the number of turns in the coils. With 100 turns on the primary, or input coil, and 10 turns on the secondary, or output coil, the voltage from the secondary will be one tenth of that impressed on the primary. A transformer in which the secondary voltage is less than the primary voltage is called a step-down transformer. Bells and toy trains are operated with transformers of this type. With such a transformer in a 110-volt A.C. line, a low-voltage bulb may be lit safely.

That the voltage ratio is reversible can be proved by impressing low-voltage interrupted current on the secondary and obtaining high voltage from the primary. Connect dry cells in series with the secondary, connect a small, 110-volt argon lamp to the primary, and interrupt the current by drawing one of the wires lightly over a file connected in the circuit, as illustrated. The lamp will glow brilliantly, although only one pole will light up. This is due to the fact that direct current is employed. If you reverse the leads, you will find the opposite pole will light when the intermittent current is supplied.



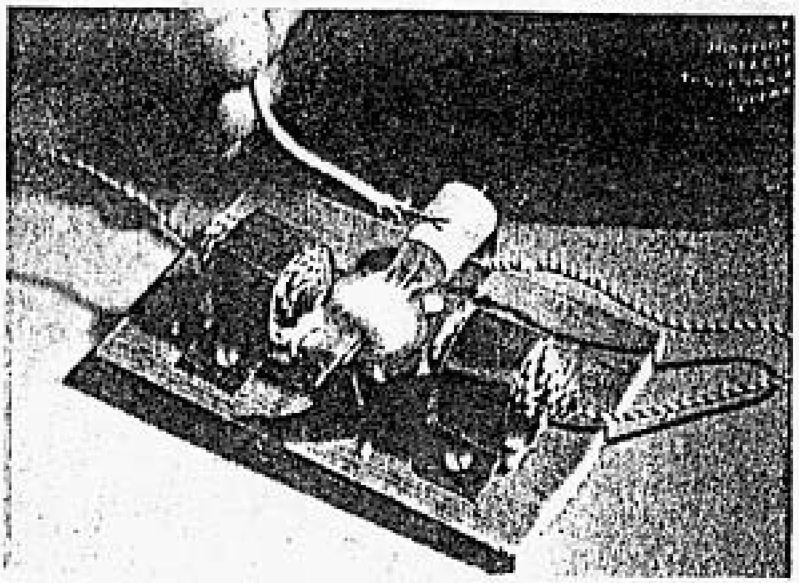


A HOMEMADE D.C. MOTOR that will really run can be constructed quickly by duplicating the apparatus at the right. Two bolts about 2" long should be annealed by heating, as in the first experiment, and then wound with a continuous length of bell wire. Wind 50 turns clockwise on one bolt, leave 4" straight, then wind 50 turns counterclockwise on the other. The direction of winding must in both cases be considered from the bolthead end. Mount the bolts about 2" apart with head facing head. Then, when connected with one or two dry cells, they will become the field magnets of your motor.

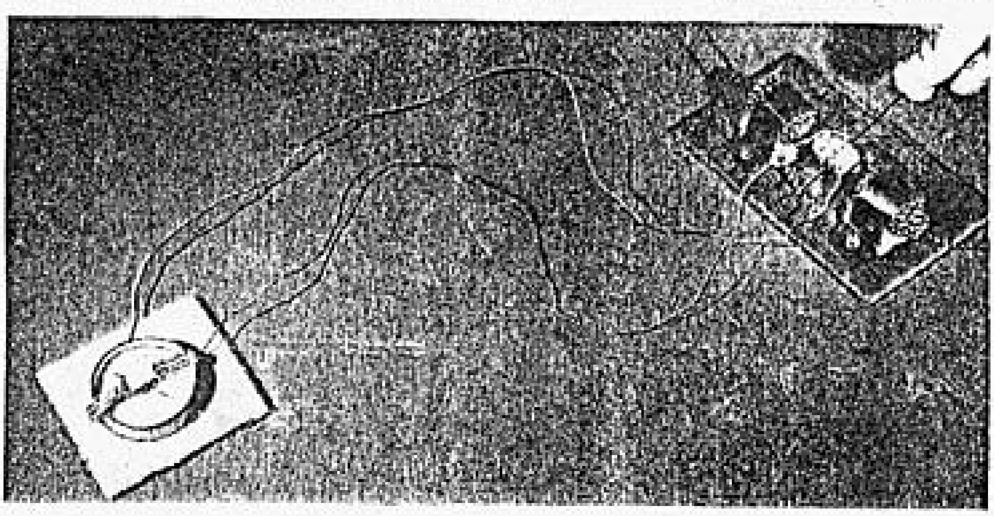
For an armature, or rotor, wind a slightly smaller bolt with about 50 turns of finer wire and mount the unit on a shaft contrived by thrusting a length of stiff wire through the coils of the winding. Crude bearings and a commutator are now all that are needed to complete the motor.

The bearings are strips of notched tin. A cork will make a good commutator when fitted with two strips of thin sheet metal. Press the cork onto the rotor shaft, as indicated, and glue the two strips of sheet metal to its sides. The strips should be just wide enough to go around the cork except for slight separations between them. Solder the two ends of the rotor windings to these improvised commutator segments; then arrange a terminal wire from one of the field magnets so that it presses lightly against the underside of the cork, and connect the other wire from the field poles to one terminal of several dry cells in series.

Hold the other terminal wire from the dry cells lightly against the cork, as shown, and the motor will spin rapidly. The function of a commutator is to reverse the direction of current flow through the armature twice in every revolution so that each pole is first attracted and then repelled by the adjacent pole of the field magnet.



ELECTRIC GENERATORS produce their current by rotating wire coils between the poles of powerful magnets so that they cut magnetic lines of force. This principle of an electric alternator may be demonstrated by means of the equipment used above, minus the commutator, but with a galvanometer added to the circuit as shown below.



For the galvanometer, use a toy compass wound around the center with 50 turns of fine, insulated wire. Connect this current-detecting device with the two ends of the armature winding, and station it far enough from the magnets so that the needle will not be influenced by stray magnetism. If you now twist the rotor shaft while current flows through the field coils, you will discover that the compass needle is deflected first in one direction and then in the other as the rotor passes through each half of a full turn. In a regular alternator, brushes would collect alternating current from rings fitted around the rotor shaft and connected with the windings which are built into the rotor.

 GRANDDAD'S ELCTRICITY BOOK

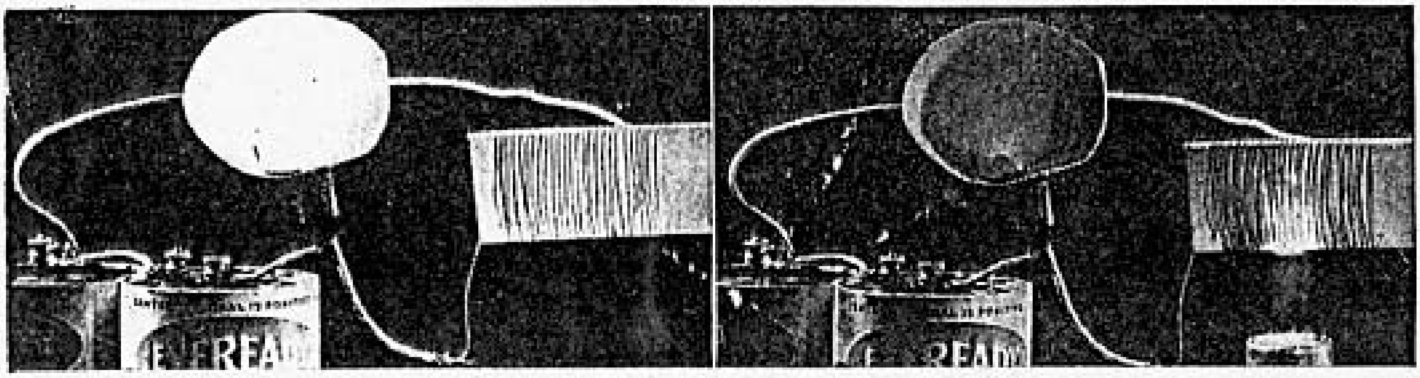
HOME EXPERIMENTS

How Heat and Electricity Affect Each Other

POPULAR SCIENCE, Dec. 1947

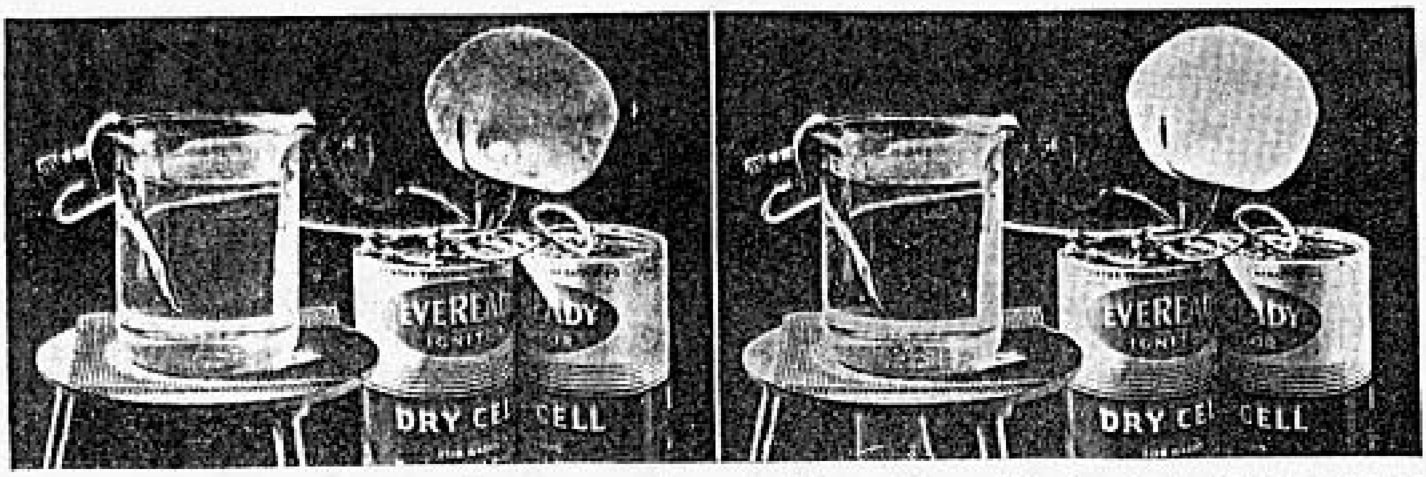
THAT all energy is somehow related is very evident in the behavior of heat and electricity. The toaster and electric iron convert kilowatts into useful heat. But a thermocouple—simply two pieces of dissimilar metals welded or soldered together—changes heat directly into electricity when one joint is put into a flame.

Heat affects electrical conductors too. When you turn on a 100-watt bulb, its cold filament has about a tenth of its hot resistance, and there is a tremendous surge of current—about 9 amp. for a millisecond or two. But the filament immediately gets hot. In a tenth of a second its resistance rises until it draws only its rated .8 amp.

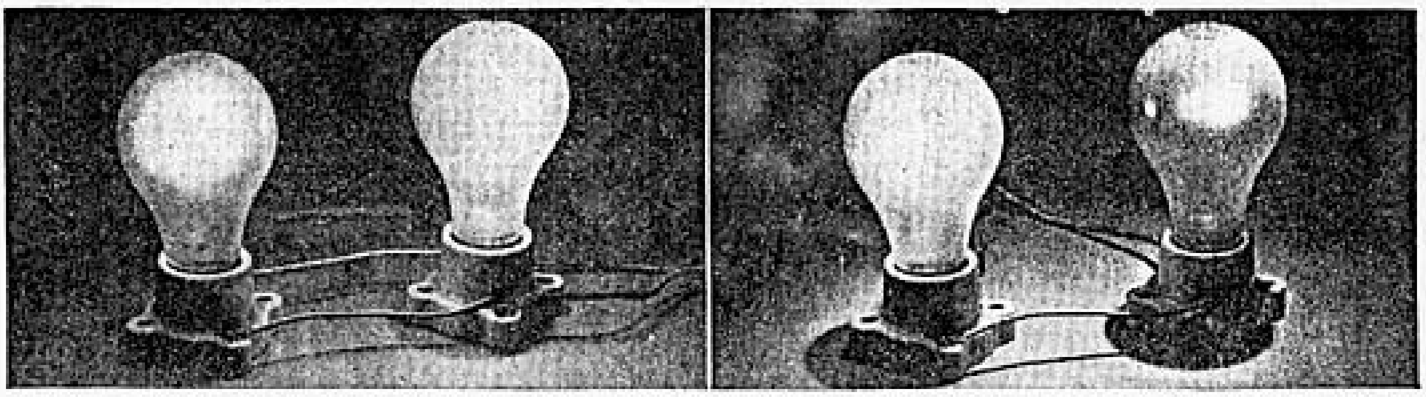


Heat Increases Resistance. You can safely use more lights on a single circuit without blowing a fuse if you turn them on one at a time. The reason? Almost all metals, including lamp filaments and heating elements, have greater resistance when they are hot than while cold. Hence, they pass less current after heating up.

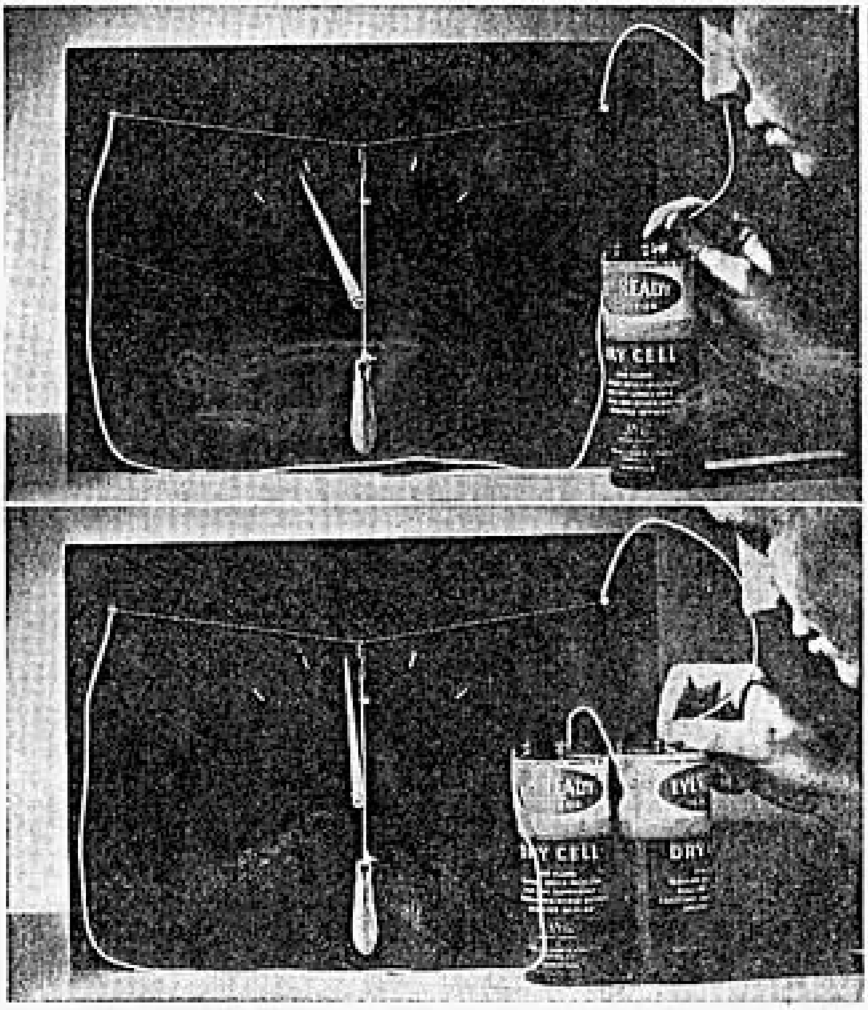
You can demonstrate this characteristic of metallic conductors by connecting a 3-volt flashlight bulb in series with two dry cells and about 10′ of thin iron wire wound around a strip of asbestos. While cold, the wire has a low resistance and enough current passes to cause the bulb to shine brightly. But put a flame under the wire, and the resistance becomes so great that the light will dim—and may go out.

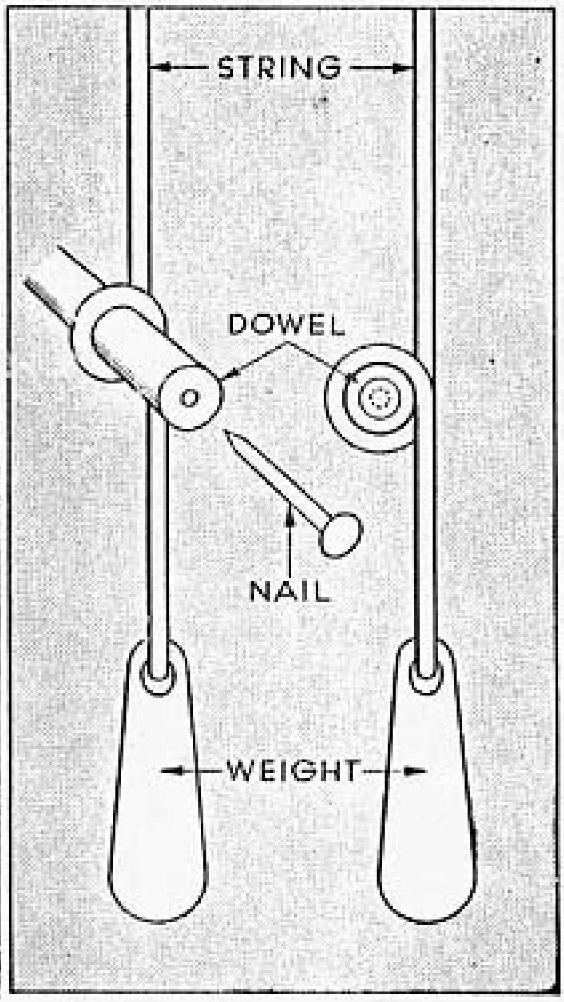


Heat Decreases Resistance. In the case of conducting solutions, or electrolytes, the resistance decreases as they are heated—as you can demonstrate by another pair of tests. Connect your bulb and dry cells in series with two metal plates suspended in a water-filled beaker. Stir salt into the water until the bulb lights dimly. Now put a flame under the solution. As the solution becomes hotter, the light will grow brighter. Because of this lowering of resistance, electrolytic rheostats must be designed large enough to carry the current that is required without overheating.



Parallel Versus Series. Heat depends on the current and resistance in a circuit. Thus, if two or more appliances of similar type, such as light bulbs or heaters, are connected in parallel, the bulb or heater with the lowest resistance—which draws the greatest current—gives the most light or heat. As an illustration, the 60-watt bulb on the right in the left photo has less resistance and so gives more light than a companion 40-watt bulb. But connect the same two bulbs in series, as at the right, and the reverse holds true. The same amount of current now passes through both, but it creates more light and heat in the bulb where it overcomes the higher resistance.



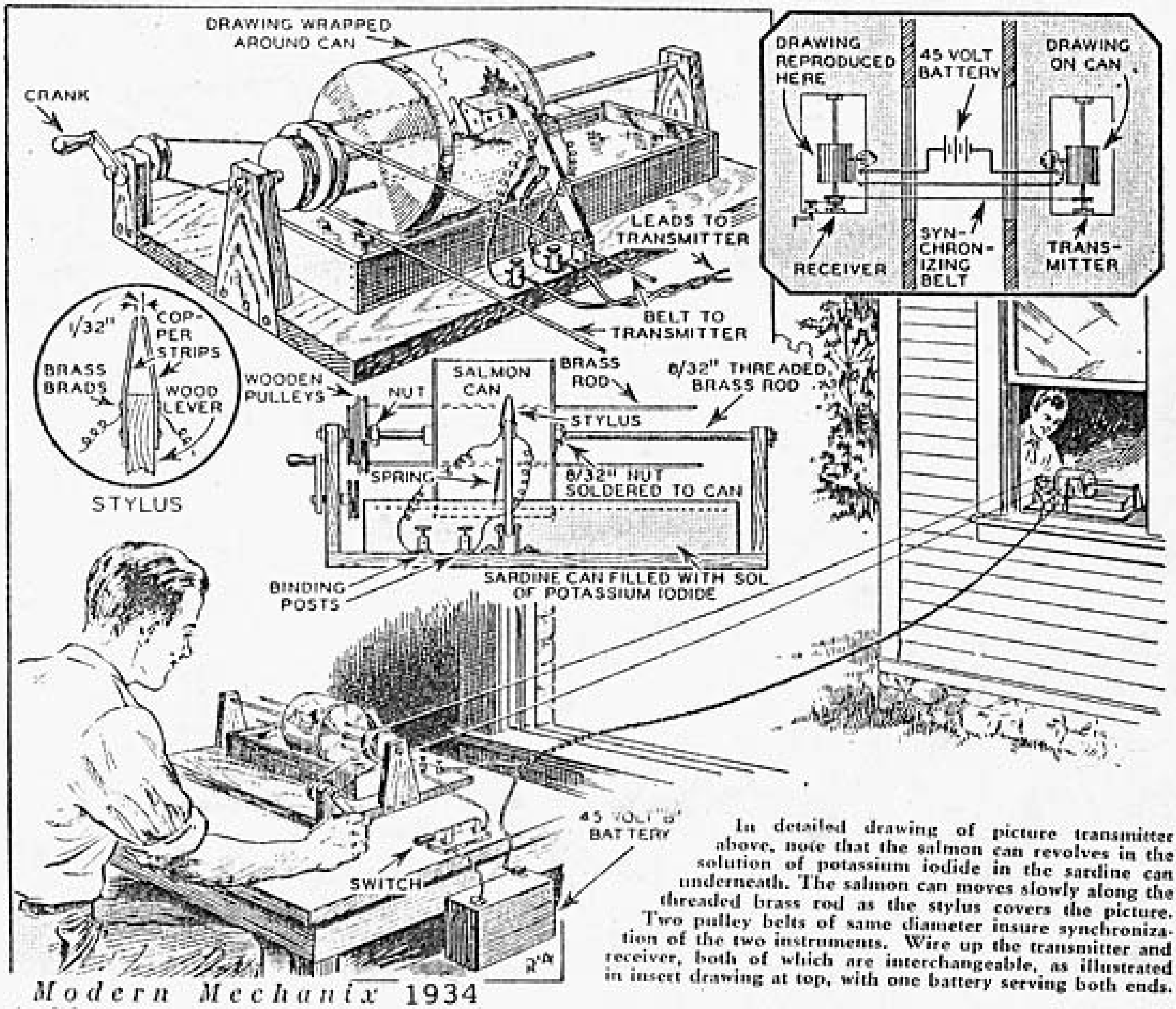


Heat Actuates Meters. Because the heat produced in a wire or circuit is proportional to the square of the current flowing through it, and because heated metals expand in a predictable way, the heating effect of electricity is used in one type of instrument to measure amperage or voltage.

You can easily demonstrate the principle of a "hot-wire" meter. Stretch a strand of iron picture wire horizontally between two nails driven into a board. At the center, suspend a wire hook connected to a string held taut by a weight. Drill a hole through the center of a short dowel, cement a cardboard pointer to the dowel, and mount the dowel to turn freely. Loop the string once around the dowel so that the pointer moves to the right when the weight is pulled down.

Connect a single dry cell to the supporting nails, and the pointer will move slightly as the wire heats, expands, and sags. Connect two, and the movement will increase.

An ELECTRICAL PICTURE TRANSMITTER



In detailed drawing of picture transmitter above, note that the salmon can revolves in the solution of potassium iodide in the sardine can underneath. The salmon can moves slowly along the threaded brass rod as the stylus covers the picture. Two pulley belts of same diameter insure synchronization of the two instruments. Wire up the transmitter and receiver, both of which are interchangeable, as illustrated in insert drawing at top, with one battery serving both ends.

Modern Mechanix 1934

A COUPLE of sardine and salmon cans, a few bits of brass and several pieces of wood are all the materials that are needed to assemble an experimental but very practical picture transmitter and receiver.

Two of each of the cans will be needed. The salmon cans should be of the small or half can size and the end that has been opened should be replaced by soldering in water tight, a new disc of tin.

Two center holes are drilled, one in each end of the salmon can and over one hole a brass 8-32 nut is placed by soldering. This is to guide the can over the threaded brass rod as illustrated. This threaded brass rod is secured to the wooden pulley wheel which turns the cans.

The sardine can is mounted to the baseboard by punching two holes in the bottom and driving in two short wood screws, which are soldered around the edges to prevent leakage. A bit of molten wax poured in will eliminate danger of rust.

Stylus Made From Copper Strips

Now for the stylus. This is formed by two copper pieces cut as illustrated in the inset sketch above. They are held to the wooden arm by small brass brads. Wires are soldered to each of the stylus members and carried to binding posts mounted on the base.

The wooden pulleys used should each be of exactly the same diameter, otherwise it will be impossible to operate the stations in synchronism, which is imperative. Two of these devices will be needed, each serving as a combination transmitter and receiver.

Operation of the Transmitter

Operation of the instruments is surprisingly simple. Upon the stylus of the transmitter there is placed the picture to be transmitted. This is drawn with a very soft pencil. The stylus of the transmitter plays over the entire drawing as the can is revolved along the rod.

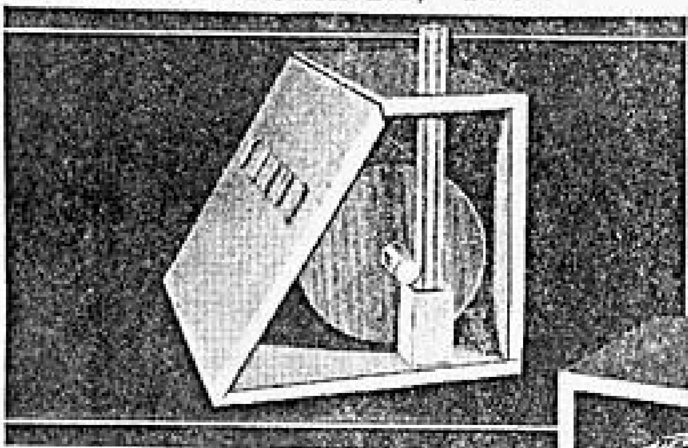
As each line of the drawing passes under the stylus, the carbon will form a conducting medium between the stylus members and a small current will flow.

At the receiver, a similar stylus is playing over the surface of a piece of paper that has been wetted with a solution of potassium iodide. When the current flows, decomposition of the solution will take place and a brown line will be left on the paper, forming the same picture as that at the transmitter.

ROBOT Plays CARD Games

Press Button—IT DEALS A HAND

MODERN MECHANIX, 1934



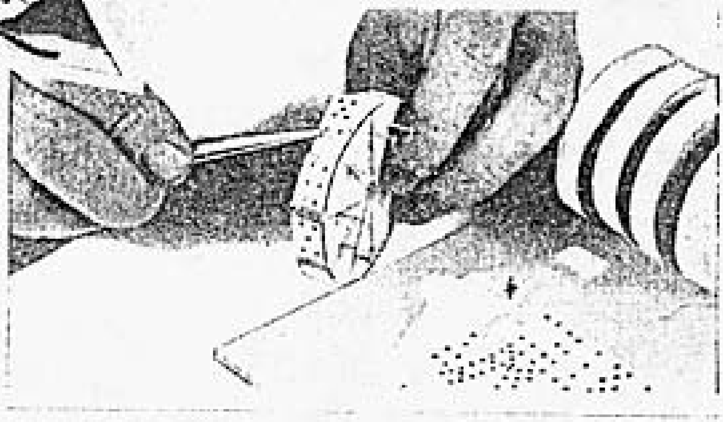
The dowel wheel contacts the push button as shown above in the side view of the mechanical robot. The photo on the right is a close-up of a wheel giving details of brad spacings.

Here is a drawing of the completed mechanical robot. With each push of the button, cards are shuffled and a new hand appears in the window.

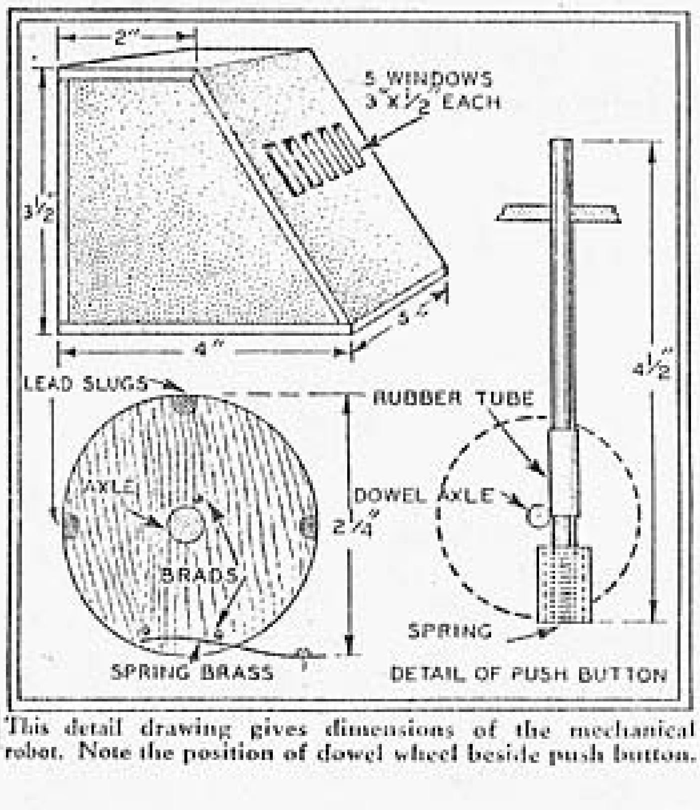
TO PLAY a game of cards with this robot merely press a button. Miniature cards are speedily shuffled and a full hand of five cards flash into view. Each hand is awarded points according to the value of the cards. A pair counts five, three of a kind counts fifteen, a straight represents fifty, and so on up the scale.

The miniature cards are made by pasting, side by side on a sheet of cardboard, fifty ordinary playing cards (a complete deck excepting two deuces). These are taken outdoors and photographed, as large as possible, with a 4"x5" or post card size camera. Trim the tiny cards from a contact print of the negative.

Ten of the cards are glued to each of five wood wheels measuring 2¼" in diameter and ⅜" thick. The wheels are weighted with lead slugs and revolve loosely on a length of doweling. Each wheel has ten small brads nailed into it and one brad fixed near the axle to engage a bit of spring brass driven into the doweling.



After trimming the cards from a contact print of the negatives, glue ten to each of five wheels as shown above.



This detail drawing gives dimensions of the mechanical robot. Note the position of dowel wheel beside push button.

When the doweling axle turns in a clockwise direction, the wheels are engaged and turn with it. Stopping the axle allows the wheels to continue to turn with their own momentum. When they finally stop, a strip of spring on the baseboard brushes two of the ten brads in order to frame one of the cards of each wheel in its window. Each of the springs has a different tension so that no two wheels rotate with the same speed.

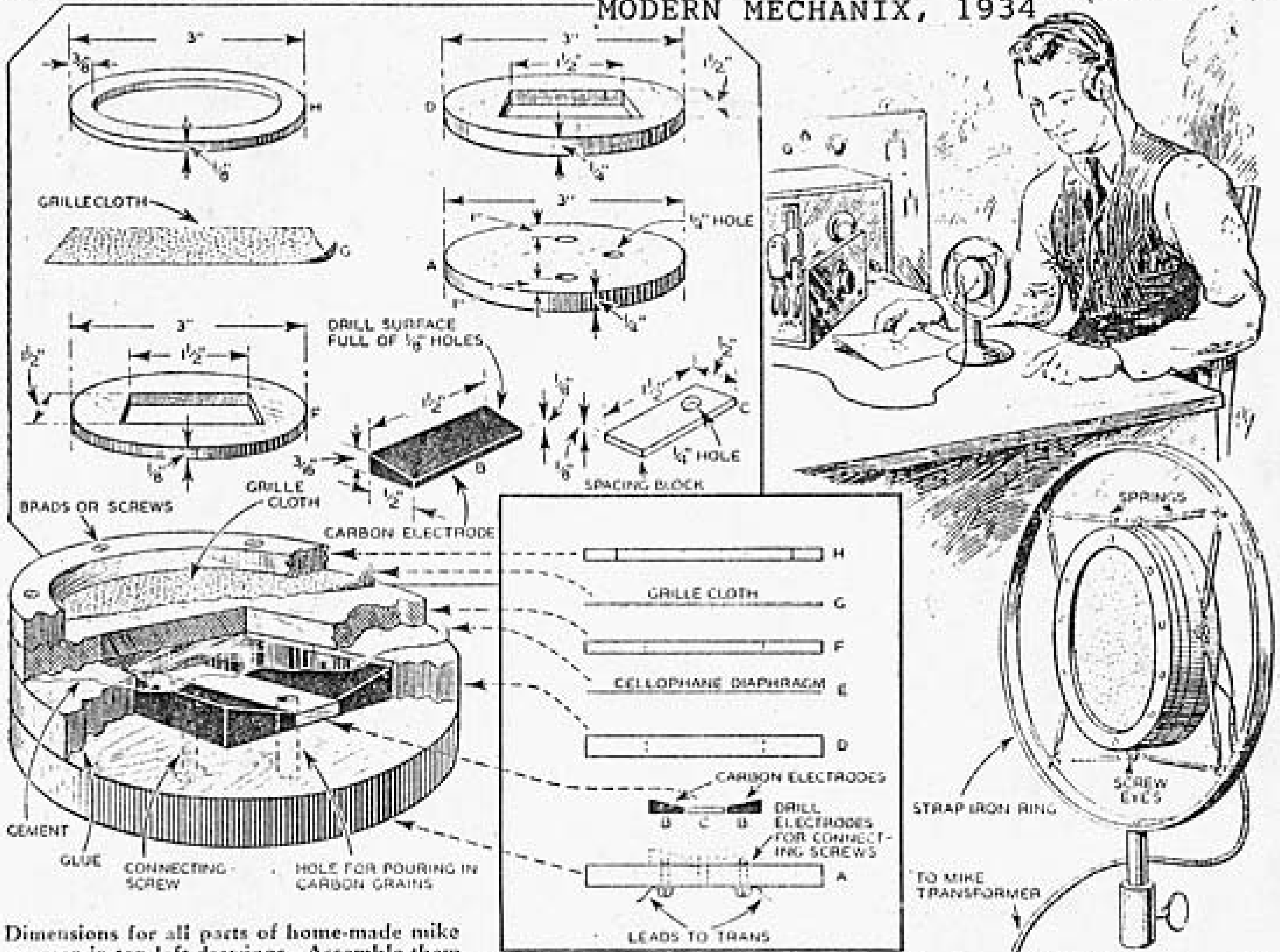
How to Make the Control Button

The control button is another piece of dowel resting in a drilled-out block containing a stiff spring. It should be covered with an inch of thin rubber tubing where it rubs against the dowel axle.

A press of the button spins the axle, giving the card wheels sufficient momentum so they rotate a number of times. Each stops at a different moment.

Making YOUR OWN Broadcast Microphone

MODERN MECHANIX, 1934



Dimensions for all parts of home-made mike are seen in top left drawings. Assemble them in manner illustrated below. Space between the cellophane diaphragm and carbon electrodes are filled with carbon grains.

IT IS possible for the average experimenter to construct a real high quality microphone that will compare very favorably with the more conventional broadcast type. It requires no great skill and very few tools, but a large stock of patience and accuracy in making the parts. All parts, unless otherwise specified, are made of wood.

First, make the two carbon electrodes B-B. An old No. 6 dry cell carbon pole furnishes the material. Cut it roughly to shape with a hack-saw and finish off by rubbing it *very carefully* against a sheet of sandpaper. Then drill, *very slowly and very lightly*, a hole through it for its connecting screw.

Now to begin building the case. Disc A is first. Drill two holes an inch from the edge to receive the machine screws that hold the carbon electrodes in place. Put the electrodes in place and pull the screws up securely—but not too tight or the electrodes will break. In between the electrodes glue the spacing block C.

Now, glue disc D on top of Disc A. Stand a weight on it while it dries. Before going any further drill a ¼-inch hole through A and C for filling the mike with carbon grains later on.

With an eighth-inch drill very carefully drill the face of each electrode—until you have a pair of electrodes that look like a reduced version of a waffle-iron. Now cement a three-inch diaphragm of cellophane E on top of disc D. Stretch it just tight enough to pull out the wrinkles—and *no tighter.*

Over the cellophane secure disc F to the rest of the microphone with brads. Finally glue a circular piece of loud-speaker grille cloth over disc F and fasten ring H on top of it with four wood screws.

Now, secure a vial of carbon grains—the kind put up for experimental use, not the kind sold for re-conditioning broadcast microphones.

Turn the mike on its face and carefully fill the filler-hole full of carbon grains. Lift it off the table and gently tap it. The grains will gradually disappear into the innards of the microphone. Repeat this until no amount of tapping will make the microphone absorb more grains of carbon. Seal the filler-hole with wax—and the mike is finished!

This type of microphone is one of the most rugged known. Couple it to a 200 ohm primary microphone transformer, using the full primary. A twenty-two and a half volt "C" will make an ideal source of current for the microphone, and you will have no need of any sort of a current control.

A professional looking mounting for the mike is illustrated in the accompanying drawings.

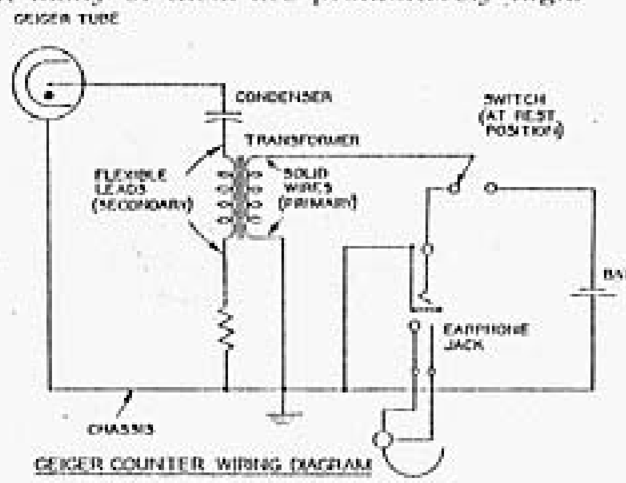
 GRANDDAD'S ELCTRICITY BOOK

pocket geiger counter

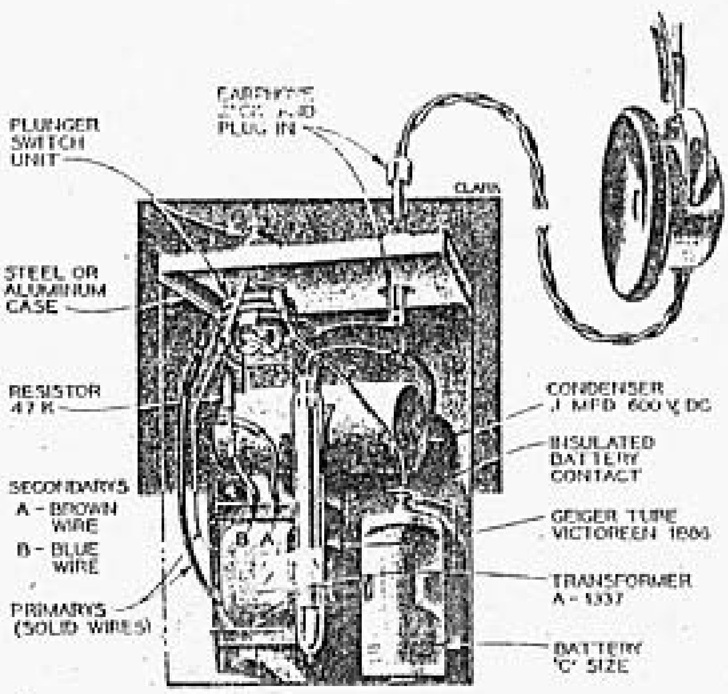
If you've found commercial units too expensive, here's good news.

MECHANIX ILLUSTRATED, May 1951

AS a public-spirited citizen you become interested in your local Civil Defense program. With your head filled with stories about the perils of radioactive radiation following an A-bomb attack, you look into the availability of Geiger counters, devices that detect the presence of gamma rays. You find them listed in electronic catalogs, but many of them are prohibitively high.



GEIGER COUNTER WIRING DIAGRAM



GENERAL ARRANGEMENT OF PARTS SHOWING WIRE HOOK-UP

Really compact and living up to its name, the self-contained instrument is easily portable.

MI presents herewith what is probably the smallest and most inexpensive Geiger counter that will actually work. Complete with battery, it is only 4½ in. long, 2½ in. wide and 1⅞ in. deep, and readily slips into a coat pocket. If you have done any radio work you may have seven of the eight required parts in your "spares" box.

Furnished especially for MI by the Terminal Radio Corporation, New York City, this counter uses a tricky but easily duplicated circuit. The heart of the instrument is a Victoreen Type 1B86 radiation counter tube, a pencil-like cylinder only ⅜ in. in diameter and 3½ in. long. All Geiger tubes require rather high voltages for their operation, but this one is rated as a "low" voltage number because it needs about 300 volts instead of the 900 or 1,200 required by its bigger brothers. A very minute current is involved at this voltage, so all the circuit components can be very small.

The only battery in the counter is a size C flashlight cell. When the push switch is plumped rapidly, current from this battery jerks through the primary of the transformer. The varying magnetic field built up by the varying primary current induces a voltage in the secondary of the transformer, which is closely wound around the primary. This voltage is in the neighborhood of several hundred volts because the secondary has many times the number of turns of wire as has the primary. The action is exactly like that of a common automobile ignition coil. The Geiger tube acts as a rectifier to straighten out the varying secondary voltage, which charges the condenser connected between the tube and the secondary winding. When the switch is allowed to come to rest, it connects an ordinary radio earphone into the primary circuit and causes the voltage buildup and charging process to stop. The condenser, now containing quite a charge of electricity, discharges slowly through the Geiger tube and enables the latter to perform as a gamma ray detector.

What do you hear in the phone? For a few seconds after the switch has been pumped, there will be a slight scratching sound; after that, no sound will be heard if no appreciable radiation is in the vicinity. Tiny samples of weak pitchblende, the ore from which radium is extracted, are available from chemical supply firms. If such a sample is brought within an inch or so of the case you will hear a steady clicking. It sounds like radio static, but is more uniform. An excellent indication is also given by the little glow beads that are attached to electric pull cords to help you find them in the dark.

Because this counter is not equipped with *measuring* facilities (as distinguished from *indicating* facilities, meaning the earphone), the strength of suspected radiation can only be approximated by loudness of the clicks.

• Since the counter responds nicely to the extremely weak radiation from glow beads and watches, it probably will go mad in the presence of uranium ore in any quantities large enough to qualify the user for the $10,000 reward offered by the Atomic Energy Commission for new sources of this element. Happy prospecting!—*Robert Hertzberg.* •

GEIGER COUNTER PARTS LIST

Radiation counter tube, Victoreen Type 1886 (Costs about $8.00)
Transformer, midget output for small loudspeaker, 25,000 ohms to 4 ohms, Stancor A-3327
Condenser, .1 mfd., 600 volt, paper
Resistor, 47,000 ohms, ½ watt
Jack, phonograph pick-up type, with matching plug
Earphone, single or double, high impedance type
Switch, SPDT, push button type, make-break
Battery, size C flashlight cell

THE BOY MECHANIC – 1913

How to Make a Small Medical Induction Coil

The coil to be described is 3½ in., full length of iron core, and ¾ in. in diameter.

Procure a bundle of small iron wire, say ¼ in. in diameter, and cut it 3½ in. long; bind neatly with coarse thread and file the ends smooth (Fig. 1). This done, make two wood ends, 1¼ by 1¼ in. and ⅜ in. thick, and varnish. Bore holes in the center of each so the core will fit in snugly and leave about ¼ in. projecting from each end (Fig. 1).

After finishing the core, shellac two layers of thick paper over it between the ends; let this dry thoroughly. Wind two layers of bell magnet wire over this, allowing several inches of free wire to come through a hole in the end. Cover with paper and shellac as before.

Wind about ⅛ in. of fine wire, such

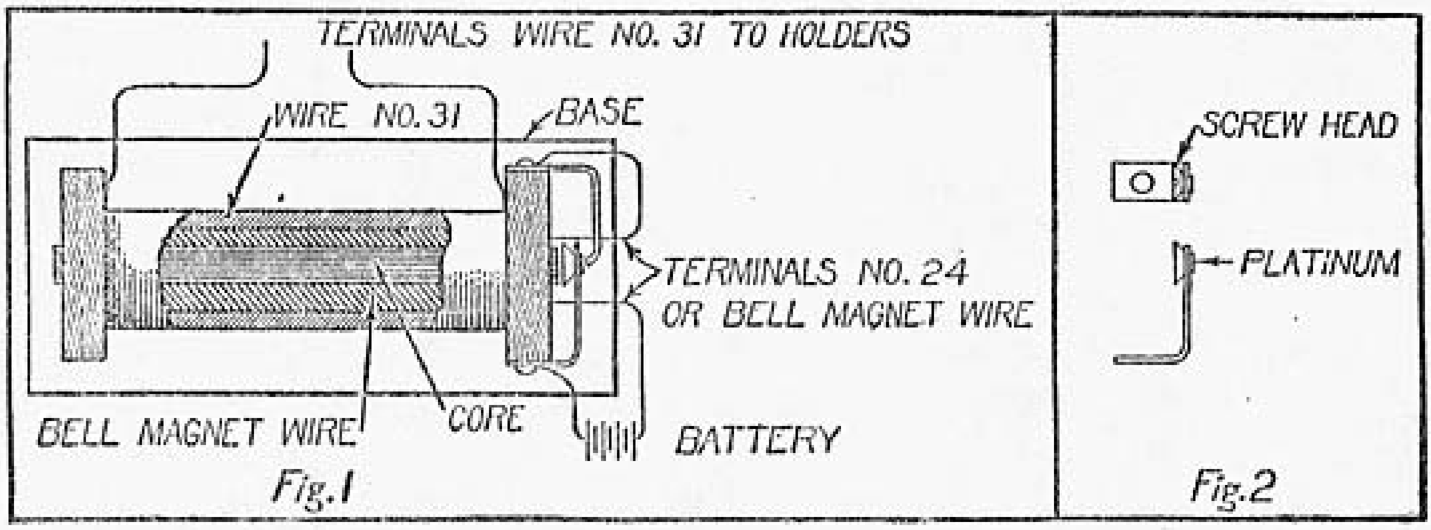


Fig. 1 Fig. 2

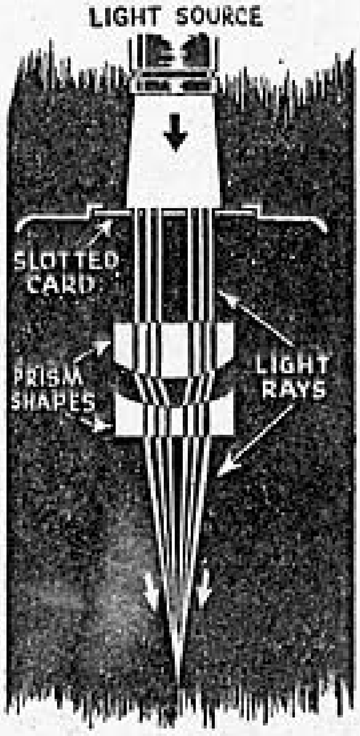
Medical Induction Coil

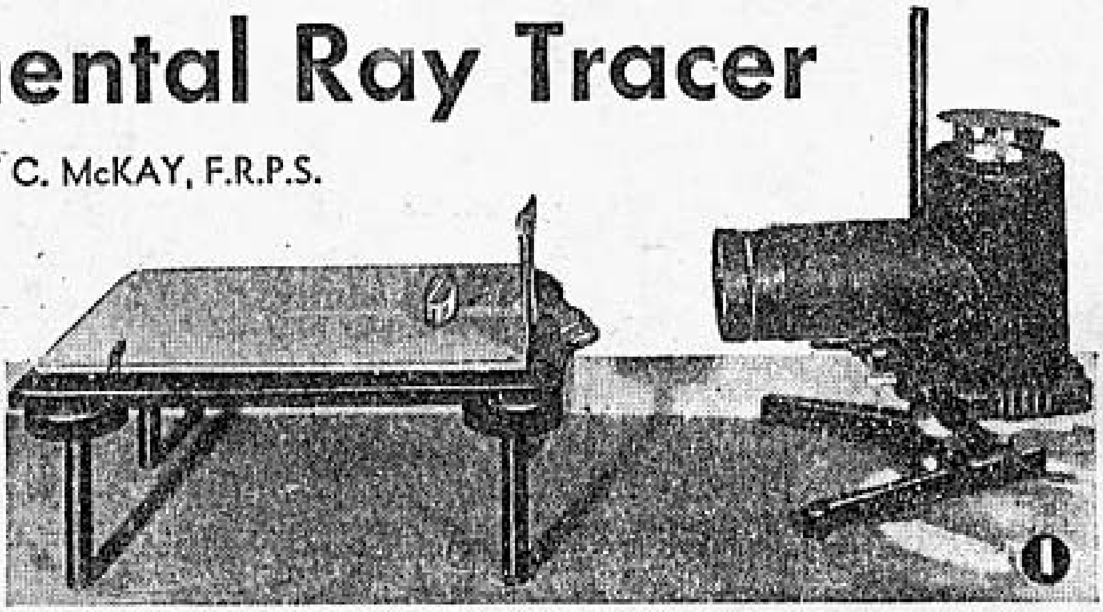
Continued on page 138

The Camera Craftsman

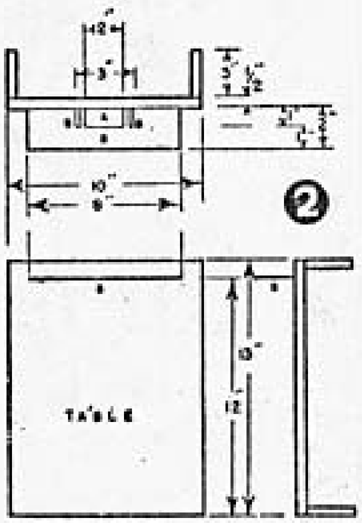
Experimental Ray Tracer

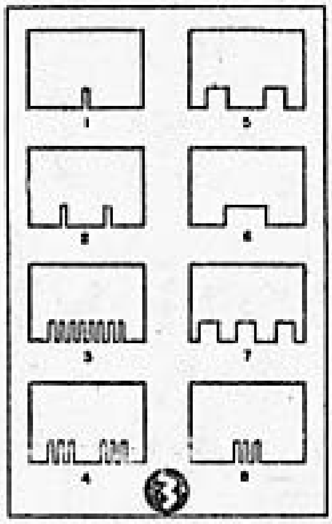
By HERBERT C. McKAY, F.R.P.S.

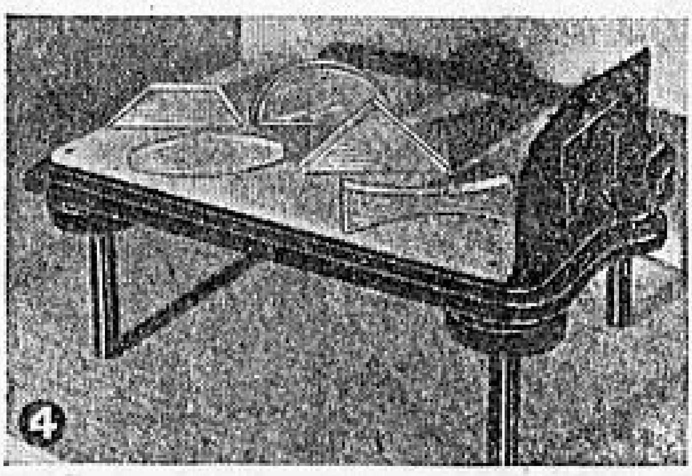




SCIENCE AND MECHANICS APRIL, 1949





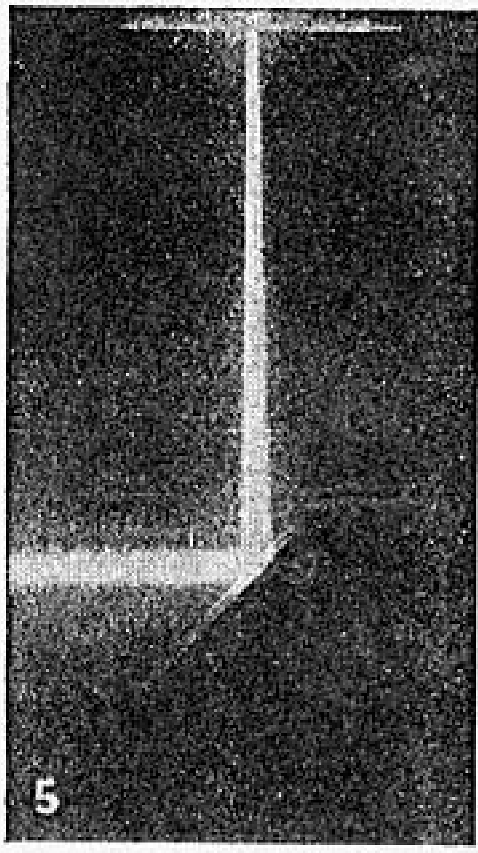


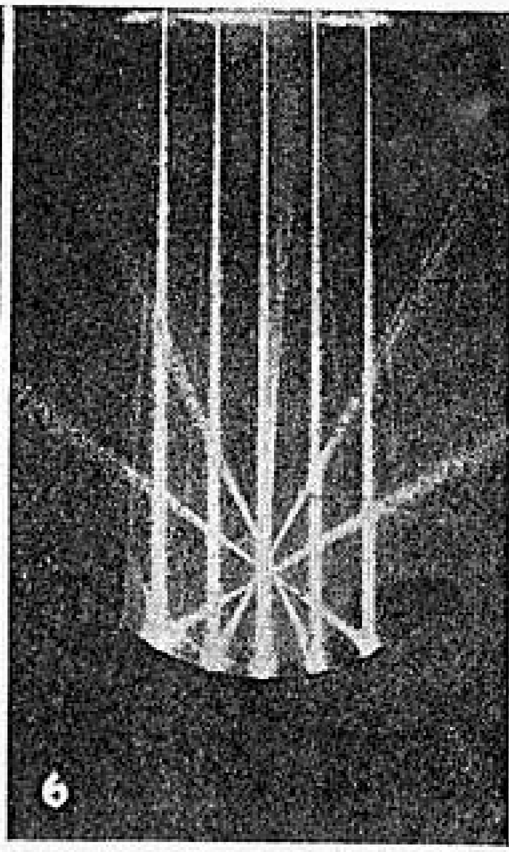
PHOTOGRAPHERS and other experimenters often have need to know the action of lenses, but the computation is an involved one even for those familiar with the various factors involved. As a result diagrams are used which are only approximately correct and often erroneous. It is easy to make a simple ray tracer which will show the actual path of rays through lenses and other shapes which may be given to transparent materials. The ray tracer is a small table about 9x13 in. and 3 or 4 in. high. Dimensions given in Fig. 2 may be varied within quite wide limits to use a table which you may have on hand.

At one end of table, place a sheet of thin metal cut from a large tin can or a sheet of pressed wood or thin plywood, at least 2 in. high. In lower edge cut an opening about 2 in. long and 1 in. high. At sides of opening place slides of bent metal so cards may be dropped into them to obscure opening. These cards (Nos. 1 to 8 in Fig. 3) have narrow slots cut into them to form ray bundles. No. 1 has a single central slot and is used when a single ray is desired, as in plane refraction. No. 2 has two single rays for showing in simplest manner the action of a lens. No. 3 is a continuous series to show the paths of individual rays in a broad beam. No. 4 has two groups of slots to provide a compound beam to show focusing action of a lens. No. 5 is the same as No. 2 but uses broad beams instead of narrow ones. No. 6 is a single broad beam, No. 7 is the same as No. 5 plus central beam, while No. 8 is the same as No. 7 except that individual beams are narrow. Many other shapes will occur to you while using the tracer.

Fig. 4 shows tracer and a collection of shapes used for tracing. Each shape corresponds to a section through the diameter of a simple, spherical lens. Sections do not have spherical surfaces, but are, optically, narrow cylindrical lenses so that their action is exerted only in the plane of the table. These shapes may be made of glass,

 GRANDDAD'S ELCTRICITY BOOK





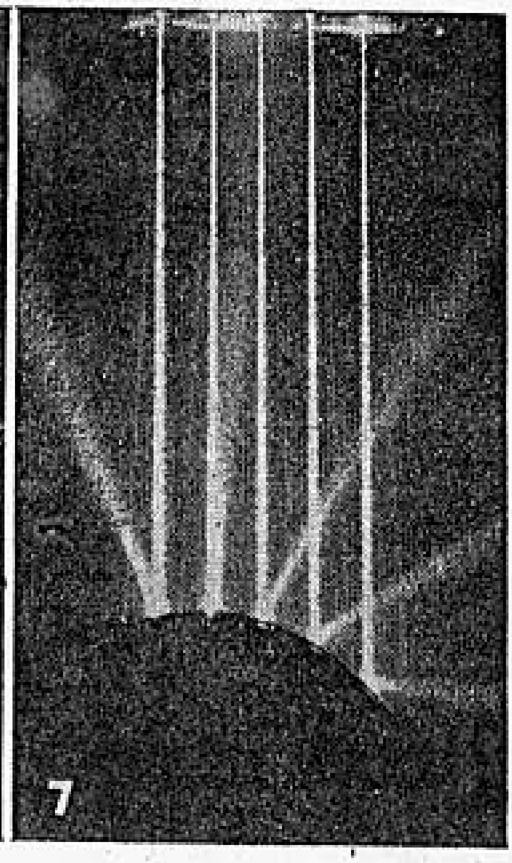


Fig. 5. Plane reflection of 90° from a 45° mirror.

Fig. 6. Reflection from a concave mirror made of carefully curved strip of polished, chrome-plated metal.

Fig. 7. Reflection from a convex surface (rear of same strip as Fig. 6).

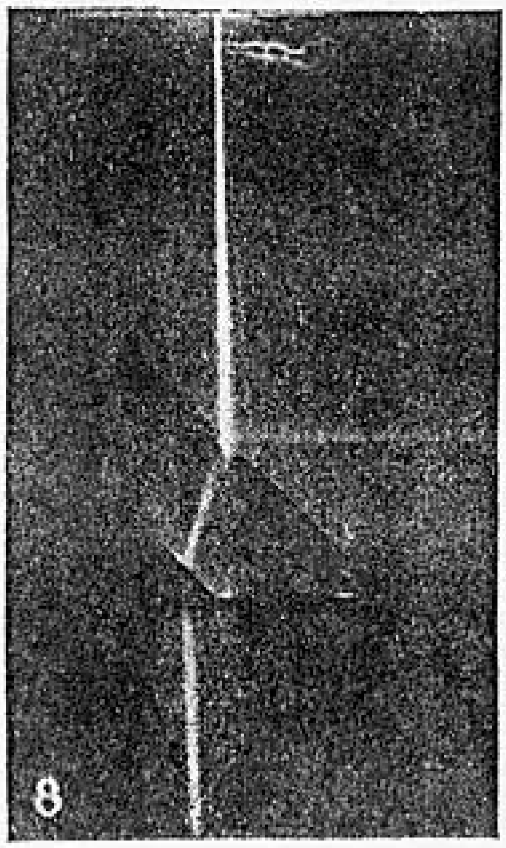
but transparent plastic material such as Lucite or Plexiglas ½ or ¾ in. thick is the easiest material to use.

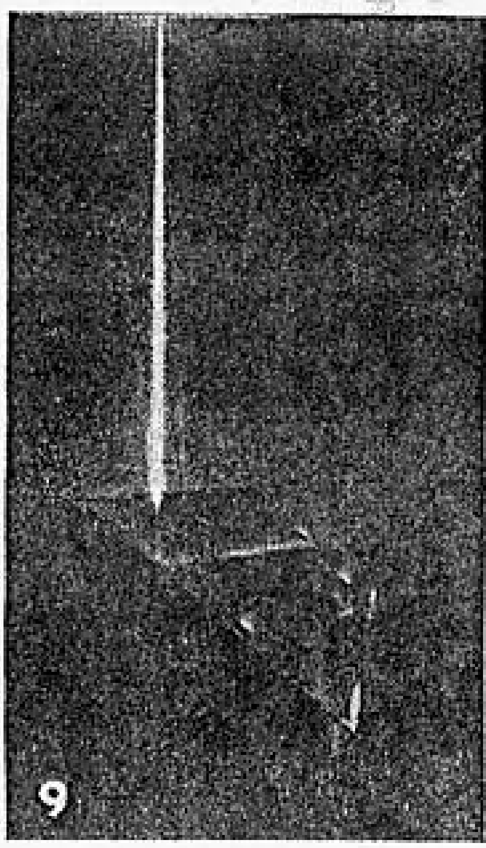
Cut desired shape from block of plastic with band saw or hand scroll saw, taking care not to cut into outline. Smooth rough edges with a bastard file, then with a single cut smooth file. When this is done, give surface a final smoothing and shaping by hand grinding with pumice powder. Grind convex surfaces by placing a small portion of wet pumice upon a slab of glass and using a rocking motion to prevent formation of flats. When possible, cut corresponding convex and concave surfaces so finishing can be done by grinding these together. This will result in a surface sufficiently accurate for the purpose. It

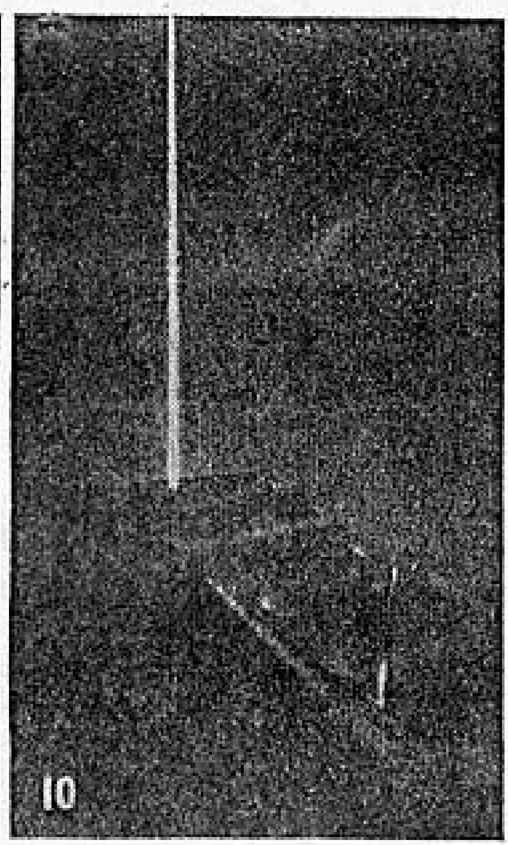
Fig. 8. Plane refraction showing displacement of ray passing through a transparent medium with plane parallel sides.

Fig. 9. Multiple internal reflection. Ray is three times reflected within body of prism.

Fig. 10. Critical angle is shown by fact that rays are partly reflected within prism and partly refracted into surrounding air.







 GRANDDAD'S ELCTRICITY BOOK

is essential that the pumice smoothing should leave a perfectly flawless, satin-smooth surface resembling the finest ground glass without the slightest indication of irregularity or scratch. Plane surfaces are best ground upon the flat glass slab.

When smoothing is completed, polish edges by hand or with a power buff, using plastic polishing soap or tripoli buffing compound. Coat buff well with compound and push edge of piece firmly into buff and then away. The first buffing should be heavy, but do not hold piece in contact with buff for long or surface will burn and pumice step will have to be repeated. It is not enough to polish out a burn on the buff.

After the first surface flow, complete polishing with a series of quick strokes against buff with increasingly lighter pressure until final strokes barely touch buff. This produces a surface equal in finish to original sides of plastic sheet, necessary for flawless optical operation. If pumice step has not been done correctly, the edge will polish but it will show irregularities which will deflect the ray just as a cheap mirror produces waves in the reflected image.

Construct table, and paint it black, with top flat white. Make lens shapes while paint is drying. Finally, cut masks from black cardboard. Light source may be sunlight introduced through an aperture in a window shade by a mirror, but unless mirror is clock driven, motion of sun will not leave it for long in one position. It is better to use an artificial source which can be focused into a substantially parallel beam. To do this, remove objective of a slide projecter and use condensers only, if they can be focused to parallel position. If objective has large aperture, it may be used to produce a slightly divergent beam. A miniature spotlight equipped with a pair of condensers instead of the usual Fresnel lens or a good microscope lamp may also be used. If none of these is available, improvise a lamp from an incandescent bulb inside a dark housing and focus it by a bull's-eye. The lamp used in Fig. 1 is a bulb type mercury vapor arc or microscope lamp. The double convex lens on table focuses beam of light from lamp.

Some suggested uses for the ray tracer are shown in Figs. 5 to 12. Tracer will also illustrate loss of light through repeated reflection; loss of light at a lens by reflection from both outer and inner surfaces; deviation and dispersion of light by a prism and many other fundamental optical phenomena. In addition you can use it in planning optical systems such as projectors, telescopes, simple spectroscopes, sights, levels, magnifiers, stereoscopes, and in laying out telephoto attachments for cameras.

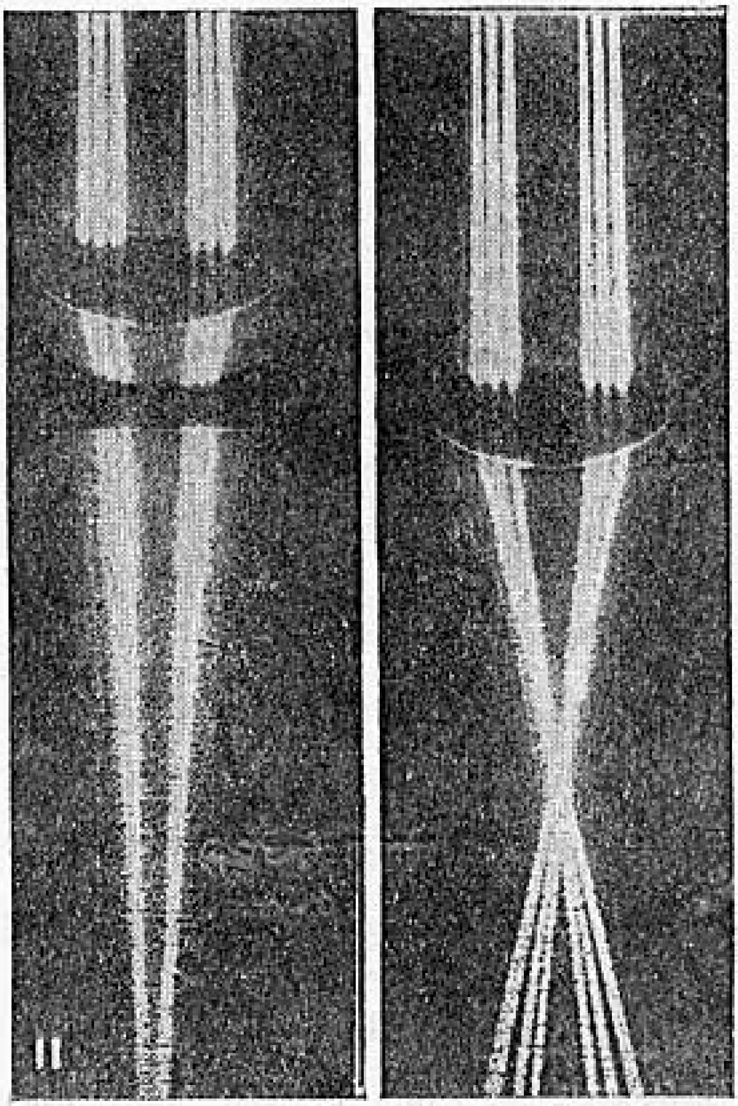


Fig. 11. Left, refraction by positive lens backed by a negative one. Right, refraction and focus by a positive lens.

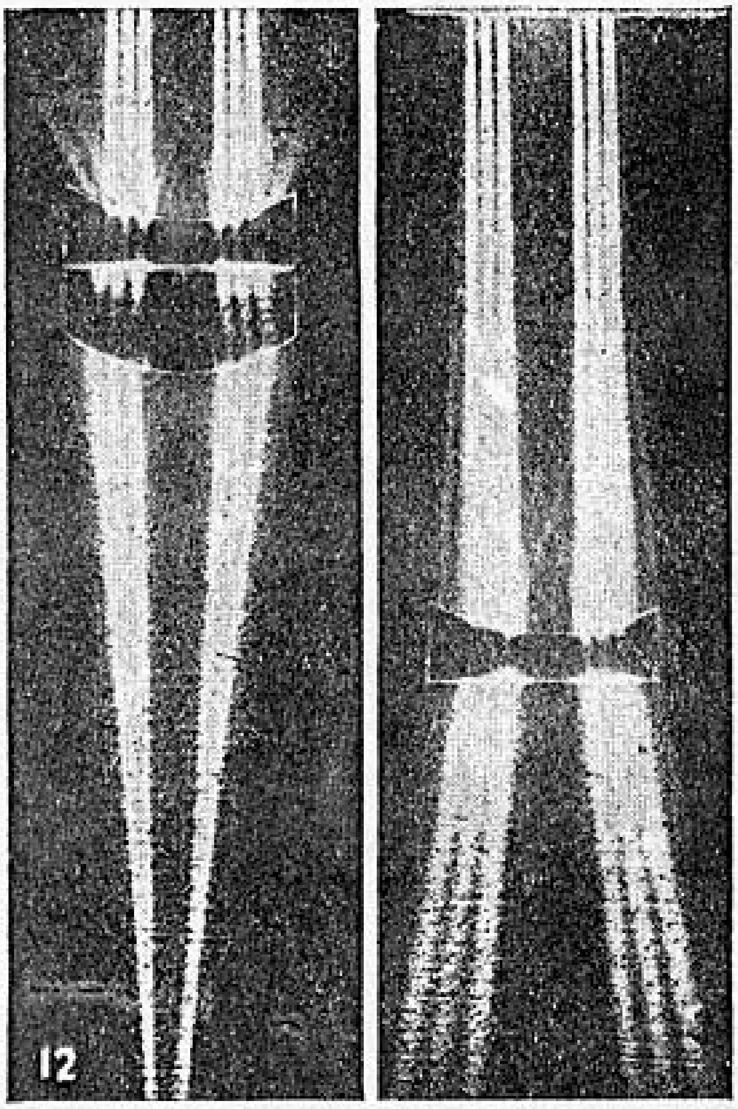
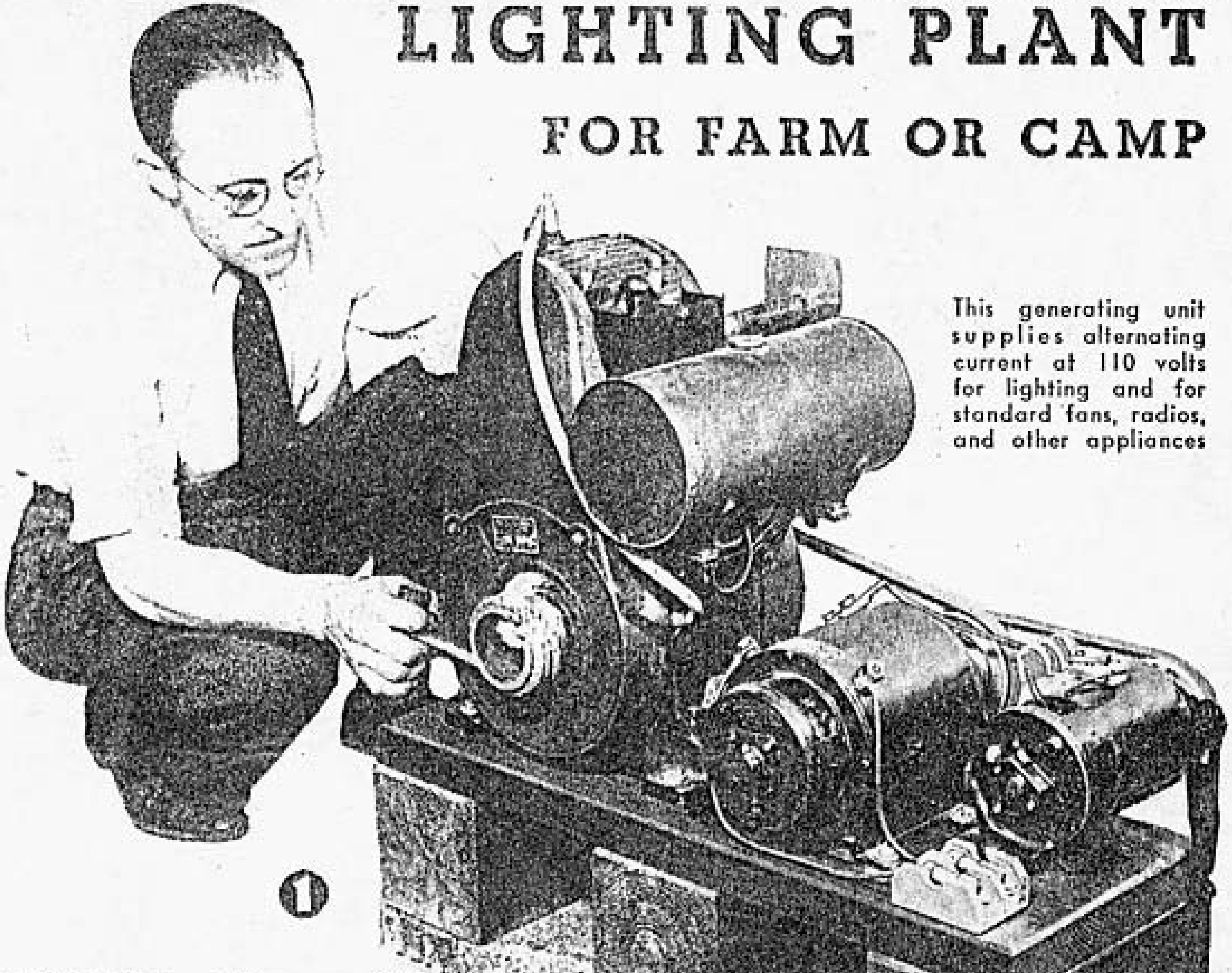


Fig. 12. Left, refraction by a negative lens backed by a positive one. Right, refraction by a negative lens.

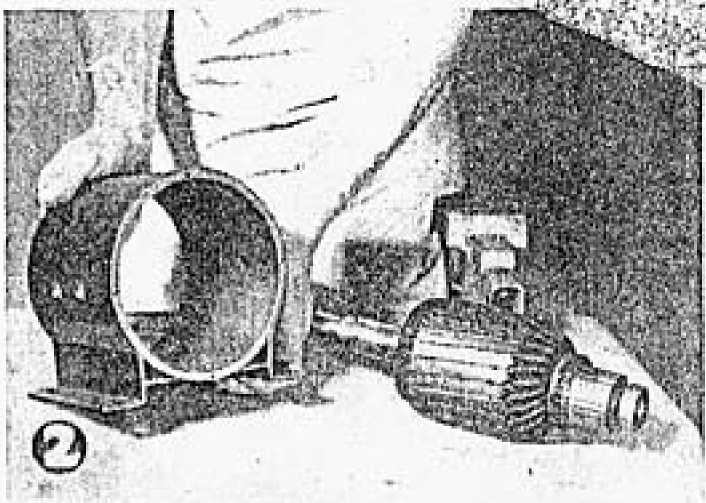
 GRANDDAD'S ELCTRICITY BOOK

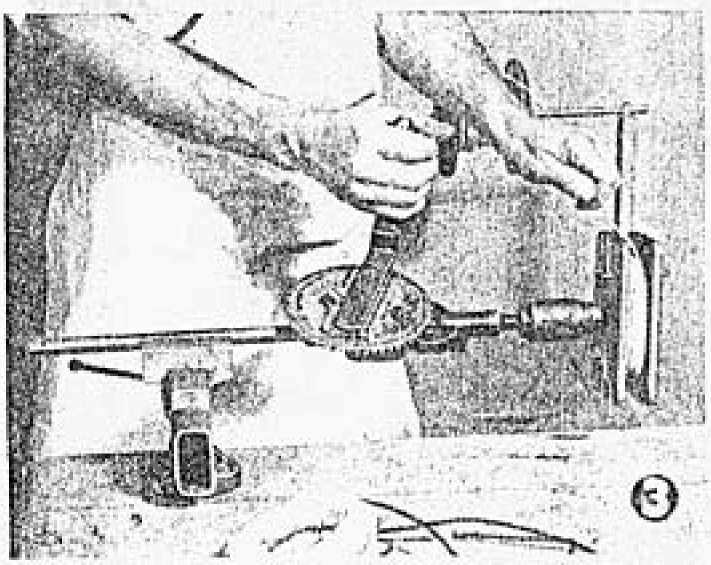
LIGHTING PLANT

FOR FARM OR CAMP



This generating unit supplies alternating current at 110 volts for lighting and for standard fans, radios, and other appliances



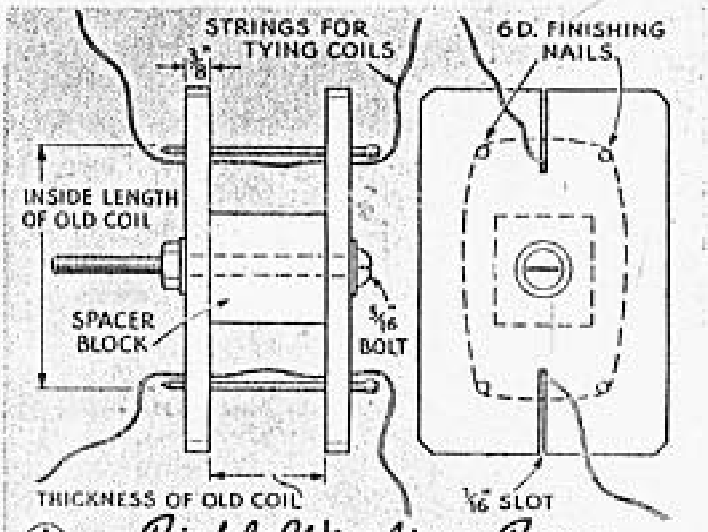


By HAROLD P. STRAND

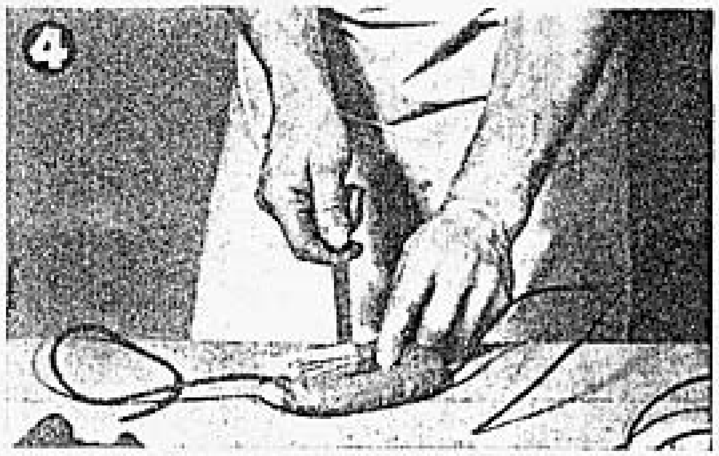
POPULAR SCIENCE JULY, 1941

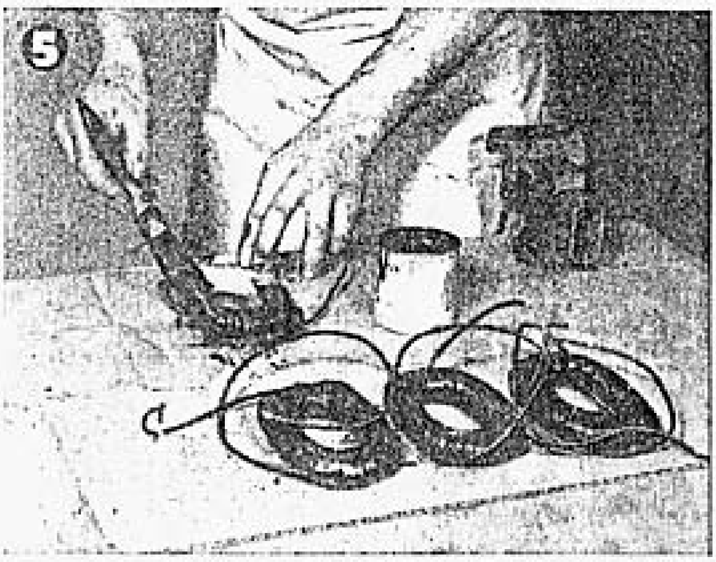
TWO old automobile generators picked up in a junk yard for four dollars form the main generator and exciter of this lighting plant. It delivers 110-115 volts, 60 cycles, at 1,800 r.p.m., and is capable of carrying 800 watts load—all that is necessary to render excellent service on the farm or at a summer home or camp where power service is not available.

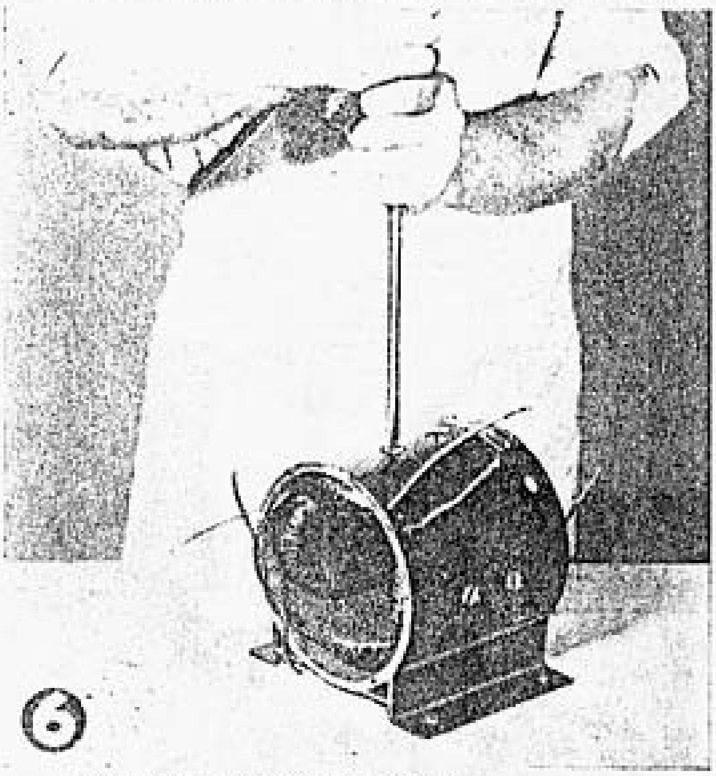
The advantages of generating the same kind of current as that supplied for ordinary house service are many, including the possibility of using standard lamps and appliances up to the capacity of the plant. In addition, it is easy to transform the voltage up or down to meet special requirements as desired. This is something that cannot be done with direct current.



Ⓐ Field-Winding Form







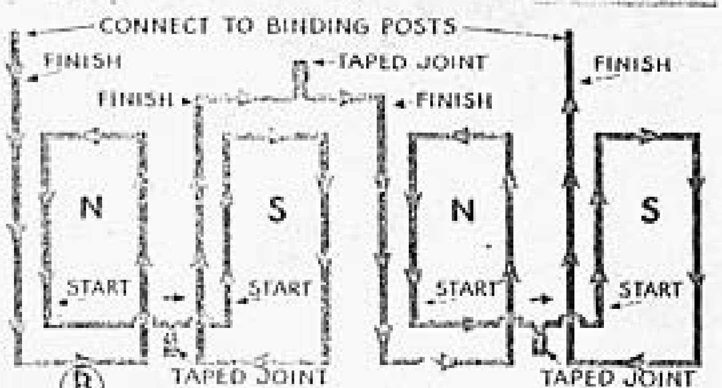
The larger of the two generators was one of the heavy 12-volt type, but any ordinary 6-volt generator will do for the exciter. The latter is used to supply D. C. voltage to the field coils of the main unit. The gas engine, rated at 2 h.p., was bought second-hand for twenty dollars and is air-cooled. The assembled unit is shown in Fig. 1, where the engine is about to be started for the first test.

The base is solidly built to prevent vibration—a 12" by 2" hardwood plank secured to three 6" by 6" blocks. A sheet of refrigerator cork was used under the blocks to lessen the noise of operation during the test, but for a permanent job, the blocks can be secured to the floor by setting them in cement or any other convenient means. The exhaust should be piped to carry the fumes outside for safety.

The first step in constructing the plant is to dismantle the large generator completely and have two pieces of 2" angle iron welded on at the sides, with two flat pieces for braces (Fig. 2). Two holes are drilled in each piece to clear 3/8" bolts. It is a good idea, when taking off the pole pieces, to mark them so that they can later be replaced in exactly the same way.

The new field coils are wound on a special form, shown at *A* in the drawings. This can be put in the lathe, or in a breast drill held in the vise (Fig. 3). The taping is first removed from one of the old coils, and measurements are taken of the inside length and width. The placing of the nails in the sides of the form will be governed by these measurements. The length of the spacer block determines the thickness of the coil, which should be made the same as the old one. Put a piece of string in each slot and wind 200 turns of No. 17 single-cotton enamel wire (about a pound).

Tie the strings tightly around the coil and remove it from the form. Make four of these



Ⓑ Developed View of Field Winding

coils exactly alike. For flexible leads, solder 6" pieces of No. 16 flexible rubber-covered wire to the ends of the windings. Mark each inside end for later identification.

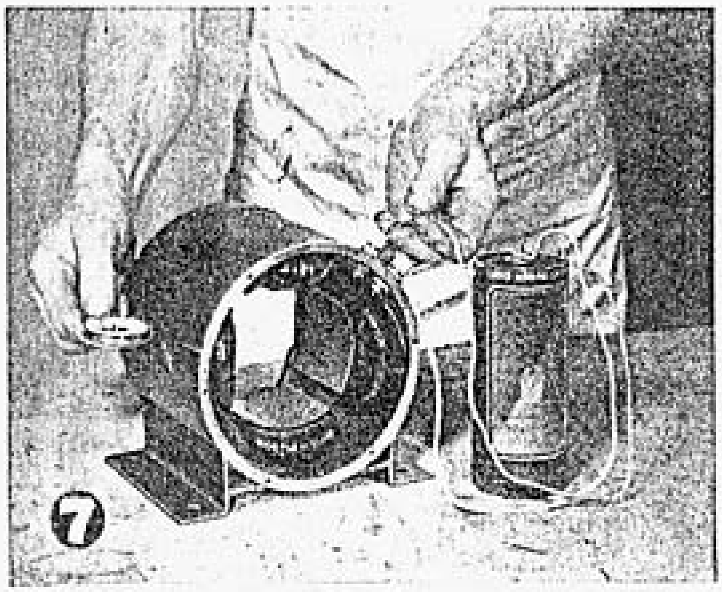
In Fig. 4 the taping is being done. The first layer is wound with strips of varnished cloth. Take care to wrap a small piece of the cloth around each joint and then bind it down tightly with the succeeding turn. Follow with a wrapping of cotton tape.

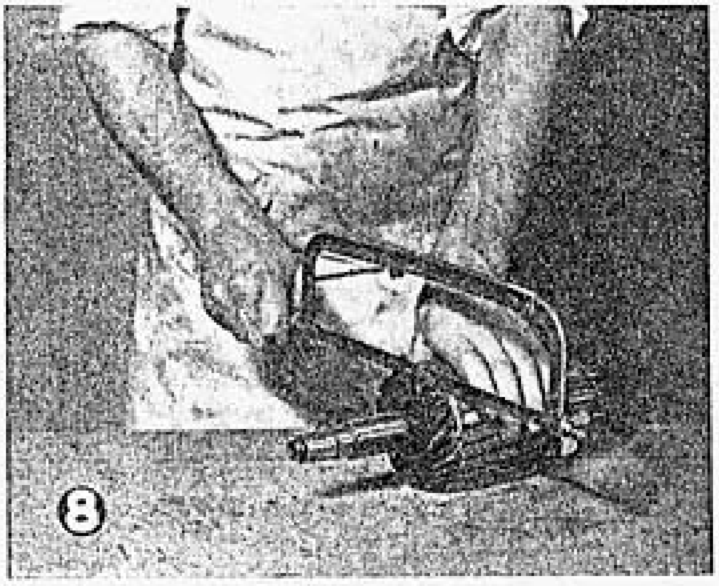
Next, insulate the coils thoroughly with a good insulating varnish (Fig. 5). They are allowed to drain for a short period, after which a baking in a moderately hot oven is recommended.

The placing of the new coils in the frame should be done with due respect for the polarity. In the drawing *B* the connections are shown, and it should be noted that a "finish" end of the first coil is left out for the terminal post. The coils are then connected, start to start, finish to finish, start to start, and the last finish end connects to the other post. This reverses the current for each pole as indicated.

In Fig. 6 the screws that secure the pole pieces are being drawn tight, the latter being replaced in their original positions. After the three joints have been made, solder and tape them. Two binding posts are then mounted on the frame with insulating washers, and the leads connected to them. Testing is done with a battery and compass as in Fig. 7. As the frame is turned over to bring each pole in turn near the compass, the opposite end of the needle should be attracted in each case in successive order. Also use a series test lamp to make sure no grounds exist to the frame.

The work on the armature is started by





Continued from page 132

as used on telephone generators, around the coil, leaving long terminals. Soak the whole in melted paraffin and let cool; bind tightly with black silk.

The vibrator is made of a piece of thin tin to which is soldered the head of an iron screw and on the other side a small piece of platinum, which can be taken from an old electric bell (Fig. 2).

Of course, a regulator must be had for the vibrator; this can be accomplished by bending a stout piece of copper wire as shown. The connections and the base for setting up are shown in the figures.—Contributed by J. T. R., Washington, D. C.

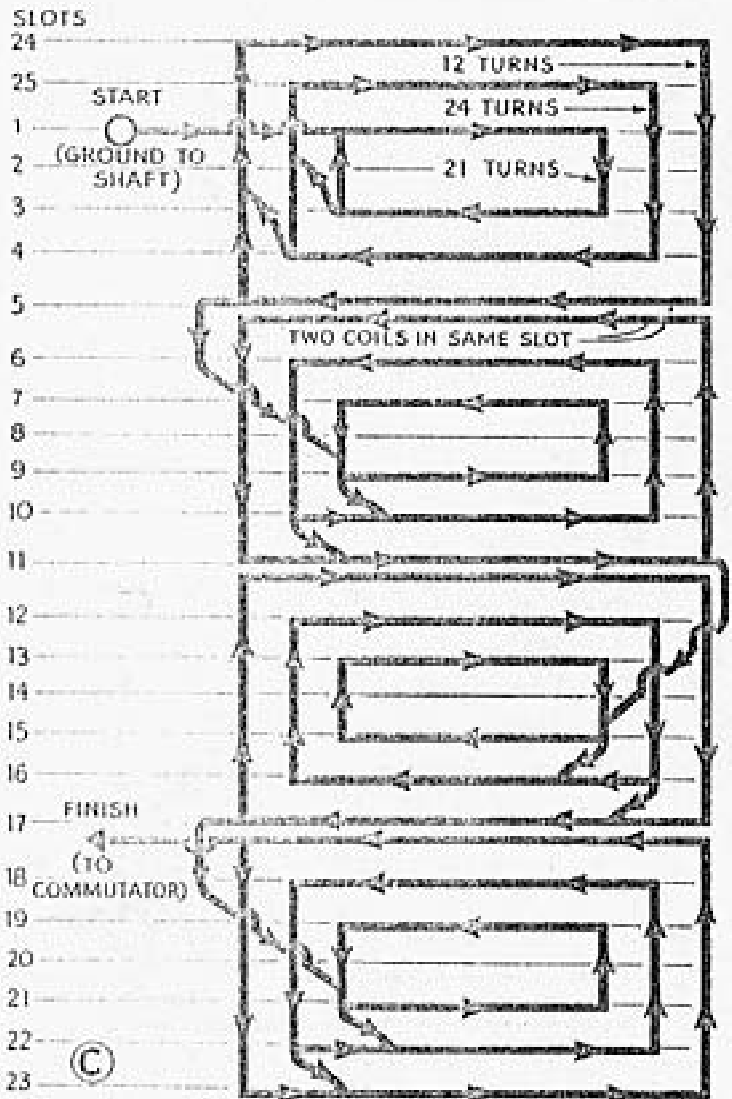
stripping off all the old wire and insulation. In Fig. 8 a hack saw is being used to cut off the old coils. The slot wedges can be punched out, and the wires unsoldered from the commutator. It is then an easy matter to pull out the wires and clean the armature down to the iron core.

The slots are reinsulated with some 0.010" armature paper cut in strips that will project over the ends of the slots about 1/4" and about 1/8" above the top. These are laid in each slot and fitted against the round surface by using a round stick or pencil.

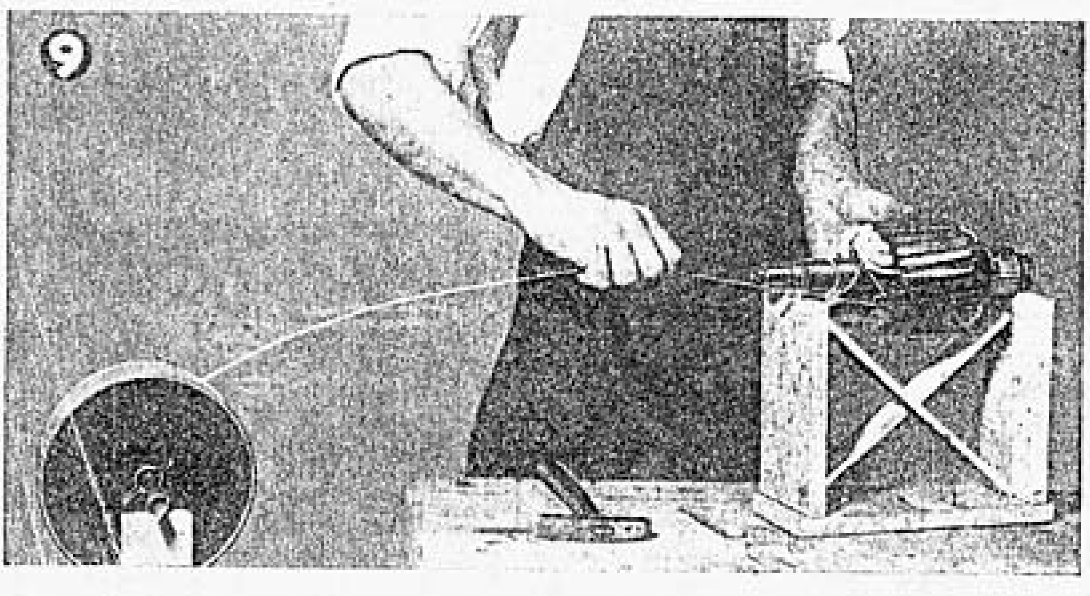
The general winding scheme is made clear in drawing *C* and Fig. 9. Use No. 15 S. C. E. (single-cotton enamel) wire and start with a turn around the shaft. The wire then enters slot 1, proceeds to slot 3, and continues for 21 turns. From there it is carried in the same direction to slots 25 and 4 to make 24 turns. Twelve turns are then put in slots 24 and 5, from which the wire is taken in a *reverse* direction to slot 9, and 21 turns are put in slots 9 and 7. This method is carried out for the entire job. Use one continuous wire, without joint or splice. Each coil in a group is wound in the same direction, but each group as a whole is wound in reverse fashion from the preceding and following one.

Connect the start of the winding to the shaft by drilling and tapping the latter for a 10-32 machine screw, as in Fig. 10. The finish end is soldered to a commutator riser, and a continuous band of solder is carried all around the tops of all risers to form one complete collector ring. Before attaching either end of the winding, it would be well to use a series test lamp to make sure the winding is not grounded to the core. Thin strips of fiber can then be placed in the slots to keep the wires in place. Follow with a good application of the insulating varnish, and bake as before.

The generator is next assembled, with one insulated brush only bearing against the collector. A No. 14 flexible lead is connected from this brush to the insulated binding post, which is one of the original heavy posts on top. See that the other heavy post is grounded, which means that no insulation at all is used under it, and all paint or grease is scraped off the frame at this point to insure a good contact. Figure 11 shows the two units being set up on the base, and the method of tightening the exciter belt. The exciter is pivoted upon its lower mounting lug, and adjusted by moving the other bolt up or down in the slotted bracket at the extreme left. Some holes are

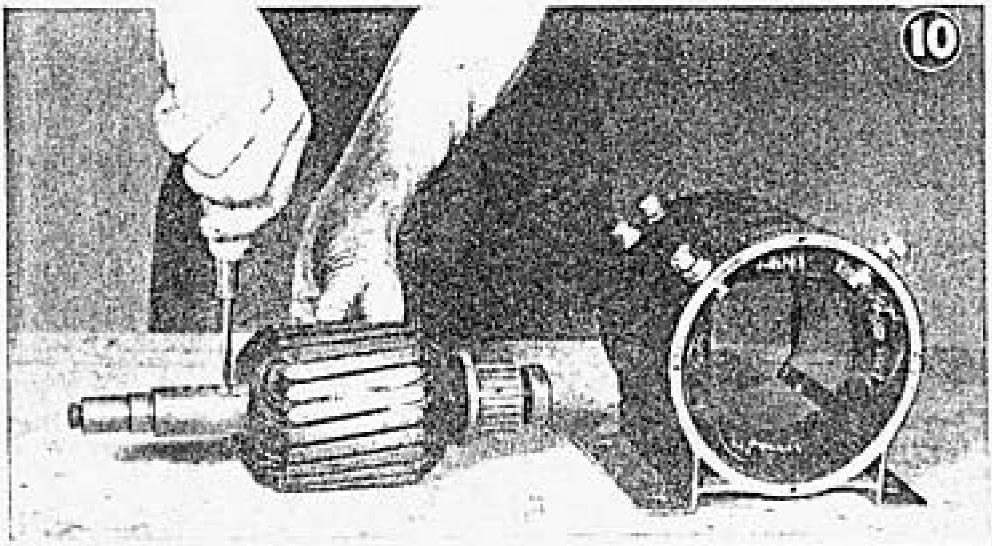


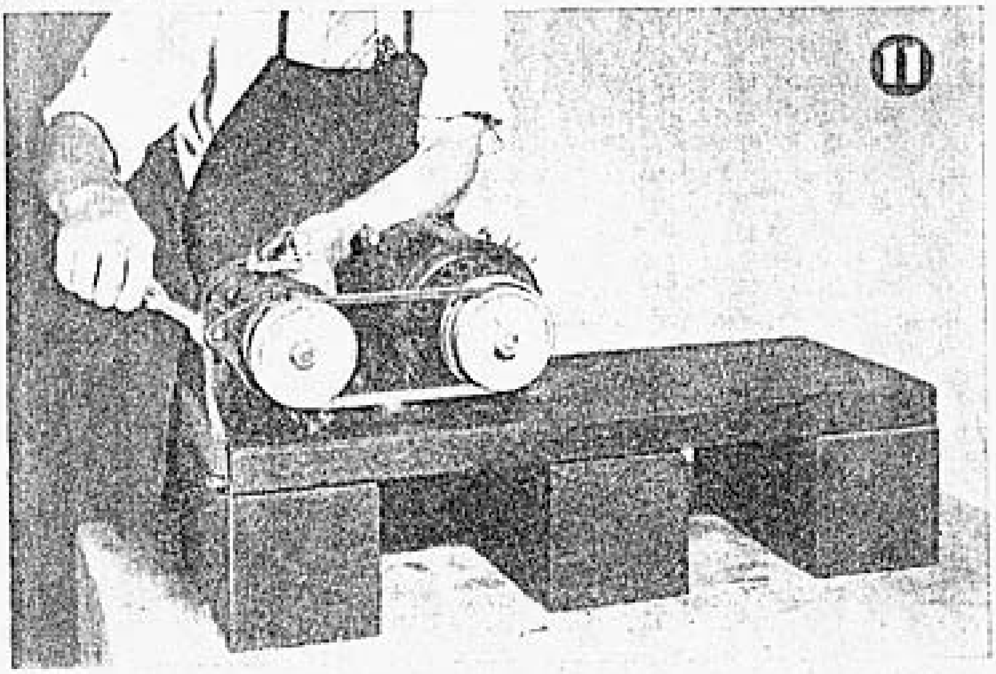
Developed View of Armature Winding

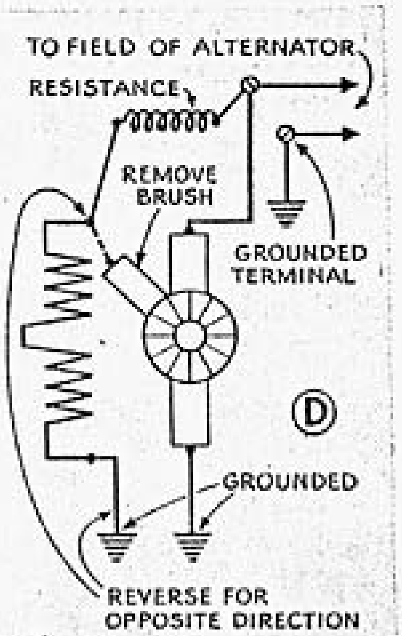


The armature winding is a continuous length. Wind evenly and tamp the wire in place to get in the required turns. Make all end loops alike to keep armature in balance

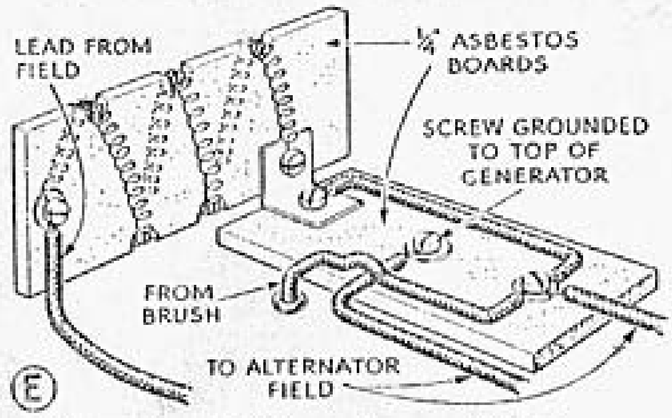
After winding armature as at left, test for grounds with a series lamp before making terminal connections







Exciter Connections



Details of Resistance Unit

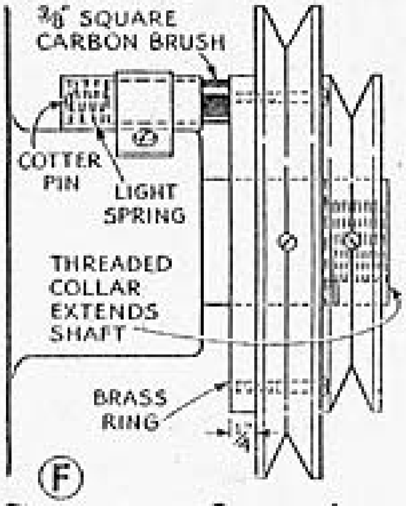
drilled in the bearing housings of the main generator before assembly to improve ventilation.

The exciter must be tested by driving it to learn its direction of generating. As you face the commutator, it should generate when running clockwise to be the same as the alternator. If it generates when going the other way, open it up and reverse the two field leads. Also, the third or regulating brush is removed.

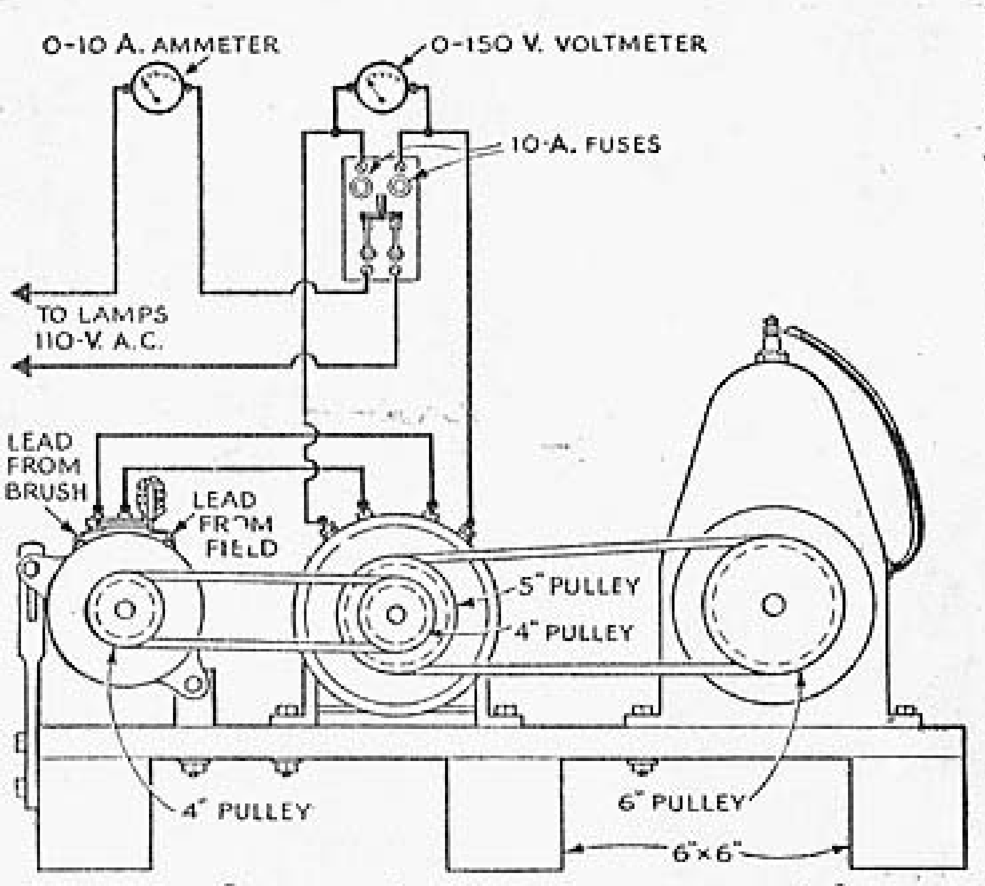
Drawing *D* shows the diagram of connections, and how the lead that normally connects to the third brush is carried up and connects to some resistance wire to limit the field current. The amount of this wire must be determined by experiment with an ammeter. Use some coiled No. 18 or 19 resistance wire (the usual heating element used in electric ranges). Drawing *E* illustrates the method of making a terminal block and form for the wire on top of the exciter. Sufficient resistance must be used to allow only about 3 amperes to flow in the exciter field circuit, which in the average case may take about 6" of close-coiled wire if it is wound on a 3/16" arbor.

To prevent the grounded side of the A. C. current from having to pass through the bearings, a special grounding brush should be made and attached to the end of the bearing housing as in drawing *F*. The method of extending the shaft to take the second pulley is also shown—a threaded collar made to screw on the threaded end of the shaft.

Drawing *G* shows the general arrangement of the units and the wiring plan. A speed counter should be used when first starting the plant to determine the best engine-speed settings. For 60 cycles the generator must be run close to 1,800 r.p.m. Once set, the engine governor should regulate it fairly uniformly. The voltage is then checked, and it should be around 115 volts, no-load. If it is high or low, don't change the engine speed, but try varying the exciter speed with a larger or smaller pulley,



Details of Grounding Brush and Pulleys



General Arrangement of Units and Wiring Connections

as may be required. Another method is to vary the resistance in the exciter field circuit *(E)*, which in turn will affect the A. C. output.

In calculating pulley sizes required to drive the generator at the correct speed for 60-cycle current, the usual simple formula is used (see "Pulley Speeds and Sizes," P.S.M., Dec. '38, p. 195). The engine in this case has a 6" pulley and runs at 1,500 r.p.m. To find the speed at which an alternator must turn to generate 60-cycle current, multiply the number of cycles (60) by the number of seconds in a minute (60) and divide by the number of *pairs* of poles. Our four-pole generator, must therefore turn at 1,800 r.p.m.

To find the size of the generator pulley, multiply that of the engine pulley (6") by its speed (1,500) and divide the product by the required generator speed (1,800), which will give 5" as the required pulley size.

RUBBER-STAMP NEGATIVES [*METAL ETCHING—7*]

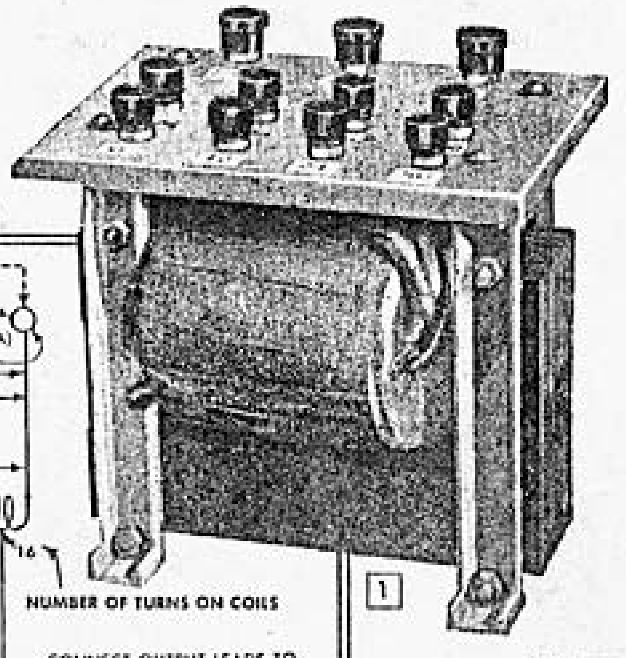
In some cases it is desired to etch metal with a rubber stamp in such a way that the background is etched, but the trade-mark, letters, or numbers remain untouched, in bright metal. This is the negative or reverse process.

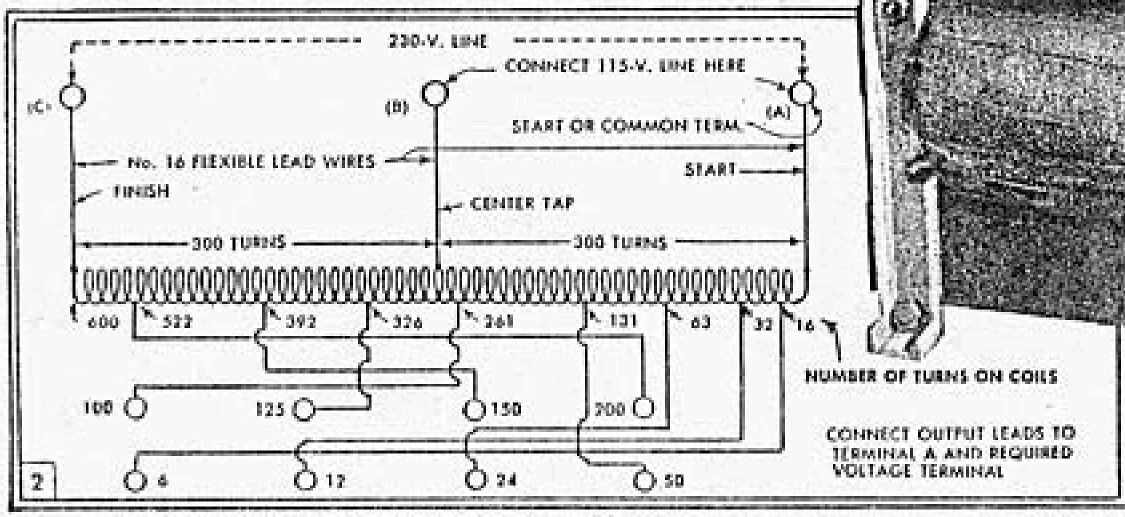
Clean the metal thoroughly with dry abrasive. Use a camel's-hair brush to paint asphaltum varnish very thinly over the surface of a piece of glass. Press the rubber stamp upon the glass so as to coat the letters evenly with asphaltum. Now press the stamp down gently on the metal. Remove it carefully so as not to smear the impression. Let dry hard before applying the etching solution. Clean the stamp thoroughly with kerosene or thin oil and wipe it dry after each impression is made.

Build a putty or wax fence around the section to be etched. With a cotton swab, apply a few drops of the etching solution and let it remain until the metal is etched to the desired depth. For steel, use equal parts of muriatic acid and commercial nitric acid. After the asphaltum has been removed with kerosene or lacquer thinner, polish and apply oil to prevent rust. For copper or brass, use water to which an equal amount of nitric acid has been added, or, for a quick job, use full-strength commercial nitric acid.

POPULAR SCIENCE MONTHLY SHOP DATA FILE

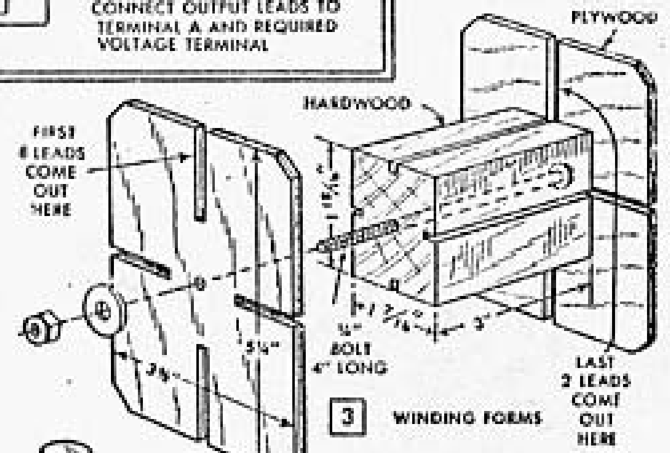
Auto-Transformer Design and Construction

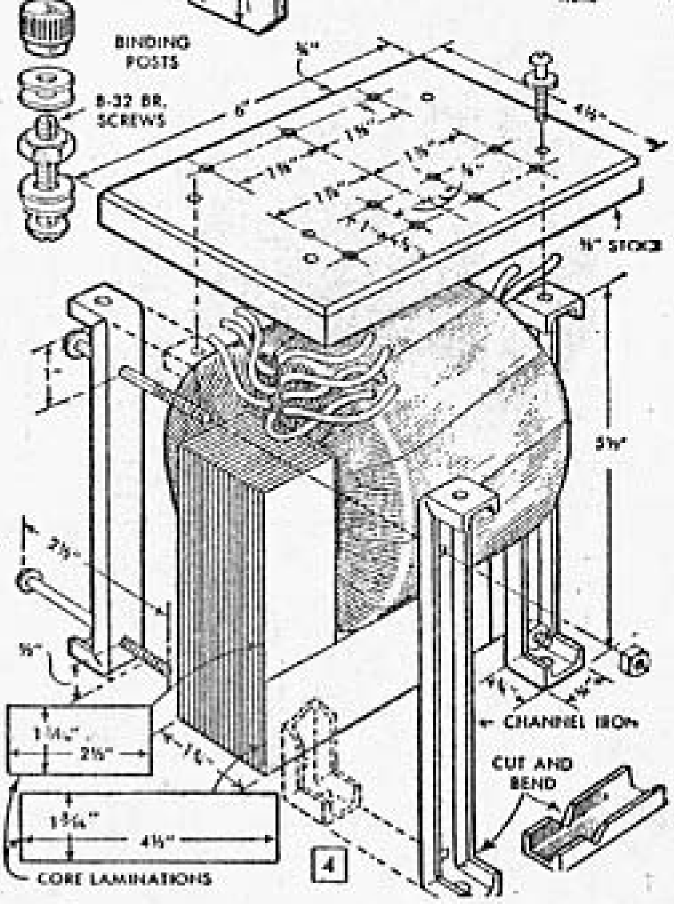




POPULAR MECHANICS, 1948

By Harold P. Strand



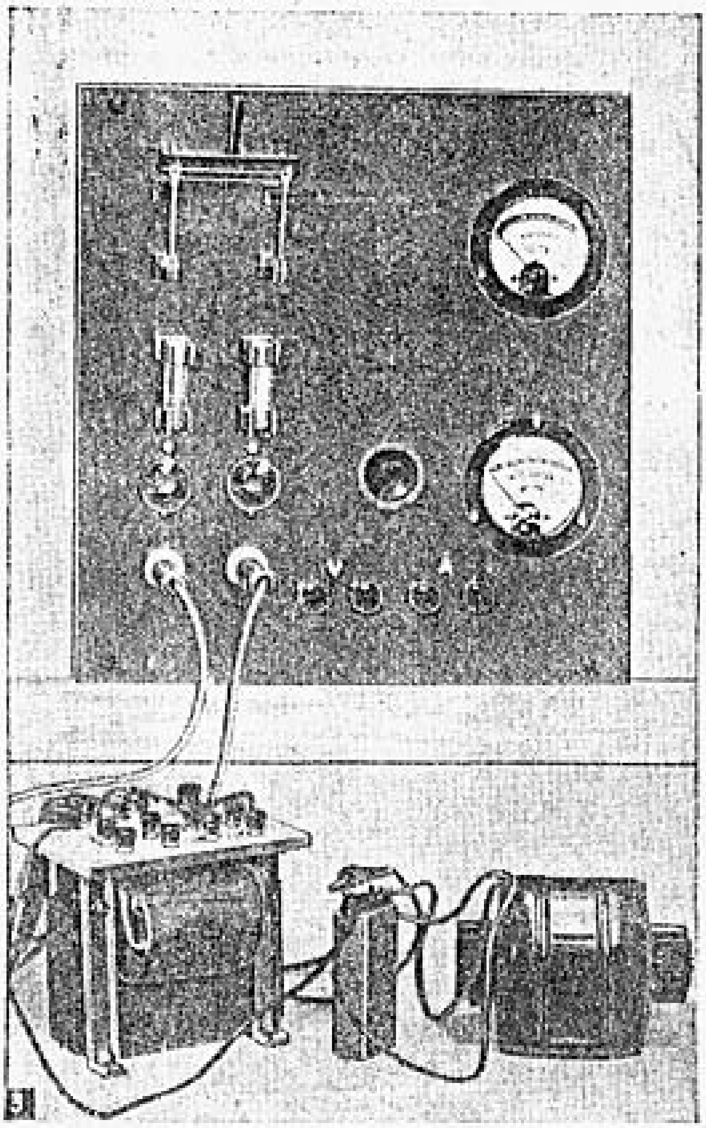


AN AUTO-TRANSFORMER that will provide a wide selection of voltages and have enough capacity to care for reasonably heavy loads is a handy piece of equipment to have around the workshop. The one illustrated in Fig. 1 is designed for such service and will be found easy to build, requiring a minimum of materials. If 115 volts are supplied, 6, 12, 24, 50, 100, 125, 150, 200 and 230 volts can be taken off. For 230 volts, connect the output leads to terminals A and C, Fig. 2. Otherwise connect to terminal A and the required voltage terminal. These are no-load voltages, and if it is desired to maintain this potential at load conditions, about 2 or 3 percent can be added to the specified turns for each tap. You can apply 230 volts across the full winding also. In this case reduced voltages are delivered down to 6 volts.

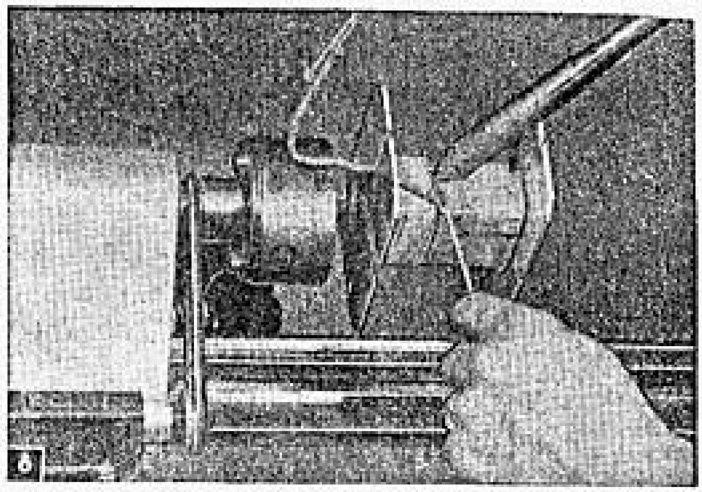
The winding is done with No. 16 enameled or double cotton-covered wire. This will handle loads of 3 to 4 amperes, or higher for short periods. If greater capacity is desired, add about 25 percent to the cross-sectional area of the core and use No. 14 wire for the coil. This will result in a larger coil, however, and the core will have to be altered to accommodate it.

In figuring the number of turns per volt, it will be noted that the 115-volt line is across 300 turns. Therefore, dividing 300 by 115 gives 2.6 turns per volt. For the first tap, 6 volts, there should be 6 times 2.6

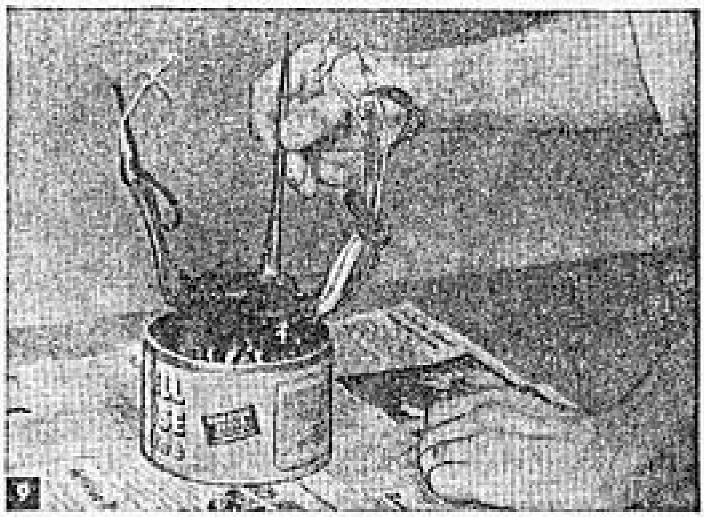
 GRANDDAD'S ELCTRICITY BOOK



Here the transformer is being used on a test bench to check an electric motor that has been repaired



Soldering the tap for 6 volts after 16 turns. Note the sleeve on the length of wire used for the tap



After the coil has been taped, it is impregnated with insulating varnish and baked for several hours

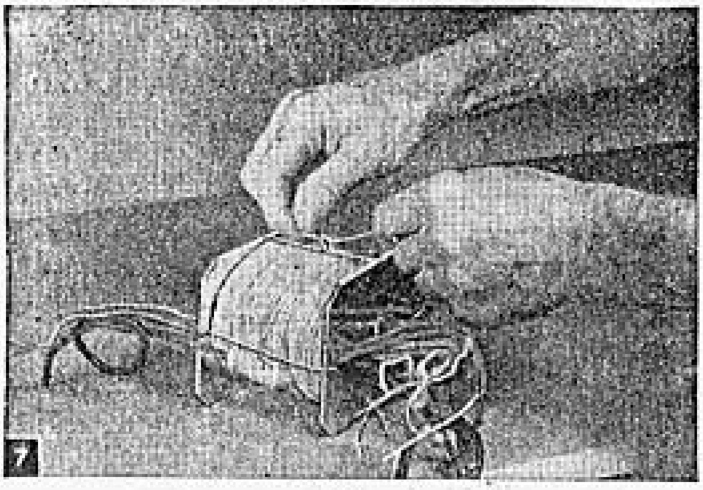
which equals 15.6 or 16 turns. This is the way in which all the taps are figured and it thus is possible to design the transformer to deliver any special voltages desired.

To make the coil, the form shown in Fig. 3 is used. The center is hardwood and the sides are plywood. The slots are used as channels through which string is passed to tie the coil. A ¼-in. bolt holds the form together, the end being chucked in a lathe for winding. Wrap 2 turns of armature paper around the center, allowing it to lap over the sides about ⅛ in. Secure the paper in place with cellulose tape.

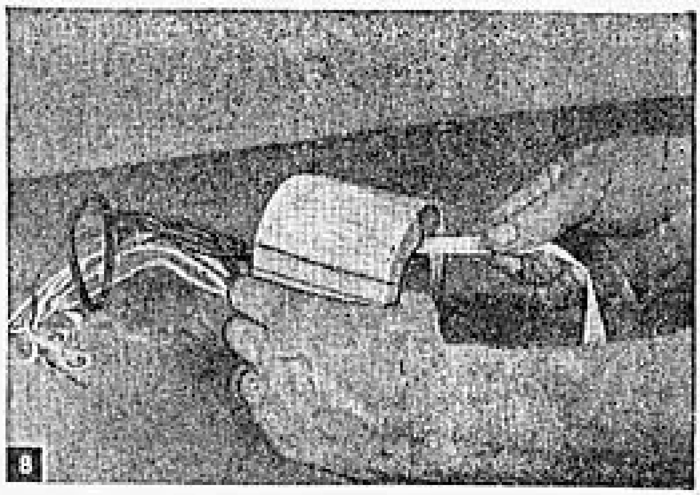
When winding, use a very slow speed and be prepared to stop quickly. To start the coil, solder and tape a length of No. 16 flexible insulated lead wire to the end of the coil wire and place this in the slot next to the chuck. The first tap is made at the sixteenth turn, Fig. 6. No. 16 magnet wire is used and a cotton sleeve is placed over it. After taping, place a small piece of varnished cambric under the connection and another one over it, using cellulose tape to hold the cloth in place. Bring the lead out the same slot as the original one. Continue the winding, making the taps at the required number of turns. When you have made 300 turns, again use flexible insulated wire for the lead. All taps so far, including the one made at 392 turns, are brought out the same slot. The last two connections are brought out the corresponding slot in the opposite side. The lead connecting to the end of the wiring, after soldering and taping, is fastened to the body of the coil with cellulose tape. This last lead is, of course, flexible insulated wire. A total of 600 turns is required.

Four strings are passed through the channels in the form and the coil is tied tightly, Fig. 7. Taping is done with white cotton coil tape, which is wrapped tightly and evenly, as in Fig. 8. The completed coil is dipped in insulating varnish and baked in an oven at 200 to 275 deg. F. for 2 or 3 hours. If such facilities are not available, pour the varnish in a coffee can and use a brush to impregnate the coil thoroughly, Fig. 9. Then let it drain for about half an hour and suspend it over a stove until thoroughly dry.

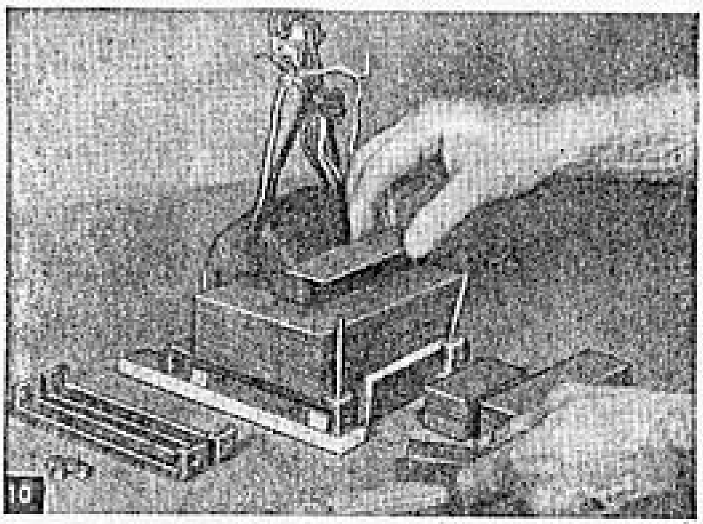
The core is made from strips of 26-gauge silicon, transformer grade, steel. All strips are cut 1$\frac{3}{16}$ in. wide. They are cut in 2½ and 4½-in. lengths. All duplicate pieces should match exactly and the ends must be



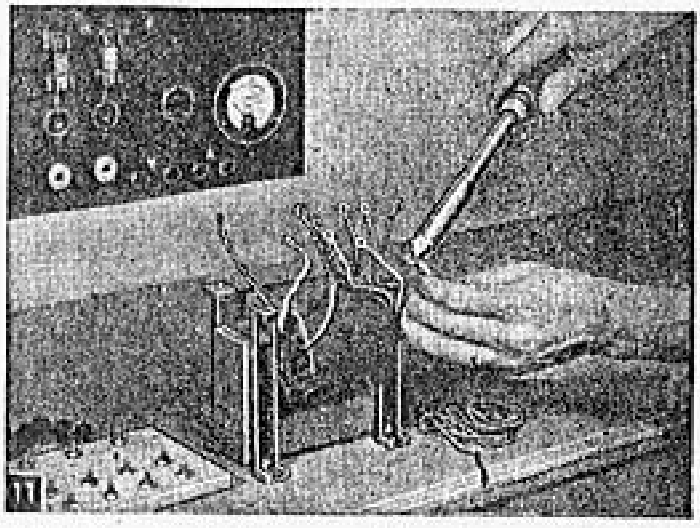
Before the coil is removed from the form, it is tied tightly with string to hold it while being taped



The coil is wound with white cotton tape. During this process, the string is removed from the wire



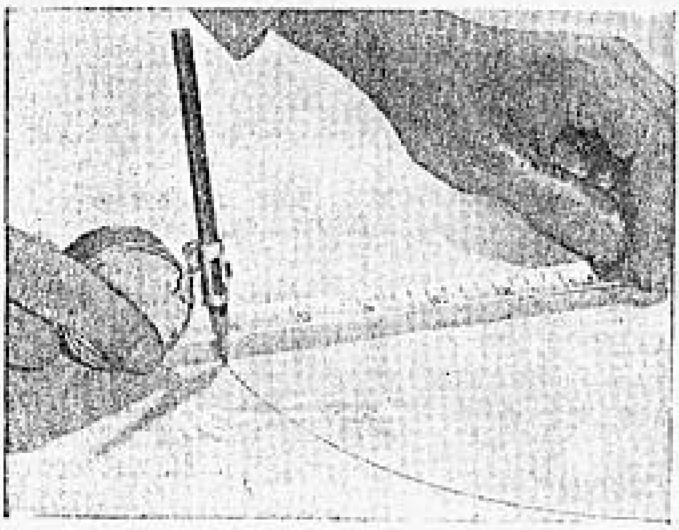
When assembling the core, be sure that the laminations are perfectly flat and that the ends are square



Next, terminal clips are soldered to all the leads after they have first been cut to the proper length

square. It might be well to check the dimensions of the coil to see that the core pieces, cut to these dimensions, will fit the coil. Make two piles of each length and when the stacks measure 1¾ in. high, tightly compressed, you have enough. The laminations must be absolutely flat to make a core that will work well.

Details of the channel-iron brackets, panel and method of assembly are given in Fig. 4. The laminations are assembled as in Fig. 10. Overlapping of the pieces should be alternated for each layer. After the brackets are assembled, the core can be squared up by laying the three exposed sides on a metal plate and tapping with a hammer. Terminal lugs are soldered to the leads from the coil, Fig. 11, and fastened to binding posts on the instrument panel. The leads are connected in the sequence shown in Fig. 2. It would be well to letter and number the terminals as indicated on this same drawing. All metal parts and the panel should be given several coats of enamel. Fig. 5 shows the completed unit in service, ready to test a motor that has been repaired.

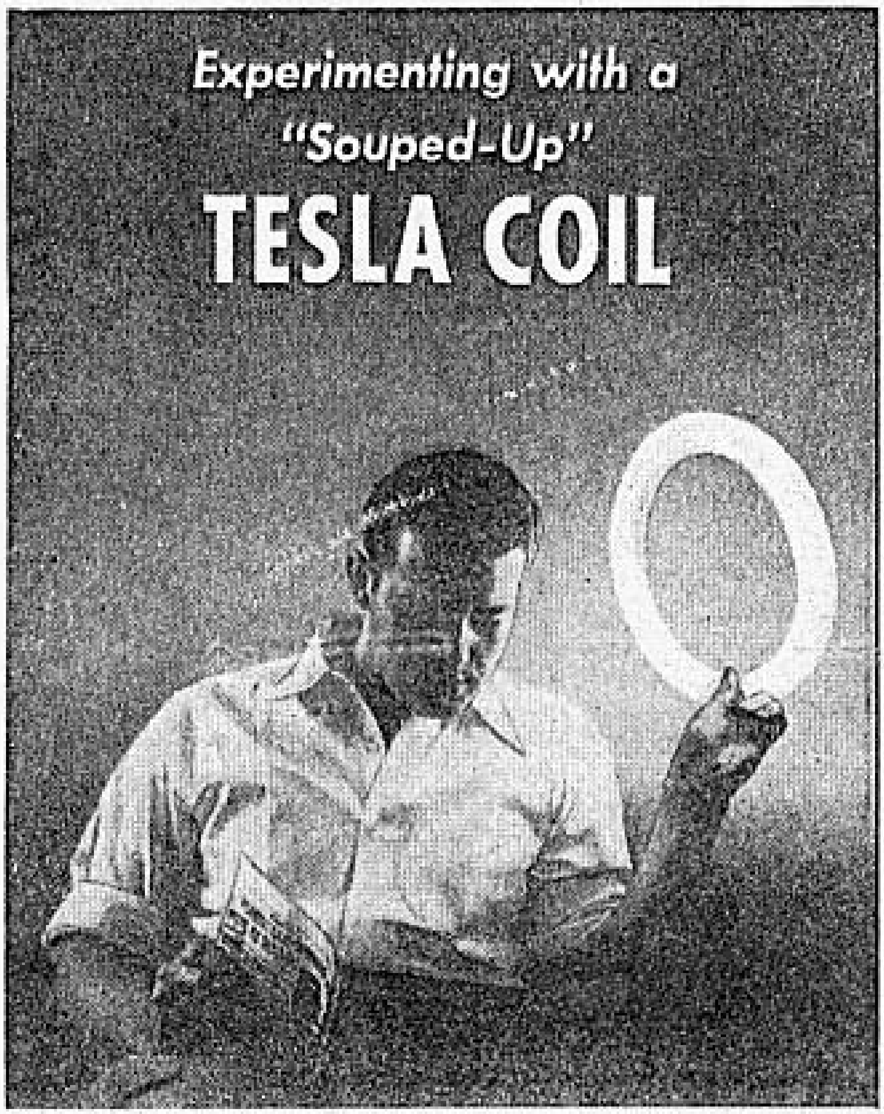


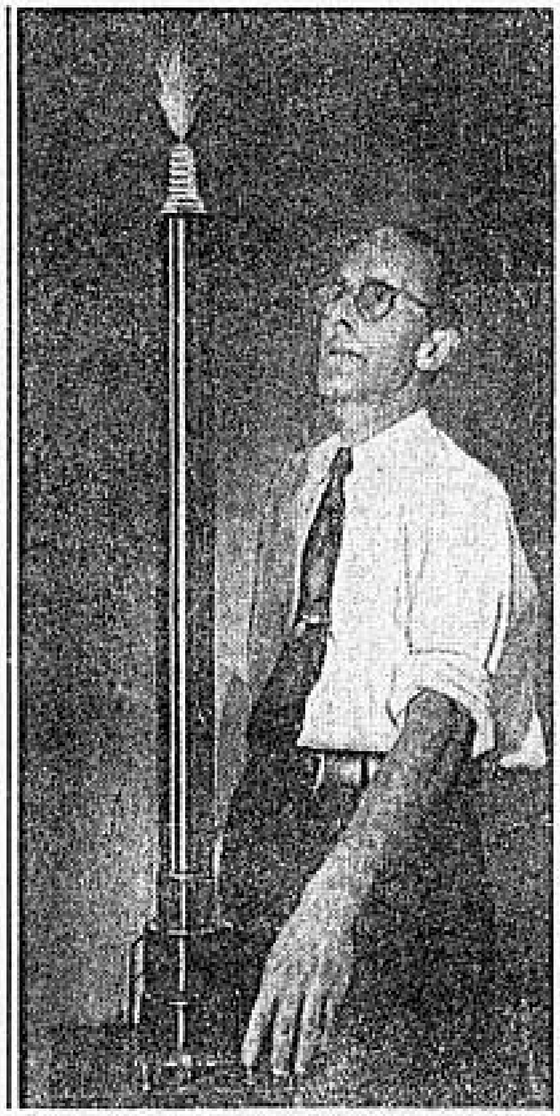
Combination Tape and Compass Performs Dual Function

If you have a steel measuring tape, make it do double duty by adding a compass attachment. With this improvised instrument you can draw large circles and do other layout work that ordinarily requires a beam compass. Secure the pencil clip from an inexpensive compass of the type used by students and solder it to the case in such a position that the pencil will be at right angles to the tape when it is extended as shown in the illustration.

Orville Buser, Kankakee, Ill.

ELECTRICITY





Husky 4-in. brush discharge radiates enough energy with a crackling noise to light Circline bulb in the next room.

Science and Mechanics October, 1953

By HAROLD P. STRAND
Electrical Editor

Craft Print Project No. 191

WITH more power from this bigger Tesla coil, you can perform more of the eerie electrical wonders first demonstrated by Nicola Tesla in 1892. This hotter coil develops 70,000 volts at 500,000 cycles per second frequency and is now on permanent display at the new Museum of Science in Boston, Mass., where it is demonstrated daily. With more potent power, you can perform experiments not open to the smaller coil described in the April 1952 issue of Science and Mechanics (Fig. 7).

Even though you'll be experimenting with 70,000 volts, the high frequency (500,000 *cps*) keeps it harmless. Currents at high frequencies travel over conductor surfaces only, traveling over your skin to ground without damaging any internal organs. Basically this Tesla-type coil uses two vacuum tubes as high-frequency oscillators and a resonant coil tuned to about 500,000 *cps*. Because of the tuning requirements, you must use the values indicated for parts, or the coil will not perform.

To wind the tall secondary coil, secure the *Bakelite* 1¾-in. tubing (polystyrene is better but more expensive and harder to get). Wind on the 2400 turns of #29 *Formex* magnet wire and cover the bottom and top leads with varnished tubing. An easy way to wind this coil is to fit wood plugs at each end of the tubing and mount in a lathe. Hand feed the wire and wind the turns closely together. Cover the windings with hot paraffin wax. Wind the primary coil according to Fig. 2. Both coils should be wound in the same direction when mounted in position.

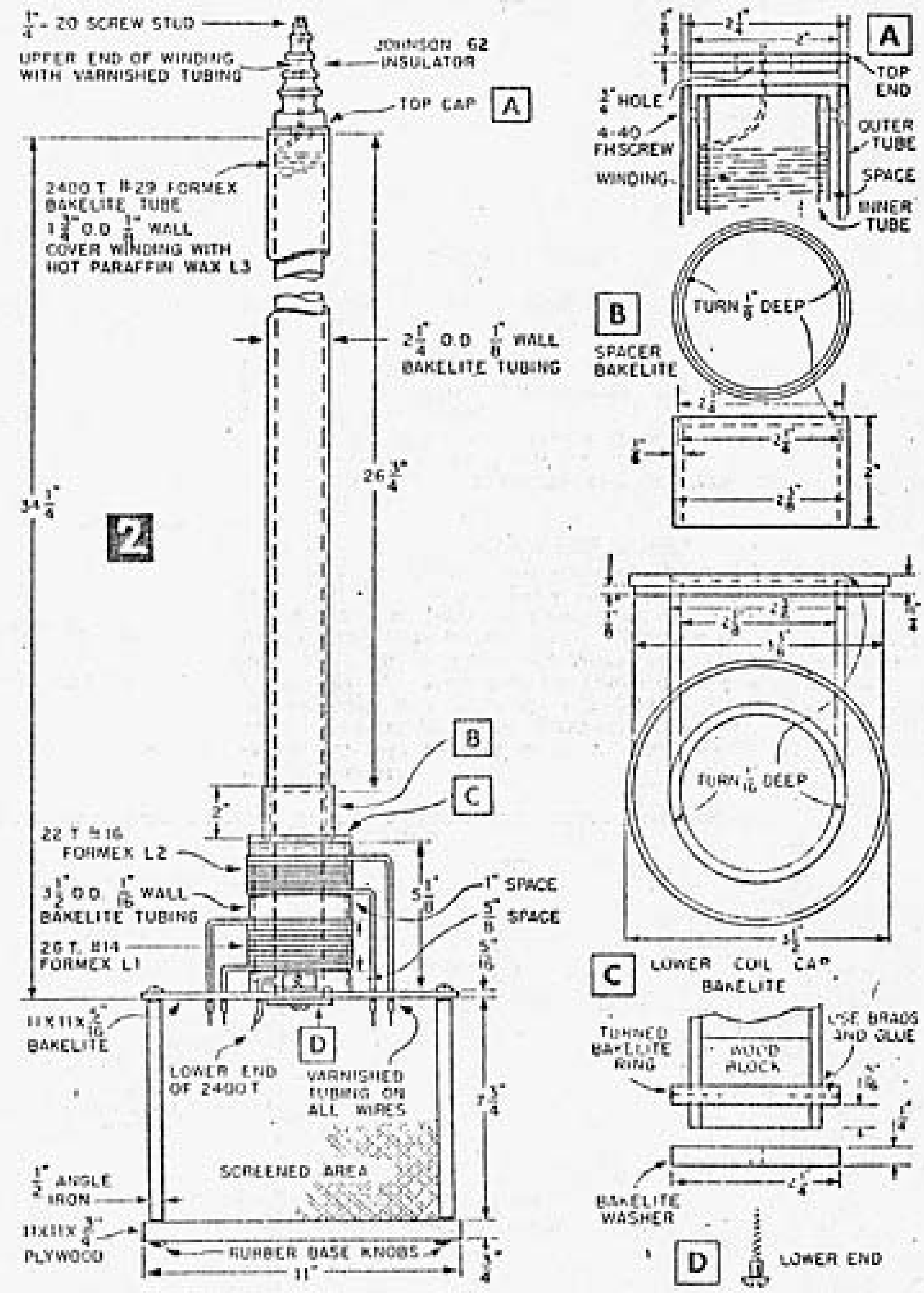
Make up the lower mounting box from ¾-in. plywood for the base and ½ x ½-in. angle irons at the corners. The top is a 5/16-in. thick piece of *Bakelite*. Mount the top and bottom to the corner irons by cutting away one leg of angle and bending other leg over. Bolt through with 6-32 *rh* bolts. Lay out the bottom piece for mounting the parts (Fig. 8) and drill mounting holes to suit the holes in each part. Form the metal screening to enclose the three sides of the base,

MATERIALS LIST—TESLA COIL

1	pc.	5/16 sheet Bakelite (black) 11x11"
1	pc.	Bakelite tubing, 1/8 wall, 2¼" O.D., 26¾" long
1	pc.	Bakelite tubing, 1/8" wall, 1¾" O.D., 34¼" long. If bakelite tubing is unavailable at this length, use polystyrene (best) or cardboard well soaked in hot paraffin wax (last choice)
1	pc.	Bakelite tubing, 1/8" wall, 2⅜" O.D., 2" long
1	pc.	Bakelite tubing, 1/16" wall, 3½" O.D., 5⅝" long
1	pc.	sheet Bakelite, 2½x2½x¼". Top cap
1	pc.	sheet Bakelite, 3¾x3¾x¼". Lower coil cap
2	pcs.	sheet Bakelite, 2x2x¼". Washer, bottom of coil
1		Johnson #62 porcelain insulator and mounting ring
1	pc.	plywood, 11x11x¾". Base board
4	pcs.	½x½x9" angle iron
4		rubber base knobs
4	pcs.	perforated sheet steel or aluminum. Base cage
		About ½ lb. #29 heavy Formex wire, or Formvar. (Heavy means insulation)
		About 25 ft. #16 Heavy Formex wire
		About 30 ft. #14 Heavy Formex wire
		Varnished tubing for wires under panel
1		plate transformer, 115 volts 60 cycles pri. 1200 volts sec. at 350 ma.
1		filament transformer, 115 volts 60 cycles pri. 7.5 volts at 8 amp. sec.
1		1250 ohm, 25 watt adjustable resistor
1		.0007-mfd., 1—.0005-mfd., 1—.0004-mfd., 3000-volt mica transmitting capacitors
1		.0008-mfd. 3000-volt mica transmitting capacitor
1		.005-mfd. 2500-volt mica transmitting capacitor
2		porcelain 4-pin sockets
4		½" porcelain spacers
1		fuse mount for 3AG glass fuse
1		10-amp. 3AG fuse
1		2-terminal Jones terminal strip
		8 ft. #18 two wire rubber cord
1		attachment plug cap
2		Hytron 5514 transmitting tubes
2		S.P.S.T. toggle switches 6 amp., 115 volts
1		insulated ground terminal post (make from 10-32 screw, nut, washer and Bakelite thumb nut)
		Misc. wire, screws, nuts and so on
		Material to make attachments for experiments taken from drawings

SOURCES OF SUPPLY

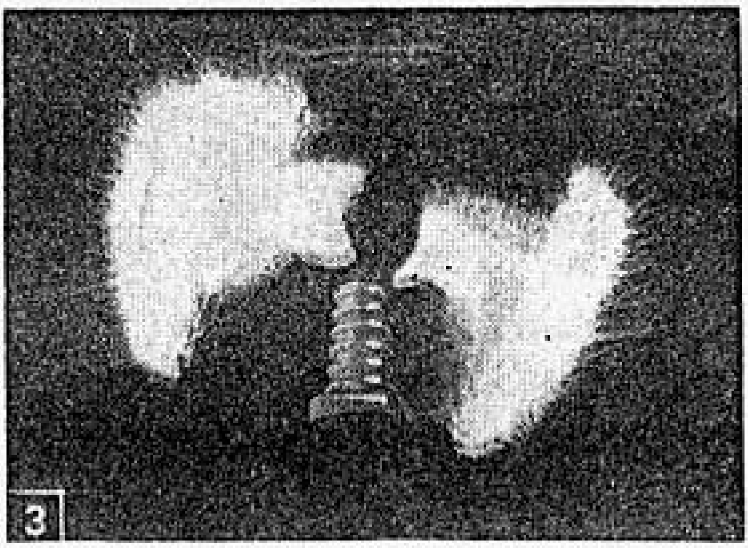
Radio and electrical parts—(Allied Radio, 833 West Jackson Blvd., Chicago 7, Ill., or Radio Shack Corp., 167 Washington St., Boston, Mass., or Hatry and Young, Inc., 811 Boylston St., Boston). Magnet wire—(Now in short supply. Try radio stores, electric motor repair shops, or Insulation and Wires, Inc., 1040 Tremont Street, Boston, Mass.). Sheet phenolic (Bakelite) and phenolic tubing—(Huse-Liberty Mica Company, 171 Camden Street, Boston, Mass. Forest Products Co., 194 Broadway, Cambridge, Mass.) Lucite tubing may also be used as an excellent substitute for Bakelite and is cheaper.

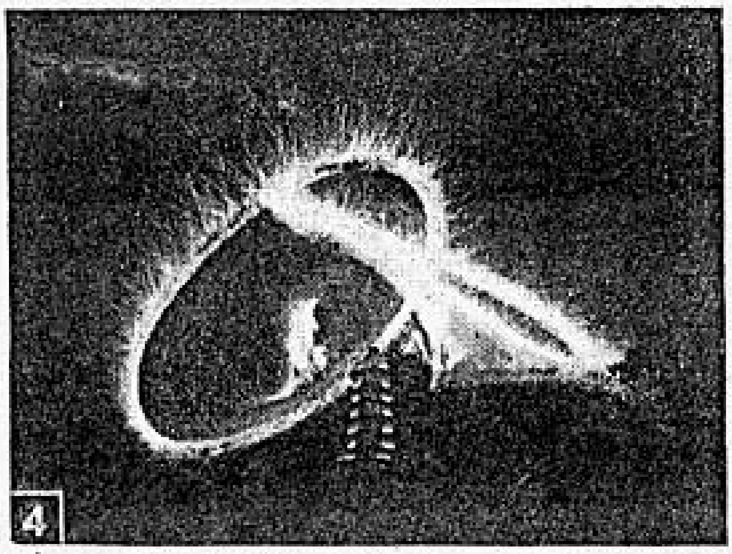


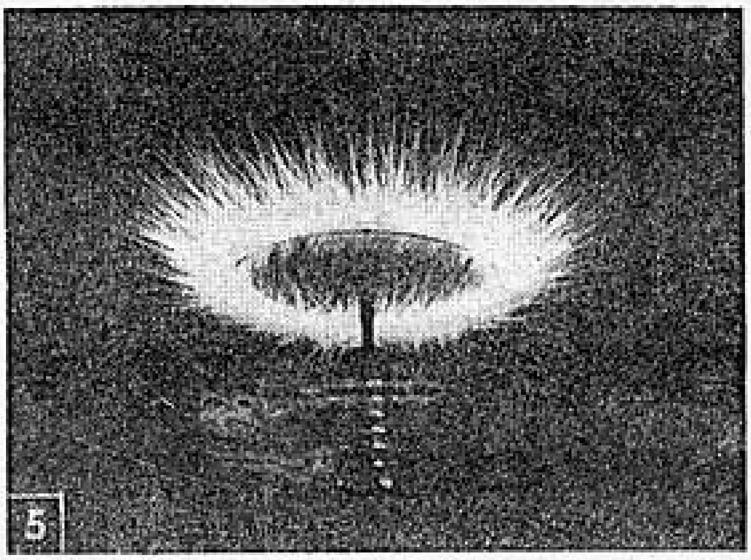
but do not fasten it in place until all parts are mounted and wired. Three 6-32 *rh* bolts along the back of each side hold the screen.

Turn the *Bakelite* washers and mounting discs for mounting both primary and secondary coils. Use varnish instead of cement to hold them together. When all parts are assembled and wired according to the schematic diagram (Fig. 9) cover the tall coil with a 2¼ in. O.D. x ⅛ in. *Bakelite* tube to protect the winding and help reduce radiation of the high-frequency current to the surrounding air. Connect the ground terminal to a water pipe or other ground connection. The coil will work, however, without this ground connection. To put the coil in operation, first throw switch #1 (Fig. 9), wait 30 seconds, then throw switch #2. This allows time for the *Hytron* tube filaments to warm up. On the first trial, connect a 0-500 *ma* d-c milliammeter from the center tap of the filament transformer to ground as shown in Fig. 9. Current reading on this meter should be 325-375 *ma* max. or something is wrong. Recheck wiring and make sure primary coil leads are connected right.

Let's get on with the experiments. With the coil operating properly, you should be getting a brush discharge from the top end of the coil about 4 in. high (Fig. 1). A spectacular sight is the rotating wire experiment which takes on added tempo with this more powerful coil. Use a 12-in. length of .006-.008-in. *Nichrome* wire shaped according to Fig. 11A. Fig. 3 shows the result of a very energetic whirling







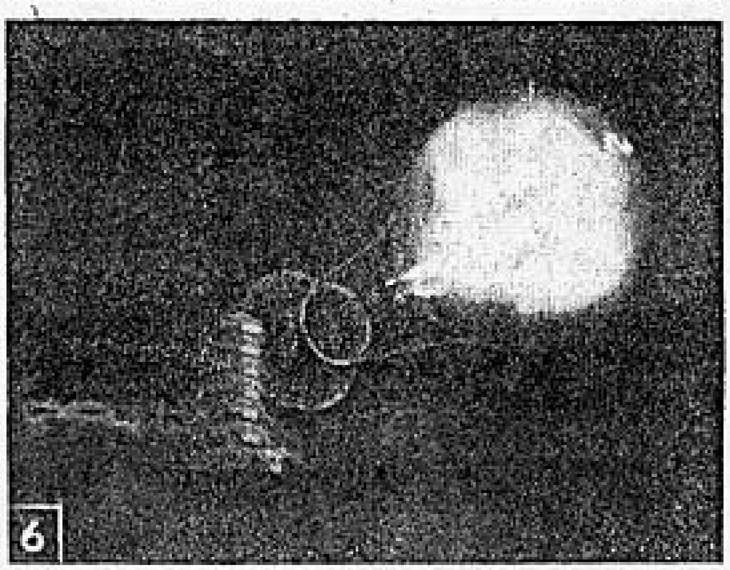


Fig. 3. Whirling wire showers brilliant lavender sparks from white-hot tips of Nichrome wire.

Fig. 4. Variety pattern from whirling wires and lavender sparks.

Fig. 5. Electrical fireworks from pinwheel propelled by sparking discharge from wire tips.

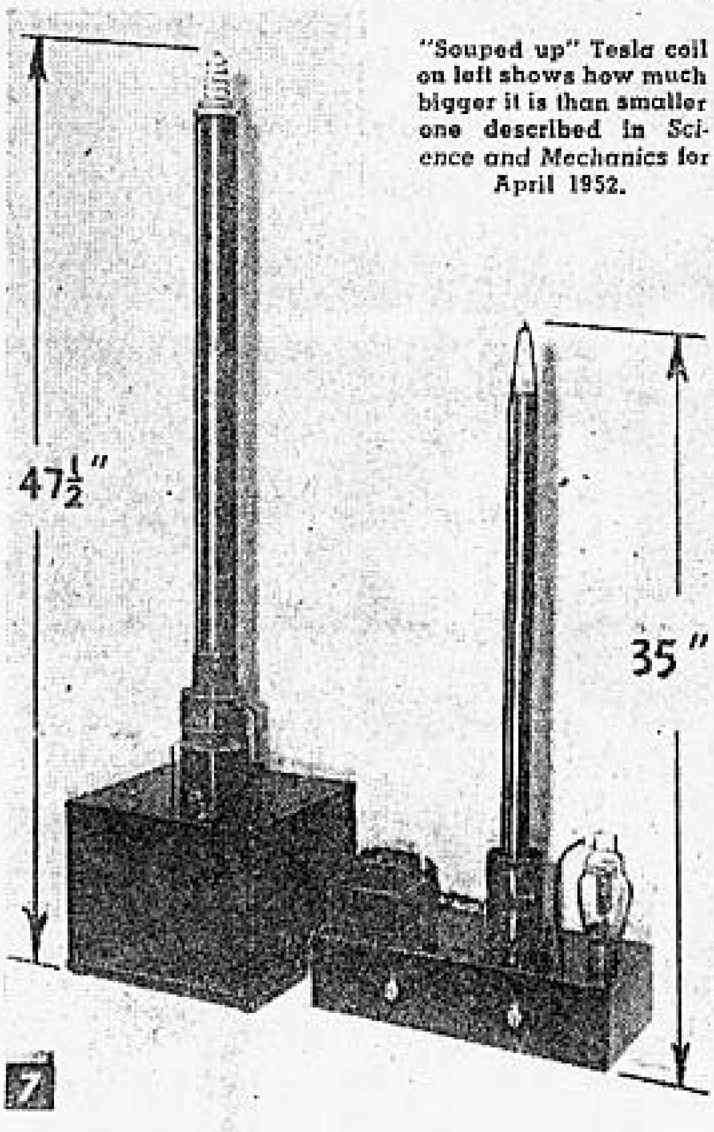
Fig. 6. Bulb in socket fastened to top of coil with stiff wire blossoms with wavering rose flames inside while supports are bright purple.

of the wire ends with bright lavender streamers coming out all along the wire and rotating in almost perfect 6-in. circles.

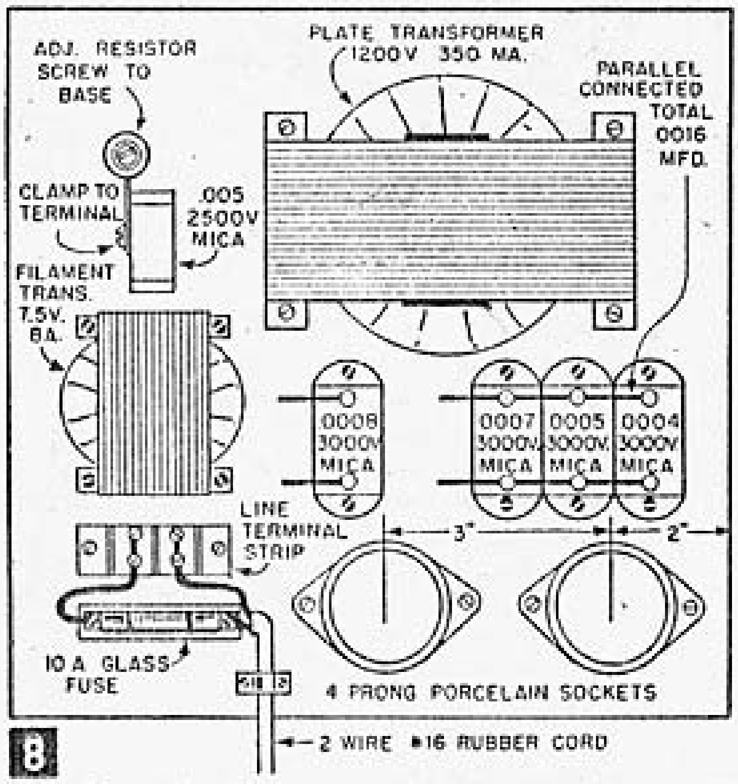
Another rotating wire effect (Fig. 4) can be obtained by shaping the wires as shown in Fig. 11B with the ends pointing up.

A real rotating pinwheel is a new experiment possible with the added power of this coil Make the wire and pivot according to Fig. 12. When you throw the switch, vivid lavender discharges at the ends of the wire vane exert thrust and start the wire to rotating. It soon builds up to a fairly high speed and forms a ring of lavender fire with bursting discharges (Fig. 5).

The lamp experiment (Fig. 6) which could be performed with the first coil is even better with more power. Attach a short piece of stiff wire to one terminal of a porcelain lamp receptacle with exposed screw terminals. Form a loop in the free end of the wire and fasten it to the top end of the coil with a ¼-20 nut (Fig. 6). The other terminal of the receptacle is not used. Screw in a 200-watt clear lamp and throw the switch. Beautiful rose colored wavering flames seem to



"Souped up" Tesla coil on left shows how much bigger it is than smaller one described in *Science and Mechanics* for April 1952.

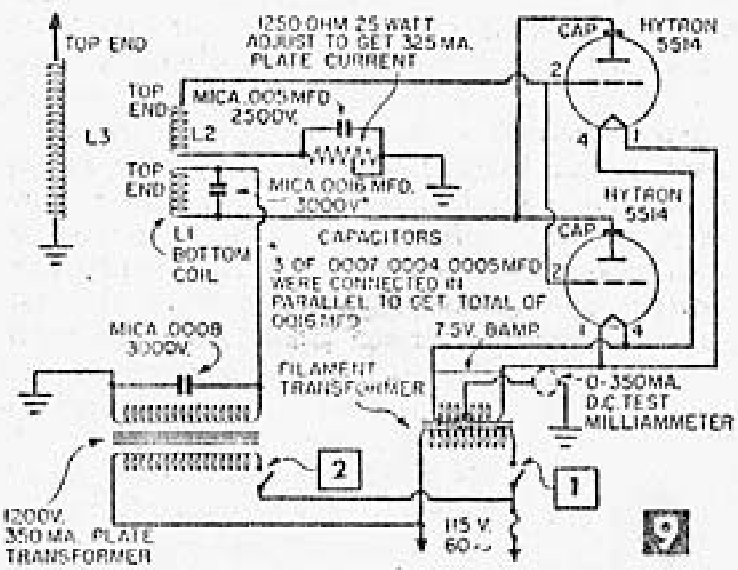


8

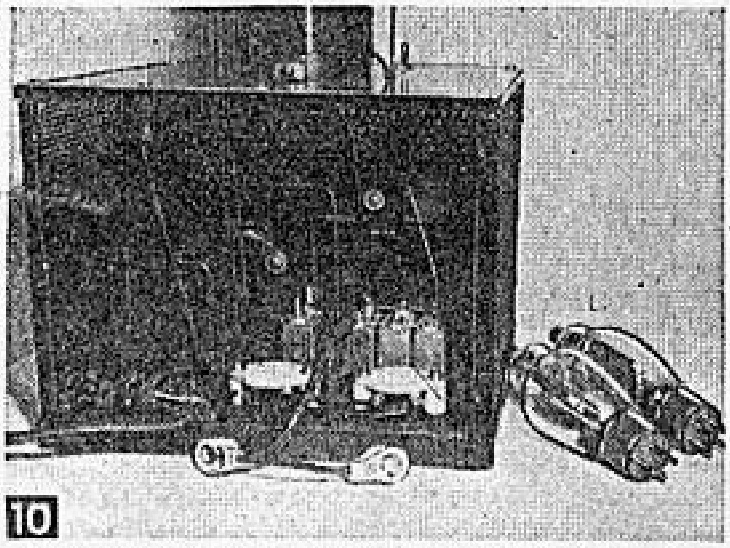
float from the filament to the glass. The main wires supporting the filament are lighted in lavender for a colorful contrast.

To prove the high-frequency current actually passes through glass, hold a small screwdriver, with a well insulated plastic handle and touch the end of the blade to the bulb. The flames inside will reach toward this point of external contact. If the screwdriver is drawn slightly away from the glass, short sparks will jump to the end of the blade. The current actually finds a path to ground through the glass bulb, screwdriver and your body. Fig. 6 shows the flames, but it would take color to do the sight justice.

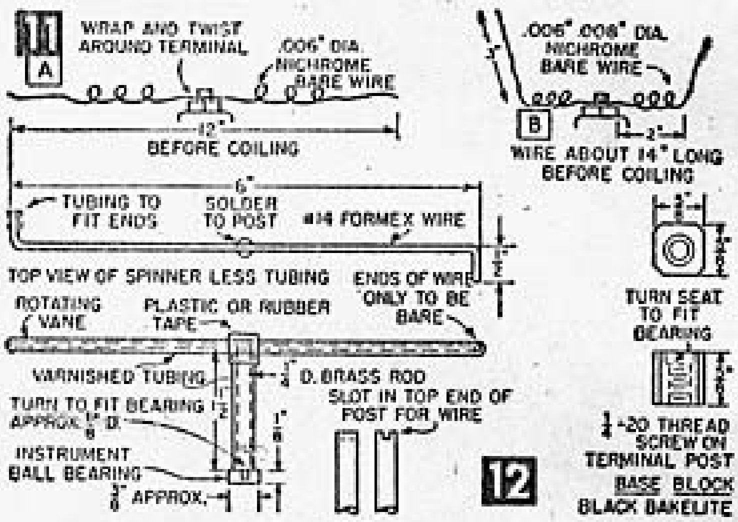
An experiment that will mystify your friends is the remote lighting of a fluorescent lamp, like the 32-watt *Circline* type shown in Fig. 1. First, place the Tesla coil on the floor in an adjoining room, but near the wall. Throw the switch for the usual brush discharge and then close the door. In the room away from the coil but near the wall, sit down and prepare to read in a dim light. To get more light, simply pick up the fluorescent lamp in your hand and hold it near the wall and there you have it—electric light without wires! Tesla first dreamed of radiating energy to light entire buildings in this manner, but the scheme would be inefficient, not to mention radio and TV interference.



9


10

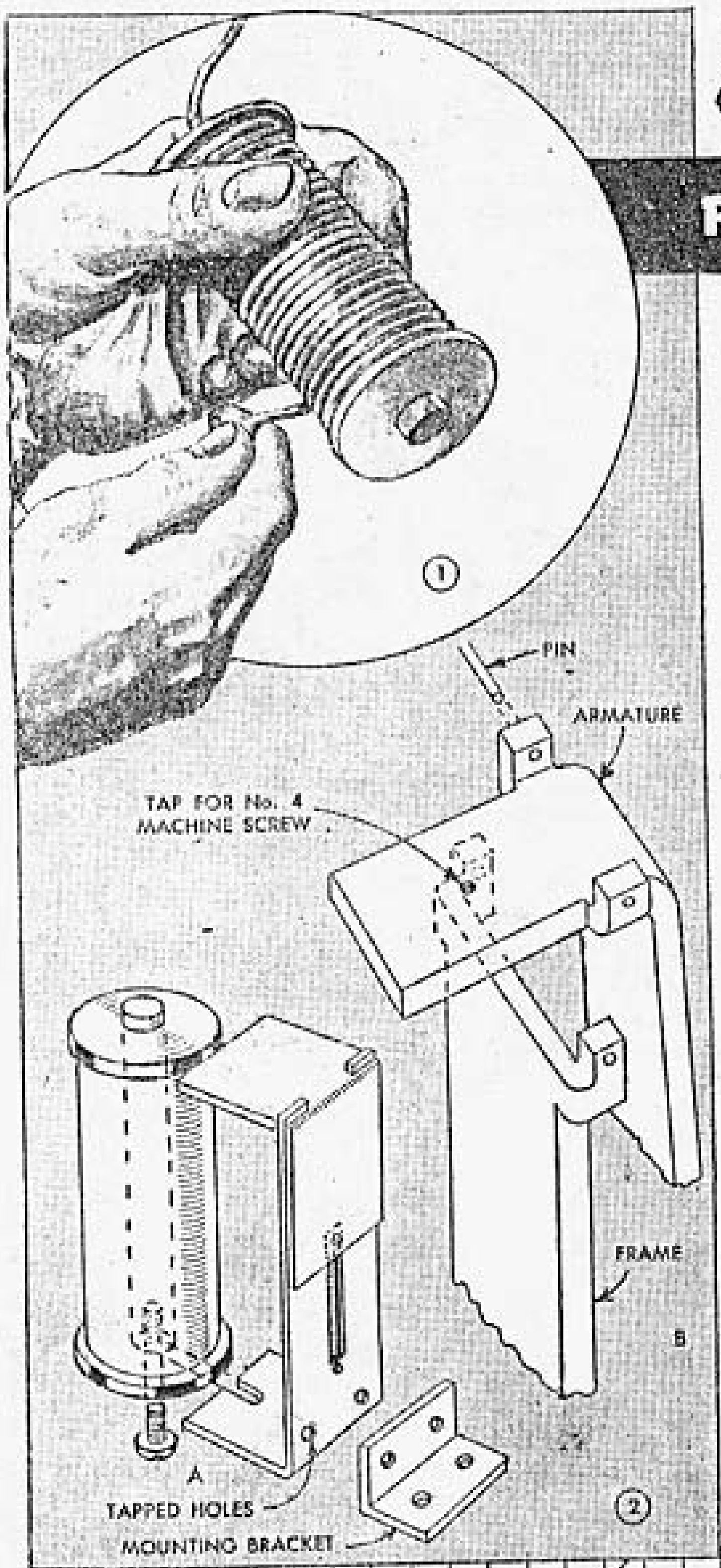
Back of base box with Hytron tubes removed. Note how tube sockets are mounted on porcelain spacers. All wiring is covered with varnished tubing.



12

The high frequency radiating from the Tesla coil lights the lamp several feet from the wall, but with diminished light as it gets farther away. Interference from the coil can be picked up on radios and television sets all over the neighborhood, so be considerate of your neighbors and do your experimenting early in the morning or when they might not be listening or viewing their favorite programs.

Radiating energy through the wall shows how hard it is to confine this high-frequency energy. Therefore, cover all parts of any metal used with enamel, lacquer, shellac or varnish except where actual discharge is wanted. Varnished tubing is another good insulating material. None of these insulators actually confines the energy, but they do help and keep visible discharges to points not covered. *Nichrome* wire resists the heat generated at the end of the wires, so use it instead of copper, which burns away and often throws hot metal from pinwheels. END



Build Your

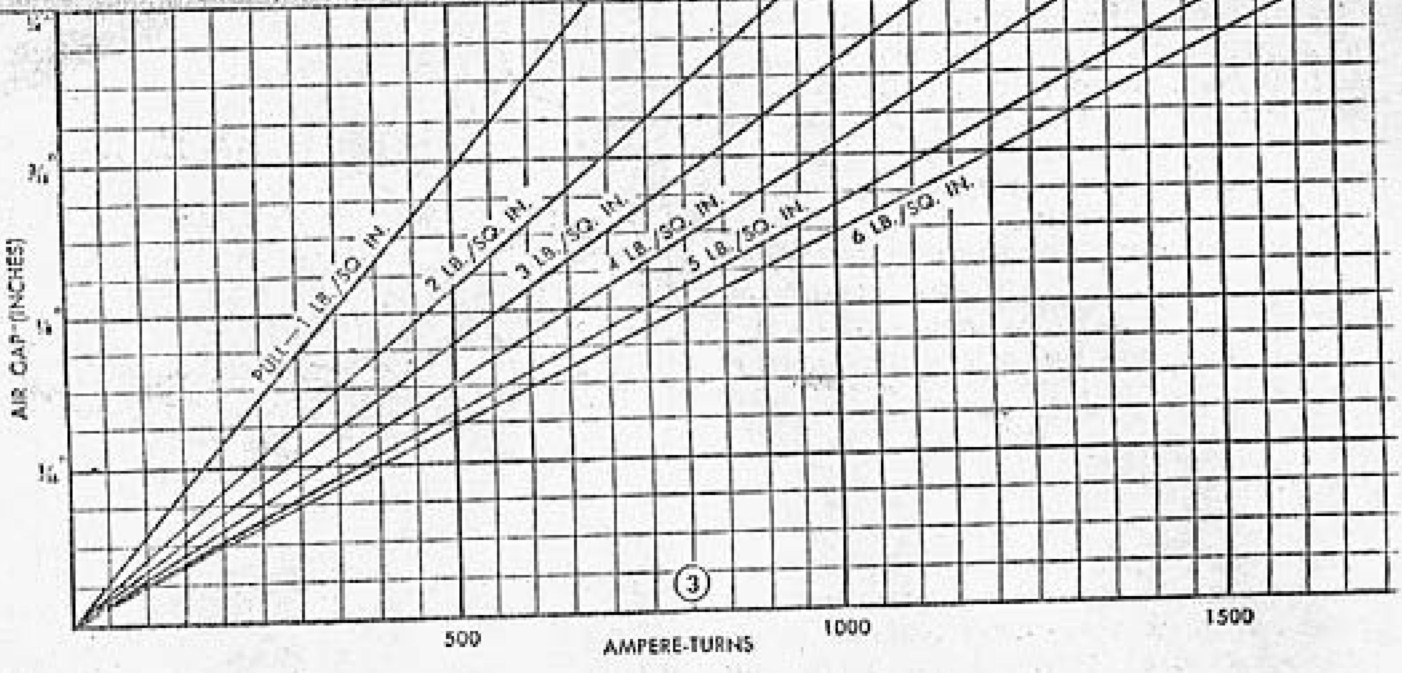
PART 1 - D. C. RELAYS

POPULAR MECHANICS, 1948

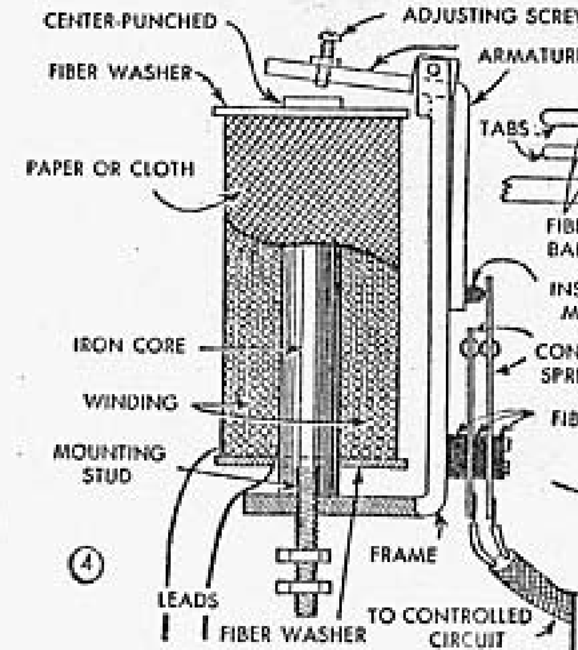
By C. A. Crowley

A RELAY is a simple device for controlling one electrical circuit by means of another. A low-voltage current flowing through the coil of a relay energizes it and causes movement of the relay armature, which, in turn, opens or closes one or more circuits to be controlled. Relays are important in places where a controlling device such as a home or office thermostat, a photoelectric cell, a burglar alarm, a fire alarm or other equipment is used, that can stand only a small current, but which must control a heavy current such as that required by a heater or motor. Relays also can be used to control shop motors remotely at a number of locations with ordinary push buttons.

It will be seen from Fig. 4 that the relay consists of a core, a coil wound on the core a frame or "heel" piece, an armature and an arm on the armature which moves the contact springs. In some designs there are additional springs as in Fig. 6, A, where the moving contact is placed directly on the armature, while in Fig. 6, B, as well as in other designs shown, the fixed and moving contacts are insulated from the frame and the moving contact is operated by a fiber "button" mounted on the armature. This form of construction generally is preferable to grounding the moving contact to the frame and armature. In any case, the contact springs must be insulate



Own RELAYS



④

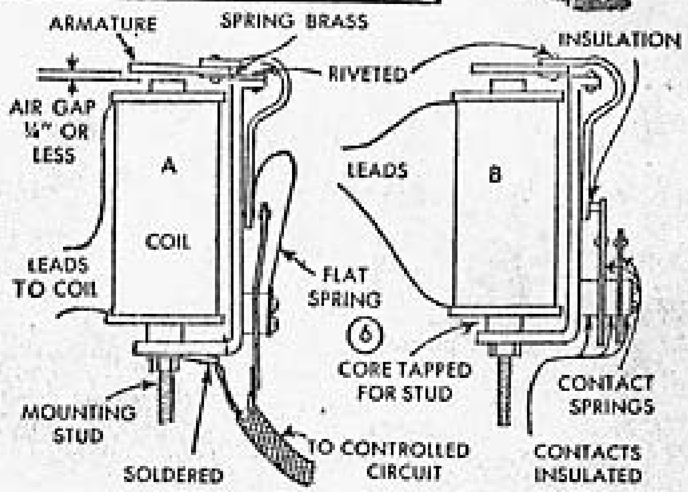
⑤ TOTAL PULL FOR VARIOUS SIZES OF MAGNET CORES						
Diameter of Core	Lb. Pull Per Sq. In. of Core Area					
	1	2	3	4	5	6
¼"	.05	.10	.15	.20	.25	.30
⅜"	.11	.22	.33	.44	.55	.66
½"	.20	.39	.59	.78	.98	1.17
⅝"	.31	.61	.92	1.22	1.53	1.84

carefully and completely from each other as shown in the detail Fig. 4.

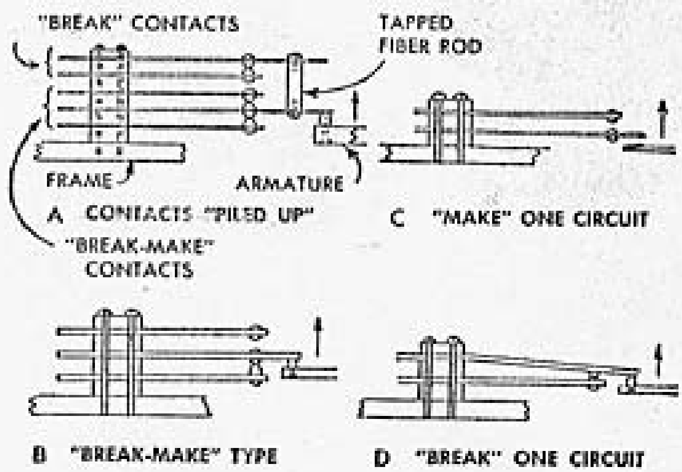
When deciding upon the type to use for a given purpose the following generalizations will be helpful: Heavy contact springs to handle large currents — use designs shown in Fig. 2, B, and Fig. 4; light contact springs to handle medium or small currents — use design shown in Fig. 6, B; simple two-contact relays for low voltages—use design shown in Fig. 6, A, and for sensitive relays to operate on very small currents such as those available from photoelectric cells, radio tubes, etc., use design shown in Fig. 2, A.

The frame and armature should be formed from ⅛-in. soft flat iron, which should be about the same width as the diameter of the coil to be wound. Contact springs are made from nickel silver or spring brass, and contact units may be assembled as in Fig. 7, details B, C and D. Two or more spring units also can be operated by one armature, either "piled up" as shown in Fig. 7, A, or side by side as in Fig. 9. Contact points for light and medium currents can be made from silver wire, forced into a hole drilled in the spring and then riveted down as in Fig. 8. For heavier currents, silver rivets or tungsten contacts of the type shown in Fig. 8 should be used. The arm which opens and closes the contact springs must be an integral part of the armature or must be rigidly attached to it. It also should be insulated from the contact springs as in Fig. 11.

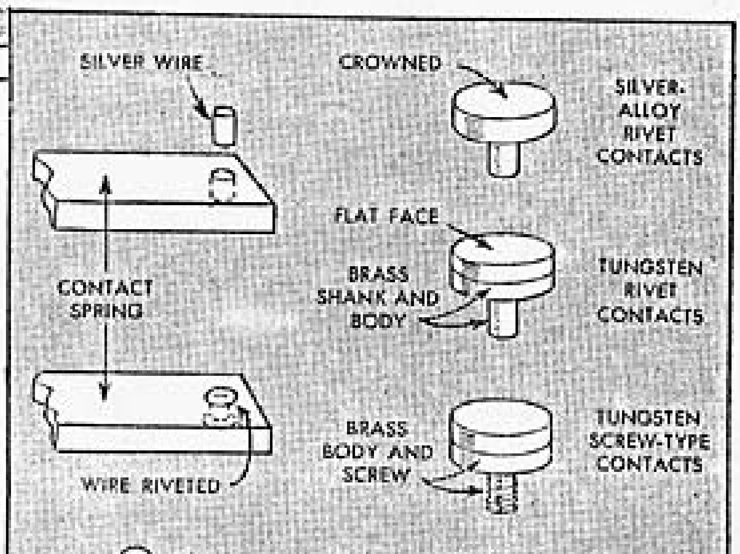
Having determined the general design characteristics the next step is to calculate the coil size and winding data. The gov-



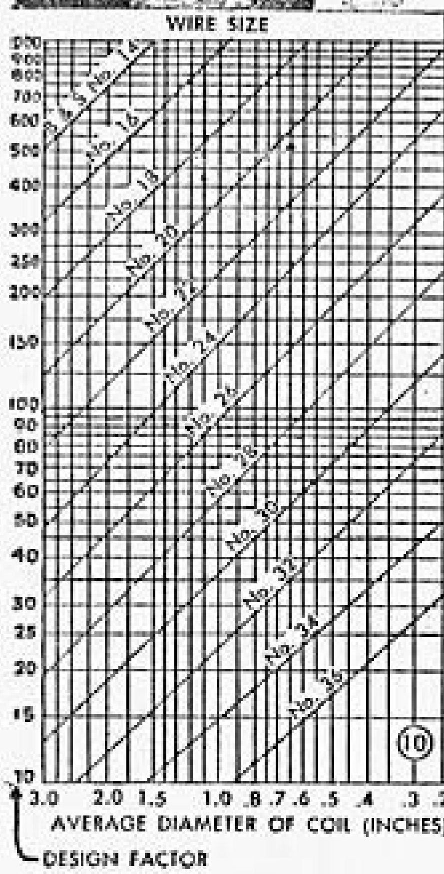
⑥



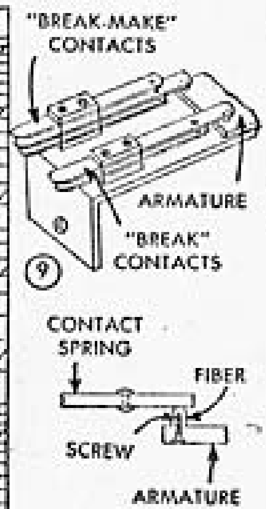
⑦



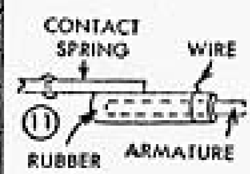
(8) METHODS OF MAKING CONTACTS



(10)



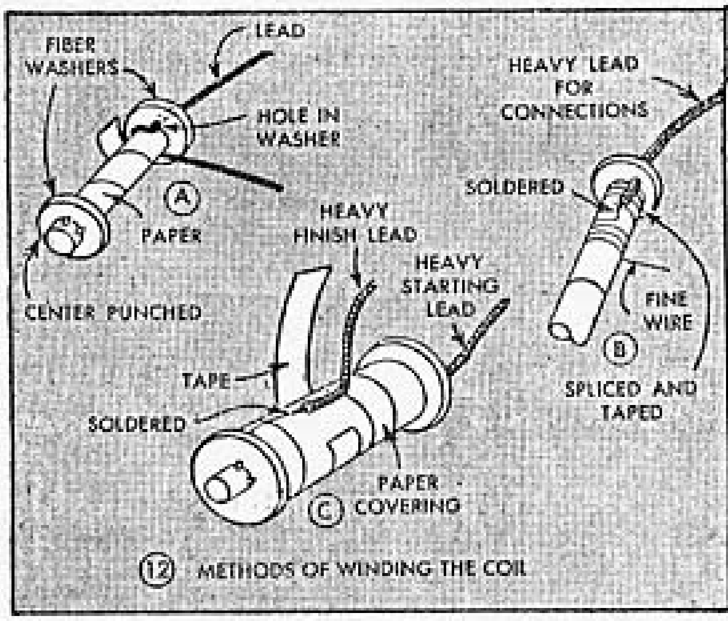
(9)



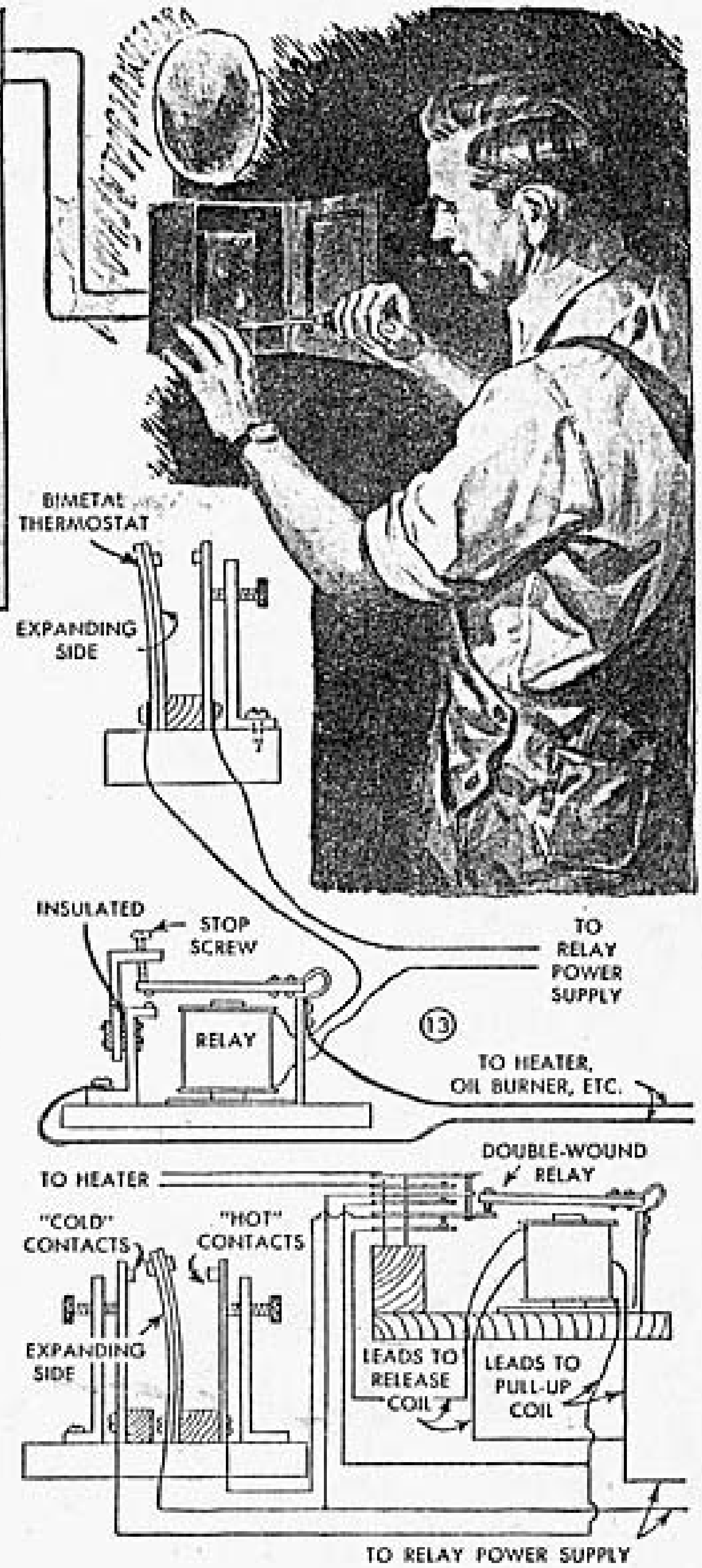
(11)

erning characteristic is the pull required of the magnet which will operate the relay. This, in turn, depends on the tension of the springs which hold the armature and contacts in their normal positions. Tension on an average contact spring should not exceed 1 oz., or .0625 lb., and may be less with very light springs. For a greater number of contact springs operated by one armature, or if an auxiliary spring is used, the pull required will be correspondingly greater. After estimating the pull required, the next step is to determine the core size. The core required will range from ¼ to ½ in. in diameter for most relays. For ordinary purposes a ¼-in. diameter core will be ample. However, for larger or heavy-duty relays, a heavier core may be more desirable. Refer to Fig. 5, from which it will be easy to calculate the pull required per sq. in. of core area, that is, the cross-sectional area of the core. As an example, suppose it is desired to construct a relay to operate three light springs. The pull required would be .0625 by 3 or .1875 lb. Now, referring to the table it will be seen that a ¼-in.-diameter core wound to give a pull of 4 lbs. per sq. in. of magnet surface will pull .2 lb., or a little more than the requirement. However, as indicated in Fig. 5, a ⅜-in. core wound for a pull of 2 lbs. per sq. in. or a ½-in. core wound for a pull of 1 lb. per sq. in. would also meet the need. Since it is desirable to use the smallest practical core diameter, the ¼-in. core is selected. However, for low-voltage relays it is sometimes desirable to use a larger core to reduce the current required.

Next step is to determine the number of ampere-turns required to give the desired pull. This depends on the air gap, or space between the end of the core and the armature when the relay is in the open position. See Fig. 6, A. This gap should be not more than ¼ in. and preferably should be less. In highly sensitive relays the allowable gap usually is between 1/32 and 1/16 in. For purposes of illustration use an air gap of ⅛ in. Referring to Fig. 3, find the air gap, ⅛ in., along the left-hand edge of the chart, then read straight across to the line marked with the required pull per sq. in. Then read down to the bottom where the number of ampere-turns required will be found, in this example approximately 660. Thickness of the coil should roughly equal the diameter of the magnet core, in this case approximately ¼ in., making the overall diameter of the coil ¾ in. Length of the coil proper should be about 1½ in., which is the length of the winding space. The core



(12) METHODS OF WINDING THE COIL



must be somewhat longer to allow for thickness of the insulating washers. However, these dimensions are not critical. The coil can be made longer or thicker.

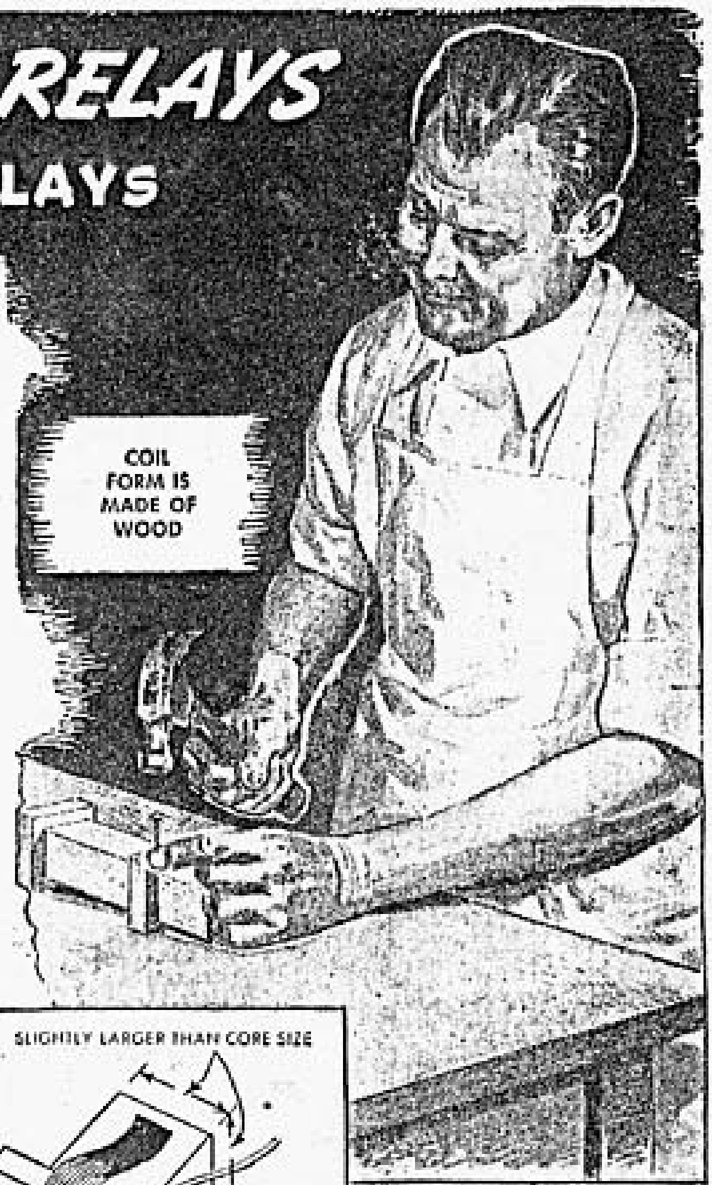
The wire size for the coil is determined by the operating voltage. As an example assume that the relay is for an alarm system which will be operated on four No. 6 dry cells in series, giving a total of 6 volts. The "design factor" for a d.c. relay is found by dividing the ampere-turns by the voltage, that is, 660 ampere-turns divided by 6, or 110. Next determine the average diameter of the coil by adding the diameter of the core to the outside diameter of the coil and dividing by 2. From this it will be found that the average diameter of a coil ¾ in. outside diameter, wound on a ¼-in. core, is 0.5 in. Now, with the aid of the chart, Fig. 10, find the design factor, 110, along the left-hand margin. Next, find the average diameter of the coil, 0.5 in., along the bottom. Finally, read straight across from the left and straight up to the intersection of the two lines. This intersection is nearest the line marked "No. 28 B & S," which is the size of wire required.

With these calculations completed you're ready to wind the coil after the manner shown in Fig. 1. First, cut the core 1¾ in. long and fit a fiber insulating washer at each end with a space of 1½ in. between. Washers should be a tight fit and slightly larger than the outside diameter of the finished coil. Wrap the core with several turns of brown paper and coat with shellac. Start the winding as in Fig. 12, A and B, which suggest two methods of anchoring the starting end of the wire. Each two or three layers of winding should be wrapped with thin paper and coated with shellac. In winding d.c. relays it is not necessary to count the turns of wire but care should be taken to wind evenly so that the space will be filled uniformly. When the coil is finished it should be wrapped with paper or varnished cloth. If wound with fine wire, heavier leads should be soldered on and taped securely as in Fig. 12, B and C. The coil then can be mounted in the frame in the manner indicated in Fig. 4.

Contact springs should be fastened rigidly to the frame and fully insulated from it with fiber, bakelite or a similar insulating material, as in Fig. 4. Usually it will be found that the greatest sensitivity is secured when this adjusting screw just barely extends below the lower face of the armature. Provide a lock nut so that the screw can be held in the proper position. Fig. 13 details the connections for two practical applications of relay-controlled circuits.

Build Your Own RELAYS

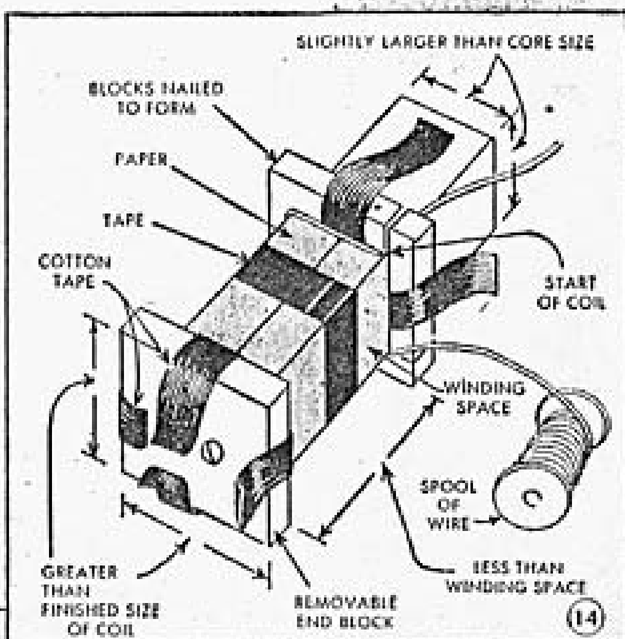
PART 2-A. C. RELAYS

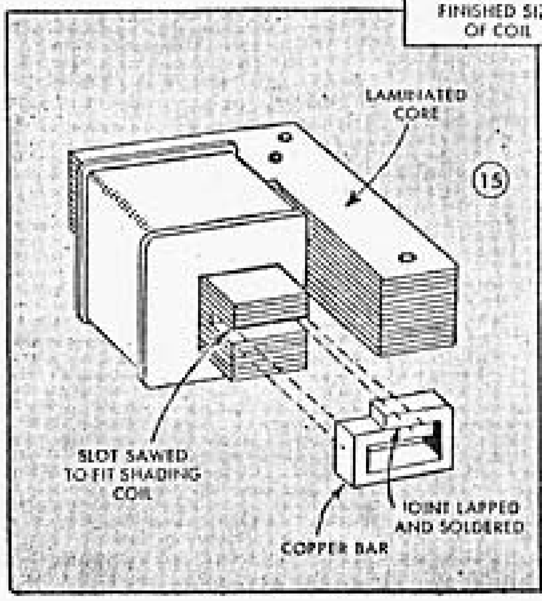


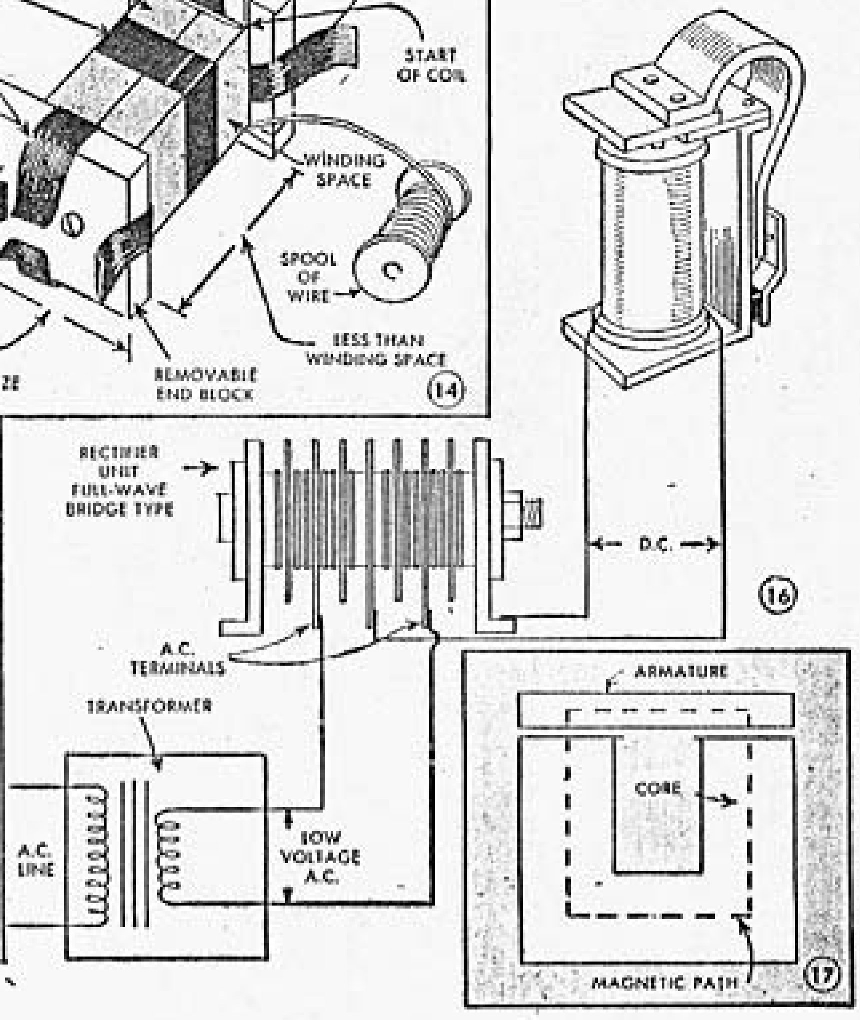
By C. A. Crowley

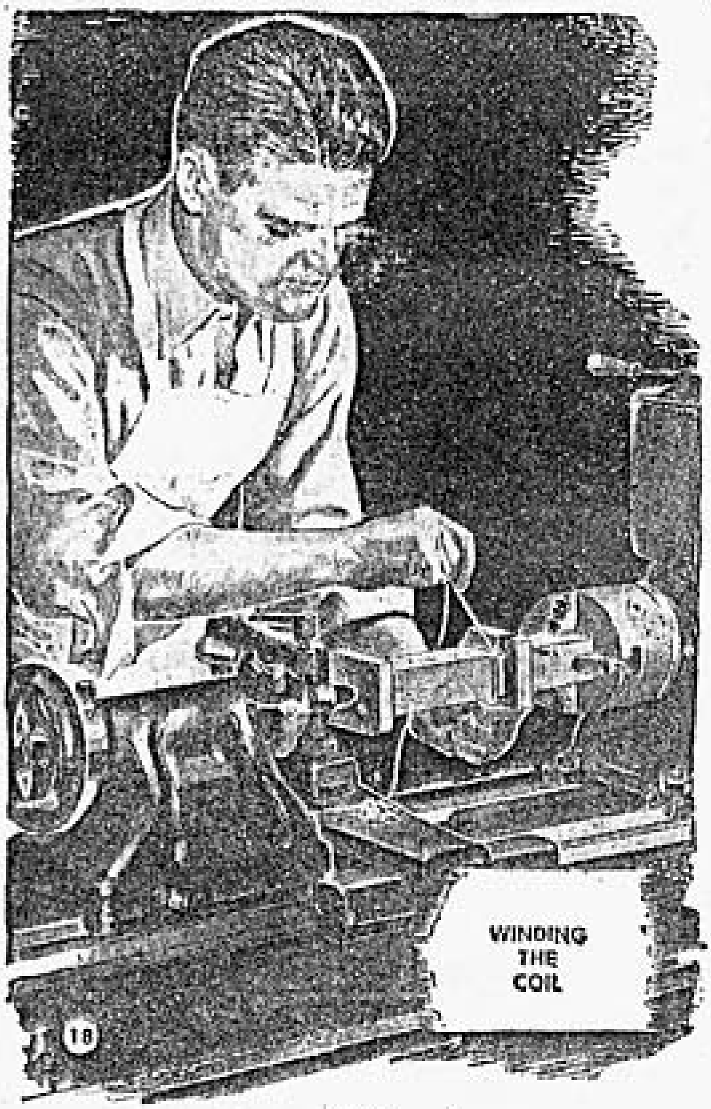
RELAYS made according to instructions given in Part I will not operate satisfactorily on alternating current. However, with minor changes in design, they can be made to operate on a.c. if they are connected in series with a dry-disk rectifier, as shown in Fig. 16. In such cases, the relay must not be operated at a.c. voltages higher than the rating of the rectifier used. Since that is usually less than the line voltage, the relay must be operated with low voltage from a transformer. The type of connection shown in Fig. 16, having a full-wave bridge type of rectifier, should be used. To design a relay to operate on rectified a.c., it is necessary to calculate the pull and ampere turns as for a d.c. magnet. Then divide the ampere turns by the a.c. voltage and multiply by 1.35 to get the design factor. This design factor can be used in the same way as for a d.c. relay to determine the wire size from the chart, Fig. 21. The coil then can be wound as described in Part I.

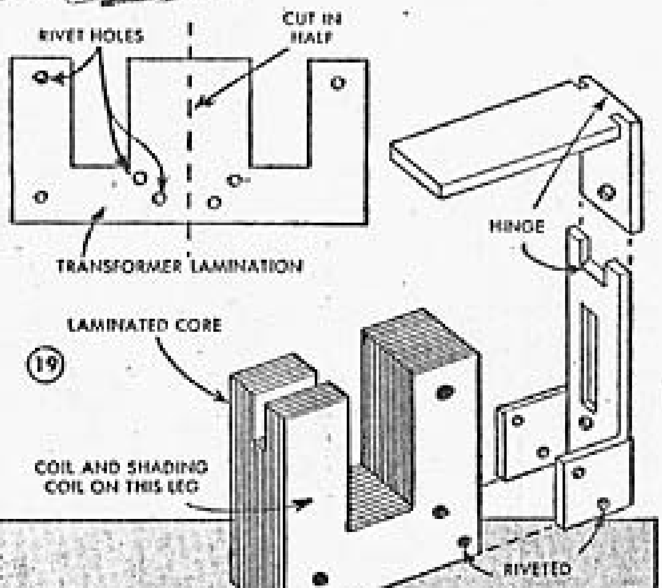
If the relay is to be operated continuously, frequently, or on a voltage of more than 25, it is best to use a coil wound on a laminated core. A

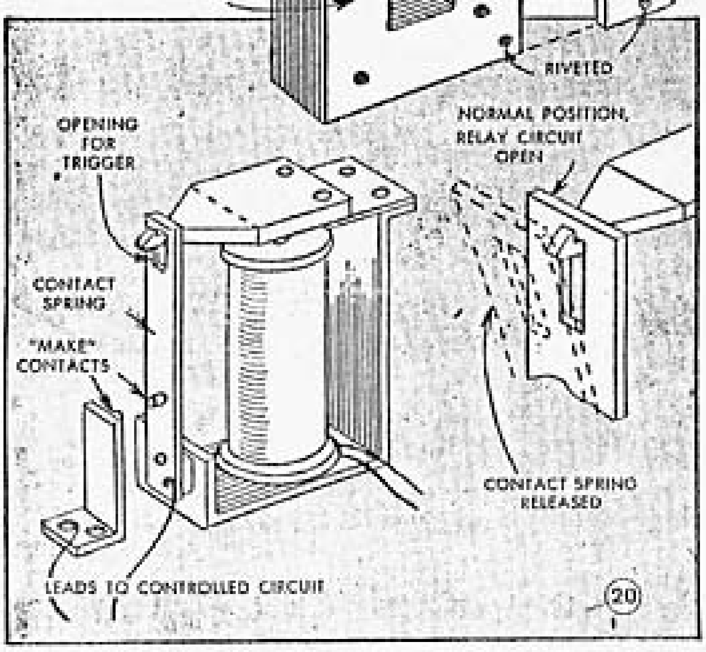












laminated core taken from an old radio transformer will be suitable but will require some alteration. The laminations can be sawed in half as in Fig. 19 to make a U-shaped core. The number of turns required to wind the coil for 60-cycle current can be found by multiplying the voltage by 4.7 and dividing by the winding-core area. For example, if the core is ½ in. thick and ½ in. wide, the core area is 0.25 sq. in., and to operate the relay on 110 volts a.c. will require 110 multiplied by 4.7 divided by 0.25 or 2070 turns.

On 25-cycle current, the number of turns is equal to 11.3 times the voltage, divided by the winding-core area. The wire size can be calculated by measuring the magnetic path, indicated in Fig. 17, dividing by the number of turns and multiplying by 50,000. This gives the required wire size in circular mils. Assuming that the magnetic path measures 4.25 in., the wire size required is 4.25 divided by 2070 multiplied by 50,000, or 103 circular mils. The corresponding gauge number can be found by referring to the chart, Fig. 21. Here you can see that the closest size to 103 circular mils is No. 30 wire, which has a cross-sectional area of 101 circular mils. Using this wire size, which is only a little smaller than the calculated size, will slightly reduce the pull of the relay and also will reduce its operating temperature. Since a slight reduction in pull will be satisfactory in this case, the relay can be wound with No. 30 wire. If the next larger size of wire above the calculated value is used, the pull of the relay will be increased, which is not necessary, and the relay also will heat more, which is undesirable.

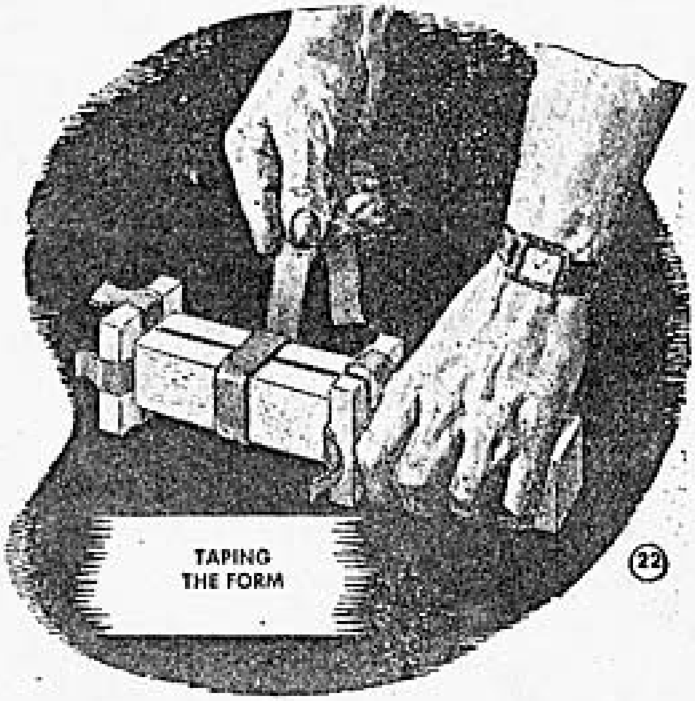
The coil can be wound directly on the core if desired, using essentially the same method as for a d.c. relay coil. However, due to the shape of the laminated core, it will be necessary to wind the coil on the

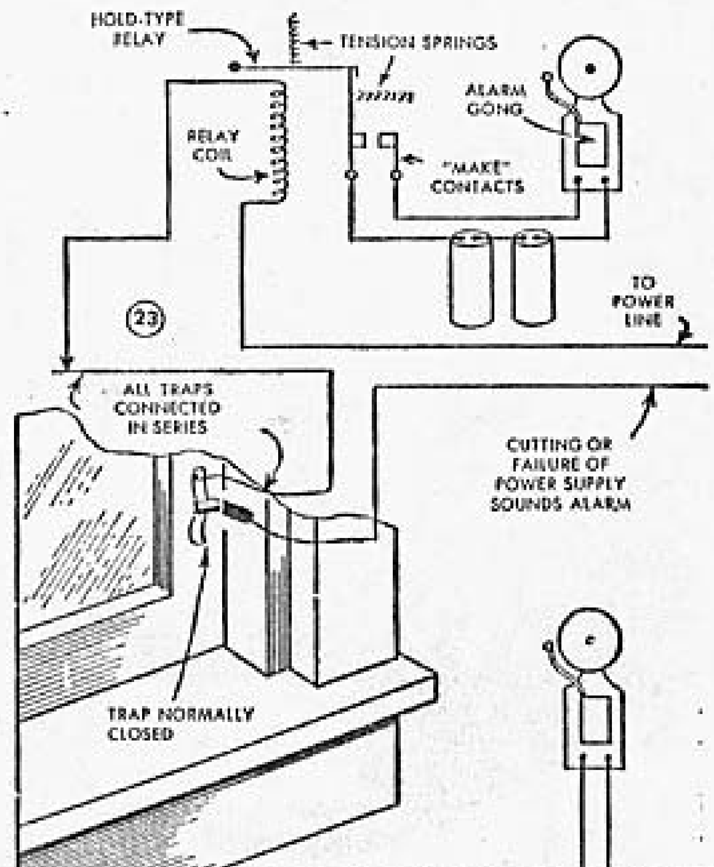
(21) WIRE SIZE AND GAUGE NUMBERS

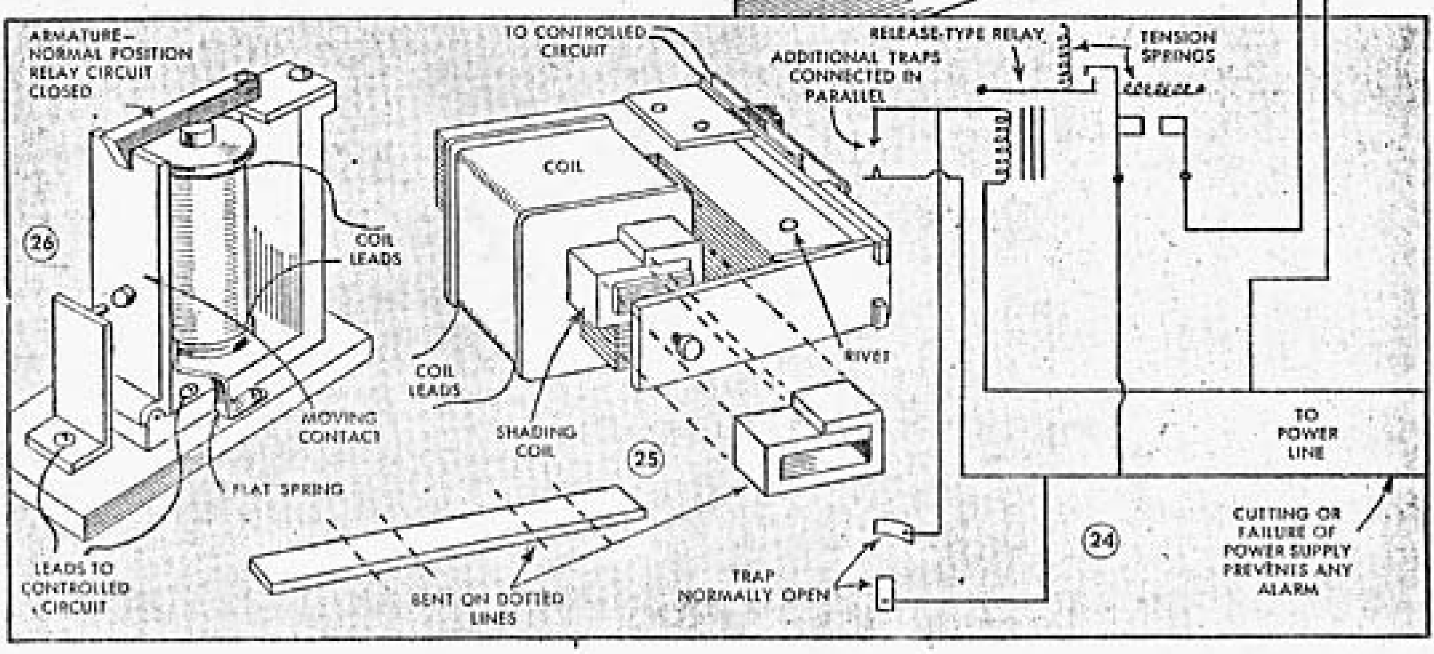
B & S Gauge	Area (Circular Mils)	B & S Gauge	Area (Circular Mils)
10	10380.	24	404.
11	8234.	25	320.
12	6530.	26	254.
13	5178.	27	202.
14	4107.	28	160.
15	3257.	29	127.
16	2583.	30	101.
17	2048.	31	80.
18	1624.	32	63.
19	1288.	33	50.
20	1022.	34	40.
21	810.	35	32.
22	642.	36	25.
23	510.		

bottom of the "U." Another method is to wind the coil on a form and then slip it onto one of the arms of the core. In this case, the form should be constructed as shown in Fig. 14, about 1/16 in. larger each way than the core on which the coil will be fitted, and with the winding space between the end blocks slightly shorter than the space for the coil on the relay core. The form should be long enough to be held in the hand, Fig. 22, or in a lathe, Fig. 18, while winding. Small blocks are nailed to the form at the proper place, leaving a slight space between two of the blocks for the start end of the coil. The end block is attached with screws for easy removal, and the form is tapered slightly toward that end so that the finished coil can be slipped off the form without binding. Four pieces of plain cotton tape then are placed lengthwise in the winding space, and a strip of brown paper is wrapped two or three times around the form, Fig. 14. It is held in place by a band of friction tape. The coil is wound to the required number of turns in tight, even layers. After each layer of windings is finished, a layer of brown paper should be wrapped around the coil as additional insulation, Fig. 27. If space is lacking, use a layer of brown paper over every second or third layer of wire. When the required number of turns has been wound, the ends of the cotton tape are brought together over the coil and tied tightly. After removing the end block from the form, the coil can be slipped off and placed in correct position on the core.

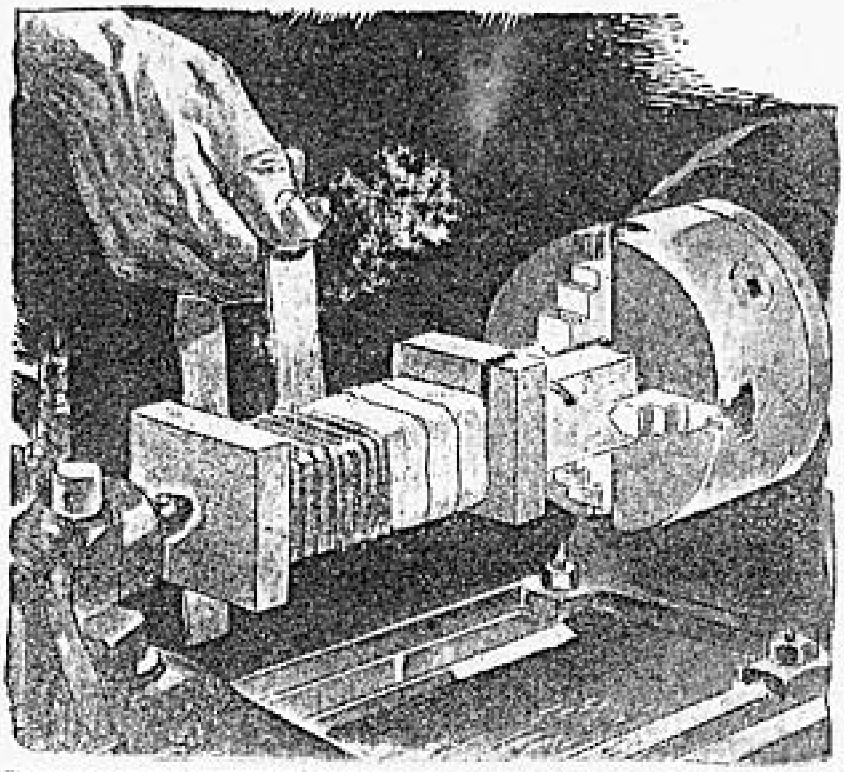
The shading coil, shown in Figs. 15 and 24, is very important, as without this an a.c. relay will hum. The shading coil can be installed by sawing a slot in one of the poles of the magnet, Fig. 30, and inserting a flat copper bar. This is looped around the laminations, Fig. 25, and the ends of the bar are lapped and soldered together. Un-



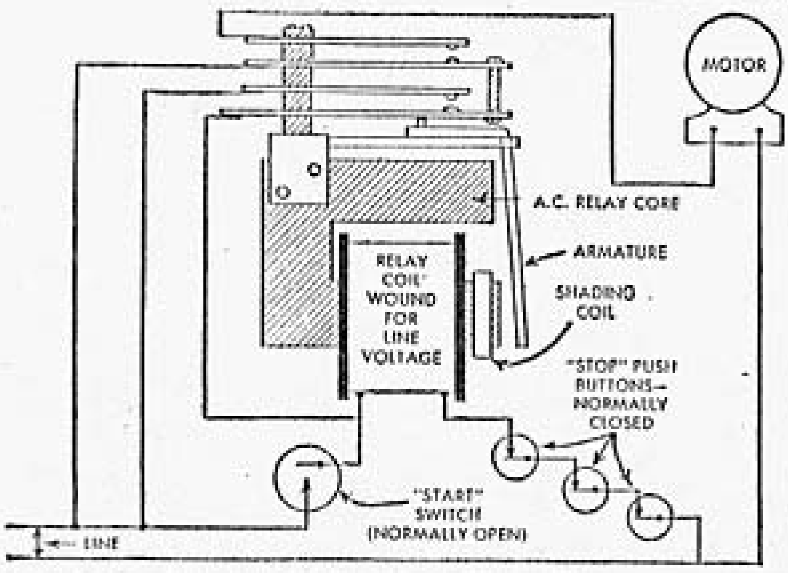




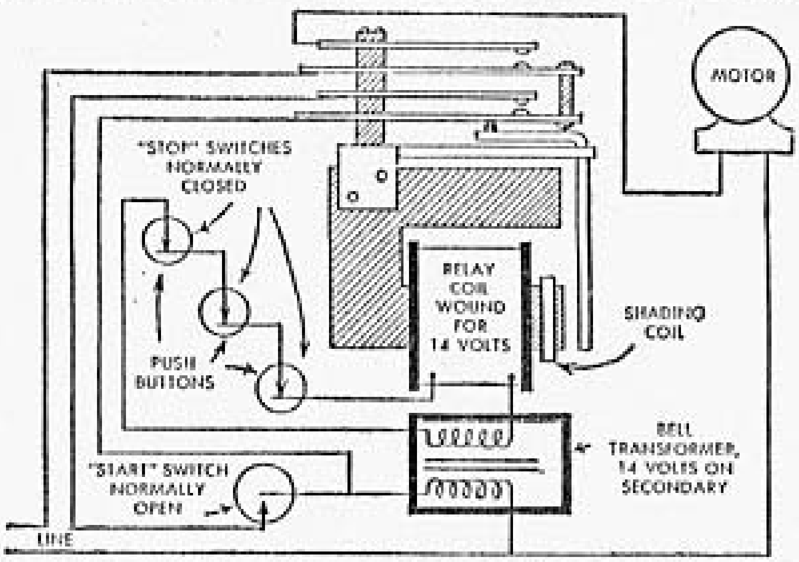
 GRANDDAD'S ELCTRICITY BOOK



(27) EACH LAYER OF WINDING WRAPPED WITH BROWN PAPER



(28) SAFETY MOTOR RELAY



(29) LOW-VOLTAGE MOTOR RELAY

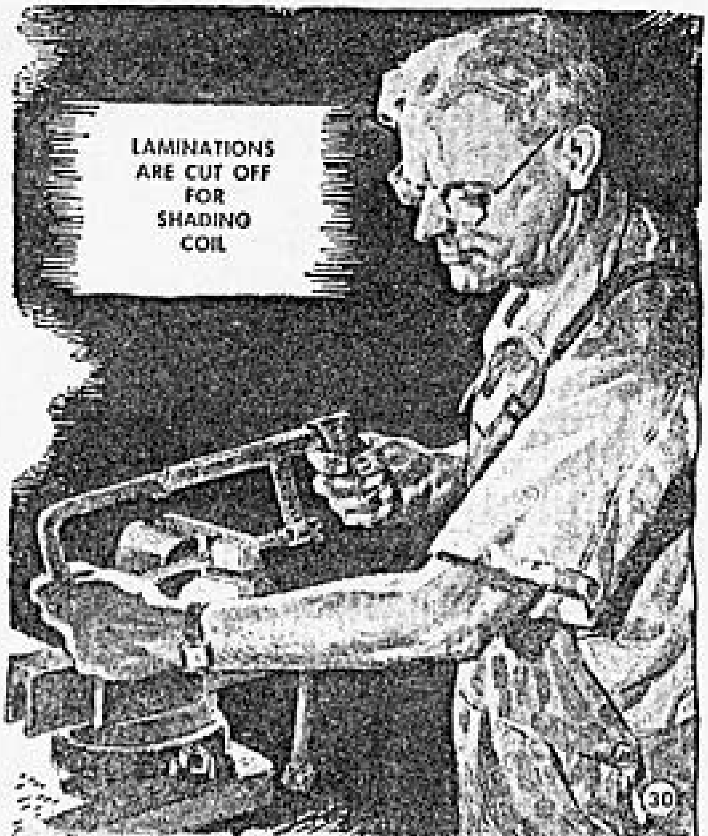
less the joint is lapped and soldered, the shading coil will not perform its function properly.

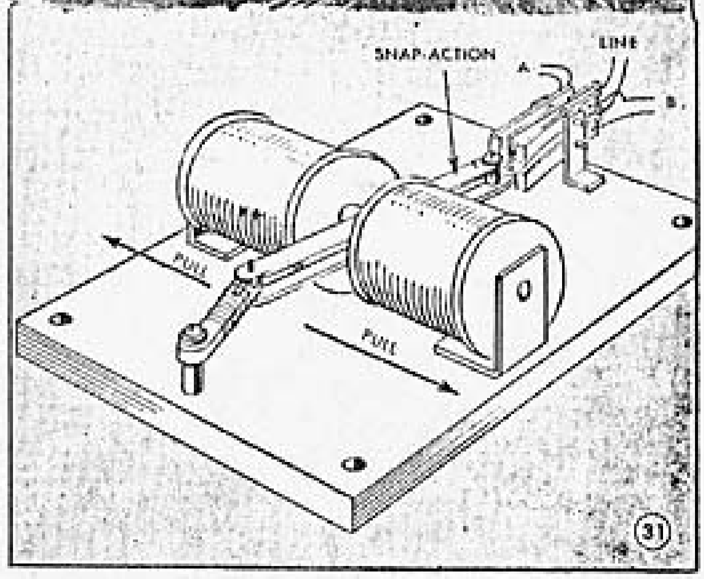
The armature of the relay can consist of a piece of flat iron of suitable dimensions, hinged as shown in Fig. 19 or in some other convenient way. Other methods of armature attachment were given in Part I. The armature can be used to operate spring contacts in the same way as shown for d.c. relays in Part I. A.c. relays offer the advantage of convenience of power supply and, if properly designed and built, can be made to operate satisfactorily.

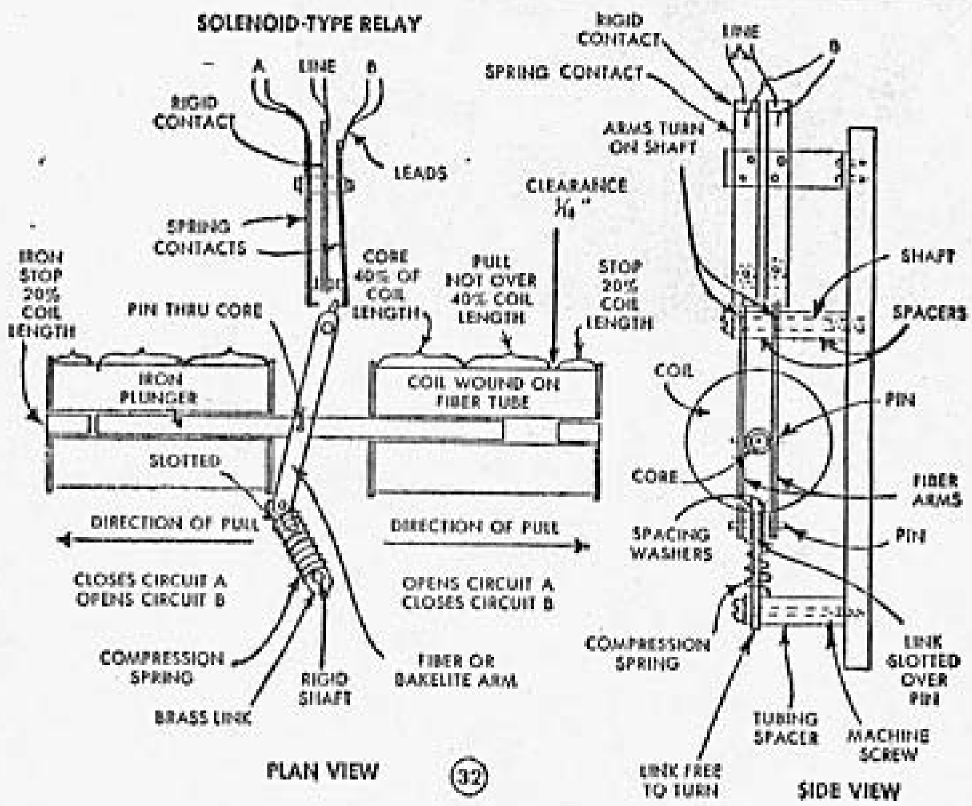
Numerous special types of relays will be found valuable in a number of applications. The "release" type relay shown in Figs. 20 and 24 can be adapted to alarm systems and the like. The advantage of relays of this type is that they do not require any power except when the traps are sprung. When the armature is pulled down, it releases the spring arm which closes the circuit and sounds the alarm. Once started, the alarm will continue to sound until the relay is reset by hand. The "hold" type relay shown in Figs. 23 and 26 is similar in action except that the contact spring is held as long as the relay current flows. The contact spring is released whenever the relay current is interrupted, and remains in that position until reset by hand. This type can be applied advantageously to burglar-alarm systems, as in Fig. 23, and has the advantage that cutting the power supply to the relay will sound the alarm. By use of fusible strips of metal foil in the circuit, the "hold" type relay also can be used for fire alarms. Although these types of relays generally are designed for d.c. current they can be operated on a.c. with dry-disk rectifiers, or if desired can be designed for a.c., using a laminated core as described.

Figs. 28 and 29 show two systems for control of motors which add to shop safety. The system shown in Fig. 28 uses an a.c. relay, operated directly off the line, to control the motor. Pushing the "start" button, which is a normally open push button, operates the relay and starts the motor. The second pair of contacts on the relay energizes the coil and holds the relay in closed position. The "stop" push buttons, which are normally closed push buttons connected in series with the relay as shown, should be placed in convenient locations near every machine operated by the motor and convenient to every operator. Double-contact push buttons can be used for the stop switches if only the top contacts are used. Pushing any one of the stop switches disengages the relay and stops the motor. The motor then can be restarted only from the main control station where the start switch is installed. If the stop button is blocked down, it is impossible for any worker in the shop to restart the machine until the block is removed. This is very important when a repair is being made to a saw, press or other machine which might cause a serious accident if it were started while repair work was being done on it. The system shown in Fig. 29 accomplishes the same result; however, the relay and stop buttons are operated on low voltage and therefore the control wiring can be installed with ordinary bell wire, without using conduits or fittings required with 110-volt installations.

Another very useful type of relay is that shown in Figs. 31 and 32. This consists of a pair of solenoids, with the plunger operating a toggle switch. The coils are best wound on a fiber or bakelite thin-walled tube, with washers of the same material at the ends. The coil dimensions are calculated just as for an ordinary d.c. relay. The contacts can be arranged in any desired way, using single or double-throw and single or multiple-pole arrangement. It is important to adjust the length of the fixed and moving cores as designated in the plan-view, Fig. 32. The solenoid-type relay can be used to stop and start a motor with push buttons, and has the advantage that current need not flow through the relay except during stop and start operations. Those uses of relays which have been described thus far doubtless will suggest other applications in which relays of different types can be made to serve a practical purpose in controlling circuits or appliances about the home, office or manufacturing plant. By using these fundamental suggestions it is possible to build much more elaborate control systems than those described.







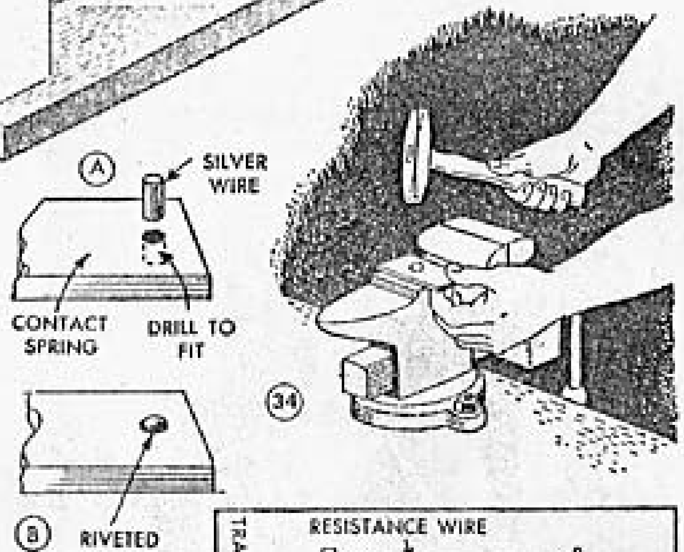
Build Your Own RELAYS

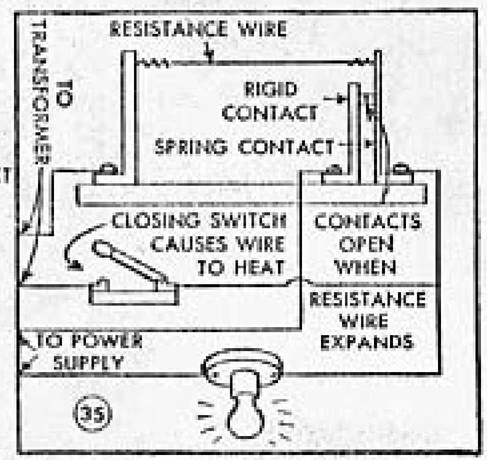
PART 3—THERMAL RELAYS

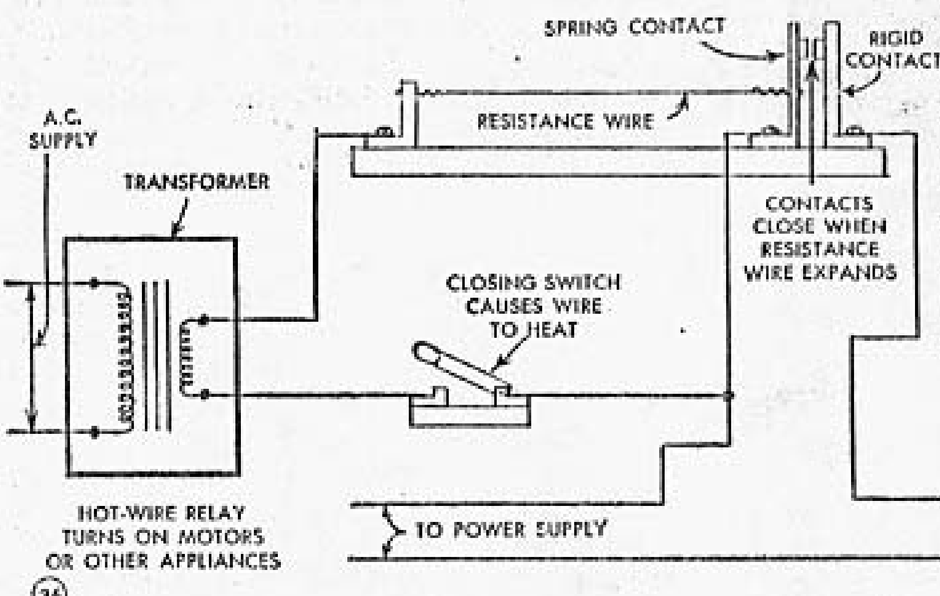
By C. A. Crowley

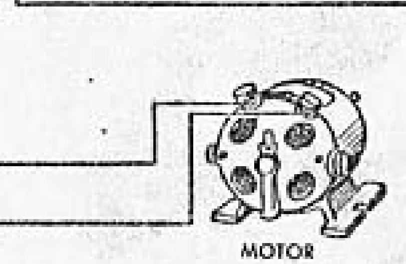
THERE are two principal types of thermal relays; the hot-wire type, Figs. 35 and 36, and the thermostatic or bimetal type, Fig. 44. The hot-wire relay consists of a resistance wire held under tension by a contact spring. When current from a battery or low-voltage transformer is passed through the wire it is heated and expands or stretches, permitting the contact to close or to open, depending on which type of relay is in use. Thermal relays can be used to control motors, lights, heaters or any other electrical apparatus. It is frequently desirable to insulate the low-voltage controlling circuit, which operates the relay, from the circuit that is to be controlled. A method of insulating the relay circuit from the controlled or operating circuit is shown in Fig. 37, A.

Both the hot-wire and bimetal types are actually delayed-action relays, since the contacts will not close until the wire has had time to heat and expand. The time interval between closing of the relay circuit and operation of the relay can be controlled by adjustment of the gap between the contacts, using a machine screw as in Fig. 37, B. Another method of speeding up the operation of a thermal relay is to slip a length of glass tubing over the resistance wire as in Fig. 40. This will retard heat loss from the wire and cause it to expand more rapidly. However, relays which are speeded in closing by this method will be correspondingly slower to open when the current is shut off. To slow down a hot-wire relay, one can increase the gap be-



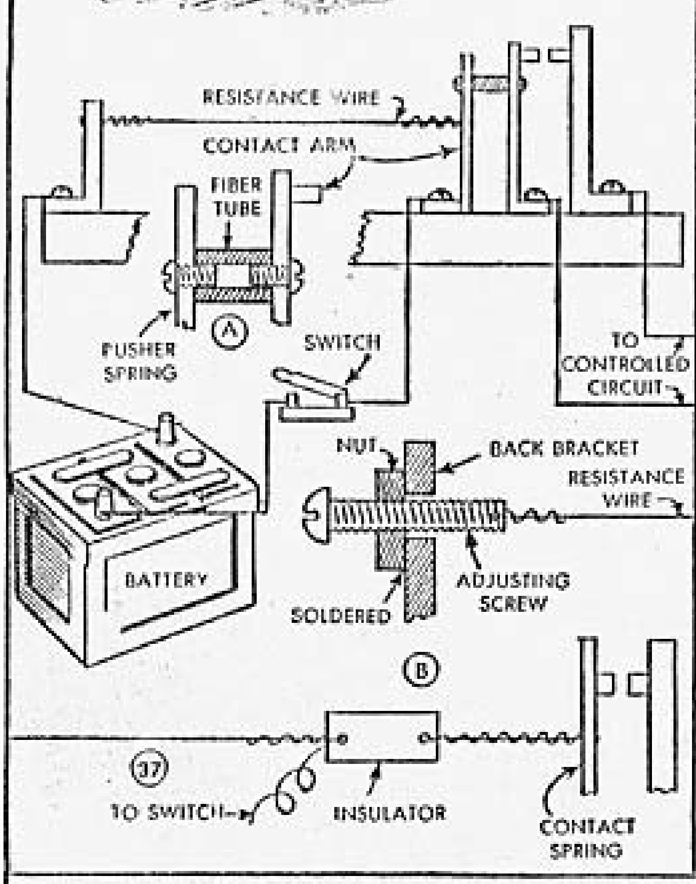






HOT-WIRE RELAY TURNS ON MOTORS OR OTHER APPLIANCES

36



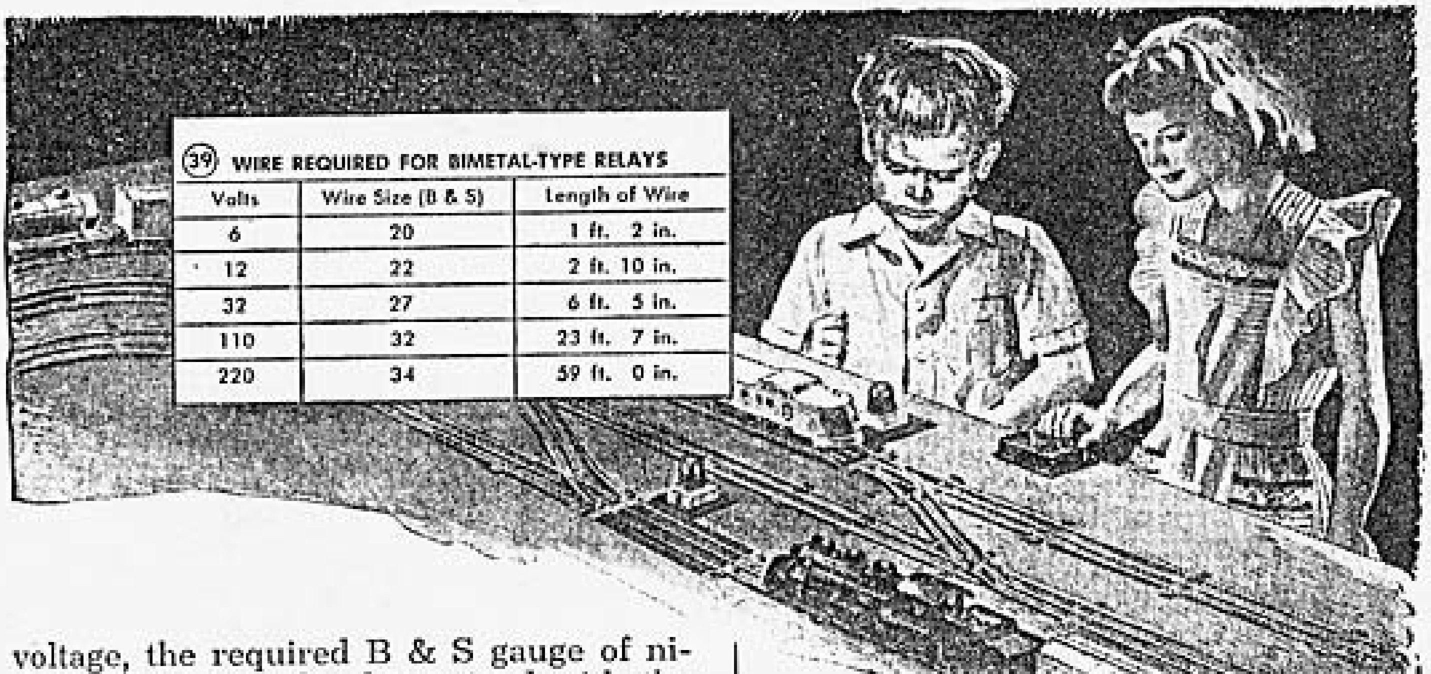
tween the contacts, but if the gap is too great the contacts won't close. Another method is to connect a rheostat in series with a hot wire as in Fig. 43. By increasing the resistance it is possible to increase the time interval to almost any desired extent. Fig. 43 shows how two identical relays can be made to operate consecutively by adjusting the control rheostats to different positions. Details A and B in Fig. 41 show, by comparison, how a short length of wire can be used to give a larger contact movement as indicated by positions L1 and L2. For example, by connecting the wire in the position shown in Fig. 41, B, the wire must expand only 1/32 in. to move the contacts 1/16 in.

The design of hot-wire relays is simple. Where alternating current is available, a low-voltage transformer with an output of 6 to 20 volts is the most convenient source of the relay current. By using low voltage, all relay wiring can be laid with bell wire. If a.c. current is not available, a 6-volt storage battery, Fig. 37, is a good power supply. After selecting the length of wire and the

(38)

DESIGN OF HOT-WIRE RELAYS

Voltage	12" Wire				6" Wire				8" Wire			
	B & S	Ohms	Amps.	Watts	B & S	Ohms	Amps.	Watts	B & S	Ohms	Amps.	Watts
6	20 22	.625 1.017	10 7	75 50	28	2.05	4	25	24	1.29	5	30
8	24 26	1.61 2.57	6 4	60 50	32	5.09	2	25	26 28	2.06 3.28	5 3	40 30
10	26 28	2.57 4.10	5 3	50 40	34	8.2	2	25	28 30	3.28 5.20	4 3	40 30
12	28 30	4.10 6.50	3 2	40 30	34	8.2	2	25	30 32	5.20 8.13	3 2	40 25
14	30 32	6.50 10.17	3 2	40 30					32 34	8.13 13.10	2 2	30 25
16	32 34	10.17 16.4	2 2	30 25					34	13.10	2	25
18	34	16.4	2	30					34	13.10	2	30
20	34	16.4	2	30								

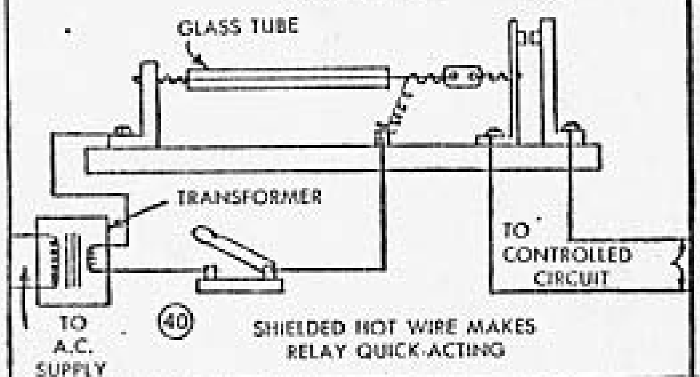


(39) WIRE REQUIRED FOR BIMETAL-TYPE RELAYS

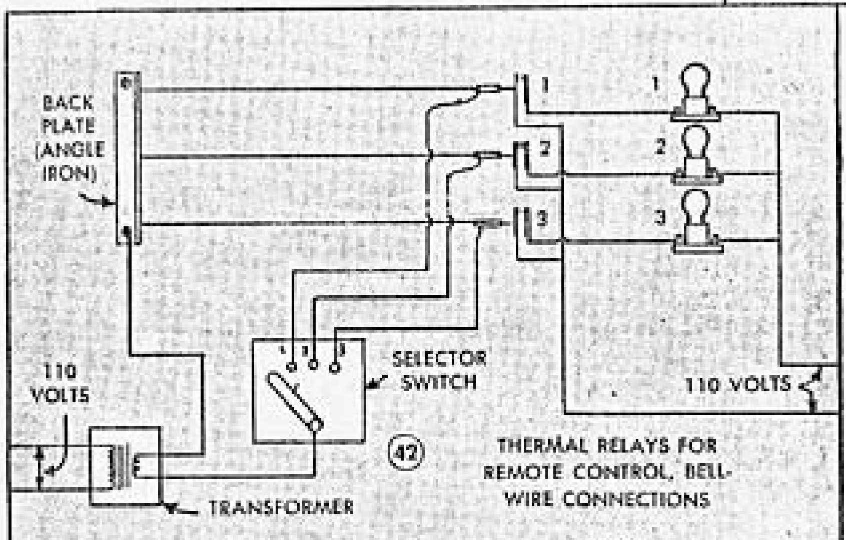
Volts	Wire Size (B & S)	Length of Wire
6	20	1 ft. 2 in.
12	22	2 ft. 10 in.
32	27	6 ft. 5 in.
110	32	23 ft. 7 in.
220	34	59 ft. 0 in.

voltage, the required B & S gauge of nichrome wire can be determined with the aid of the table in Fig. 38. For example, if the wire is to be 8 in. long and operated at 14 volts, No. 32 or 34 wire can be used. The smaller wire will operate at higher temperature and give faster operation. Increasing the voltage with a given size of wire will increase the speed of action. The contacts should be capable of carrying the currents required. Silver contacts can be made as shown in Fig. 34, A and B.

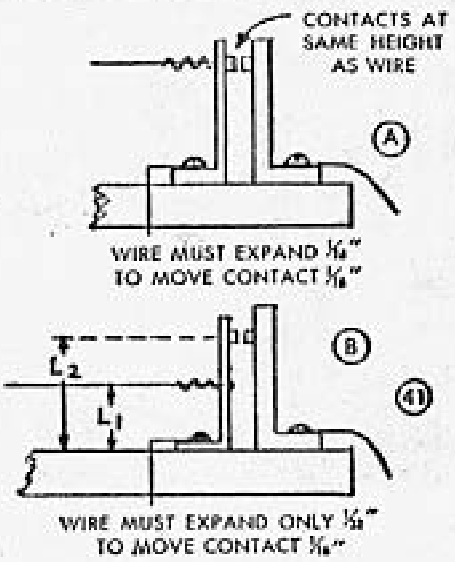
Hot-wire relays can be used in place of



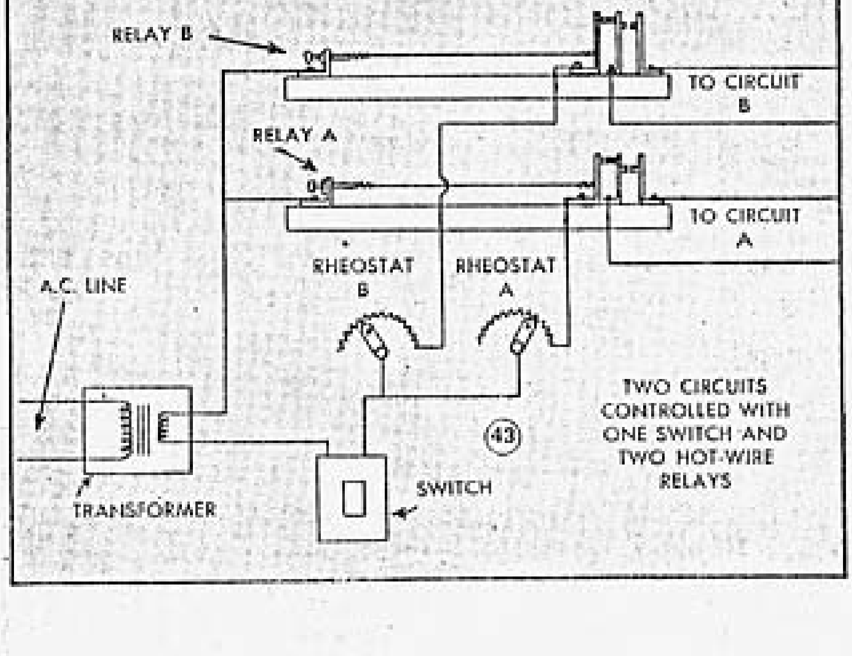
(40) SHIELDED HOT WIRE MAKES RELAY QUICK-ACTING



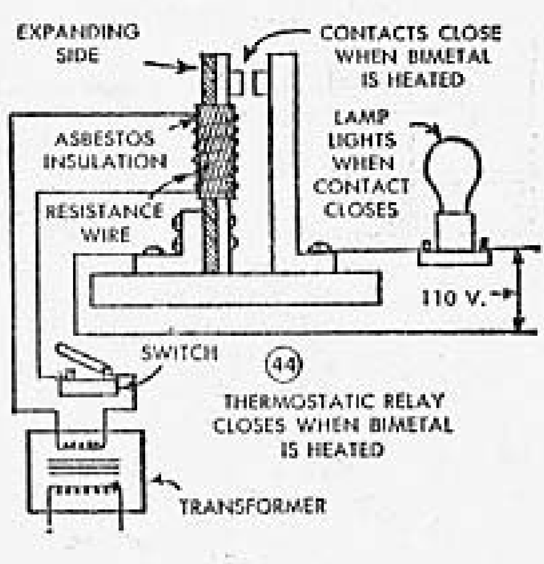
(42) THERMAL RELAYS FOR REMOTE CONTROL, BELL-WIRE CONNECTIONS



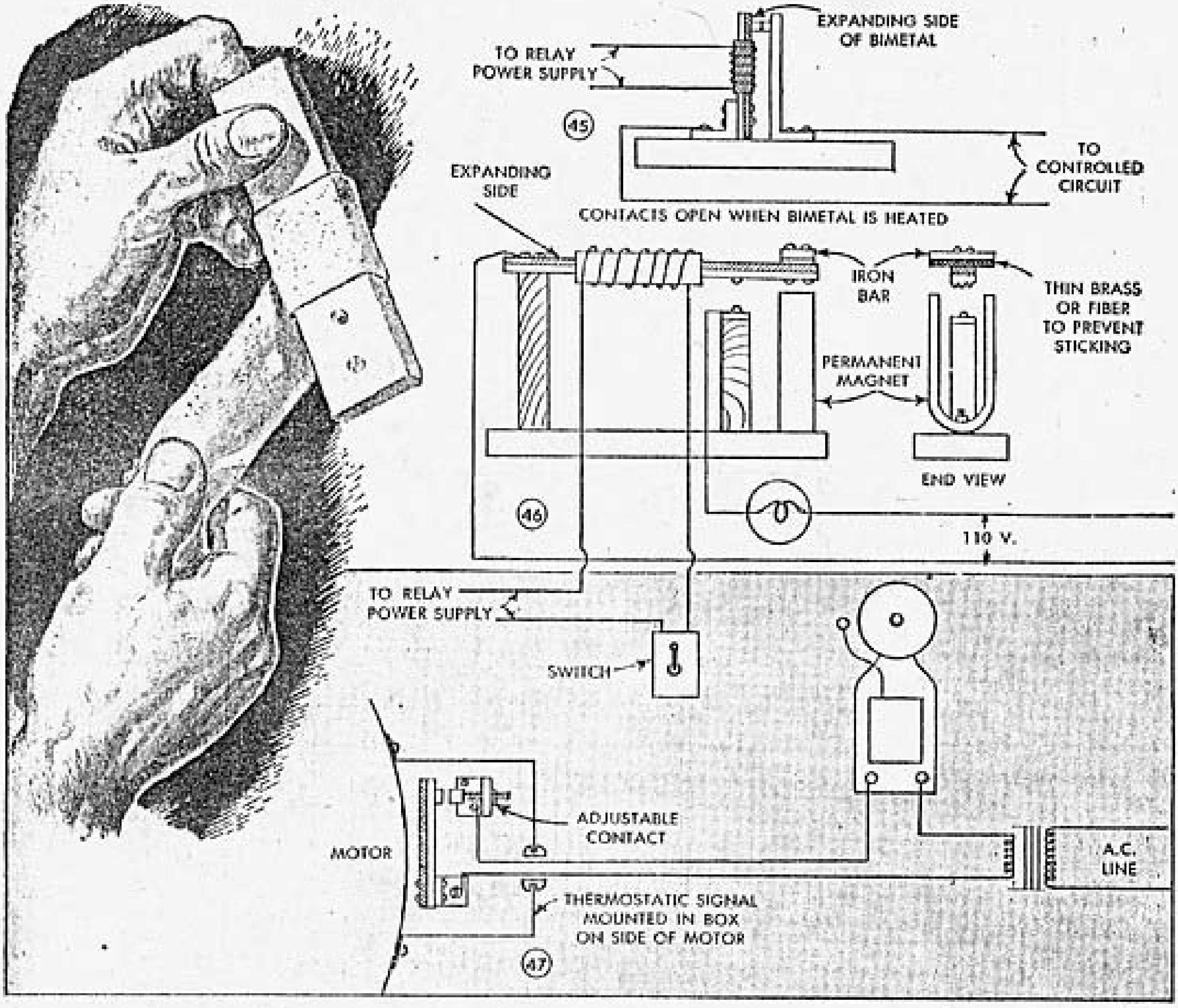
(41)



(43) TWO CIRCUITS CONTROLLED WITH ONE SWITCH AND TWO HOT-WIRE RELAYS



(44) THERMOSTATIC RELAY CLOSES WHEN BIMETAL IS HEATED

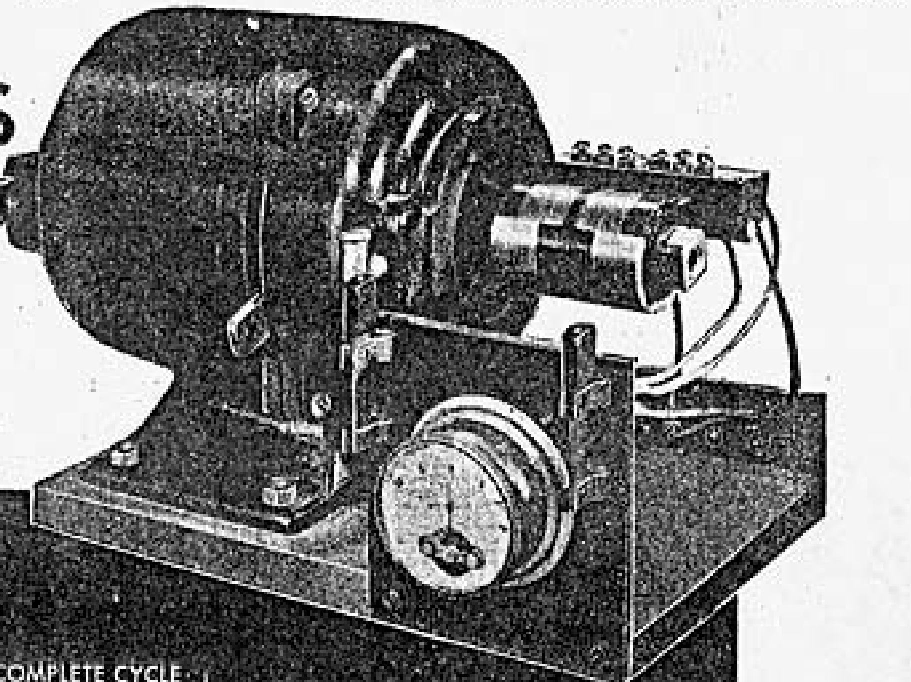


magnetic relays in most cases except on emergency controls where rapid action is essential or where heavy sparking will occur when contact is broken. In Fig. 42 a group of thermal relays is used for remote control of a group of lamps. By setting the selector switch any one of the remote circuits can be controlled and time delay can be made short or long. In Fig. 43 two motors are controlled by one switch, but can be made to go on at any desired time interval after throwing the switch by adjusting the rheostat controls. The delayed action hot-wire relay also can be used to ring a bell if a door is left open for an appreciable period of time, Fig. 33. Normal use of the door will not cause annoying ringing, but warning will be given if the door is left ajar.

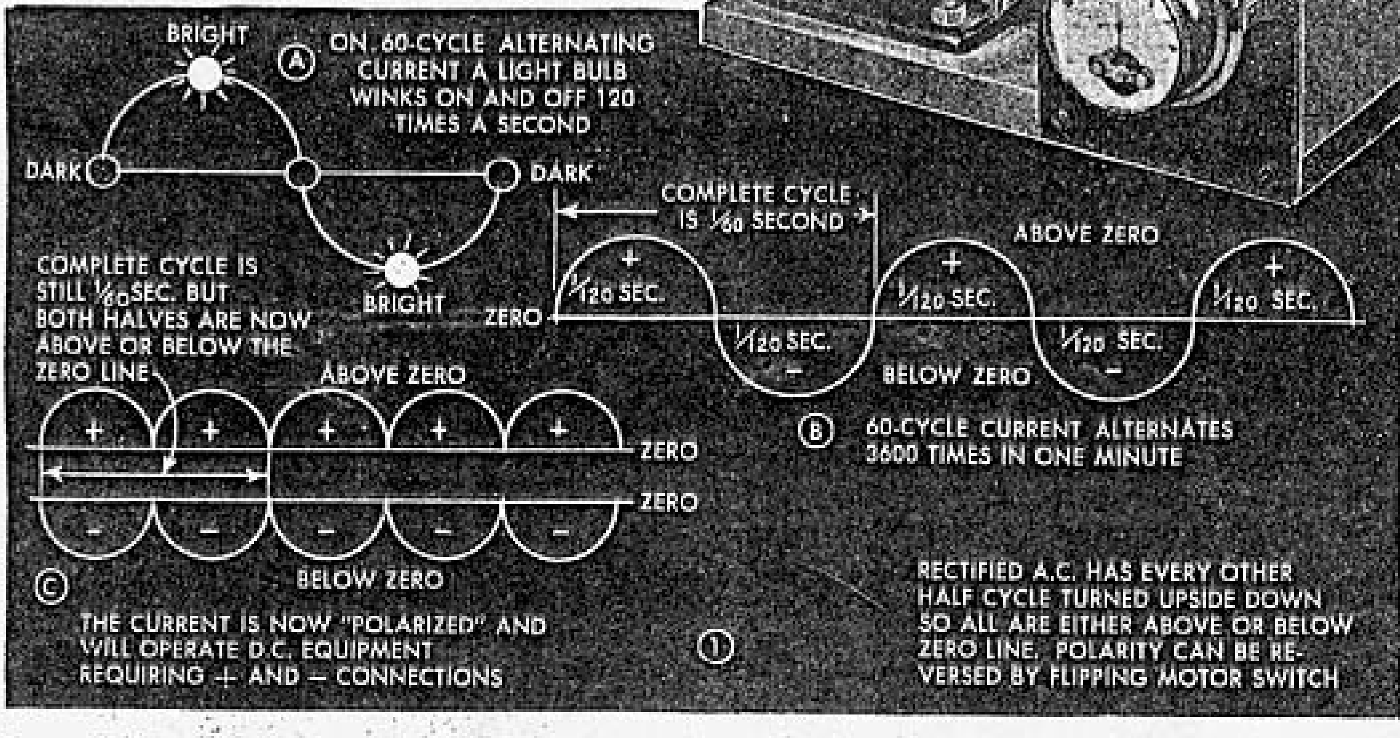
Bimetal-type relays, Figs. 44 and 45, consist of a strip of thermostatic bimetal about which a heating element of nichrome wire is wound. A thin layer of asbestos paper is wound around this, as shown in Fig. 44. When the resistance coil is heated, it causes the bimetal to bend and open or close the contacts. To lengthen the time delay, a heavier layer of asbestos is wound around the bimetal strip. To shorten the time lag, the nichrome wire is wound over a thin layer of asbestos paper, and a layer of asbestos is wound over the coil. In either case, the relay will be slower to open. The time lag of bimetal relays also can be controlled by adjusting the contact gap and by connecting a rheostat in series with the heater coil, as already explained for hot-wire relays.

The design of bimetal relays often requires a little experimentation. Ordinarily, a strip of bimetal 0.030 in. thick, ½ in. wide and 4 to 6 in. long will be suitable for the element. The size of nichrome wire required then can be found by referring to the chart, Fig. 39, which also gives the approximate length of wire required. The ends of the nichrome wire must be fastened to the copper-wire leads with machine screws or by brazing. Figs. 44 to 47 inclusive show a number of applications of bimetal relays. In Fig. 47 the bimetal thermostat without winding is secured to the metal frame of an electric motor so that a bell will ring if the motor overheats. Fig. 46 details a snap-action type of bimetal relay.

SYNCHRONOUS CURRENT RECTIFIER



By Alexander Maxwell
POPULAR MECHANICS, 1948



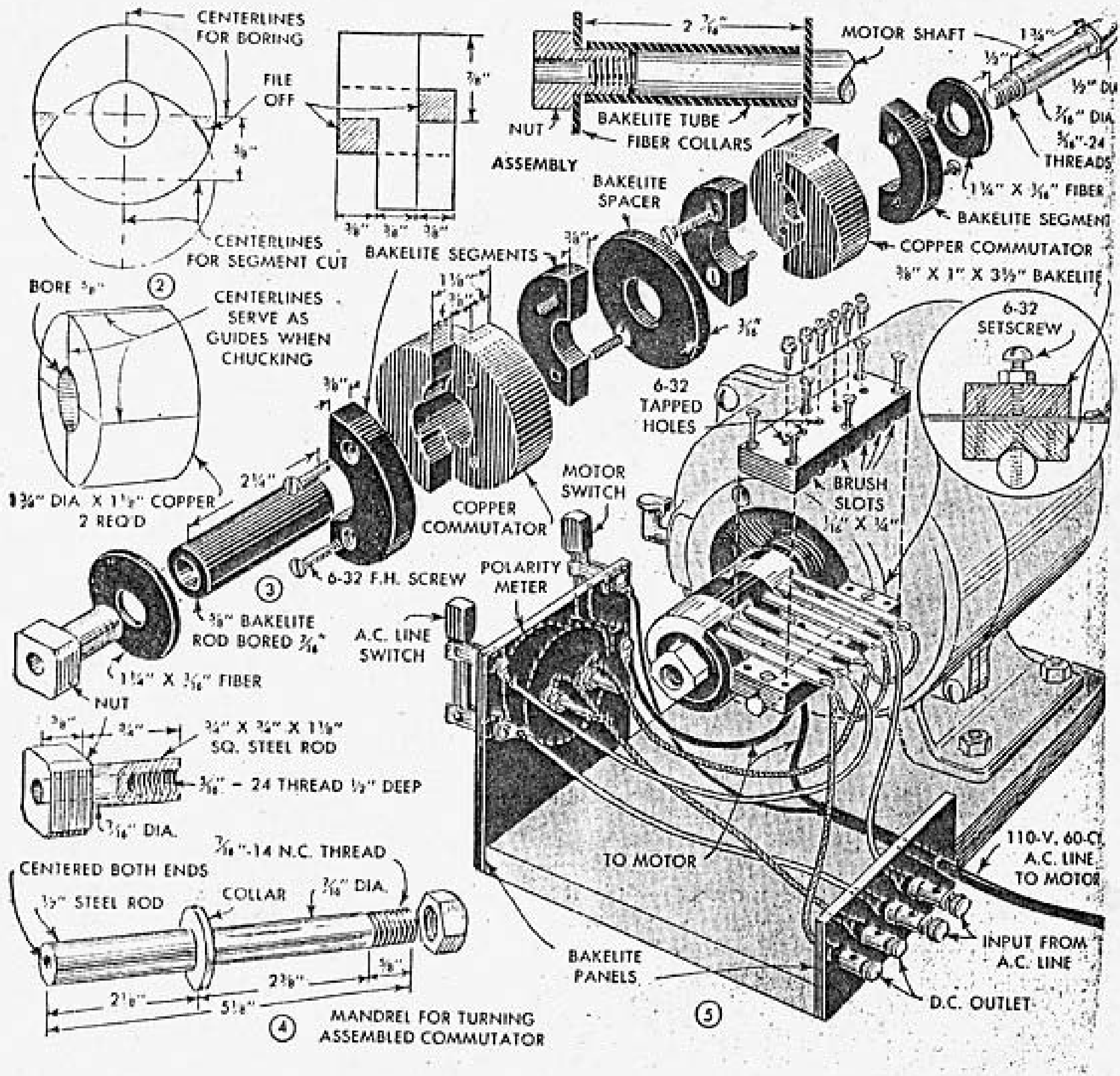
One of the simplest and most convenient ways to obtain a source of direct current is first to transform alternating current to the desired voltage, and then rectify it. This synchronous rectifier will handle high and low voltages equally well, the capacity in amperes being limited only by the size of the commutator and brushes

MANY are the applications for this synchronous rectifier, which is one of the most economical methods of rectifying electric current. Model railroaders will find that it will carry their entire system—polarized relays, block signals and permanent-magnet locomotives—delivering a reliable source of power necessary for smooth performance. It also can be used in electroplating, battery charging, operating electric-eye mechanisms, polarized relay control systems, arc lights and other electrical equipment requiring a d.c. source of current, the exception being radio.

The heart of the rectifier is a 3600-r.p.m. single-phase 60-cycle motor. It need not be powerful, for a ⅛-hp. motor will handle a commutator capable of carrying a 2-kilowatt load. The synchronous speed is necessary to agree with the frequency of the generating station. In Fig. 1, details A and B, the manner in which alternating current functions is shown. The current goes from peak voltage to zero twice during the cycle. When the current is rectified it becomes polarized and will operate equipment requiring positive and negative connections. When the rectifier motor is rotating in exact synchronization with the power-station generator, a commutator with make-and-break switches will divide the cycles as shown in detail C of Fig. 1. Then positive current is delivered at one terminal and negative at the other. To get full efficiency, the break must come as the cycle starts. At this instant the line is dead and there will be little or no tendency to arc. Should the change come at the peak of the cycle, enough arcing might result to melt the brushes. To adjust the commutator, rotate it on the motor shaft until the point is found where arcing is at the minimum, then tighten the locknut. Use only a 6-volt power source when making this adjustment.

Since most synchronous motors are intended for direct connection to the devices they operate, they usually have long shafts and are centered so the entire armature may be placed in a lathe and the shaft turned down to specifications, Fig. 3. Bake-

 GRANDDAD'S ELCTRICITY BOOK

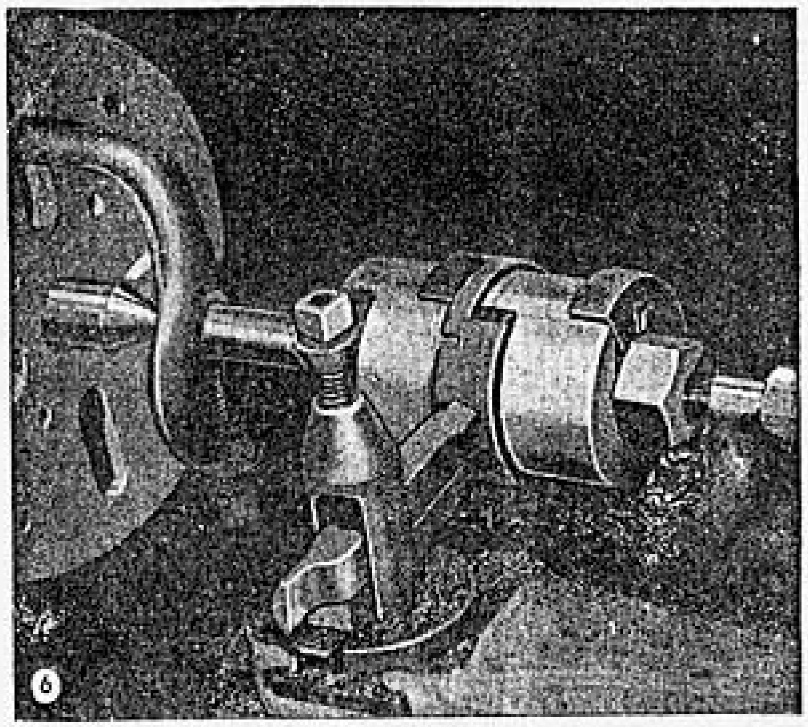


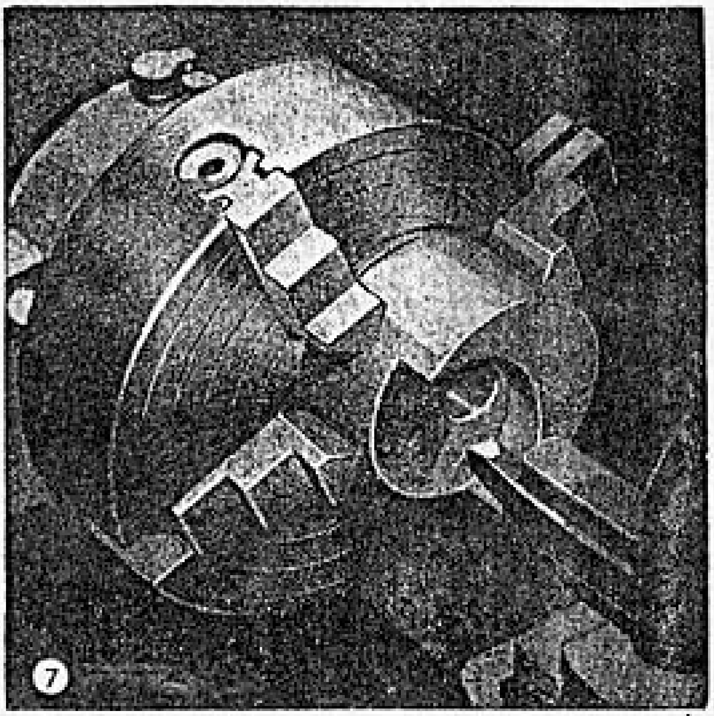
lite is used for the insulating material on the commutator, Fig. 3, which is rough cut to the dimensions given with allowances for finishing. The Bakelite tube should be made from a piece of molded rod, although it can be cut from molded sheets. Bore first, then turn to size while on the motor armature. This tube should be a snug fit.

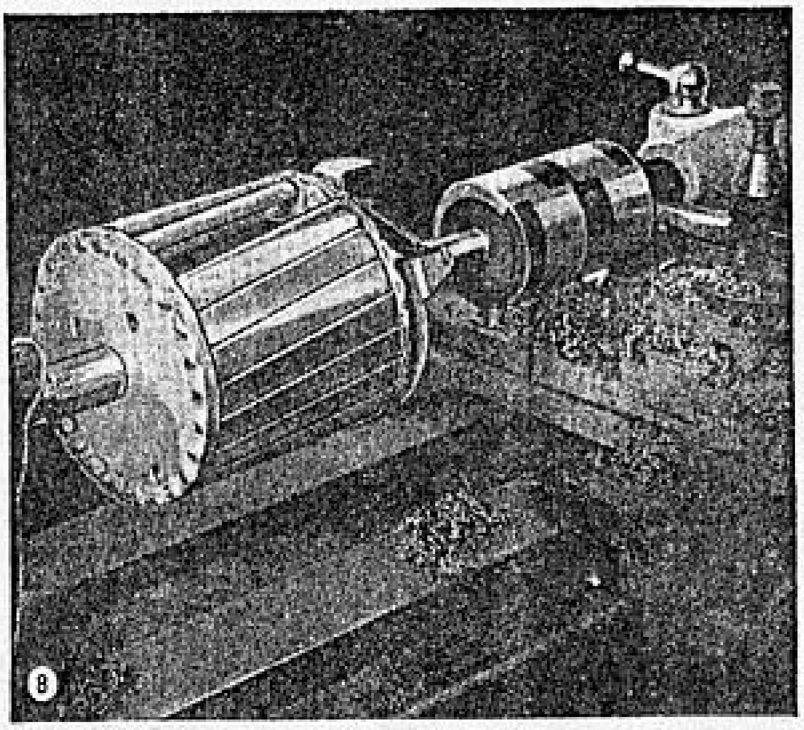
One of the most difficult steps is building up the copper commutator segments. After boring and rough finishing, the segment is cut as indicated in Fig. 7 and the portion that is shaded is filed flat, Fig. 2. The rough-cut Bakelite segments are secured to the copper commutators with flathead machine screws, Fig. 3, and the unit is slipped over the tube. It should be an easy press fit; if it binds it will throw the commutator out of line when the locknut is tightened. This assembly is slipped on a special mandrel, Figs. 4 and 6, and turned down until all lines disappear. Then the commutator is placed on the armature which is chucked in the lathe and a series of light finishing cuts are taken, Fig. 8. All cuts should be light, and sufficient oil should be used.

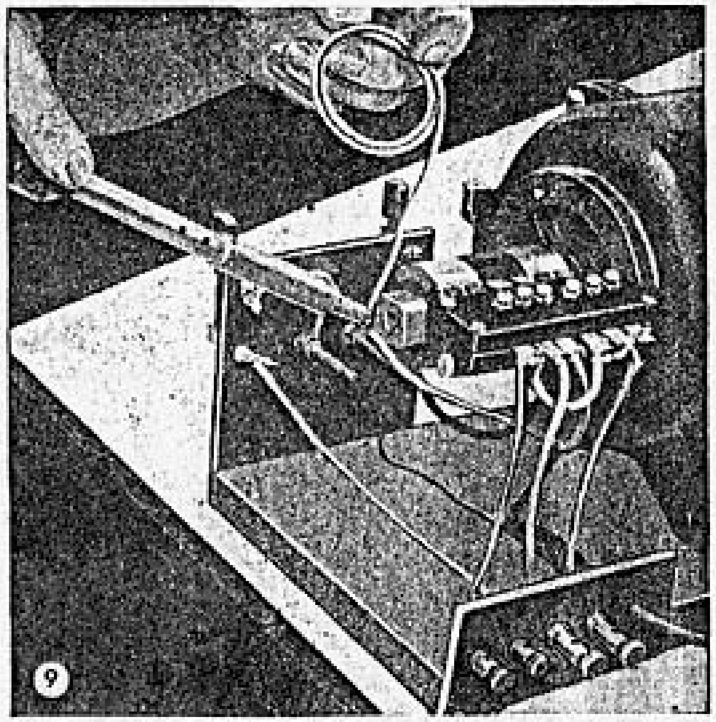
The brush assembly is supported on a bolt or rod which screws into the end bell of the motor. It will be necessary to drill and thread a hole at the proper location. Or a wooden pedestal can be screwed to the base as a support. The brushes are held between two Bakelite plates, the lower one resting on the support rod. Since the lower plate rests on the rod, a V-groove is cut down the center for a better fit. Bore mounting holes at each end of the plate, and drill and tap two similar holes in the support rod. Mount with flathead screws.

The upper plate has six shallow slots cut in it to take the brushes, Fig. 5, and it also must be drilled and tapped for the six setscrews and locknuts. Six assembly bolts are used to hold the two plates together.









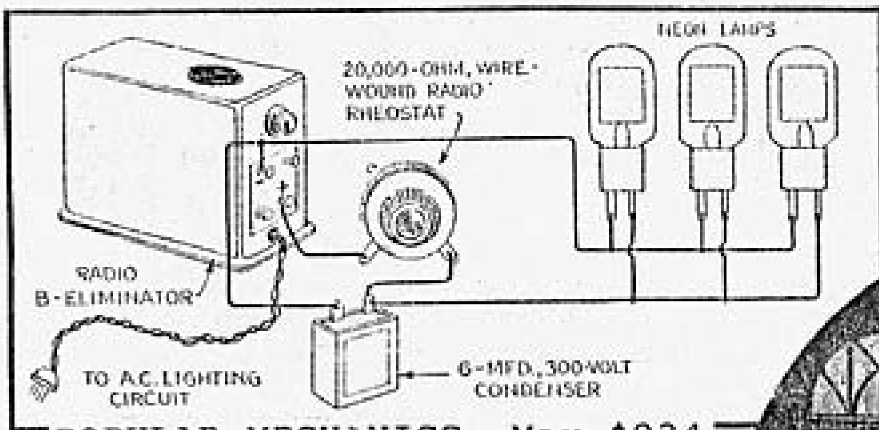
The brushes are made of thin strips of phosphor-bronze spring stock built up to a thickness of 1/16 in. The ends to which the wires are connected are soldered together. File the contacting end to fit the curvature of the commutator. When adjusting the brushes, remember that the pressure need be only enough to assure contact.

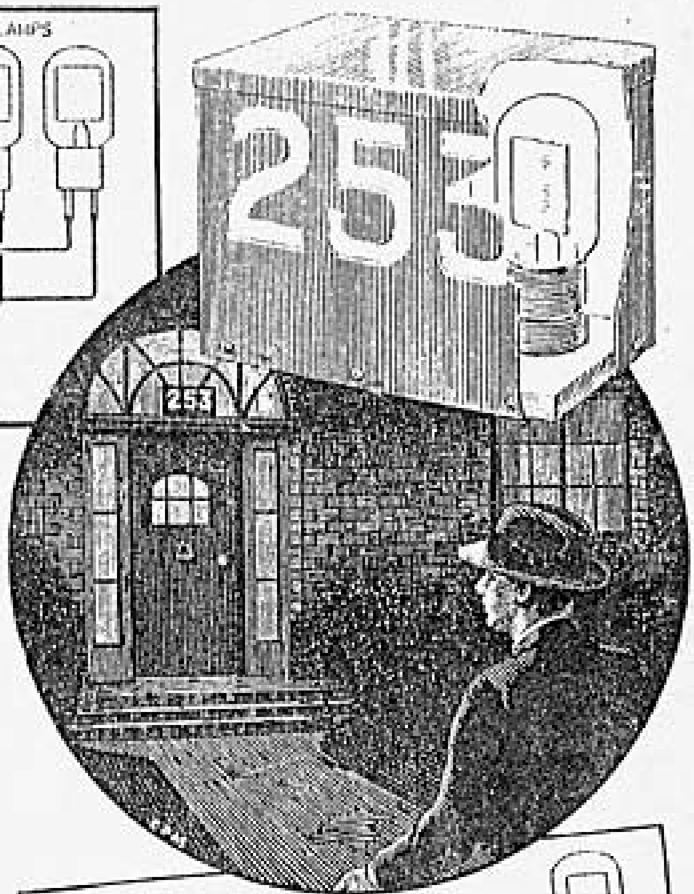
Fig. 5 shows the wiring connections and Fig. 9 shows one of the connections being made. Use stranded insulated wire heavy enough to carry the load. To secure the proper operation, the two halves of the commutator must register so the make-and-break lines are in perfect alignment. Also, to secure the correct connections, the two outside brushes should ride on the copper when the two inside brushes ride on the Bakelite and vice versa.

The polarity meter, Fig. 5, is required because a synchronous rectifier will produce positive or negative current at either d.c. outlet terminal, depending upon which half of the cycle it starts. To reverse polarity, quickly open and close the motor switch, repeating this if necessary until correct polarity is obtained. The meter is an ordinary charge-discharge ammeter of sufficient capacity to carry the load. In addition to the motor switch, there is another one which connects to the a.c. input. The terminals for this switch are connected to the line directly or through a transformer, depending upon the voltage that is desired.

When starting the unit, always turn the motor switch on first and the line switch after the motor has been operating at full speed for 10 seconds. When stopping the rectifier, always open the line switch first. Doing this avoids serious arcing. There should never be any load on the commutator when the motor is not in operation.

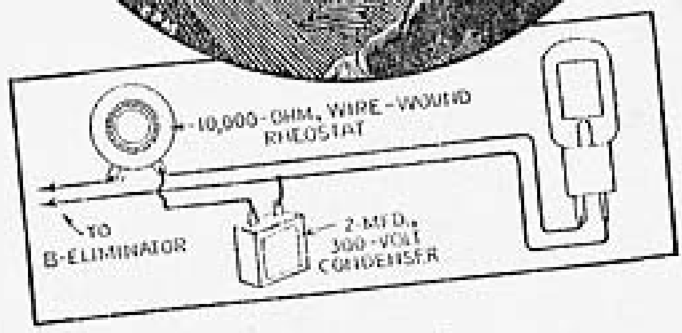
Flashing Neon Sign for Your House Numbers





POPULAR MECHANICS, May 1934

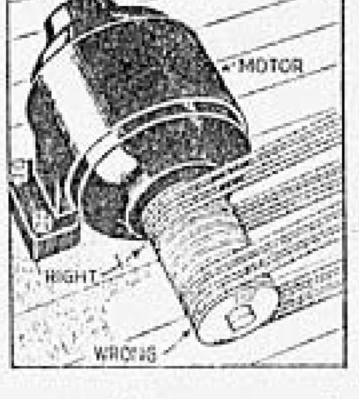
Distinctive from ordinary house numbers, your friends will easily find your home at night, if you have a flashing neon sign, which is both simple and inexpensive to make. The parts needed are a neon tube, a condenser, a rheostat and an old radio B-eliminator. By adjusting the rheostat, the number of flashings per minute can be controlled. The house numbers are cut out of a tin box, which is painted black, and a piece of frosted glass is slipped behind the cut-out letters. This gives the contrast necessary to see the numbers during the day time. One or more neon tubes are mounted inside the box. It is suggested that three tubes be used if you have three numbers. The tubes are held in regular four-prong radio-tube sockets, mounted on a wooden base that fits inside of the can. It is important, when connecting the tubes, to get their polarity correct. This is easily determined by connecting them to the eliminator; if the large plate does not glow red, reverse the connections. If the plate glows red but only over a part of its surface, the voltage is too low. Most tubes require about 135 volts for good operation. When the positive prong has been located by this method it should be marked so that no mistakes will be made when making the final connections. If your number has only two numerals, use two tubes and a 4-mfd., 300-volt condenser. For other sizes of signs, allow an extra 2-mfd. capacity in the condenser for each tube. The rheostat should be wire wound, as the carbon-pile type will not give good results.



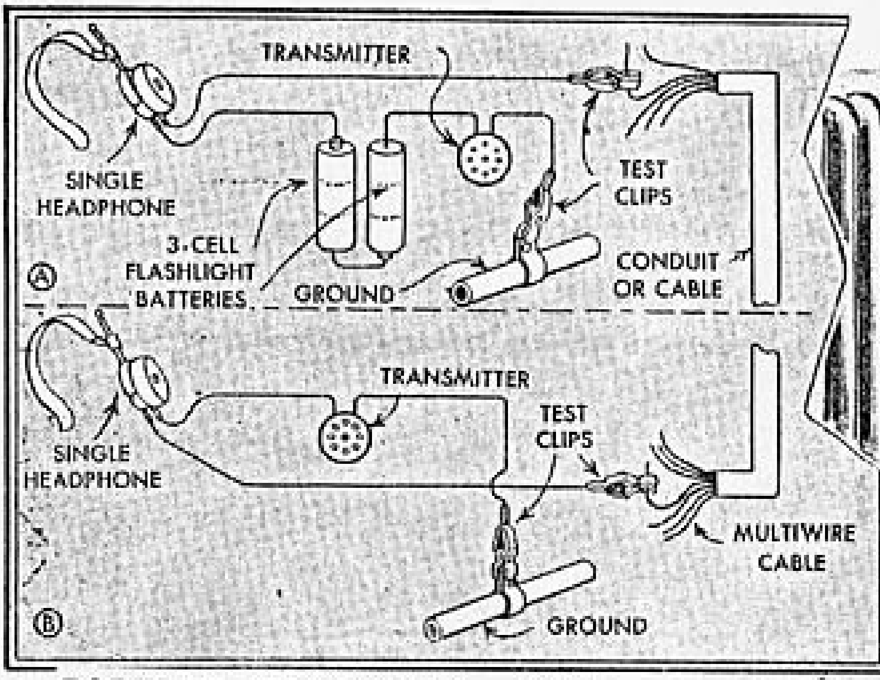
¶ Remove the burrs from the slots of screws after driving them into the work, as they are dangerous to the hands.

Improving V-Belt Drives on Motors

The manner in which an electric motor is belted determines the life of the bearings to a certain extent. When a multiple V-pulley is used on the motor shaft, and only two or three belts are used, they should be run on the part of the pulley closest to the motor, as shown, as this puts less strain on the bearings than when the belts are run near the end of the pulley. This holds true on any belt drive, which is one reason why double-ply belts are usually preferable to single-ply ones. The center of pull of a double-ply belt is closer to the center of the bearing.—W. F. Schaphorst, Newark, N. J.



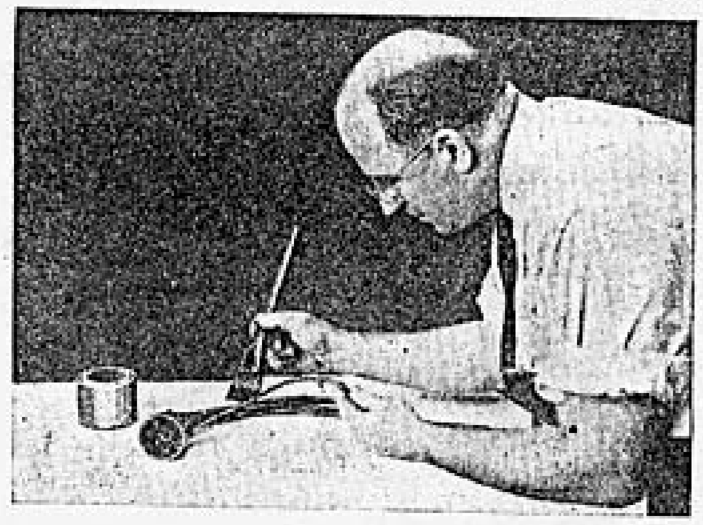
Tester to Check Circuits in Multi-Wire Cables



POPULAR MECHANICS, 1945

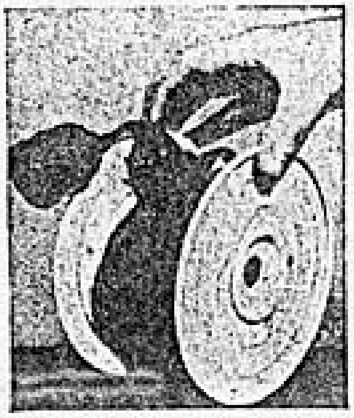
Electricians who install or repair telephones, annunciators, burglar alarms, etc., that are connected with multi-wire cables will find a set of these testers a timesaver in tracing the circuits through the cables. A set consists of two individual testers each having a single headphone, transmitter (carbon microphone), and two clips wired as shown. Tester A has two three-cell flashlight batteries or six 1½-volt single cells, connected in series between the transmitter and the headphone. In use, tester A is connected at the source of the cable. One of the clips is attached to a water pipe or, if the cable being tested is armored, the clip can be clamped to it. The other clip is fastened to one of the wires to be traced. Tester B at the other end of the cable is connected as shown—one clip to the ground and the other to the various wires individually until the voice of the workman using tester A can be heard. Each wire in the cable is checked in this way until all have been traced. The batteries are taped together and can be carried in the pocket. If a chest support for the transmitter is not available, one can be made from a heavy piece of wire to fit around the neck or chest so that both hands are free. Care should be taken so that the attachment clips do not contact each other in order to avoid injury to the transmitter.

Lacquer Coating Protects Insulation on Car Ignition Wires

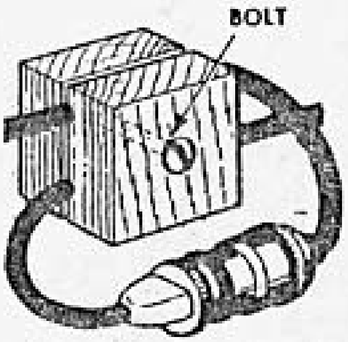


If the insulation breaks or peels off the high-tension ignition wires of your car, the efficiency of the motor will be reduced considerably. If it is impossible to replace these wires with new ones for some time, they should be protected against heat and grease, which rapidly deteriorate the insulation. To do this, give them a coat of clear lacquer. Before applying the lacquer, however, clean the wires of all grease by washing them with gasoline and allowing the wires to dry thoroughly.

EXTENSION CORDS

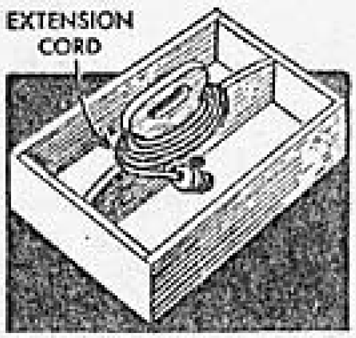


Sharp kinks in extension cords caused by hanging them from hooks or nails are likely to result in broken insulation and dangerous exposure of the wire. The cords can be stored conveniently without kinking or tangling simply by winding them on discarded metal wire spools. These spools, on which wire is wound for shipment from the manufacturer, can usually be obtained from a local hardware or electrical-supply dealer.



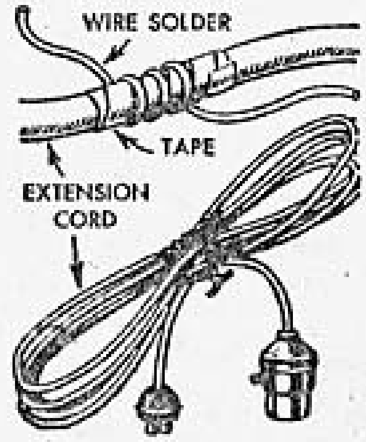
Made from two blocks of wood bolted together, this clamp prevents breaking the connection of an extension cord. It is especially handy when using an extension cord to operate portable electric tools, hedge shears, or a vacuum cleaner where there is a considerable strain on the connection. The clamp is made by drilling two parallel holes, slightly smaller in diameter than the extension cord, through a wooden block. Then the block is sawed apart lengthwise through the centers of both of the holes. The cords are placed in the holes, as shown, and the two pieces of the block are bolted together. Thus, any strain on the extension cord will be absorbed by the block and the connection will not be broken.

Toolbox Handle Serves as Reel For Winding Extension Cord



To keep an extension cord from becoming tangled or buried under an assortment of tools when stored loosely in a toolbox, one man made the center partition of his toolbox into a combination handle and reel. The partition is jigsawed from one piece in the shape shown, a handhole being cut in the top. When not in use the extension cord is wrapped around the handle, reeling off smoothly when required.

Wire Solder Used as Tie String On Electrical Extension Cord

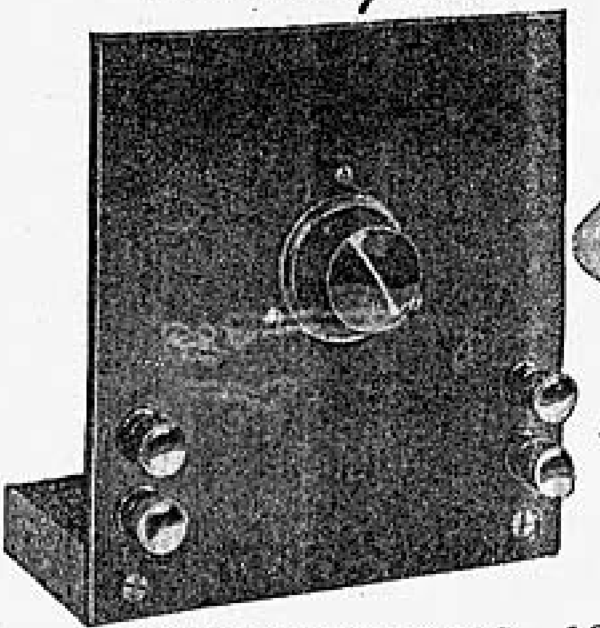


To keep a long extension cord looped when not in use, tie it with a length of wire solder as indicated. The solder will always be at hand if it is given two or three turns around the center of the cord and taped in place.

Extension Cord Wound on Reel To Hold It Off the Floor

If an extension cord is wound on a reel it can be set directly on your work, and the cord will be kept off the floor where it might be walked on or otherwise damaged. A reel can be made from a metal spool of the type used for holding lamp cord or water-pump packing. A hole is cut in the reel as shown to take the cord, which is protected from abrasion by a rubber grommet. After the cord has been pulled through the hole so that the socket seats tightly in the spool core, the core is filled with tar to hold the cord, which then is wound on the reel and fed out as required. The cord can be kept from unwinding by a notch filed in the lower flange and smoothed to keep the insulation of the cord from being cut. If desired, a wire cage may be attached to the reel to protect the lamp.

Variable VOLTAGE REGULATOR *has many uses*

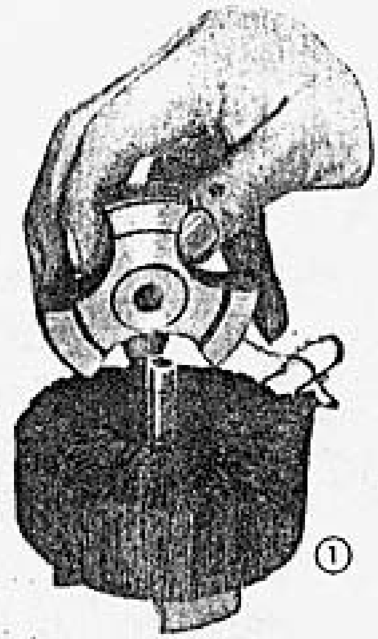


POPULAR MECHANICS, 1948

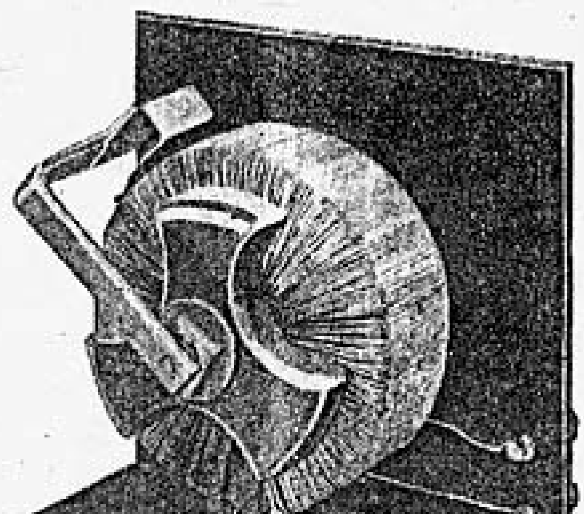
By Alexander Maxwell

THIS A.C. current regulator gives a smooth and continuous voltage control from zero to maximum and can be used as either a step-up or step-down transformer to increase or reduce voltage. The transformer is of the "doughnut" type, mounted on a panel, and is designed to carry a 100-watt load continuously, but easily is constructed for higher voltages by increasing the transformer core and wire sizes proportionately. The panel is fitted with two sets of binding posts, Fig. 6, those marked "high" connecting to the two ends of the coil, while those marked "low" connect to the slide and one end of the coil. When used as a step-down transformer, the electrical source is connected to the "high" terminals and the slide is adjusted to get the desired voltage. If the regulator is used as a step-up transformer, the electrical source is connected to the "low" terminals. It's best not to build up the voltage to more than twice that of the input, because of the loss by heating.

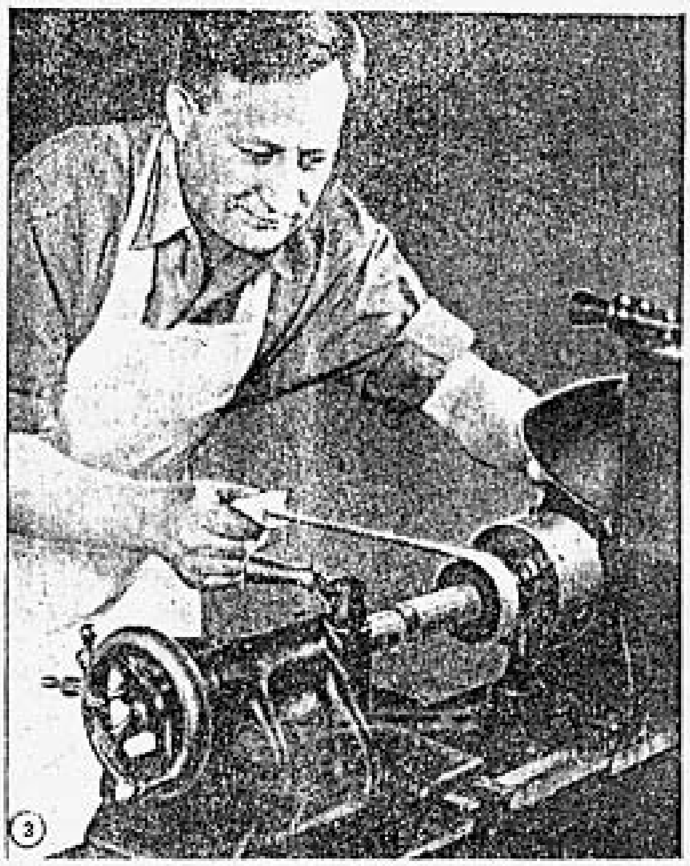
In making the regulator you begin with the transformer core which is wound on a wooden mandrel in the lathe as in Fig. 3, using transformer iron of the "ribbon" type. Start the winding by cutting a shallow groove lengthwise in the mandrel. Then bend a hook in one end of the iron ribbon and insert in the groove. Run the lathe at the lowest speed with the back gears engaged. It's advisable to wind and unwind the ribbon several times to soften the metal so it will bend easily and fit snugly. When the winding is finished the core should be about 4 in. in diameter. It then is fitted with a compression band of the same material, as shown in Fig. 10. This band should reduce the diameter of the core to about 3¾ in. The band is left in place under the windings as it holds the core securely and reduces the



①

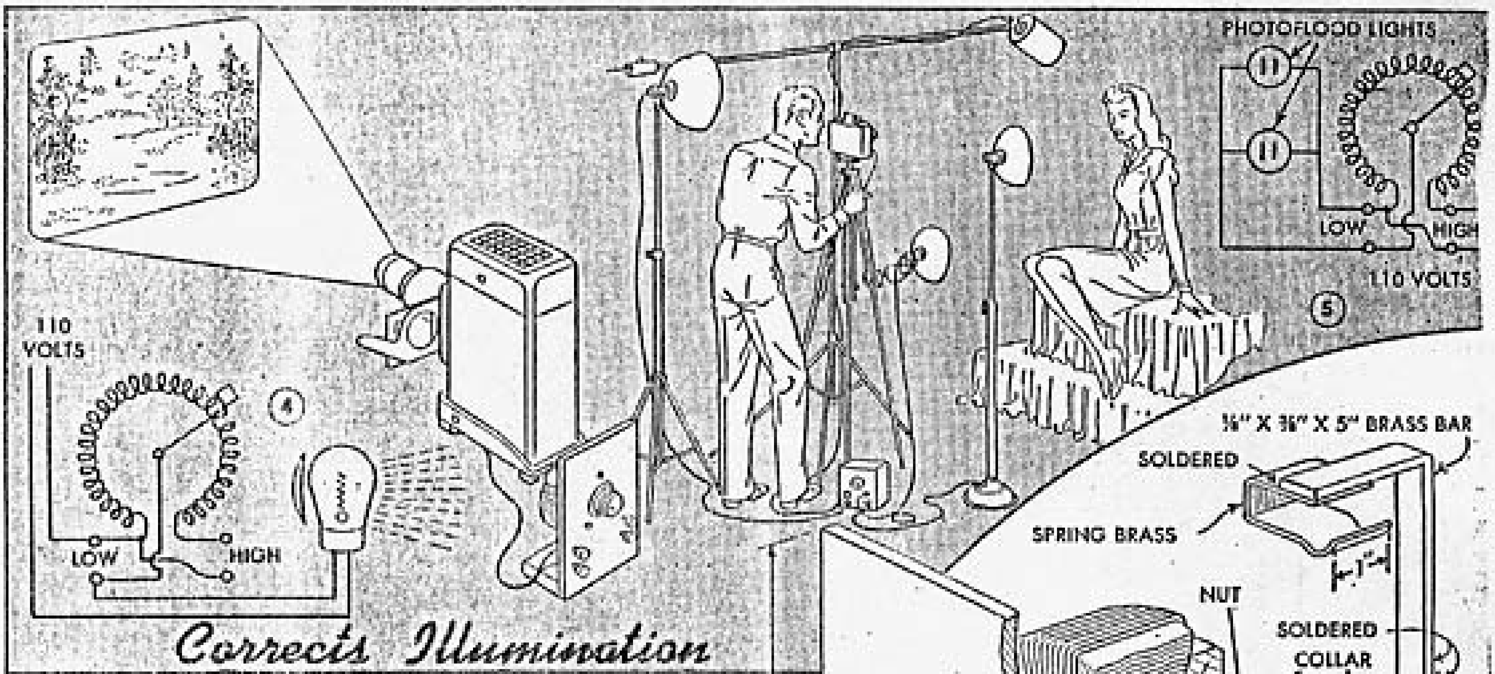


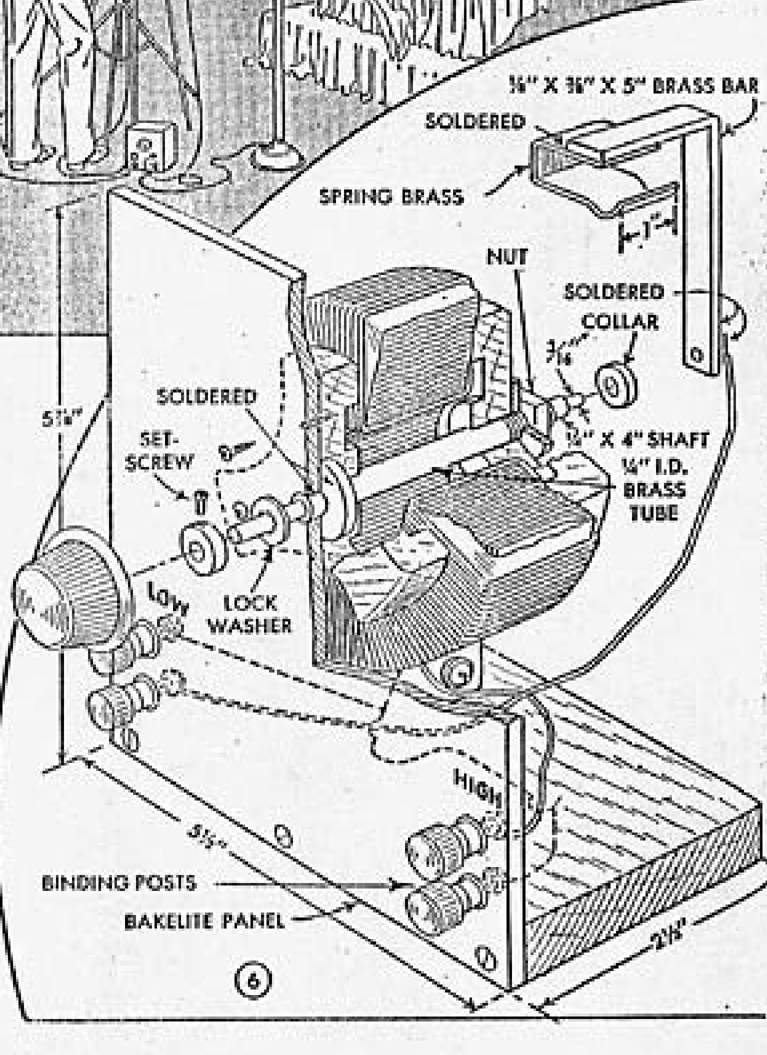
②



wire also can be bared with a fine scratch wheel as in Fig. 7.

The finished coil is mounted on the panel as in Figs. 1, 2 and 6, the latter showing in detail how the mounting is assembled. First turn two hardwood end plates to the dimensions given in Fig. 11 and mount the coil and end plates on a sleeve made from brass tubing as in Fig. 6. Be sure that the coil is centered on the sleeve, then draw up the nut to grip the coil between the end plates and hold it securely in place. Next, the ¼ by 4-in. steel shaft carrying the slide is cut to length and turned down to 3/16 in. in diameter at one end to take the slide arm as indicated. The slide and arm are made as in the upper right-hand detail of Fig. 6, and are soldered to the shouldered end of the shaft against a collar as shown in Fig. 2. The slide must be adjusted carefully at the point of contact so that it touches only one wire at a time, as indicated in the upper left-hand detail of Fig. 10. An adjusting knob completes this assembly. The bake-

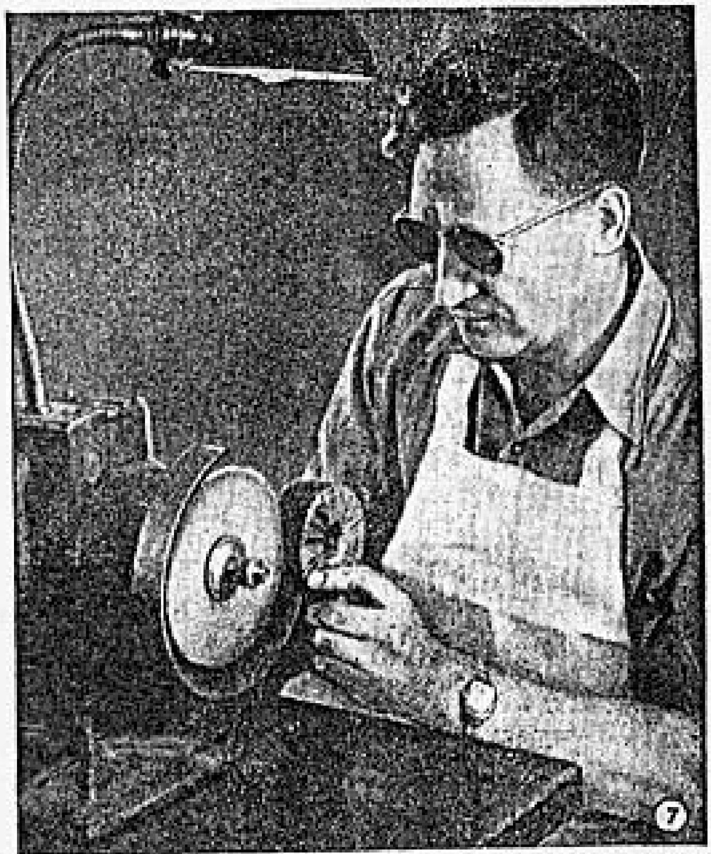


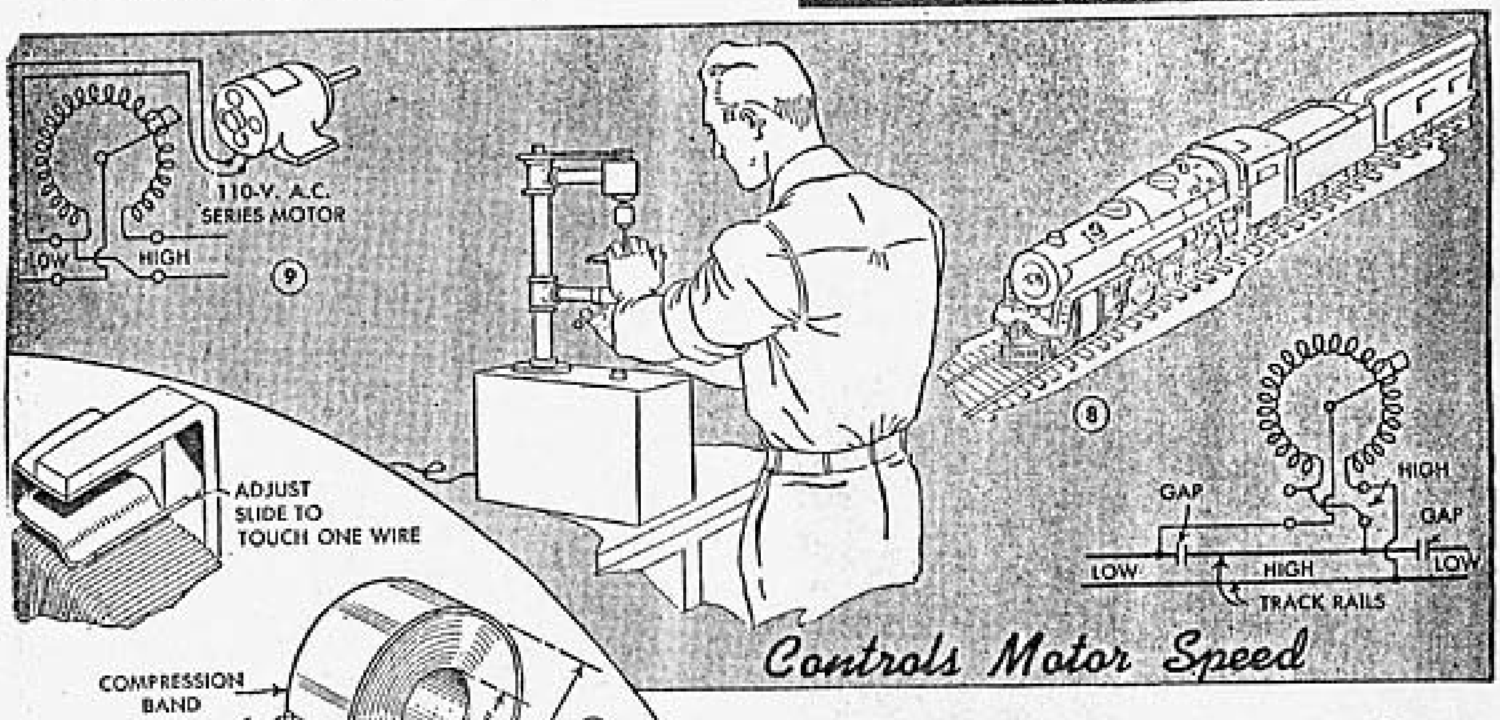


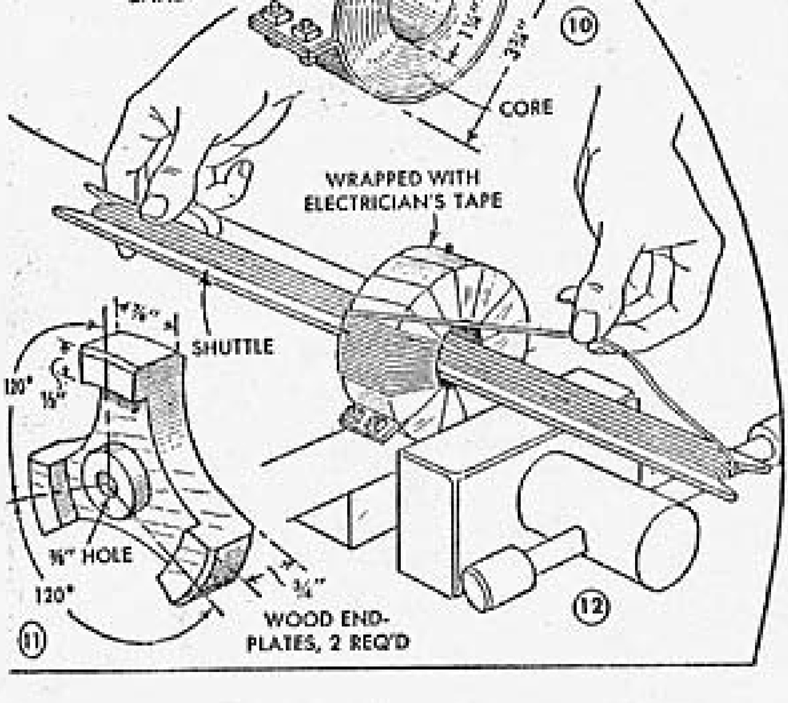
tendency of the regulator to create a hum.

The load-carrying capacity of this type transformer is primarily determined by the amount of iron in the core and the size of the wire used in the coil. This one is wound with No. 22-30 cotton covered wire, the windings being in one layer at the circumference of the core, three or more layers at the center opening of the core. The winding is done with an improvised "shuttle" as in Fig. 12. Care should be taken to keep the wire under uniform tension and to wind the turns tightly together side by side. When the winding is finished coat with a baking enamel and dry in an oven. To bare the wire for the slide contact, use fine emery cloth and be very careful not to damage the insulation between the windings. The lite panel is screwed to a hardwood base and, after fitting and wiring the high and low terminals, the unit is ready for use.

Figs. 4, 5, 8 and 9 suggest a number of uses and give the wiring diagrams for each application. For these particular purposes a smooth, positive change from one voltage to another is especially desirable. For example, regulating the output of a projection bulb as in Fig. 4, or controlling the brilliancy and illumination factors of photo lights as in Fig. 5, are common applications of this type of voltage regulator. In both instances the light intensities can be varied to emphasize delicate detail on the screen or on the subject to be photographed. And, of course, by cutting down the voltage when posing the subject for an indoor shot as in Fig. 5 you prolong the life of high-intensity bulbs as the lights can be raised to full brilliancy for the short interval of the exposure and then immediately decreased in brighiness. Be sure that the combined wattage of the lights does not





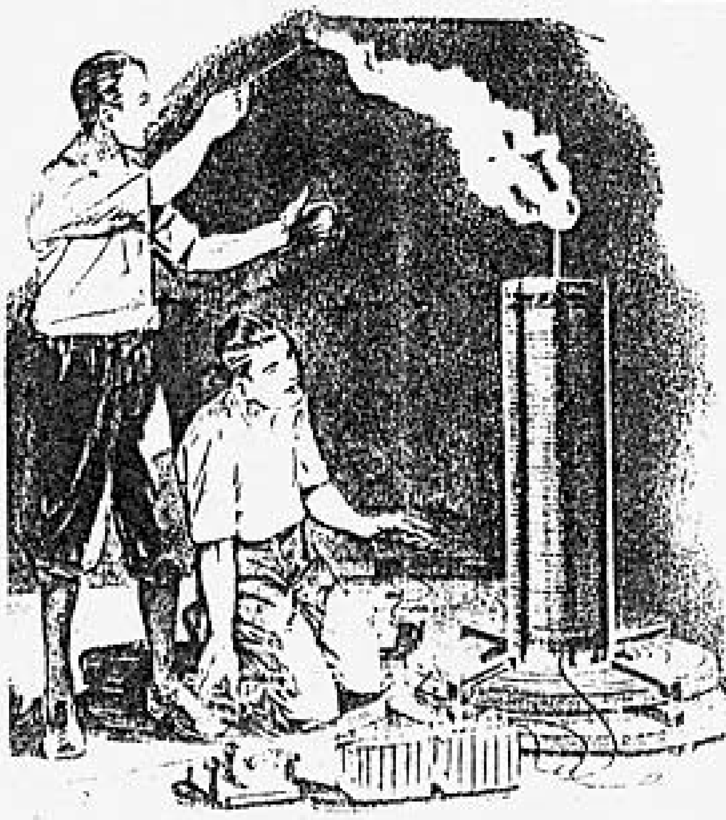


exceed the capacity of the transformer.

The regulator also can be used to control a small series motor through a range of speeds without the current loss due to heat, as is the case where a rheostat is used. Often, on large model railway layouts, there is a portion of track where a number of factors combine to slow the speed of the train. This portion of the track can be insulated from the rest and the regulator used as a step-up transformer to feed it. Current for the regulator is taken from the section just ahead. As the train enters the "slow" section the regulator slide is advanced until the train maintains the desired speed. When the train reaches the end of the section the locomotive again receives power from the regular source.

MAKE Artificial LIGHTNING

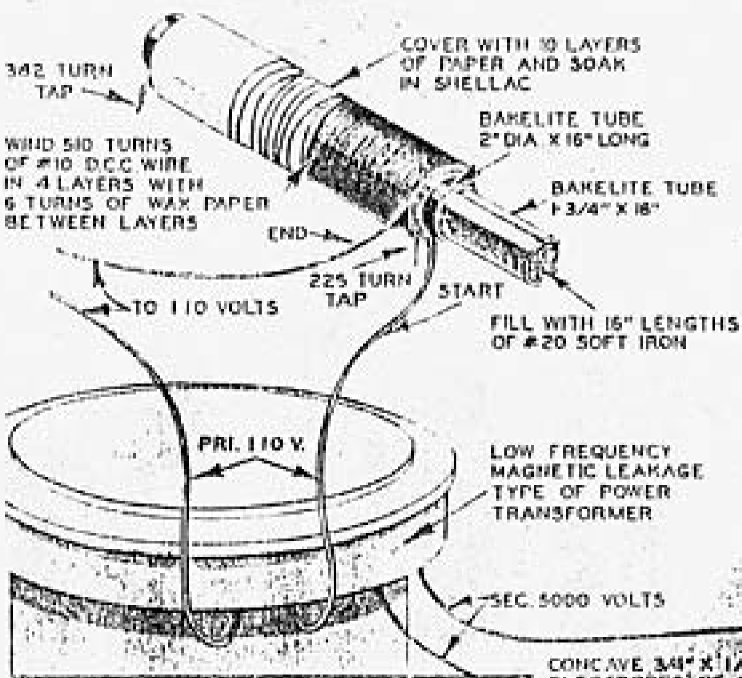
by John L. Welbourn

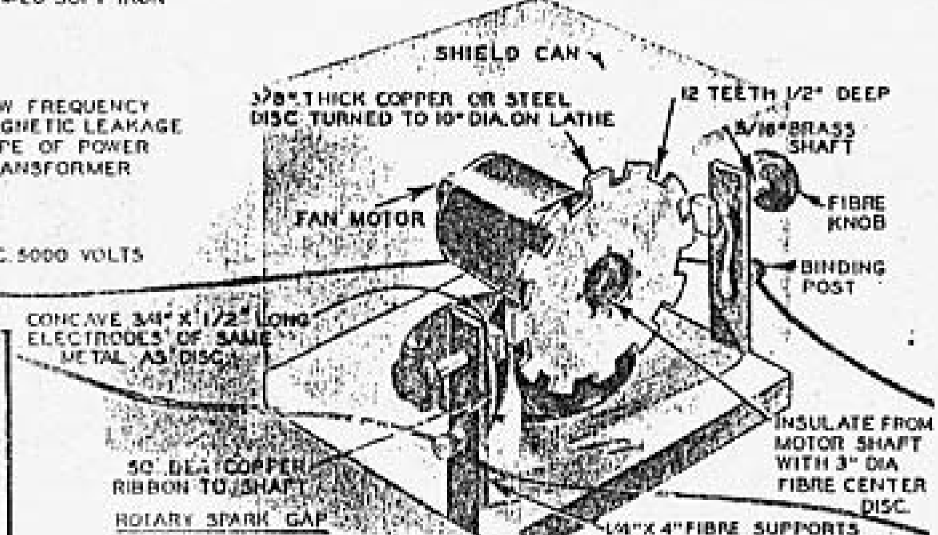


EDITOR'S NOTE—*This equipment is particularly suited for science class-room demonstrations. At no time should a demonstration be attempted by one unfamiliar with the apparatus. Although the giant brush discharge is harmless to the average person, a shock from any part of the equipment other than the high-frequency transformer will carry with it serious consequences to the person involved. It is suggested that when this apparatus is demonstrated before a group of persons, they be warned not to touch the apparatus and to stand a respectful distance from the low-voltage equipment.*

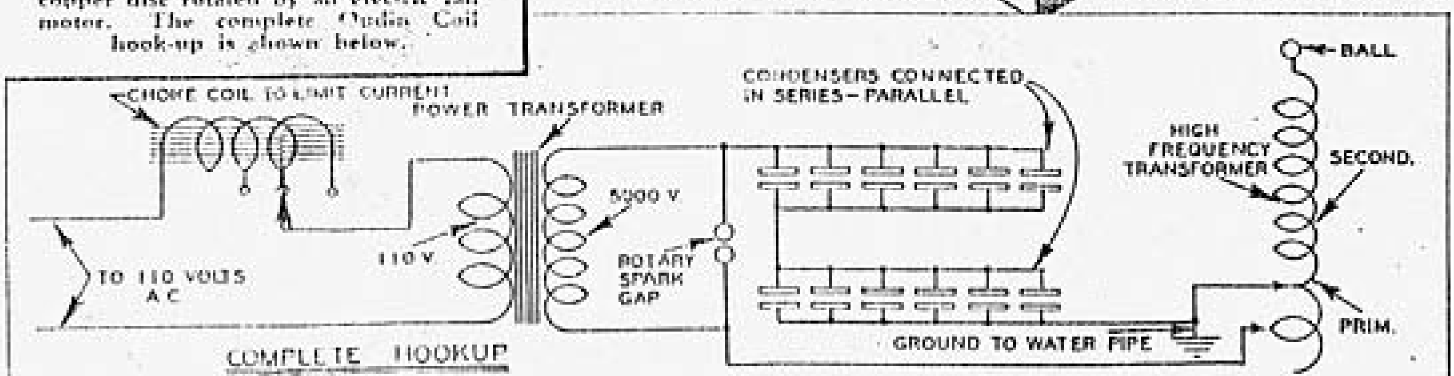
Modern Mechanix July, 1937

THE apparatus about to be described is capable of throwing a spark four and a half feet long. In spite of its deadly appearance, this spark is quite harmless. The operator may hold a metal rod in his hand and let it jump to the end of the rod and run through his body to ground, not only without harm, but without any sensation of shock. A rather spectacular stunt is to hold one wire leading to an incandescent light, and bring the other end near the coil. The lamp will be lighted by the current passing through the body and may in a few minutes even be





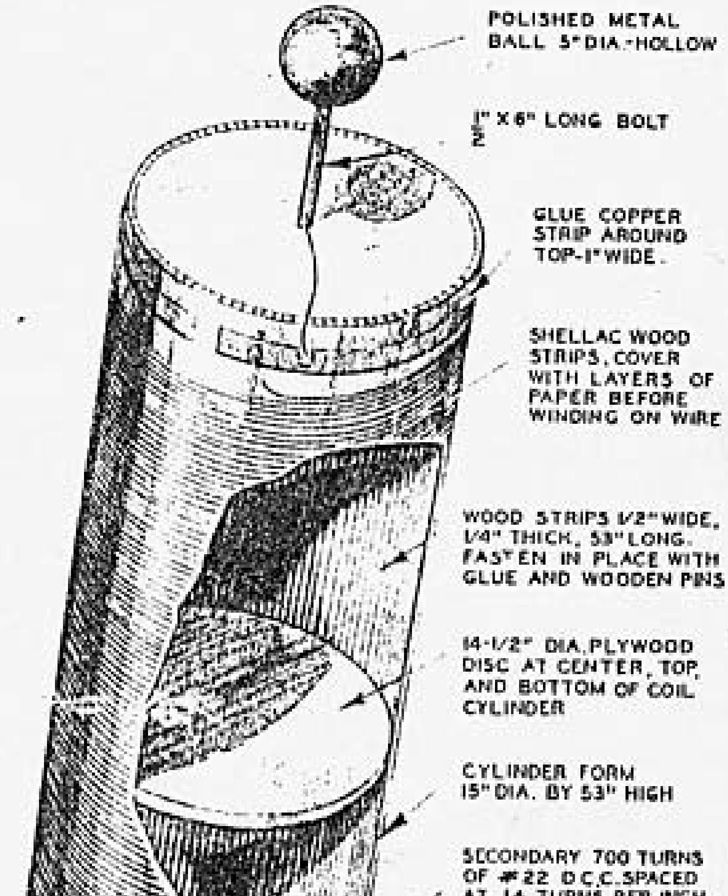
Above is shown the construction of the reactance choke which regulates the flow of current in the low-frequency transformer. A 5,000-volt heavy duty radio transformer supplies current to the Oudin Coil. The rotary spark gap described at right consists of a slotted copper disc rotated by an electric fan motor. The complete Oudin Coil hook-up is shown below.

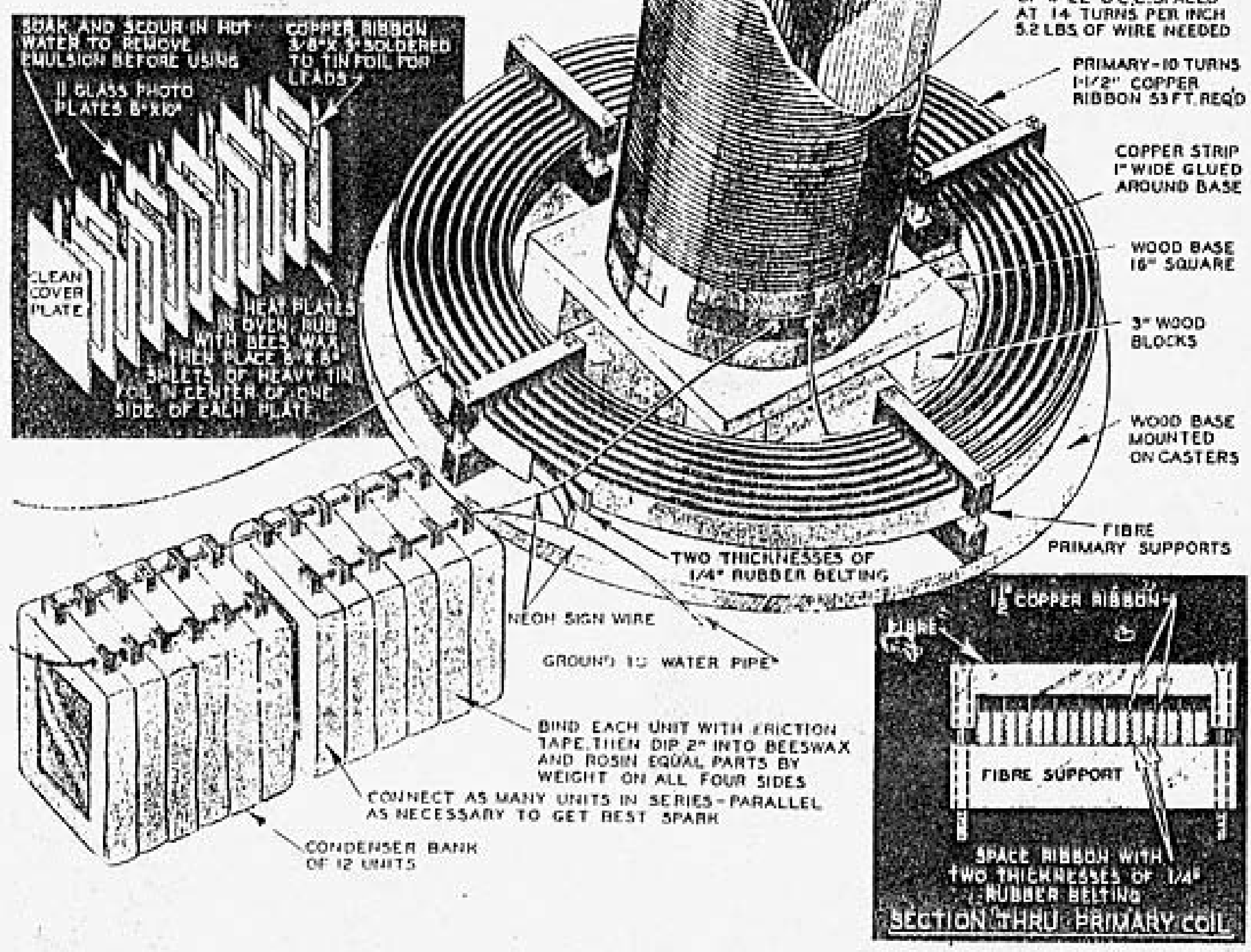


WITH GIANT OUDIN COIL

burned out. A mystifying trick is to hold a short length of neon tube in one's hand, and approach the coil. Long before there is any sign of a spark jumping to the tube, it will light with its characteristic glow.

Many interesting experiments can be performed from an insulated platform. Since the spark jumps to grounded objects, if one stands on a board supported by glass insulators (milk bottles will do temporarily) and touches the discharge ball with a metal rod, sparks may be drawn from one's body by anyone standing on the ground. Care must be taken not to draw sparks from the bare skin, as they might cause a blister. A finger ring, or even a spoon in the mouth, can be used as good contacts from which to draw the spark. A peculiar and weird effect can be had, when one is so charged, by raising the free hand above the head in a darkened room. The person will then be





The Oudin Coil is assembled in the manner described above. Condensers are made by sandwiching tin foil between glass plates which are connected in a series-parallel arrangement. To prevent voltage breakdown, submerge condensers in oil.

dimly seen outlined by a purple discharge. Small flames will dart from the raised hand, hair, and even from the tips of the ears.

Perhaps the most awe-inspiring spectacle is the coil operating under full power in a dark room. Long streamers of purple fire dart out in all directions from the discharge ball, emitting at the same time an almost deafening noise. A grounded wire is now slowly moved towards the discharge ball. The streamers change their direction and snap at the wire. Suddenly a heavy spark bridges the gap, and the air becomes thick with ozone.

Many experiments can be performed with this apparatus, and this short sketch gives an idea of some of them.

Before beginning the actual construction of the device, it is well to know something of the principle involved. Briefly, it is this: as the frequency of an alternating, high voltage current rises, it loses many of its normal characteristics. At extremely high frequencies it is almost a totally different kind of electricity. It produces no sensation of the shock when taken through the body, because as the frequency becomes higher, the path of travel becomes closer to the surface. At extremely high frequencies this path of travel is so close to the surface that it does not touch the nerves. This is known as "skin affect." It has a tendancy to diffuse off the conductor into the air, causing the beautiful brush discharges often seen on insulated wires. This also accounts for the lighting of neon tubes without wire connection. The current refuses to be stopped by nearly all insulators, oil being one of the few insulators having some protective qualities.

In order to produce a current of this nature, four distinct pieces of apparatus are necessary. They are: a low-frequency transformer which converts the low voltage current from the lighting circuit into high voltage current suitable for charging the condenser; a condenser which is composed of alternate sheets of metal and glass; a spark gap which consists of two electrodes separated by air; and a high frequency transformer.

The low frequency transformer should have an output of 3,000 to 5,000 volts. The transformer is of the magnetic leakage type such as used for radio purposes. Since the construction of a transformer of this size embodies considerable difficulties, the reader should, if possible, obtain one already constructed.

A power line transformer may be converted into one of the magnetic leakage type at little trouble or expense. A small transformer, such as is put on poles to step down current from 5,000 volts to 110 or 220, can undoubtably be purchased from an electrical junk-yard or direct from the local power company at a very reasonable cost. The power drawn by the unaltered transformer probably will be too large, but this need cause no worry as it may be reduced by the choke about to be described.

The choke consists of 510 turns of No. 10 D. C. C. copper magnet wire. This coil is wound in four layers on a bakelite tube 16 inches long and two inches in diameter. To wind the coil, lightly force two square blocks into the ends of the tube and mount it in a lathe. In the absence of a lathe one can easily construct a coil winder to be turned by hand or a foot treadle. Shellac the tube and cover it with a layer of waxed paper. Then begin winding the coil ¼-inch from the end of the tube to the other end, leaving the same margin. After completing the first winding, cover the layer with six sheets of waxed paper and wind back to the starting end. Solder a tap of wire to the last turn of this layer, cover as before with waxed paper, and wind another layer. This layer also should be tapped and insulated with waxed paper. The last layer is wound to within 1 inch of the end and the wire anchored to the coil with friction tape. The completed coil is now covered with ten sheets of waxed paper and liberally soaked with shellac.

The tube to contain the core should be small enough to slip in and out of the coil easily. It is packed with soft iron wire of No. 20 gauge and the ends trimmed to make a smooth job. About ten pounds will be needed for the core. By using the taps to vary the number of turns and by sliding the core back and forth in the coil, the value of reactance is readily changed. If the reactance is not sufficient to prevent "blowing" of fuses, wind another layer of No. 14 wire on the coil. The reactance coil is connected in series with the primary of the low frequency transformer, as shown in the diagram.

The purpose of the condenser is to store the high voltage current momentarily. When sufficient energy charge is stored it discharges across the spark gap. While this discharge may seem to be only one continuous spark, it is in reality thousands of discharges first in one direction and then in the other. No sooner does the potential fall to a low value than the condenser is recharged, starting the cycle of operations all over again. By this process the frequency is raised to the required point.

The condenser is made from glass plates, sheets of tin foil and copper ribbon for tab connections. The glass plates can be bought from a photographer already cut 8x10 inches and are preferable to window glass because they are free from bubbles and other imperfections. To clean them they should be soaked in hot water and then scoured to remove the emulsion.

To make the condenser, 132 plates will be required. It might be well to have a few extra in case some are broken or prove defective. Sixty of the cleaned plates are now covered in the center on both sides with heavy tin foil cut 6x8 inches. This tin foil may be purchased from wholesale hardware dealers in rolls a foot wide. As is readily seen, 40 feet will be needed. If it cannot be obtained in this form, a florist might be able to supply it in sheets.

To fix the tin foil in place, the plates are heated in an oven, rubbed with a cake of beeswax, and the tin-foil sheet pressed on the center so as to leave a margin of one inch on each edge. Both sides of the plates are covered in this manner. Any ridges or wrinkles in the foil should be pressed out by rubbing gently from the center with a wad of cloth. Copper strips ½ of an inch wide and three inches long are soldered to the upper left hand corner of each sheet of tin-foil after which the condenser is ready for assembling.

First a plate without tin foil is taken, then a plate prepared with the foil is placed on top of it, then another clean one is placed on top of the prepared plate. These plates are stacked together until five of the prepared plates have been used. A clean plate is then placed on top of the pile to act as a cover. The unit is then bound with friction tape to prevent the plates from separating during the insulating process. When all the plates have been used there will be 12 units ready for insulating.

The first method of insulating is perhaps the best if it be not desirable to move the condenser very much. It consists of submerging the entire condenser in a tank of transformer oil. If this is done be sure that the wires from the individual units are above the surface of the liquid. The other method of insulating consists of dipping the edges of each unit to a depth of two inches in a hot mixture consisting of equal weights of beeswax and rosin.

We now come to the construction of the spark gap. This consists essentially of a fan motor turning a copper or steel disc, slotted as shown on page 94. The discharge electrodes are placed on either side of this disc so that when it revolves new faces are constantly being presented to the spark. This not only keeps the metal from oxidizing but constantly circulates a current of fresh cool air between the electrodes.

The motor for this gap may be of any convenient size. An old fan motor is best as it uses little current and has a fairly high operating speed. The rotating disc should be at least ⅛-inch thick and 10 inches square. After finding the center of the piece of metal, a circle of 10 inch diameter is drawn, then one of 9 inches and finally one of 3-inch diameter. The metal plate is next mounted on a wooden faceplate in the lathe and a cut taken through the metal on the 3-inch circle and a similar cut taken on the 10-inch circle. The disc should now be divided with 24 radial lines running from the center and crossing the edge at 24 equidistant points. Since the radius of a circle is equal to ⅙ the circumference, the 9-inch circle can easily be divided into six parts with a compass, each of these parts cut in half and then each part once more halved making 24 equal parts. Alternate segments between the 9-inch circle and the edge are removed. This is best done by cutting the two edges down as far as the circle and then breaking off the fragment. This is entirely permissabe since the bottom of the cut does not have to be smooth.

To insulate the motor from the high tension current, the disc is mounted on an insulating hub, which in turn is fastened to the motor shaft. The disc is placed on the fibre and six holes drilled around the edge of the fibre and on through the metal. The two are then bolted or riveted together.

The motor with the completed rotating disc mounted on the shaft should be bolted to a suitable base. Opposite the edges of the disc screw a piece of fibre ½-inch thick, 1-inch wide and high enough to extend an inch above the motor shaft. These form the supports for the stationary electrodes. The electrodes are made of brass and ground or filed slightly concave to fit the curve of the disc. The side opposite the concave face of each electrode is drilled and threaded upon a ⅛-inch brass rod which in turn passes through ⅜-inch holes drilled in the fibre supports in such a position that the electrodes are nearly level with the motor shaft. Strips of heavy copper ribbon are soldered to the brass rods and establish connection with binding posts placed a few inches beneath the rods on the fibre supports.

We now come to the final piece of apparatus and perhaps the most difficult to construct, the high frequency transformer. This transformer consists essentially of a large cylinder upon which wire is wound in a single layer for the secondary coil with a flat spiral of copper or brass ribbon about the base to act as the primary. Because it deals with high frequency electricity, no metal core is necessary. The cylinder for the secondary is 53 inches high and 15 inches in diameter. It is constructed without the use of nails throughout for nails will cause considerable loss in current due to brush leakage. The cylinder is formed on three plywood discs 14½ inches in diameter from mounting board or strips of wood ½-inch wide, ¼-inch thick and 53 inches long. The strips are placed side by side and as close together as possible. When the entire circumference has been covered you should have a solid, well constructed, wooden cylinder. It should now be shellacked and covered with a layer of wrapping paper. This serves to remove the rough edges left by the strips.

The winding on the secondary consists of 700 turns of No. 22 D. C. C. copper magnet wire, with the turns spaced 14 to the inch. This will amount to about 2,670 feet or 5.2 pounds of wire. To wind the coil pass a metal rod through the cylinder and mount it between two saw-horses. Before winding the wire on the cylinder, glue a band of one inch copper ribbon around the cylinder, one inch from the top and another placed three inches from the bottom. The bands should not meet, a space of about one inch being left between ends. Solder one end of the wire to the top band and start winding. The spacing between turns may be obtained by winding heavy cord alongside of the wire. Shellac liberally applied will hold the turns in place.

The discharge ball is of metal and about 5 inches in diameter, mounted on top of the coil. A toilet tank float will serve the purpose very well. Complete the secondary coil by connecting a wire between the metal ball and the top of the coil.

The primary coil is wound with copper or brass ribbon 1½ inches wide in the form of a flat spiral. About 53 feet of the ribbon for the 21-inch outer diameter of the 10-turn spiral winding will be required. The primary supports consist of 8 pieces of fibre 8½ inches long, 2 inches wide and 1 inch thick. The four top pieces have a section cut away as in the drawing so as to keep the coil from spreading. Holes are drilled in these pieces, ⅜ of an inch from the ends, large enough to permit the passage of six inch bolts.

The primary coil is mounted on a wooden base 37 inches in diameter with the four fibre pieces to support the primary located so that the primary will be in the center of the board. The supports are then bolted to the base, thus holding the primary securely in place.

Mount the secondary inside the primary coil on a wooden base 16 inches square, supported on four wooden blocks. Place the blocks so they rest flush with the edges at the corners of the board, and drill holes for a good sized bolt to pass through each corner of the board for mounting the secondary coil to the base. A piece of copper ribbon is soldered to the inside turn of the primary coil, and to the bottom of the secondary winding, completing the coil construction.

The apparatus is now ready for connecting and operating. The wires are connected according to the diagram. For the sake of simplicity the rotating disc is omitted in the diagram of the spark gap. The spark gap motor is of course connected to the input line through a suitable switch. The wire from the secondary of the low frequency transformer is automotive high tension wire; that from the condenser should be special, heavily insulated neon sign cable, as should that also from the spark gap. GREAT CARE MUST BE TAKEN NEVER TO TOUCH THE LOW FREQUENCY TRANSFORMER. The condenser when charged will retain a considerable quantity of electricity for days, so it is well to "short" the connections for a second (with a well insulated metal rod) before touching them. The grounded connections may be of braided ribbon or other heavy uninsulated wire connected to a water pipe. This ground should be a water pipe, *never a gas pipe*. Under no circumstances should the coil be operated unless this ground is established.

The coil is now ready to be set in operation. Clip the wires from the condenser and the spark gap to convenient turns of the primary of the high frequency transformer, start the spark gap motor, and turn on the power. A loud crackling noise should be heard and streamers of fire seen darting from the discharge ball. Vary the number and position of the turns used in the primary of the high frequency transformer and perhaps alter the capacity of the condenser until maximum output is obtained. Be sure that all power is shut off when these adjustments are made, and discharge the condensers as mentioned above before touching anything metallic.

THE BOY MECHANIC – 1913

How to Make a Small Electric Furnace

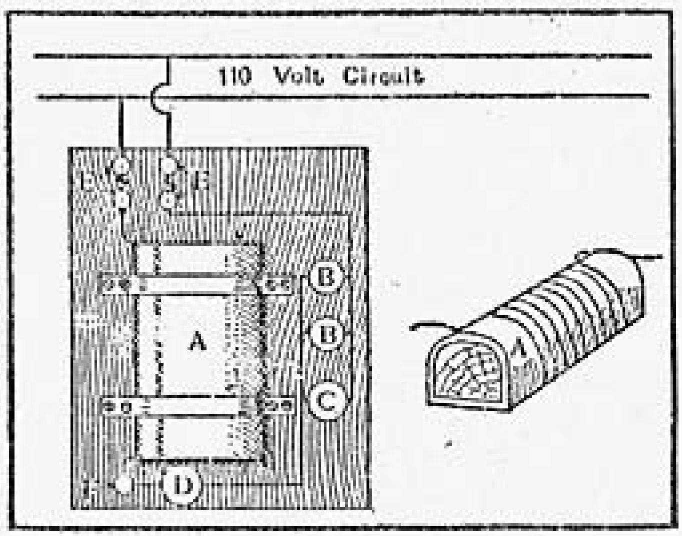
Take a block of wood and shape into a core. One like a loaf of bread, and about that size, serves admirably. Wrap a layer of asbestos around it and cover this with a thin layer of plaster-of-paris. When the plaster is nearly dry wind a coil of No. 36 wire around it, taking care that the wire does not touch itself anywhere. Put another course of plaster-of-paris on this, and again wind the wire around it. Continue the process of alternate layers of plaster and wire until 500 ft. or more of the latter has been used, leaving

 GRANDDAD'S ELCTRICITY BOOK

about 10 in. at each end for terminals. Then set the whole core away to dry.

For a base use a pine board 10 in. by 12 in. by 1 in. Bore four holes at one end for binding-posts, as indicated by E E. Connect the holes in pairs by ordinary house fuse wire. At one side secure two receptacles, B B, and one single post switch, C. Place another switch at I and another binding-post at F. The oven is now ready to be connected.

Withdraw the wooden core from the coils of wire and secure the latter by bands of tin to the board. Connect the ends of the wire to binding-posts E and F, as shown. From the other set of binding-posts, E, run a No. 12 or No. 14 wire, connecting lamp receptacles, B B, and switch, C, in parallel. Connect these three to switch, D, in series with binding-post, F, the terminal of the coil. Place 16-cp. lights in the receptacles and connect the fuses with a 110-volt lighting circuit. The apparatus is now ready for operation. Turn on switch, D, and the lamps, while C is open. The coil will commence to become warm, soon drying out the plaster-of-paris. To obtain more heat



Electric Furnace

open one lamp, and to obtain still more open the other and close switch C.—Contributed by Eugene Tuttles, Jr., Newark, Ohio.

Homemade Telegraph Key

A simple and easily constructed telegraph key may be made in the following manner: Procure a piece of sheet brass, about $\frac{1}{32}$ in. thick, and cut out a strip 3½ in. long by ¾ in. wide. Bend as shown in Fig. 1 and drill a hole for the knob in one end and a hole for a screw in the other. Procure a small wood knob and fasten it in place with a small screw. Cut a strip of the same brass 2¾ in. long and $\frac{5}{16}$ in. wide and bend as shown in Fig. 2. Drill two holes in the feet for screws to fasten it to the base, and one hole in the top part for a machine screw, and solder a small nut on the under side of the metal over the hole.

Mount both pieces on a base 4¼ by 2¾ by ¼ in., as in Fig. 3, and where

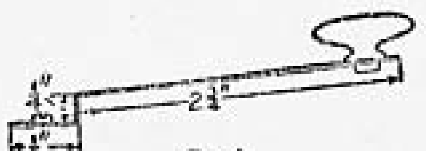


Fig.1

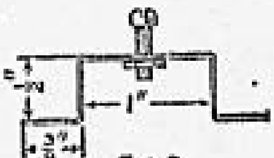


Fig.2

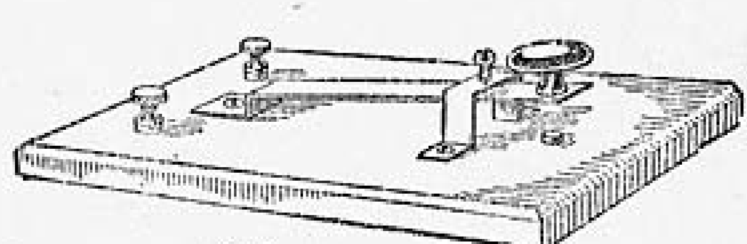


Fig.3

Brass Key on a Wood Base

the screw of the knob strikes the base when pressed down, put in a screw or brass-headed tack for a contact. Fasten the parts down with small brass wood-screws and solder the connections beneath the base. Binding-posts from an old battery cell are used on the end of the base. The screw on top of the arch is used to adjust the key for a long or short stroke.—Contributed by S. V. Cooke, Hamilton, Canada.

THE BOY MECHANIC – 1913

Homemade Electric Stove

By J. F. THOLL

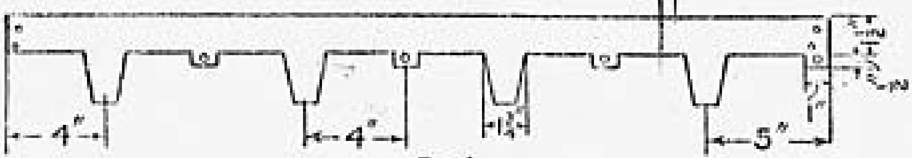


FIG. 1

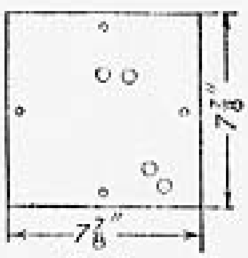


FIG. 2

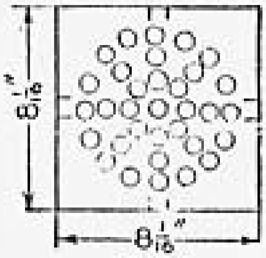


FIG. 3

FIG. 4

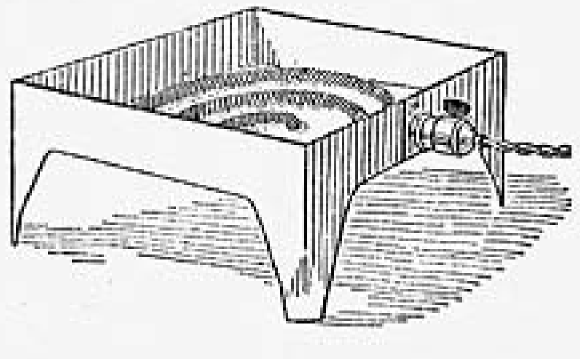


FIG. 5

Pattern for Parts of the Electric Stove

The construction of an electric stove is very simple, and it can be made by any home mechanic having a vise and hand drill. The body is made of sheet or galvanized iron, cut out and drilled as shown in Fig. 1.

Each long projection represents a leg, which is bent at right angles on the center line by placing the metal in the jaws of a vise and hammering the metal over flat. If just the rim is gripped in the vise, it will give a rounding form to the lower part of the legs. The small projections are bent in to form a support for the bottom.

The bottom consists of a square piece of metal, as shown in Fig. 2. Holes are drilled near the edges for stove bolts to fasten it to the bottom projections. Two of the larger holes are used for the ends of the coiled rod and the other two for the heating-wire terminals. The latter holes should be well insulated with porcelain or mica. The top consists of a square piece of metal drilled as shown in Fig. 3. Four small ears are turned down to hold the top in place.

One end of the coiled rod is shown in Fig. 4. This illustrates how two pins are inserted in holes, drilled at right angles, to hold the coil on the bottom plate. The coiled rod is $\frac{3}{16}$ in. in diameter and 27 in. long. The rod is wrapped with sheet asbestos, cut in ½-in. strips.

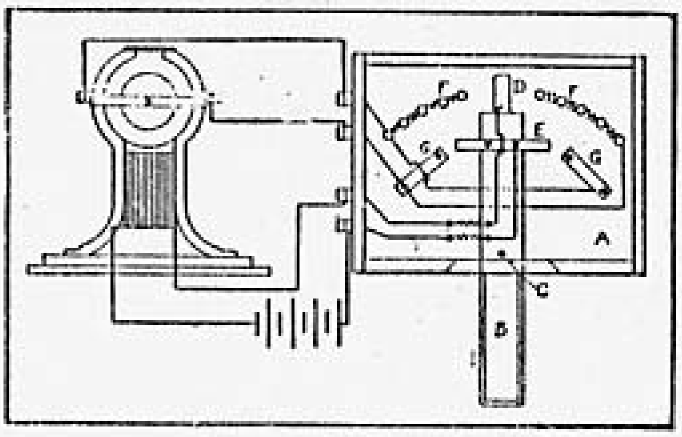
The length of the heating wire must be determined by a test. This wire can be purchased from electrical stores. Stovepipe wire will answer the purpose when regular heating wire cannot be obtained. The wire is coiled around the asbestos-covered rod, so that no coil will be in contact with another coil. If, by trial, the coil does not heat sufficiently, cut some of it off and try again. About 9½ ft. of No. 26 gauge heating wire will be about right. The connection to an electric-lamp socket is made with ordinary flexible cord, to which is attached a screw plug for making connections.

THE BOY MECHANIC – 1913

Controller for a Small Motor

An easy way of making a controlling and reversing device for small motors is as follows:

Cut a piece of wood (A) about 6 in. by 4½ in., and ¼ in. thick, and another piece (B) 6 in. by 1 in., and ¼ in. thick. Drive a nail through this near the center for a pivot (C). To the under side of one end nail a copper brush (D) to extend out about an inch. On the upper side, at the same end, nail another brush (E) so that it projects at both sides and is bent down to the level of the end brush. Then on the board put



Reverse for Motor

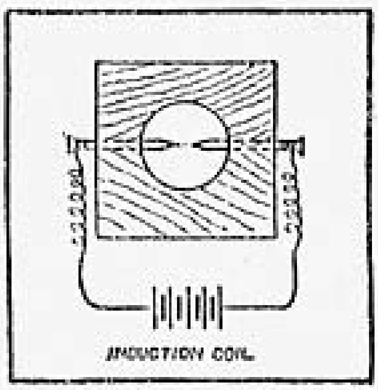
a semi-circle of brass-headed tacks as shown at F, leaving a small space at the middle and placing five tacks on either side, so that the end brush will come in contact with each one. Connect these tacks on the under side of the board with coils of German-silver wire, using about 8 in. of wire to each coil. Fix these by soldering or bending over the ends of the tacks. Then nail two strips of copper (G) in such position that the side brush will remain on the one as long as the end brush remains on the tacks on that side.

Put sides about 1½ in. high around this apparatus, raising the board a little from the bottom to allow room for the coil. A lid may be added if desired. Connect up as shown.—Contributed by Chas. H. Boyd, Philadelphia.

THE BOY MECHANIC – 1913

To Explode Powder with Electricity

A 1-in. hole was bored in the center of a 2-in. square block. Two finishing-nails were driven in, as shown in the sketch. These were connected to terminals of an induction coil. After everything was ready the powder was poured in the hole and a board weighted with rocks placed over the block. When the button is pressed or the circuit closed in some other way the discharge occurs. The distance between the nail points—which must be bright and clean—should be just enough to give a good, fat spark.—Contributed by Geo. W. Fry, San Jose, Cal.

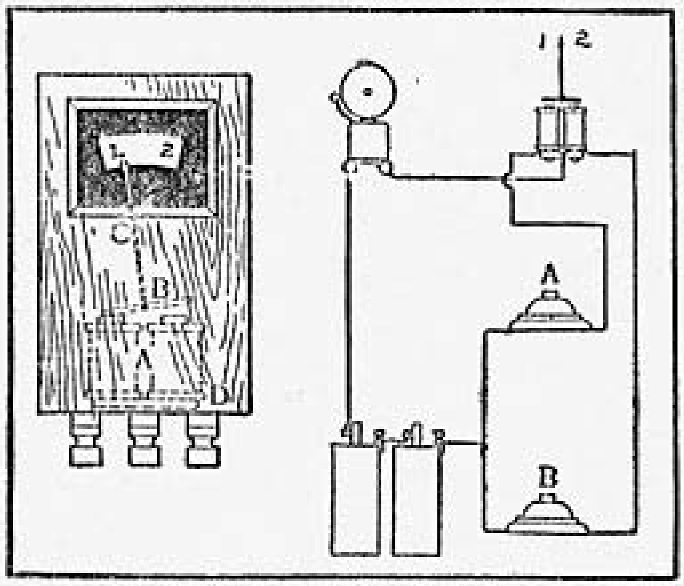


THE BOY MECHANIC – 1913

Homemade Annunciator

When one electric bell is operated from two push-buttons it is impossible to tell which of the two push-buttons is being operated unless an annunciator or similar device is used. A very simple annunciator for indicating two numbers can be made from a small box, Fig. 1, with an electric-bell magnet, A, fastened in the bottom. The armature, B, is pivoted in the center by means of a small piece of wire and has an indicator or hand, C, which moves to either right or left, depending on which half of the magnet is magnetized. If the back armature, D, of the magnet is removed the moving armature will work better, as this will prevent the magnetism from acting on both ends of the armature.

The wiring diagram, Fig. 2, shows how the connections are to be made. If the push-button A is closed, the bell will ring and the pointer will point at 1, while the closing of the push-button B will ring the bell and move the pointer to 2.—Contributed by H. S. Bott, Beverly, N. J.

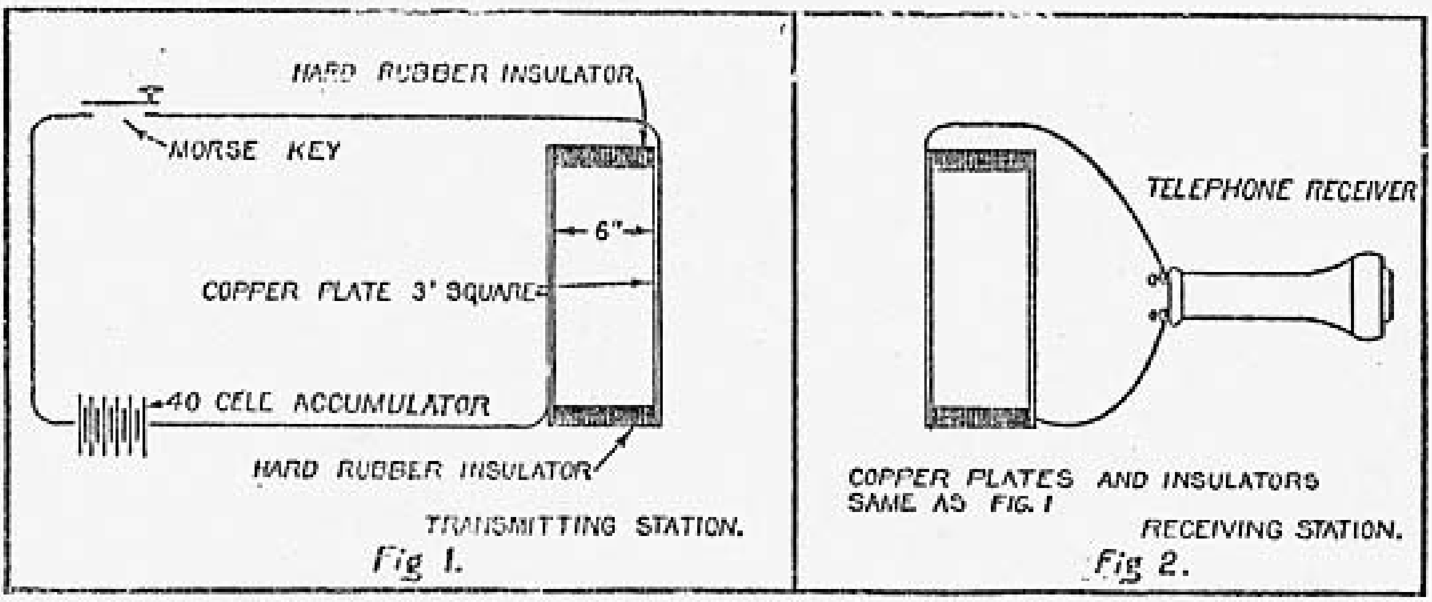


Annunciator and Wiring Diagram

THE BOY MECHANIC – 1913

Simple Wireless System

The illustrations will make plain a simple and inexpensive apparatus for wireless telegraphy by which I have had no difficulty in sending messages across 1½ miles of water surface. It is so simple that the cuts scarcely need explanation. In Fig. 1 is seen the sending apparatus, consisting of a 40-cell battery connected with two copper plates 36 by 36 by ⅛ in. The plates are separated 6 in. by a piece of hard rubber at each end.



Simple Wireless System

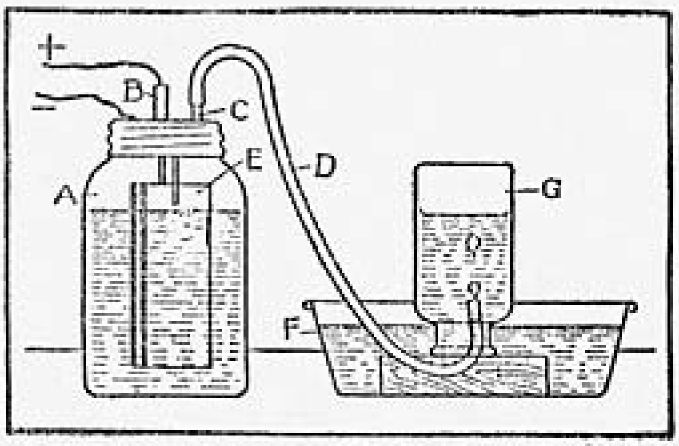
In Fig. 2 are seen duplicates of these insulated plates, connected with an ordinary telephone rèceiver. With this receiver I can hear distinctly the electric signals made by closing and opening the Morse key in Fig. 1, and I believe that in a short time I shall be able to perfect this system so as to send wireless messages over long distances.—Contributed by Dudley H. Cohen, New York.

THE BOY MECHANIC – 1913

Small Electrical Hydrogen Generator

A small hydrogen generator may be made from a fruit jar, A (see sketch), with two tubes, B and C, soldered in the top. The plates E can be made of tin or galvanized iron, and should be separated about ⅛ in. by small pieces of wood. One of these plates is connected to metal top, and the wire from the other passes through the tube B, which is filled with melted rosin or wax, to make it airtight. This wire connects to one side of a battery of two cells, the other wire being soldered to the metal top of the jar, as shown. The jar is partly filled with a very dilute solution of salphuric acid, about 1 part of acid to 20 of water.

When the current of electricity passes between the plates E, hydrogen gas is generated, which rises and passes through the rubber hose D, into the receiver G. This is a wide-mouth bottle, which is filled with water and inverted over a pan of water, F. The gas bubbling up displaces the water and fills the bottle.



Hydrogen Generator

If the receiver is removed when half full of gas, the remaining space will be filled with air, which will mix with the

 GRANDDAD'S ELCTRICITY BOOK

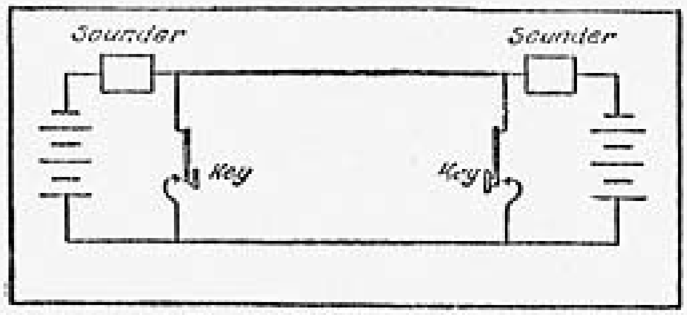
gas and form an explosive mixture. If a lighted match is then held near the mouth of the bottle a sharp report will be heard.

If the bottle is fitted with a cork containing two wires nearly touching, and the apparatus connected with an induction coil, in such a manner that a spark will be produced inside the bottle, the explosion will blow out the cork or possibly break the bottle. Caution should be used to avoid being struck by pieces of flying glass if this experiment is tried, and under no condition should a lighted match or spark be brought near the end of the rubber hose D, as the presence of a little air in the generator will make an explosive mixture which would probably break the jar.

THE BOY MECHANIC – 1913

Simple Open-Circuit Telegraph Line

By using the circuit shown in the sketch for short-distance telegraph lines, the extra switches and wiring found in many circuits are done away with. Closing either key will operate both sounders, and, as the resistance of



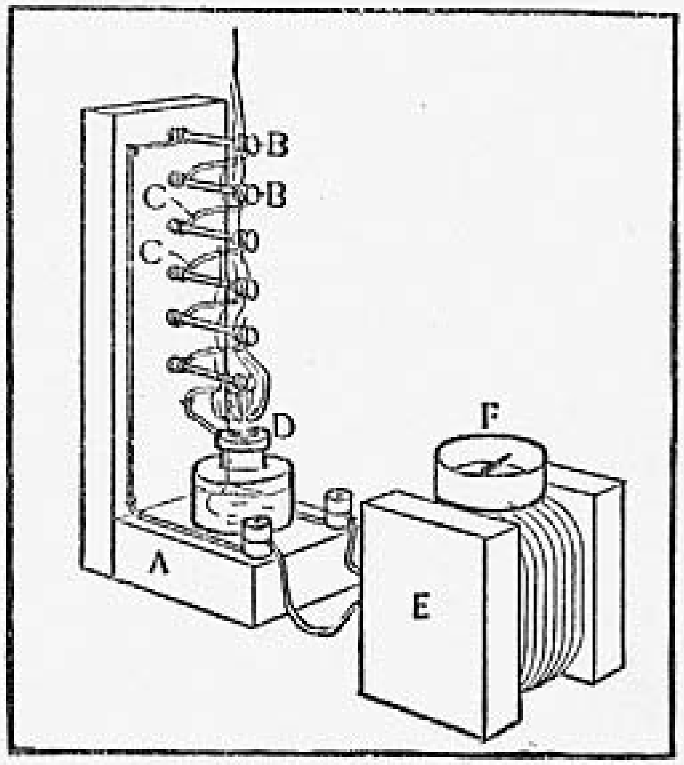
Simple Telegraph Line

the sounders is very high, the batteries do not run down for a long time.—Contributed by A. D. Stoddard, Clay Center, Kan.

THE BOY MECHANIC – 1913

How to Make a Thermo Battery

A thermo battery, for producing electricity direct from heat, can be made of a wooden frame, A, with a number of nails, B, driven in the vertical piece and connected in series with heavy copper wires, C. The connections should all be soldered to give good results, as the voltage is



Thermo Battery

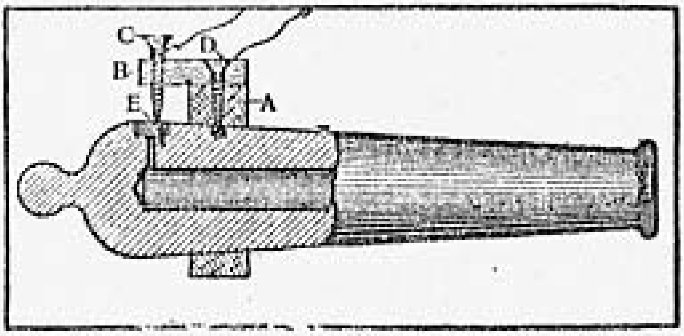
very low and the resistance of an unsoldered joint would stop the current.

The heat may be supplied by an alcohol lamp or other device, and the current may then be detected by means of a simple galvanometer consisting of a square spool of No. 14 or No. 16 single-covered wire, E, with a pocket compass, F, placed on top. Turn the spool in a north and south direction, or parallel with the compass needle. Then, when the nail heads are heated and the circuit completed, the needle will swing around it at right angles to the coils of wire. Applying ice or cold water to the nail heads will reverse the current.—Contributed by A. C. A., Chicago.

THE BOY MECHANIC – 1913

How to Discharge a Toy Cannon by Electricity

A device for discharging a toy cannon by electricity can be easily made by using three or four dry batteries, a switch and a small induction coil capable of giving a ⅛-in. spark. Fasten a piece of wood, A, to the cannon, by means of machine screws or,



Electrical Attachment for Discharging Toy Cannon

if there are no trunnions on the cannon, the wood may be made in the shape of a ring and slipped on over the muzzle. The fuse hole of the cannon is counterbored as shown and a small hole is drilled at one side to receive a small piece of copper wire, E. The wood screw, C, nearly touches E and is connected to one binding post of the induction coil. The other binding post is connected with the wood screw, D, which conducts the current into the cannon, and also holds the pieces of wood, A and B, in position.

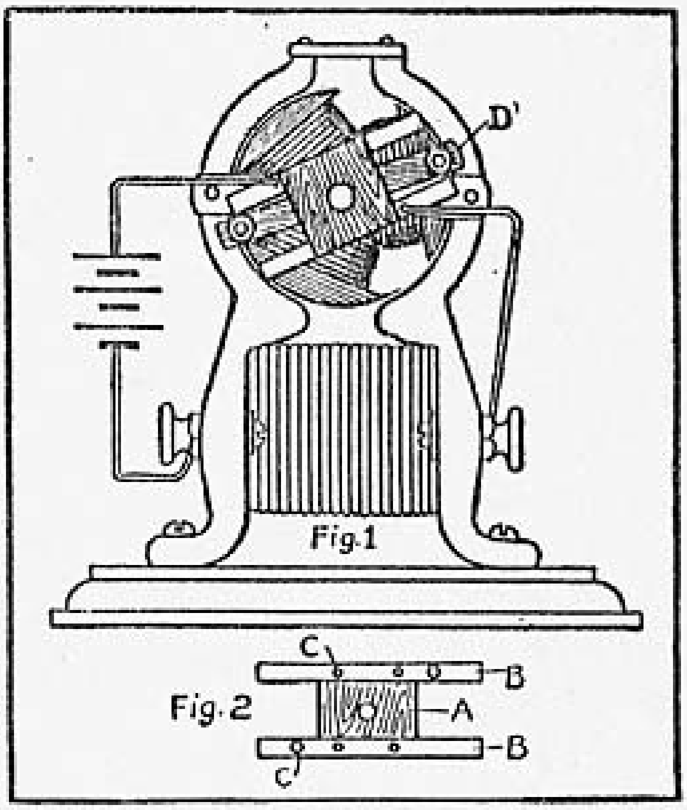
When the cannon is loaded, a small quantity of powder is placed in the counterbore, and the spark between C and E ignites this and discharges the cannon. A cannon may be fired from a distance in this way, and as there is no danger of any spark remaining after the current is shut off, it is safer than the ordinary cannon which is fired by means of a fuse.—Contributed by Henry Peck, Big Rapids, Mich.

THE BOY MECHANIC – 1913

Direct-Connected Reverse for Small Motors

A simple reverse for small motors can be attached directly to the motor as shown in Fig. 1. Fig. 2 shows the construction of the reverse block: A is a strip of walnut 5/8 in. square and 3/8 in. thick with strips of brass or copper (BB) attached as shown. Holes (CC) are drilled for the wire connections and they must be flush with the surface of the block. A hole for a 1/2-in. screw is bored in the block. In Fig. 1, D is a thin strip of walnut or other dense, hard wood fitted to the binding posts of the brush holders, to receive the screw in the center.

Before putting the reverse block on the motor, remove all the connections between the lower binding posts and the brush holders and connect both ends of the field coil to the lower posts. Bend the strips BB (Fig. 2) to the proper position to make a wiping contact with the nuts holding the strip of wood D, Fig. 1. Put the screw in tight



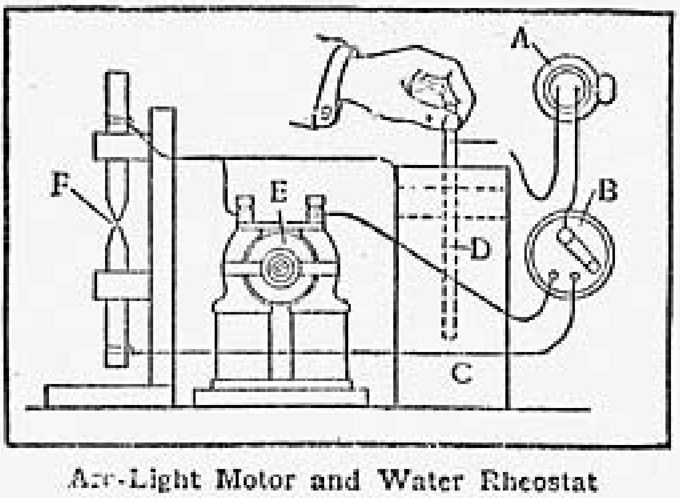
Direct-Connected Reverse

enough to make the block turn a little hard. Connect as shown in the illustration. To reverse, turn the block so the strips change connections and the motor will do the rest.—Contributed by Joseph B. Keil, Marion, Ohio.

THE BOY MECHANIC – 1913

Easy Experiments with Electric-Light Circuit

An electric-light circuit will be found much less expensive than batteries for performing electrical experiments. The sketch shows how a small arc light and motor may be connected to the light socket, A. The light is removed and a plug with wire connections is put in its place. One wire runs to the switch, B, and the other connects with the water rheostat, which is used for reducing the current.



Arc-Light Motor and Water Rheostat

A tin can, C, is filled nearly to the top with salt water, and a metal rod, D, is passed through a piece of wood fastened at the top of the can. When the metal rod is lowered the current increases, and as it is withdrawn the current grows weaker. In this way the desired amount of current can be obtained.

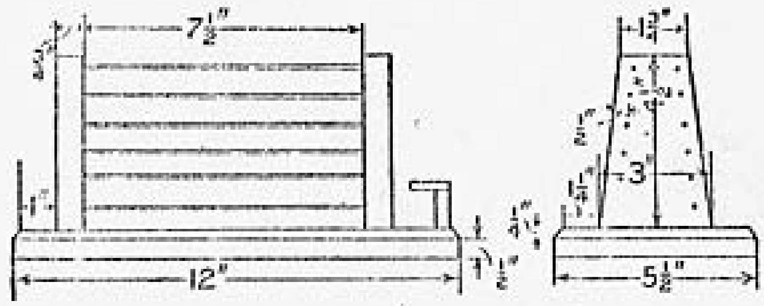
By connecting the motor, E, and the arc light, F, as shown, either one may be operated by turning switch B to the corresponding point. The arc light is easily made by fastening two electric-light carbons in a wooden frame like that shown. To start the light, turn the current on strong and bring the points of the carbons together; then separate slightly by twisting the upper carbon and at the same time drawing it through the hole.

THE BOY MECHANIC – 1913

How to Make an Electric Toaster

The electric toaster shown in the sketch is not hard to make. The framework comprising the base and the two uprights may be made either of hardwood or asbestos board, says Popular Electricity. If constructed of the former, the portion of the base under the coil, and the inside surfaces of the two uprights should be covered with a 1/8-in. sheet of well made asbestos paper, or thin asbestos board may be substituted for this lining. Asbestos board is to be preferred, and this material in almost any degree of hardness may be purchased. It can be worked into shape and will hold wood-screws. The detail drawing gives all dimensions necessary to shape the wood or asbestos board.

After preparing the base and uprights, drill 15 holes, 1/4 in. deep, into the inside face of each upright to support the No. 6 gauge wires shown. The wires at the top and bottom for holding the resistance wire are covered with asbestos paper and the holes for these wires are 3/4 in. from the top and bottom, respectively, of the uprights. The wires that form the cage about the heater coil and are used for a support for the toast are 15 pieces of No. 6 gauge iron wire each 8 in. long. The screws that hold the uprights in position should have the heads countersunk on the under side of the base. The binding-posts should now be set in position and their protecting cover-

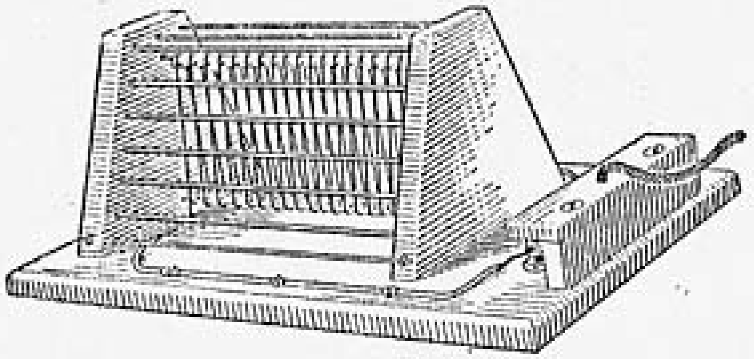


Detail of Toaster

ing containing the reinforced cord left until the other parts are finished.

To assemble, secure one upright in position using 1½-in. wood-screws. Place the other upright where it belongs without fastening it and put the stretcher wires for holding the resistance wire in place. Put the asbestos paper on these and with the assistance of a helper begin winding on the heater coil. Use 80 ft. of 18-per-cent No. 22 gauge German-silver wire. Wind the successive turns of wire so they will not touch each other and fasten at each end with a turn or two of No. 16 gauge

 GRANDDAD'S ELCTRICITY BOOK



Toaster Complete

copper wire. When this is complete have the helper hold the stretcher wires while you tip the unfastened upright out and insert the wires of the cage, then fasten the upright in place.

The wire from the binding-posts to the coil may be what is known as underwriters' wire or asbestos-covered wire No. 14 gauge, which is held in place by double-headed tacks containing an insulation at the head. These may be procured from electrical supply houses. Connect the reinforced cord and terminals to the binding screws and fasten the cover in place. This toaster will take four amperes on 110-volt circuit.

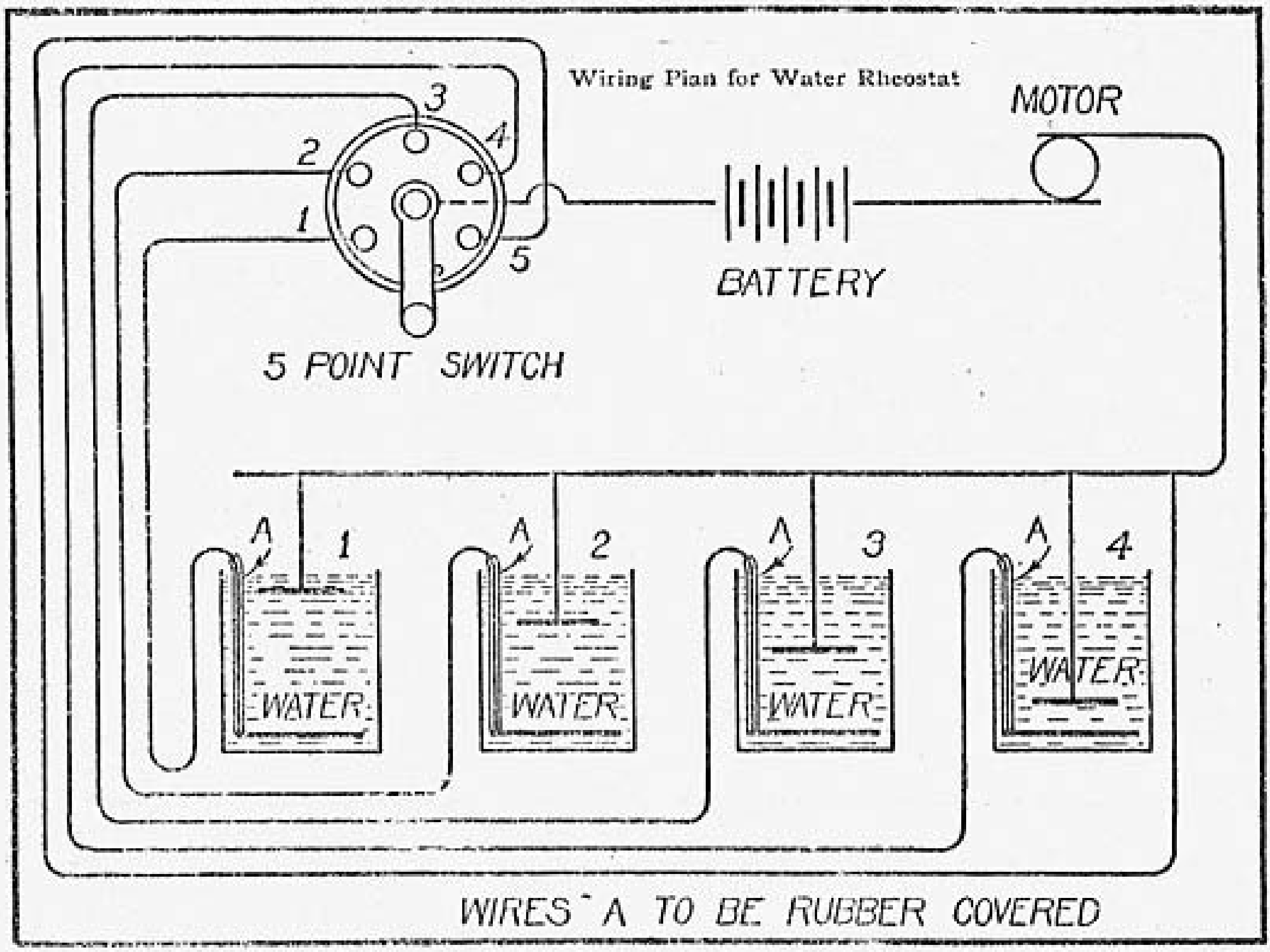
THE BOY MECHANIC – 1913

How to Make a Simple Water Rheostat

The materials necessary are: One 5-point wood-base switch, 4 jars, some sheet copper or brass for plates, about 5 ft. of rubber-covered wire, and some No. 18 gauge wire for the wiring.

The size of the jars depends on the voltage. If you are going to use a current of low tension, as from batteries, the jars need not be very large, but if you intend to use the electric-light current of 110 voltage it will be necessary to use large jars or wooden boxes made watertight, which will hold about 6 or 7 gal. Each jar to be filled with 20 parts water to 1 part sulphuric acid. Jars are set in a row in some convenient place out of the way.

Next cut out eight copper or brass disks, two for each jar. Their size also depends on the voltage. The disks that are placed in the lower part of the jars are connected with a rubber-



Wiring Plan for Water Rheostat

covered wire extending a little above the top of the jar.

To wire the apparatus, refer to the sketch and you will see that jar No. 1 is connected to point No. 1 on switch; No. 2, on No. 2, and so on until all is complete and we have one remaining point on switch. Above the jars place a wire to suspend the other or top disks in the solution. This wire is also connected to one terminal on the motor and to remaining point on switch. The arm of the switch is connected to one terminal of battery, or source of current, and the other terminal connected direct to remaining terminal of motor.

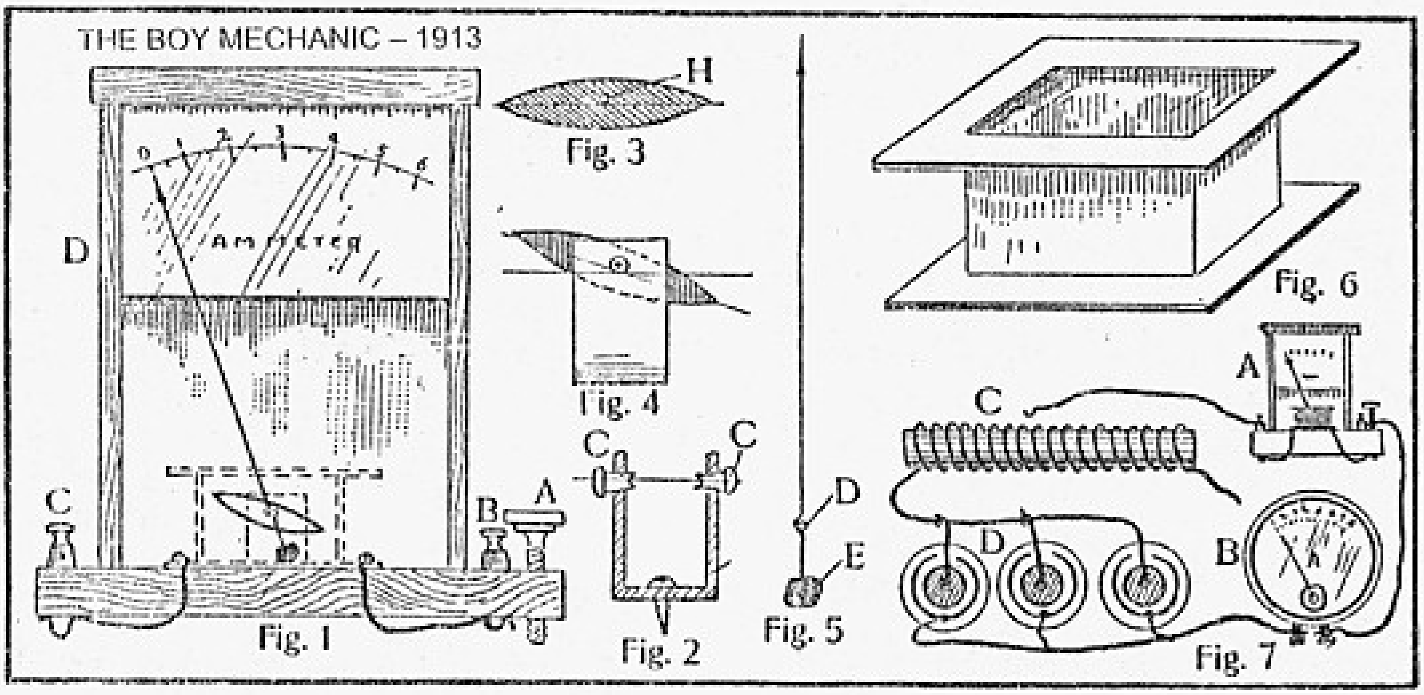
Put arm of switch on point No. 1 and lower one of the top disks in jar No. 1 and make contact with wire above jars. The current then will flow through the motor. The speed for each point can be determined by lowering top disks in jars. The top disk in jar No. 2 is lower down than in No. 1 and so on for No. 3 and No. 4. The connection between point No. 5 on switch, direct to wire across jars, gives full current and full speed.

How to Make an Ammeter

Every amateur mechanic who performs electrical experiments will find use for an ammeter, and for the benefit of those who wish to construct such an instrument the following description is given: The operative principle of this instrument is the same as that of a galvanometer, except that its working position is not confined to the magnetic meridian. This is accomplished by making the needle revolve in a vertical instead of a horizontal plane. The only adjustment necessary is that of leveling, which is accomplished by turning the thumbscrew shown at A, Fig. 1, until the hand points to zero on the scale.

First make a support, Fig. 2, by bending a piece of sheet brass to the shape indicated and tapping for the screws CC. These should have hollow ends, as shown, for the purpose of receiving the pivoted axle which supports the hand. The core, Fig. 3, is made of iron. It is 1 in. long, ¼ in. wide and ⅛ in. thick. At a point a little above the center, drill a hole as shown at H, and through this hole drive a piece of knitting-needle about ½ in. long, or long enough to reach between the two screws shown in Fig. 2. The ends of this small axle should be ground pointed and should turn easily in the cavities, as the sensitiveness of the instrument depends on the ease with which this axle turns.

After assembling the core as shown



Complete Ammeter and Details

in Fig. 4, it should be filed a little at one end until it assumes the position indicated. The pointer or hand, Fig. 5, is made of wire, aluminum being preferable for this purpose, although copper or steel will do. Make the wire 4½ in. long and make a loop, D, ½ in. from the lower end. Solder to the short end a piece of brass, E, of such weight that it will exactly balance the weight of the hand. This is slipped on the pivot, and the whole thing is again placed in position in the support. If the pointer is correctly balanced it should take the position shown in Fig. 1, but if it is not exactly right a little filing will bring it near enough so that it may be corrected by the adjusting-screw.

Next make a brass frame as shown in Fig. 6. This may be made of wood, although brass is better, as the eddy currents set up in a conductor surrounding a magnet tend to stop oscillation of the magnet. (The core is magnetized when a current flows through the instrument.) The brass frame is wound with magnet wire, the size depending on the number of amperes to be measured. Mine is wound with two layers of No. 14 wire, 10 turns to each layer, and is about right for ordinary experimental purposes. The ends of the wire are fastened to the binding posts B and C, Fig. 1.

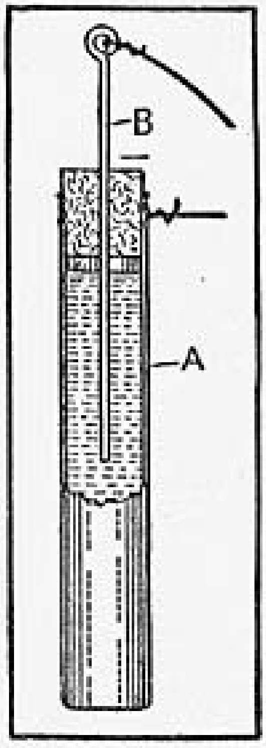
A wooden box, D, is then made and provided with a glass front. A piece of paper is pasted on a piece of wood, which is then fastened in the box in such a position that the hand or pointer will lie close to the paper scale. The box is 5½ in. high, 4 in. wide and 1¾ in. deep, inside measurements. After everything is assembled put a drop of solder on the loop at D, Fig. 5, to prevent it turning on the axle.

To calibrate the instrument connect as shown in Fig. 7, where A is the homemade ammeter; B, a standard ammeter; C, a variable resistance, and D, a battery, consisting of three or more cells connected in multiple. Throw in enough resistance to make the standard instrument read 1 ohm and then put a mark on the paper scale of the instrument to be calibrated. Continue in this way with 2 amperes, 3 amperes, 4 amperes, etc., until the scale is full. To make a voltmeter out of this instrument, wind with plenty of No. 36 magnet wire instead of No. 14, or if it is desired to make an instrument for measuring both volts and amperes, use both windings and connect to two pairs of binding posts.—Contributed by J. E. Dussault, Montreal.

THE BOY MECHANIC – 1913

How to Make a Water Rheostat

A water rheostat may be made by fitting a brass tube with a cork, through which a piece of wire is passed. The brass tube may be an old bicycle hand pump, A (see sketch), filled with water. Pushing the wire, B, down into the water increases the surface in contact, and thus decreases the resistance. An apparatus of this kind is suitable for regulating the current from an induction coil, when the coil is not provided with a regulator, and by using a piece of pipe instead of the tube, it can be used to regulate the speed of a motor.



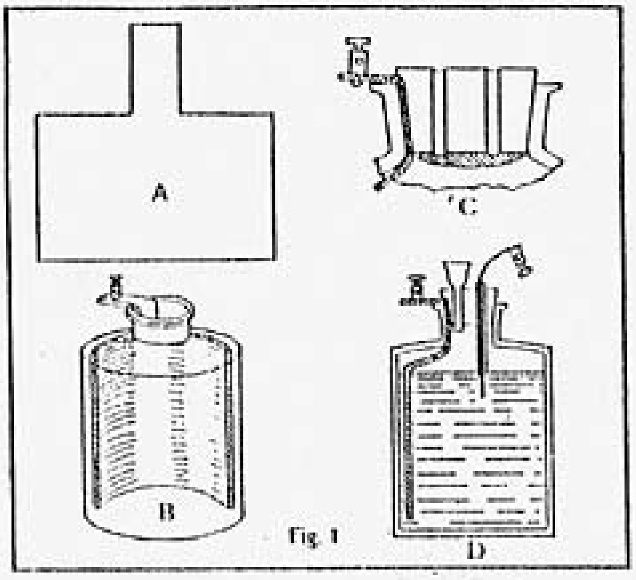
Water Rheostat

When the pipe is used, a piece of brass or copper rod should be substituted for the wire, in order to increase the surface. Adding salt to the water will decrease the resistance, and, when used with a motor, will give a greater speed.—Contributed by John Koehler, Ridgewood, N. J.

THE BOY MECHANIC – 1913

How to Make an Interrupter

The Wenult interrupter is an instrument much used on large coils and is far more efficient than the usual

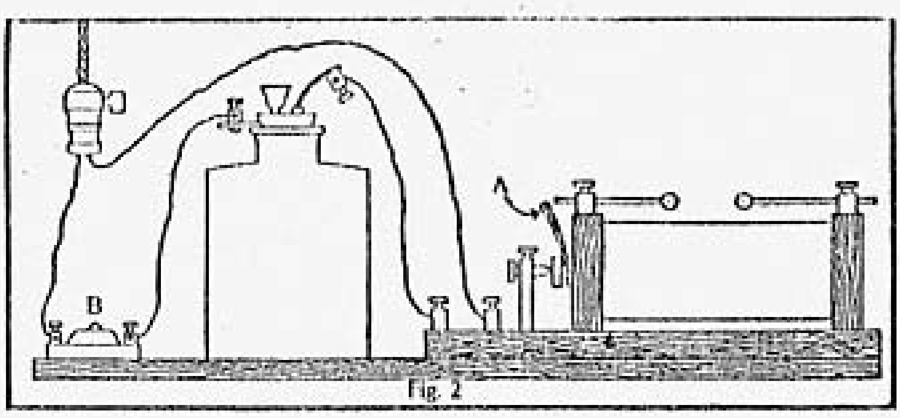


Details of Interrupter

form of vibrators. It can also be used with success on small coils as well as large. Although it is a costly instrument to purchase, it can be made with practically no expense and the construction is very simple.

First procure a wide-mouthed bottle about 4 in. high, provided with a rubber stopper. This stopper should be pierced, making two holes about $\frac{1}{4}$ in. in diameter.

From a sheet of lead $\frac{1}{16}$ in. in thickness cut a piece shaped like A, Fig. 1. Common tea lead folded several times will serve the purpose. When in the bottle this lead should be of such a size that it will only reach half way around, as shown in B. To insert the lead plate, roll it up so it will pass through the neck of the bottle, then smooth it



The Completed Instrument

out with a small stick until it fits against the side, leaving the small strip at the top projecting through the neck of the bottle. Bend this strip to one side and fit in the stopper, as shown in C. A small binding-post is fastened at the end of the strip.

Having fixed the lead plate in position, next get a piece of glass tube having a bore of about 1/32 of an inch in diameter. A piece of an old thermometer tube will serve this purpose. Insert this tube in the hole in the stopper farthest from the lead plate. Get a piece of wire that will fit the tube and about 6 in. long, and fasten a small binding-post on one end and stick the other into the tube. This wire should fit the hole in the tube so it can be easily moved. In the hole nearest the lead plate insert a small glass funnel.

The interrupter as it is when complete is shown at D, Fig. 1. Having finished the interrupter, connect it with the electric-light circuit as shown in Fig. 2. Fill the bottle with water to about the line as shown in D, Fig. 1. Adjust the wire in the small glass tube so that it projects about $\frac{1}{8}$ in. Add sulphuric acid until the water level rises about $\frac{1}{16}$ in. Turn on the current and press the button, B. If all adjustments are correct, there will be a loud crackling noise from the interrupter, a violet flame will appear at the end of the wire and a hot spark will pass between the secondary terminals. If the interrupter does not work at first, add more sulphuric acid through the funnel and press the wire down a lamp cord, passed through a hole in the bottom of the can and knotted inside to prevent pulling out.

A disk of thin sheet-iron, such as is used by photographers for tintypes (Ferrotype), should be cut to the diameter of the can, taking care not to bend the iron. The magnet should then be placed in the bottom of the can in an upright position and enough of a melted mixture of beeswax and resin poured in to hold it in position.

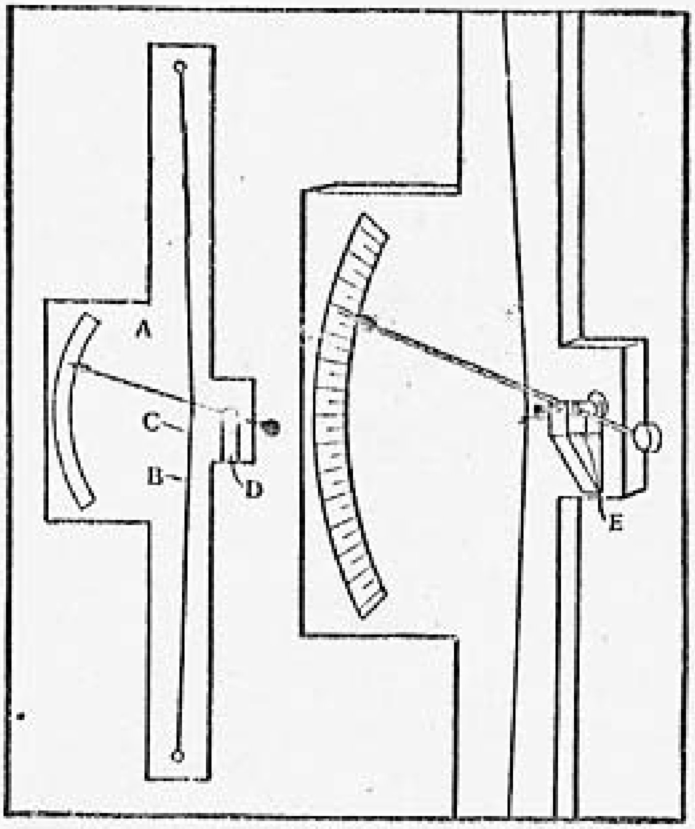
While the wax is still in a plastic condition the magnet should be located centrally and adjusted so that the end will be $\frac{1}{16}$ in. or less below the level of the top of the copper ring.

After the wax has hardened the disk is slipped in and fastened tightly by a ring of solder when the instrument is ready for use.

THE BOY MECHANIC – 1913

How to Make a Hygrometer

A homemade hygrometer, for determining the degree of moisture in the atmosphere, is shown in the accompanying sketch and consists of a board, A, with a nail at each end to hold the silk thread B. A second piece of silk thread, C, is tied to the center of B and connects with an indicating hand or pointer supported by the bracket D. The axle on which the pointer revolves consists of a piece of round wood, about the size of a lead-pencil, with a pin driven in each end. A piece of tin, E, is cut V-shaped at each end and bent up at the ends to form bearings for the pins. The silk thread C is fastened to the wooden axle and is wrapped one or two turns around it, so that when



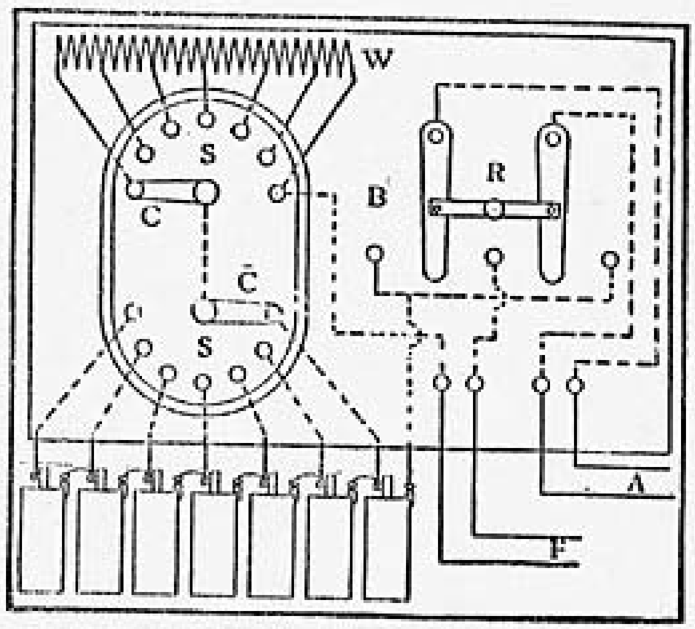
The Hygrometer

the thread is pulled the pointer will move on the scale. It will be noticed that the thread B is not perfectly straight, but bends toward D. For this reason a very small shrinkage of B, such as occurs when the atmosphere is dry, will cause an increased movement of C, which will be further increased in the movement of the pointer. An instrument of this kind is very interesting and costs nothing to make.—Contributed by Reader, Denver.

THE BOY MECHANIC – 1913

A Controller and Reverse for a Battery Motor

Secure a cigar or starch box and use to make the base, B. Two wood-base switches, S S, are cut off a little past the center and fastened to the base with a piece of wood between them. The upper switch, S, is connected to different equal points on a coil of wire, W, while the lower switch, S, is connected each point to a battery, as shown. The reverse switch, R, is



Motor Reverse and Controller

made from two brass or copper strips fastened at the top to the base with screws and joined together by a piece of hard rubber or wood with a small handle attached. Connect wires A to the armature and wires F to the field of the motor. By this arrangement one, two or three and so on up until all the battery cells are used and different points of resistance secured on the coil of wire. The reverse lever when moved from right to left, or left to right, changes the direction of the armature in the motor from one way to the other.—Contributed by J. Fremont Hilscher, Jr., West St. Paul, Minn.

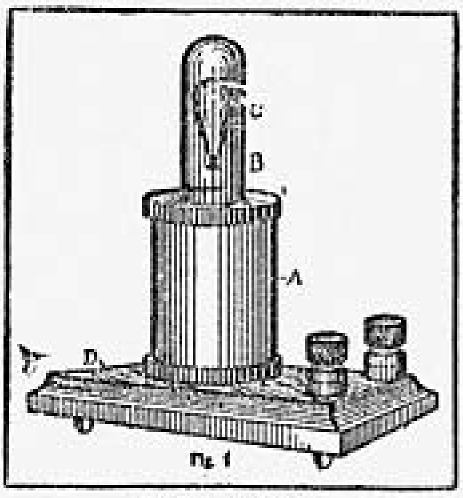
THE BOY MECHANIC – 1913

How to Make a Galvanoscope

A galvanoscope for detecting small currents of electricity can be made from a coil of wire, A; a glass tube, B, full of water; a core, C; and a base, D, with binding posts as shown. The core C, which is made of iron and cork, is a trifle lighter than the water it displaces and will therefore normally remain in the top of the tube; but as soon as a current of electricity passes through the coil, the core is drawn down out of sight. The current required is very small, as the core is so nearly balanced that the least attraction will cause it to sink.

The glass tube may be a test tube, as shown in Fig. 2, or an empty developer tube. If one has neither a test tube nor developer tube, an empty pill bottle may be used. The washers at the ends of the coil can be made of fiber, hard rubber, or wood; or can be taken from an old magnet. The base may be made of wood or any other insulating material and should have four short legs on the bottom. Make the coil of single-covered wire about No. 18 and connect ends to binding posts as shown in Fig. 2.

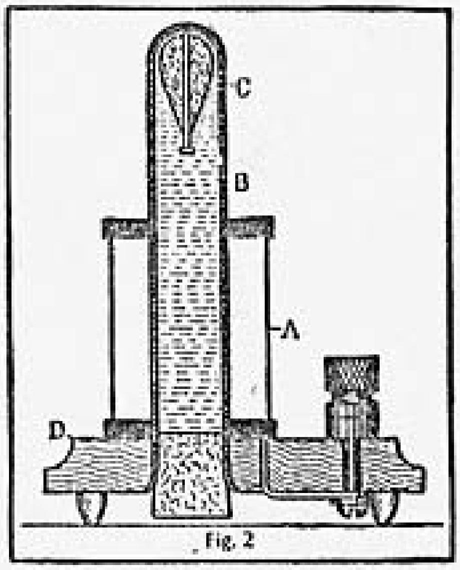
The core is made by pushing a small nail through a piece of cork. It should be made so that it will rise slowly when placed under water. Some filing may be necessary to get the weight just right, but it should be remembered that the buoyancy of the core can be adjusted after the parts are assembled, by pressing the cork in the bottom of the test tube. This causes compression in the water so that some is forced into the upper cork, reducing its displacement and causing it to sink. The lower cork is then slowly withdrawn, by twisting, until the core slowly rises.



Galvanoscope

The instrument will then be adjusted ready for use.

Connect the binding posts to a single cell of battery—any kind will do, as a slight current will answer. On com-



Interior View

pleting the circuit the core will descend; or put in a switch or push button on one of the battery wires. If the button be concealed where the operator can reach it, the core will obey his command to rise or fall, according to his control of the current. This is a mysterious looking instrument, the core being moved without visible connection to any other part.

THE BOY MECHANIC – 1913

How to Make a Telegraph Key and Sounder

The sounder, Fig. 1, is made from an

 GRANDDAD'S ELCTRICITY BOOK

old electric-bell magnet, D, fastened to a wooden base. The lever, A, can be made of brass and the armature, C, is made of iron. The pivot, E, is made from a wire nail and is soldered to A. It should be filed to a point at each end so as to move freely in the bearings, B, which are pieces of hard wood.

The spring, H, is fastened at each end by pins, bent as shown, and should not be too strong or the magnet will be unable to move the armature. The

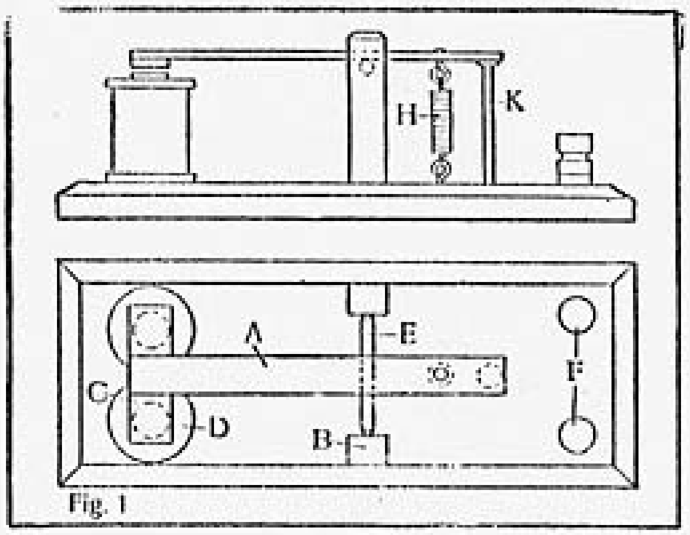


Fig. 1

SOUNDER—A, brass; B, wood; C, soft iron; DD, coils wound with No. 26 wire; E, nail soldered on A; FF, binding posts; H spring

stop, K, is a wire nail driven deep enough in the base to leave about ⅛ in. between the armature and the magnet. The binding posts, F, may be taken from old dry batteries and are connected to the two wires from the magnet by wires run in grooves cut in the base.

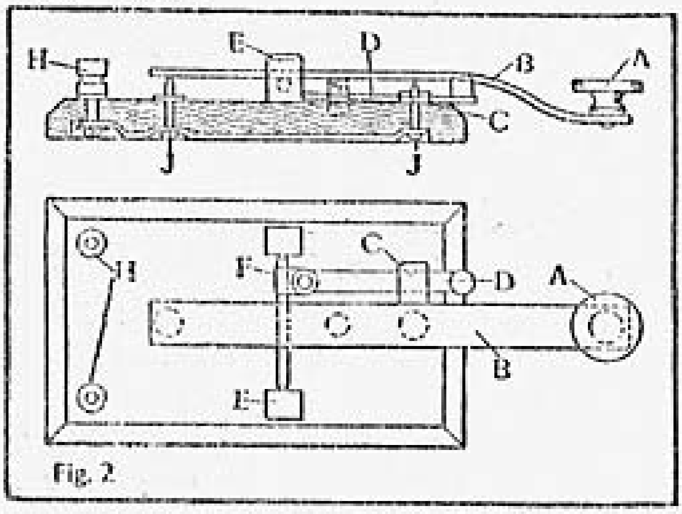


Fig. 2

KEY—A, wood; B, brass or iron soldered to nail; C, brass; D, brass; E, wood; F, connection of D to nail; HH, binding posts

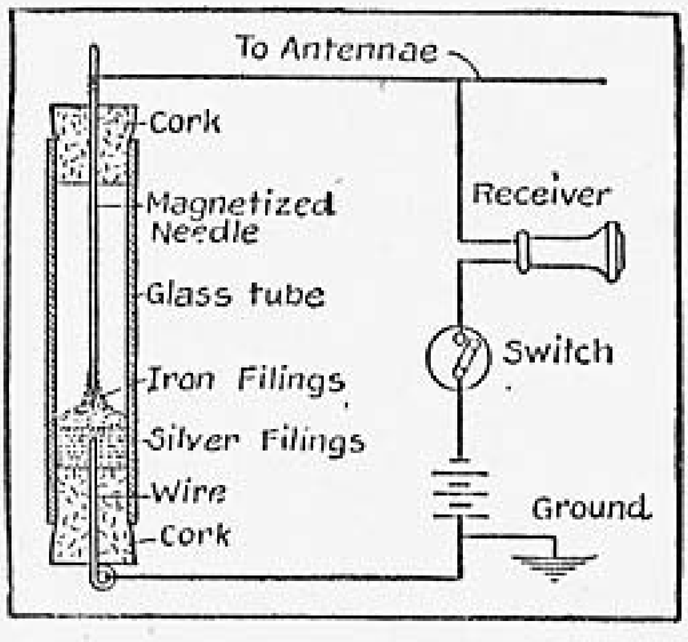
The base of the key, Fig. 2, is also made of wood and has two wooden bearings, E, which are made to receive a pivot, similar to the one used in the sounder. The lever of the key is made of brass and has a hardwood knob, A, fastened near the end. A switch, D, connects with the pivot at F and can be either made from sheet brass, or taken from a small one-point switch. The binding posts are like those of the sounder, and are connected to the contacts, K, by wires run in grooves cut in the wood

THE BOY MECHANIC – 1913

Easily Made Wireless Coherer

A good wireless coherer may be made with very little expense, the only materials necessary being a glass tube, two corks, a magnetized needle and a quantity of iron and silver filings. Push a piece of wire through one cork and place in the bottom of the tube, as shown in the sketch.

Pour in the filings and insert the top cork with the needle pushed through



Detail of Coherer

from above. The point of the needle should barely touch the filings and by slightly agitating the tube the iron filings will separate from the silver and cling to the magnetized needle, as shown.

In operation, the device must stand

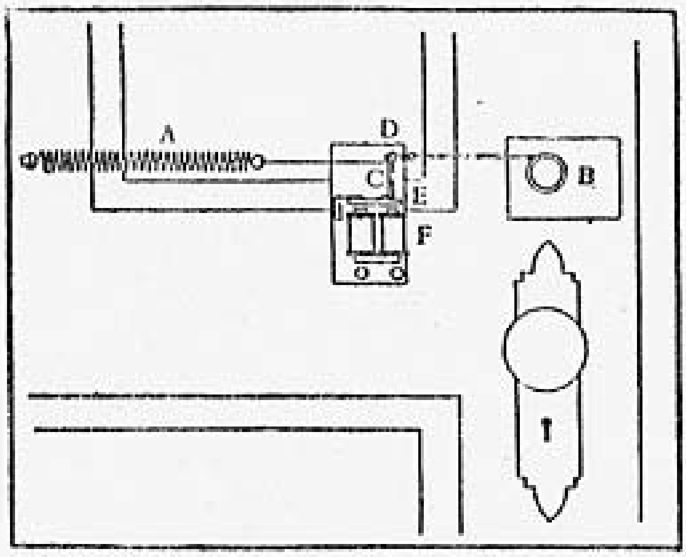
on end and should be connected in the circuit as shown in the sketch. When the electrical waves strike the needle, the conductivity of the filings is established and a click is heard in the receiver.—Contributed by Carl Formhals, Garfield, Ill.

THE BOY MECHANIC – 1913

Electric Door-Opener

A very convenient and efficient device for unlocking any door fitted with a spring lock is shown in the accompanying sketches. A fairly stiff spring, A, is connected by a flexible wire cord to the knob B. The cord is also fastened to a lever, C, which is pivoted at D and is released by a magnetic trigger, E, made from the armature and magnet of an old electric bell.

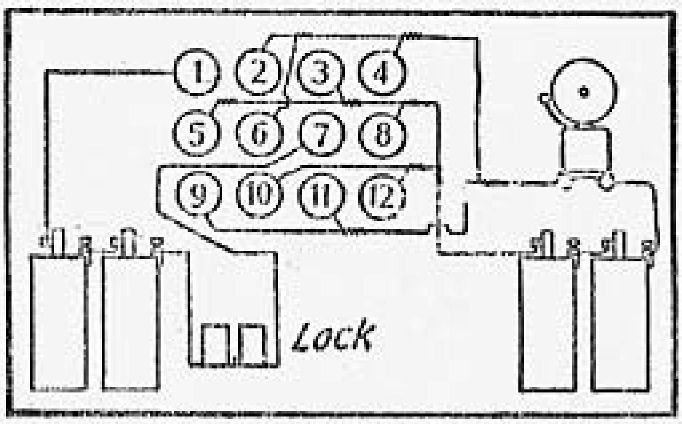
When the circuit is completed by means of a secret contact device outside the door, the magnet, F, pulls down the armature, which releases the trigger and allows the spring to open the lock. If there are metal numbers on the outside of the door they may be used for the secret contact, if desired,



Apparatus Placed on Inside of Door

but if there are no numbers on the door, a small contact-board may be constructed by driving about 12 brass-headed tacks into a thin piece of wood and making connections at the back as shown in the wiring diagram.

In this particular diagram the tacks numbered 1 and 7 are used for unlocking the door, the others being connected with the electric-bell circuit as indicated, for the purpose of giving an alarm should anybody try to experiment with the secret contacts. By means of a pocket knife or other metal article the operator can let himself in at any time by connecting the tacks numbered 1 and 7, while a person not knowing the combination would be liable to sound the alarm. Of course, the builder of this device may choose a combination of his own and may thus prevent anybody else from entering the door, even those who read this description.—Contributed by Perry A. Borden, Gachville, N. B.



Wiring Diagram

THE BOY MECHANIC – 1913

One-Wire Telegraph Line

The accompanying wiring diagram shows a telegraph system that requires no switches and may be operated with open-circuit batteries on a one-wire

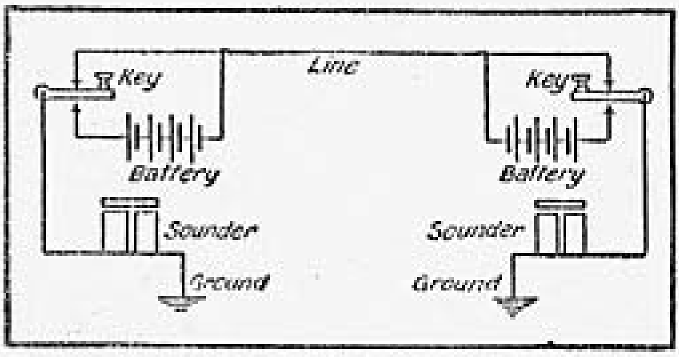


Diagram of One-Wire Line

line with ground connections at each end. Any telegraph set in which the key makes double contact can be connected up in this way.—Contributed by R. A. Brown, Fairport, N. Y.

THE BOY MECHANIC – 1913

Homemade Grenet Battery

Procure an ordinary carbon-zinc, sal-ammoniac battery and remove the zinc rod. If the battery has been used before, it is better to soak the carbon cylinder for a few hours to remove any remaining crystals of sal ammoniac from its pores.

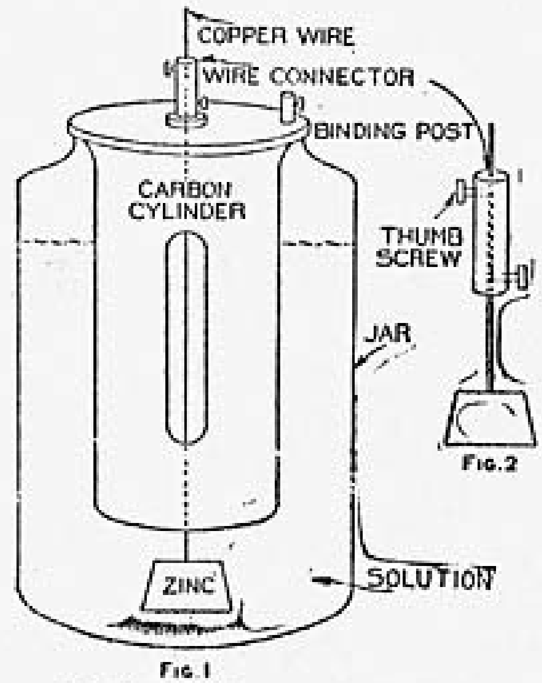
The truncated, conical zinc required is known as a fuller's zinc and can be bought at any electrical supply dealer's, or, it may be cast in a sand mold from scrap zinc or the worn-out zinc rods from sal-ammoniac batteries. It should be cast on the end of a piece of No. 14 copper wire. Amalgamation is not necessary for the zinc one buys, but if one casts his own zinc, it is necessary to amalgamate it or coat it with mercury. This may be done as follows:

Dip a piece of rag in a diluted solution of sulphuric acid (water 16 parts, acid 1 part); rub the zinc well, at the same time allowing a few drops of mercury to fall on a spot attacked by the acid. The mercury will adhere, and if the rubbing is continued so as to spread the mercury, it will cover the entire surface of the zinc, giving it a bright, silvery appearance.

Next procure what is known as a wire connector. This is a piece of copper tube about 1½ in. long having two thumb screws, one on each end on opposite sides (Fig. 2). The upper screw is to connect the battery wire, the lower one to raise and lower the zinc. The battery is now complete, and the solution (Fig. 1) must be prepared. Proceed as follows:

In 32 oz. of water dissolve 4 oz. potassium bichromate. When the bichromate has all dissolved, add slowly, stirring constantly, 4 oz. sulphuric acid. Do not add the acid too quickly or the heat generated may break the vessel containing the solution. Then pour the solution into the battery jar, until it is within 3 in. of the top. Thread the wire holding the zinc through the porcelain insulator of the carbon cylinder and also through the wire connector. Pull the zinc up as far as it will go and tighten the lower thumb screw so that it holds the wire secure. Place the carbon in the jar. If the solution touches the zinc, some of it should be poured out. To determine whether or not the zinc is touched by the solution, take out the carbon and lower the zinc. If it is wet, there is too much liquid in the jar. The battery is now ready for use.

To cause a flow of electricity, lower the zinc until it almost touches the bottom of the jar and connect an electric bell or other electrical apparatus by means of wires to the two binding posts.



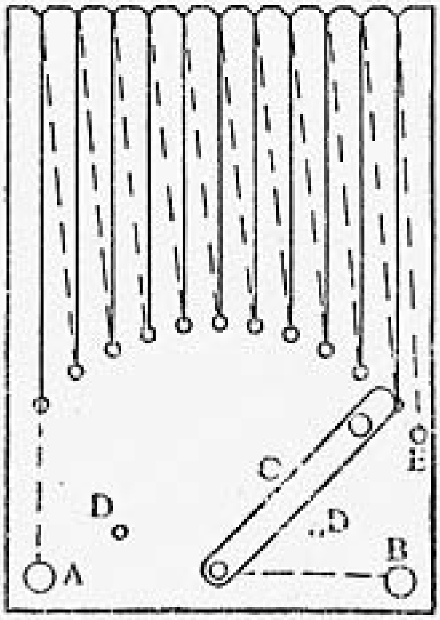
Details of Homemade Battery

This battery when first set up gives a current of about two volts. It is useful for running induction coils, or small electric motors. When through using the battery, raise the zinc and tighten the lower thumb screw. This prevents the zinc wasting away when no current is being used.—Contributed by H. C. Meyer, Philadelphia.

THE BOY MECHANIC – 1913

A Battery Rheostat

In a board 7 in. long and 5 in. wide bore holes about 1/4 in. apart, in a semicircle 2 in. from the bottom, and cut notches in top end to correspond with the holes. From a piece of brass a switch, C, is cut with a knob soldered on at the end. Nails for stops are placed at DD.



Two binding-posts are placed in board at A and B. With about 9 ft. of fine iron wire attach one end to the bottom of post A and run through first hole and over in first notch to back of board and then through second hole and over second notch and so on until E is reached, where the other end of wire is fastened. Connect switch to post B. —Contributed by Edmund Kuhn, Jr., East Orange, N. J.

THE BOY MECHANIC – 1913

How to Make an Efficient Wireless Telegraph

By GEORGE W. RICHARDSON

A simple but very efficient wireless telegraph may be constructed at slight cost from the following description:

The sending apparatus consists of nothing but an induction coil with a telegraph key inserted in the primary circuit, i. e., the battery circuit. This apparatus may be purchased from any electrical-supply house. The price of the coil depends upon its size, and upon the size depends the distance signals can be transmitted. If, however, one wishes to construct his own coil he can make and use, with slight changes, the jump-spark coil described elsewhere in this book. This coil, being a 1-in. coil, will transmit nicely up to a distance of one mile; while a 12-in. coil made on the same plan will transmit 20 miles or even more under favorable conditions.

Change the coil described, as follows: Insert an ordinary telegraph key in the battery circuit, and attach two small pieces of wire with a brass ball on each, by inserting them in the binding-posts of the coil as shown at B B″. Of these two terminal wires one is grounded to earth, while the other wire is sent aloft and is called the aerial line. This constitutes all there is to the sending apparatus.

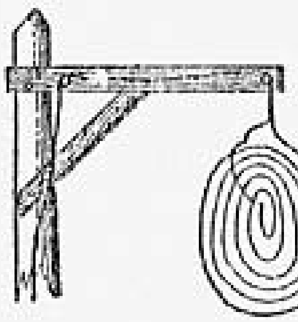
Now for the receiving apparatus. In the earlier receiving instruments a coherer was used, consisting of a glass tube about 1/8-in. diameter, in which were two silver pistons separated by nickel and silver filings, in a partial vacuum. This receiver was difficult of adjustment and slow in transmission. An instrument much less complicated and inexpensive and which will work well can be made thus:

Take a 5-cp. incandescent lamp and break off the tip at the dotted line, as shown in Fig. 5. This can be done by giving the glass tip or point a quick blow with a file or other thin edged piece of metal. Then with a blow-torch heat the broken edges until red hot and turn the edges in as seen in Fig. 6. Remove the carbon filament in the lamp and bend the two small platinum wires so they will point at each other as in Fig. 6, W W. Screw the lamp into an ordinary wall socket which will serve as a base as in Fig. 7. Make a solution of 1 part sulphuric acid to 4 parts of water, and fill the lamp about two-thirds full (Fig. 7). This will make an excellent receiver. It will be necessary to adjust the platinum points, W W, to suit the distance the message is to be worked. For a mile or less the points

 GRANDDAD'S ELCTRICITY BOOK

should be about $\frac{1}{16}$ in. apart, and closer for longer distances.

The tuning coil is simply a variable choking coil, made of No. 14 insulated copper wire wound on an iron core, as shown in Fig. 7. After winding, carefully scrape the insulation from one side of the coil, in a straight line from top to bottom, the full length of the coil, uncovering just enough to allow a good contact for the sliding piece. The tuning is done by sliding the contact piece, which is made of light copper wire, along the convolutions of the tuning coil until you can hear the signals. The signals are heard in a telephone receiver, which is shown connected in shunt across the binding-posts of the lamp holder with one or two cells of dry battery in circuit, Fig. 7.



The aerial line, No. 6 stranded, is run from binding-post B through the choking or tuning coil, and for best results should extend up 50 ft. in the air. To work a 20-mile distance the line should be 100 or 150 ft. above the ground. A good way is to erect a wooden pole on a house or barn and carry the aerial wire to the top and out to the end of a gaff or arm.

To the end of the aerial wire fasten a bunch of endless loops made of about No. 14 magnet wire (bare or insulated), attaching both ends to the leading or aerial wire. The aerial wire should not come nearer than 1 ft. at any point to any metal which is grounded.

Run a wire from the other binding-post, A, to the ground and be sure to make a good ground connection.

For simple experimental work on distances of 100 ft. only, an ordinary automobile spark coil can be used in place of the more elaborate coil, Figs. 1 to 4.

The above-mentioned instruments have no patents on them, and any one is at liberty to build and use them. The writer does not claim to be the originator, but simply illustrates the above to show that, after all, wireless is very simple when it is once understood. The fundamental principles are that induction travels at right angles, 90°, to the direction of the current. For an illustration, if a person standing on a bridge should drop a pebble into the water below, after contact he would note circles radiating out over the surface of the water. These circles, being at right angles, 90°, to the direction of the force

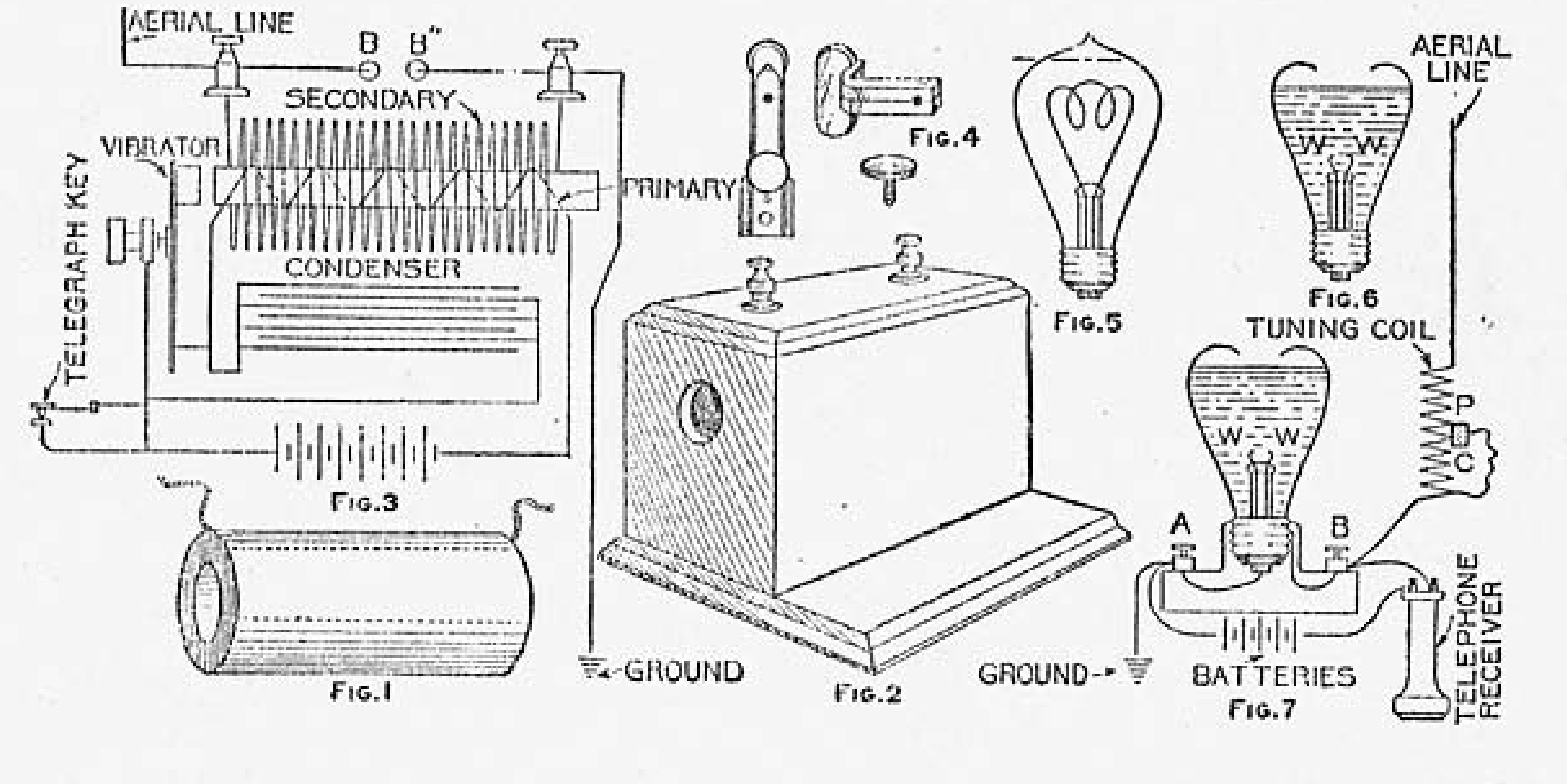


Fig.1 Fig.2 Fig.3 Fig.4 Fig.5 Fig.6 Fig.7

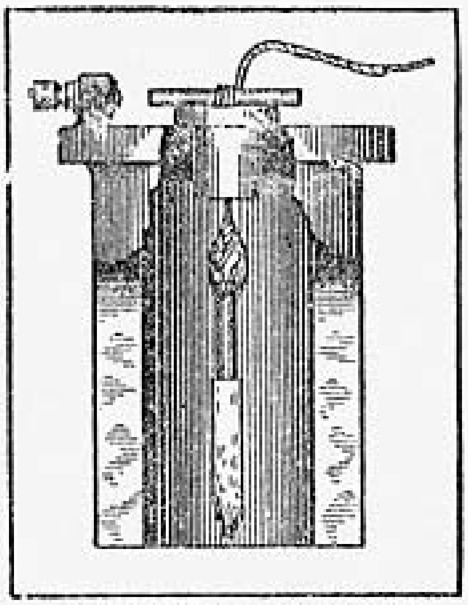
 GRANDDAD'S ELCTRICITY BOOK

that caused the circles, are analogous to the flow of induction, and hence the aerial line, being vertical, transmits signals horizontally over the earth's surface.

THE BOY MECHANIC – 1913

To Use Old Battery Zincs

When the lower half of a battery zinc becomes eaten away the remaining part can be used again by suspending it from a wire as shown in the cut. Be sure and have a good connection at the zinc binding post and cover that with melted paraffin. This prevents corrosion, which would otherwise occur from the action of the sal ammoniac or other chemical. The wire may be held at the top by twisting it around a piece



Showing Zinc Suspended

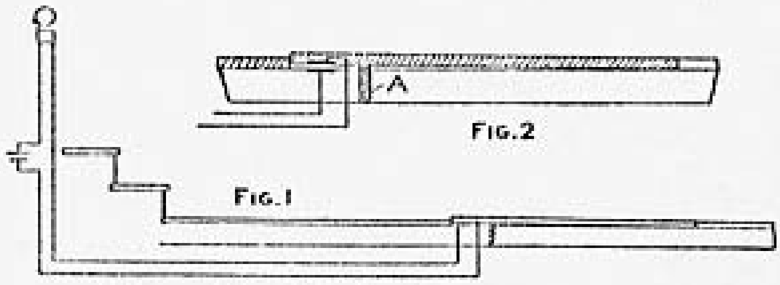
of wood or by driving a peg through the hole in the porcelain insulator.—Contributed by Louis Lauderbach, Newark, N. J.

THE BOY MECHANIC – 1913

Callers' Approach Alarm

This alarm rings so that callers approaching the door may be seen before they ring the bell and one can exercise his pleasure about admitting them.

If one has a wooden walk, the alarm is easy to fix up. Take up about 5 ft. of the walk and nail it together so as to make a trapdoor that will work easily. Place a small spring under one end to hold it up about 1/4 in. (A, Fig. 2). Nail a strip of tin along the under side of the trap near the spring and fasten another strip on the baseboard, so that they will not touch, save when a weight is on the trap. Connect up an electric bell, putting the batteries and bell anywhere desired, and using rub-



Alarm Rings When Caller Approaches

ber-covered wire outside the house, and the alarm is complete.

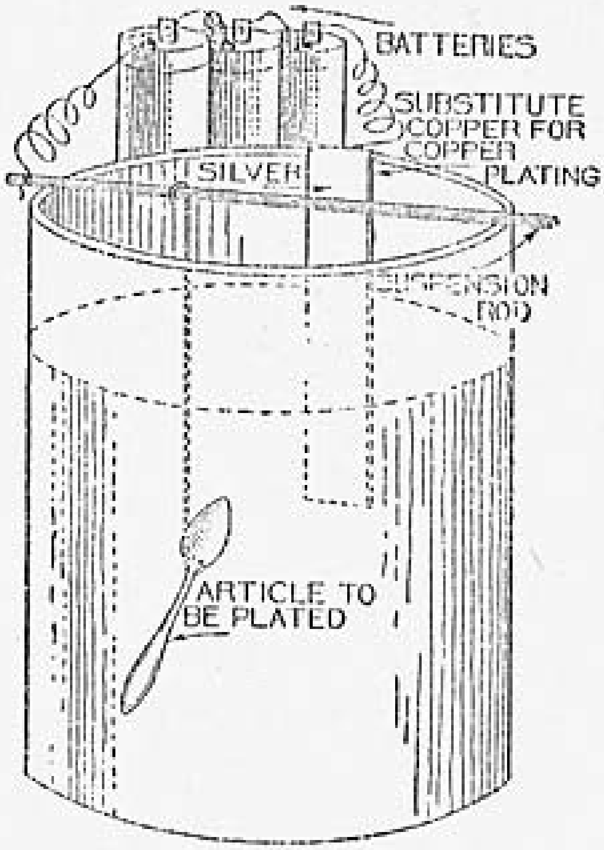
When a person approaching the house steps on the trap, the bell will ring and those in the house can see who it is before the door bell rings.—Contributed by R. S. Jackson, Minneapolis, Minn.

THE BOY MECHANIC – 1913

Easy Method of Electroplating

Before proceeding to electroplate with copper, silver or other metal, clean the articles thoroughly, as the least spot of grease or dirt will prevent the deposit from adhering. Then polish the articles and rub them over with a cloth and fine pumice powder, to roughen the surface slightly. Finally, to remove all traces of grease, dip the articles to be plated in a boiling potash solution made by dissolving 4 oz. American ash in 1½ pt. of water. Do not touch the work with the hands again. To avoid touching it, hang the articles on the wires, by which they are to be suspended in the plating bath, before dipping them in the potash solution; then hold them by the wires under running water for ten minutes to completely remove every trace of the potash.

For plating with copper prepare the following solution: 4 oz. copper sul-



Electroplating Apparatus

phate dissolved in 12 oz. water; add strong ammonia solution until no more green crystals are precipitated. Then add more ammonia and stir until the green crystals are re-dissolved giving an intense blue solution. Add slowly a strong solution of potassium cyanide until the blue color disappears, leaving a clear solution; add potassium cyanide again, about one-fourth as much in bulk as used in the decolorizing process. Then make the solution up to 2 qt. with water. With an electric pressure of 3.5 to 4 volts, this will give an even deposit of copper on the article being plated.

A solution for silverplating may be prepared as follows: Dissolve ¾ oz. of commercial silver nitrate in 8 oz. of water, and slowly add a strong solution of potassium cyanide until no more white precipitate is thrown down. Then pour the liquid off and wash the precipitate carefully. This is best done by filling the bottle with water, shaking, allowing precipitate to settle and then pouring off the water. Repeat six times. Having finished washing the precipitate, slowly add to it a solution of potassium cyanide until all the precipitate is dissolved. Then add an excess of potassium cyanide—about as much as was used in dissolving the precipitate—and make the solution up to 1 qt. with water. This solution, with an electric pressure of 2 to 4 volts, will give a good white coat of silver in twenty minutes to half-an-hour; use 2 volts for large articles, and 4 volts for very small ones. If more solution is required, it is only necessary to double all given quantities.

Before silverplating, such metals as iron, lead, pewter, zinc, must be coated with copper in the alkaline copper bath described, and then treated as copper. On brass, copper, German silver, nickel and such metals, silver can be plated direct. The deposit of silver will be dull and must be polished. The best method is to use a revolving scratch brush; if one does not possess a buffing machine, a hand scratch brush is good. Take quick, light strokes. Polish the articles finally with ordinary plate powder.

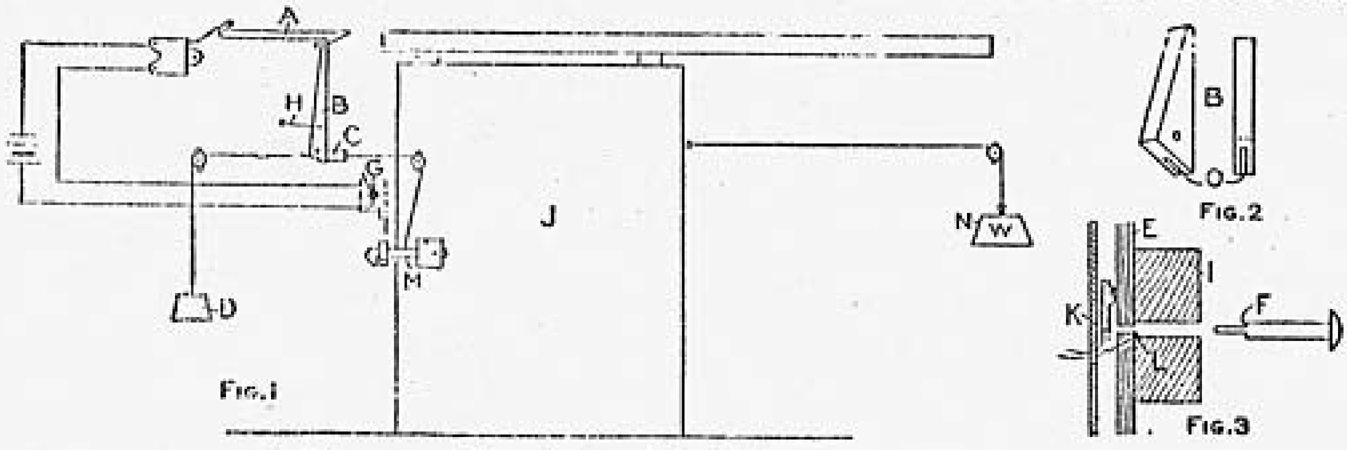
The sketch shows how to suspend the articles in the plating-bath. If accumulators are used, which is advised, be sure to connect the positive (or red) terminal to the piece of silver hanging in the bath, and the negative (or black) terminal to the article to be plated. Where Bunsen cells are used, the carbon terminal takes the place of the positive terminal of the accumulator.—Model Engineer.

THE BOY MECHANIC – 1913

An Ingenious Electric Lock for a Sliding Door

The apparatus shown in Fig. 1 not only unlocks, but opens the door, also, by simply pressing the key in the keyhole.

In rigging it to a sliding door, the materials required are: Three flat pulleys, an old electric bell or buzzer, about 25 ft. of clothesline rope and some No. 18 wire. The wooden catch,



Electric Lock for Sliding Door

A (Fig. 1), must be about 1 in. thick and 8 in. long; B should be of the same wood, 10 in. long, with the pivot 2 in. from the lower end. The wooden block C, which is held by catch B, can be made of a 2-in. piece of broomstick. Drill a hole through the center of this block for the rope to pass through, and fasten it to the rope with a little tire tape.

When all this is set up, as shown in Fig. 1, make a key and keyhole. A 1/4-in. bolt or a large nail sharpened to a point, as at F, Fig. 3, will serve for the key. To provide the keyhole, saw a piece of wood, I, 1 in. thick by 3 in. square, and bore a hole to fit the key in the center. Make a somewhat larger block (E, Fig. 3) of thin wood with a 1/8-in. hole in its center. On one side of this block tack a piece of tin (K, Fig. 3) directly over the hole. Screw the two blocks together, being careful to bring the holes opposite each other. Then, when the point of the key touches the tin, and the larger part (F, Fig. 3) strikes the bent wire L, a circuit is completed; the buzzer knocks catch A (Fig. 1), which rises at the opposite end and allows catch B to fly forward and release the piece of broomstick C. The weight D then falls and jerks up the hook-lock M, which unlocks the door, and the heavier weight N immediately opens it.

Thus, with a switch as in Fig. 3, the door can only be opened by the person who has the key, for the circuit cannot be closed with an ordinary nail or wire.

B, Fig. 2, shows catch B, Fig. 1, enlarged; O, Fig. 2, is the cut through which the rope runs; H, Fig. 1, is an elastic that snaps the catch back into place, and at G the wires run outside to the keyhole.

This arrangement is very convenient when one is carrying something in one hand and can only use the other. Closing the door winds up the apparatus again.—Contributed by E. H. Klipstein, 116 Prospect St., East Orange, New Jersey.

THE BOY MECHANIC – 1913

Reversing-Switch for Electrical Experiments

A homemade reversing-switch, suitable for use by students of electrical and engineering courses in performing experiments, is shown in the diagram.

Referring to Fig. 1, A represents a pine board 4 in. by 4 in. and a is a circular piece of wood about 1/4 in. square, with three brass strips, b^1, b^2, b^3, held down on it by two terminals, or binding posts, c^1, c^2, and a common screw, d. Post c^1 is connected to d by means of an insulated wire, making them carry the same kind of current (+ in the sketch).

About the center piece H moves a disk, held down by another disk F (Fig. 2), which is fastened through the center piece to the wooden base, A, by means of two wood screws. On the disk G are two brass strips, e^1 and e^2, so arranged that, when handle K is

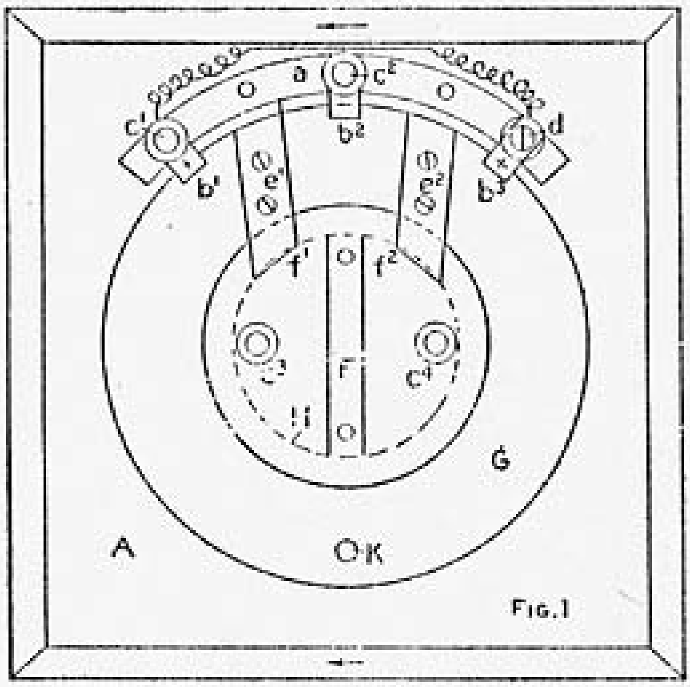


Fig. 1

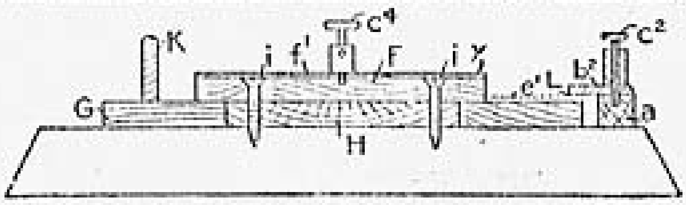


Fig. 2

Suitable for Students' Use

turned to one side, their one end just slips under the strips b^1, b^2, or b^2, b^3, respectively, making contact with them, as shown in Fig. 2, at L, while their other ends slide in two half-circular brass plates f^1, f^2, held down on disk F by two other terminals, c^3, c^4, making contact with them as shown at y, Fig. 2.

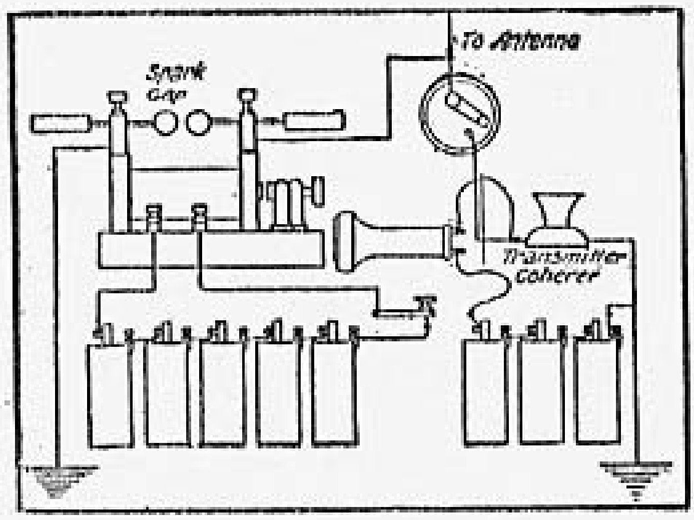
The action of the switch is shown in Fig. 1. Connect terminal c^1 to the carbon of a battery, and c^2 to the zinc. Then, if you turn handle K to the right, so that the strips e^1 and e^2 touch b^1 and b^2, respectively, terminal c^3 will show +, and c^4 — electricity; vice versa, if you turn the handle to the left so that e^1 and e^2 touch b^2 and b^3, respectively, terminal c^3 will show —, and c^4 + electricity.

The switch is easy to make and of very neat appearance.

How to Receive Wireless Telegraph Messages with a Telephone

Any telephone having carbon in the transmitter (all ordinary telephones have carbon transmitters) can be used to receive wireless messages by simply making a few changes in the connections and providing a suitable antenna. Connect the transmitter and receiver in series with three dry cells and run one wire from the transmitter to the antenna. Connect the other transmitter wire to a water or gas pipe in order to ground it, and then hold the receiver to your ear. Any wireless telegraph message within a radius of one mile will cause the transmitter to act as a coherer, thus making the message audible in the receiver.

By using an ordinary telephone transmitter and receiver and a ½-in. jump spark coil, a complete wireless telegraph station may be made, which will send or receive messages for a radius of one mile. The accompanying wiring diagram shows how to make the connections. By putting in an extra switch three of the sending batteries may be switched in when receiving,



Wiring Diagram for Wireless Telegraph

thus obviating the necessity of an extra set of batteries.—Contributed by A. E. Joerin.

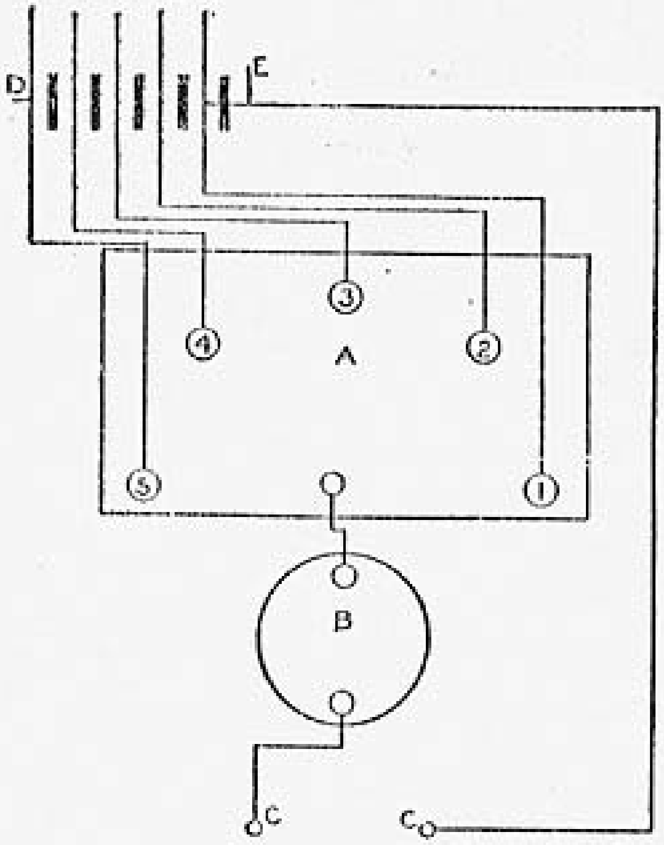
THE BOY MECHANIC – 1913

Connecting Up Batteries to Give Any Voltage

Referring to the illustration: A is a five-point switch (may be home-made); B is a one-point switch, and C and C^1 are binding posts. When

 GRANDDAD'S ELCTRICITY BOOK

switch B is closed and A is on No. 1,



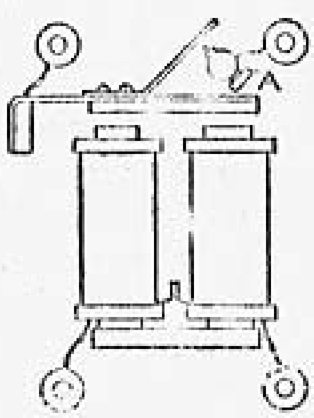
you have the current of one battery; when A is on No. 2 you receive the current from two batteries; when on No. 3, from three batteries; when on No. 4, from four batteries, and when on No. 5, from five batteries. More batteries may be connected to each point of switch B.

I have been using the same method for my water rheostat (homemade). I have the jars of water where the batteries are and the current coming in at a and b.—Contributed by Eugene F. Tuttle, Jr., Newark, Ohio.

THE BOY MECHANIC – 1913'

Relay Made from Electric Bell

It is not necessary to remove the adjusting-screw when changing an electric bell into a relay.

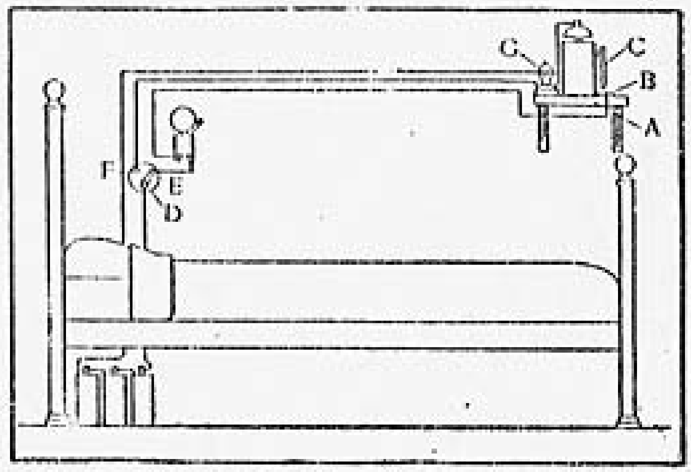


Simply twist it around as at A and bend the circuit-breaking contact back as shown. It may be necessary to remove the head of the screw, A, to prevent short-circuiting with the armature.—

Handy Electric Alarm

An electric alarm which one may turn off from the bed without arising combined with a light which may be turned on and off from a lying position, so one can see the time, is the device of H. E. Redmond, of Burlington, Wis.

The alarm clock rests on a shelf, A,



Handy Electric Alarm

which has a piece of metal, B, fastened in such a position that the metal rod C, soldered to the alarm winder, will complete the circuit and ring the bell. The two-point switch D is closed normally at E, but may be closed at F any time desired, thus turning on the small incandescent light G, which illuminates the face of the clock. When the alarm goes off, the bell will continue to ring until the switch is opened.

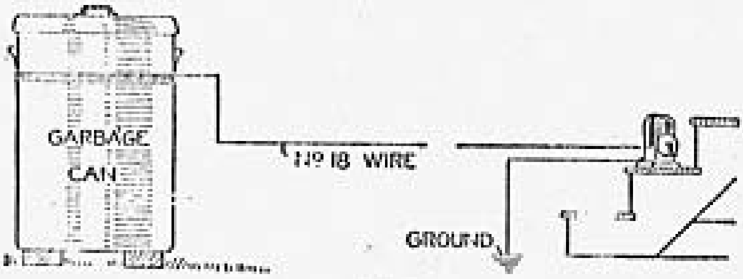
THE BOY MECHANIC - 1913

To Keep Dogs and Cats Away from the Garbage-Can

Last summer I was annoyed a great deal by dogs upsetting our garbage-can on the lawn, but finally executed a plan that rid the yard of them in one afternoon.

I first secured a magneto out of an old telephone, then drove a spike in a damp place under the porch, attached a wire to the spike and ran the wire to one of the poles of the magneto. Then I set the garbage-can on some blocks of wood, being careful not to have it touch the ground at any point. I next ran a wire from the other pole of the

 GRANDDAD'S ELCTRICITY BOOK



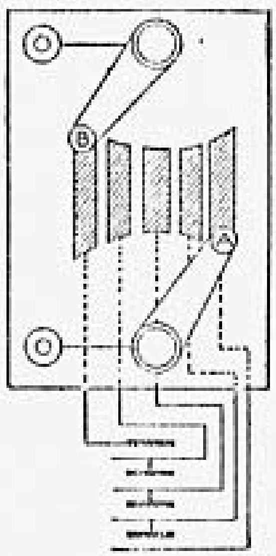
magneto to the can, wrapping the wire around the can several times. Then I sat down on the porch to wait.

It was not long before a big greyhound came along, putting his forepaws on the top of the can to upset it. At the same instant I gave the magneto a quick turn, which sent the dog away a very surprised animal. This was repeated several times during the afternoon with other dogs, and with the same result.—Contributed by Gordon T. Lane, Crafton, Pa.

THE BOY MECHANIC – 1913

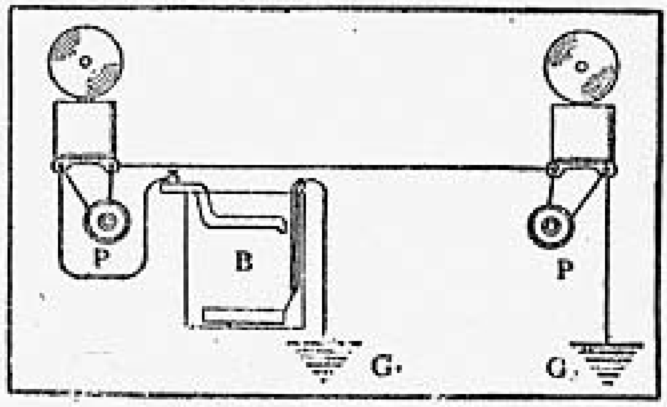
Battery Switch

In cases where batteries are used in series and it is desirable to change the strength and direction of the current frequently, the following device will be found most convenient. In my own case I used four batteries, but any reasonable number may be used. Referring to the figure, it will be seen that by moving the switch A toward the left the current can be reduced from four batteries to none, and then by moving the switch B toward the right the current can be turned on in the opposite direction to the desired strength. In the various positions of these two switches the current from each individual cell, or from any adjacent pair of cells, may be used in either direction.—Contributed by Harold S. Morton, Minneapolis.



Return-Call Bell With One Wire

To use only one wire for a return-call bell connect up as shown in the diagram, using a closed circuit or gravity battery, B. The current is flowing through both bells all the time, the same as the coils of a telegraph sounder, but is not strong enough to ring both connected in series. Pressing



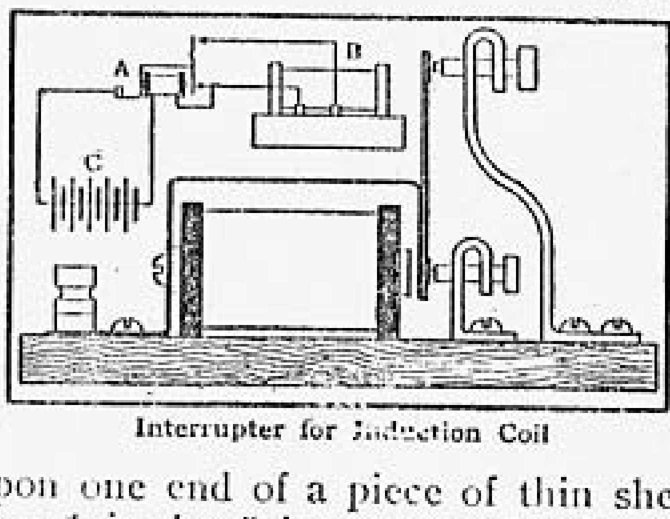
Wiring Diagram

either push button, P, makes a short circuit of that bell and rings the one at the other end of the line.—Contributed by Gordon T. Lane, Crafton, Pa.

THE BOY MECHANIC – 1913

Circuit Breaker for Induction Coils

Amateurs building induction coils are generally bothered by the vibrator contacts blackening, thus giving a high resistance contact, whenever there is any connection made at all. This trouble may be done away with by departing from the old single-contact vibrator and using one with self-cleaning contacts as shown. An old bell magnet is rewound full of No. 26 double cotton-covered wire and is mounted



Interrupter for Induction Coil

upon one end of a piece of thin sheet iron 1 in. by 5 in. as per sketch. To the other end of the strip of iron is soldered a piece of brass 1/64 in. by ¼ in. by 2 in., on each end of which has been soldered a patch of platinum foil ¼ in. square.

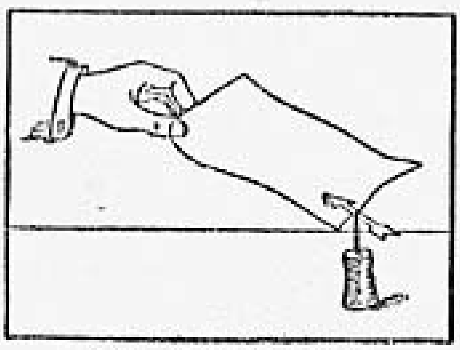
The whole is connected up and mounted on a baseboard as per sketch, the contact posts being of $\frac{1}{16}$ in. by ½ in. brass, bent into shape and provided with platinum tipped thumb screws. The advantage of this style of an interrupter is that at each stroke there is a wiping effect at the heavy current contact which automatically cleans off any carbon deposit.

In the wiring diagram, A is the circuit breaker; B, the induction coil, and C, the battery.—Contributed by A. G. Ward, Wilkinsburg, Pa.

THE BOY MECHANIC – 1913

How to Make an Electroscope

An electroscope for detecting electrified bodies may be made out of a piece of note paper, a cork and a needle. Push the needle into the cork, and cut the paper in the shape of a small arrow. Balance the arrow on the needle



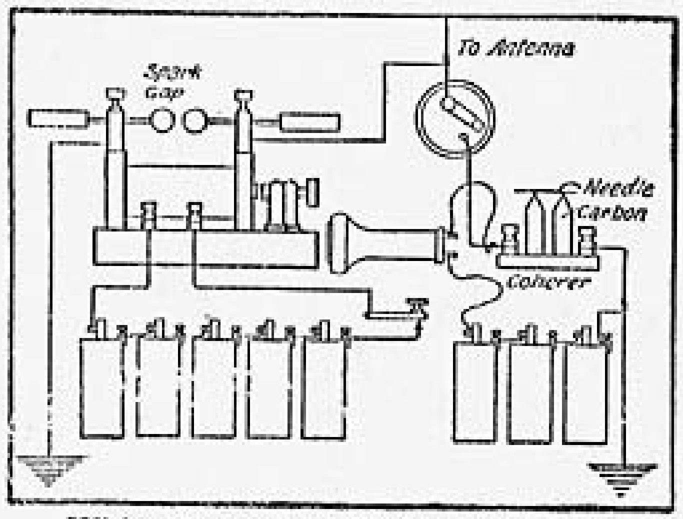
Simple Electroscope

as shown in the sketch, and the instrument will then be complete. If a piece of paper is then heated over a lamp or stove and rubbed with a piece of cloth or a small broom, the arrow will turn when the paper is brought near it.—Contributed by Wm. W. Grant, Halifax, N. S., Canada.

THE BOY MECHANIC – 1913

A Short-Distance Wireless Telegraph

The accompanying diagrams show a wireless-telegraph system that I have used successfully for signaling a distance of 3,000 ft. The transmitter consists of an induction coil, about the size used for automobiles, a key or push-button for completing the circuit, and five dry batteries. The small single-point switch is left open as shown when sending a message, but when receiving it should be closed in order that the electric waves from the antenna may pass through the coherer. The coherer in this case is simply two electric-light carbons sharpened to a wedge at one end with a needle con-



Wiring Diagram for Wireless Telegraph

necting the two, as shown. An ordinary telephone receiver is connected in series with the coherer, as shown. To receive messages hold the receiver to the ear and close the switch, and answer by oponing the switch and operating the key.—Contributed by Coulson Glick, Indianapolis.

THE BOY MECHANIC – 1913

Miniature Electric Lighting

Producing electric light by means of small bulbs that give from one-half to six candle power, and a suitable source of power, is something that will interest the average American boy.

These circular bulbs range from ¼ to 2 in. in diameter, and cost 27 cents each complete with base. They are commonly known as miniature battery bulbs, since a battery is the most popular source of power. The ½-cp. bulbs are usually 2½ volts and take ¼

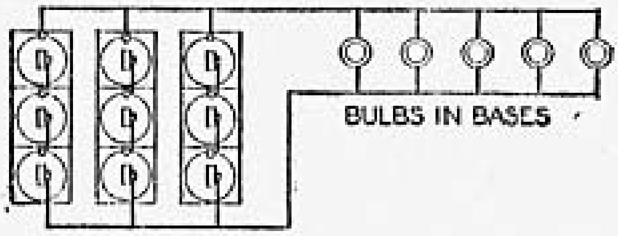


FIG. 1

ampere of current. It requires about three medium dry cells to operate it. However, there is now upon the market a battery consisting of 3 small dry cells connected in series, put up in a neat case with 2 binding posts, which sells for 25 cents. This is more economical than dry cells, as it gives about 4 volts and 3 amperes. It will run as large a lamp as 3½ volts, 1 cp., for some time very satisfactorily. More than one lamp can be run by connecting the bulbs in parallel, as indicated by Fig. 1, which shows the special battery with 3 dry cells in the case, and the 2 binding posts for connection with

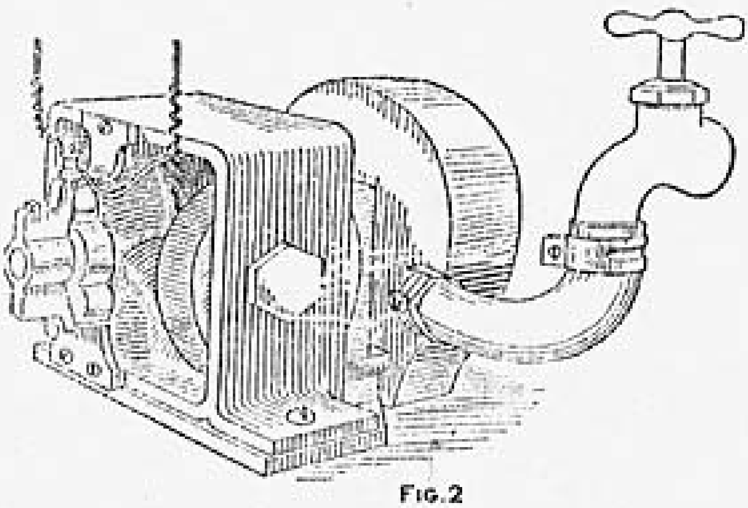


FIG. 2

the bulbs. In this case it is also advisable to connect several batteries in parallel also, so as to increase the current, but maintain the voltage constant. Thus, the individual cells are in multiple series, i. e., multiples of series of three. By keeping in mind the ampere output of the battery and rating of the lamp, one can regulate the batteries as required. It must be remembered, in this connection, that any battery which is drawn upon for half of its output will last approximately three times as long, as if drawn upon for its total output. Thus, in any system of lamps, it is economical to provide twice as many batteries as necessary. This also supplies a means of still maintaining the candle power when the batteries are partially exhausted, by connecting them in series. However, this must be done with very great caution, as the lights will be burnt out if the voltage is too high.

Persons living in the city will find an economical means of lighting lamps by securing exhausted batteries from any garage, where they are glad to have them taken away. A certain number of these, after a rest, can be connected up in series, and will give the proper voltage.

In conclusion, for battery power: Connecting batteries in series increases the voltage, and slightly cuts down the current or amperage, which is the same as that of one battery; while connecting batteries in parallel increases the amperage, but holds the voltage the same as that of one cell. Thus, if the voltage and amperage of any cell be known, by the proper combination of these, we can secure the required voltage and amperage to light any miniature lamp. And it might be said that dry cells are the best for this purpose, especially those of low internal resistance.

For those having a good water supply there is a more economical means of maintenance, although the first cost is greater. Fig. 2 shows the scheme. A small dynamo driven by a water motor attached to a faucet, generates the power for the lights. The cost of the smallest outfit of the kind is about \$3 for the water motor and \$4 for the dynamo. This dynamo has an output of 12 watts, and will produce from 18 to 25 cp., according to the water pressure obtainable. It is advisable to install the outfit in the basement, where the water pressure is the greatest, and then lead No. 18 B & S. double-insulated wire wherever needed. The dynamo can also be used as a motor,

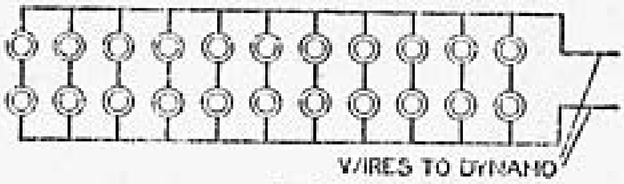


Fig. 3

and is wound for any voltage up to ten. The winding should correspond to the voltage of the lamps which you desire to run. However, if wound for 6 volts, one could run parallel series of two 3-volt, 1-cp. lamps; making, as in Fig. 3, 11 series, or 22 lights. If wound for 10 volts, it would give 1¼ amperes and run four 6-cp. lamps. Thus, it will be seen that any candle power lamp can be operated by putting the proper number of lights in each series, and running the series in parallel. So, to secure light by this method, we simply turn on the water, and the water consumption is not so great as might be imagined.

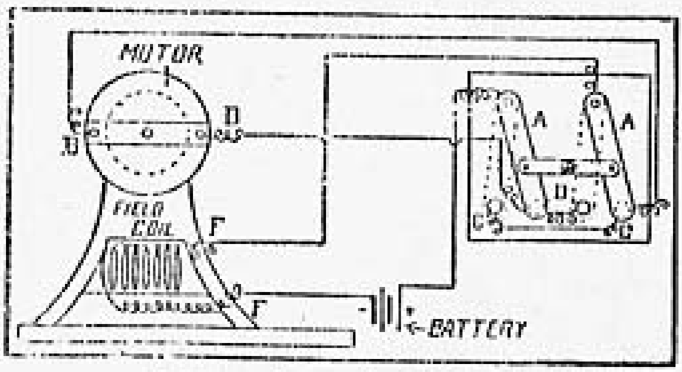
For the party who has electric light in his house there is still an easier solution for the problem of power. If the lighting circuit gives 110 volts he can connect eleven 10-volt lamps in series. These will give 3 cp. each, and the whole set of 11 will take one ampere of current, and cost about the same as a 32-cp. lamp, or 1¼ cents per hour. Simply connect the miniature circuit to an Edison plug, and insert in the nearest lamp socket. Any number of different candle power lamps can be used providing each lamp takes the same amount of current, and the sum of their voltages equals the voltage of the circuit used. This arrangement of small lights is used to produce a widely distributed, and diffused light in a room, for display of show cases, and for Christmas trees. Of all these sources of power the two last are the most economical, and the latter of these two has in its favor the small initial cost. These lamps are by no means playthings or experiments, but are as serviceable and practical as the larger lamps.

THE BOY MECHANIC – 1913

Reversing a Small Motor

All that is necessary for reversing the motor is a pole-changing switch. Connect the two middle posts of the switch with each other and the two outside posts with each other. Then connect one of the outside posts of the switch to one brush of the motor and one middle post to the other brush.

Connect one bar of the switch to one end of the field coil and the other bar to one pole of the battery, and connect the other pole of the battery to the other field coil. To reverse the motor, simply change the switch.



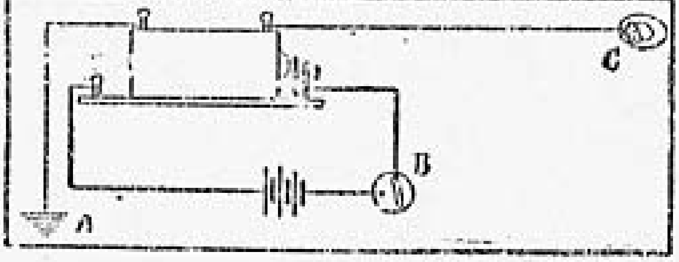
Reverse for a Small Motor

Referring to the illustration, the letters indicate as follows: FF, field of motor; BB, brushes of motor; AA, bars of pole-changing switch; DD, center points of switch; CC, outside points of switch.—Contributed by Leonard E. Parker, Plymouth, Ind.

THE BOY MECHANIC – 1913

To Drive Away Dogs

The dogs in my neighborhood used to come around picking up scraps. After I connected up my induction coil, as shown in the sketch, we were not bothered with them. A indicates the ground; B, switch; and C, a bait of meat, or a tempting bone.



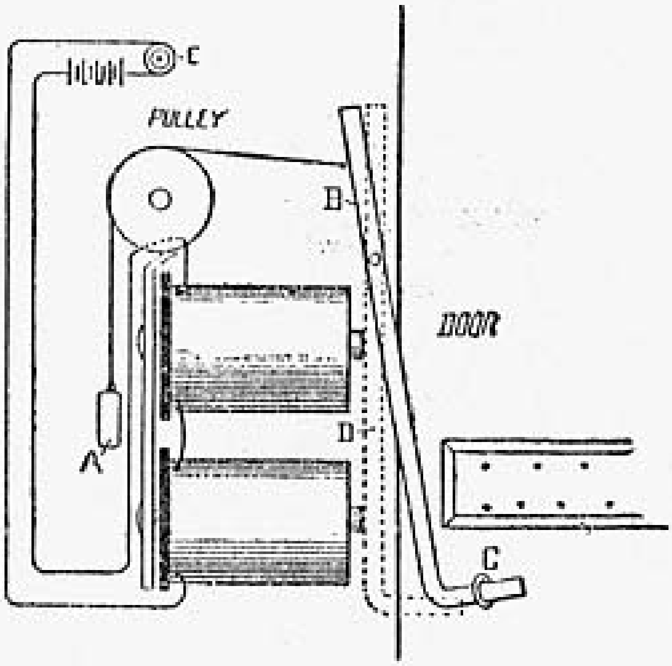
Shocking-Machine

THE BOY MECHANIC – 1913

An Automatic Lock

The illustration shows an automatic lock operated by electricity, one cell being sufficient. When the circuit is broken a weight A, attached to the end of the armature B, tends to push the other end of the armature into the screw eye or hook C, which is in the door, thus locking the door.

To unlock the door, merely push the button E. The magnet then draws the armature out of the screw eye and the door is unlocked. The dotted line at D shows the position of the armature when the circuit is complete and the door unlocked. The weight must be in proportion to the strength of the magnet. If it is not, the door will not



Automatic Electric Lock for Doors

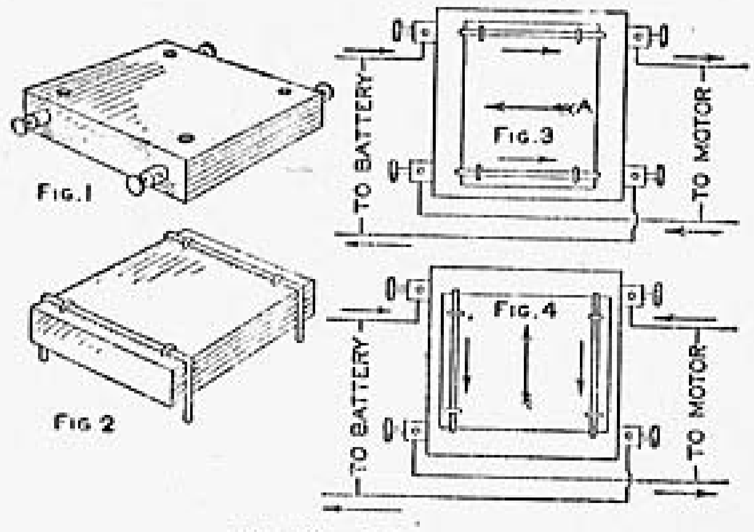
lock, or would remain locked. The button can be hidden, as it is the key to the lock.—Contributed by Claude B. Melchior, Hutchinson, Minn.

THE BOY MECHANIC – 1913

Simple Current Reverser

On a block of hardwood draw a square (Fig. 1) and drill a hole in each corner of the square. Fill these holes with mercury and connect them to four binding posts (Fig. 1).

On another block of wood fasten two wires, as shown in Fig. 2, so that their ends can be placed in the holes in the first block. Then connect up with the



Details of Reverser

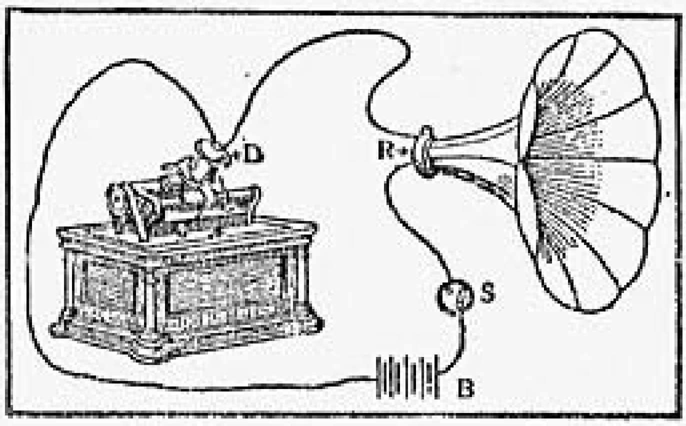
motor and battery as in Fig. 3. When the block is placed on with the big arrow A pointing in the direction indicated in Fig. 3, the current flows with the small arrows. To reverse turn through an angle of 90 degrees (Fig. 4). — Contributed by F. Crawford Curry, Brockville, Ontario, Canada.

THE BOY MECHANIC – 1913

How to Transmit Phonograph Music to a Distance

An interesting experiment, and one calculated to mystify any one not in the secret, is to transmit the music or speech from a phonograph to another part of the house or even a greater distance. For an outdoor summer party the music can be made to come from a bush, or tree, or from a bed of flowers. The apparatus is not difficult to construct.

The cut shows the arrangement. Procure a long-distance telephone trans-



The Long-Distance Phonograph

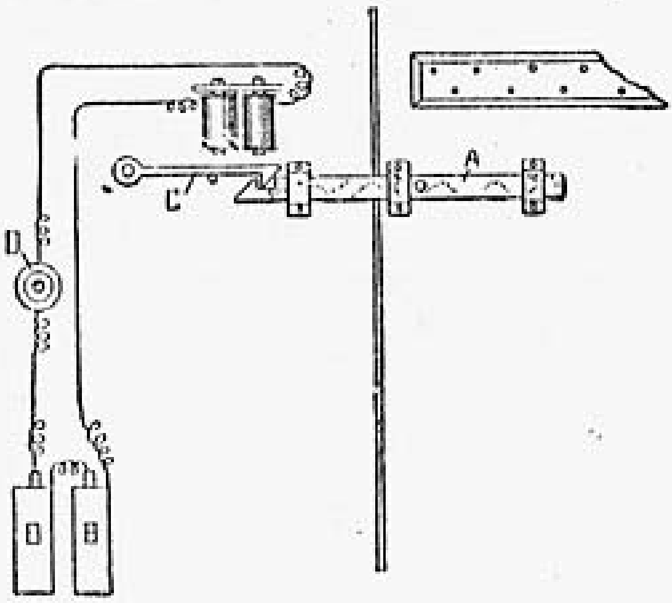
 GRANDDAD'S ELCTRICITY BOOK

mitter, D, including the mouthpiece, and fasten it to the reproducer of the phonograph. Also a watch case receiver, R, which fasten to the horn. These parts may be purchased from any electrical-supply house. Connect two wires to the transmitter, running one direct to the receiver, and the other to the battery, thence to a switch, S, and then to the receiver. The more batteries used the louder will be the sound produced by the horn, but avoid using too much battery or the receiver is apt to heat.—Contributed by Wm. J. Farley, Jr., Camden, N. J.

THE BOY MECHANIC – 1913

Another Electric Lock

The details of the construction of an electrically operated lock are shown in the illustration. When the door is closed and the bolt A pushed into posi-



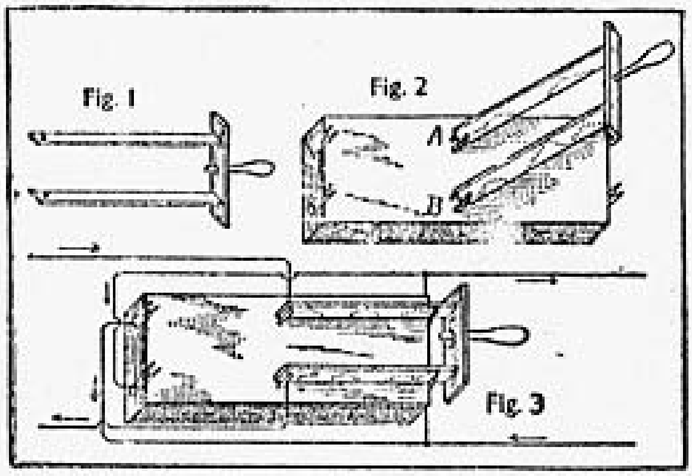
Simple Electric Lock

tion, it automatically locks. To unlock, push the button D, which act will cause the electromagnet to raise the latch C, when the bolt may be drawn and the door opened.—Contributed by A. D. Zimmerman, Boody, Ill.

THE BOY MECHANIC – 1913

Simple Switch for Reversing a Current

Take two strips of copper or brass and fasten them together by means of gutta-percha (Fig. 1); also provide them with a handle. Saw out a rectangular block about one and one-half times as long as the brass strips and fasten to it at each end two forked pieces of copper or brass, as in Fig. 2. Fasten on the switch lever, as at A and B, Fig. 2, so that it can rotate about these points. Connect the wires as shown in Fig. 3. To reverse, throw



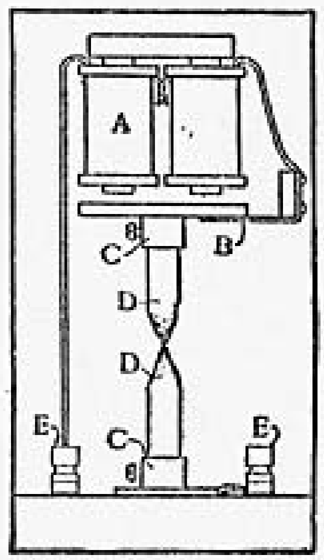
Simple Current-Reversing Switch

the lever from one end of the block to the other.—Contributed by R. L. Thomas, San Marcos, Tex.

THE BOY MECHANIC – 1913

Homemade Arc Light

By rewinding an electric-bell magnet with No. 16 wire and connecting it in series with two electric-light carbons, as shown in the sketch, a small arc will be formed between the carbon points when the current is applied. In the sketch, A is the electric-bell magnet; B, the armature; C C, carbon sockets; D, carbons, and E E, binding posts. When connected with 10 or 12 dry batteries this lamp gives a fairly good light.—Contributed by Morris L. Levy, San Antonio, Tex.

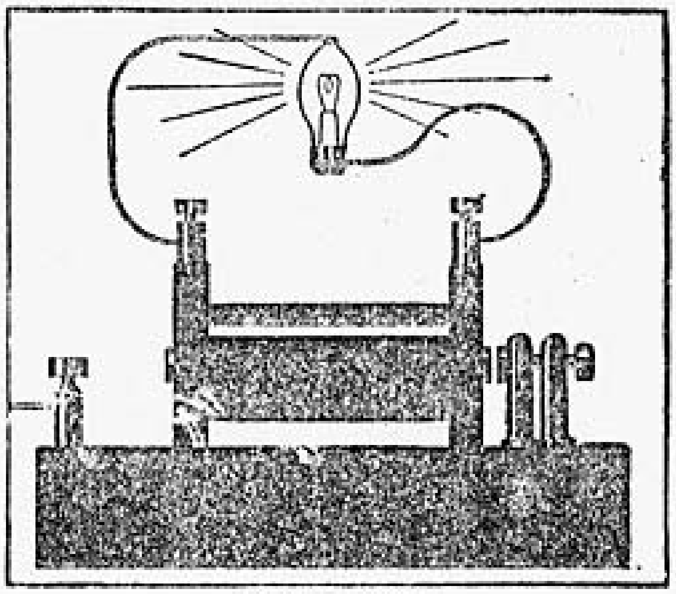


Arc Light

THE BOY MECHANIC – 1913

Lighting an Incandescent Lamp with an Induction Coil

An incandescent lamp of low candle-power may be illuminated by connecting to an induction coil in the manner shown in the sketch. One wire is connected to the metal cap of the lamp and the other wire is fastened to the glass tip. If the apparatus is then placed in the dark and the current turned on, a peculiar phosphorescent glow will fill the whole interior of the lamp. The induction coil used for this purpose should give a spark about ½ in. long or more.—Contributed by Joseph B. Bell, Brooklyn.



Geissler Tube

How to Make a Jump-Spark Coil

THE BOY MECHANIC – 1913

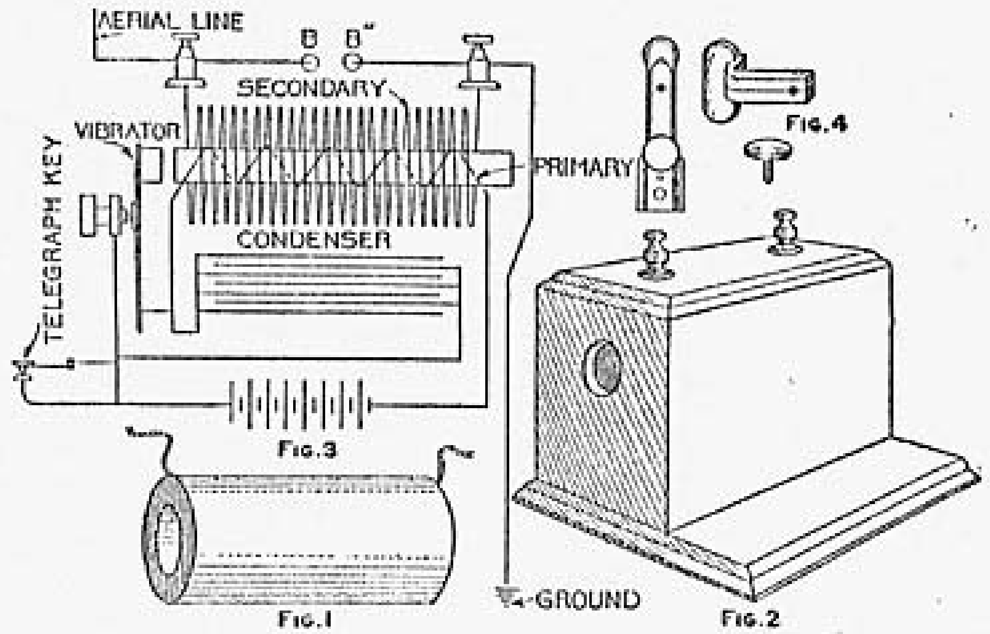
The induction coil is probably the most popular piece of apparatus in the electrical laboratory, and particularly is it popular because of its use in experimental wireless telegraphy. Ten years ago wireless telegraphy was a dream of scientists; today it is the plaything of school-boys and thousands of grown-up boys as well.

Divested of nearly all technical phrases, an induction coil may be briefly described as a step-up transformer of small capacity. It comprises a core consisting of a cylindrical bundle of soft-iron wires cut to proper length. By means of two or more layers of No. 14 or No. 16 magnet wire, wound evenly about this core, the bundle becomes magnetized when the wire terminals are connected to a source of electricity.

Should we now slip over this electromagnet a paper tube upon which has been wound with regularity a great and continuous length of No. 36 magnet wire, it will be found that the lines of force emanating from the energized core penetrate the new coil-winding almost as though it were but a part of the surrounding air itself, and when the battery current is broken rapidly a second electrical current is said to be induced into the second coil or secondary.

All or any of the parts of an induction coil may be purchased ready-made, and the first thing to do is to decide which of the parts the amateur mechanic can make and which would be better to buy ready-made. If the builder has had no experience in coil-winding it would probably pay to purchase the secondary coil ready-wound, as the operation of winding a mile or more of fine wire is very difficult and tedious, and the results are often unsatisfactory. In ordering the secondary it is always necessary to specify the length of spark desired.

The following method of completing a 1-in. coil illustrates the general details of the work. The same methods and circuits apply to small and larger coils. The ready-made secondary is in solid cylindrical form, about 6 in. long and 2⅞ in. diameter, with a hole through the winding 1¼ in. in diameter, as shown in Fig. 1. The secondary will stand considerable handling without fear of injury, and need not be



Jump-Spark Coil

set into a case until the primary is completed. The primary is made of fine annealed No. 24 iron wire cut 7 in. or 8 in. in length, as the maker prefers, and bundled to a diameter of 7/8 in. The wires may be straightened by rolling two or three at a time between two pieces of hard wood. If the amateur has difficulty in procuring this wire, the entire core may be purchased ready-made.

After the core wires are bundled, the core is wrapped with one or two layers of manila paper. The straighter the wire the more iron will enter into the construction of the core, which is desirable. Beginning half an inch from one end, No. 16 cotton-covered magnet wire is wound from one end to the other evenly and then returned, making two layers, and the terminals tied down to the core with twine. Core and primary are then immersed in boiling paraffine wax to which a small quantity of resin and beeswax has been added. This same wax may be used later in sealing the completed coil into a box. Over this primary is now wrapped one layer of okonite tape, or same thickness of heavily shellacked muslin. This completed primary will now allow of slipping into the hole in the secondary.

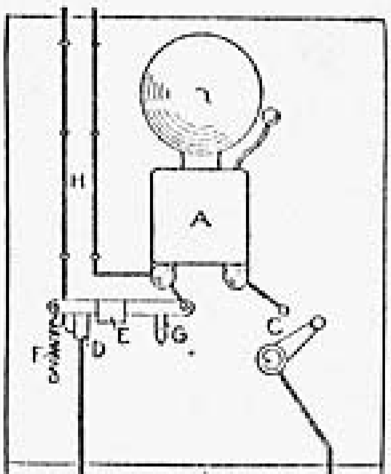
Should the secondary have been purchased without a case, a wooden box of mahogany or oak is made, large enough to contain the secondary and with an inch to spare all around, with room also for a small condenser; but if it is not convenient to do this work, a box like that shown in Fig. 2 may be purchased at a small cost. A 7/8-in. hole is bored in the center of one end, through which the primary core projects 1/8 in. This core is to be used to attract magnetically the iron head of a vibrating interrupter, which is an important factor of the coil. This interrupter is shaped as in Fig. 4, and is fastened to the box in such a way that the vibrator hammer plays in front of the core and also that soldered connections may be made inside the box with the screws used in affixing the vibrator parts to the box. The condenser is made of four strips of thin paper, 2 yd. long and 5 in. wide, and a sufficient quantity of tin-foil. When cut and laid in one continuous length, each piece of tin-foil must overlap the adjoining piece a half inch, so as to form a continuous electrical circuit. In shaping the condenser, one piece of the paper is laid down, then the strip of tin-foil, then two strips of paper and another layer of foil, and finally the fourth strip of paper. This makes a condenser which may be folded, beginning at one end and bending about 6 in. at a time. The condenser is next wrapped securely with bands of paper or tape, and boiled in pure paraffine wax for one hour, after which it is pressed under considerable weight until firm and hard. One of the sheets of tin-foil is to form one pole of the condenser, and the other sheet, which is insulated from the first, forms the other pole or terminal. (This condenser material is purchasable in long strips, ready for assembling.)

The wiring diagram, Fig. 3, shows how the connections are made. This method of connecting is suitable for all coils up to 1½-in. spark, but for larger coil better results will be obtained by using an independent type of interrupter, in which a separate magnet is used to interrupt the circuit. Besides the magnetic vibrators there are several other types, such as the mercury dash-pot and rotary-commutator types, but these will become better known to the amateur as he proceeds in his work and becomes more experienced in coil operation.

THE BOY MECHANIC – 1913

Combined Door Bell and Electric Alarm

This device consists of a battery and bell connection to an alarm clock which also acts as a door bell, the whole being mounted on a board 18 in. long and 12 in. wide.



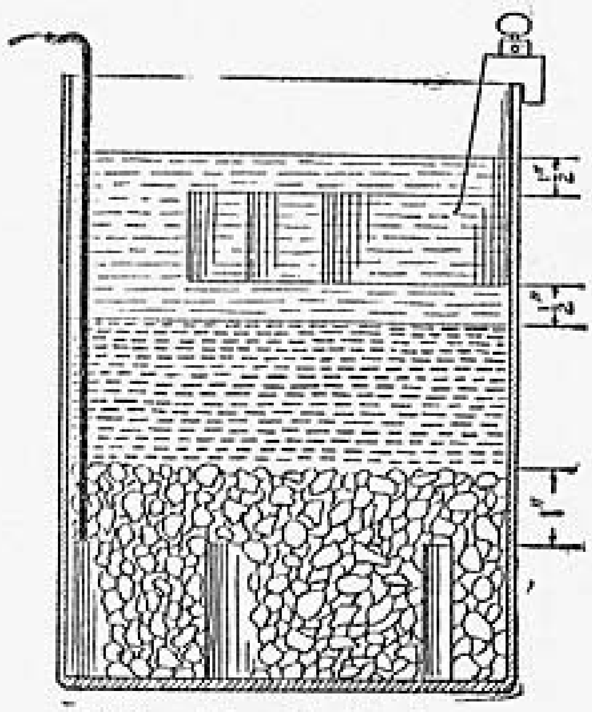
Referring to the sketch accompanying this article, the letters indicate as follows: A, bell; B, battery; C, switch; D, V-shaped copper strip; E, copper lever with 1-in. flange turned on one side, whole length, 4 in.; F, spring to throw lever E down in V-shaped piece to make connection; G, lever to hold out E when device is used as a door bell; lines H, go, one from bell, A, and one from battery, B, to the door; I, shelf for clock.

See that the ring in the alarm key of the clock works easily, so that when it is square across the clock it will drop down. Fasten a piece of copper about

THE BOY MECHANIC – 1913

Why Gravity Batteries Fail to Work

Many amateur electricians and some professionals have had considerable trouble with gravity batteries. They



Setting Up a Gravity Battery

follow directions carefully and then fail to get good results. The usual trouble is not with the battery itself, but with the circuit. A gravity battery is suitable only for a circuit which is normally closed. It is therefore undesirable for electric bells, induction coils and all other open-circuit apparatus. The circuit should also have a high resistance. This makes it impractical for running fan motors, as the motor would have to be wound with fine wire and it would then require a large number of batteries to give a sufficiently high voltage.

To set up a gravity battery: Use about 3½ lb. of blue stone, or enough to cover the copper element 1 in. Pour in water sufficient to cover the zinc ½ in. Short-circuit for three hours, and the battery is ready for use. If desired for use immediately, do not short-circuit, but add 5 or 6 oz. of zinc sulphate.

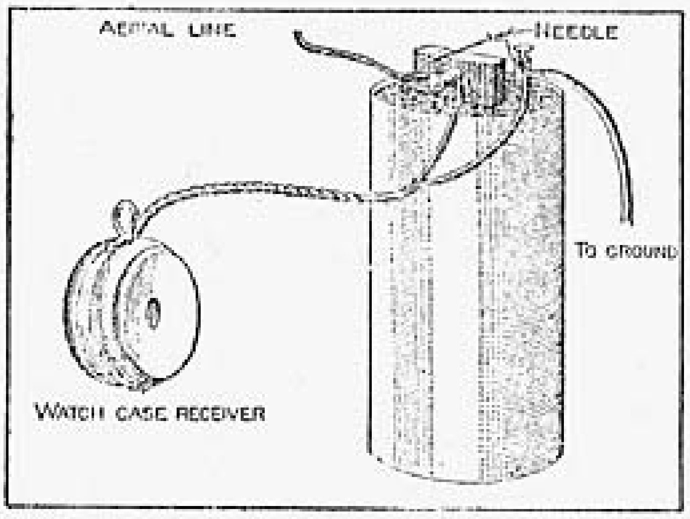
Keep the dividing line between the blue and white liquids about ½ in. below the bottom of the zinc. If too low, siphon off some of the white liquid and add the same amount of water, but do not agitate or mix the two solutions. This type of battery will give about 0.9 of a volt, and should be used on a circuit of about 100 milli-amperes.

THE BOY MECHANIC – 1913

How to Make a Simple Wireless Telegraph

By ARTHUR E. JOERIN

An efficient wireless-telegraph receiving apparatus for distances up to 1,000 ft. may be constructed in the following manner: Attach a watchcase telephone receiver to a dry cell, or battery, of any make. The negative pole, or zinc, of the cell is connected to a ground wire. This is done by attaching to a gas or water pipe. The positive pole, or carbon, of the cell is connected to the aerial line. This aerial collector can be made in various ways, either by using a screen wire or numerous wires



For Distances up to 1000 Feet

made in an open coil and hung in the air. File a V-shaped groove in the upper end of the carbon of the cell. Attach a small bent copper wire in the binding post that is attached to the zinc of the cell. In the bend of this wire add the V-shaped groove filed into the carbon, lay a needle. This will complete the receiving station. Use a spark coil in connection with a telegraph key for the sending station, making a ground with one wire, and have the other connected with another aerial line.

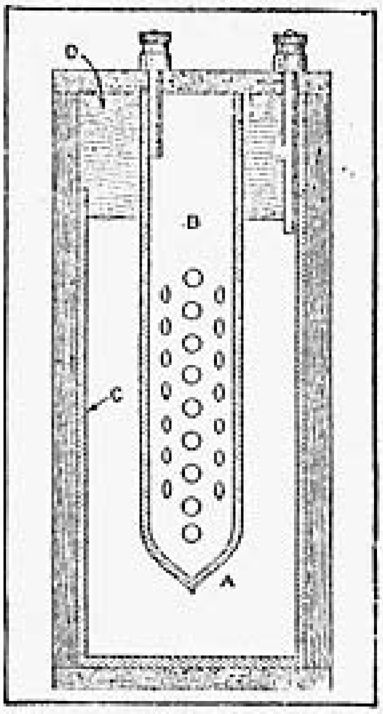
By connecting the telephone receiver to the cell and at the same time having a short circuit a receiving station is made. As the telephone offers a high resistance, part of the current will try to take the shorter high resistance through the needle. If the waves strike across the needle, the resistance is less, and thus less current travels through the telephone receiver. If the wave ceases, the resistance between the needle and the carbon is increased, and as less current will flow the short way, it is compelled to take the longer metallic way through the windings of the receiver, which will cause the clickings that can be heard.

THE BOY MECHANIC – 1913

How to Make a Small Storage Battery

The cell of a storage battery consists of two plates, a positive and a negative, made of lead and placed in a dilute solution of sulphuric acid. Large batteries made of large cells have a great number of plates, both positive and negative, of which all positive plates are connected to one terminal and the negative plates to the other terminal. The storage cell, as described below, is the right size to be charged by a few gravity cells and is easily made.

Secure a piece of 1¾-in. lead pipe, 5 in. long, and cut both



ends smooth and square with the pipe. Solder a circular disk of lead to one end, forming a cup of the pipe. As this cup must hold the sulphuric acid it must be perfectly liquid-tight.

It is also necessary to get another lead pipe of the same length but only ¾ in. in diameter. In this pipe should be bored as many ⅛-in. holes as possible, except for about 1 in. on each end. One end of this tube is hammered together as shown at A in the sketch to make a pocket to hold the paste. This, of course, does not need to be watertight.

A box of wood is made to hold the larger tube or cup. This box can be square, and the corners left open around the cup can be filled with sawdust. A support is now made from a block of wood to hold the tube, B, in place and to keep it from touching the cup C. This support or block, D, is cut circular with the same diameter as the lead cup C. The lower portion of the block is cut away so it will just fit inside of the cup to form a stopper. The center of this block is now bored to make a hole the same size as the smaller lead pipe. Place the lead pipe in the hole and immerse it in smoking hot paraffine wax, and leave it until the wood has become thoroughly saturated with the hot wax. Use care to keep the wax from running on the lead at any place other than the end within the wood block. Two binding-posts should be attached, one to the positive, or tube B, and the other to the negative, or tube C, by soldering the joint.

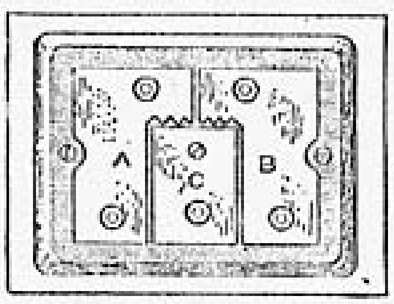
A paste for the positive plate is made from 1 part sulphuric acid and 1 part water with a sufficient amount of red lead added to make of thick dry consistency. When mixing the acid and water, be sure to add the acid to the water and not the water to the acid. Also remember that sulphuric acid will destroy anything that it comes in contact with and will make a painful burn if it touches the hands. Stir the mixture with a stick and when a good dry paste is formed, put it into the smaller tube and ram it down until the tube is almost filled. The paste that may have come through the holes is scraped off and the tube set aside to dry. The large tube or cup is filled with a diluted solution of sulphuric acid. This solution should be about one-twelfth acid. The cell is now complete and ready for storing the current.

The cell may be charged with three gravity cells. These are connected in series and the positive terminal binding-post on the storage cell is connected to the wire leading from the copper plate in the gravity cell. The other plate is connected to the zinc. The first charge should be run into the cell for about one week and all subsequent charges should only take from 10 to 12 hours.

THE BOY MECHANIC – 1913

How to Make a Lightning Arrester

Secure a piece of wood about $3\frac{1}{2}$ in. square that will furnish a nice finish and round the corners and make a small rounding edge as shown in the sketch.



From a piece of brass $\frac{1}{16}$ in. thick cut two pieces alike, A and B, and match them together, leaving about $\frac{1}{16}$ in. between their upper edges and fasten them to the wood with binding-posts. The third piece of brass, C, is fitted between the pieces A and B allowing a space of $\frac{1}{16}$-in. all around the edge. One binding-post and a small screw will hold the piece of brass, C, in place on the wood. The connections are made from the line wires to the two upper binding-posts and parallel from the lower binding-posts to the instrument. The third binding-post on C is connected to the ground wire. Any heavy charge from lightning will jump the saw teeth part of the brass and is grounded without doing harm to the instruments used.—Contributed by Edwin Walker, Chicago, Ill.

Heat and Expansion

Take an electric light bulb from which the air has not been exhausted and immerse it in water and then break off the point. As there is a vacuum in the bulb it will quickly fill with water. Shake the bulb gently until a part of the water is out and then screw the bulb into a socket with the point always downward. Apply the current and the heated air inside will soon expand and force the water out with great rapidity. Sometimes this experiment can be done several times by using the same bulb.--Contributed by Curtiss Hill, Tacoma, Wash.

THE BOY MECHANIC – 1913

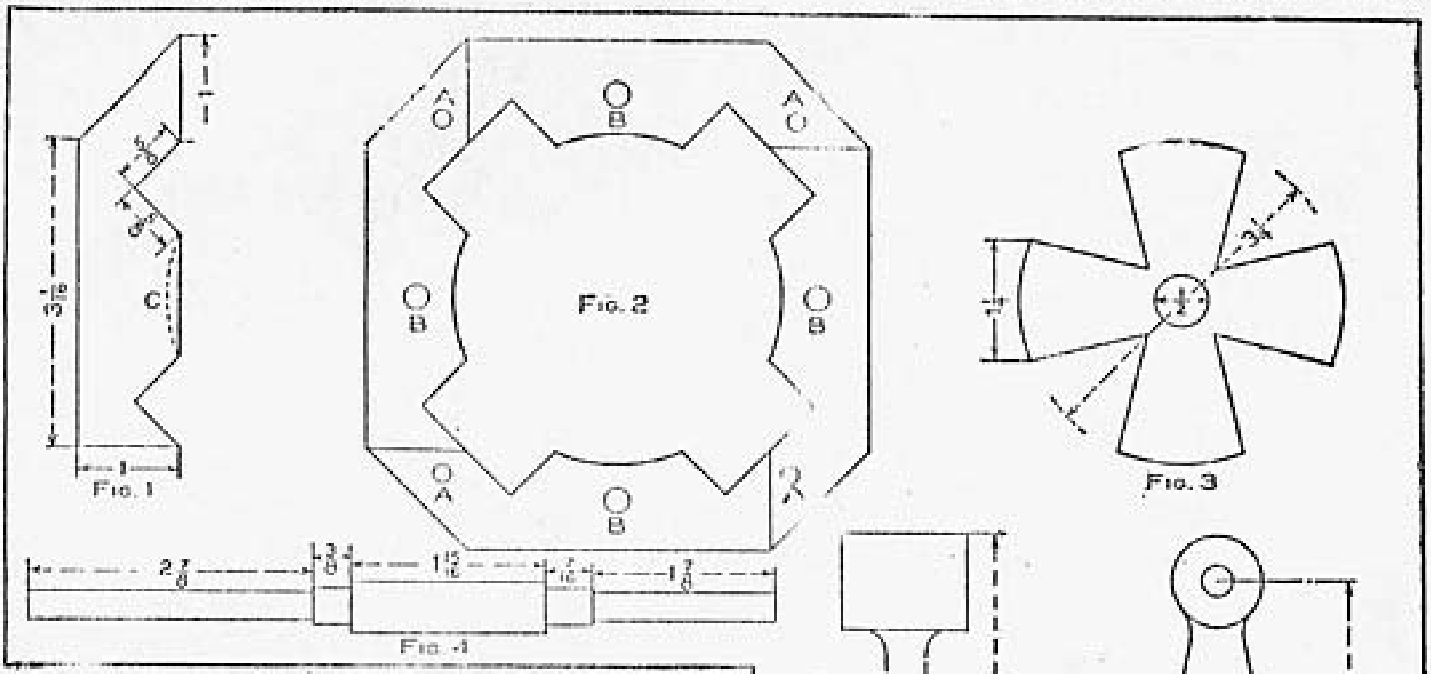
How to Make a Small Single-Phase Induction Motor

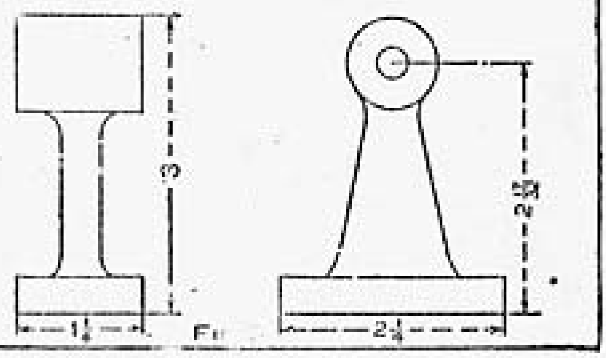
By C. H. Bell

The following notes on a small single-phase induction motor, without auxiliary phase, which the writer has made, may be of interest to some of our readers, says the Model Engineer. The problem to be solved was the construction of a motor large enough to drive a sewing machine or very light lathe, to be supplied with 110-volt alternating current from a lighting circuit, and to consume, if possible, no more current than a 16-cp. lamp. In designing, it had to be borne in mind that, with the exception of insulated wire, no special materials could be obtained.

The principle of an induction motor is quite different from that of the commutator motor. The winding of the armature, or "rotor," has no connection with the outside circuit, but the current is induced in it by the action of the alternating current supplied to the winding of the field-magnet, or "stator." Neither commutator nor slip rings are required, and all sparking is avoided. Unfortunately, this little machine is not self-starting, but a slight pull on the belt just as the current is turned on is all that is needed, and the motor rapidly gathers speed provided no load is put on until it is in step with the alternations of the supply. It then runs at constant speed whether given much or little current, but stops if overloaded for more than a few seconds.

The stator has four poles and is built up of pieces of sheet iron used for stove pipes, which runs about 35 sheets to the inch. All the pieces are alike and cut on the lines with the dimensions as shown in Fig. 1, with the dotted line, C, to be filed out after they are placed together. Each layer of four is placed with the pointed ends of the pieces alternately to the right and left so as to break joints as shown in Fig. 2. The laminations were carefully built up on a board into which heavy wires had been driven to keep them in place until all were in position and the whole could be clamped down. In the middle of the pieces $\frac{1}{4}$-in. holes, B, were then drilled and $\frac{1}{4}$-in. bolts put in and tightened up, large holes being cut through the wood to enable this to be done. The armature tunnel was then carefully filed out and all taken apart again so that the rough edges could be scraped off and the laminations given a thin coat of shellac varnish on one side. After assembling a second time, the bolts were coated with shellac and put into place for good. Holes 5-32 in. in di-





ameter were drilled in the corners, A, and filled with rivets, also varnished before they were put in. When put together they should make a piece 2 in. thick.

This peculiar construction was adopted because proper stampings were not available, and as every bit of sheet iron had to be cut with a small pair of tinners' snips, it was important to have a very simple outline for the pieces. They are not particularly accurate as it is, and when some of them got out of their proper order while being varnished, an awkward job occurred in the magnet which was never entirely corrected. No doubt some energy is lost through the large number of joints, all representing breaks in the magnetic circuit, but as the laminations are tightly held together and the circuit is about as compact as it could possibly be, probably the loss is not as great as it would appear at first sight.

The rotor is made of laminations cut from sheet iron, as shown in Fig. 3, which were varnished lightly on one side and clamped on the shaft between two nuts in the usual way. A very slight cut was taken in the lathe afterwards to true the circumference. The shaft was turned from ½-in. wrought iron, no steel being obtainable, and is shown with dimensions in Fig. 4. The bearings were cast of babbitt metal, as shown in Fig. 5, in a wooden mold and bored to size with a twist drill in the lathe. They are fitted with ordinary wick lubricators. Figures 6 and 7 are sections showing the general arrangement of the machine.

The stator is wound full with No. 22 double cotton-covered copper wire, about 2½ lb. being used, and the connections are such as to produce alternate poles—that is, the end of the first coil is joined to the end of the second, the beginning of the second to the beginning of the third, and the end of the third to the end of the fourth, while the beginnings of the first and fourth coils connect to the supply.

The rotor is wound with No. 24 double cotton-covered copper wire, each limb being filled with about 200 turns, and all wound in the same direction. The four commencing ends are connected together on one side of the rotor, and the four finishing ends are soldered together on the other. All winding spaces are carefully covered with two layers of cambric soaked in shellac, and as each layer of wire was wound, it was well saturated with varnish before the next was put on.

This type of motor has drawbacks, as before stated, but if regular stampings

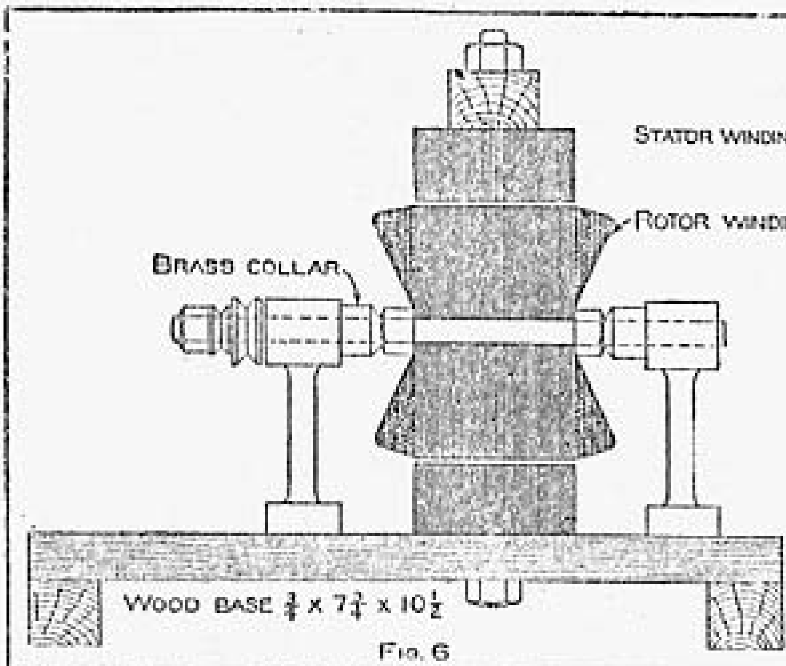


Fig. 6

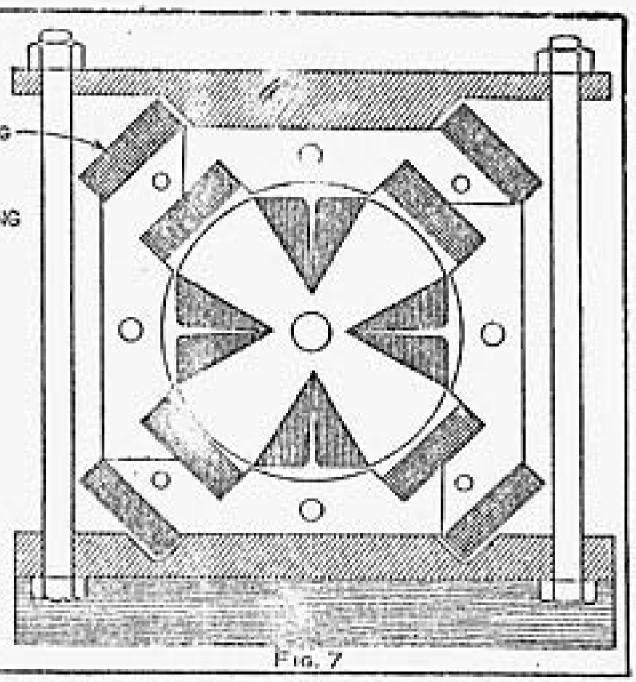


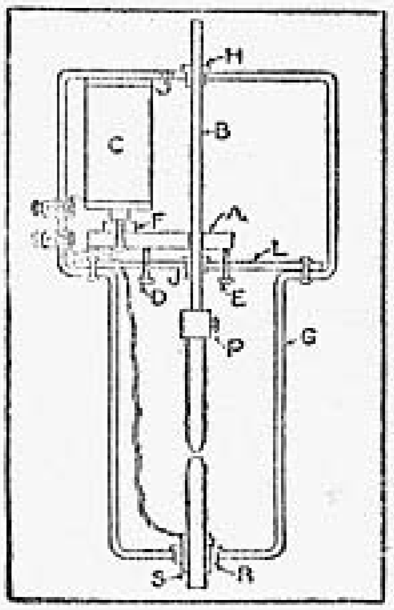
Fig. 7

are used for the laminations, it would be very simple to build, having no commutator or brushes, and would not easily get out of order. No starting resistance is needed, and as the motor runs at constant speed, depending upon the number of alterations of the supply, a regulating resistance is not needed.

THE BOY MECHANIC – 1913

Home-Made Arc Lamp

The frame of the lamp is made from bar metal $\frac{3}{4}$ in. wide and $\frac{1}{8}$ in. thick, bent and welded to make a continuous loop in the shape as shown at G in the sketch. This frame should be about $10\frac{1}{2}$ in. long with the upper or wider part 4 in. long, and the lower part $6\frac{1}{2}$ in. long. The width should be about $5\frac{1}{4}$ in. at the top and 4 in. at the bottom. A cross bar, L, made of the same material, is fitted into the off-set in the frame and riveted. Holes are drilled through the frame and brass bushings, H and J, are fitted for bearings to receive the adjusting brass rod, B, which should be $\frac{1}{4}$ in. in diameter. A brass curtain rod can be used for the rod B, and on its lower end a socket, P, is soldered.



A piece of brass 2 in. long, $\frac{1}{2}$ in. wide and $\frac{1}{8}$ in. thick is used for the armature, A, to be operated by the magnet coil, C. The coil, C, is made in the usual manner by wrapping No. 14 cotton-covered magnet wire on a wooden spool that has a soft iron core. The spool is about $2\frac{1}{2}$ in. long. The armature, A, is drilled, making a hole just a little larger than the rod, B, and is adjusted in place by two set screws, D and E. A soft piece of iron, F, is fastened to the opposite end of the armature with a screw, which should be placed directly under the end of the coil's core. This end of the armature may be kept from swinging around by placing it between a U-shaped piece of brass fastened to the cross piece L. At the bottom end of the frame, and directly centering the holes H and J, a hole is drilled to receive a hard rubber bushing, R, for insulating the brass ferrule, S, that holds the lower carbon.

One connection is made from the main to the upper binding-post, which is in turn connected to one terminal of the coil, C, the other coil terminal being attached to the frame. The other main connection is made to the lower binding-post, which is also connected to the brass ferrule, S, by soldering.

The two binding-posts are insulated from the frame the same as the ferrule S. When using on a 110-volt circuit there must be some resistance in connection, which may be had by using german silver wire, or a water rheostat heretofore described.—Contributed by Arthur D. Bradley, Randolph, Mass.

THE BOY MECHANIC – 1913

Another Electric Lamp Experiment

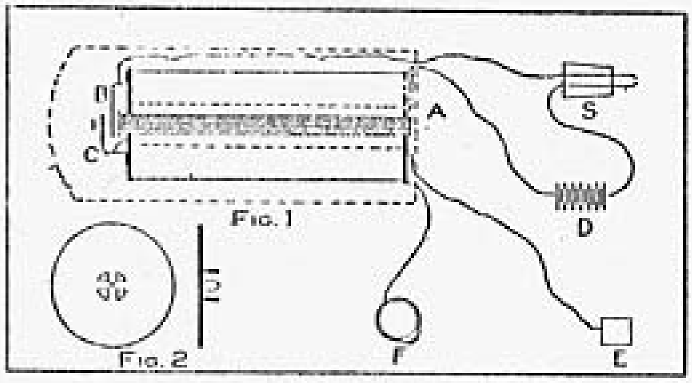
Break a portion of the end off from a 16-cp. globe that has been thrown away as useless. Shake the globe until all the filament is broken away, leaving only the ends of the platinum wire exposed. Screw the globe into a socket that sets upright and fill it with salt water. Make one connection to the socket from the positive wire of a 110-volt circuit and the other to a ground. When the current is turned on small stars will be seen in the globe, which show up fine at night.—Contributed by Lindsay McMillan, Santa Maria, Cal.

THE BOY MECHANIC – 1913

How to Give an Electric Shock While Shaking Hands

There is nothing quite so startling as to receive an electric shock unexpectedly and such a shock may be given to a friend while shaking hands upon meeting. The shock produced is not harmful and the apparatus can be carried in the pocket. It consists of a small induction coil that can be constructed at home.

The core of the coil, A, Fig. 1, is constructed in the usual manner, of small soft-iron wire to make a bundle about $\frac{3}{16}$ in. in diameter and 2 in. long. The coil ends are made from cardboard, about 1 in. in diameter, with a $\frac{3}{16}$-in. hole in the center. The hole should be cut as shown in Fig. 2, so as to have four small pieces that can be bent out, leaving the projections as shown. After wrapping three or four turns of paper around the bundle of



Details of Induction Coil

wires the cardboard ends are put on with the projections inside, so the coils of wire will hold them in place. About 70 turns of No. 24 gauge double-covered magnet wire is first placed on the core, for the primary, and then 1,500 turns of No. 32 or 34 gauge double-covered wire is wrapped on top of the primary, for the secondary. Sufficient length of wire must be left outside at each end of both windings to make connections. The vibrator B, Fig. 1, and the support C are made from thin spring steel, about ⅛ in. wide, bent as shown and securely fastened to the cardboard end of the coil. The armature is made from a soft piece of iron, about $\frac{3}{16}$ in. in diameter and $\frac{1}{16}$ in. thick, which is soldered to the end of the vibrator directly opposite the end of the core. A small screw is fitted in the end of the support, C, for adjustment, which should be tipped with platinum and also a small piece of platinum placed where the screw will touch the vibrator, B.

One of the primary wires is connected to the screw support. The vibrator is connected to a flash lamp battery, D. The other primary wire is connected to a switch, S, which in turn is connected to the other terminal of the battery. The switch, S, may be made from a ⅜-in. cork with the wires put through about $\frac{3}{16}$ in. apart and allow them to project about ½ in. The plate E is cut about ½ in. square from a piece of copper and is fastened to the heel of one shoe and connected with a wire from the secondary coil which must be concealed inside of the trouser leg. The other secondary wire is connected through the coat sleeve to a finger ring, F. The vibrator screw must be properly adjusted. When the vibrator is not working the armature should be about 1/16 in. from the core and directly opposite.

The coil when complete will be about 2½ in. long and 1 in. in diameter. The coil can be placed in an old box that has been used for talcum powder or shaving stick. The space around the coil in the box can be filled with paper to keep it tight.

The coil and battery are carried in the pockets and the cork button put in the outside coat pocket, where it can be pressed without attracting attention.

THE BOY MECHANIC – 1913

How to Make an Induction Coil

A small shocking coil, suitable for medical purposes, may be constructed of materials found in nearly every amateur mechanic's collection of odds and ends. The core, A, Fig. 1, is a piece of round soft iron rod about ¼ in. in diameter and about 4 in. long. A strip of stiff paper about ¾ in. wide is covered with glue and wrapped around one end of the core, as shown at B, until the diameter is about ⅜ in. The portion of the core remaining uncovered is then wrapped with a piece of paper about 4 in. wide. No glue is used on this piece, as it is removed later to form the space, C, after the paper shell, D, has been wound upon it. This paper shell is made of stiff paper and glue the same as B and is made about 3/64 in. thick. Two pieces of hardwood, EE, 1¾ in. square and about 5/16 in. thick, are drilled in the center and glued on the ends of the paper shell as shown.

The primary winding consists of 4 or 5 layers of No. 18 or 20 single cotton-covered magnet wire, the ends of which may be passed through small holes in the wooden ends. If a drill small enough is not available, the holes may be made with a hot knitting needle or a piece of wire heated to redness. After the primary coil is wound it should be thoroughly insulated before winding the secondary. This may be done by wrapping with 4 or 5 thicknesses of paper.

The secondary coil should be wound with single covered wire, preferably silk-covered, although cotton will do. The more turns there are on the secondary the higher the voltage will be, so the wire used must be fine. Number 32 to 36 will give good results, the latter giving more voltage but less amperage. Each layer of the secondary winding should be insulated from the others by a piece of thin paraffined paper wrapped over each layer as it is finished. It is well not to wind to the extreme ends of the paper insulations, but to leave a space of about ⅛ in. at each end of the winding to prevent the wires of one layer slipping over the ends of the paraffin paper and coming in contact with the layer beneath, thus causing a short circuit. The secondary winding should

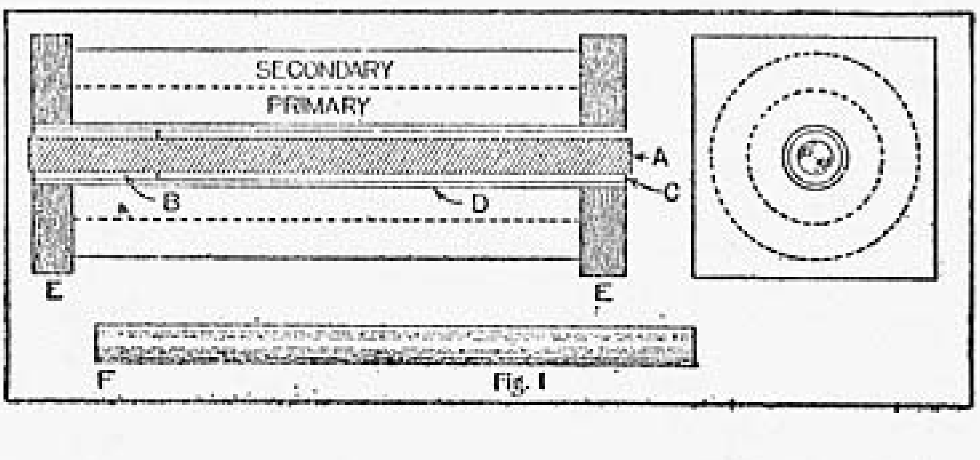


Fig. I

 GRANDDAD'S ELCTRICITY BOOK

have at least a dozen layers and should be carefully wound to prevent short circuiting.

In order to reduce the strength of the current a piece of brass tubing, F, is pushed into the space, C, surrounding the core, or if no brass tubing of the required size is on hand, roll a paper tube, cover with 4 or 5 thicknesses of tinfoil and then wrap with more paper, using glue to hold the tinfoil in place and to keep the tube from unwinding. When the tube is pushed all the way in, the current produced

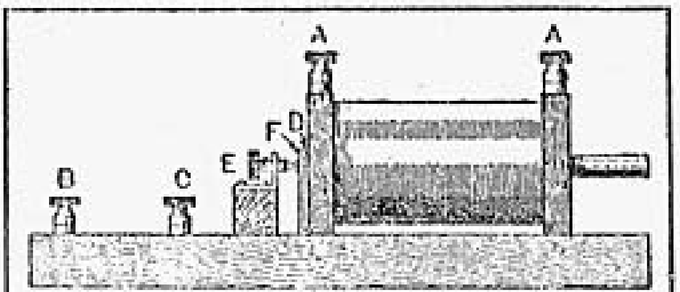


Fig. 2

will be almost unnoticeable, but when it is withdrawn the current will be so strong that a person cannot let go the handles until the coil is shut off. After the secondary coil is wound it should be covered with stiff paper, and the whole coil, including the wood ends, should then be enameled black.

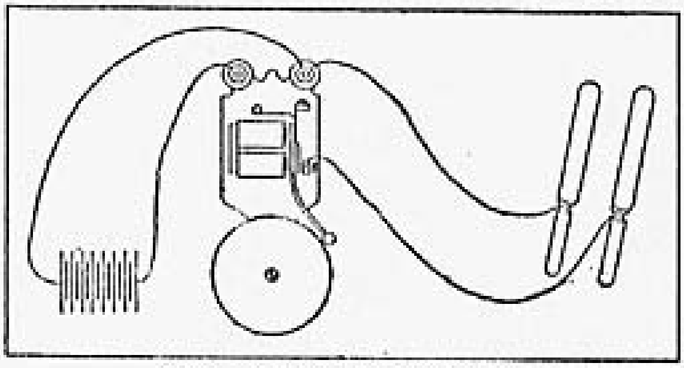
It is then ready to be mounted on a wooden base as shown in Fig. 2. The secondary terminals are connected to the binding-posts, AA, which may be fastened on the base if desired. One wire from the primary is connected with the binding-post, B, and the other is connected with the armature, D, which may be taken from an old electric bell. The contact screw, E, also from an electric bell, is connected to the binding-post, C. The contact spring, F, should be bent against and soldered to the armature in order to make the vibrations more rapid.

If a false bottom is used on the base, all the wiring may be concealed, which adds greatly to the appearance, and if desired a small switch may be added. The handles, which may be old bicycle pumps or electric light carbons, are connected to the binding-posts, AA, by means of wires about 3 or 4 ft. long. This coil when operating with the tube pulled all the way out and connected to a single dry cell will give a current stronger than most persons can stand.

THE BOY MECHANIC – 1913

Home-Made Shocking Machine

An ordinary electric bell may be connected up in such a way as to produce the same results as an expensive


Inexpensive and Effectual

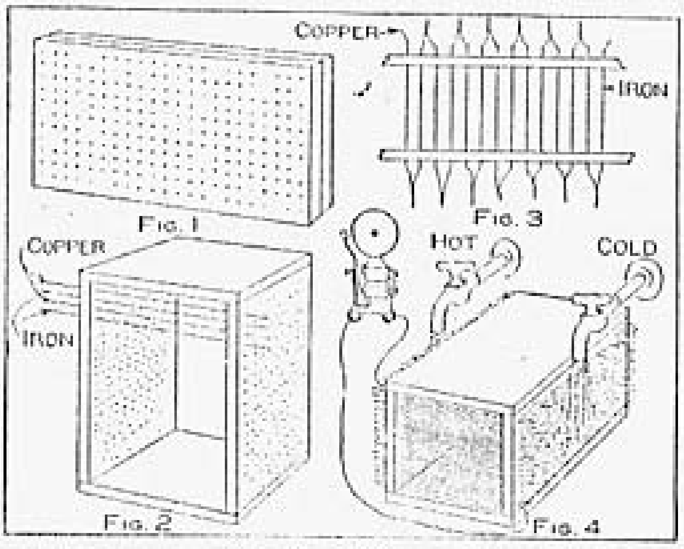
shocking machine. The connections are made from the batteries to the bell in the usual manner. Two other wires are then connected, one to the binding-post of the bell that is not insulated from the frame and the other to the adjusting screw on the make and break contact of the bell as shown in the sketch. The other ends of the wires are connected each to a common table knife. This will give quite a good shock and a much larger one can be had by placing one knife in a basin of water and while holding the other knife in one hand, dipping the fingers of the other hand in the water.—Contributed by D. Foster Hall.

THE BOY MECHANIC – 1913

How to Make a Thermoelectric Battery

By ARTHUR E. JOERIN

A novel way of producing an electric current by means of hot and cold water, heat from a match or alcohol lamp, is obtained from a device constructed as shown in the sketch. Take two hardwood boards, marble, or slate



Details of Battery

plates, about 8 or 10 in. long, place them together, as in Fig. 1, and mark and drill about 500 holes. These two pieces should be separated about 8 in. and fastened with boards across the ends, as shown in Fig. 2.

Take soft copper wire, not smaller than No. 18 gauge, and cut in lengths to pass through the holes in the two boards, leaving sufficient end to make a tie. It will require about 70 ft. of wire to fill one-half the number of holes. Also, cut the same number of lengths from the same gauge galvanized-iron wire to fill the remaining holes. The wires are put through the holes in the boards alternately, that is: begin with copper, the next hole with iron, the next copper, the next iron, and so on, twisting the ends together as shown in Fig. 3. The connections, when complete, should be copper for the first and iron for the last wire.

When the whole apparatus is thus strung, the connections, which must be twisted, can be soldered. Connect one copper wire to the bell and the other terminal, which must be an iron wire, to the other post of the bell. The apparatus is then short-circuited, yet there is no current in the instrument until a lighted match, or, better still, the flame of an alcohol lamp is placed at one end only.

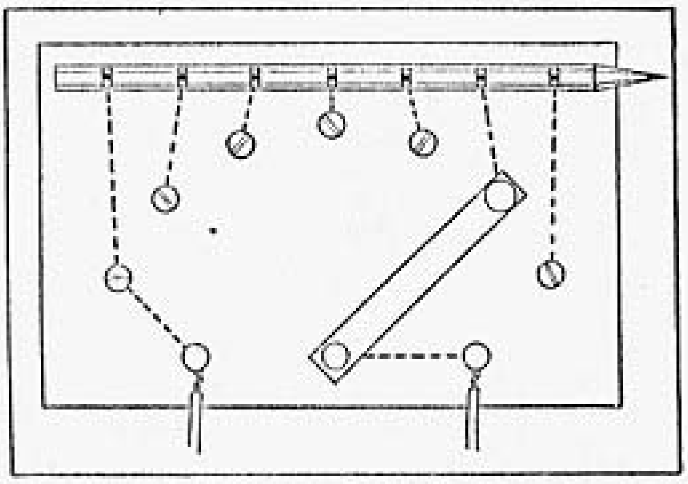
Best results are obtained by putting ice or cold water on one side and a flame on the other. The experimenter may also place the whole apparatus under sink faucets with the hot water turned on at one terminal and the cold water at the other. The greater the difference of temperature in the two terminals, the more current will be obtained.

Very interesting experiments may thus be performed, and these may lead to the solving of the great thermoelectric problem.

THE BOY MECHANIC – 1913

How to Make a Lead Pencil Rheostat

Take an ordinary lead pencil and cut seven notches at equal intervals on the pencil down to and around the lead, leaving it bare. A seven-point switch is constructed on a board of suitable size making the points by using screws that will go through the board. A small piece of tin or brass will do for a switch and is fastened as shown. The connections are made on the back side of the board as shown by the dotted lines. This will reduce 40 to 50 volts down to 5 or 10 volts for short lengths


Simple Rheostat

of time.—Contributed by Roy Newby, San Jose, Cal.

THE BOY MECHANIC – 1913

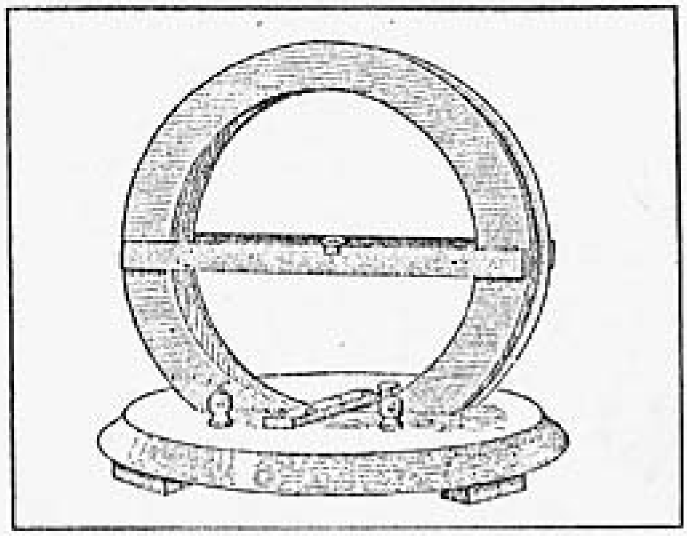
How to Make a Tangent Galvanometer

Secure a piece of wood ½ in. thick and cut out a ring with an outside diameter of $10\frac{1}{2}$ in. and an inside diameter of 9 in. and glue to each side two other rings $\frac{1}{4}$ in. thick with the same inside diameter as the first ring and 11 in. outside diameter, thus forming a $\frac{1}{4}$-in. channel in the circumference of the ring. If a lathe is at hand, this ring can be made from a solid piece and the channel turned out. Cut another circular piece 11 in. in diameter for a base. Make a hole in the center of this piece 1 in. wide and $6\frac{5}{16}$ in. long, into which the ring first made should fit so that its inner surface is just even with the upper surface of the baseboard. The ring is held upright in the hole by a small strip screwed to the base as shown. All screws and brads that are used must be of brass. The cutting of these circular pieces is not so difficult if a band saw driven by power is used. They can be cut by means of a key-hole saw if a band saw is not accessible.

Before mounting the ring on the base, the groove should be wound with 8 turns of No. 16 double cotton-covered magnet wire. The two ends may be tied together with a string to hold them temporarily.

Fasten two strips of wood $\frac{1}{4}$ in. thick, $\frac{5}{8}$ in. wide and 11 in. long across the sides of the ring with their upper edges passing exactly through the center of the ring. An ordinary pocket compass, about $1\frac{1}{4}$ in. in diameter, is fitted in these strips so that the center of the needle or pointer will be exactly in the center of the ring and its zero point mark at the half-way point between the two strips. Put the ring in place on the base, as shown in the sketch, and connect the two ends of the wire to two binding-posts that are previously attached to the base. Coat the entire surface with brown shellac. Any deviation from the dimensions will cause errors in the results obtained by its use.

Remove all pieces of iron or steel and especially magnets in the near vicinity of the instrument when in use. Place the galvanometer on a level table and turn it until the needle, pointing north and south, and swinging freely, lies exactly in the plane of the coil, as shown in the cut. The needle then will point to zero if the directions have been followed closely. Connect one



Tangent Galvanometer

cell of battery to the instrument and allow the current to flow through the coils. The needle of the compass will be deflected to one side or the other, and will finally come to rest at a certain angle—let us say 45 deg. The dimensions of the instrument are such that when the deflection is 45 deg. the current flowing through the coils upon the ring is $\frac{1}{2}$ ampere. The ampere is the unit chosen to designate the strength of the electric current. For other angles the value of the current may be found from the following table:

Angles.	Current.
10 deg.	.088 amp.
20 "	.182 "
30 "	.289 "
40 "	.420 "
45 "	.500 "
50 "	.600 "
55 "	.715 "
60 "	.865 "
70 "	1.375 ."

As the magnetic force that acts upon a magnet needle varies in different places the values given for the current will not be true in all parts of the country. The table gives correct values for the immediate vicinity of Chicago and that part of the United States lying east of Chicago, and north of the Ohio river. The results given

 GRANDDAD'S ELCTRICITY BOOK

should be multiplied by 1.3 for places south of the Ohio river and east of the Mississippi.

THE BOY MECHANIC – 1913

How to Make a Non-Polarizing Battery

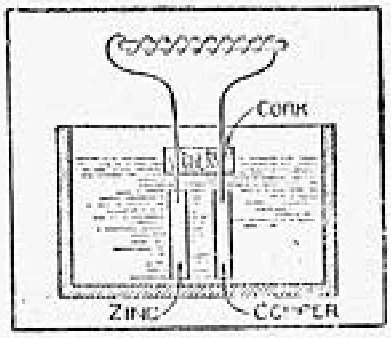
Bichromate batteries are very expensive to maintain and dry cells do not furnish enough amperage for some kinds of experimental work. A cell of battery that will run 10 hours with an output of over 1 ampere can be made as follows: Secure a jar about 4 in. in diameter and 8 in. high and place in the bottom of this jar the lower half of a tin baking powder can, to which a wire has been soldered for connections. Place in the can a mixture of 2 oz. black oxide of copper, 1 oz. black oxide of manganese and some iron filings.

Purchase a small crowfoot zinc and hang it about 1 in. above the half can. Prepare a 10 per cent solution of caustic soda and fill the jar within 1 in. of the top. Place on top the solution a thin layer of kerosene or paraffin. The cell will only cost about 50 cents to make and 25 cents for each renewal. When renewing, always remove the oil with a siphon.—Contributed by Robert Canfield, University Park, Colo.

THE BOY MECHANIC – 1913

A Floating Electromagnet

A piece of iron placed in a coil of wire carrying a current of electricity becomes an electromagnet. If such a coil and iron core be made small enough they can be attached to a cork and the cork, floating on a solution, will allow the magnet to point north and south. The sketch shows how to make such an instrument. A



coil of insulated wire is wrapped around a small iron core, leaving a few inches of each end free for connections. The insulation is removed from these ends and they are run through a piece of cork. Attach to the wires, on the under side of the cork, a piece of zinc to one end and a piece of copper to the other. The cork is then floated on a solution of acid, with the zinc and copper hanging in the solution. If zinc and copper are used, the solution is made from water and blue vitriol. If zinc and carbon are used, the solution is made from sal ammoniac and water.

The float will move about on the solution until the magnet iron will point north and south. If two of them are floating on the same solution, they will move about and finally arrange themselves end to end with the coils and magnet cores pointing north and south.—Contributed by C. Lloyd Enos.

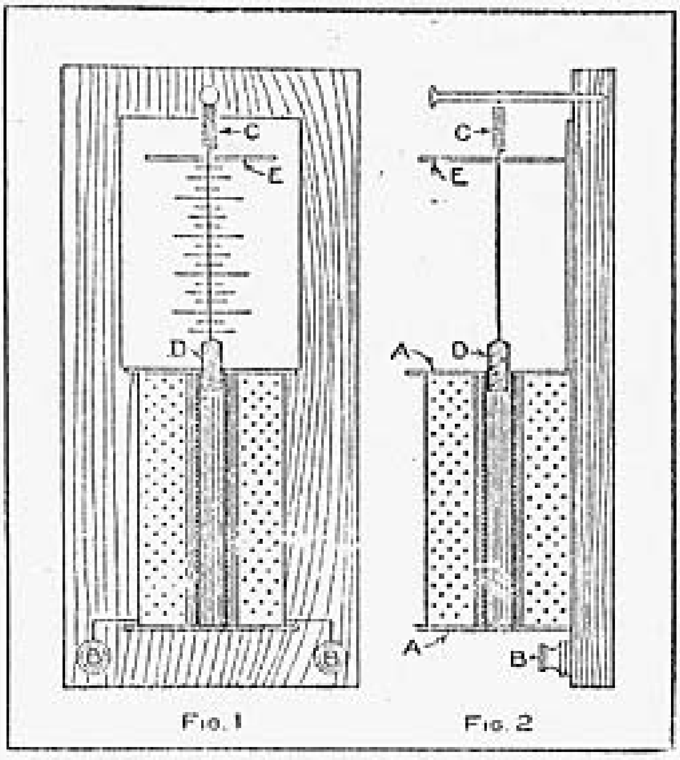
THE BOY MECHANIC – 1913

Home-Made Battery Voltmeter

Secure a piece of brass tube 3 in. long that has about $\frac{1}{4}$-in. hole. Put ends, A, $1\frac{1}{4}$ in. square and cut from heavy cardboard on this tube. Make a hole in the center of each cardboard just large enough to allow the brass tube to fit tight. Put on two or three layers of stout paper around the brass tube and between the cardboard ends. Wind evenly about 2 oz. of No. 26 cotton-covered magnet wire on the paper between the ends and leave about 2 in. of wire on each end extending from the coil. Use a board $\frac{1}{2}$ in. thick, 3 in. wide and 6 in. long for the base and fasten the coil to it, as shown in Fig. 1. Bore holes for binding-posts, B, one on each side of the board, and connect the two wires from the coil to them. At the other end of the board and in the center drive a wire nail and attach a small spring, C, to it. The spring should be about 1 in. long. Take a small piece of soft iron, D, $\frac{1}{2}$ in. long and just large

 GRANDDAD'S ELCTRICITY BOOK

enough to slip freely through the brass



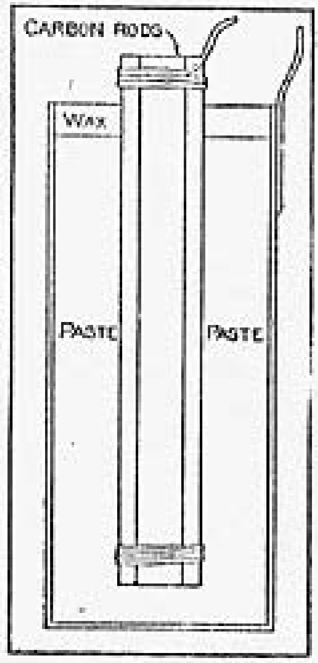
Battery Voltmeter Construction

tube and solder a piece of copper wire to it; the other end of the copper wire being hooked to the spring, C. The copper wire must be just long enough to allow the piece of iron, D, to hang part way in the end of the coil and still hold the spring in place. A circular piece of cardboard, E, is slipped over the spring to where the spring joins the wire. This cardboard is to serve as the pointer. A piece of paper 1½ in. wide and 2½ in. long is glued to the board so that it will be directly under the cardboard pointer and fit snugly up against the top of the coil.

The paper can be calibrated by connecting one cell of battery to the binding-posts. The iron plunger, D, is drawn into the tube and consequently the pointer, E, is drawn nearer to the coil. Make a mark directly under the place where the pointer comes to rest. At the place mark the number of volts the cell reads when connected with a voltmeter. Do the same with two or three cells and mark down the result on the scale. By dividing off the space between these marks you may be able to obtain a surprisingly correct reading when connected with the battery cells to be tested.

How to Make a Dry Battery Cell

Dry battery cells are composed of the same materials for the poles, but instead of the liquid commonly used a paste is formed by mixing sal ammoniac and other salts with water and packed in the cell so it cannot spill.



A cell of this kind can easily be made, and to make it the proper size a sheet of zinc 8½ in. long and 6 in. wide will be required. This zinc is rolled into a cylinder 2½ in. in diameter. This will allow for a lap of ⅝ in., which is tightly soldered only on the outside of the seam. Close one end of the cylinder by soldering a disk of zinc over it, making a watertight receptacle. All soldering should be done on the outside and none of the solder allowed to run on the inside of the seam. All seams on the inside should be painted with asphaltum in order to cover any particles of solder. Do not paint any surface, only the joints. Secure three carbon rods ½ in. in diameter and 6 in. long which are copper plated. Carbons used in arc lamps will do. File the rods to remove the copper plate, leaving about ½ in. of the plate at one end. Tie the three rods in a close bundle with the copper-plated ends together and make a contact with each rod by soldering a wire to the plated ends, allowing one end of the wire to project about 2 in. for a connection. The plated ends of the carbons should be covered with paraffin for about 1 in. This is done by immersing them in a dish of smoking hot melted paraffin until the pores are thoroughly saturated.

The salts for filling are ¼ lb. zinc oxide, ¼ lb. sal ammoniac, ¾ lb. plaster of paris, ¼ lb. chloride of zinc mixed into a paste by adding ½ pt. of water. Form a ½-in. layer of paste in the bottom of the cylinder and place the ends of the carbon rods on this with their plated ends up. Hold the rods in the center of the cylinder and put the paste in around the rods with a stick. Pack the paste in, closely filling the cylinder to within ¾ in. of the top. This space at the top is filled with a mixture of ½ lb. of resin and 2 oz. beeswax melted together. This wax seals the cell and prevents any evaporation. Connection is made to the zinc by soldering a wire to the outside of the cylinder.

THE BOY MECHANIC – 1913

How to Paraffin Wire

The following description of how to make an apparatus with which to paraffin wire as needed makes clear a method of construction that is simple and easy to put together in a short time.

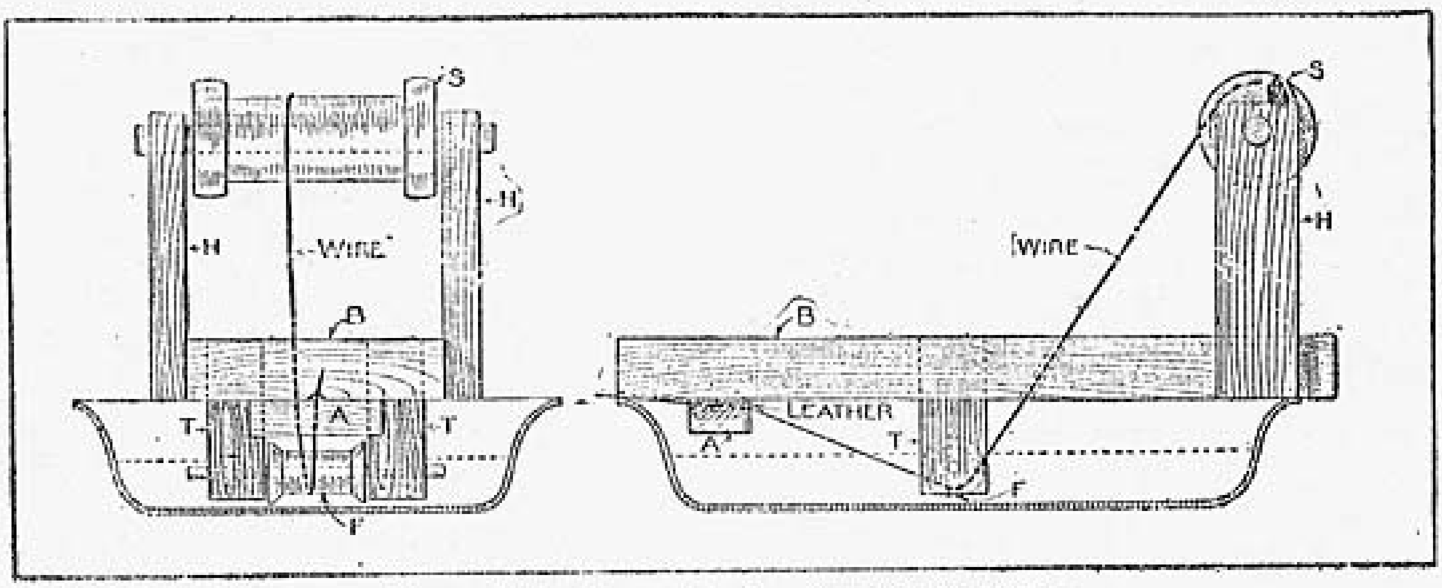
Secure a pan to be used for this purpose only; one that will hold about 1 qt. The details of the construction are given in the diagram, in which P is the pan; B is a base of 1-in. pine; S is the spool of wire supported near one end of the base by nailing on standards H and H; F is a spool, with narrow flanges, supported near the bottom of the pan by the standards T and T. These may be made of two short pieces of a roller fitted into the holes bored in the base; A is a block of 1-in. pine with a piece of leather tacked on one side. Four nails should be driven in the base just outside of the edge of the pan to keep it from sliding off the pan.

Bore a hole in the base between the two spools and pass the wire through this hole, under the spool in the paraffin, then through a small hole in the leather and a notch in the block A, and a notch between the base and the pan. Tie a string around the wire between the leather and the paraffin, making the knots so they will not pull through the hole in the leather. This makes the wire smooth, and by making the string tighter or looser you can regulate the thickness of the paraffin, says Electrician and Mechanic. Place the pan on the stove; when the paraffin is melted, pull out the wire as needed. To keep the pan from sliding place a flatiron or some other weight on it.

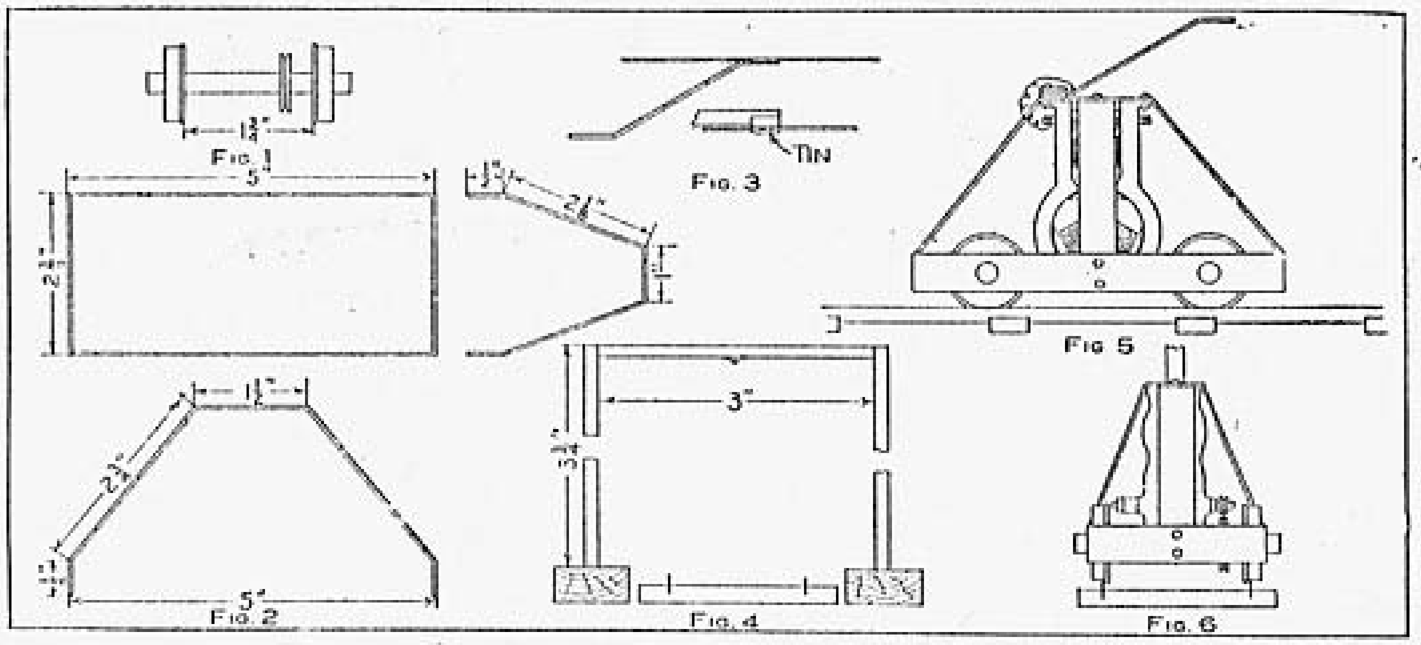
THE BOY MECHANIC – 1913

How to Make a Miniature Electric Locomotive

A miniature electric railway is a thing that attracts the attention of almost any person. The cost of a toy electric locomotive is beyond the reach of many boys who could just as well



Home-Made Apparatus for Paraffining Wire



The Different Parts for Making the Electric Locomotive

make such a toy without much expense and be proud to say they "built it themselves." The electric locomotive described herewith uses for its power a small battery motor costing about $1. The first thing to do is to make the wheels and axles. If one has no lathe, the wheels can be turned at some machine shop. Four wheels are made from a round bar of metal, as shown in Fig. 1. Each wheel is 1/4 in. thick and 1 in. in diameter, with a 1/16-in. flange and a 1/4-in. hole drilled in the center. Each pair of wheels is fitted on a 1/4-in. axle, about 2⅝ in. long. One of the axles should be fitted with a grooved belt wheel, as shown. Make the frame from three pieces of heavy brass, as shown in Fig. 2.

The first piece, or main part of the frame, is made from brass, 3/4 in. wide and 16 in. long, bent into an oblong shape and the ends soldered or bolted together. If the ends are to be soldered, before doing so drill four 1/4-in. holes 1 in. from the ends and insert the ends of the axles. The other two pieces are 1/2 in. wide and of the dimensions shown in the sketch. These pieces are riveted in the middle of the oblong frame, each in its proper place. The motor is now bolted, bottom side up, to the top of the piece fastened to the frame lengthwise. A trolley, Fig. 3, is made from a piece of clock spring, bent as shown, and a small piece of tin soldered to the top end for a brush connection. A groove is made in the tin to keep the trolley wire in place.

The trolley wire is fastened to supports made of wood and of the dimensions given in Fig. 4. The trolley should be well insulated from the frame. The parts, put together complete, are shown in Fig. 5. Run a belt from the pulley on the motor to the grooved wheel on the axle, as shown in Fig. 6, and the locomotive is ready for running.

In making the connections the travel of the locomotive may be made more complicated by placing a rheostat and controlling switches in the line, so that the engine can be started and stopped at will from a distance and the speed regulated. Automatic switches can be attached at the ends of the line to break the circuit when the locomotive passes a certain point.

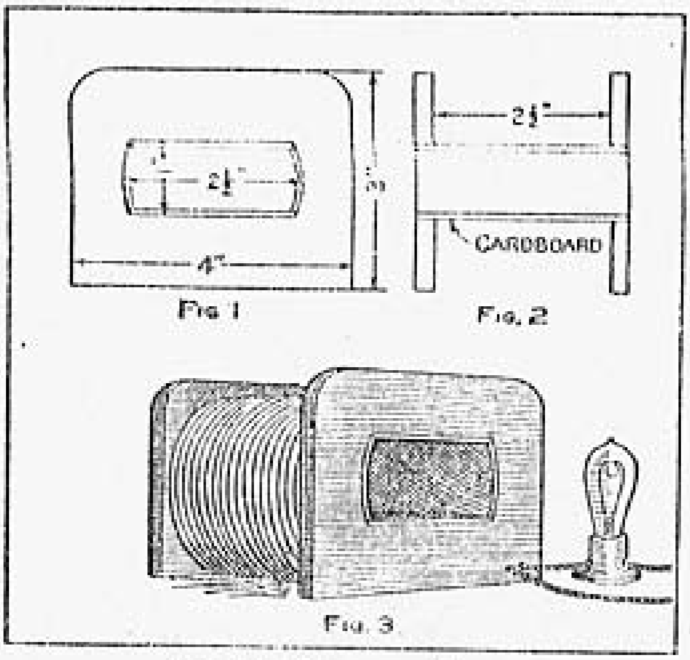
One connection from the batteries is made to the trolley wire and the other to a rail. The connection for the motor runs from one binding post to the trolley and this connection must be well insulated to avoid a short-circuit. The other binding-post is connected to the frame.

The cost of making the wheels and purchasing the track will not be over $1.50. The track can be made from strips of tin put in a saw cut made in pieces of wood used for ties. This will save buying a track.—Contributed by Maurice E. Fuller, San Antonio, Texas.

Demagnetizing a Watch

THE BOY MECHANIC – 1913

A test can be made to know if your watch is magnetized by placing a small compass on the side of the watch nearest the escapement wheel. If the compass pointer moves with the escapement wheel the watch is magnetized. A magnetized watch must be placed in a



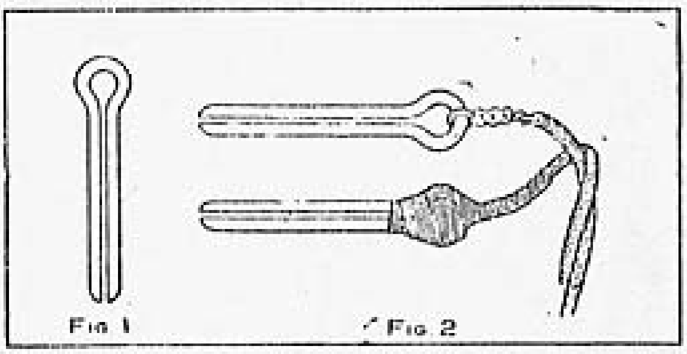
Watch Demagnetizer

coil that has an alternating current of electricity flowing through it to remove the magnetism. A demagnetizer can be made as shown in the illustration. Two end pieces for the coil are made as shown in Fig. 1 from ¼-in. wood. These ends are fastened together, Fig. 2, with cardboard 3 in. long glued to the inside edges of the holes cut in them. Wind upon the spool thus formed about 2 lb. of No. 16 cotton-covered copper wire. As it will be necessary to place a 16-cp. lamp in series with the coil, both the coil and lamp can be mounted on a suitable base and connected as shown in Fig. 3. The current, which must be 110-volt alternating current, is turned on the lamp and coil and the magnetized watch slowly drawn through the opening in the center of the coil.

THE BOY MECHANIC – 1913

Wire Terminals for Battery Connections

Good connections on the end of wires for batteries can be made from cotter pins, Fig. 1, about 1½ in. long. Each end of the wire is put through the eye of a cotter pin, twisted around itself



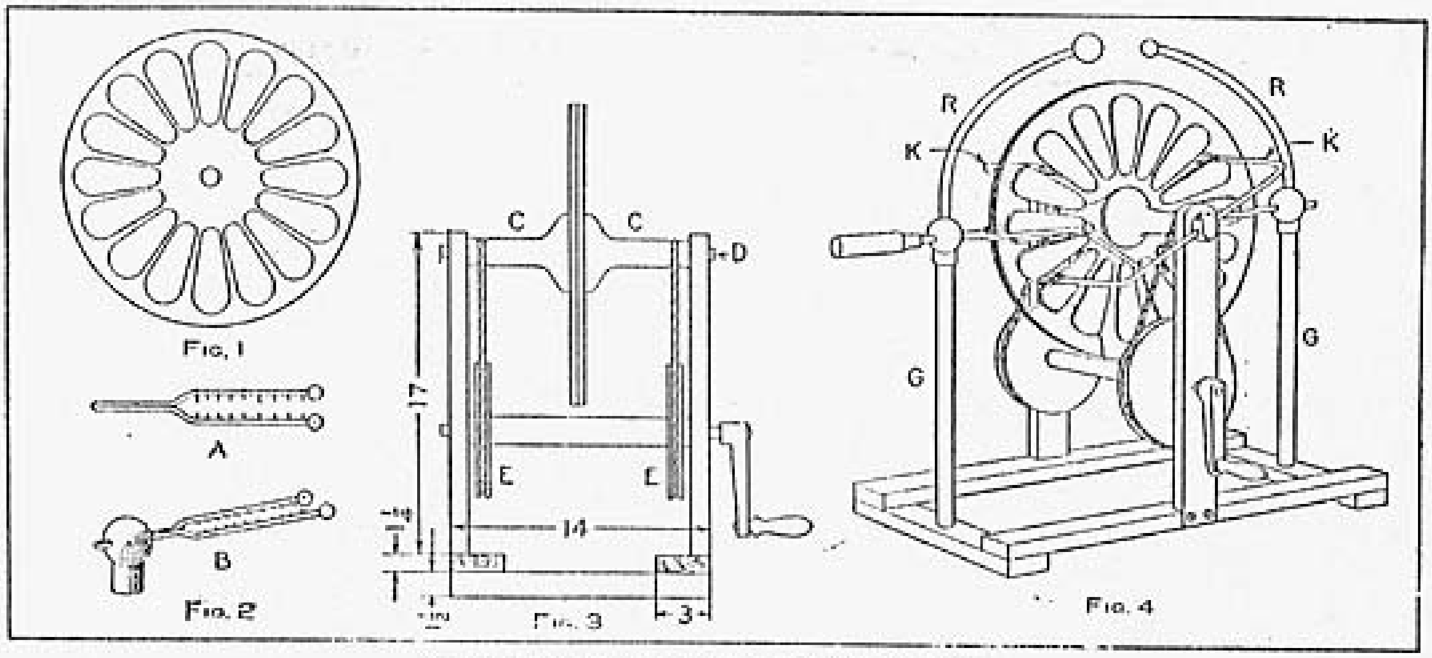
Cotter Pin Wire Terminals

and soldered. The connection and eye are then covered with tape as shown in Fig. 2. When connecting to batteries, spread the pin and push the parts under the nut with one part on each side of the binding-post. When the nuts are tightened the connection will be better than with the bare wire.—Contributed by Howard S. Bott.

THE BOY MECHANIC – 1913

How to Make a Static Machine

Static electricity is produced by revolving glass plates upon which a number of sectors are cemented; these sectors, passing through neutralizing brushes, distribute electric charges to collecting combs attached to discharging rods. The glass selected for the plates must be clear white glass, free from wrinkles, and of a uniform thickness. Two plates are necessary to make this machine, and the glass should be of sufficient size to cut a circular plate 16 in. in diameter. A hole must be made exactly in the center of each plate, and this should be done before cutting the circle. One of the best ways to make the hole is to drill the glass with a very hard-tempered drill, the cutting edge of which should be kept moistened with 2 parts tur-



Details of a Homemade Static Machine

pentine and 1 part sweet oil while drilling. The hole is to be made ¾ in. in diameter. The circle is then marked on each plate and cut with a glass cutter. The plates are trued up, after they are mounted, by holding a piece of emery wheel to the edges while they are turning. Water should be applied to the edges while doing the work.

The sectors are cut from tinfoil, 1½ in. wide at one end, ¾ in. at the other, and 4 in. long. A thin coat of shellac varnish is applied to both sides of the plates, and 16 sectors put on one side of each plate, as shown in Fig. 1. The divisions can be marked on the opposite side of the plate and a circle drawn as a guide to place the sectors at proper intervals.

The sectors should lie flat on the glass with all parts smoothed out so that they will not be torn from their places as the plates revolve. The shellac should be tacky when the pieces of tinfoil are put in place.

The collectors are made, as shown in Fig. 2, from about ¼-in. copper wire with two brass balls soldered to the ends. The fork part is 6 in. long and the shank 4 in. Holes are drilled on the inside of the forks, and pins inserted and soldered. These pins, or teeth, should be long enough to be very close to the sectors and yet not scratch them when the plates are turning.

The frame of the machine is made from any kind of finished wood with dimensions shown in Fig. 3, the side pieces being 24 in. long and the standards 3 in. wide. The two pieces, C C, Fig. 3, are made from solid, close-grained wood turned in the shape shown, with the face that rests against the plate 4 in. in diameter, and the outer end 1½ in. in diameter, the smaller end being turned with a groove for a round belt. Before turning the pieces a hole is bored through each piece for the center, and this hole must be of such a size as to take a brass tube that has an internal diameter of ¾ in. The turned pieces are glued to the glass plates over the center holes and on the same side on which the sectors are fastened. Several hours' time will be required for the glue to set. A fiber washer is then put between the plates and a brass tube axle placed through the hole. The plates, turned wood pieces, and brass axle turn on a stationary axle, D.

The drive wheels, EE, are made from ⅞-in. material 7 in. in diameter, and are fastened on a round axle cut from a broom handle. This wood axle is centrally bored to admit a metal rod tightly, and extends through the standards with a crank attached to one end.

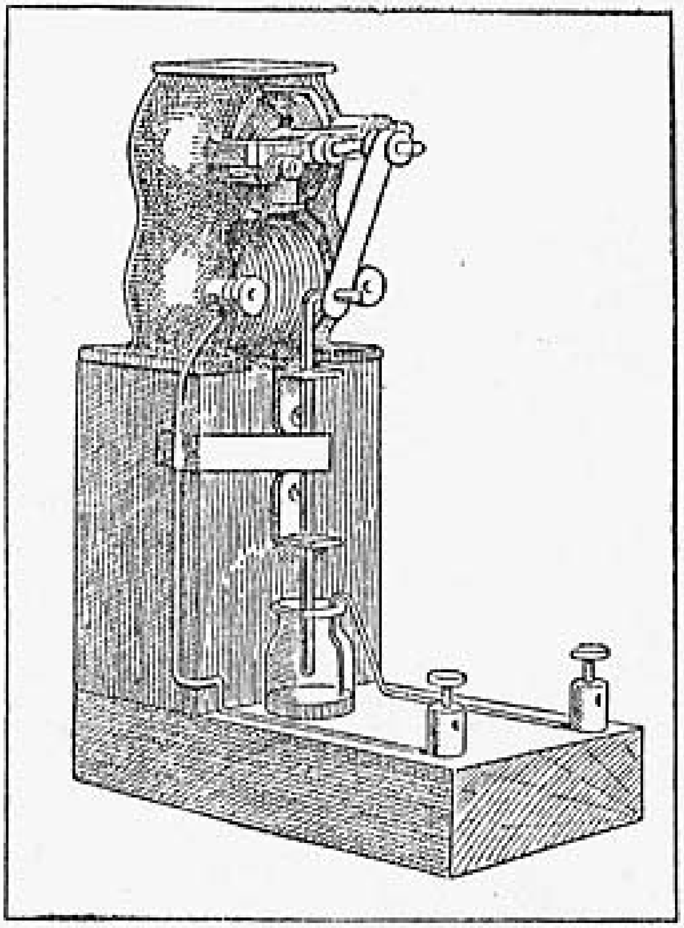
Two solid glass rods, GG, Fig. 4, 1 in. in diameter and 15 in. long, are fitted in holes bored into the end pieces of the frame. Two pieces of 1-in. brass tubing and the discharging rods, RR, are soldered into two hollow brass balls 2 or 2½ in. in diameter. The shanks of the collectors are fitted in these brass balls with the ends extending, to which insulating handles are attached. Brass balls are soldered to the upper ends of the discharging rods, one having a 2-in. ball and the other one ¾ in. in diameter.

Caps made from brass are fitted tightly on the ends of the stationary shaft, D, and drilled through their diameter to admit heavy copper rods, KK, which are bent as shown. Tinsel or fine wire such as contained in flexible electric wire are soldered to the ends of these rods, and the brushes thus made must be adjusted so they will just touch the plates. The caps are fitted with screws for adjusting the brushes. These rods and brushes are called the neutralizers. A little experimenting will enable one to properly locate the position of the neutralizers for best results.—Contributed by C. Lloyd Enos, Colorado City, Colo.

THE BOY MECHANIC – 1913

Mercury Make-and-Break Connections for Induction Coils

Induction coils operating on low voltage have a make-and-break connection called the "buzzer" to increase the secondary discharge. Two types of make-and-break connection are used, the common "buzzer" operated by the magnetism of the core in the coil and the mercury break operated by a small motor. The sketch herewith shows how to make the motor-operated break. Two blocks of wood are nailed together in the shape of an L and a small motor fastened to the top of the vertical piece. The shaft of the motor is bent about ⅛ in. in the shape of a crank, so that in turning it will describe a circle ¼ in. in diameter. A small connecting bar is cut from a piece of brass ⅛ in. thick, ¼ in. wide and 1 in. long and a hole drilled in each end; one hole to fit the motor shaft and the other to slip on a No. 12 gauge wire. Two L-shaped pieces of brass are fastened to the side of the block and drilled with holes of such a size that a No. 12 gauge wire will slip through snugly. Place a No.



Motor-Driven Make-and-Break

12 gauge wire in these holes and bend the top end at right angles.

Put the connecting brass bar on the motor shaft with washers fitted tight on each side and slip the other end over the bent end of the wire. Have the wire plenty long so it can be cut to the proper length when the parts are all in place. A small round bottle about ½ in. in diameter is now fitted in a hole that has been previously bored into the middle of the bottom block and close up to the vertical piece. This should only be bored about half way through the block. The wire is now cut so at the length of the stroke the end will come to about one-half the depth, or the middle of the bottle.

Fill the bottle with mercury to a point so that when the motor is running, the end of the wire will be in the mercury for about one-half of the stroke. Cover the mercury over with a little alcohol. A No. 14 gauge iron wire is bent and put into the side of the bottle with the end extending to the bottom. The other end of this wire is attached to one binding-post placed at the end of the bottom block. The other binding-post is connected to a small brass brush attached to the side of the vertical piece, which is placed with some pressure on the moving wire. The motor can be run with a current from a separate course or connected as shown on the same batteries with the coil. The proper height of the mercury can be regulated for best results. The motor must run continuous if the coil is used for writing code signals, wireless, etc.—Contributed by Haraden Pratt, San Francisco, Cal.

THE BOY MECHANIC – 1913

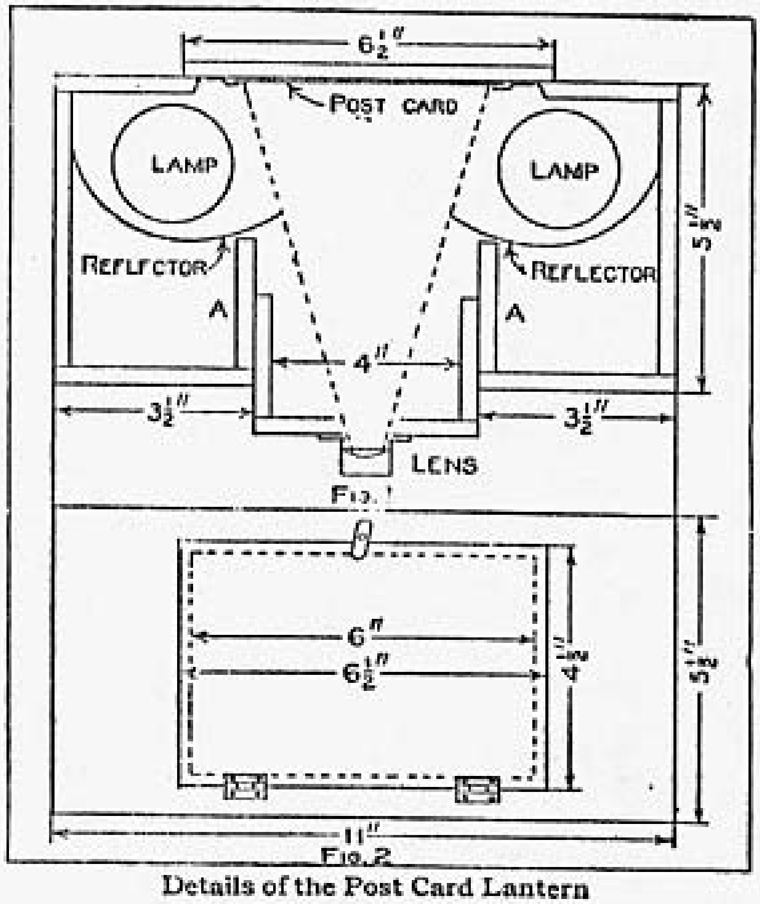
An Electric Post Card Projector

A post card projector is an instrument for projecting on a screen in a darkened room picture post cards or any other pictures of a similar size. The lantern differs from the ordinary magic lantern in two features; first, it requires no expensive condensing lens, and second, the objects to be projected have no need of being transparent.

Two electric globes are made to cast the strongest possible light on the picture card set between them and in front of which a lens is placed to project the view on the screen, the whole being enclosed in a light-tight box. The box can be made of selected oak or mahogany. The lens to be used as a projector will determine the size of the box to some extent. The measurements given in these instructions are for a lens of about 5 in. focal length. The box should be constructed of well-seasoned wood and all joints made with care so they will be light-tight.

The portion shown carrying the lens in Fig. 1 is made to slide in the main body of the lantern for focusing. A box should first be made 5½ in. wide, 5½ in. high and 11 in. long. A hole is cut in the back of the box 4 by 6 in. represented by the dotted line in Fig. 2. This will be ¾ in. from the top and bottom and 2½ in. from each end of the outside of the box. Two strips of wood ½ in. wide and 6½ in. long are fastened along the top and bottom of the back. The door covering this hole in the back, and, which is also used as a carrier for the post cards, is made from a board 4½ in. wide and 6½ in. long. The door is hinged to the lower strip and held in position by a turn button on the upper strip. The slides for the picture cards are made from strips of tin bent as shown, and tacked to the inside surface of the door.

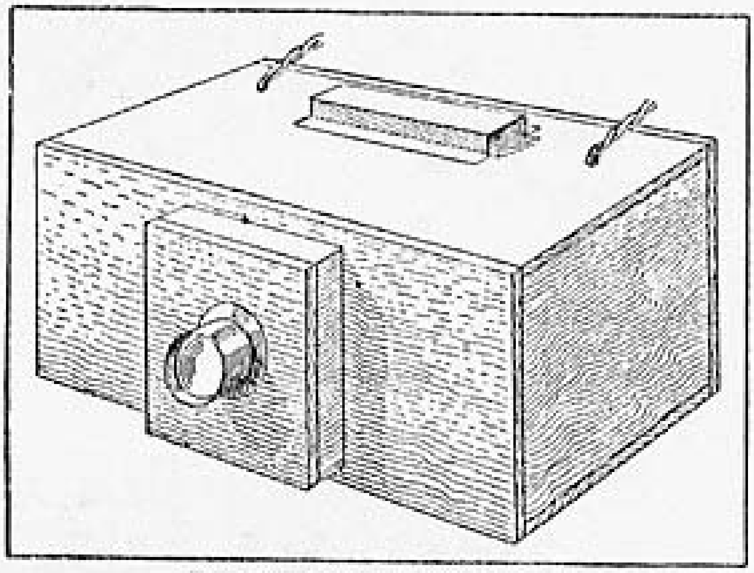
The runners to hold the part carrying the lens are two pieces 2¼ in. wide by 5 in. long and should be placed vertically, AA, as shown in Fig. 1, 3½ in. from each end. An open space 4 in. wide and 5 in. high in the center is for the part carrying the lens to slide for focusing. The part carrying the lens is a shallow box 4 by 5 in. and 2 in. deep in the center of which a hole is cut to admit the lens. If a camera lens is used, the flange should be fastened with screws to the front part of this



Details of the Post Card Lantern

shallow box. The sides of this box should be made quite smooth and a good, but not tight, fit into the runners. Plumbago can be rubbed on to prevent sticking and to dull any rays of light.

Two keyless receptacles for electric globes are fastened to the under side of the top in the position shown and connected with wires from the outside. Two or three holes about 1 in. in diameter should be bored in the top between and in a line with the lights. These will provide ventilation to keep the pictures from being scorched or becoming buckled from the excessive heat. The holes must be covered over on the top with a piece of metal or wood to prevent the light from showing on the ceiling. This piece should not be more than ½ in. high and must



Post Card Lantern Complete

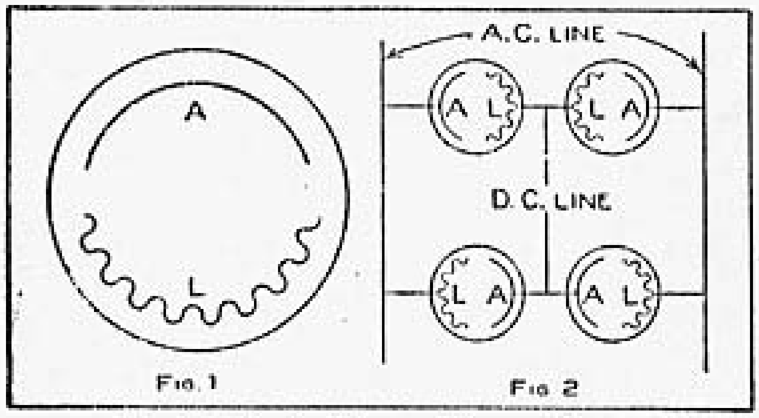
be colored dead black inside to cause no reflection.

The reflectors are made of sheet tin or nickel-plated metal bent to a curve as shown, and extending the whole height of the lantern. The length of these reflectors can be determined by the angle of the lens when covering the picture. This is clearly shown by the dotted lines in Fig. 1. The reflectors must not interfere with the light between the picture and the lens, but they must be sufficiently large to prevent any direct light reaching the lens from the lamps. In operation place the post card upside down in the slides and close the door. Sliding the shallow box carrying the lens will focus the picture on the screen.

THE BOY MECHANIC – 1913 -

How to Make an Electrolytic Rectifier

Many devices which will change alternating current to a direct current



Electrolytic Rectifier and Connections

have been put on the market, but probably there is not one of them which suits the amateur's needs and pocketbook better than the electrolytic rectifier.

For the construction of such a rectifier four 2-qt. fruit jars are required. In each place two electrodes, one of lead and one of aluminum. The immersed surface of the aluminum should be about 15 sq. in. and the lead 24 sq. in. The immersed surface of the lead being greater than that of the aluminum, the lead will have to be crimped as shown in Fig. 1. In both Fig. 1 and 2, the lead is indicated by L and the aluminum by A.

The solution with which each jar is to be filled consists of the following:

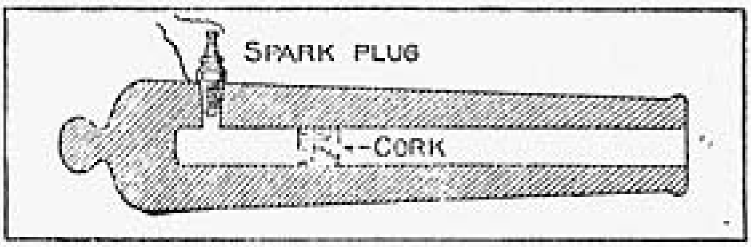
Water	2 qt.
Sodium Carbonate	2 tablespoonfuls
Alum	3 tablespoonfuls

Care should be taken to leave the connections made as shown in Fig. 2. The alternating current comes in on the wires as shown, and the direct current is taken from the point indicated.

The capacity of this rectifier is from 3 to 5 amperes, which is sufficient for charging small storage batteries, running small motors and lighting small lamps.—Contributed by J. H. Crawford, Schenectady, N. Y.

A Gas Cannon

If you have a small cannon with a bore of 1 or 1½ in., bore out the fuse hole large enough to tap and fit in a small sized spark plug such as used on a gasoline engine. Fill the cannon with gas from a gas jet and then push a



Gas Cannon Loaded

cork in the bore close up to the spark plug. Connect one of the wires from a battery to a spark coil and then to the spark plug. Attach the other wire to the cannon near the spark plug. Turn the switch to make a spark and a loud report will follow.—Contributed by Cyril Tegner, Cleveland, O.

How to Make an Ammeter

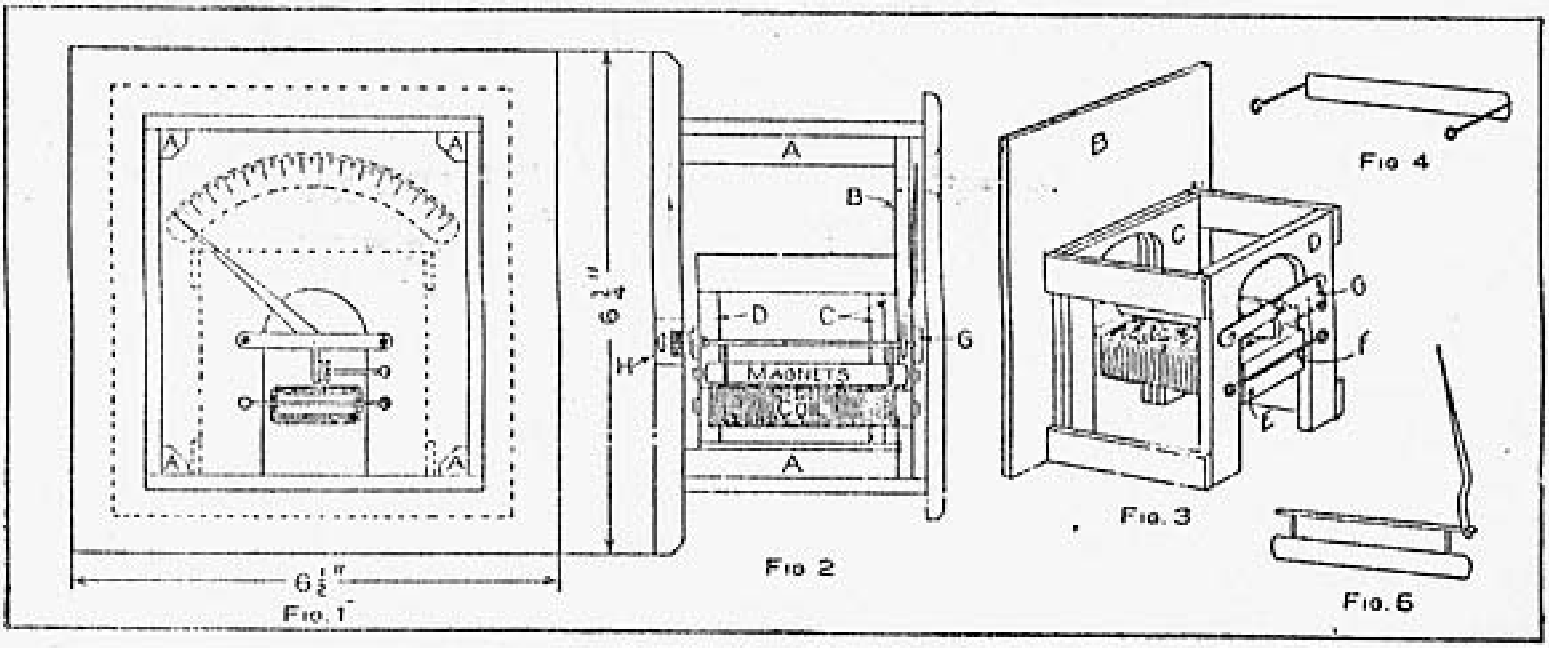
The outside case of this instrument is made of wood taken from old cigar boxes with the exception of the back. If carefully and neatly made, the finished instrument will be very satisfactory. The measurements here given need not be strictly followed out, but can be governed by circumstances. The case should first be made and varnished and while this is drying, the mechanical parts can be put together.

The back is a board ⅜ in. thick, 6½ in. wide and 6¾ in. long. The outer edges of this board are chamfered. The other parts of the case are made from the cigar box wood which should be well sandpapered to remove the labels. The sides are 3¼ in. wide and 5 in. long; the top and bottom, 3¼ in. wide and 4½ in. long. Glue a three-cornered piece, A, Fig. 1, at each end on the surface that is to be the inside of the top and bottom pieces. After the glue is set, fasten the sides to the pieces with glue, and take care that the pieces are all square. When the glue is set, this square box is well sandpapered, then centered, and fastened to the back with small screws turned into each three-cornered piece.

The front, which is a piece 5¼ in. wide and 6½ in. long, has a circular opening cut near the top through which the graduated scale may be seen. This front is centered and fastened the same as the back, and the four outside edges, as well as the edges around the opening, are rounded. The whole case can now be cleaned and stained with a light mahogany stain, and varnished. Cut another piece of board, B, Figs. 2 and 3, to just fit inside the case and rest on the ends of the three-cornered pieces, A, and glue to this board two smaller pieces, C, 3 in. square, with the grain of the wood in alternate directions to prevent warping. All of these pieces are made of the cigar box wood. Another piece, D, ⅜ in. thick and 3 in. square, is placed on the other pieces and a U-shaped opening 1¾ in. wide and 2½ in. high sawed out from all of the pieces as shown. The piece D is attached to the pieces C with four ½-in. pieces 2⅝ in. long.

A magnet is made from a soft piece of iron, E, about ⅜ in. thick, 1¼ in. wide and 2¾ in. long. Solder across each end of the iron a piece of brass wire, F, and make a turn in each end of the wires, forming an eye for a screw. These wires are about 2½ in. long. Wind three layers of about No. 14 double cotton-covered copper wire on the soft iron and leave about 5 or 6 in. of each end unwound for connections.

The pointer is made as shown in Fig. 5 from 1/16-in. brass wire filed to make a point at both ends for a spindle. About ½ in. from each end of this wire are soldered two smaller brass wires which in turn are soldered to a strip of light tin ¼ in. wide and 2⅝ in. long. The lower edge of this tin should be about ½ in. from the spindle. The



Details of an Ammeter

pointer is soldered to the spindle ¼ in. from one end. All of these parts should be brass with the exception of the strip of tin. Another strip of tin, the same size as the first, is soldered to two brass wires as shown in Fig. 4. These wires should be about 1 in. long.

The spindle of the pointer swings freely between two bars of brass, G, 1/16 in. thick, ¼ in. wide and 2½ in. long. A small hole is countersunk in one of the bars to receive one end of the spindle and a hole ⅛ in. in diameter is drilled in the other and a thumb nut taken from the binding-post of an old battery soldered over the hole so the screw will pass through when turned into the nut. The end of the screw is countersunk to receive the other end of the spindle. A lock nut is necessary to fasten the screw when proper adjustment is secured. A hole is drilled in both ends of the bars for screws to fasten them in place. The bar with the adjusting screw is fastened on the back so it can be readily adjusted through the hole H, bored in the back. The pointer is bent so it will pass through the U-shaped cut-out and up back of the board B. A brass pin is driven in the board B to hold the pointer from dropping down too far to the left. Place the tin, Fig. 4, so it will just clear the tin, Fig. 5, and fasten in place. The magnet is next placed with the ends of the coil to the back and the top just clearing the tin strips. Two binding screws are fitted to the bottom of the back and connected to the extending wires from the coil.

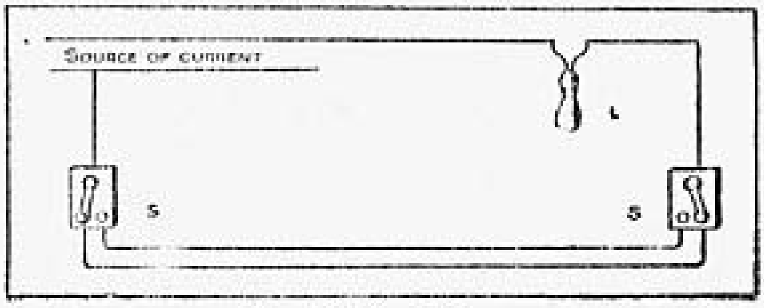
The instrument is now ready for calibrating. This is done by connecting it in series with another standard ammeter which has the scale marked in known quantities. In this series is also connected a variable resistance and a battery or some other source of current supply. The resistance is now adjusted to show .5 ampere on the standard ammeter and the position of the pointer marked on the scale. Change your resistance to all points and make the numbers until the entire scale is complete.

When the current flows through the coil, the two tinned strips of metal are magnetized, and being magnetized by the same lines of force they are both of the same polarity. Like poles repel each other, and as the part Fig. 4 is not movable, the part carrying the pointer moves away. The stronger the current, the greater the magnetism of the metal strips, and the farther apart they will be forced, showing a greater defection of the pointer.—Contributed by George Heimroth, Richmond Hill, L. I.

THE BOY MECHANIC – 1913

Electric Light Turned On and Off from Different Places

How nice it would be to have an electric light at the turn in a stairway, or at the top that could be turned on before starting up the stair and on reaching the top turned out, and vice



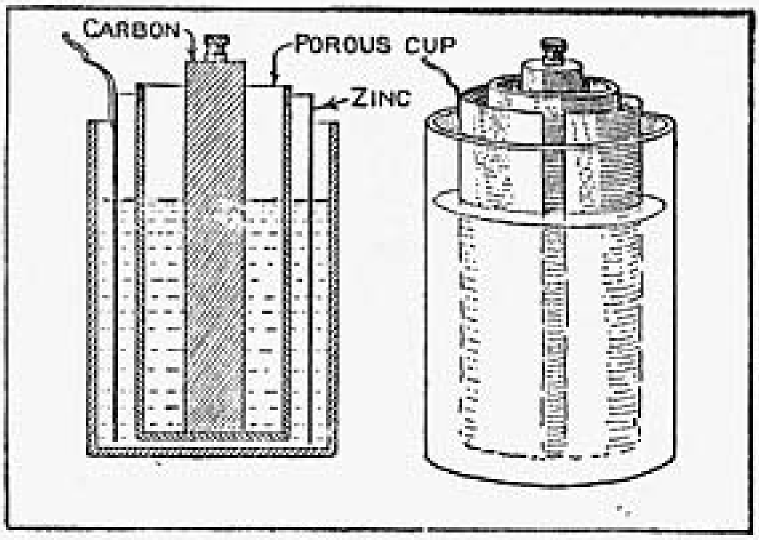
The Wiring Diagram

versa when coming down. The wiring diagram as shown in the illustration will make this a pleasant reality. This wiring may be applied in numerous like instances. The electric globe may be located at any desired place and the two point switches are connected in series with the source of current as shown in the sketch. The light may be turned on or off at either one of the switches.—Contributed by Robert W. Hall, New Haven, Conn.

THE BOY MECHANIC – 1913

How to Make a Bunsen Cell

This kind of a cell produces a high e. m. f. owing to the low internal resistance. Procure a glass jar such as used for a gravity battery, or, if one of these cannot be had, get a glazed vessel of similar construction. Take a piece of sheet zinc large enough so that when it is rolled up in the shape of a cylinder it will clear the edge of the jar by about ½ in. Solder a wire or binding-post to the edge of the cylinder for a connection. Secure a small unglazed vessel to fit inside of the zinc, or such a receptacle as used in a sal ammoniac cell, and fill it with a strong solution of nitric acid. Fill the outer jar with a



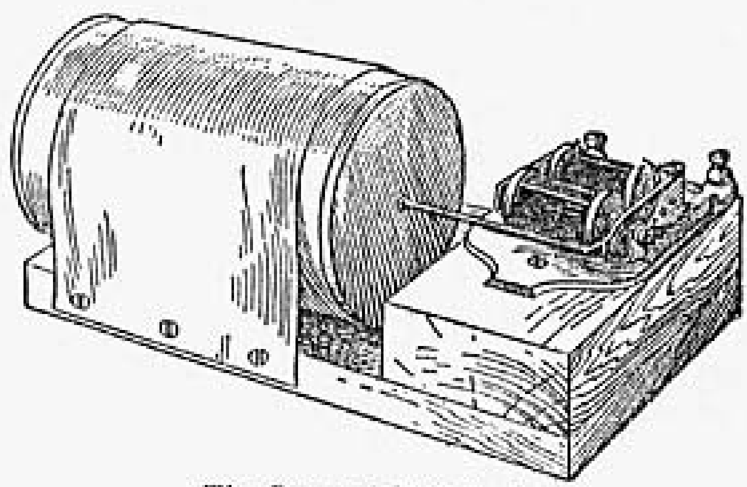
Cross Section and Completed Cell

solution of 16 parts water and 5 parts sulphuric acid. The connections are made from the zinc and carbon.

THE BOY MECHANIC – 1913

How to Make an Electrical Horn

Secure an empty syrup or fruit can, any kind having a smooth flat bottom will do. If the bottom is not perfectly flat, it will interfere with the regular tone vibrations, and not produce the right sound. Remove the label by soaking it in hot water. Take an ordinary electrical bell and remove the gong, clip off the striking ball and bend the rod at right angles. Cut a block of wood ¾ in. thick, 5 in. wide and 8 in. long for the base. Fasten the can on it with a piece of sheet brass or



Tin Can and Bell Parts

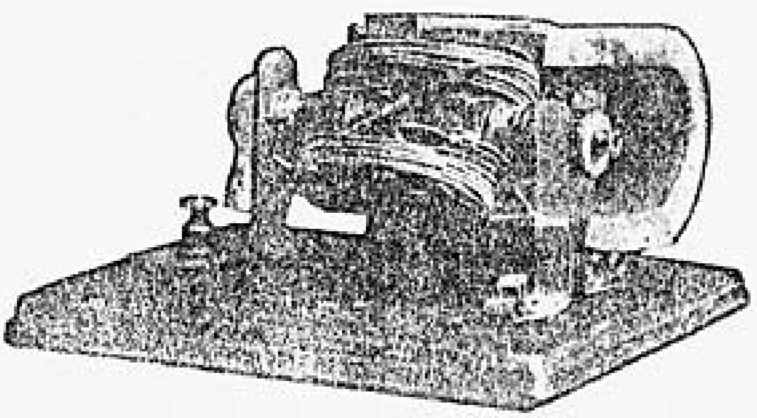
tin as shown in the sketch. Mount the bell vibrator on the base, using a small block of wood to elevate it to the level of the center of the can, and solder the end of the vibrator rod to the metal.

Connect two dry cells to the bell vibrator, and adjust the contact screw until a clear tone is obtained. The rapidly moving armature of the bell vibrator causes the bottom of the can to vibrate with it, thus producing sound waves. The pitch of the tone depends on the thickness of the bottom of the can. This horn, if carefully adjusted and using two cells of dry battery, will give a soft pleasant tone that can be heard a block away. If the two projecting parts of the vibrator are sawed off with a hacksaw, it can be mounted on the inside of the can. This will make a very compact electric horn, as only the can is visible.—Contributed by John Sidelmier, La Salle, Ill.

THE BOY MECHANIC – 1913

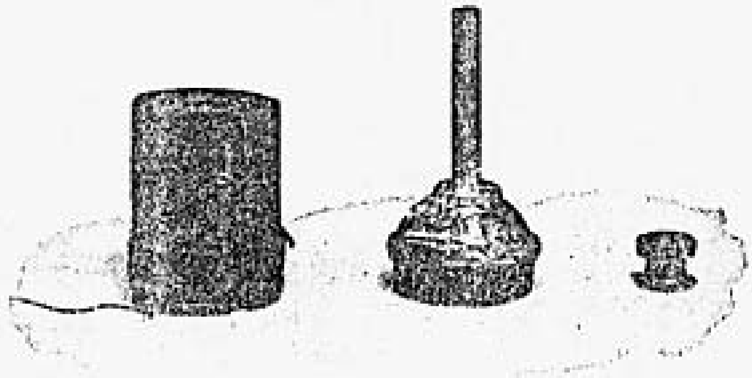
A Small Home-Made Electric Motor

The accompanying photographs show the construction of a very unique electric motor, the parts consisting of the frame from an old bicycle pedal wrapped with insulated wire to make the armature and three permanent magnets taken from an old telephone magneto. The pedal, being ball bearing, rotated with very little friction and at a surprisingly high rate of speed.



The Motor Complete

The dust cap on the end of the pedal was removed and a battery connection, having quite a length of threads, was soldered to it as shown in the photograph. The flanges were removed from an ordinary spool and two strips of brass fastened on its circumference for the commutator. The spool was held in position by a small binding



Commutator Parts

post nut. The shape of this nut made a good pulley for a cord belt.—Contributed by John Shahan, Attalla, Ala.

THE BOY MECHANIC – 1913

Finding the Horsepower of Small Motors

A small motor often excites curiosity as to its true horsepower, or fraction of a horsepower. Guesses in this direction vary remarkably for the same motor or engine. It is comparatively easy to determine the horsepower put out by almost any machine by the following method which is intended for small battery motors and small steam engines.

Before giving the description, it may be well to know what horsepower means. Horsepower is the rate of work and a unit is equal to 33,000 ft. lb. per minute, or 550 ft. lb. per second. That is lifting 33,000 lb. 1 ft. in one minute or 550 lb. 1 ft. in one second. This may be applied to the problem of finding the horsepower of a motor by fastening a piece of twine about 25 ft. long to the shaft of the engine or motor to be tested in such a way that when the shaft revolves it will wind up the string similar to a windlass. Place the motor in such a position that the twine will hang freely without touching anything; out of a high window will do. Fasten a weight to the other end of the line as heavy as the motor or engine can lift and still run. It must weigh enough to slow the power down a little, but not to stop it.

 GRANDDAD'S ELCTRICITY BOOK

Mark the position of the weight and start the motor, at the same time accurately measuring time in minutes and seconds it takes to lift the weight from the lowest point to the highest. Next measure accurately the distance in feet covered by the weight in its ascent and obtain the correct weight in pounds of the weight.

Multiply the weight by the distance covered and divide the result by the number of minutes or fraction of a minute obtained and divide this last result by 33,000 and the quotient will be the horsepower of the motor or engine.

Perhaps an illustration will make this solution much plainer. Suppose the motor will lift a weight of 1 lb. and still revolve, 30 ft. in 10 seconds or 1/6 of a minute. Multiplying 1 by 30 we get 30, which divided by 1/6 gives 180. This in turn divided by 33,000 equals in round numbers 1/200 part of a horsepower.—Contributed by Harold H. Cutter.

THE BOY MECHANIC – 1913

How to Build a Wind Vane with an Electric Indicator

Quite often it is practically impossible to ascertain the direction of the wind by observing an ordinary wind vane on account of the necessity of locating the vane at such a height that it may give a true indication. By means of the device shown in Fig. 2, the position of the vane may be determined without actually looking at the vane itself and the indicating device may be located almost anywhere and independently of the position of the wind vane.

The principle upon which the device operates is that of the Wheatstone bridge. The position of the moving contact A, Fig. 1, is controlled by the wind vane. This contact is made to move over a specially constructed resistance R, Fig. 2. A second movable contact, B, is controlled by the observer and moves over a second resistance, identical with that over which the contact A moves. These two resistances are connected so as to form the two main branches of a Wheatstone bridge; the points A and B are connected to the current-detecting device, which may be a galvanometer or telephone receiver, and current is supplied by a number of dry cells.

In order to obtain a balance—that is, no current through the receiver—the points A and B must occupy corresponding positions on their respective resistances. If the two resistances over which the points A and B move are mounted in the same position with respect to the cardinal points of the compass, then the points themselves will always be in the same position with respect to the cardinal points when a balance is obtained. The arrow head on the wind vane and the point A are made to occupy corresponding positions, and hence the position of the point B, when no current passes through the receiver, is an indication of the direction in which the wind vane is pointing.

The principal parts in the construction of the device are shown in the illustration, and the following description of their construction may be of interest to those who contemplate building the indicator.

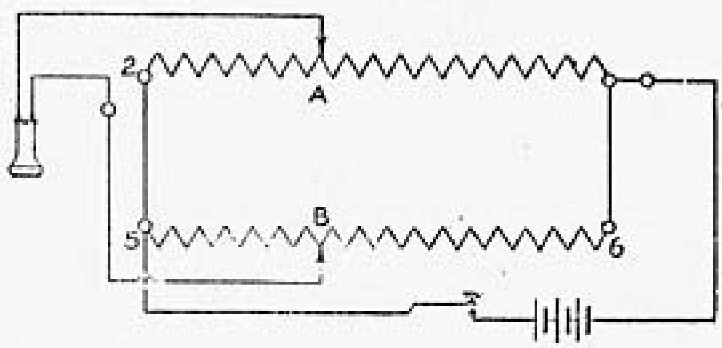


Fig. 1—The Diagram of a Wheatstone Bridge Which Shows the Points of Contact So Placed That a Balance is Obtained

Procure two pieces of $\frac{1}{16}$-in. hard rubber, 1½ in. wide by 24 in. long. Clamp these, side by side, between two boards and smooth down their edges and ends, and then file small slots in the edges with the edge of a three-cornered file. These slots should all be equally spaced about $\frac{3}{32}$ in. apart.

Have the pieces clamped together while filing the slots and mark one edge top and one end right so that the pieces may be mounted alike. Now procure a small quantity of No. 20 gauge bare manganin wire. Fasten one end of this wire to one end of the pieces of rubber by winding it in and out through three or four small holes and then wind it around the piece, placing the various turns in the small slots that were filed in the edges. After completing the winding, fasten the end just as the starting end was attached. Wind the second piece of rubber in a similar manner and make sure to have the length of the free ends in each case the same. Obtain a cylinder of some kind, about 8 in. in diameter, warm the pieces of rubber by dipping them in hot water, bend them around the cylinder and allow them to cool.

A containing case, similar to that shown in cross section in the upper portion of Fig. 2 should now be constructed from a good quality of tin or copper. The inside diameter of this case should be about 1 in. more than the outside diameter of the resistance ring R, and it should be about 3 in. deep. The top C may be made curved as shown in the illustration, and should be fastened to the case proper by a number of small machine screws. The base of this case may be made so that the whole device can be mounted on the top of a pole.

Mount a piece of ¼-in. steel rod, about ½ in. long, with a conical hole in one end, in the center of the bottom of the case as shown by M. A number of supports, similar to the one shown, should be made from some ¼-in. hard rubber and fastened to the sides of the case, to support the resistance ring. The dimensions of these supports should be such that the ends of the piece of rubber, forming the ring, are against each other when it is in place. The upper edge of the ring should be about 2 in. above the bottom of the case.

Next, mount a piece of brass tube,

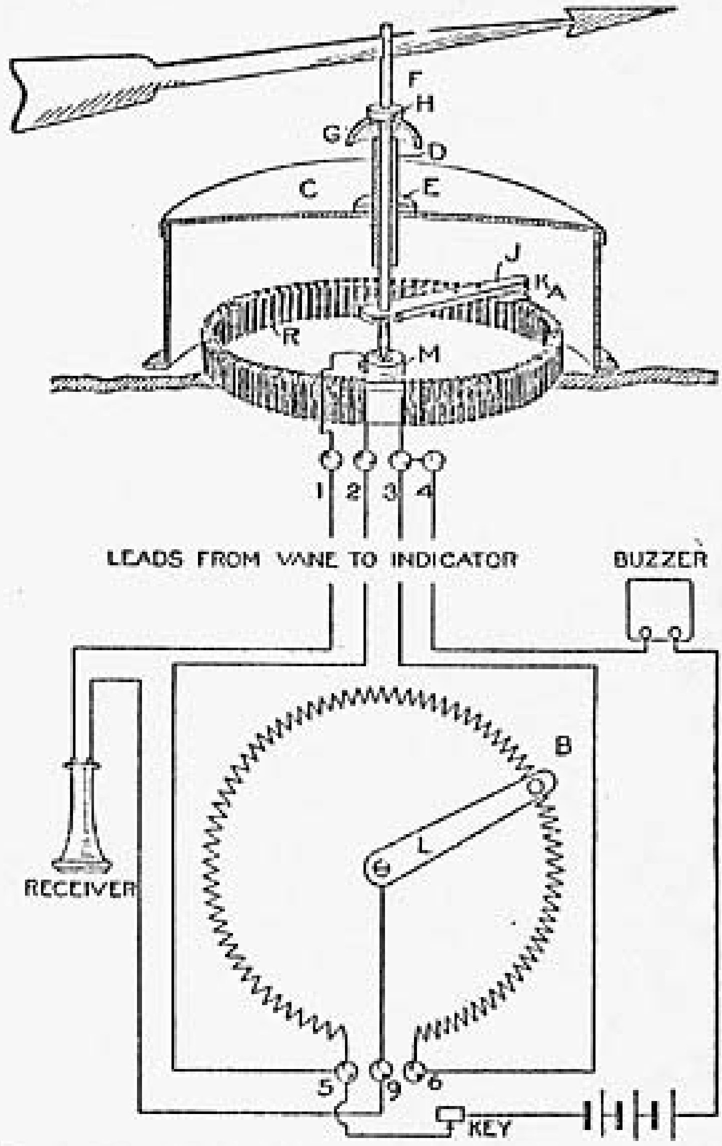


Fig. 2—The Weather Vane with Resistance Coil, and Diagram of Indicator Which is Identical with That of the Vane

D, in the exact center of the top and perpendicular to it. A washer, E, may also be soldered to the top so as to aid in holding the tube. Procure a piece of steel rod, F, that will fit in the tube D and turn freely. Sharpen one end of this rod and mount a brass wind vane on the other end. A small metal cup, G, may be soldered to a washer, H, and the whole mounted on the steel rod F in an inverted position as shown, which will prevent water from getting down inside the case along the rod. The cup G may be soldered directly to the rod. Make a small arm, J, of brass, and fasten a piece of light spring, K, to one side of it, near the outer end, then mount the arm on the steel rod so that it is parallel to the vane and its outer end points in the same direction as the arrow on the vane. The free end of the light spring on the arm J should be broad enough to bridge the gap between adjacent turns of wire on the resistance ring. Four bindings should then be mounted on the inside of the case and all insulated from it with the exception of number 1. Numbers 2 and 3 are connected to the ends of the winding and number 4 is connected to number 3.

A second outfit should now be constructed, identical with the one just described except that it should have a flat top with a circular scale mounted on it, and the arm L should be controlled by a small handle in the center of the scale. The position of the contact B may be indicated on the scale by a slender pointer, attached to the handle controlling the arm L.

Four leads of equal resistance should be used in connecting the two devices and the connections made as shown. An ordinary buzzer placed in the battery circuit will produce an interrupted current through the bridge circuit and a balance will be obtained by adjusting the contact point B until a minimum hum is heard in the telephone receiver.

THE BOY MECHANIC – 1913

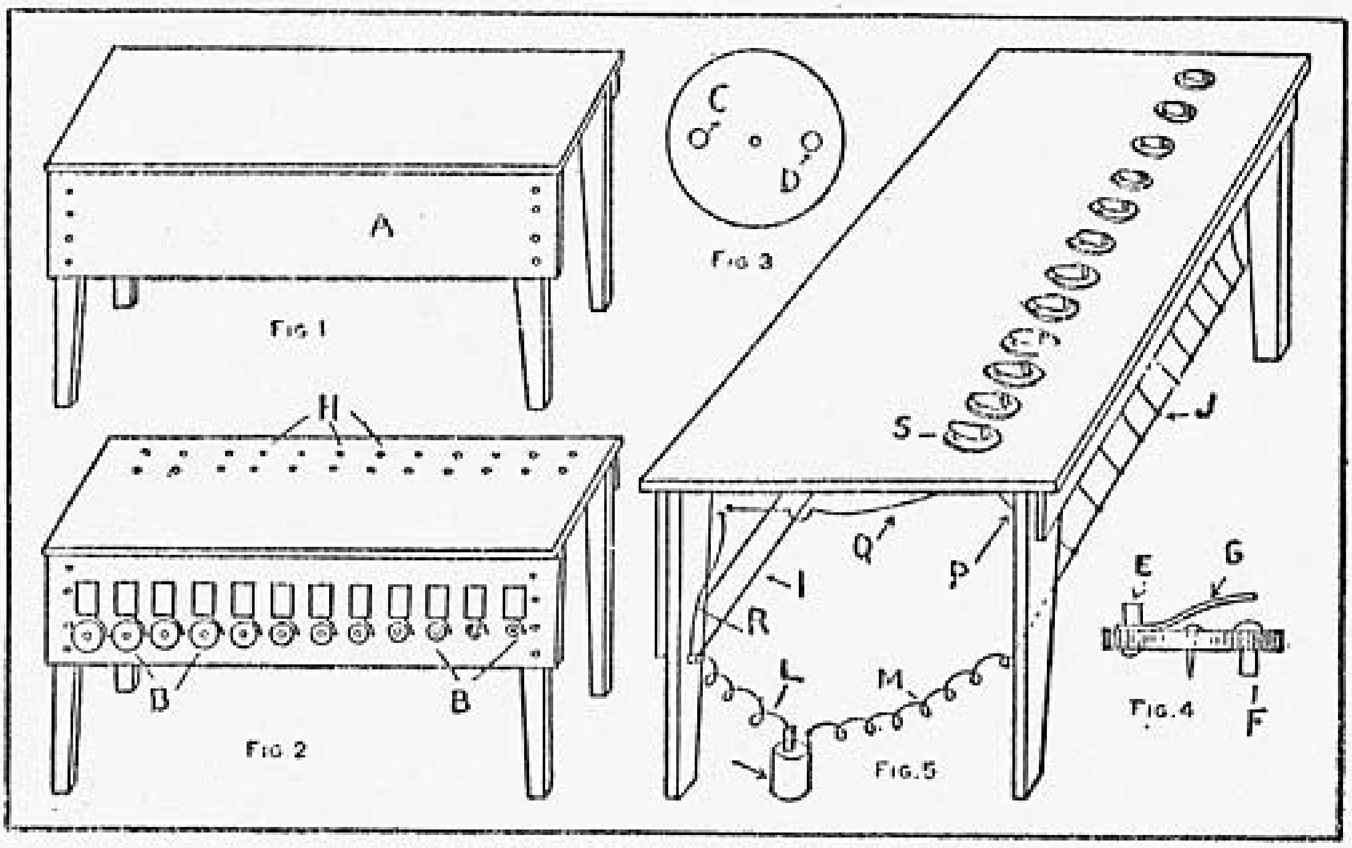
To Make an Electric Piano

Make or buy a table, about 3 ft. long and 1 ft. or more wide, and about 2½ ft. high. Nail a board, A, Fig. 1, about 8 in. wide and of the same length as the table, to the table, as shown in the illustration. Paint the table any color desired.

Purchase a dozen or so battery electric bells (they are cheaper if bought by the dozen) and screw them to the board, as in Fig. 2. Arrange the bells in the scale shown at B, Fig. 2. Bore two holes near the posts of each bell for the wires to pass through.

Buttons for the bells may be purchased, but it is cheaper to make them in the following way: Take a piece of wood and cut it round, about 2½ in. in diameter and ¼ in. thick, Fig. 3, and bore two holes, C and D, through it. Then get two posts, about 1 in. long, (battery posts will do) and put them through the holes as in Fig. 4. Cut out a piece of tin, ⅜ in. wide, punch a hole through it and put in under post E, so that when it is pressed down, it will touch post F. It may be either nailed or screwed down.

Make two holes in the table for each button and its wires, as at H, Fig. 2. Nail or screw the buttons to the table,



How the Electric Piano is Constructed

 GRANDDAD'S ELCTRICITY BOOK

as shown in Fig. 5, with the wires underneath. The connections are simple: I, Fig. 5, is a wire running from one end of the table to the other end, attached to a post at each end; J is another wire attached in the same way; L is the carbon wire running from the batteries to I; M is the zinc wire running from the batteries to wire J; O indicates the batteries; P is a wire running from J to one post of a button; Q is another wire running from the other post of the button to one of the posts of the bell; R is a wire running from I to one post of the bell. When the button S is pressed, the bell will ring. Each button should be connected with its bell in the same way.—Contributed by Vincent de Ybarrondo.

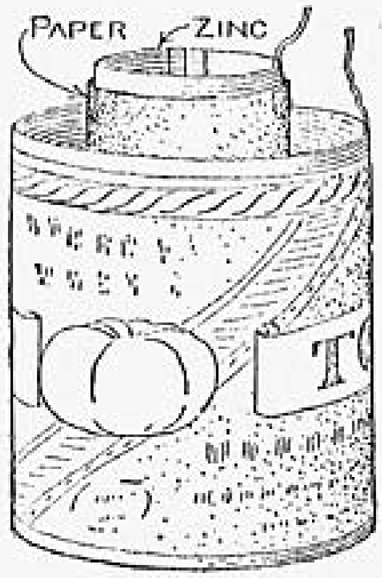
THE BOY MECHANIC – 1913

A Home-Made Daniell Cell

An effective Daniell galvanic cell may be constructed from material costing very little money. A common tin tomato can with a copper wire soldered to the top forms the jar and positive electrode. A piece of discarded stove zinc rolled into an open cylinder of about $1\frac{1}{2}$-in. diameter, 5 in. long, with a copper wire soldered at one end forms the negative electrode.

To make the porous cell, roll a piece of heavy brown wrapping paper, or blotting paper, into a tube of several thicknesses, about 5 in. long with an internal diameter of 2 in. Tie the paper firmly to prevent unrolling and close up one end with plaster of paris $\frac{1}{2}$ in. thick. It is well to slightly choke the tube to better retain the plaster. The paper used must be unsized so that the solutions can mingle through the pores.

Two liquids are necessary for the cell. Make a strong solution in a glass or wooden vessel of blue vitriol in water. Dilute some oil of vitriol (sulphuric acid) with about 12 times its measure of water and keep in a bottle when not in use. In making up the solution, add the acid to the water with constant stirring. *Do not add water to the acid.*



The cell is charged by placing the zinc in the paper tube and both placed into the tin can. Connect the two wires and pour the dilute acid into the porous cell around the zinc, and then immediately turn the blue vitriol solution into the can outside the paper cup.

A current generates at once and metallic copper begins to deposit on the inside of the can. It is best to let the action continue for a half hour or so before putting the cell into use.

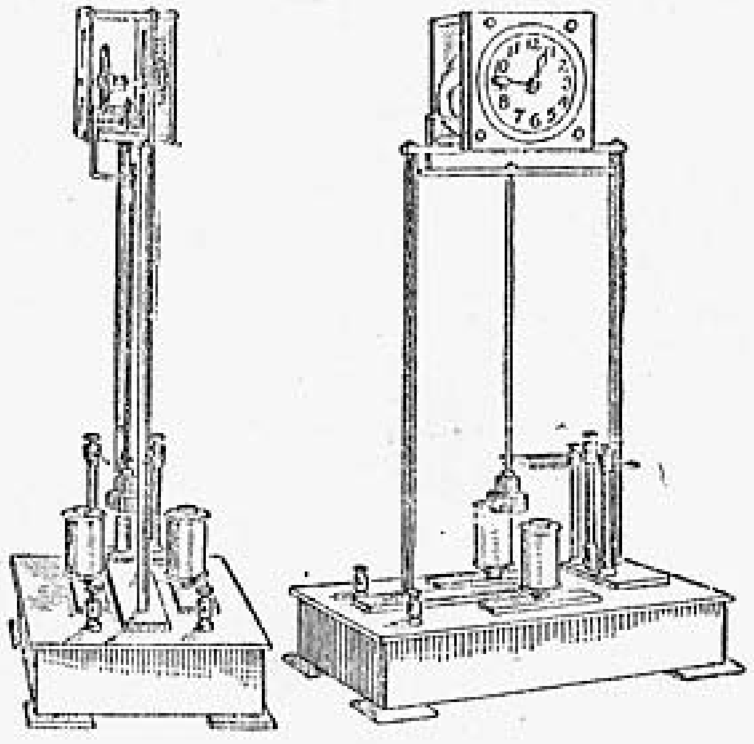
THE BOY MECHANIC – 1913

Home-Made Electric Clock

The clock illustrated herewith is driven by means of electromagnets acting directly on the pendulum bob. Unlike most clocks, the pendulum swings forward and backward instead of laterally. The construction is very simple, and the result is not only novel but well worth while, because one does not have to bother about winding a clock, such as this one, says the Scientific American.

The clock is mounted on a wooden base measuring $3\frac{3}{4}$ by $6\frac{1}{2}$ in., by $1\frac{5}{16}$ in. thick. Secured centrally on this base is a $\frac{1}{8}$ by $\frac{3}{4}$-in. bar, 6 in. long and at each side of this, $\frac{5}{16}$ in. away, is an

 GRANDDAD'S ELCTRICITY BOOK



Magnetic Clock

electromagnet, $\frac{3}{4}$ in. in diameter and $1\frac{7}{8}$ in. high. Two uprights, $7\frac{1}{2}$ in. high and $\frac{3}{4}$ in. in diameter, are secured in the base bar, and are connected at the top by a brass yoke piece on which the clock frame is supported. Just below the yoke piece a hole is drilled in each upright to receive the pivot pins of the crosspiece secured to the upper end of the pendulum rod. The pendulum bob at the lower end is adjusted to swing just clear of the electromagnets. Mounted at the right-hand side of the base are three tall binding-posts, the center one being $2\frac{3}{4}$ in. high, and the other two $2\frac{5}{8}$ in. high. Each is fitted with a piece of copper wire provided with a small brass spring tip. These springs lie in the plane of the pendulum, which serves to swing the central tip first against one and then against the other of the side tips, thereby closing the circuit of first one magnet and then the other. Each magnet attracts the pendulum until its circuit is broken by release of the center tip, and on the return swing of the pendulum the circuit of the other magnet is similarly closed. Thus the pendulum is kept in motion by the alternate magnetic impulses. The clock train is taken from a standard clock and the motion of the pendulum is imparted to the escape wheel by means of a pawl, bearing on the latter, which is lifted at each forward stroke of the pendulum by an arm projecting forward from the pivotal end of the pendulum rod.

THE BOY MECHANIC – 1913

How to Make Miniature Electric Lamp Sockets

A socket for a miniature lamp can be made as shown in the sketch. A brass spring wire is wound around the base of the threads on the lamp and an eye turned on each end to receive a screw and a binding-post, as shown in Fig. 1. A piece of metal, preferably copper, is attached to a wood base as shown in Fig. 2 and the coil-spring socket fastened across it in the opposite direction. Bend the wire so that the spring presses the lamp against the metal. If the wire fits the lamp loosely, remove the lamp and press the sides of the coil closer together. The metal parts can

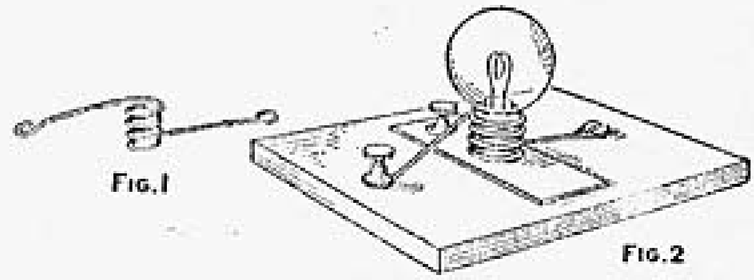


Fig. 1 Fig. 2

Wire Socket

be attached to any smooth surface of wood without making a regular base. —Contributed by Abner B. Shaw, No. Dartmouth, Mass.

THE BOY MECHANIC -- 1913

How to Make an Electric Stove

The parts necessary for making an electric stove are: Two metal pie plates of the same size; 4 lb. of fire clay; two ordinary binding posts; about 1 lb. of mineral wool, or, if this cannot be obtained, thick sheet asbestos; one oblong piece of wood, 1 in. thick, 12 in. wide and 15 in. long; one small switch; one fuse block; about 80 ft. of No. 22 gauge resistance wire,—

German-silver wire is better, as it stands a higher temperature; two middle-sized stove bolts with nuts; one glass tube, about 1/4 in. in diameter and 9 in. long, which can be bought from a local druggist, and two large 3-in. screws.

If a neat appearance is desired, the wood can be thoroughly sandpapered on one side and the corners and edges rounded off on the upper side. Punch holes in one of the pie plates, as shown in Fig. 1. The two holes, E and F, are on the rim and should be exactly on a line with the hole D punched in the center. The holes B and C are about 3 in. apart and should be at equal distances from the center hole D. The rim of the second plate is drilled to make two holes, AA, Fig. 2, that will match the holes E and F in the first plate, Fig. 1. A round collar of galvanized iron, FF, Fig. 4, 3 in. high, is made with a diameter to receive the first plate snugly. Two small flaps are cut and turned out and holes punched in their centers, AA, to receive screws for holding it to the base. Two bolts are soldered in the holes E and F, Fig. 1, and used to hold the

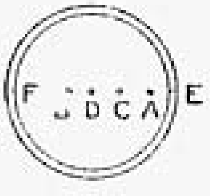


FIG. 1

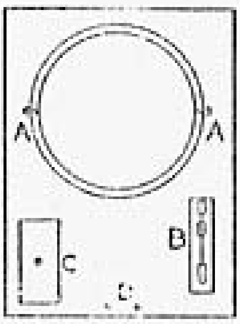


FIG. 2

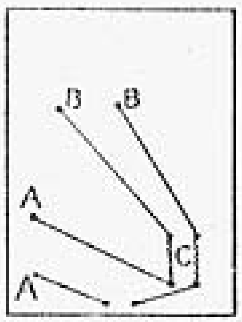


FIG. 3

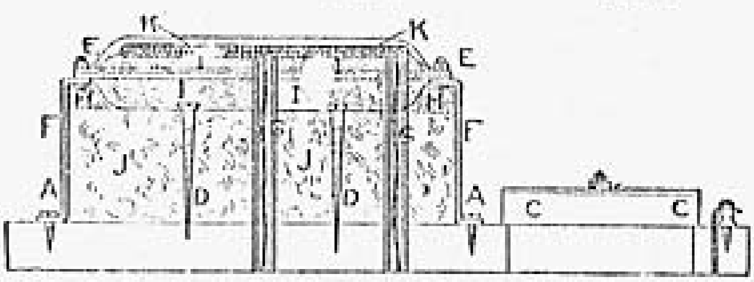


FIG. 4

Details of Electric Stove

rims of both plates together, when they are placed in opposite positions, as shown in Fig. 4. This will make an open space between the plates. The collar is then screwed to one end of the base, as shown in Fig. 2.

Two holes are bored through the base to correspond with the holes D and A in the bottom plate. The glass tube is cut to make two pieces, each 4½ in. long. This can be done easily by filing a nick in the tube at the proper point and breaking it. These tubes are forced into the holes bored in the base, and, if the measurements are correct, should extend about 1/4 in. above the collar. The mineral wool, JJ, Fig. 4, is then packed down inside the collar, until it is within 1 in. of the top. This will allow the plate, Fig. 1, to rest on the wool and the ends of the glass tubes, GG, Fig. 4, to project through the holes D and A of the plate, Fig. 1. The rim of the plate should be level with the top edge of the collar. If asbestos is used, the sheets should be cut into disks having the same diameter as the inside of the collar, and holes cut to coincide with the holes D and A of the plate. The small scraps should be dampened and made into pulp to fill the space H, Fig. 4. The plate, Fig. 1, is held to the base by two screws which are run through the holes BC and take the position shown by DD, Fig. 4.

The two binding-posts are attached on the base at D, Fig. 2, also the switch B and the fuse block C, holes being bored in the base to make the wire connections. The reverse side of the base, with slits cut for the wires, is shown in Fig. 3. The points marked BB are the glass tubes; AA, the holes leading to the switch; and C, the fuse block. The wires run through the glass tubes GG, Fig. 4, are allowed to project about 1 in. for connections.

The best way to find the correct length of the resistance wire is to take a large clay or drain tile and wind the wire tightly around it, allowing a space between each turn. The tile is then set on its side with a block or brick under each end. It should not be set on end, as the turns of the wires, when heated, will slip and come in contact with each other, causing a short circuit. When the tile is in place, a short piece of fuse wire is fastened to each of its two ends. A 5-ampere fuse wire is about strong enough. A connection is made to these two wires from an electric-light socket. The wire will get hot but probably remain the same color. If this is the case, one of the feed wires is disconnected from the fuse wire and gradually moved farther down the coil until a point is found where the resistance wire glows a dull red. This point marks the proper length to cut it, as the wire should not be allowed to become any hotter. If the wire gets bright hot when the current is turned on, more wire should be added. The wire is then made into a long coil by winding it around a large wire nail. The coils should be open and about 1/8 in. apart.

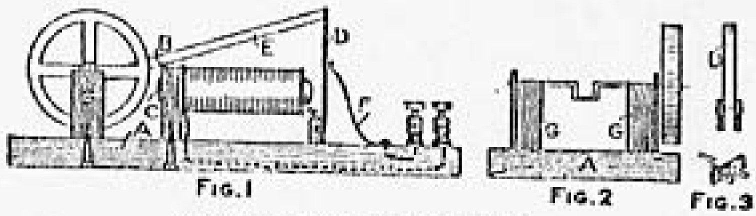
Next, the fire clay is moistened and well mixed, using care not to get it too wet. It should have the proper consistency to mould well. The clay, H, Fig. 4, is then packed in the first plate to a height of about 1/4 in. above the rim. While the clay is damp, one end of the coil is connected with the wire in the central glass tube, and the coil laid in a spiral winding on the damp clay, KK, and pressed into it. When this is done, the other end is connected to the wire projecting from the outer glass tube. As these connections cannot be soldered, the ends of the wires should be twisted closely together, so that the circuit will not become broken. Make sure that the coils of wire do not touch each other or the top plate. The fuse wire (about 5 amperes) is put into the fuse block, and wires with a socket adapter connected to the two binding-posts. The top plate is put in place and screwed down. This completes the stove.

It should be set aside in a warm place for a few days to dry out the packing. If it is not thoroughly dry, steam will form when the current is applied. It should not be left heated in this condition. The top plate is used when cooking and removed when making toast.—Contributed by R. H. Cnonyn, St. Catherines, Can.

THE BOY MECHANIC – 1913

An Electric Engine

The parts of this engine are supported on a base 3/4 in. thick, 4 in. wide and 7 in. long. The upright B, Fig. 1,



Shaft Turned by Magnetism

which is 1/2 in. thick and 3 in. high, is secured across the base about one-third of the distance from one end and fastened with a wood screw put through from the under side. The magnet core C is made of a carriage bolt, 2 1/2 in. long, which is fastened in a hole in the top part of the upright B so that the end C will protrude slightly. Before placing the bolt in the hole of the upright, slip on two cardboard washers, each 1 in. in diameter, one at the head end and the other against the upright B. Wrap a thin piece of paper around the bolt between the washers and wind the space full of No. 22-gauge magnet wire, allowing each end to project for connections.

The driving arm D, Figs. 1 and 3, is made of a piece of soft sheet iron, 1/2 in. wide and 3 in. long. A small block is fastened to the lower end of the metal and pivoted between two uprights, 1/2 in. high, which are fastened to the base. The uprights on each side of the block are better shown in Fig. 3.

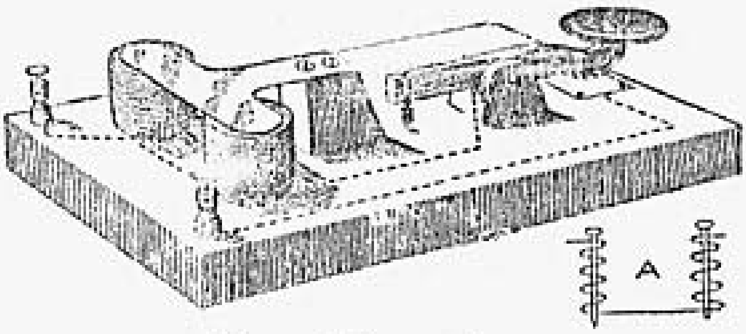
Two supports, each 1/2 in. thick and 3 in. high, are fastened with screws about half way between the end of the base and the upright B, Fig. 1. The end view of these supports is shown in Fig. 2, at GG. A 1/8-in. hole is bored through the top part of each support so they will be in a line for the axle. The axle is made of a piece of steel 1/8 in. in diameter and about 4 in. long. An offset is bent in the center, as shown, for the crank. A small flywheel is attached to one end of the shaft. The connecting rod E, Fig. 1, is made of wood and fastened to the upper end of the driving arm D with a small screw or nail. The contact F is made of a strip of copper, 1/4 in. wide. This is to open and close the circuit when the engine is running. The connections are made as shown in Fig. 1.

Connect two dry cells to the binding-posts and turn the flywheel. The current passing through the magnet pulls the driving arm toward the bolt head, which gives the shaft a half turn. The turning of the shaft pulls the arm away from the copper piece F, causing a break in the current. As the shaft revolves, the arm is again brought back against the copper strip F, thus the current is broken and applied at each revolution of the shaft.—Contributed by S. W. Herron, Le Mars, Iowa.

THE BOY MECHANIC – 1913

Homemade Telegraph Key

A piece of wood, 1/2 in. thick, 2 in. wide and 5 in. long, is used for the base of this instrument. Two wire



Key and Connections

nails, each 1 in. long, are used for the cores of the magnets. Each nail is wound with three or four layers of fine insulated magnet wire, about No. 25 gauge, similar to that used in electric bells, leaving about 1/4 in. of the end bare so that they may be driven into the wood base. The connections for the coils are shown in the sketch, at A.

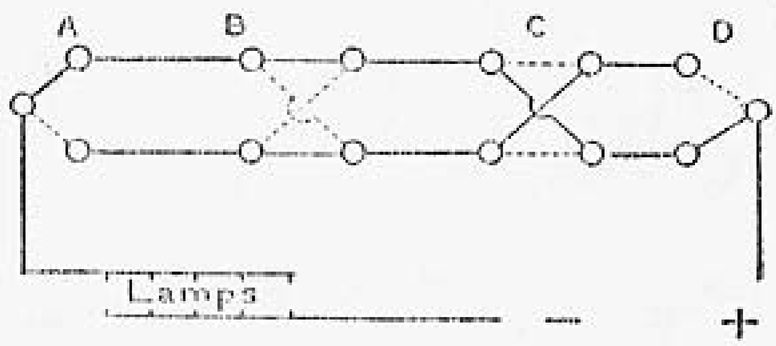
About 1 in. behind the coils is fastened a small block of wood, the top of which is just even with the top of the nails in the coils. A piece of tin, cut in the shape of the letter T, is fastened with two screws to the top of this block, and the end bent slightly so as to clear the top of the nails about 1/32 in.

The key lever is cut from a thin piece of wood, in the shape shown in the sketch, and pivoted in a slotted block which is used as a base for the key. A piece of bare copper wire is fastened along the under side of the key, as shown by the dotted lines. A rubber band, passing over the end of the key and attached to the base with a tack, acts as a spring to keep the key open. A small piece of tin is fastened to the base under the knob of the key. This is for making the contact between the copper on the key and the wires from the coils, when the key is pushed down.—Contributed by W. H. Lynas.

THE BOY MECHANIC – 1913

Turning Lights On and Off from Any Number of Places

This can be done by the use of any number of reversing switches such as



Wiring Diagram

those shown at B and C. These are inserted between the two-way switches A and D. Turning such a switch up or down connects the four contact pieces either diagonally as at C, or lengthwise as at B. The diagram shows connection from A to D, when the lamps will be on, but by turning either of these four switches into its alternative position, shown by the dotted lines, the circuit will be broken and the lights extinguished. When this has been done, the circuit may be restored and the lamps lighted again by altering either of the four switches in exactly the same way, and so on.

It will be observed that a reversing switch used in this way practically undoes whatever is done by the other switches. In the accompanying diagram only two reversing switches are shown and the lights can be independently controlled from four distinct positions. Any number of reversing switches can be placed between the two-way switches A and D to increase the number of places from which the lights could be turned on and off.—Contributed by J. S. Dow, Mayfield, London.

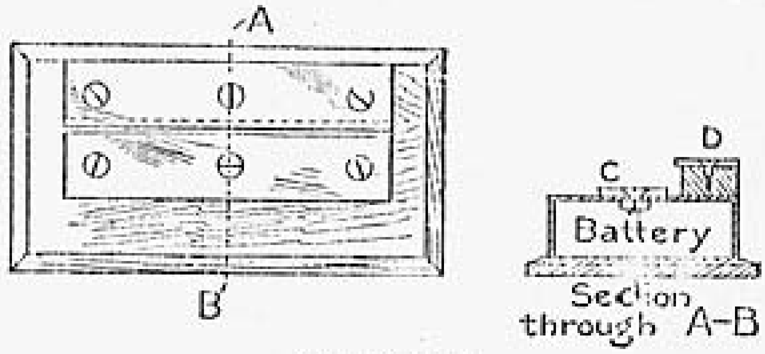
How to Make an Electric Pendant Switch

It is often desired to use a pendant switch for controlling clusters of incandescent lamps. When such a switch is not at hand, a very good substitute can be made by screwing a common fuse plug into a key socket and connecting the socket in series with the lamps to be controlled. In this way you get a safe, reliable, fused switch.—Contributed by C. C. Heyder, Hansford, W. Va.

THE BOY MECHANIC – 1913

Testing Small Electric Lamps

The accompanying sketch shows the construction of a handy device for testing miniature electric lights. The base is made to take in an electric flash lamp battery. Two strips of brass, C and D, are connected to the battery. The lamp is tested by putting the metal end on the lower brass strip and the side against the upper one. A great number of lamps can be



Lamp Tester

tested in a short time by means of this device.—Contributed by Abner B. Shaw, North Dartmouth, Mass.

THE BOY MECHANIC – 1913

A Pocket Voltammeter

Remove the works and stem from a discarded dollar watch, drill two $\frac{3}{16}$-in. holes in the edge, ¾ in. apart, and insert two binding-posts, Fig. 1, insulating them from the case with cardboard. Fold two strips of light cardboard, ½ in. wide, so as to form two oblong boxes, ½ in. long and $\frac{3}{16}$ in. thick, open on the edges. On one of these forms wind evenly the wire taken from a bell magnet to the depth of ⅛ in. and on the other wind some 20-gauge wire to the same depth. Fasten the wire with gummed label to keep it from unwinding.

Glue the coils to the back of the case and connect one wire from each binding-post as shown in Fig. 2, while the other two wires are connected to an induction coil lead which is inserted in the hole from which the stem was removed. Fasten a brass-headed tack to the case at the point F with sealing wax or solder and bend a wire in the shape shown in Fig. 3 to swing freely on the tack. Attach a piece of steel rod, ¾ in. long, in the center coil, C, Fig. 2.

A rubber band, D, connects the steel rod C with the top of the watch case. The ends of the rubber are fastened with sealing wax. The rubber keeps the pointer at zero or in the middle of the scale. Do not use too strong a rubber. A dial may be made by cutting a piece of stiff white paper so it will fit under the crystal of the watch. An arc is cut in the paper, as shown in Fig. 1, through which the indicator works.

To calibrate the instrument, first mark the binding-post A, which is connected to the coil of heavy wire, for amperes and the other post, V, to the coil of small wire for volts. Connect the lead and the post marked A to one, two and three cells and each time mark the place of the pointer on the dial. Take corresponding readings on a standard ammeter and mark the figures on the dial. The volt side of the dial may be calibrated in the same manner, using a voltmeter instead of the ammeter. The place where the

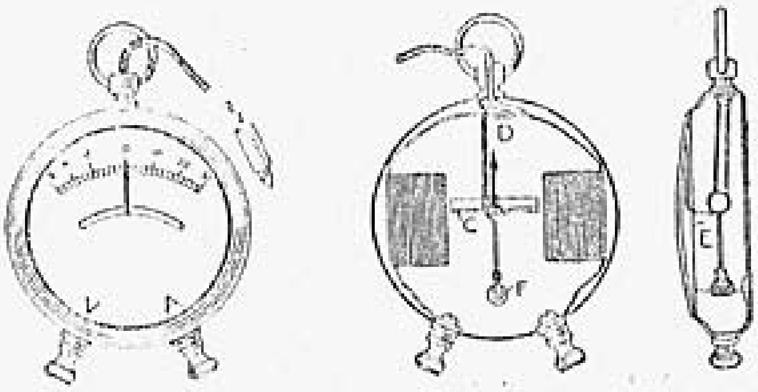


Fig 1 Fig 2 Fig 3

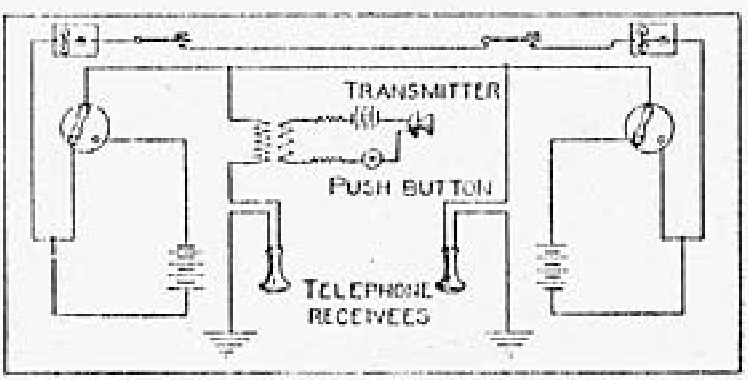
Voltammeter in a Watch Case

indicator comes to rest after disconnecting the current is marked zero.—Contributed by Edward M. Teasdale, Warren, Pa.

THE BOY MECHANIC – 1913

Combination Telegraph and Telephone Line

The accompanying diagrams show connections for a short line system



Wiring Diagram

(metallic circuit) of telegraph where a telephone may be used in combination on the line. The telephone receivers can be used both as receivers and transmitters, or ordinary telephone transmitters, induction coils and battery may be used in the circuit with a receiver. If a transmitter is used, its batteries may be connected in circuit with a common push button which is held down when using the telephone. On a 1000-ft. line, four dry cells will be sufficient for the telegraph instruments and two cells for the telephone.—Contributed by D. W. Miller.

THE BOY MECHANIC – 1913

How to Make a Telegraph Instrument and Buzzer

The only expenditure necessary in constructing this telegraph instrument is the price of a dry cell, providing one has a few old materials on hand.

Procure a block of wood about 6 in. long and 3 in. wide and take the coils out of an old electric bell. If you have no bell, one may be had at the dealers for a small sum. Fasten these coils on the blocks at one end as in Fig. 1.

Cut a piece of tin 2 in. long and ½ in. wide and bend it so the end of the tin when fastened to the block will come just above the core of the coil. Cut another piece of tin 3 in. long and bend it as shown at A, Fig. 2. Tack these two pieces of tin in front of the coils as shown in the illustration. This completes the receiver or sounder.

To make the key, cut out another piece of tin (X, Fig. 1) 4 in. long and bend it as shown. Before tacking it to the board, cut off the head of a nail and drive it in the board at a point where the loose end of the tin will cover it. Then tack the key to the board and connect the wires of the battery as in Fig. 1. Now, move the coils back and forth until the click sounds just the way you wish and you are ready to begin on the Morse code.

When tired of this instrument, con-

 GRANDDAD'S ELCTRICITY BOOK

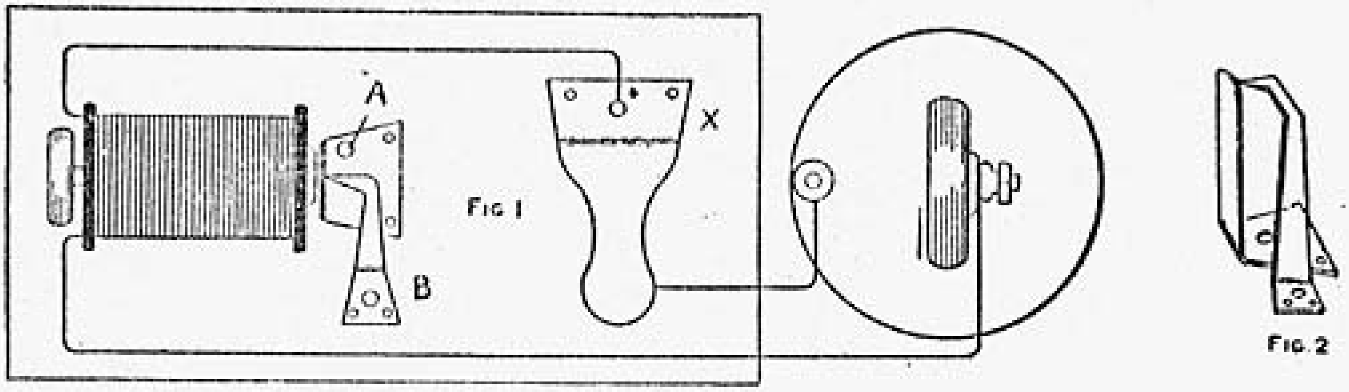


Fig. 1

Fig. 2

Home-Made Telegraph Instrument

nect the wire from the coils to the key to point A and the one connected at the point under the key to B, leaving the other wire as it is. By adjusting the coils the receiver will begin to vibrate rapidly, causing a buzzing sound.—Contributed by John R. McConnell.

THE BOY MECHANIC – 1913

How To Make a Small Searchlight

The materials required for a small searchlight are a 4-volt lamp of the loop variety, thin sheet brass for the cylinder, copper piping and brass tubing for base. When completed the searchlight may be fitted to a small boat and will afford a great amount of pleasure for a little work, or it may be put to other uses if desired.

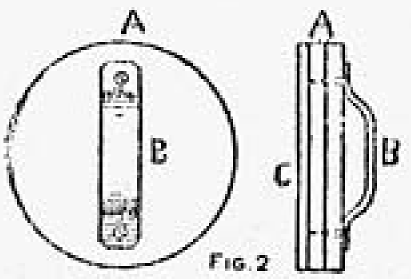


Fig. 2

Make a cylinder of wood of the required size and bend a sheet of thin brass around it. Shape small blocks of boxwood, D, Fig. 1, to fit the sides and pass stout pieces of brass wire through the middle of the blocks for trunnions. Exactly through the middle of the sides of the cylinder drill holes just so large that when the blocks containing the trunnions are cemented to the cylinder there is no chance of contact between cylinder and trunnion, and so creating a false circuit.

The trunnion should project slightly into the cylinder, and after the lamp has been placed in position by means of the small wood blocks shown in Fig. 1, the wires from the lamp should be soldered to the trunnions. It is best to solder the wire to the trunnions before cementing the side blocks inside the cylinder.

Turn a small circle of wood, A, Fig. 2, inside the cylinder to fit exactly and fasten to it a piece of mirror, C, Fig. 2, exactly the same size to serve as a reflector. Painting the wood with white enamel or a piece of brightly polished metal will serve the purpose. On the back of the piece of wood fasten a small brass handle, B, Fig. 2, so that it may readily be removed for cleaning.

In front of cylinder place a piece of magnifying glass for a lens. If a piece

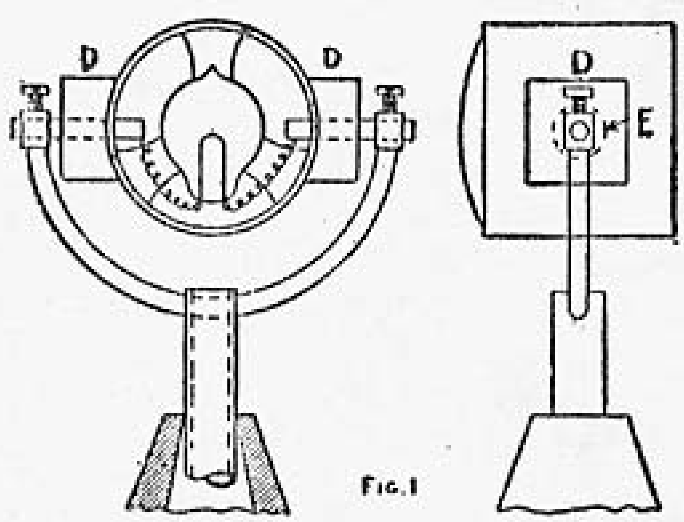


Fig. 1

Front View Side View

to fit cannot be obtained, fit a glass like a linen tester to a small disc of wood or brass to fit the cylinder. If magnifying glass cannot be had, use plain glass and fit them as follows:

Make two rings of brass wire to fit tightly into the cylinder, trace a circle (inside diameter of cylinder) on a piece

 GRANDDAD'S ELCTRICITY BOOK

of cardboard; place cardboard on glass and cut out glass with a glass cutter; break off odd corners with notches on cutters and grind the edge of the glass on an ordinary red brick using plenty of water. Place one brass ring in cylinder, then the glass disc and then the other ring.

For the stand fill a piece of copper piping with melted rosin or lead. When hard bend the pipe around a piece of wood which has been sawed to the shape of bend desired. Then melt out the rosin or lead. Make an incision with a half-round file in the under side of the tube for the wires to come through. Make the base of wood as shown in Fig. 1. One-half inch from the top bore a hole large enough to admit the copper pipe and a larger hole up the center to meet it for the wires to come down.

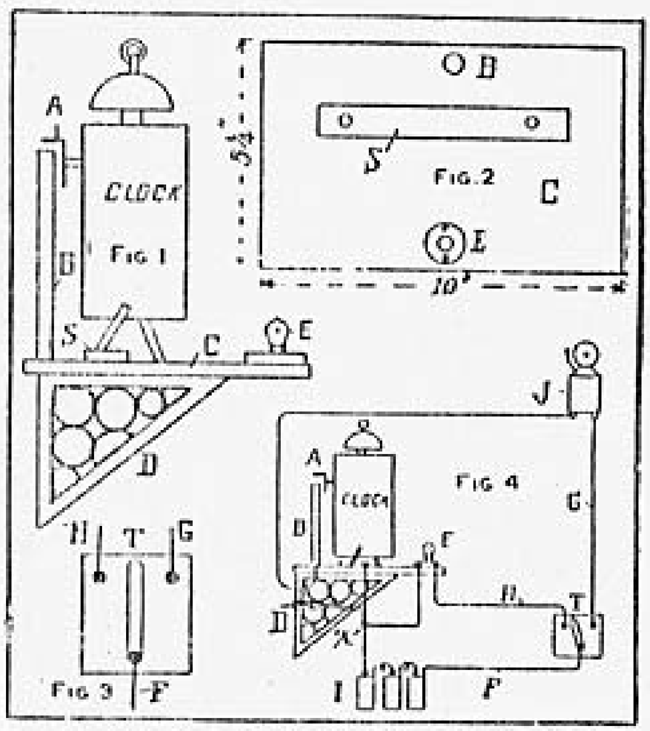
If it is desired to make the light very complete, make the base of two pieces of brass tube—one being a sliding fit in the other and with projecting pieces to prevent the cylinder from going too far. The light may then be elevated or lowered as wished. On two ordinary brass terminals twist or solder some flexible wire, but before doing so fix a little bone washer on the screws of the terminal so as to insulate it from the tube. When the wires have been secured to the terminals cover the joint with a piece of very thin india rubber tubing, such as is used for cycle valves. The two wires may now be threaded down the copper tube into the base, and pulled tight, the terminals firmly fixed into the tubes; if too small, some glue will secure them. To get the cylinder into its carriage, put one trunnion into the terminal as far as it will go and this will allow room for the other trunnion to go in its terminal.

THE BOY MECHANIC – 1913

Electric Alarm that Rings a Bell and Turns on a Light

The illustration shows an alarm clock connected up to ring an electric bell, and at the same time turn on an electric light to show the time. The parts indicated are as follows: A, key of alarm clock; B, contact post, 4 in. long; C, shelf, $5\frac{1}{4}$ by 10 in.; D, bracket; E, electric bulb ($3\frac{1}{2}$ volts); S, brass strip, $4\frac{1}{4}$ in. long, $\frac{3}{8}$ in. wide and 1/16 in. thick; T, switch; F, wire from batteries to switch; G, wire from bell to switch; H, wire from light to switch; I, dry batteries; J, bell; X, point where a splice is made from the light to wire leading to batteries from brass strip under clock. Push the switch lever to the right before retiring.

To operate this, set alarm key as shown in diagram, after two turns have been made on the key. When alarm goes off, it turns till it forms a connection by striking the contact post and starts the electric bell ringing. Throw lever off from the right to center, which stops bell ringing. To throw on light throw levers to the left. The bell is then cut out but the light remains on till lever is again thrown in the center.



Details of Alarm Construction

In placing clock on shelf, after setting alarm, be sure that the legs of clock are on the brass strip and that the alarm key is in position so it will come in contact with the contact post in back of clock. The contact post may be of ¼-in. copper tubing, or ¼-in. brass rod.

The advantage of this is that one can control the bell and light, while lying in bed, by having the switch on the baseboard, near the bed, so it can be reached without getting out of bed.—Contributed by Geo. C. Brinkerhoff, Swissvale, Pa.

THE BOY MECHANIC – 1913

Homemade Electric Bed Warmer

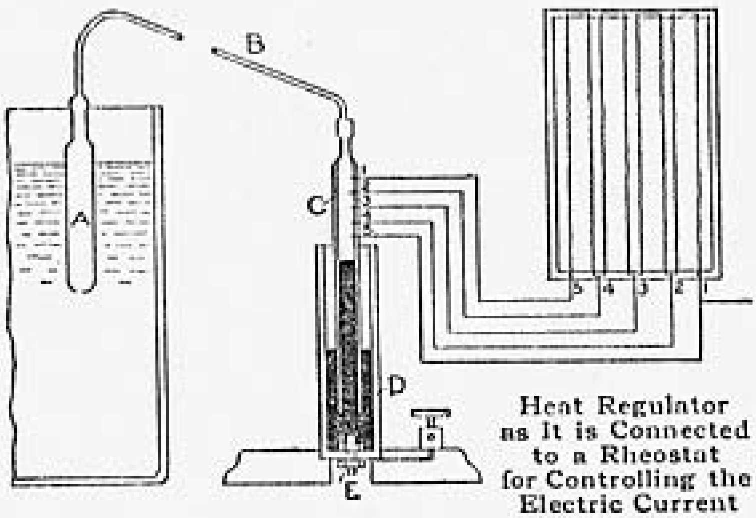
The heat developed by a carbon-filament lamp is sufficiently high to allow its use as a heating element of, for instance, a bed warmer. There are a number of other small heaters which can be easily made and for which lamps form very suitable heating elements, but the bed warmer is probably the best example. All that is required is a tin covering, which can be made of an old can, about 3½ in. in diameter. The top is cut out and the edge filed smooth. The lamp-socket end of the flexible cord is inserted in the can and the shade holder gripped over the opening. A small lamp of about 5 cp. will do the heating.

A flannel bag, large enough to slip over the tin can and provided with a neck that can be drawn together by means of a cord, gives the heater a more finished appearance, as well as making it more pleasant to the touch.

THE BOY MECHANIC – 1913

Automatic Electric Heat Regulator

It is composed of a closed glass tube, A, Fig. 1, connected by means of a very small lead pipe, B, to another glass tube, C, open at the bottom and having five pieces of platinum wire (1, 2, 3, 4 and 5), which project inside and outside of the tube, fused into one side. This tube is plunged into an ebonite vessel of somewhat larger diameter, which is fastened to the base by a copper screw, E. The tube C is filled to a certain height with mercury and then petroleum. The outer ends of the five platinum wires are soldered



Heat Regulator as It is Connected to a Rheostat for Controlling the Electric Current

Fig. 1

to ordinary copper wires and connections made to various points on a rheostat as shown. The diagram, Fig. 2, shows how the connections to the supply current are made.

The apparatus operates as follows: The tube is immersed in the matter to be heated, a liquid, for instance. As

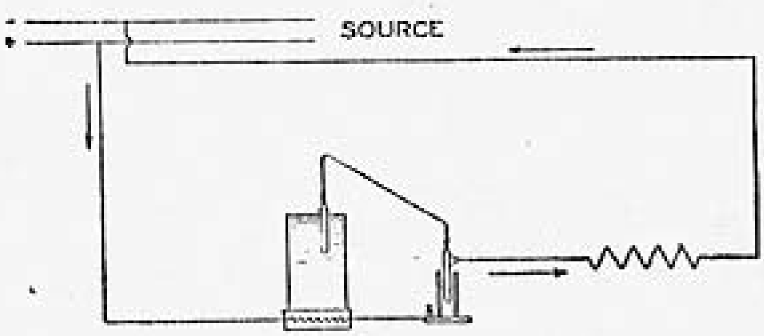


Fig. 2

Wiring Diagram Showing How the Connections to a Source of Current Supply are Made

the temperature of this rises, the air expands and exerts pressure on the petroleum in the tube C so that the level of the mercury is lowered. The current is thus compelled, as the platinum wires with the fall of the mercury are brought out of circuit, to pass through an increasing resistance, until, if necessary, the flow is entirely stopped when the mercury falls below the wire 5.

With this very simple apparatus the temperature can be kept constant within a 10-deg. limit, and it can be made much more sensitive by increasing the number of platinum wires and placing them closer together, and by filling the tube A with some very volatile substance, such as ether, for instance. The petroleum above the mercury prevents sparking between the platinum wire and the mercury when the latter falls below any one of them.

THE BOY MECHANIC – 1913

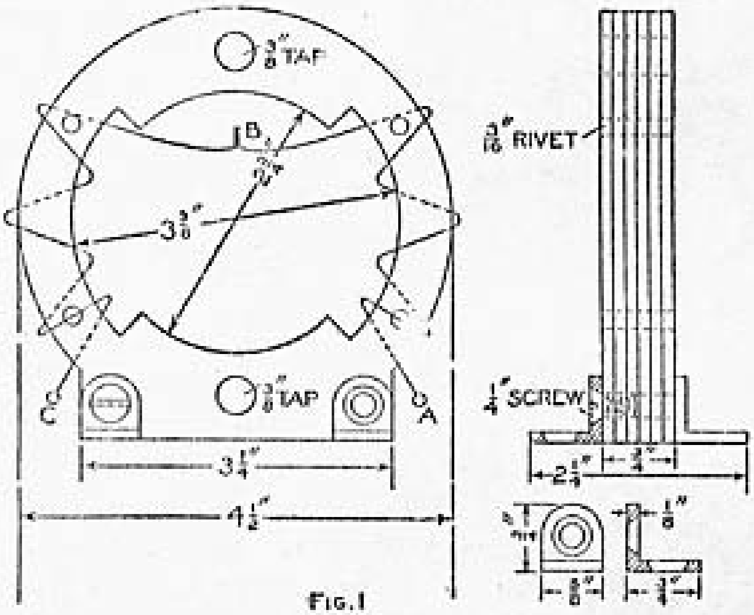
How to Make a Small Electric Motor

By W. A. ROBERTSON

The field frame of the motor, Fig. 1, is composed of wrought sheet iron, which may be of any thickness so that, when several pieces are placed together, they will make a frame ¾ in. thick. It is necessary to lay out a template of the frame as shown, making it $\frac{1}{16}$ in. larger than the dimensions given, to allow for filing to shape after the parts are fastened together. After the template is marked out, drill the four rivet holes, clamp the template, or pattern, to the sheet iron and mark carefully with a scriber. The bore can be marked with a pair of dividers, set at ⅛ in. This will mark a line for the center of the holes to be drilled with a ¼-in. drill for removing the unnecessary metal. The points formed by drilling the holes can be filed to the pattern size. Be sure to mark and cut out a sufficient number of plates to make a frame ¾ in. thick, or even $\frac{1}{16}$ in. thicker, to allow for finishing.

After the plates are cut out and the rivet holes drilled, assemble and rivet them solidly, then bore it out to a diameter of 2¾ in. on a lathe. If the thickness is sufficient, a slight finishing cut can be taken on the face. Before removing the field from the lathe, mark off a space, 3⅜ in. in diameter, for the field core with a sharp-pointed tool, and for the outside of the frame, 4½ in. in diameter, by turning the lathe with the hand. Then the field can be finished to these marks, which will make it uniform in size. When the frame is finished so far, two holes, 3⅝ in. between centers, are drilled and tapped with a ⅜-in. tap. These holes are for the bearing studs. Two holes are also drilled and tapped for ¼-in. screws, which fasten the holding-down lugs or feet to the frame. These lugs are made of a piece of ⅛-in. brass or iron, bent at right angles as shown.

The bearing studs are now made, as shown in Fig. 2, and turned into the threaded holes in the frame. The bearing supports are made of two pieces of ⅛-in. brass, as shown in the left-hand sketch, Fig. 3, which are fitted on the studs in the frame. A ⅝-in. hole is



The Field-Coil Core is Built Up of Laminated Wrought Iron Riveted Together

drilled in the center of each of these supports, into which a piece of ⅝-in. brass rod is inserted, soldered into place, and drilled to receive the armature shaft. These bearings should be fitted and soldered in place after the armature is constructed. The manner of doing this is to wrap a piece of paper on the outside of the finished armature ring and place it through the opening in the field, then slip the bearings on the ends of the shaft. If the holes in the bearing support should be out of line, file them out to make the proper adjustment. When the bearings are located, solder them to the supports, and build up the solder well. Remove the paper from the armature ring and see that the armature revolves freely in the bearings without touching the

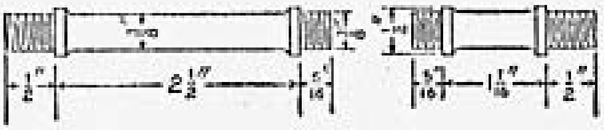
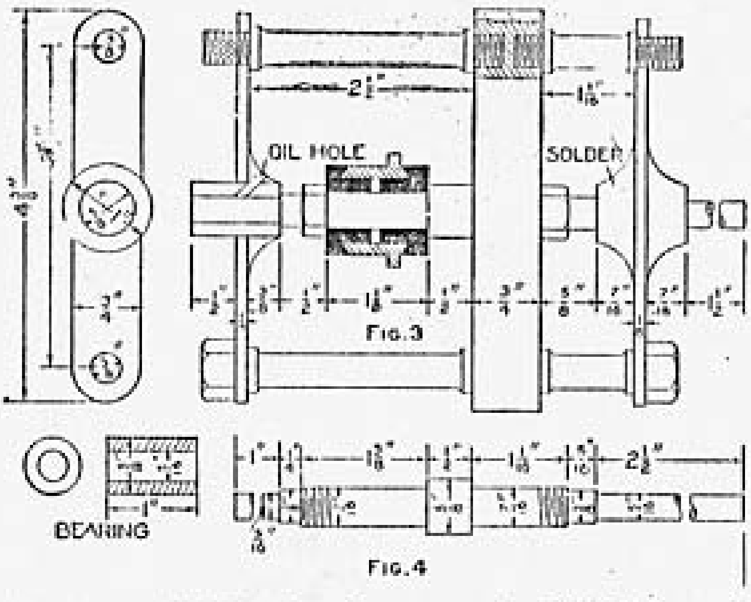


FIG. 2
The Bearing Studs are Turned from Machine Steel Two of Each Length being Required

inside of the field at any point. The supports are then removed and the solder turned up in a lathe, or otherwise finished. The shaft of the armature, Fig. 4, is turned up from machine steel, leaving the finish of the bearings until the armature is completed and fastened to the shaft.

The armature core is made up as fol-



The Assembled Bearing Frame on the Field Core and the Armature Shaft Made of Machine Steel

lows: Two pieces of wrought sheet iron, 1/8 in. thick, are cut out a little larger than called for by the dimensions given in Fig. 5, to allow for finishing to size. These are used for the outside plates and enough pieces of No. 24 gauge sheet iron to fill up the part between until the whole is over 3/4 in. thick are cut like the pattern. After the pieces are cut out, clamp them together and drill six 1/8-in. holes through them for rivets. Rivet them together, and anneal the whole piece by placing it in a fire and heating the metal to a cherry red, then allowing it to cool in the ashes. When annealed, bore out the inside to 1 11/16 in. in diameter and fit in a brass spider, which is made as follows: Procure a piece of brass, 3/4 in. thick, and turn it up to the size shown and file out the metal between the arms. Slip the spider on the armature shaft and secure it solidly with the setscrew so that the shaft will not turn in the spider when truing up the armature core. File grooves or slots in the armature ring so that it will fit on the arms of the spider. Be sure to have the inside of the armature core run true. When this is accomplished, solder the arms of the spider to the metal of the armature core. The shaft with the core is then put in a lathe and the outside turned off to the proper size. The sides are also faced off and finished. Make the core 3/4 in. thick. Remove the core from the lathe and file out slots 1/4 in. deep and 7/16 in. wide.

The commutator is turned from a piece of brass pipe, 3/4 in. inside diameter, as shown in Fig. 6. The piece is placed on a mandrel and turned to 3/4 in. in length and both ends chamfered to an angle of 60 deg. Divide the surface into 12 equal parts, or segments. Find the centers of each segment at one end, then drill a 1/8-in. hole and tap it for a pin. The pins are made of brass, threaded, turned into place and the ends turned in a lathe to an outside diameter of 1 1/4 in. Make a slit with a small saw blade in the end of each pin for the ends of the wires coming from the commutator coils. Saw the ring into the 12 parts on the lines between the pins.

The two insulating ends for holding these segments are made of fiber turned to fit the bore of the brass tubing, as shown in Fig. 7. Procure 12 strips of mica, the same thickness as the width of the saw cut made between the segments, and use them as a filler and insulation between the commutator bars. Place them on the fiber hub and slip the hub on the shaft, then clamp the whole in place with the nut, as shown in Fig. 3. True up the commutator in a lathe to the size given in

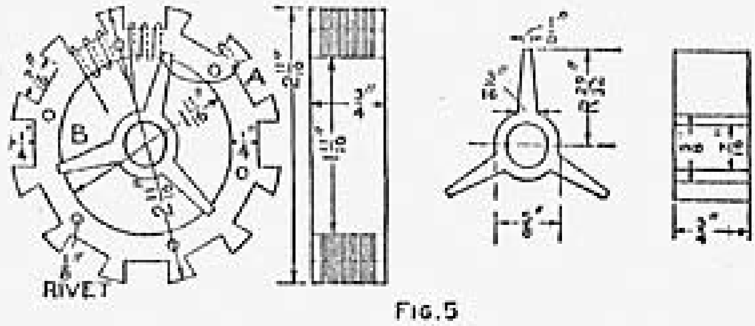


Fig.5

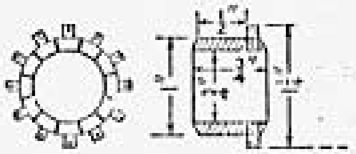


Fig.6

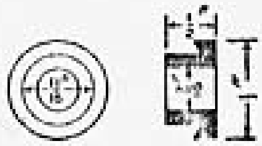


Fig.7

Armature-Ring Core, Its Hub and the Construction of the Commutator and Its Insulation

Fig. 6.

The brush holder is shaped from a piece of fiber, as shown in Fig. 8. The studs for holding the brushes are cut from $\frac{5}{16}$-in. brass rod, as shown in Fig. 9. The brushes consist of brass or copper wire gauze, rolled up and flattened out to ⅛ in. thick and ¼ in. wide, one end being soldered to keep the wires in place. The holder is slipped on the projecting outside end of the bearing, as shown in Fig. 3, and held with a setscrew.

The field core is insulated before winding with 1/64-in. sheet fiber, washers, 1⅛ in. by 1½ in., being formed for the ends, with a hole cut in them to fit over the insulation placed on the cores. A slit is cut through from the hole to the outside, and then they are soaked in warm water, until they become flexible enough to be put in place. After they have dried, they are glued to the core insulation.

The field is wound with No. 18 gauge double-cotton-covered magnet wire, about 100 ft. being required. Drill a small hole through each of the lower-end insulating washers. In starting to wind, insert the end of the wire through the hole from the inside, at A, Fig. 1, and wind on four layers, which will take 50 ft. of the wire, and bring the end of the wire out at B. After one coil, or side, is wound start at C in the same manner as at A, using the same number of turns and the same length of wire. The two ends are joined at B.

The armature ring is insulated by covering the inside and brass spider with $\frac{1}{16}$-in. sheet fiber. Two rings of $\frac{1}{16}$-in. sheet fiber are cut and glued to the sides of the ring. When the glue is set, cut out the part within the slot ends and make 12 channel pieces from 1/64-in. sheet fiber, which are glued in the slots and to the fiber washers. Be sure to have the ring and spider covered so the wire will not touch the iron or brass.

Each slot of the armature is wound with about 12 ft. of No. 21 gauge double-cotton-covered magnet wire. The winding is started at A, Fig. 5, by bending the end around one of the projections, then wind the coil in one of the slots as shown, making 40 turns, or four layers of 10 turns each, shellacking each layer as it is wound. After the coil is completed in one slot, allow about 2 in. of the end to protrude, to

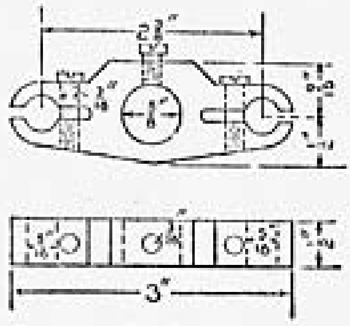


Fig.8

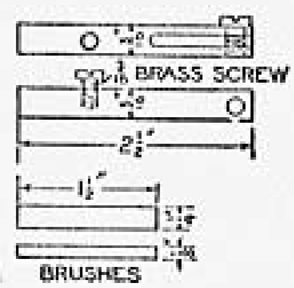


Fig.9

The Insulated Brush Holder and Its Studs for Holding the Brushes on the Commutator

fasten to the commutator segment. Wind the next slot with the same number of turns in the same manner, and so on, until the 12 slots are filled. The protruding ends of the coils are connected to the pins in the commutator segments after the starting end of one coil is joined to the finishing end of the next adjacent. All connections should be securely soldered.

The whole motor is fastened with screws to a wood base, 8 in. long, 6 in. wide and 1 in. thick. Two terminals are fastened at one side on the base, and a switch at the other side.

To connect the wires, after the motor

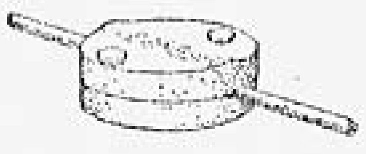
 GRANDDAD'S ELCTRICITY BOOK

is on the stand, the two ends of the wire, shown at B, Fig. 1, are soldered together. Run one end of the field wire, shown at A, through a small hole in the base and make a groove on the under side so that the wire end can be connected to one of the terminals. The other end of the field wire C is connected to the brass screw in the brass brush stud. Connect a wire from the other brush stud, run it through a small hole in the base and cut a groove for it on the under side so that it can be connected through the switch and the other terminal. This winding is for a series motor. The source of current is connected to the terminals. The motor can be run on a 110-volt direct current, but a resistance must be placed in series with it.

THE BOY MECHANIC – 1913

Substitute for Insulating Cleats

In wiring up door bells, alarms and telephones, as well as experimental work the use of common felt gun wads make a very good cleat for the wires. They are used in the manner illustrated in the accompanying sketch. The insulated wire is placed between two wads and fastened with two nails or screws. If one wad on the back is not thick enough to keep the wire away from the support, put on two wads behind and one in front of the wire and fasten in the same manner as described.



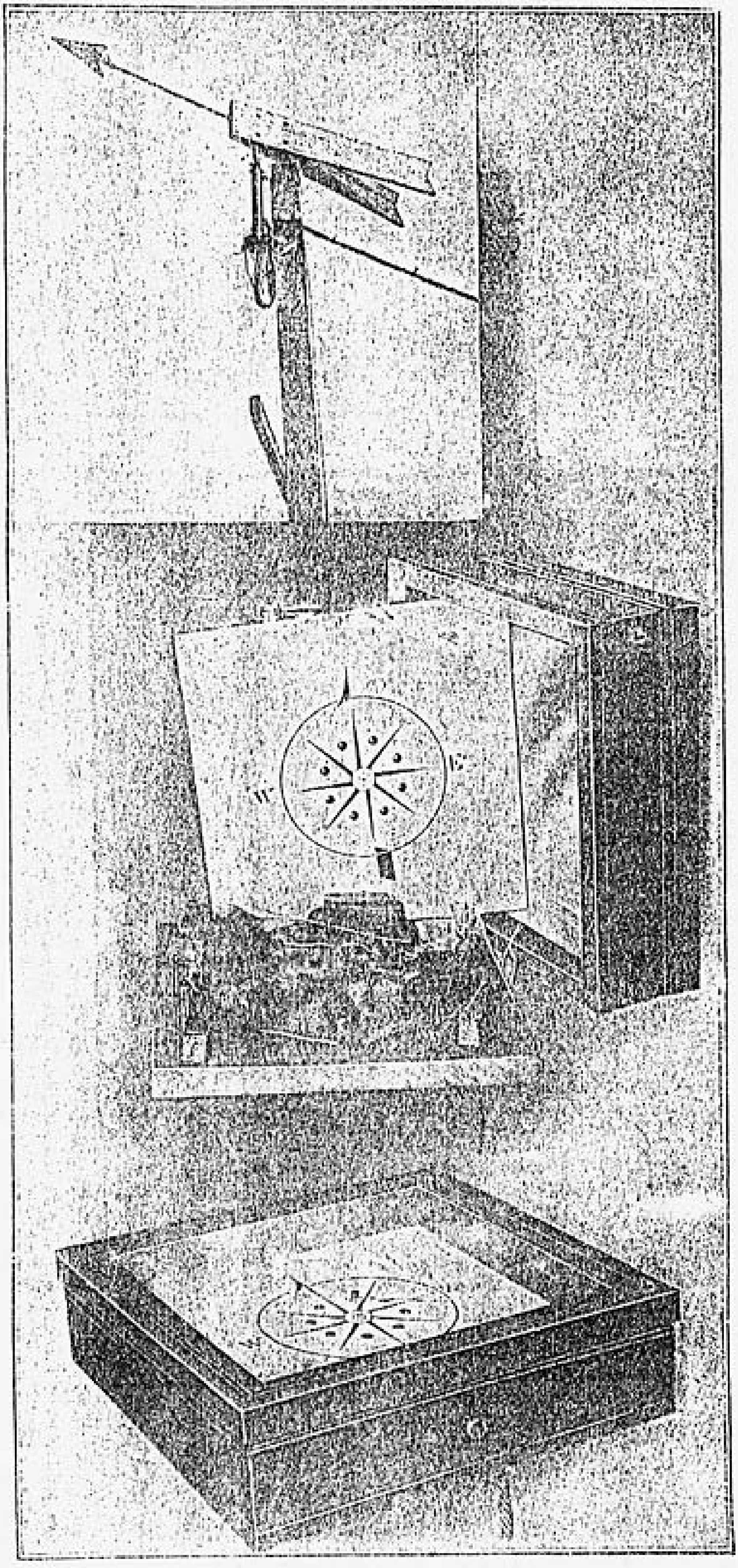
THE BOY MECHANIC – 1913

Electrically Operated Indicator for a Wind Vane

The accompanying photograph shows a wind vane connected with electric wires to an instrument at considerable distance which indicates by means of a magnetic needle the direction of the wind. The bearings of the vane consist of the head of a wornout bicycle. A ½-in. iron pipe extends from the vane and is held in place by the clamp originally used to secure the handle bar of the bicycle. In place of the forks is attached an eight-cylinder gas engine timer which is slightly altered in such a manner that the brush is at all times in contact, and when pointing between two contacts connects them both. Nine wires run from the timer, one from each of the eight contacts, and one, which serves as the ground wire, is fastened to the metallic body. The timer is set at such a position that when the vane points directly north, the brush of the timer makes a connection in the middle of a contact. When the timer is held in this position the brush will make connections with each of the contacts as the vane revolves.

The indicating device which is placed in a convenient place in the house consists of eight 4-ohm magnets fastened upon a 1-in. board. These magnets are placed in a 10-in. circle, 45 deg. apart and with their faces pointing toward the center. Covering these is a thin, wood board upon which is fastened a neatly drawn dial resembling a mariner's compass card. This is placed over the magnets in such a manner that there will be a magnet under each of the eight principal points marked on the dial. Over this dial is a magnetic needle or pointer, 6 in. long, perfectly balanced on the end of a standard and above all is placed a cover having a glass top. The eight wires from the timer contacts connect with the outside wires of the eight magnets separately and the inside wires from the magnets connect with the metal brace which holds the magnets in place. A wire is then connected from the metal brace to a push button, two or three cells of dry battery and to the ground wire in connection with the timer. The wires are connected in such a manner that when the vane is pointing in a certain direction the battery will be connected in series with the coil under that part of the dial representing the direction in which the vane is pointing, thus magnetizing the core of the magnet which attracts the opposite pole of the needle toward the face of the magnet and indicating the way the wind is blowing. The pointer end of the needle is painted black.

If the vane points in such a direction that the timer brush connects two contacts, two magnets will be magnetized and the needle will point midway between the two lines represented on the dial, thus giving 16 different directions. Around the pointer end of the needle is wound a fine copper wire, one end of which extends down to about ⅛ in. of the dial. This wire holds the needle in place when the pointer end is directly over the magnet attracting it; the magnet causing the needle to "dip" will bring the wire in contact with the paper dial. Without this attachment, the needle would swing a few seconds before coming to a standstill.


The Wind Vane, Magnets and Indicator

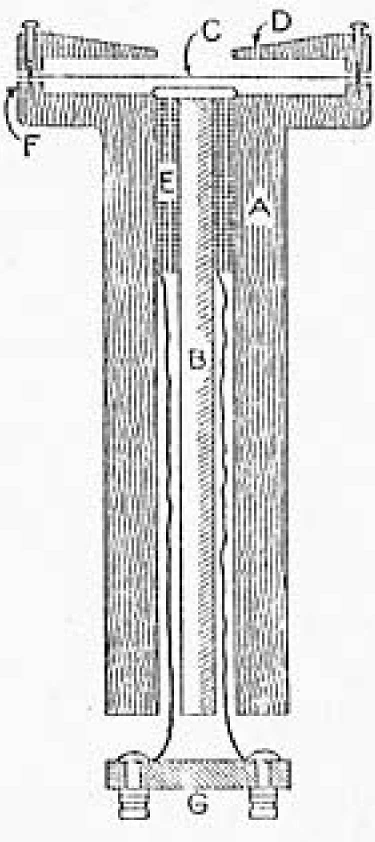
The vane itself is easily constructed as can be seen in the illustration. It should be about 6 ft. long to give the best results. The magnets used can be purchased from any electrical store in pairs which are called "instrument magnets." Any automobile garage can supply the timer and an old valueless bicycle frame is not hard to find. The cover is easily made from a picture frame with four small boards arranged to take the place of the picture as shown.

The outfit is valuable to a person who is situated where a vane could not be placed so as to be seen from a window and especially at night when it is hard to determine the direction of the wind. By simply pressing the push button on the side of the cover, the needle will instantly point to the part of the dial from which the wind is blowing.—Contributed by James L. Blackmer, Buffalo, N. Y.

THE BOY MECHANIC – 1913

Homemade Telephone Receiver

The receiver illustrated herewith is to be used in connection with the transmitter described elsewhere in this volume. The body of the receiver, A, is made of a large wooden ribbon spool. One end is removed entirely, the other sawed in two on the line C and a flange, F, is cut on the wood, 1/8 in. wide and 1/16 in. deep. A flange of the same size is made on the end D that was sawed off, and the outside part tapered toward the hole as shown. The magnet is made of a 30-penny nail, B, cut to the length of the spool, and a coil of wire, E, wound on the head end. The coil is 1 in. long, made up of four layers of No. 22 gauge copper magnet wire, allowing the ends to extend out about 6 in. The nail with the coil is then put into the hole of the spool as shown. The diaphragm C, which is the essential part of the instrument, should be made as carefully as possible from ferrotype tin, commonly called tintype tin. The diaphragm is placed between the flanges on the spool and the end D that was sawed off. The end piece and diaphragm are both fastened to the spool with two or three slender wood screws, as shown.



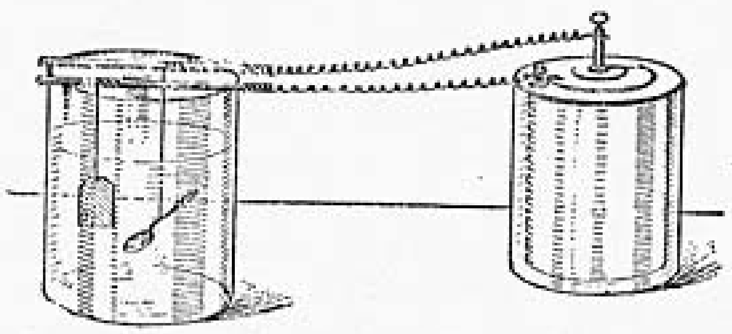
A small wooden or fiber end, G, is fitted with two binding posts which are connected to the ends of the wire left projecting from the magnet winding. The binding posts are attached to the line and a trial given. The proper distance must be found between the diaphragm and the head of the nail. This can be accomplished by moving the nail and magnet in the hole of the spool. When the distance to produce the right sound is found, the nail and magnet can be made fast by filling the open space with melted sealing wax. The end G is now fastened to the end of the spool, and the receiver is ready for use.

THE BOY MECHANIC – 1913

How to Make a Small Silver Plating Outfit

Take an ordinary glass fruit jar or any other receptacle in glass, not metal, which will hold 1 qt. of liquid and fill it with rain or distilled water and then add 3/4 oz. of silver chloride and 1 1/2 oz. of c. p. potassium cyanide. Let this dissolve and incorporate well with the water before using. Take an ordinary wet battery and fasten two copper wires to the terminals and fasten the other ends of the wires to two pieces of heavy copper wire or ¼-in. brass pipe. The wires must be well soldered to the brass pipe to make a good connection. When the solution is made up and entirely dissolved the outfit is ready for plating.

Procure a small piece of silver, a silver button, ring, chain or anything made entirely of silver and fasten a small copper wire to it and hang on the brass pipe with connections to the carbon of the battery. Clean the article to be plated well with pumice and a brush saturated in water. When cleaning any article there should be a copper wire attached to it. Do not touch the article after you once start to clean it, or the places touched by your fingers will cause the silver plate to peel off when finished. When well scoured, run clear, cold water over the article and if it appears greasy, place in hot water. When well cleaned place in the plating bath and carefully watch the results. If small bubbles come to the surface you will know that you have too much of the anode or the piece of silver hanging in the solution and you



Plating Jar and Battery

must draw out enough of the piece until you can see no more bubbles. Leave the piece to be plated in the solution for about one-half hour, then take the article out and with a tooth brush and some pumice, clean the yellowish scum off, rinse in clear water and dry in sawdust. When thoroughly dry, take a cotton flannel rag and some polishing powder and polish the article. The article must have a fine polish before plating if it is desired to have a finely polished surface after the plate is put on.

In order to see if your battery is working, take a small copper wire and touch one end to the anode pipe and the other end to the pipe holding the article to be plated. When these two parts touch there will be a small spark. Always take the zincs out of the solution when not in use and the batteries will last longer. This description applies only to silver plating. Articles of lead, pewter, tin or any soft metal cannot be silver plated unless the article is first copper plated.

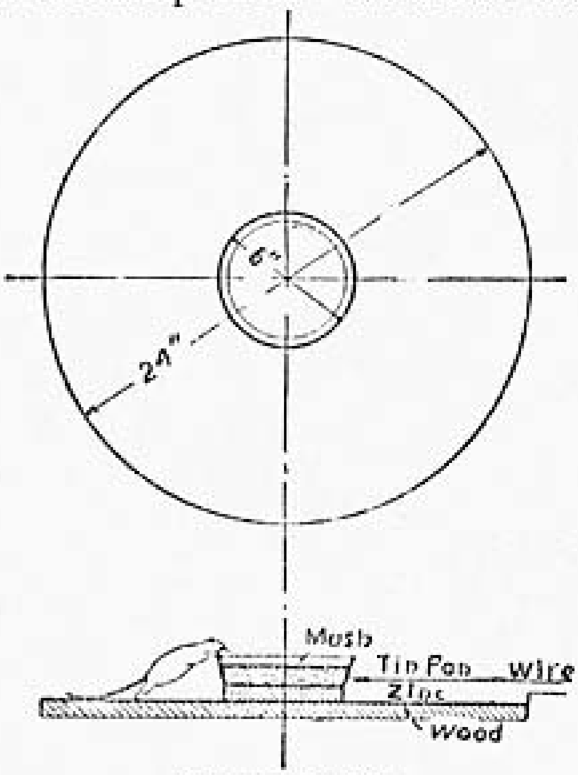
THE BOY MECHANIC - 1913

Electric Rat Exterminator

Some time ago we were troubled by numerous large rats around the shop, particularly in a storehouse about 100 ft. distant, where they often did considerable damage. One of the boys thought he would try a plan of electrical extermination, and in order to carry out his plan he picked up an old zinc floor plate that had been used under a stove and mounted a wooden disk 6 in. in diameter in the center. On this disk he placed a small tin pan about 6 in. in diameter, being careful that none of the fastening nails made an electrical connection between the zinc plate and the tin pan.

This apparatus was placed on the floor of the warehouse where it was plainly visible from a window in the shop where we worked and a wire was run from the pan and another from the zinc plate through the intervening yard and into the shop. A good sized induction coil was through connected with these wires and about six dry batteries were used to run the induction coil whenever a push button was manipulated.

It is quite evident that when a rat put its two fore feet on the edge of the pan in order to eat the mush which it contained, that an electrical connection would be made through the body of the rat, and when we pushed the button up in the shop the rat would be thrown



Electric Rat Trap

2 or 3 ft. in the air and let out a terrific squeak. The arrangement proved quite too effective, for after a week the rats all departed and the boys all regretted that their fun was at an end.—Contributed by John D. Adams, Phoenix, Ariz.

THE BOY MECHANIC – 1913

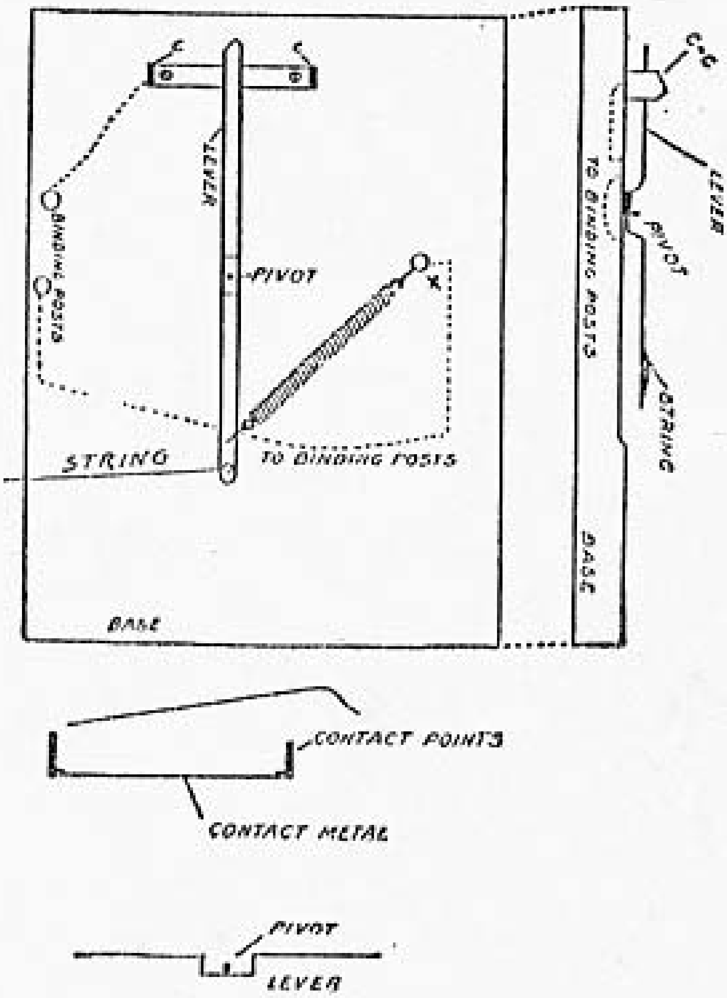
Renewing Dry Batteries

Dry batteries, if not too far gone, can be renewed by simply boring a small hole through the composition on top of each carbon and pouring some strong salt water or sal ammoniac solution into the holes. This kink is sent us by a reader who says that the process will make the battery nearly as good as new if it is not too far gone beforehand.

THE BOY MECHANIC – 1913

How to Make a Simple Burglar Alarm

Take a piece of any wood about 6 by 8 in. for the base. This may be finished in any way desired. For the contact points use brass or any sheet metal which will be satisfactory. Take a piece about 2½ or 3 in. in length and bend the ends up about ½ in. in a ver-



Simple Burglar Alarm

tical position as shown. Fasten this to the top of the board using screws or nails. Under this strip of metal fasten a copper wire which can be connected to a binding-post on the board if desired. Take another piece of metal about 4½ in. in length and make a lever of it in the shape shown in the diagram. Fasten this so that one end of it will swing freely, but not loosely between the ends of the other piece marked C-C. Near the end fasten a spiral spring, S, which can be obtained almost anywhere. Fasten the end of this to the screw marked X. Also fasten to this screw a copper wire leading to the binding-post. In the lower end of the lever make a small hole to fasten a string through.

This string may be fastened across a door or window and any movement of it will pull it to the contact point on the right. If the string is cut or broken the spring will pull the lever to the contact point on the left and thus complete the circuit. If the string is burned it will also act as a fire alarm.

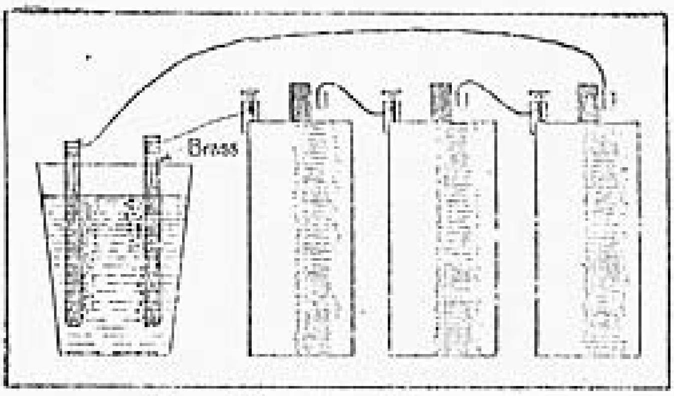
THE BOY MECHANIC – 1913

An Interesting Electrical Experiment

Anyone possessing a battery having an electromotive force of from 4 to 20 volts can perform the following experiment, which is particularly interesting on account of the variation of results with apparently the same conditions.

Immerse two pieces of brass in a strong solution of common salt and water. Connect one piece to the positive wire and the other to the negative, taking care that the brass pieces do not touch each other.

After the current has passed one



How Wires are Connected

or two minutes, the solution will become colored, and if the process is continued a colored pigment will be precipitated. The precipitate varies considerably in color and may be either yellow, blue orange, green or brown, depending on the strength of the current, the strength of the solution, and the composition of the brass.

THE BOY MECHANIC – 1913

Another Way to Renew Dry Batteries

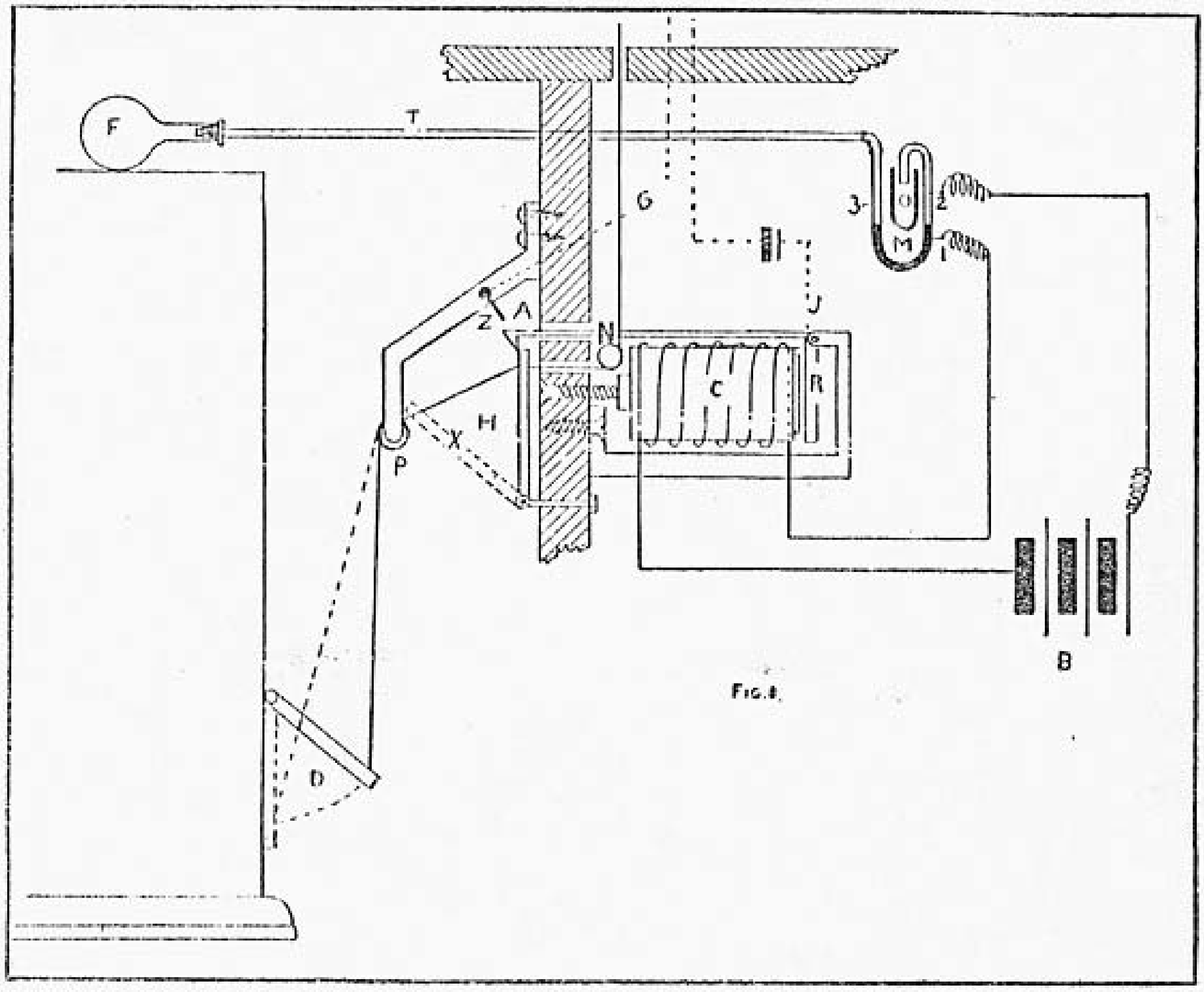
There are many methods of renewing dry batteries, and I have used several of them, but I found the following the best: Remove the paper cover and with a ¼-in. drill make about six holes around the side of the zinc, about ½ in. from the bottom. Then drill another row of holes about half way up the side and put the battery to soak in a solution of sal ammoniac for 48 hours. Then remove and plug the holes up with hard soap, and replace in the paper box, when it will give nearly as strong a current as when new.

THE BOY MECHANIC – 1913

How to Make an Electric Furnace Regulator

We have a furnace in our house and a part of my work each evening last winter was to go down in the basement at 9 o'clock, fill the furnace with coal for the night and stay there until it was burning in good shape, then to close the draft door. As this performance requires from twenty to thirty minutes I concluded to make a self-acting device which would close the draft and leave the furnace safe, without any further attention on my part, after putting in the coal and opening it up to burn. As some other boys may like to build the same regulator I will tell just how to make one and how it operates.

Referring to Fig. 1, you will see a straight cord is attached to the draft door of the furnace, D, and is run over the pulley P and finally is attached to a small piece of iron, H. This piece of iron is hinged to I. To the other side of H another cord G is fastened, which passes over the pulley N and terminates in any convenient place in the rooms above. This piece of iron H is held in place by the release A. Now C is a coil of wire from a door bell. R is an armature which works A on pivot J. M is a U-tube, filled with mercury, one end being connected to a half liter glass flask F by the tube T, and the other end terminates in an overflow tube O. B is a battery of three bichromate cells which are connected up with the C and the platinum points 1—2, which are fused into the U-tube.



Details of Furnace Regulator Construction

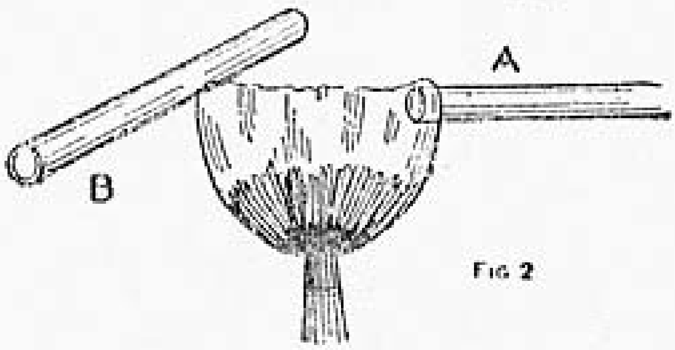
On fixing the furnace the iron piece H takes position X, this being the normal position when draft door D is closed. On arriving upstairs I pull the cord G, which causes the piece H to become fixed in the vertical position by means of A. This opens the draft door at the same time. Now when the furnace heats up sufficiently it causes the air to expand in F, which causes the mercury in M to rise a little above the point 2. This immediately causes a current to flow through C which in turn draws R towards it, raises A and causes H to drop to position X. This shuts the furnace door. Now the furnace, of course, cools down, thus causing the air in F to contract and consequently opening the circuit through C. If at any time the furnace should overheat, the raising of A, on which is grounded a wire from a signal bell upstairs, will make a circuit through the bell by means of the point Z and wire leading therefrom. This bell also serves to tell me whether H has dropped or not. This same device of regulating the draft D can be used to regulate the damper, found on the coal doors of most furnaces, by simply fusing a platinum point on the other side of M and changing the cord which is attached to D. A two-contact switch could also be inserted to throw connections from 2 to 3. It would work in this manner: The damper door, of course, which keeps a low fire, would be up in a position similar to D; on the furnace cooling too much, connection, due to contracting of air in F, would be made through 3 and C, causing H to drop, thus closing door. This

 GRANDDAD'S ELCTRICITY BOOK

simple device worked very well all last winter and gave me no trouble whatever.

If you cannot readily procure a U-tube, you can make one, as I did, and the work is interesting.

The U-tube is constructed in the following manner. A glass tube is closed at one end. This is done by holding the tube in one corner of a gas flame, somewhat near the dark area (A, Fig. 2), and constantly turning the tube. when it will be found that the glass has melted together. Now, after it is cool, about 3 or 4 in. from the sealed end, the tube is held steadily so that the flame will heat one small portion (B, Fig. 2). After this small portion is heated blow into the tube, not very hard, but just enough to cause tube to bulge out. Allow to cool. Then reheat the small bulged portion, blow quite hard, so that the glass will be blown out at this point, forming a small hole. Now insert about ½ in. of platinum wire and reheat, holding platinum



Making the U-Tube

wire by means of a small pliers so that it will be partly in the tube and partly without. The platinum will stick to the glass, and if glass is sufficiently heated one will be able to pull it, by means of pliers, from one side of the hole to the other, thus sealing the wire into the tube. Another wire is sealed in the same way about 1 in. from the first. Now, to bend the tube, one must hold it, with both hands, in the flame and turn constantly until soft. Quickly withdraw from flame and bend, just as you would a piece of copper wire. Allow to cool slowly.

The several tubes are connected with a short piece of rubber tubing.

The total cost of materials for constructing the apparatus complete will not amount to more than one dollar.—Contributed by M. G. Kopf, Lewis Institute, Chicago.

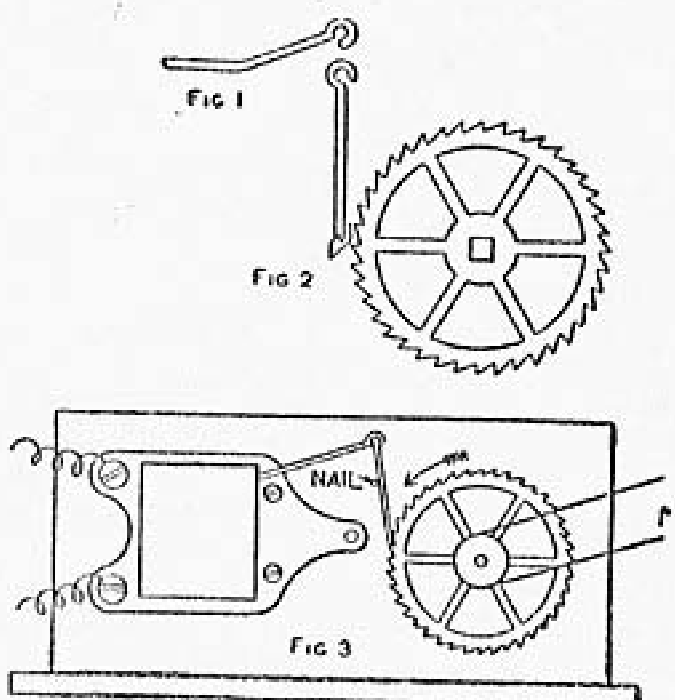
THE BOY MECHANIC – 1913

Novel Electric Motor

The materials necessary to make this motor are an old electric bell of the "buzzer" type and a cogwheel from an old clock.

Remove the hammer-head and gong from the bell, then bend the end of the hammer into a loop, as in Fig. 1. Now make a little wire catch like Fig. 2, and fasten its loop into the loop of the hammer. Mount the bell on a small board as in Fig. 3 and fasten the cogwheel almost on a line with it. Now press down the hammer and place a nail in the position shown in the diagram so that the catch touches one of the teeth.

Fasten the board in an upright position and attach two dry batteries to the binding-posts. If properly connected, the fly-wheel will turn quite rapidly and with amazing force for so small a machine. The machine, however, has a fixed direction as shown by the arrow,



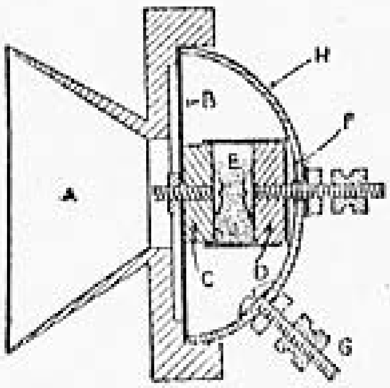
Novel Electric Motor

but the belting can be arranged so as to send the models in a reversed direction if required. The materials for the motor should not cost more than 25c for the bell and if you have an old bell it will cost next to nothing.—Contributed by Fred C. Curry, Brockville, Ontario.

THE BOY MECHANIC – 1913

Home-Made Telephone Transmitter

The parts for transmitting the sound are encased in a covering, H, made from the gong of an old electric bell. A round button, D, is turned or filed from the carbon electrode of an old dry cell and a hole drilled through the center to fit in a binding-post taken from the same battery cell. This button must be carefully insulated from the



shell, H, by running the binding-post through a piece of small rubber tube where it passes through the hole and placing a rubber or paper washer, F, under the carbon button, and an insulating washer under the nut on the outside. This will provide one of the terminals of the instrument. Construct a paper tube having the same diameter as the button and with a length equal to the depth of the bell case, less 1/8 in. Glue or paste this tube to the button so it will form a paper cup with a carbon bottom.

The diaphragm, B, which is the essential part of the instrument, should be made as carefully as possible from ferrotype tin, commonly called tintype tin. Cut a circular piece from this metal the exact size of the outside of the shell. A hole is made in the center of the disk a little larger than a binding-post that is taken from another old battery cell. When making the hole in the disk be careful not to bend or crease the tin. Scrape the black coating from the tin around the outside about 1/4 in. wide and a place about 1 in. in diameter at the center.

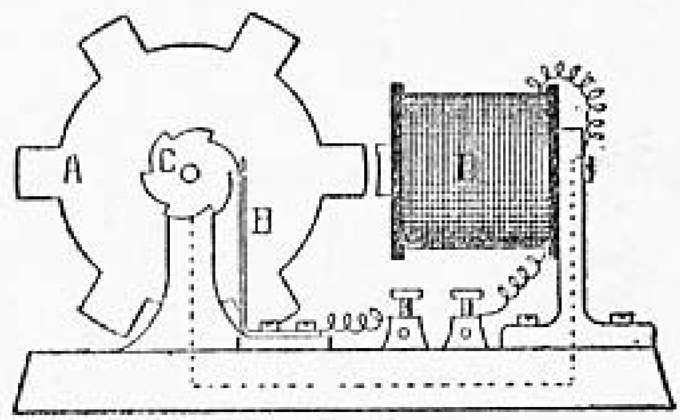
The second electrode, C, is made the same as D, and fastened to the tin diaphragm with the binding-post without using any insulation. A third binding-post, G, is fastened to the shell through a drilled hole to make the other terminal. The mouthpiece, A, may be turned from wood in any shape desired, but have a flange on the back side that will make a tight fit with the outside of the shell.

Fill the paper tube with powdered carbon, E, which can be made by pounding and breaking up pieces of carbon to about the size of pin heads. Powdered carbon can be purchased, but if you make it be sure to sift out all the very fine particles. Assemble the parts as shown and the transmitter is ready for use. If speech is not heard distinctly, put in a little more, or remove some of the carbon and try it out until you get the instrument working nicely.—Contributed by Harold H. Cutter, Springfield, Mass.

THE BOY MECHANIC – 1913

Another Electric Motor

This form of electric motor is used largely in England in the form of an indicator. It is very easily made and



Electric Motor

if you have an old electro-magnet will cost practically nothing.

A large soft-iron wheel is mounted on an axle with a pulley-wheel on one end and a circuit breaker on the other end. The teeth on the circuit-breaker must be the same number as on the soft-iron wheel.

The electro-magnet is mounted so that its core is level with the axle and in a line with the wheel. One wire from it is attached to one binding screw and the other end is grounded to the iron frame that supports it. This frame is connected to the frame supporting the wheel. A small brush presses on the circuit-breaker and is connected to the other binding screw.

In the diagram A represents the iron wheel; B, the brush; C, the circuit-breaker; D, the magnet. The wire connecting the two frames is shown by a dotted line.

To start the motor, attach your battery to the screws and turn the wheel a little. The magnet attracts one of the teeth on the wheel, but as soon as it is parallel with the core of the magnet the circuit is broken and the momentum of the wheel brings another tooth to be attracted.

To reverse the motor reverse the connections and start the wheel the other way. Be sure that the frames are screwed down well or the motor will run jerkily and destroy the connections.—Contributed by F. Crawford Curry, Brockville, Ontario.

THE BOY MECHANIC – 1913

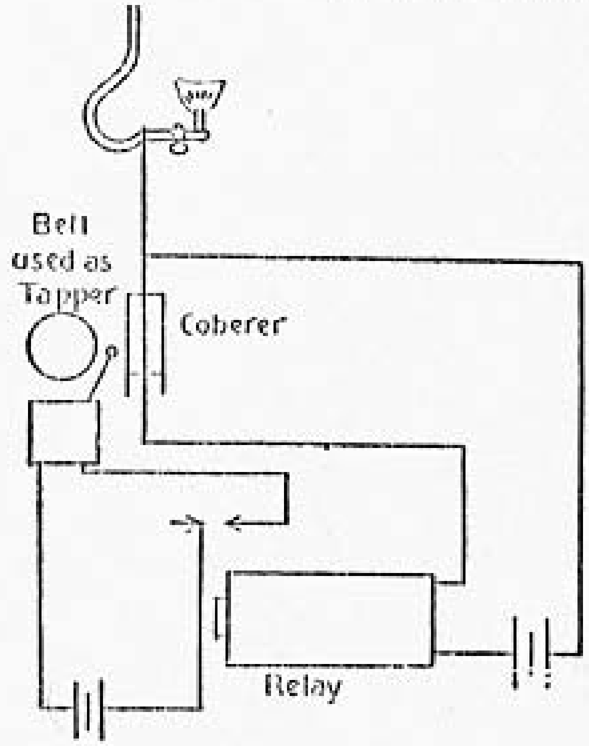
To Renew Old Dry Batteries

Remove the paper that covers the cell and knock several good-sized holes in the zinc shell. Place the battery in a glass jar, fill it two-thirds full of strong sal ammoniac (or salt) solution and connect the terminals to whatever apparatus the current is to be used for. A few drops of sulphuric acid quickens and improves the action. The output of the cell will be nearly as great as when the battery was first bought.—Contributed by C. W. Arbitt, Austin, Texas.

THE BOY MECHANIC – 1913

Ringing a Bell by Touching a Gas Jet

The experiment of scuffling the feet over a carpet and then producing a spark which will light the gas by touching the chandelier is described on another page. One of our correspondents says that if a wire is connected to the chandelier and led to one terminal of the coherer of a wireless telegraph outfit the bell will ring every time the



Touch the Gas Jet and Ring the Bell

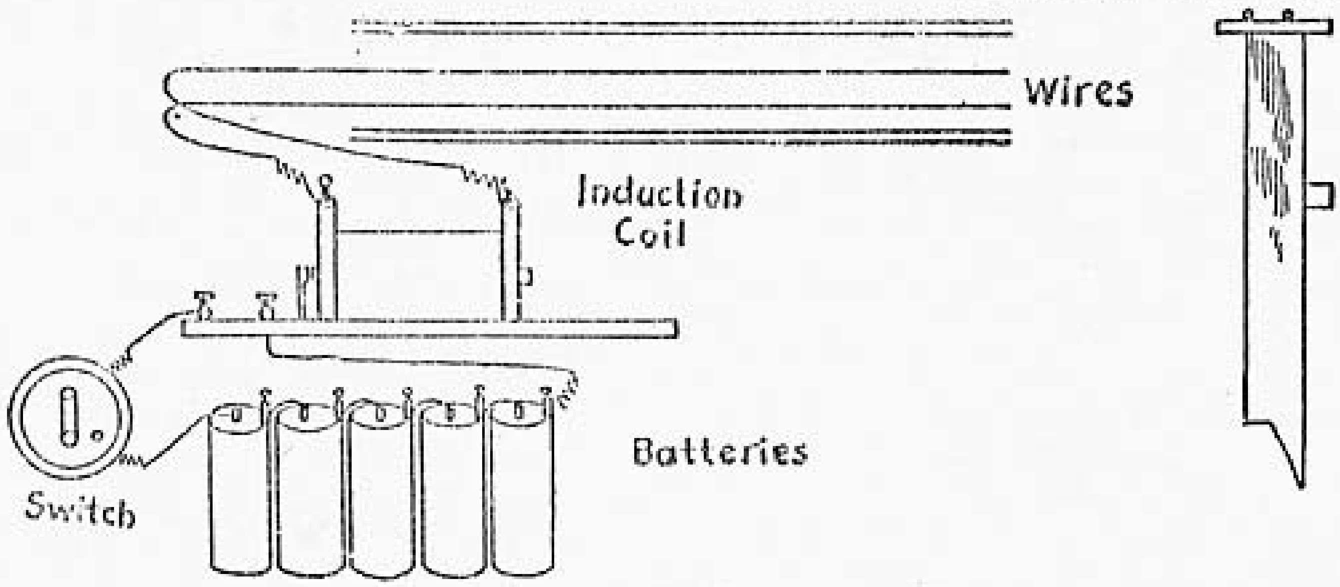
spark is produced by touching the chandelier, and that, as the chandeliers are all connected by the gas-pipe, the bell will ring, no matter in which room the spark is produced.

THE BOY MECHANIC – 1913

How to Rid Your Yard of Cats

The following is a description of a device I built at my home in Brooklyn, which not only gave us relief from the nightly feline concerts, but also furnished much amusement to my friends.

I first ran two bare copper wires along the top of the fence about 1 in. apart, fastening them down with small staples, care being taken that they did not touch. To the ends of these wires I fastened ordinary insulated bell wire,



Electric Apparatus for Driving Away Cats

running them to the house and connecting them to the upper binding-posts of an induction coil; I then ran a wire from the lower binding-post of my coil through the batteries back to the other lower binding-post of coil, breaking the circuit by putting in an ordinary switch. The more batteries used, the stronger the current. The switch should always be left open, as it uses up the current very rapidly.

When "tabby" is well on the wires I close the switch and she goes the length of the fence in bounds, often coming back to see what the trouble is, thus receiving another shock.—Contributed by Charles L. Pultz.

THE BOY MECHANIC – 1913

How to Construct an Annunciator

Oftentimes a single electric bell may be connected in a circuit so that it can be operated from more than one push button. These push buttons are usually located in entirely different parts of the building and it is necessary to have some means of determining the particular push button that was pressed and caused the bell to operate. The electric annunciator is a device that will indicate or record the various calls or signals that may be sent over the circuits to which the annunciator is connected. A very simple and inexpensive annunciator may be made in the following way:

Before taking up the construction of the annunciator it would be best to make a diagrammatic drawing of the circuit in which the annunciator is to operate. The simplest circuit that will require an annunciator is one where the bell may be operated from either of two push buttons. In this case the annunciator must be constructed to give only two indications. Fig. 1 shows how the various elements of such a circuit may be connected. B is an ordinary vibrating electric bell, M1 and M2 are the two electromagnets of the annunciator, A is a battery of several dry cells, and P1 and P2 are the push buttons from either of which the bell may be operated.

When the push button P1 is pressed the circuit is completed through the winding of the magnet M1 and its core becomes magnetized. In a similar manner the core of the magnet M2 becomes magnetized when the push button P2 is pressed and the circuit completed through the winding of the magnet M2.

If an iron armature, that is supported by a shaft through its center and properly balanced, be placed near the ends of the cores of M1 and M2, as shown in Fig. 2, it may assume the position indicated by either the full or dotted lines, depending upon which of the magnets, M1 or M2, was last magnetized. The position of this armature will serve to indicate the push button from which the bell was operated. The magnets should be placed inside a case and the indication may be made by a pointer attached to the shaft, supporting the armature.

If you are able to secure the electromagnets from a discarded electric bell they will work fine for the magnets M1 and M2. They should be disconnected from their iron support and mounted upon some non-magnetic material, such as brass or copper, making the distance between their centers as small as possible. The piece of metal upon which the magnets are mounted should now be fastened, by means of two wood screws, to the back of the board, shown in Fig. 6, that is to form the face of the annunciator. It should be about 1/8 in. thick, 1/2 in. wide and long enough to extend a short distance beyond the cores of the magnets M1 and M2. Drill a 1/16-in. hole through its center, as shown in Fig. 2. Drive a piece of steel rod into this hole, making sure the rod will not turn easily in the opening, and allow about 1/2 in. of the rod to project on one side, and 1 1/2 in. on the other side.

Drill a hole in the board upon which the magnets are mounted so that when the long end of the rod carrying the armature is passed through the hole, the armature will be a little more than 1/16 in. from each magnet core. The short end of the rod should be supported by means of a piece of strip brass bent into the form shown in Fig. 3.

Drill a hole in the center of this piece, so the rod will pass through it. When the armature has been put in its proper place, fasten this strip to the board with two small wood screws. You may experience some difficulty in locating the hole in the board for the rod, and it no doubt would be best to drill this hole first and fasten the magnets in place afterwards.

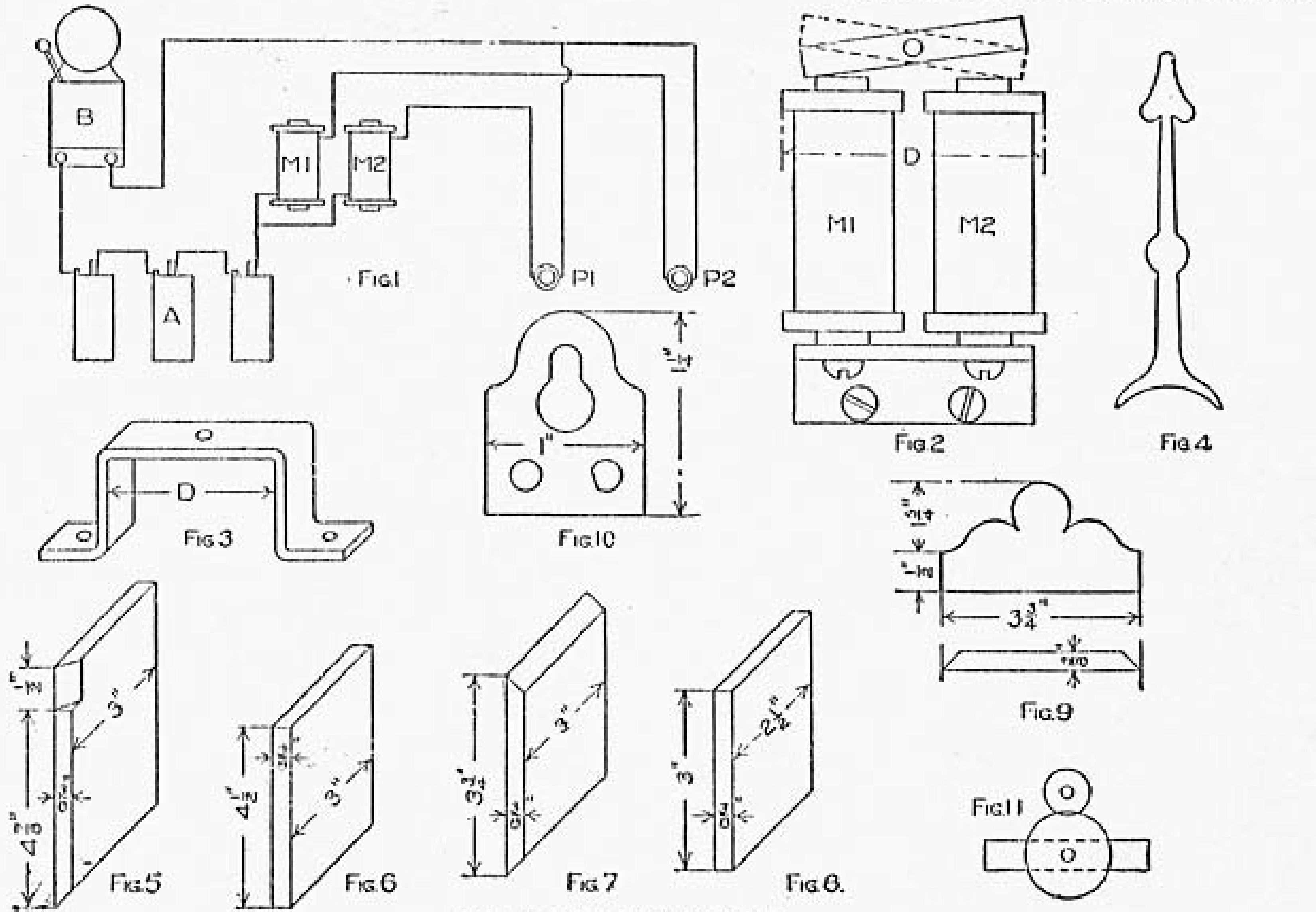
Two small collars should be fastened to the rod to prevent its moving endwise. Fit the collars tightly on the rod to hold them in place.

Cut the long end of the rod off so it projects through the face of the annunciator about 3/8 in. Take some very thin sheet brass and cut out a needle or indicator as shown in Fig. 4. In a small piece of brass drill a hole so it will fit tight on the other end of the rod. Solder the indicator to this piece and force it in place on the end of the rod.

When the armature is the same distance from each core, the indicator should be parallel to the long dimension of the face of the case. The case of the instrument may be made in the following way:

Secure a piece of 3/8-in. oak, or other hard wood, 3 in. wide and 2 1/2 ft. long. Then cut from this board the following pieces: two whose dimensions correspond to those of Fig. 5 and are to form the sides of the case; two whose dimensions correspond to those of Fig. 6 and are to form the back and the face of the case; three whose dimensions correspond to those of Figs. 7, 8, and 9 and are to form the lower and upper end of the case and the finish for the top.

Secure a piece of window glass, 4 1/2 in. by 3 1/8 in. that is to be used as the front. Before assembling the case cut on the inner surface of the pieces forming the sides and the lower end, a groove just wide enough to take the glass and 1/16 in. in depth. The outer edge of this groove should be 3/8 in. from the outer edge of the frame. After the case is fastened together there should be a slot between the piece forming the upper end and the piece that serves as a finish at the top, that will allow the glass to be slipped into place. A small strip of wood should be tacked over this slot, after the glass is put in place, to prevent the dust and dirt from falling down inside of the



Details of the Annunciator

case.

The piece upon which the works are to be mounted may be fastened in place by means of four round-headed brass screws that pass through the sides of the case. It should be fastened about ½ in. back of the glass front. The back may be fastened inside of the case in a similar manner.

Cut two pieces, from some sheet brass, whose dimensions correspond to those of Fig. 10. These pieces are to be used in supporting the case by means of some small screws. Fasten three binding-posts, that are to form the terminals of the annunciator, on the top of the upper end of the case. Mark one of these binding-posts C and the other two L1 and L2. Connect one terminal of each of the magnet windings to the post marked C and the other terminal to the posts L1 and L2. You can finish the case in any style you may desire. Oftentimes it is desirable to have it correspond to the finish of the woodwork of the room in which it is to be placed. The distance the point of the indicator will move through depends upon the distance between the cores of the magnets and the distance of the armature from these cores. These distances are oftentimes such that the indications of the cell are not very definite. If the armature is moved too far from the cores there is not sufficient pull exerted by them when magnetized, to cause the position of the armature to change.

Mount on the shaft carrying the armature a small gear wheel. Arrange another smaller gear to engage this on and fasten the indicator to the shaft of the smaller gear. Any movement now of the armature shaft will result in a relative large movement of the indicator shaft. Figure 11 shows the arrangement of the gears just described.

TELEGRAPH CODES.

MORSE, USED IN THE UNITED STATES AND CANADA.
CONTINENTAL, USED IN EUROPE AND ELSEWHERE.
PHILLIPS USED IN THE UNITED STATES FOR "PRESS" WORK.

Dash = 2 dots. Long dash = 4 dots.
Space between elements of a letter = 1 dot.
Space between letters of a word = 2 dots.
Interval in spaced letters = 2 dots.
Space between words = 3 dots.

LETTERS

	MORSE	CONTINENTAL
A	.-	.-
B	-...	-...
C	.. .	-.-.
D	-..	-..
E	.	.
F	.-.	..-.
G	--.	--.
H	....	....
I	..	..
J	-.-.	.---
K	-.-	-.-
L	——	.-..
M	--	--
N	-.	-.
O	. .	---
P	.....	.--.
Q	..-.	--.-
R	. ..	.-.
S	...	...
T	-	-
U	..-	..-
V	...-	...-
W	.--	.--
X	.-..	-..-
Y	.. ..	-.--
Z	... .	--..
&	. ...	

NUMERALS

	MORSE	CONTINENTAL
1	.--.	.----
2	..-..	..---
3	...-.	...--
4	....-	....-
5	---	.....
6	......	-....
7	--..	--...
8	-....	---..
9	-..-	----.
0	——	-----

PUNCTUATION, ETC.

	MORSE	CONTINENTAL
. Period	..--..	......
: Colon	-.-...	.----...
; Semicolon	.-..-.	-.-.-.
, Comma	.-.-	.-.-.-
? Interrogation	-..-.	..--..
! Exclamation	---.	--..--
Fraction line		
- Hyphen		-....-
' Apostrophe		.----.
£ Pound Sterling		-.-..
¶ Paragraph	----	
Italics or underline		..--.-
( ) Parentheses	.-..-	-.--.-
[ ] Brackets, " " Quotation marks		-.-.-.-

PHILLIPS

. Period	.. --..
: Colon	-.- ..
:— Colon dash	-.- .-..
; Semicolon	.... ..
, Comma	.-.-
? Interrogation	-..-.
! Exclamation	---.
Fraction line	.
— Dash	-... .-..
- Hyphen	.... .-..
£ Pound Sterling	..... .-..
/ Shilling mark	...- -
$ Dollar mark	... .-..
d Pence	-..
Capitalized letter	.. . .-..
Colon followed by quotation :"	-.- ..-.
c Cents	...
. Decimal point	-.- . . -
¶ Paragraph	- ---
Italics or underline	..- .--. ..-. .--..
( ) Parentheses	.......-. ....- .. ..
[ ] Brackets	-.. .-... -.... -....
" " Quotation marks	..-.-. ....-. --. --.
Quotation within a quotation " ' ' "	..-.-. .-.-.. ...-.. .. ..

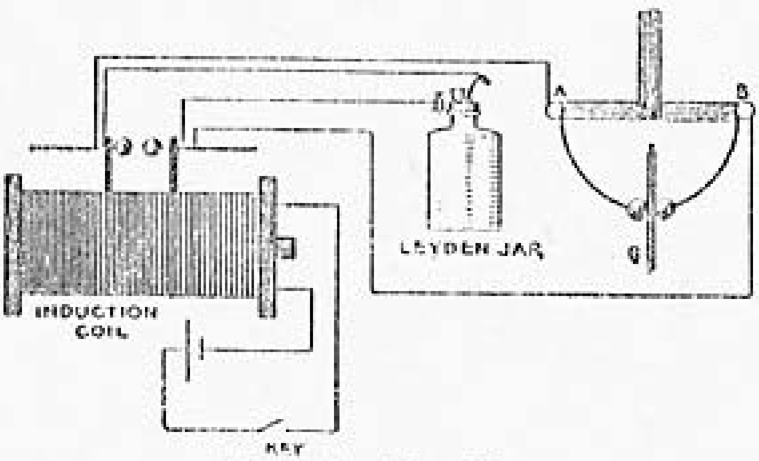
ABBREVIATIONS IN COMMON USE

MIN. Minute.	SIG. Signature.	CO. Company.	TW. To-morrow.
MSGR. Messenger.	PD. Paid.	D.H. Deadhead.	TGM. Telegram.
MSK. Mistake.	QK. Quick.	EX. Express.	TKT. Ticket.
NO. Number.	GBA Give better address.	FRT. Freight.	RC. Receive.
NTG. Nothing.	BN. Been.	FR. From.	ML. Mail.
N.M. No more.	BAT. Battery.	GA. Go Ahead.	LAT. Latitude.
O.K. All right.	BBL. Barrel.	P.O. Post Office.	DEG. Degree.
OFS. Office.	COL. Collect.	RPT. Repeat.	AN. Answer.
OPR. Operator.	CK. Check.	HQRS. Headquarters.	EXA. Extra.

THE BOY MECHANIC – 1913

Piercing Glass Plates with a Spark Coil

Anyone possessing a 1-in. induction coil and a 1-qt. Leyden jar can easily perform the interesting experiment of piercing glass plates. Connect the Leyden jar to the induction coil as shown in the diagram. A discharger is now constructed of very dry wood and boiled in paraffine for about 15 minutes. The main part of the discharger, A B, is a piece of wood about 6 in. long and to the middle of it is fastened a wood handle by means of one or two wood screws. A binding-post is fastened to each end of the main piece or at A and B as shown in the diagram.



Puncturing Glass Plates

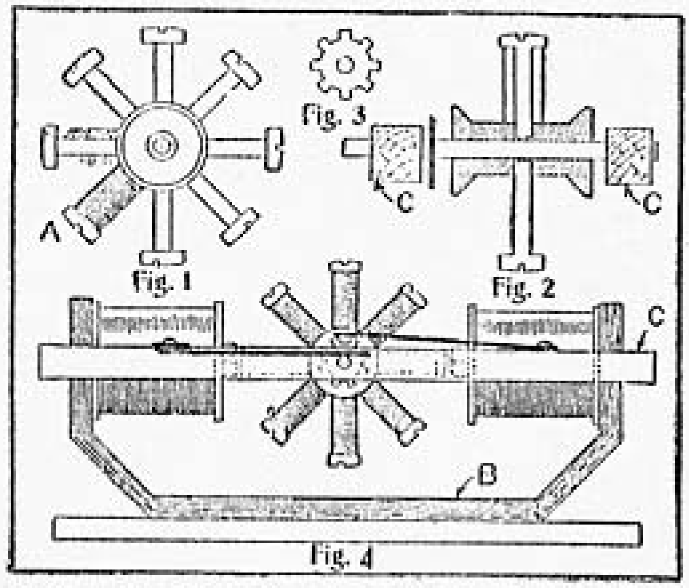
Two stiff brass wires of No. 14 gauge and 6 in. long, with a small brass ball attached to one end of each, are bent in an arc of a circle and attached one to each binding-post.

A plate of glass, G, is now placed between the two brass balls and the coil set in action. The plate will soon be pierced by the spark. Larger coils will pierce heavier glass plates.—Contributed by I. Wolff, Brooklyn, N. Y.

THE BOY MECHANIC – 1913

How to Make a Small Motor

The accompanying sketch shows how to make a small motor to run on a battery of three or four dry cells and with sufficient power to run mechanical toys. The armature is constructed, as shown in Figs. 1 and 2, by using a



Details of Small Electric Motor

common spool with 8 flat-headed screws placed at equal distances apart and in the middle of the spool. Each screw is wound with No. 24 gauge iron wire, as shown at A, Fig. 1. The commutator is made from a thin piece of copper, 1 in. in diameter and cut as shown in Fig. 3, leaving 8 points, $\frac{1}{8}$ in. wide and $\frac{1}{8}$ in. deep. The field is built up by using 8 strips of tin, 12 in. long and 2 in. wide, riveted together and shaped as shown at B, Fig. 4. Field magnets are constructed by using two $\frac{3}{8}$-in. bolts, $1\frac{1}{2}$ in. long. A circular piece of cardboard is placed on each end of the bolt, leaving space enough for the bolt to pass through the field B, and to receive a nut. Wind the remaining space between the cardboards with 30 ft. of No. 22 double-wound cotton-covered copper wire. A light frame of wood is built around the magnets, as shown at C, Fig. 4. Holes are made in this frame to receive the axle of the armature. Two strips of copper, $\frac{1}{4}$ in. wide and 3 in. long, are used for the brushes. The armature is placed in position in its bearings and the brushes adjusted as shown in Fig. 4, one brush touching the shaft of the armature outside of the frame, and the other just touching the points of the commutator, which is placed on the shaft inside of the frame. Connect the outside wire of one magnet to the inside wire of the other, and the re-

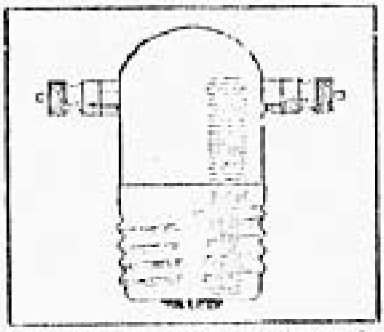
 GRANDDAD'S ELCTRICITY BOOK

maining ends, one to the batteries and back to the brush that touches the shaft, while the other is attached to the brush touching the commutator. In making the frame for the armature bearings, care should be taken to get the holes for the shaft centered, and to see that the screws in the armature pass each bolt in the magnets at equal distances, which should be about $1/8$ in.

THE BOY MECHANIC – 1913

A Home-Made Electric Plug

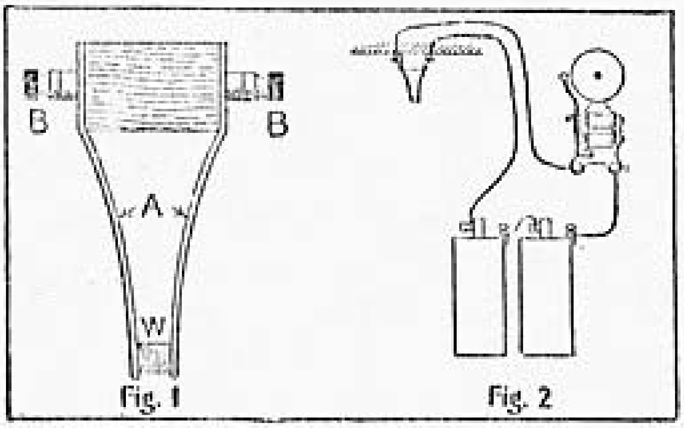
A plug suitable for electric light extension or to be used in experimenting may be made from an old electric globe. The glass is removed with all the old composition in the brass receptacle, leaving only the wires. On the ends of the wires, attach two small binding-posts. Fill the brass with plaster of paris, and in doing this keep the wires separate and the binding-posts opposite each other. Allow the plaster to project about $\frac{3}{4}$ in. above the brass, to hold the binding-posts as shown.—Contributed by Albert E. Welch, New York.



THE BOY MECHANIC – 1913

How to Make an Electric Fire Alarm

On each end of a block of wood, 1 in. square and $1\frac{1}{2}$ in. long, fasten a strip of brass $\frac{1}{4}$ by 3 in., bent in the shape as shown in the sketch at A, Fig. 1. These strips should have sufficient bend to allow the points to press tightly together. A piece of beeswax, W, is inserted between the points of the brass strips to keep them apart and to form the insulation. A binding-post, B, is attached to each brass strip on the ends of the block of wood. The device is fastened to the wall or ceiling, and wire connections made to the batteries and bells as shown in the dia-



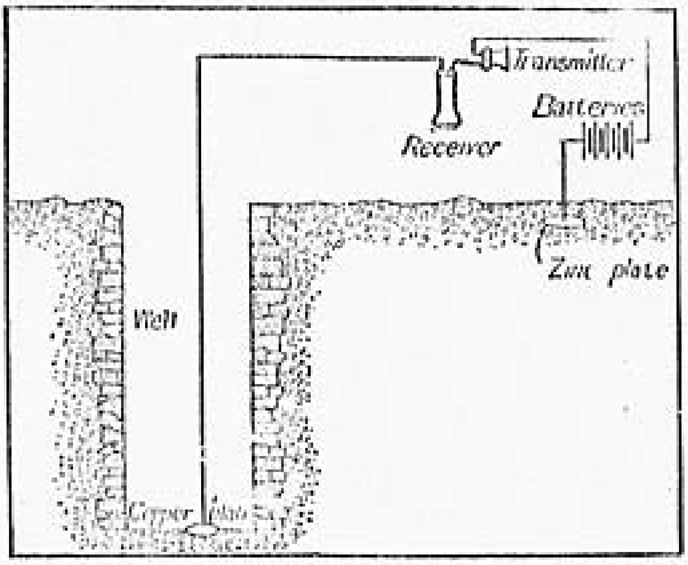
Fire Alarm Device

gram, Fig. 2. When the room becomes a little overheated the wax will melt and cause the brass strips to spring together, which will form the circuit and make the bell ring. Each room in the house may be connected with one of these devices, and all on one circuit with one bell.

THE BOY MECHANIC – 1913

How to Make a Wireless Telephone

A noted French scientist, Bourbouze, was able to keep up communication with the outside during the



Details of Wireless 'Phone Installation

siege of Paris by making practical application of the earth currents. The distance covered is said to have been about 30 miles. Another scientist was able to telephone through the earth without the aid of wires. Nothing, however, has been made public as to how this was accomplished.

It is my object to unveil the mystery

 GRANDDAD'S ELCTRICITY BOOK

and to render this field accessible to others, at least to a certain degree, for I have by no means completed my researches in this particular work.

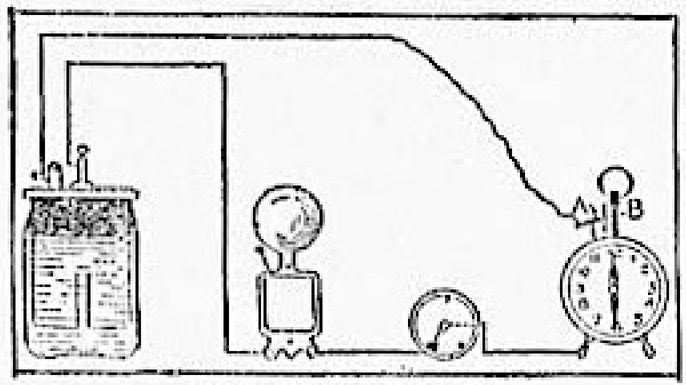
In order to establish a wireless communication between two points we need first of all a hole or well in the ground at each point. In my experiments I was unable to g t a deep well, but the instruments worked fine for a distance of 200 ft., using wells about 25 ft. deep. As in ordinary telephone lines, we require a transmitter and receiver at each point. These must be of the long-distance type. If a hole is dug or a well is found suitable for the purpose, a copper wire is hung in the opening, allowing the end to touch the bottom. To make the proper contact an oval or round—but not pointed—copper plate is attached to the end of the wire. If a well is used, it is necessary to have a waterproof cable for the part running through the water. The top end is attached to the telephone transmitter and receiver, as in the ordinary telephone, to the batteries and to a zinc plate, which is to be buried in the earth a few feet away from the well or hole, and not more than 1 ft. under the surface. A battery of four dry cells is used at each station.

Both stations are connected in the same way, as shown in the sketch. This makes it possible for neighbors to use their wells as a means of communication with each other.—Contributed by A. E. Joerin.

THE BOY MECHANIC – 1913

A Novel Electric Time Alarm

All time alarms run by clockwork must be wound and set each time. The accompanying diagram shows how to make the connection that will ring a bell by electric current at the time set without winding the alarm. The bell is removed from an ordinary alarm clock and a small metal strip attached, as shown at B. An insulated connec-



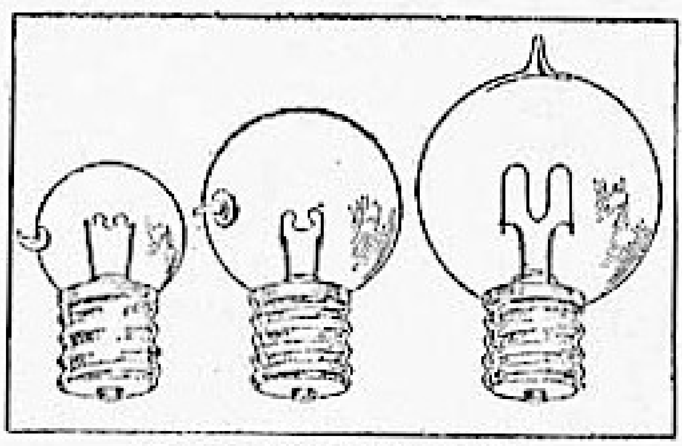
Electric Time Alarm

tion is fastened on the clapper of the bell, as shown at A. The arm holding the clapper must be bent to have the point A remain as close to the strip B as possible without touching it. The connection to the battery is made as shown. When the time set for the alarm comes the clapper will be moved far enough to make the contact. In the course of a minute the catch on the clapper arm will be released and the clapper will return to its former place.

THE BOY MECHANIC – 1913

Miniature Electric Lamps

After several years' research there has been produced a miniature electric bulb that is a great improvement and a decided departure from the old kind which used a carbon filament. A metallic filament prepared by a secret chemical process and suspended in the bulb in an S-shape is used instead of the old straight span. The voltage is gauged by the length of the span. The brilliancy of the filament excels anything of its length in any voltage.


Types of "Radium" Lamps

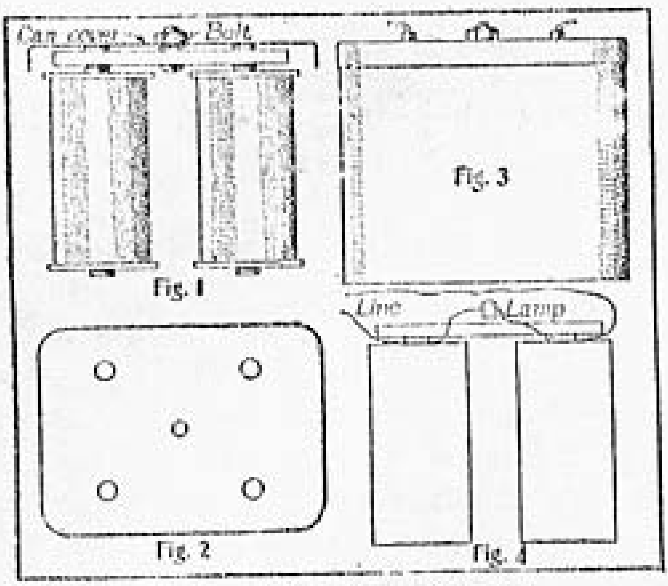
Of course, the filament is not made of the precious metal, radium; that simply being the trade name. However, the filament is composed of certain metals from which radium is extracted.

The advantages of the new bulb are manifold. It gives five times the light on the same voltage and uses one-half of the current consumed by the old carbon filament. One of the disadvantages of the old style bulb was the glass tip, which made a shadow. This has been obviated in the radium bulb by blowing the tip on the side, as shown in the sketch, so as to produce no shadow.

THE BOY MECHANIC – 1913

How to Make a 110-Volt Transformer

Secure two magnets from a telephone bell, or a set of magnets wound for 2,000 ohms. Mount them on a bar of brass or steel as shown in Fig. 1. Get an empty cocoa can and clean it good to remove all particles of cocoa and punch five holes in the cover, as shown in Fig. 2. The middle hole is to be used to fasten the cover to the brass bar with a bolt. The other four holes are for the wire terminals. A piece of rubber tubing must be placed over the wire terminals before inserting them in the holes. Fill the can with crude oil, or with any kind of oil except kero-



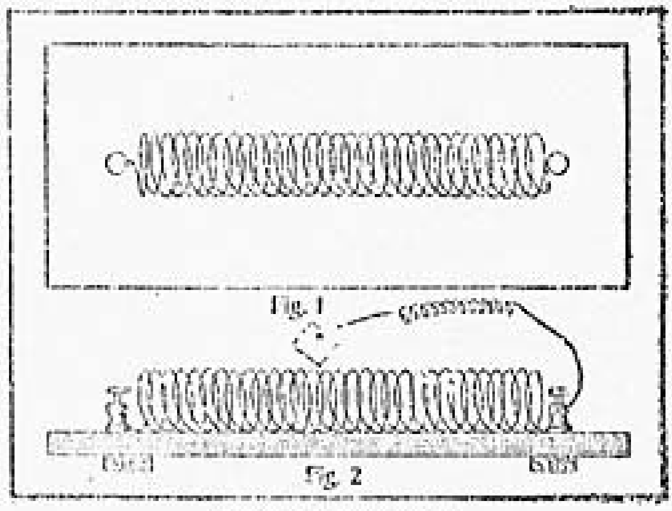
Parts of the Transformer

sene oil, and immerse the magnets in it by fitting the cover on tight (Fig. 3). The connections are made as shown in the diagram, Fig. 5. This device may be used on 110-volt current for electroplating and small battery lamps, provided the magnets are wound with wire no larger than No. 40.—Contributed by C. M. Rubsan, Muskogee, Okla.

THE BOY MECHANIC – 1913

A Simple Battery Rheostat

A spring from an old shade roller is mounted on a board 4 in. wide, 9 in. long and $\frac{3}{8}$ in. thick. A binding-post is fastened to this board at each end, to which is attached the ends of the spring, as shown in Fig. 1. The temper of a small portion of each end of the



Battery Rheostat

spring will need to be drawn. This can be accomplished by heating over an alcohol lamp or in a fire and allowing it to cool slowly. The ends are then shaped to fit the binding-posts. A wire is connected to one of the binding-posts and a small square piece of copper is attached to the other end of the wire, as shown in Fig. 2. When this device is placed in a circuit the current can be regulated by sliding the small square copper piece along the spring.—Contributed by H. D. Harkins, St. Louis, Mo.

THE BOY MECHANIC – 1913

Electric Anaesthesia

It is a well known fact that magnetism is used to demagnetize a watch, and that frost is drawn out of a frozen member of the body by the application of snow. Heat is also drawn out of a burned hand by holding it close to the fire, then gradually drawing it away. The following experiment will show how a comparatively feeble electric current can undo the work of a strong one.

I once tried to electrocute a rat which was caught in a wire basket trap and accidentally discovered a painless method. I say painless, because the rodent does not object to a second or third experiment after recovering, and is apparently rigid and without feeling while under its influence.

To those who would like to try the experiment I will say that my outfit consisted of an induction coil with a 3/8-in. iron core about 3 in. long. The primary coil was wound with four layers of No. 20 wire and the secondary contains 4 oz. No. 32 wire, and used on one cell of bichromate of potash plunge battery. The proper amount of current used can be determined by giving the rodent as much as a healthy man would care to take. Fasten one secondary electrode to the trap containing the rat and with a wire nail fastened to the other terminal, hold the vibrator of the coil with your finger and let the rat bite on the nail and while doing so release the vibrator. In three seconds the rat will be as rigid as if dead and the wires can be removed.

Now connect your wires to the primary binding-posts of the coil and wind the end of one of them around the rat's tail and start the vibrator. Touch the other terminal to the rat's ear and nose. In a few minutes he will be as lively as ever.—Contributed by Chas. Haeusser, Albany, N. Y.

THE BOY MECHANIC – 1915

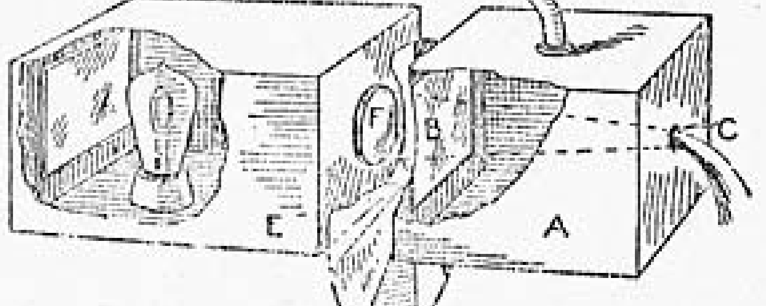
While winding an induction coil, I found it necessary to test the sections for continuity. Having no galvanometer, I connected a battery and low-resistance telephone receiver in series with the section and battery. The battery and telephone receiver may also be used for testing out the secondary of an induction coil, to determine if it is burnt out.—Contributed by John M. Wells, Moosomin, Can.

THE BOY MECHANIC – 1915

An Electric Display for a Show Window

A novel window display that is very attractive, yet simple in construction and operation, can be made in the following manner: First, make a small watertight chamber, A, as long as the focal length of the lens to be used, and having a glass window, B, at one end, and a small round opening, C, at the other. In this opening is placed a cork through which a glass tube about 2 in. long is inserted. The tube makes a smooth passage for the stream of water flowing out of the box. Water from any source of supply enters the chamber through the tube D, which may be a pipe or hose, whichever is most convenient. The interior is painted a dull black.

A convenient and compact light is placed at the window end of the box. A very good light can be made by placing an electric light with a reflector in a closed box and fastening a biconvex lens, F, in the side facing the window



The Arrangement of the Boxes Showing the Path of the Light Rays through the Water of the water box. When the electric light and the water are turned on, the light is focused at the point where the water is issuing from the box, and follows the course of the stream of water, illuminating it in a pleasing manner.

A still better effect can be obtained by passing colored plates between the lens F and the window B. A glass disk with sectors of different colors may be revolved by any source of power, such as a small electric motor or even a waterwheel turned by the flowing water.

Two or three streams of water flowing in different colors make a very pretty display and may be produced by using two or more boxes made up in the same manner. The apparatus should be concealed and nothing but the box end or tube with the flowing water shown.—Contributed by Grant Linton, Whitby, Ont.

THE BOY MECHANIC – 1915

An Electric Water Heater

Procure the barrel and cap from a hand bicycle pump and prepare them as follows: Make a tube of paper, about double the thickness of a postal card, to fit snugly in the pump barrel and oil it slightly before slipping it into place. Procure some resistance wire of the proper length and size to heat quickly. The wire can be tested out by coiling it on some nonconducting material, such as an earthen jug or glazed tile, and connecting one end to the current supply and running the other wire of the supply over the coil until it heats properly. Cut the resistance at this point and temporarily coil it to fit into the bottom of the pump barrel, allowing one end to extend up through the space in the center with sufficient length to make a connection to supply wires.

Mix some dental plaster to the consistency of thick cream and, while keeping the wire in the center of the pump barrel, pour in the mixture until it is filled to within 1½ in. of the top. Allow the plaster to set for about a day, then remove it from the barrel and take off the paper roll. The coil of wire at the bottom is now straightened out and wound in a coil over the outside of the plaster core, allowing sufficient end for connecting to the supply wires.

Cut two or three disks of mica to fit snugly in the bottom of the pump barrel, also cut a mica sheet to make a covering tube over the coil on the plaster core and insert the whole into the barrel. The two terminals are connected to the ends of a flexible cord which has a plug attached to the opposite end. Be sure to insulate the ends of the wire where they connect to the flexible cord inside of the pump barrel under the cap. In winding the resistance wire on the core, be sure that one turn does not touch the other. The heater when connected to a current supply and placed in 1 qt. of water will bring it to a boil quickly.—Contributed by A. H. Waychoff, Lyons, Colo.

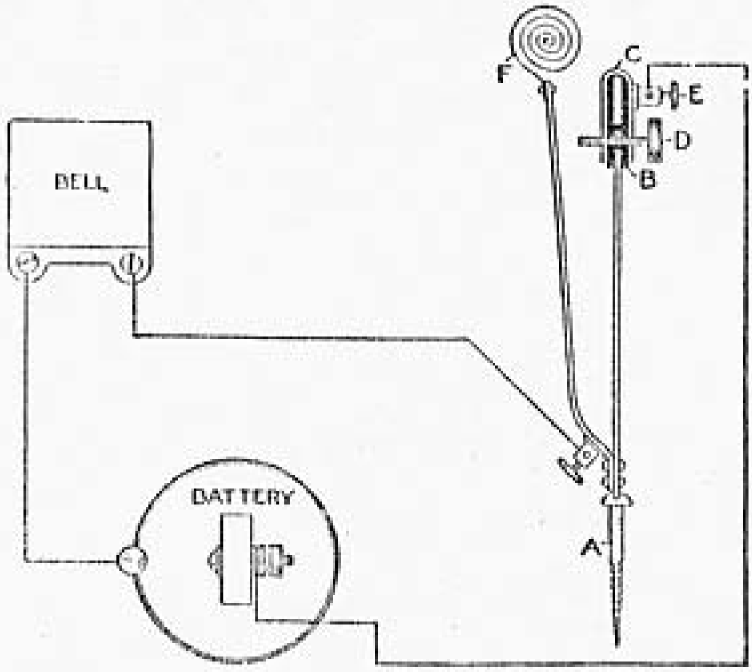
An Electric Heating Coil Made of Resistance Wire Placed in a Bicycle-Pump Barrel for Boiling Water

THE BOY MECHANIC – 1915

How to Make an Electric Fishing Signal

A unique electric fishing signal, which may be rigged up on a wharf or pier, and the electric circuit so arranged as to operate an electric bell or buzzer, located in the fisherman's cottage, or any other convenient place, may be constructed as follows: Obtain two pieces of $\frac{1}{16}$-in. spring brass, one 6 in. long and ¾ in. wide, and the other 7 in. long and ½ in. wide. Mount a 2-in. brass wood screw, A, in one end of the 6-in. piece as shown.

Place over the end of the 6-in. piece a thin sheet of insulating fiber, B, al-



Construction of the Parts to Make the Contact Points and the Electric Connections

lowing it to extend down on each side about 1 in. Then bend a piece of $\frac{1}{16}$-in. brass, C, over the insulating fiber, allowing it to extend down on each side the same distance as the insulating fiber. Drill a small hole through the lower ends of the U-shaped piece of brass, C, the insulation, B, and the 6-in. piece, while they are all in place. Remove the insulation and the U-shaped brass piece, and tap the holes in the brass for a machine screw, D. Enlarge the hole in the 6-in piece, and provide an insulating bushing for it with an opening of the same diameter as the brass machine screw. Mount a small binding post, E, on one side of the U-shaped piece of brass, and the parts may then be put together and held in place by means of the brass screw.

Drill two holes in the other end of the 6-in piece, also two holes in one end of the 7-in piece, and rivet them together with two small rivets. The 7-in. piece should project beyond the end of the 6-in. piece. A piece of thin spring brass should be made into the form of a spiral, F, and fastened to the upper end of the 7-in. piece. Provision should be made for attaching the fishline to the inside end of the brass spiral. A small binding post should be soldered to either the 6-in. or 7-in. piece, at the bottom.

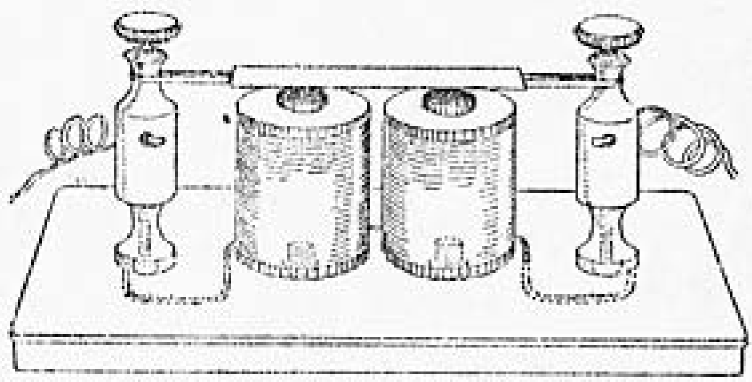
If the device is set up with the head of the brass adjusting screw in the top of the 6-in. piece, pointing in the direction the line to the fishing hook is to run, and if a fish pulls upon the line, the 7-in. piece is pulled over and touches the point of the adjusting screw. If a battery and bell, or buzzer, is connected as shown, the circuit will be completed when the 7-in. piece comes in contact with the adjusting screw, and the bell will ring.

THE BOY MECHANIC – 1915

Homemade Telegraph Sounder

The material required to construct a telegraph sounder, like the one shown in the sketch, consists of two binding posts, magnets, a piece of sheet metal, and a rubber band. These are arranged as shown, on a wood base or, better still, on a metal box. In using a metal-box base, be sure to insulate the connections at the magnet coils and binding posts.

This instrument will be found by



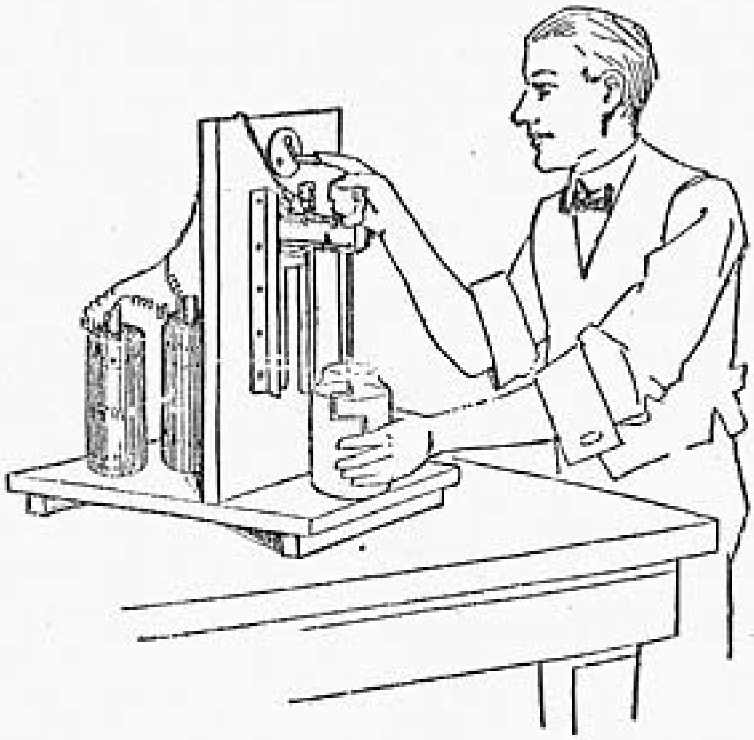
An Inexpensive and Homemade Sounder for Use in Learning the Telegraph Codes

those studying the telegraph codes to give good results, equal to any of the expensive outfits sold for this purpose. —Contributed by Chas. J. La Prille, Flushing, N. Y.

THE BOY MECHANIC – 1915

An Electric Stirring Machine

Desiring a stirring machine for mixing photographic chemicals, I set about to design the one shown in the illustration. The base and upright are made of pine, 1 in. thick, the former 8 in. wide



A Self-Contained Electric Stirring Machine for Use in Mixing Photographic Chemicals

and 10 in. long, the latter 8 in. wide and 16 in. long. A 3/8-in. slot, 12 in. long, is cut in the center of the upright, and two pieces of sheet metal or tin, 2 in. wide and 12 in. long, bent at right angles along the center of their length, are placed at equal distances, on each side of the slot, and fastened with screws. The distance between these pieces depends on the motor used, as its base should fit snugly between them.

A small battery motor is purchased, and its shaft is removed and replaced with one measuring 10 in. in length. To the end of the shaft is soldered a piece of wire, bent as shown in the sketch. A bolt is attached to the center of the motor base, so that its threaded end will pass through the slot in the upright, where it is held with a wing nut. The battery cells may be placed on the back of the upright and a small switch mounted at the top and in front. —Contributed by Ray F. Yates, Niagara Falls, N. Y.

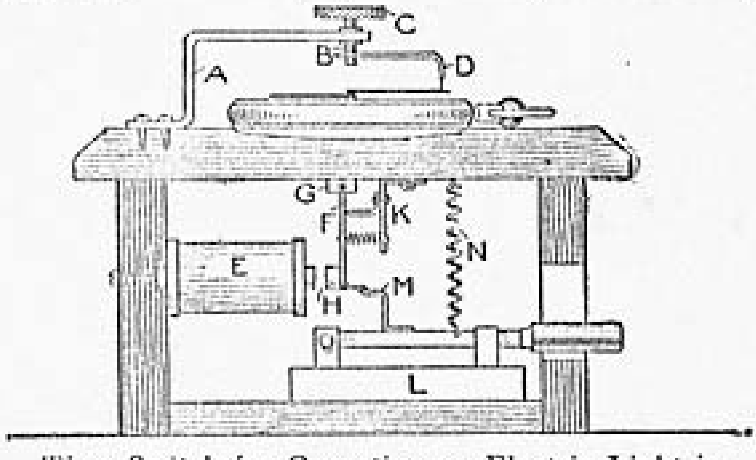
THE BOY MECHANIC - 1915.

Electric Switch for Exposing Photographic Printing Papers

The proper time to expose a printing paper under a negative should be determined and the negative marked for future printing. When this time has been found some means should be provided for making the exposure exactly the same, then the prints will be perfect and of a good tone at all times. For this purpose the instrument shown in the illustration was designed and used with entire satisfaction.

The device consists of an ordinary cheap watch, a standard, or support, for an adjusting screw, a small coil, a movable armature, a knife switch, and a trip arrangement. A neat box or case, about 5 in. square and 3 in. high, is first constructed. A round recess, 1/8 in. deep, is cut in the center of the top, to admit the watch. The standard A is made of brass, 1/8 in. thick and 1/2 in. wide, bent as shown, and a 3/16-in. hole is drilled in the end of the long arm where it will exactly center over the pivot holding the watch hands. A 3/16-in. rod, B, is closely fitted in the hole and supplied with a knurled wheel, C, on the upper end, and an L-shaped arm, D, is fastened to the lower end. The end of this arm should be filed to a point, or a very thin piece of brass soldered to it, so that the end will just touch the minute hand of the watch. The tip end of the point should be bent slightly from the perpendicular toward the direction in which the watch hands are moving, so that, when it is set, the moving hand will easily break the contact.

The magnetic arrangement consists of a 3-ohm coil, E, mounted, as shown,



Time Switch for Operating an Electric Light in Printing Photographic Developing Papers to one side of the case, where it operates the trip levers. The armature parts consist of an L-shaped piece of brass, F, pivoted at G, to which a square piece of soft iron, H, is attached. Two small parts, K, are bent and attached as shown, to furnish a limit stop for the piece F and a support for a spiral spring which holds the armature H away from the coil.

The knife switch L is fastened to the bottom of the case so that the handle will project through a slot in one side of the box. A trip piece, M, and a small eye for attaching a spiral spring, N, are soldered to the knife switch. These two attachments for the switch are insulated from the other parts.

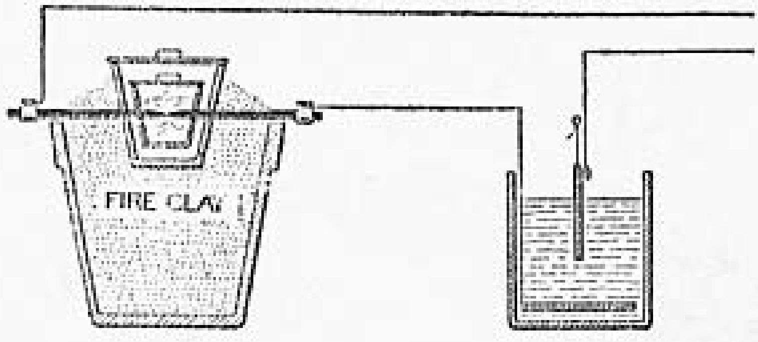
Two binding posts are mounted on top, one being connected to one terminal of the coil E and the other to the watch case. The other terminal of the coil is connected to the standard A. The two binding posts are connected in series with one or two dry cells, and the switch L is connected in series with the lamp used for printing.

The operation is as follows: The arm D, being set for a certain time, the lever of the switch L is set and the light remains lit until the minute hand strikes the point on the arm D, when the battery circuit is closed causing the coil to draw the armature H and allowing the spring N to open the switch L. The lamp is then extinguished.—Contributed by James P. Lewis, Golden, Colorado.

THE BOY MECHANIC – 1915

How to Make a Small Electric Furnace

The furnace consists of a large flower pot containing an ordinary clay crucible about 6 in. in height, the space between the two being packed with fireclay. Two ¾-in. holes are bored through the sides of the crucible about half way between the top and the bottom. Holes corresponding to these holes are molded in the fireclay, which should extend several inches above the top of the flower pot. A smaller crucible is placed inside of the large one for use in melting such metals as copper, brass and aluminum. With metals that will melt at a low degree of heat,



Electric Connections to Furnace

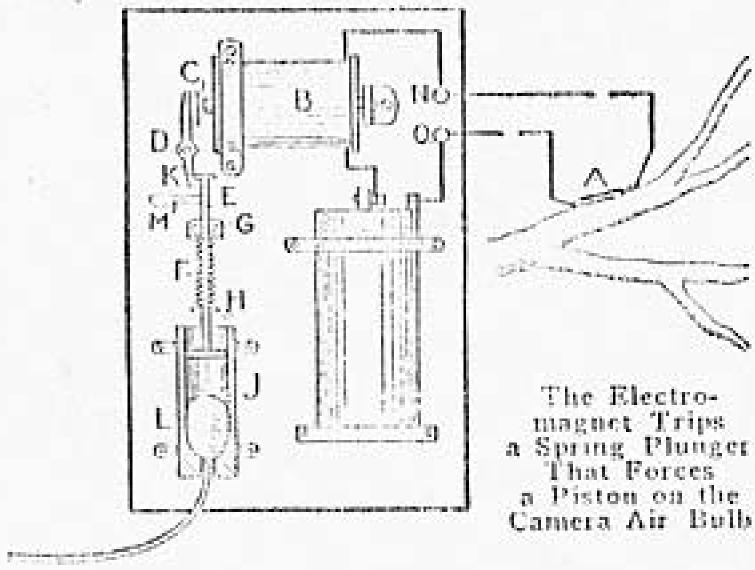
such as tin, lead or zinc, the large crucible can be used alone. Each crucible should be provided with a cover to confine the heat and keep out the air. The electrodes are ordinary arc-light carbons.

The furnace is run on an ordinary 110-volt lighting circuit and it is necessary to have a rheostat connected in series with it. A water rheostat as shown in the sketch will serve to regulate the current for this furnace. Small quantities of brass or aluminum can be melted in about 10 minutes in the furnace.—Contributed by Leonard Stebbins, Denver, Colo.

THE BOY MECHANIC – 1915

An Electrically Operated Camera Shutter

It is often quite desirable to operate the shutter of a camera from a distance, especially in photographing birds and animals. The device shown in the accompanying sketch serves the above purpose very nicely, and its construction and operation are exceedingly simple. In brief, the operation is as follows: The switch A is mounted on the limb of a tree, in such a manner that it is not conspicuous, and connected in series with a magnet, B, and a battery by means of a piece of flexible conductor, such as lamp cord. The magnet B is energized when the switch



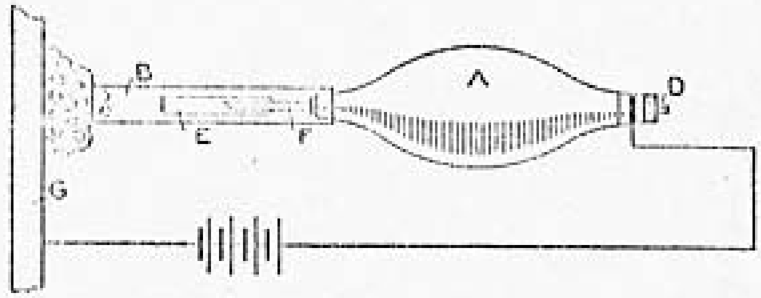
The Electromagnet Trips a Spring Plunger That Forces a Piston on the Camera Air Bulb

is closed and attracts the iron armature C, which is mounted on an arm, pivoted at D. The lower end of this arm is in the form of a latch, which supports the rod E when it is raised to its upper position. The rod E when it is raised compresses the coiled spring F, which is held between the gauge G and the washer H mounted on the rod. A small coil spring holds the armature C away from the core of the magnet B. The lower end of the rod E is in the form of a piston operating in a wooden cylinder J. The rubber bulb at the end of the tube leading to the camera shutter is located in the lower end of the cylinder J. When the rod E is released by the latch K, it moves downward in the cylinder J, due to the action of the spring F, and compresses the bulb L, causing the shutter of the camera to be operated. A small handle, M, may be mounted on the rod to be used in raising it to the upper position. The component parts of this device may be mounted on a small wooden base by means of brass straps, and the terminals of the electric circuit connected to the binding posts N and O, as shown. The switch A may be dispensed with and a push button used in its place, as the operator may station himself several hundred feet away. It may be necessary to use a battery of more than one cell in such cases.

THE BOY MECHANIC – 1915

Electroplating without a Tank

Electroplating without a plating tank is made possible with the following easily homemade apparatus described in a German scientific magazine. It consists of a rubber ball, A, fitted at one end with a glass tube, B, which carries at the opposite end a small sponge. A rod, D, passes through the rubber ball, which is tightly corked at both ends, into the glass tube B and carries at that end the anode E. A small glass tube, F, also connects the rubber ball with the larger tube B. The connections from the battery to the cathode, G, the object to be plated, and to the projecting end of the anode-carrying rod, D, are made as shown. The rubber ball is filled with the electrolyte, and is squeezed so as to force the fluid



A Hand Tool for Applying a Plate Electrically to the Surface of Metal

through the small tube F, into the larger tube, B, filling it and soaking the sponge C. The current is then turned on, and by moving the wet sponge over the cathode G, the latter will be plated. Not only is this an interesting accessory for the amateur's laboratory, but it can be used in the industry where only parts of some object are to be plated, and where it is desired to remedy bad spots without putting the articles back into the bath.

THE BOY MECHANIC – 1915.

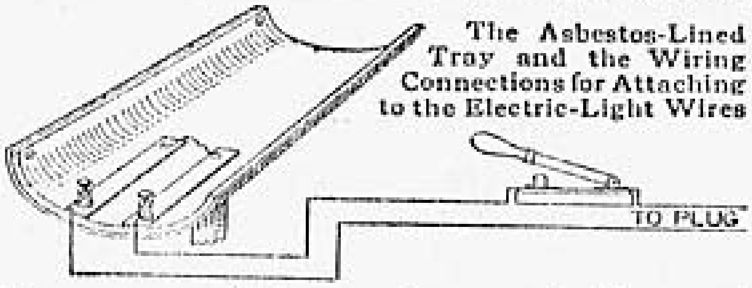
An Electrically Ignited Flash Light for Making Photographs

The results obtained in a great many cases in trying to take pictures by flashlight are exceedingly unsatisfactory, as the expression on the faces of the people in the picture usually is strained or unnatural, due to the suspense in waiting for the flash. The following simple device avoids this difficulty because the flash is set off by means of electricity, so that the operator can control the flash from a distant point and thus be able to take the picture quite unawares to his subjects.

The construction of the device is as follows: Obtain a piece of rather heavy sheet iron, about 6 in. wide and 10 in. long. Bend this piece of iron into the form shown in the sketch, and fasten a wooden handle to it with a wood screw. Obtain a sheet of 1/8-in. sheet asbestos, the same size as the piece of sheet iron, and glue it to the inside surface of the curved piece of iron. It is best to fasten the four corners down by means of some small rivets with rather large washers under the heads next to the asbestos.

Now mount two pieces of sheet copper, 1/2 in. wide and 6 in. long, parallel with each other on the surface of the asbestos and 1 1/2 in. apart, so that their ends are even with the end of the piece of asbestos. These pieces of copper should be insulated from the piece of sheet iron, and there should be a small screw in one end of each and a small binding post mounted on the other end.

Procure a piece of lamp cord, 15 or 20 ft. in length. Fasten an ordinary plug to one end of this cord and the other end to the two binding posts.



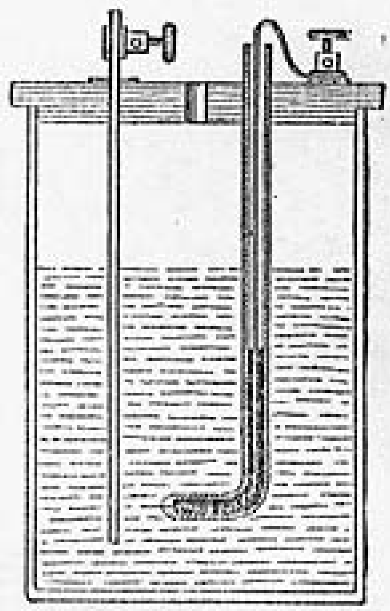
The Asbestos-Lined Tray and the Wiring Connections for Attaching to the Electric-Light Wires

Open one of the conductors in the cord at some point and introduce a single-pole switch, as shown in the sketch. Close the gap between the two pieces of copper by means of a piece of No. 32 gauge copper wire. Place the flashlight powder in position, but do not cover up the wire or have it in actual contact with the powder, and close the circuit. The operator may include himself in the picture by having a sufficiently long piece of lamp cord and the switch properly arranged.

THE BOY MECHANIC – 1915

How to Make an Electrolytic Interrupter

Obtain a glass jar or wide-mouth bottle about one-quart size. An ordinary round bottle will serve very nicely by having the top cut off, thus forming a glass jar. Make a top for the jar from a piece of 1/2-in. pine similar to the one shown in the illustration. The lower portion extends down inside the jar and serves to hold the top in place. Cut a slot in this top, 1/8 in. wide and 2 in. long. This slot should be cut at right angles to a diameter of the top and extend 1 in. on either side of the diameter. It should be about 1/2 in. from the center of the top. Directly opposite the center of the slot drill a 3/8-in hole, 1/2 in. from the center of the top. Drill a 1/4-in. hole in the center of the top to give ventilation to the jar. Boil the completed top in paraffin for a few minutes.



Obtain a piece of 1/8-in. sheet lead, 2 in. wide and about 1/2 in. longer than the depth of the jar. Mount a small binding post on one end of this piece of lead and then support it in the slot in the wooden top by means of two metal pins. The lower end of the piece of lead should be at least 1/2 in. from the bottom of the jar. Next get a piece of 3/8-in. glass tube and fuse a piece of platinum wire into one end.

Make sure the inside end of the platinum wire is not covered with the glass, and that the outside end protrudes a short distance beyond the end of the glass tube. Now bend about ¾ in. of the end of the glass tube which has the platinum in it over at right angles to the remainder of the tube. The tube should then be placed in the opening on the wooden top provided for it and a rubber band placed around it to prevent it dropping through the opening. The lower end of the tube should be a little higher than the lower end of the sheet of lead. A small quantity of mercury should be placed in the tube and a bare copper wire run down inside. The mercury affords a connection between the piece of platinum in the end of the tube and the copper wire. Connect the outside end of the copper wire under a binding post and the interrupter is complete with the exception of the solution.

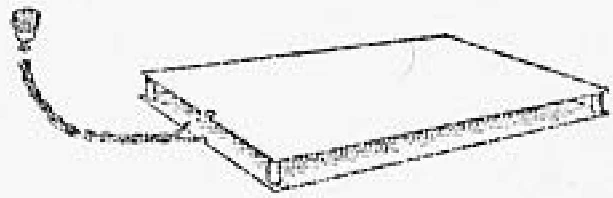
The solution for the interrupter is dilute sulphuric acid made by mixing about four parts of water and one part of acid. In preparing this mixture, be sure to pour the acid into the water, not the water into the acid. The jar should be about two-thirds filled. At least 40 volts will be required for the satisfactory operation of the interrupter. The distance between the platinum point and the lead sheet may be adjusted by simply turning the glass tube.

No condenser will be required in operating an inductor coil with an interrupter of this kind. The make-and-break interrupter, if there is one in circuit, should of course be made inoperative by screwing up the contact point against the spring.

THE BOY MECHANIC – 1915

An Electric Water Heater

A simple electric water heater may be made as follows: Procure two sheets of copper, each 4 by 6 in., and place pieces of wood or other insulating material at the corners to keep them about ¾ in. apart. Bind them with cords, or, if the wood pieces are large enough, use screws so that there will be no contact between the plates. Attach wires to the plates with solder as shown, and make connections to a plug. Pour water in an earthenware



An Inexpensive Electric Water Heater Made of Two Copper Plates

jar, place the plates in it and turn the plug in a lamp socket. Do not use a metal vessel.—Contributed by G. Henry Jones, Sylacauga, Ala.

THE BOY MECHANIC – 1915

An Alarm for a Sleepwalker

A little girl in our family would walk in her sleep and it caused us no little worry lest she might leave the house without our knowing it. I therefore rigged up an alarm device to ring a bell should she leave the room. The device consisted of a bell and battery in a circuit, and a switch which was attached to one door casing. A string was stretched across the doorway and attached to the switch lever in such a manner as to pull it closed when the string was pushed through the doorway opening. —Contributed by J. Woodburn, Toronto, Canada.

THE BOY MECHANIC – 1915

How to Build a Wind Vane with an Electric Indicator

Quite often it is practically impossible to ascertain the direction of the wind by observing an ordinary wind vane on account of the necessity of locating the vane at such a height that it may give a true indication. By means of the device shown in Fig. 2, the position of the vane may be determined without actually looking at the vane itself and the indicating device may be located almost anywhere and independently of the position of the wind vane.

The principle upon which the device operates is that of the Wheatstone bridge. The position of the moving contact A, Fig. 1, is controlled by the wind vane. This contact is made to move over a specially constructed resistance R, Fig. 2. A second movable contact, B, is controlled by the observer and moves over a second resistance, identical with that over which the contact A moves. These two resistances are connected so as to form the two main branches of a Wheatstone bridge; the points A and B are connected to the current-detecting device, which may be a galvanometer or telephone receiver, and current is supplied by a number of dry cells.

In order to obtain a balance—that is, no current through the receiver—the points A and B must occupy corresponding positions on their respective resistances. If the two resistances over which the points A and B move are mounted in the same position with respect to the cardinal points of the compass, then the points themselves will always be in the same position with respect to the cardinal points when a balance is obtained. The arrow head on the wind vane and the point A are made to occupy corresponding positions, and hence the position of the point B, when no current passes through the receiver, is an indication of the direction in which the wind vane is pointing.

The principal parts in the construction of the device are shown in the illustration, and the following description of their construction may be of interest to those who contemplate building the indicator.

Procure two pieces of $\frac{1}{16}$-in. hard rubber, $1\frac{1}{2}$ in. wide by 24 in. long. Clamp these, side by side, between two

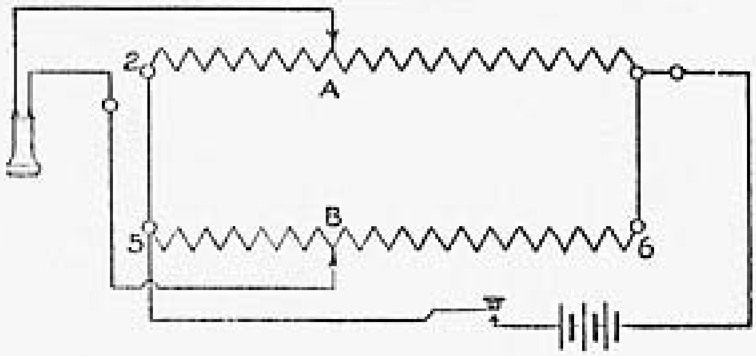


Fig. 1—The Diagram of a Wheatstone Bridge Which Shows the Points of Contact So Placed That a Balance is Obtained

boards and smooth down their edges and ends, and then file small slots in the edges with the edge of a three-cornered file. These slots should all be equally spaced about $\frac{3}{32}$ in. apart. Have the pieces clamped together while filing the slots and mark one edge top and one end right so that the pieces may be mounted alike. Now procure a small quantity of No. 20 gauge bare manganin wire. Fasten one end of this wire to one end of the pieces of rubber by winding it in and out through three or four small holes and then wind it around the piece, placing the various turns in the small slots that were filed in the edges. After completing the winding, fasten the end just as the starting end was attached. Wind the second piece of rubber in a similar manner and make sure to have the length of the free ends in each case the same. Obtain a cylinder of some kind, about 8 in. in diameter, warm the pieces of rubber by dipping them in hot water, bend them around the cylinder and allow them to cool.

A containing case, similar to that shown in cross section in the upper portion of Fig. 2 should now be constructed from a good quality of tin or copper. The inside diameter of this case should be about 1 in. more than the outside diameter of the resistance ring R, and it should be about 3 in. deep. The top C may be made curved as shown in the illustration, and should be fastened to the case proper by a number of small machine

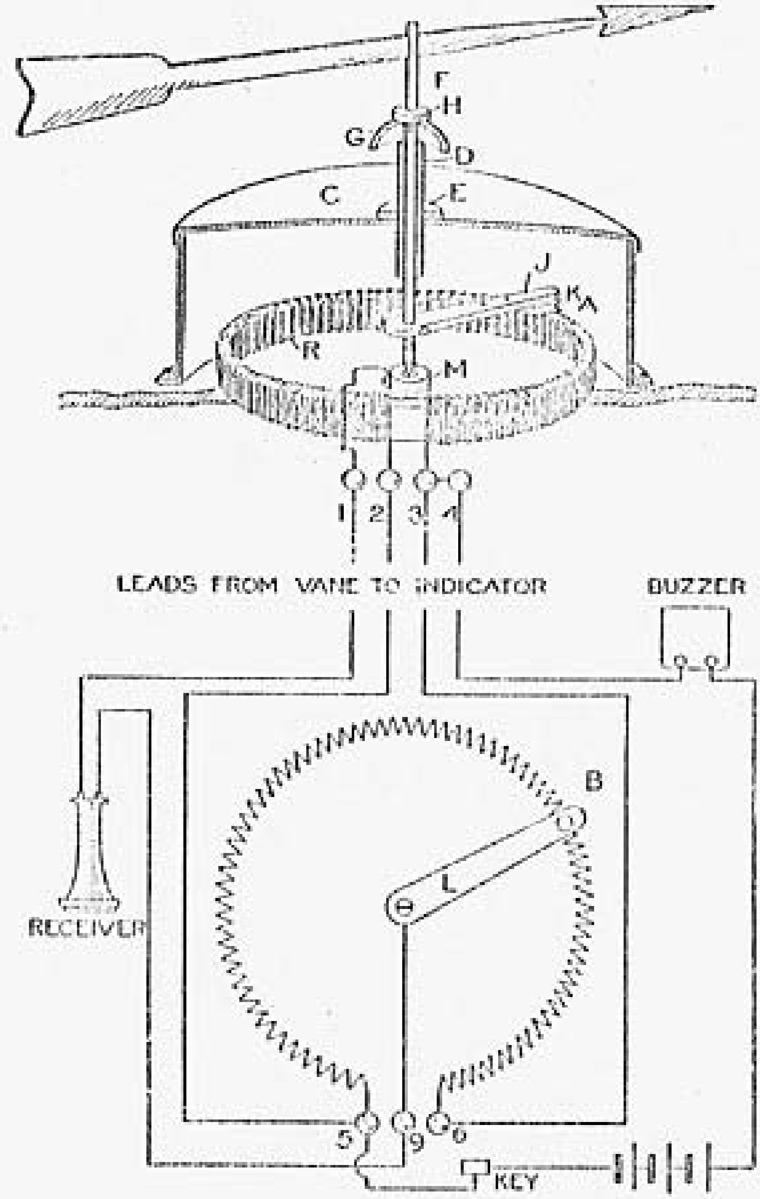


Fig. 2—The Weather Vane with Resistance Coil, and Diagram of Indicator Which is Identical with That of the Vane

screws. The base of this case may be made so that the whole device can be mounted on the top of a pole.

Mount a piece of ¼-in. steel rod, about ½ in. long, with a conical hole in one end, in the center of the bottom of the case as shown by M. A number of supports, similar to the one shown, should be made from some ¼-in. hard rubber and fastened to the sides of the case, to support the resistance ring. The dimensions of these supports should be such that the ends of the piece of rubber, forming the ring, are against each other when it is in place. The upper edge of the ring should be about 2 in. above the bottom of the case.

Next, mount a piece of brass tube, D, in the exact center of the top and perpendicular to it. A washer, E, may also be soldered to the top so as to aid in holding the tube. Procure a piece of steel rod, F, that will fit in the tube D and turn freely. Sharpen one end of this rod and mount a brass wind vane on the other end. A small metal cup, G, may be soldered to a washer, H, and the whole mounted on the steel rod F in an inverted position as shown, which will prevent water from getting down inside the case along the rod. The cup G may be soldered directly to the rod. Make a small arm, J, of brass, and fasten a piece of light spring, K, to one side of it, near the outer end, then mount the arm on the steel rod so that it is parallel to the vane and its outer end points in the same direction as the arrow on the vane. The free end of the light spring on the arm J should be broad enough to bridge the gap between adjacent turns of wire on the resistance ring. Four bindings should then be mounted on the inside of the case and all insulated from it with the exception of number 1. Numbers 2 and 3 are connected to the ends of the winding and number 4 is connected to number 3.

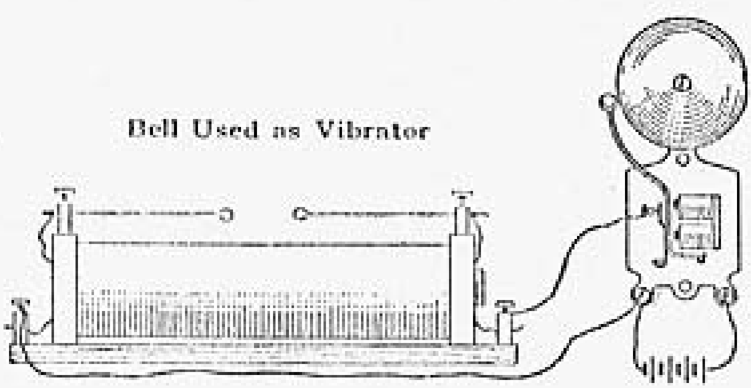
A second outfit should now be constructed, identical with the one just described except that it should have a flat top with a circular scale mounted on it, and the arm L should be controlled by a small handle in the center of the scale. The position of the contact B may be indicated on the scale by a slender pointer, attached to the handle controlling the arm L.

Four leads of equal resistance should be used in connecting the two devices and the connections made as shown. An ordinary buzzer placed in the battery circuit will produce an interrupted current through the bridge circuit and a balance will be obtained by adjusting the contact point B until a minimum hum is heard in the telephone receiver.

THE BOY MECHANIC – 1915

Vibrator for a Spark Coil

If you do not have the time to make a vibrator or electrolytic interrupter for a spark coil, a common electric door-



bell makes a good substitute. Connect one of the primary wires to the binding-post of the bell that is not insulated from the frame, and the other primary wire to the adjusting screw on the make-and-break contact of the bell, as shown in the sketch. The connections are made from the batteries to the bell in the usual manner.—Contributed by Ralph Tarshis, Brooklyn, N. Y.

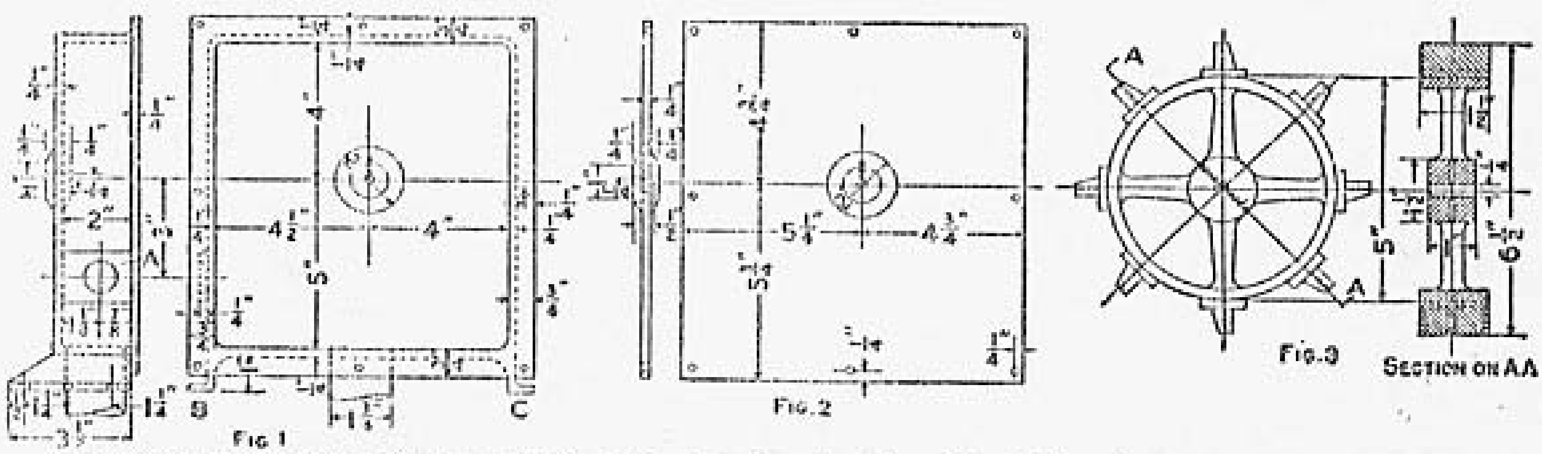
THE BOY MECHANIC – 1915

A Small Hydroelectric-Power Plant

Wherever a water pressure of over 30 lb. is available a small hydroelectric-power plant will produce sufficient electric current for any light work, such as charging storage batteries, operating sewing and washing ma-respond to the features of the model. This enables one to note the variations between the wire and the model's features. For instance, the fore-chines, toys, etc. The design is for a 6-in. hydraulic motor of the Pelton type, which will operate well on almost all city-water pressures, and at 80 lb. will drive a 100-watt generator to its full output.

The castings may be procured from any foundry cheaply, so that these parts need not trouble the builder. The patterns can be constructed easily and are not so complicated that they will tear the molds when being removed. They are made from well seasoned white pine, 1/4 in. thick. Fill in all sharp corners with small fillets. All the patterns should taper slightly from the parting line.

The motor casing is shown in Fig. 1. It is made with a wide flange so that the cover plate can be bolted to it. The lug A is to give additional strength and thickness to the side so that it may be drilled and tapped for the nozzle. The legs B and C are for bolting the case to a base or support. The outlet pipe is of lead, 1 3/4 in. outside diameter, and the hole for it in the case can be either drilled or cored. Solder the pipe flush with the inside of the casing. Drill and tap the holes around the flange for 8,32 bolts. The shaft hole must be drilled very carefully. Drill 1/4-in. holes in the feet. The oil holes are 1/8 in. in diameter. File the surface of the flange smooth and also the inside shoulder of the bearing lug. Drill and tap the nozzle hole for a 3/4-in. pipe thread.



Layout for the Casing, Cover and Wheel for the Construction of a Hydraulic Motor That will Drive a Small Dynamo, to Produce Current for Experimental Purposes, to Charge Storage Cells or to Run Electric Toys

The cover plate is shown in Fig. 2. This is bolted to the casing with 8, 32 brass bolts, ½ in. long. The holes for them are drilled $\frac{3}{16}$ in. in diameter. A shallow hole, for the end of the shaft to fit in, is drilled in the lug, as shown.

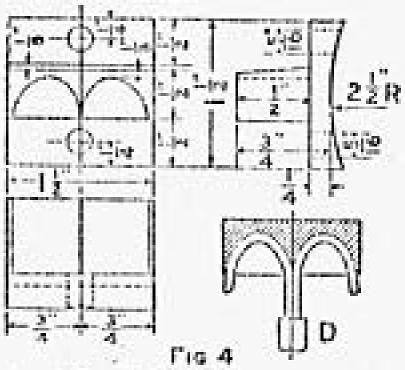


Fig 4

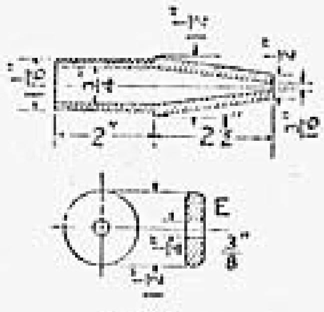


Fig.5

The Best Shape of the Buckets to Take Up the Force of the Water

It does not pass all the way through the plate. File the inside face of the lug smooth and also the edge of the plate where it joins the casing.

The wheel, with brackets attached, is shown in Fig. 3. This style of wheel need not be followed out closely. Bore the hub centrally for a ¼-in.

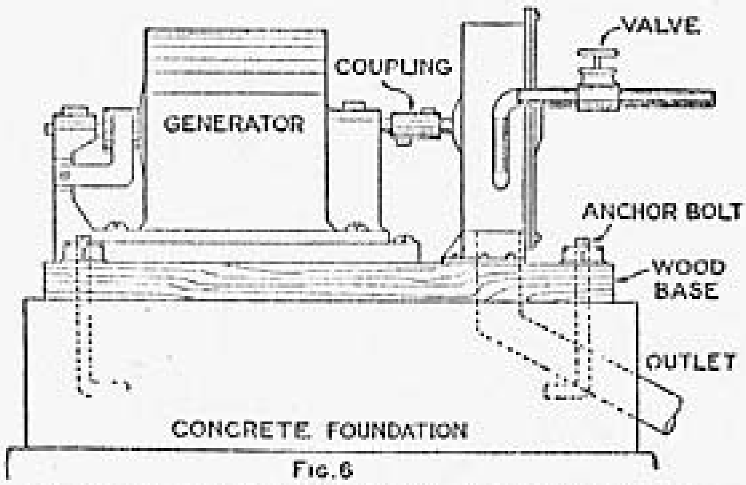


Fig.6

The Motor as It is Coupled to Drive the Dynamo, and the Water Connections

shaft and fit in two setscrews. Drill and tap the rim for the buckets with a ¼-in. standard tap. The buckets must be evenly spaced and bolted on to make the wheel balance.

The buckets are shown in Fig. 4. They may be cast from iron or babbitt. The sharp ridge in the center provides for a deviation of the water jet as it flows on the bucket. The ridge divides the bucket into two equal lobes which turn each division of the jet through almost 180 deg., using all the kinetic energy in the jet. This is shown at D. The dividing ridge must lie in the plane of the revolution, so that each bucket will enter the center of the jet. The buckets being evenly spaced on the periphery of the wheel, only one at a time receives the force of the jet, the one in front and the one behind clearing the jet.

The nozzle is shown in Fig. 5. It can be made of iron or brass. The inside gradually tapers from ¾ to $\frac{3}{16}$ in. It has a ¾-in. pipe thread and is screwed into the hole in the case from the inside and is secured with a lock nut. Enough additional threaded portion is left protruding to allow the supply pipe to be connected.

When assembling the motor, fasten the wheel to the shaft with the two setscrews, and place a metal washer, E, on each side of the wheel. Place the wheel in the casing and screw the cover plate in place. A thin rubber gasket should be placed between the cover and the casing to provide a water-tight joint.

The general arrangement of the plant is shown in Fig. 6. The motor and dynamo are mounted on a heavy wood base, which in turn is firmly bolted to a concrete foundation. Level up the two machines by the use of thin washers on the bolts between the base and machine. A heavy sleeve and setscrews are used to connect the two shafts. The connection to the water supply is made with ¾-in. pipe, with a globe valve in it to regulate the flow of water. Any dynamo of about 100-watt output can be used.

THE BOY MECHANIC – 1915

An Electric Chime Clock

By JOHN E. MAHLMEISTER

IN the construction of this clock one perfectly good and accurate alarm clock and the works of an old or discarded one are used. The clock for the accurate time is set into a frame, or

 GRANDDAD'S ELCTRICITY BOOK

casing, made of thin boards which have a circular opening cut in them to fit

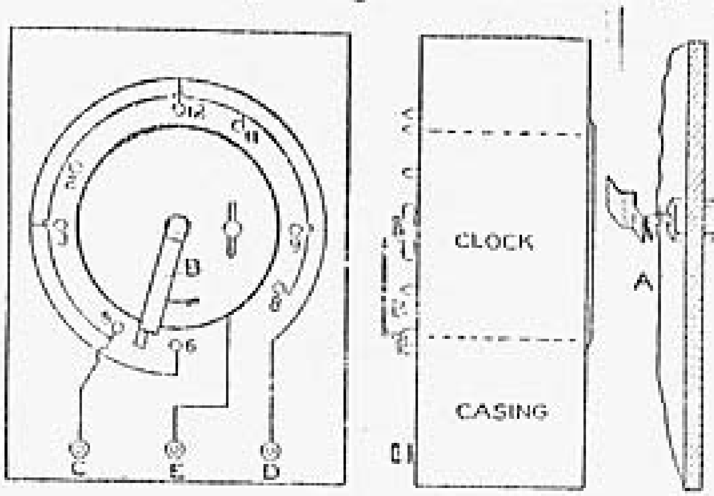


FIG. 1

The Alarm Clock in Its Case and the Location of the Contact Pins and Contact Lever

snugly on the outside casing of the clock. The back of the clock and casing are shown in Fig. 1. A circular line is drawn on the casing, about 1 in. larger in diameter than the clock, and brass machine screws with two nuts clamping on the wood back, as shown at A, are set at intervals so as to be opposite, or just back of, the hour marks 2, 3, 5, 6, 8, 9, 11, and 12. A contact spring, B, is shaped as shown and soldered to the knurled knob on the back

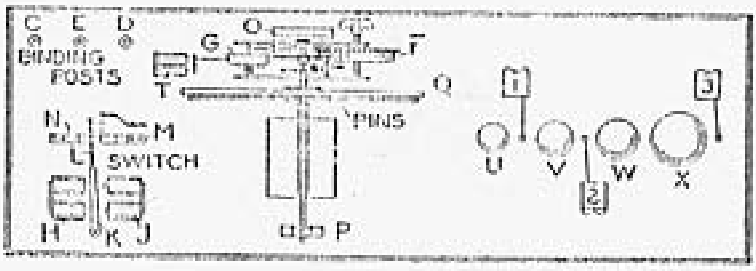


FIG. 2

Location of the Clock Works, Magnets, Binding Posts, Gongs and Strikers on the Baseboard

of the clock used for setting the hands in a position where it will travel or be parallel with the minute hand. The end of the contact spring should be shaped so that it will slide over the points of the screws easily, but in good contact. The ends of the screws should be filed to a slightly rounding point. The wiring diagram for this part of the apparatus is clearly shown, and the terminals are connected to binding posts C and D. The binding post E is connected to the metal part of the clock.

The chime part is made entirely separate and can be located at any reasonable distance from the clock. It is propelled by the works from an old clock, as shown at F, Fig. 2. The old clock is prepared for use by removing the hands, balance wheel and escapement so that the wheels will turn freely. To prevent the works from running too fast, a piece of sheet brass, G, is soldered to the shaft running at the highest speed. The brass should be as large as the space will admit. It forms a fan to catch the air and retard the speed, and also provides a means of stopping the works by the electric mechanism.

The parts for the gongs and electrical apparatus are supported on a baseboard, ¾ in. thick, 6 in. wide, and 18 in. long. The automatic switch is located at one end of the base, and consists of two sets of magnets, H and J, with an armature, K, to which is attached a stiff contact wire, L. This wire is to make contact with the spring M when the armature is drawn by the magnets J, and with N when drawn by the magnets H. The springs M and N are made of thin sheet brass, bent as shown, and mounted on the base.

A piece of wood, O, on which to mount the works of the old clock is mortised into the base. Another standard, P, of the same height as O, is also mortised into the base to provide a bearing for the end of the shaft which carries the wood disk Q, the opposite end of the shaft being connected by means of a ferrule and soldered to the end of the minute-hand shaft. The shaft should be well lined up, so that it will turn freely. The wood disk is ¼ in. thick and about 6 in. in diameter.

Mark four circles on the face of the disk, near the outside edge and ¼ in. apart. Step off the outside circle into 150 parts and draw a radial line from each mark across the four circular lines with the straight edge on the center of the disk. An arc of the disk is shown in Fig. 3, where trip pins are driven in for making the electric contacts. This part of the arc shows the method of locating the pins for the hour from 3 to 4 o'clock, with the intermediate pins for the quarter, half, and three-quarter-hour contacts. The intermediate pins are arranged in the same manner for all hours, but the hour pins, on the second circle, run from 1 pin to 12 pins consecutively. Ordinary pins, with the heads cut off, are used and should be driven in accurately on the division lines to secure proper results.

The arrangement of the springs is shown in Fig. 4. These springs, when pressed together, will close the circuit for ringing the gongs. They are made of thin sheet brass, bent as shown at R, and fastened to a piece, or block, of hard wood with screws, as shown at S. The springs numbered 3, 5, 7, and 9 are the ones made as shown at R for sliding over the pins in the disk Q, and their ends should clear the face of the disk about 1/8 in. The springs 1, 2, 4, 6, and 8 are about 1/2 in. shorter and have their ends bent up at right angles so that they will almost touch the long ones. The spring 1 should be a little shorter than 2. When fastening the

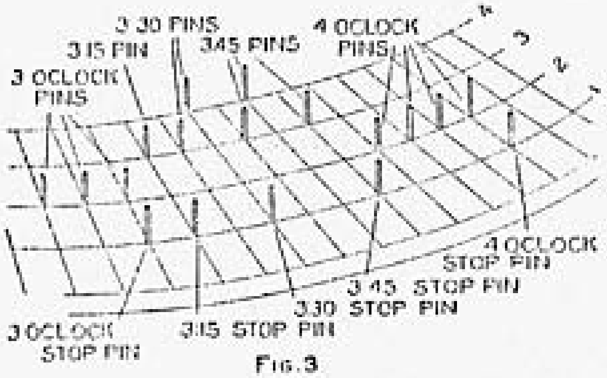
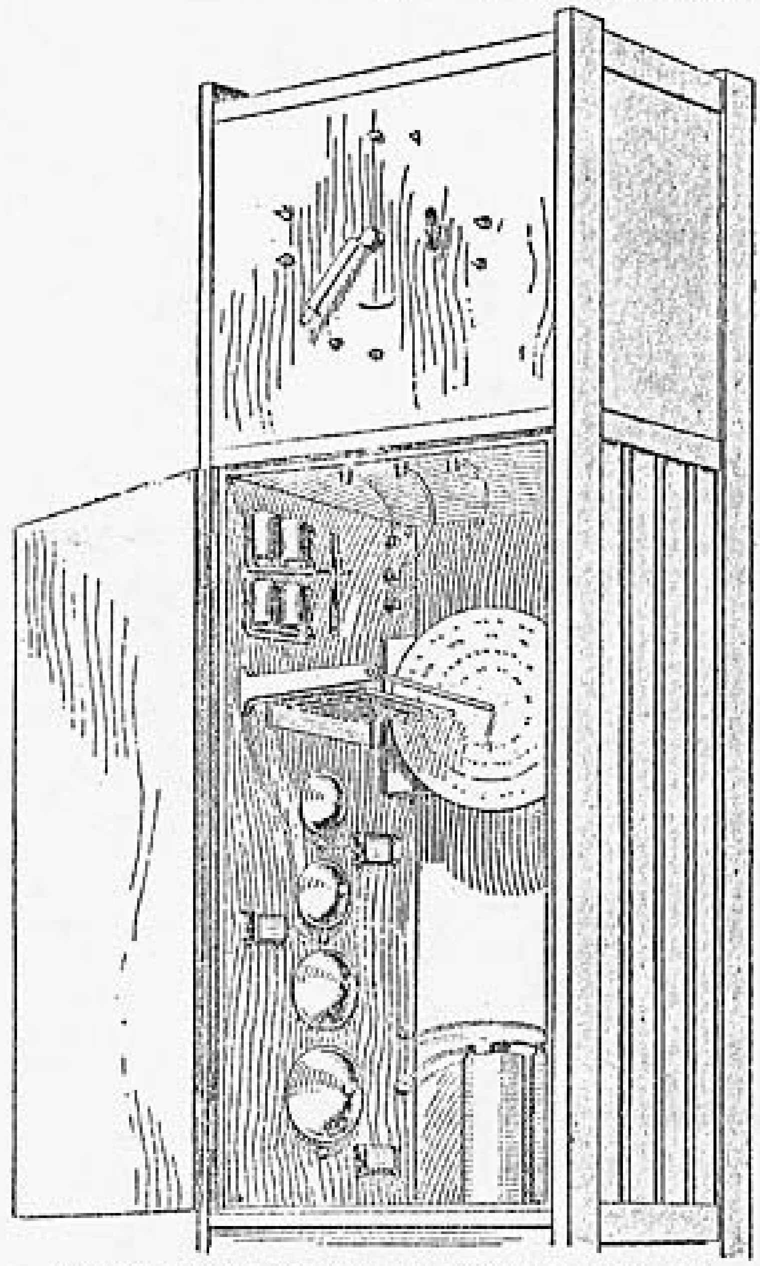


Fig. 3

The Pins are Accurately Set in Four Circular Lines and on Radial Lines

springs to the block of wood, be sure that no two springs touch and that each one is separated from the other to form no contact until the pins in the wheel force them together. The block is then fastened to the base under and parallel with the shaft carrying the disk Q, as shown.

The starting and stopping of the clockwork F is accomplished by means of a set of bell magnets, arranged, as



The Parts Constructing the Chime are Placed in the Clock Frame below the Works

shown at T, Fig. 2, with the wire attached to the armature bent to touch the brass wing of the fan G. The armature must not vibrate, but stay against the magnet cores while the current is flowing through them, thus allowing the clock wheels to turn, and as soon as the current is cut off, the armature will spring back and stop the wheels.

Arrange four gongs, U, V, W, and X, as shown in Fig. 2, and also three bell magnets with clappers 1, 2 and 3. These gongs should be selected for tone as in a chime clock. The connections to the bell magnets 1, 2, and 3 should be direct to the binding posts so that the armature will not vibrate, but give one stroke. For instance, bell magnet 1 should produce one stroke on the gong U when the current is on, and one stroke on the gong V when

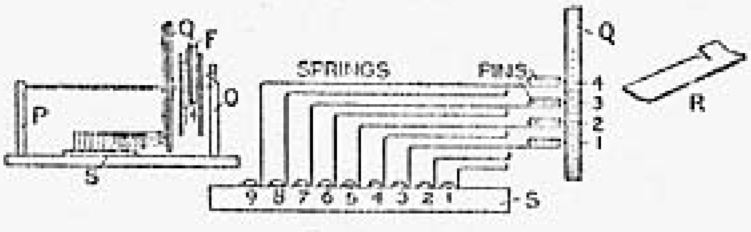


Fig. 4

The Contact Springs are Operated by the Pins on the Disk Wheel

the current breaks. The magnets 2 should cause the clapper to strike once on the gong V when the current is on, and to make one stroke on the gong W when the current is broken. The magnets 3 produce only one stroke on the gong X at a time, which is used to sound the hours.

The parts are connected up electrically as shown in Fig. 5. The lines between the clock, Fig. 1, and the bell-ringing part, Fig. 2, are connected from C to C, D to D, and E, Fig. 1, to the zinc of a battery and from the carbon to E, Fig. 2. Two dry cells will be sufficient for the current.

The working of the mechanism is as follows: Suppose the time is 6 minutes of 3 o'clock and the contact spring on the back is near the 11 pin. As soon as it touches the pin, the armature K of the switch will be drawn in contact with the spring N, then when the contact spring touches the 12 pin, the current will flow into the

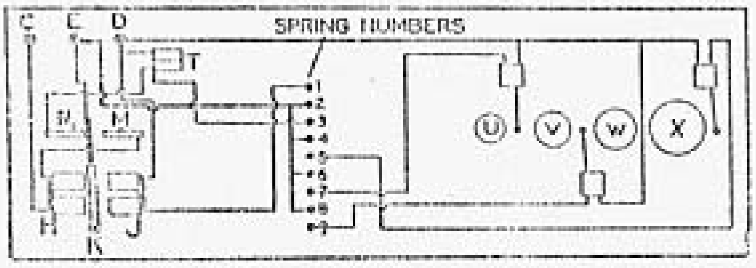


Fig. 5

The Wiring Diagram for the Location of the Wires on the Under Side of the Base

magnets T and release the wheels of the clockwork F, which turns the disk Q, and the three pins in the second row will pass over the spring 5 and press it in contact with the spring 4 three times, causing the gong X to toll out 3 o'clock. As the contact spring B will be on the contact pin 12 for about 1 minute, the wheels of the clockwork F would continue to turn and the bells ring, if it were not for the stop pin located on the outside, or first, circle of the disk Q, which pin is set in line with the last pin in the set of pins for the hour, or, in this instance, in line with the third pin. When the stop pin has passed the spring, the connection through the magnets T is broken and the clockwork F stops instantly. When the spring B strikes the 2 o'clock pin, or 10 minutes after 3 o'clock, the armature K is drawn over to N, and at the 3 pin, or 15 minutes after 3 o'clock, the bells U, V, and W will ring and then the stop pin will break the current, and so on, at every 15 minutes of the 12 hours.

THE BOY MECHANIC – 1915

A Polarity Indicator

Lines in a cable or the ends of connections at a distance from the battery must be tested to determine the polarity. Where a large amount of this work is to be done, as in automobile and motorboat repairing, it is necessary to have an indicator to save time. A cheap indicator for this purpose can be made of a 6-in. test tube having its ends sealed and inclosing a saturated solution of ammonium chloride (sal ammoniac) and water. The sealed ends are made by inserting a piece of wire through a cork and, after forcing this tightly into the end of the test tube, covering it with sealing wax.

To use, connect the terminals to the

A Simple Pocket Indicator for Finding the Negative Wire in Battery Cable Lines

battery lines, and the end of the wire in the solution giving off bubbles is the negative wire.

A Musical Doorbell

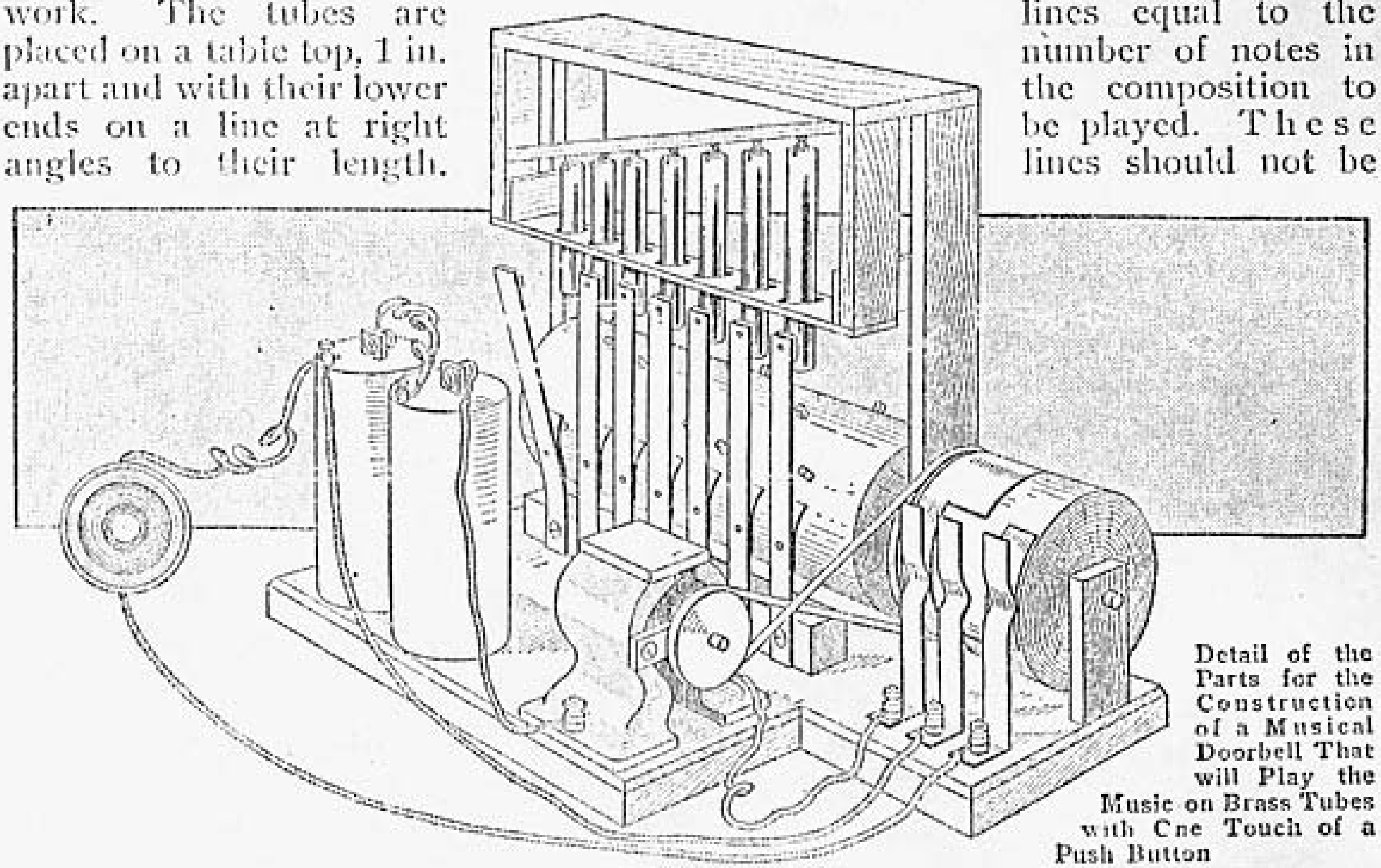
By H. MARCELLE THE BOY MECHANIC – 1915

IN the construction of this doorbell it is best to purchase a small instrument known as the "tubaphone." It consists of a rack with several pieces of brass tubing cut to different lengths to give the proper tones as they are struck. Such an instrument with eight tubes will play almost any tune, and can be purchased from 50 cents up, depending on the size. Brass tubes can be purchased, cut, and toned, but the time taken in doing this is worth more than the price of the instrument, and no changes are necessary in it to make the doorbell.

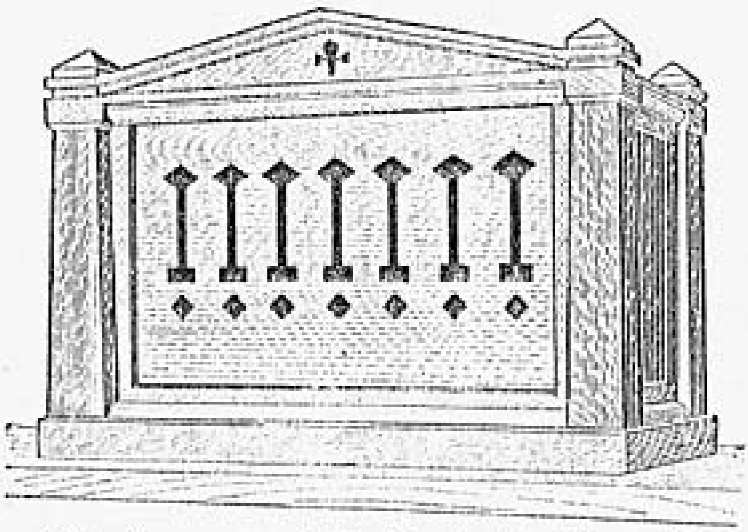
Several strips of pine, 2 in. wide and ⅞ in. thick, are procured for the framework. The tubes are placed on a table top, 1 in. apart and with their lower ends on a line at right angles to their length. Allow a space of 1 in. outside the first and last tube, and cut a piece of the wood to this length, allowing sufficient additional material to fasten on the ends of two uprights, which are cut long enough to admit the longest tube and allow sufficient room for a large roller and space at the top to swing the tubes.

A base is cut from a board, ⅞ in. thick and of sufficient size to admit the roller and tube rack, together with a small battery motor. The tube rack is fastened to the back of this base by making a tenon on the lower end of each upright, and a mortise in the baseboard to receive it.

A roller is turned from a piece of soft pine, large enough to provide room on its surface for a number of horizontal lines equal to the number of notes in the composition to be played. These lines should not be too close together. Supposing the music it is desired to play has 15 notes in its composition, then 15 horizontal



Detail of the Parts for the Construction of a Musical Doorbell That will Play the Music on Brass Tubes with One Touch of a Push Button lines must be spaced evenly on the surface of the roller. The length of the roller should be a free-working fit between the uprights. A 1/4-in. steel rod is run through its center for a shaft,



The Appearance of the Doorbell Is That of a Mission Clock on a Mantel

allowing sufficient ends for the bearings, and, in addition, at one end sufficient length for a pulley.

The motor is lined up on the base, so that its pulley wheel will run a belt on the large wheel of the roller. The current is turned on after making belt and wiring connections, a lead pencil is held directly centering the place where each tube hangs, and a line is drawn on the circumference of the roller.

A 1/8-in. hole is drilled through each tube, near one end, and a piece of catgut string run into it to make a hanger. A piece of board, long enough to fit between the uprights when placed on the slope formed by the upper ends of the tubes after their lower ends are set straight on a line at right angles to their length, and wide enough to swing the tubes clear of the frame, is fastened in place, as shown. Small screw eyes are turned into the under side of this board, at even spacings of 1 in., and used to swing the tubes by the catgut strings. Another piece of board, the same width as the former, is placed, perfectly horizontal, between the uprights a short distance above the lower ends of the hanging tubes. Evenly spaced holes are bored in this crosspiece to admit the ends of the tubes. The holes should be of such size that when they are lined with a piece of felt, the tubes will have a little play without touching the sides at any point.

The hammers are each made of a strip of sheet brass, having a length that will extend from the base to a short distance above the lower ends of the tubes. A hole is drilled in each end of the strip, the lower one being of a size to fasten it to the base crosspiece with a round-head wood screw. The hole in the upper end is used to fasten a small block of wood with a screw, for the hammer head. A small strip of felt is glued to the striking side of the block. Another piece of brass, used for a trip, is fastened to the center part of each long piece with rivets, so that its upper end will be near the center of the roller for height, and strike the end of a small peg driven into the roller. The length of these pieces, in fact, of all pieces, will depend on the length of the tubes in the tubaphone and the size roller required for the music.

The setting of the pegs in the roller requires some patience in order to get the tune correct, but one mistake will be of more value than an hour's description. The pegs can be procured from a shoemaker. If the roller is of pine, they can be driven into the wood of the roller with a hammer.

With ordinary connections to the push button and motor, the mechanism will only run while the push button is being pressed. A device that will cause the piece of music to be played through to the finish after the push button is pushed for a short time, consists of a turned piece of wood fastened to the outside surface of the driving wheel on the roller. This piece of wood should be carefully set, so that its outside surface will be true as it revolves. Three brushes, made of copper strips, are fastened to the base. The length of these brushes will depend on the size of the roller and height of the block of wood. They should be evenly spaced and fastened, so that they will be insulated from each other. One strip of brass, or copper, is fastened around the turned piece of wood. This strip must be as wide as two brushes, except for a short distance to make a break in the electrical circuit. The notch in the strip, to make this break, should be on the outside edge where it will disconnect the center brush, and its location on the turned piece of wood should be on a line with the end and the beginning of the pegs for the music. Another short strip is fastened to the turned piece of wood, where it will make a contact with the first brush when the second or middle brush is in the notch, or disconnected, and is connected to the other notched strip with a piece of wire run beneath the wood.

The wiring shown will make it possible to start the motor with the push button which will turn the roll far enough to connect the center brush; then the roller will turn until the music is played, at which point it will stop and remain in rest until the push button again makes the contact.

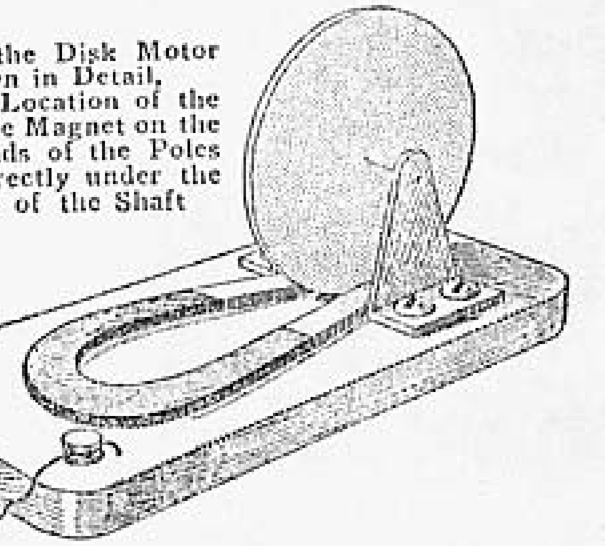
The entire mechanism can be made to set on the mantel or shelf, incased like a mission clock, and the wires running to it may be concealed.

THE BOY MECHANIC – 1915

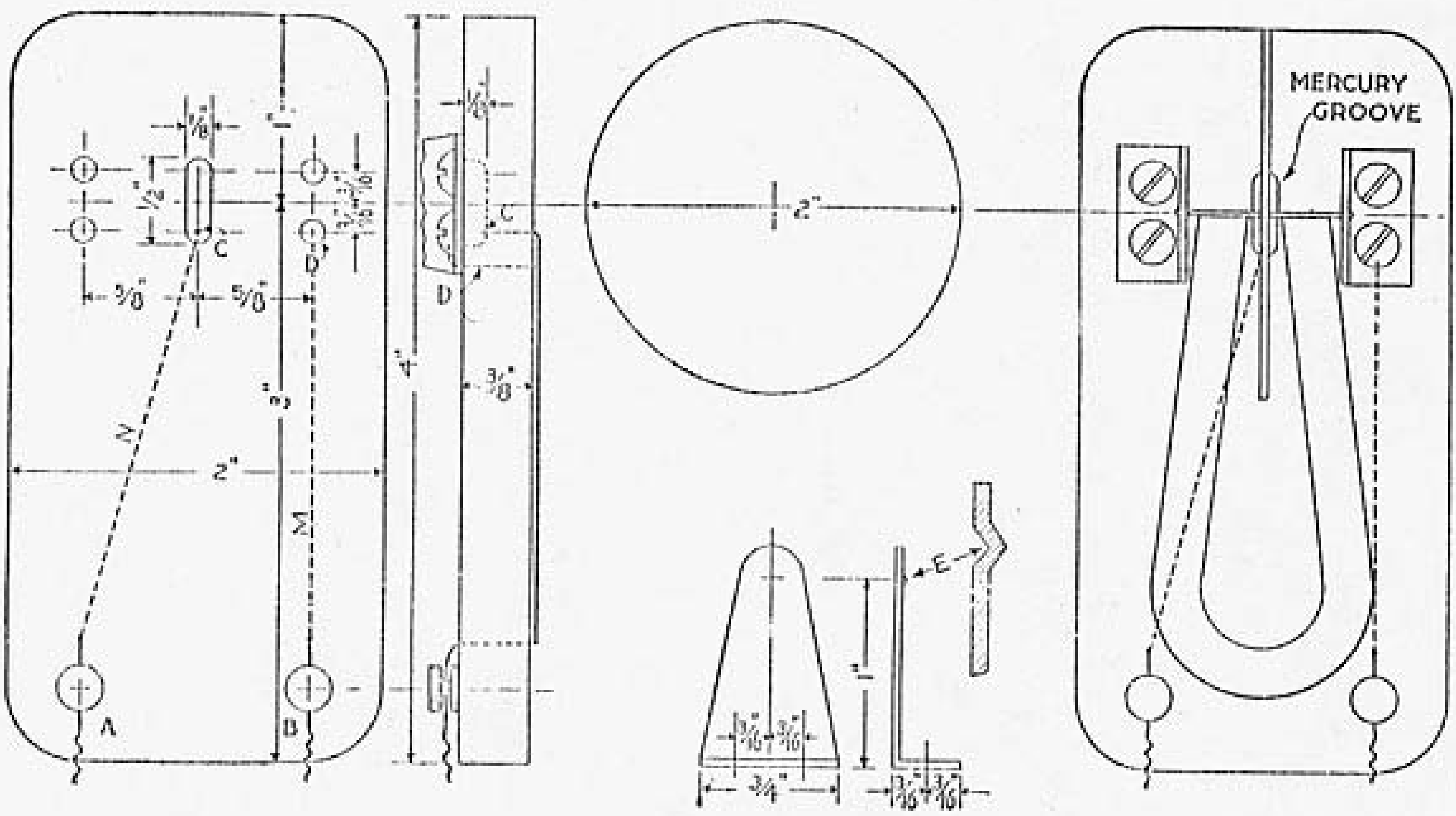
A Disk-Armature Motor

One of the simplest motors to make is the disk motor, its construction requiring a wood base, a brass disk, a 3-in. horseshoe magnet, and some mercury.

The base is made of hard wood, in the proportions shown in the sketch. The leading-in wires are connected to the binding posts A and B, and from these connections are made, on the bottom of the base, from A to the groove C cut in the upper surface of the base for the mercury, and from B to one screw, D, of



Parts of the Disk Motor Shown in Detail, Also the Location of the Horseshoe Magnet on the Base, Ends of the Poles being Directly under the Center of the Shaft



one bearing. The end of the former wire must be clean and project into the end of the groove, where it will be surrounded with mercury.

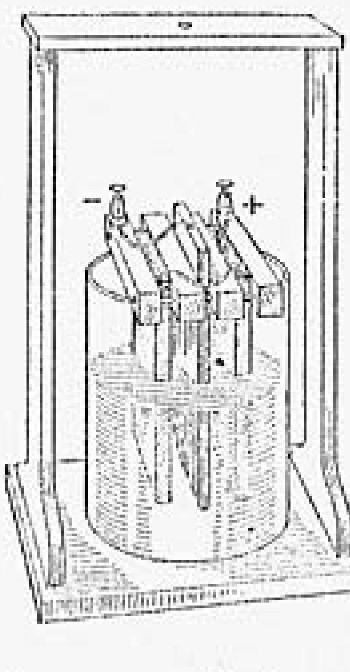
The bearings consist of thin sheet brass, cut to the dimensions shown, the bearing part being made with a well-pointed center punch, as at E. The disk wheel is made of sheet brass, 2 in. in diameter, and a needle, with the eye broken off and pointed, is used for the shaft. The needle shaft can be placed in position by springing the bearings apart at the top.

When the current is applied, the disk will revolve in a direction relative to the position of the poles on the magnet. The reverse can be made by turning the magnet over.—Contributed by Joseph H. Redshaw, Homestead, Pa.

THE BOY MECHANIC – 1915

A Homemade Wet Battery

Procure a large water bottle and have a glass cutter cut the top off so that the lower portion will form a jar about 8½ in. high. Next obtain two pieces of carbon, about 8 in. long, 4 in. wide and ¼ in. thick. Melt up some old scrap zinc and mold a piece having the same dimensions as the pieces of carbon. The mold for casting the zinc may be made by nailing some ¼-in. strips of wood on a piece of dry board, forming a shallow box, 4 in. wide and 8 in. long. Remove all the impurities from the surface of the zinc when it is melted, with a metal spoon or piece of tin. Before filling the mold with the metal, place a piece of No. 14 gauge bare copper wire through a small hole in one of the end pieces forming the mold, and allow it to project several inches inside, and make sure the mold is perfectly level. The zinc will run around the end of the wire, which is to afford a means of connecting the zinc plate to one of the binding posts forming the terminals of the cell.



Cut from some hard wood four pieces a little longer than the outside diameter of the glass jar, two of them ½ by ½ in., and two, ½ by ⅝ in. Drill a ⅛-in. hole in each end of all four pieces, the holes being perpendicular to the ½-in. dimension in each case, and about ⅜ in. from the end. Boil all the pieces for several minutes in paraffin and stand them up on end to drain. Procure two ⅛-in. brass bolts, 3½ in. long, which are to be used in clamping the elements of the cell together. The two smaller pieces of wood should be placed on each side of one end of the zinc, then the carbon pieces and the larger pieces of wood outside the carbon pieces. The carbon plates should be connected together and then connected to a binding post which forms the positive terminal of the cell. If unable to obtain pieces of carbon of the required dimensions, a number of ordinary electric-light carbons may be used. Get about ten ½-in. carbons, without the copper coating, if possible; if not, file all the copper off. Cut these carbons off, forming 8-in. lengths. File the top ends of the carbons flat and so that they all become equal in thickness, and clamp them in place by means of the brass bolts. If rods are used, they should all be connected together by means of a piece of copper wire and then to a binding post.

The plates may now be hung in the jar, the wooden pieces resting on the top of the jar and acting as a support. The solution for this cell is made by dissolving ½ lb. of potassium bichromate in ½ gal. of water, and then adding very slowly ½ lb. of strong sulphuric acid. More or less solution may be made by using the proper proportion of each ingredient.

This cell will have a voltage of two volts, a rather low internal resistance, and will be capable of delivering a large current. If it should begin to show signs of exhaustion, a little more acid may be added.

A chemical action goes on in this cell regardless of whether it supplies current to an external circuit or not, and for this reason the elements should be removed from the solution and hung directly over the jar when the cell is not in use. A simple device for this purpose may be constructed as shown. A cord may be passed through the opening in the crossbar at the top and its lower end attached to the elements. When the elements are drawn out of the solution, the upper end of the cord may be fastened in some manner. This frame can, of course, be made longer, so it will accommodate a number of cells.

THE BOY MECHANIC – 1915

The Construction of a Simple Wireless Telephone Set

By A. E. ANDREWS

In Two Parts — Part I

Among the various methods for the transmission of speech electrically, without wire, from one point to another, the so-called "inductivity" system, which utilizes the principles of electromagnetic induction, is perhaps the simplest, because it requires no special apparatus. Since this system is so simple in construction, and its operation can be easily understood by one whose knowledge of electricity is limited, a description will be given of how to construct and connect the necessary apparatus required at a station for both transmitting and receiving a message.

Before taking up the actual construction and proper connection of the various pieces of apparatus, it will be well to explain the electrical operation of the system. If a conductor be moved in a magnetic field in any direction other than parallel to the field, there will be an electrical pressure induced in the conductor, and this induced electrical pressure will produce a current in an electrical circuit of which the conductor is a part, provided the circuit be complete, or closed, just as the electrical pressure produced in the battery due to the chemical action in the battery will produce a current in a circuit connected to the terminals of the battery. A simple experiment to illustrate the fact that there is an induced electrical pressure set up in a conductor when it is moved in a magnetic field may be performed as follows: Take a wire, AB, as shown in Fig. 1, and connect its terminals to a galvanometer, G, as shown. If no galvanometer can be obtained, a simple one can be made by supporting a small compass needle inside a coil composed of about 100 turns of small wire. The terminals of the winding on the coil of the galvanometer should be connected to the terminals of the conductor AB, as shown in Fig. 1. If now the conductor AB be moved up and down past the end of the magnet N, there will be an electrical pressure induced in the conductor, and this electrical pressure will produce a current in the winding of the galvanometer

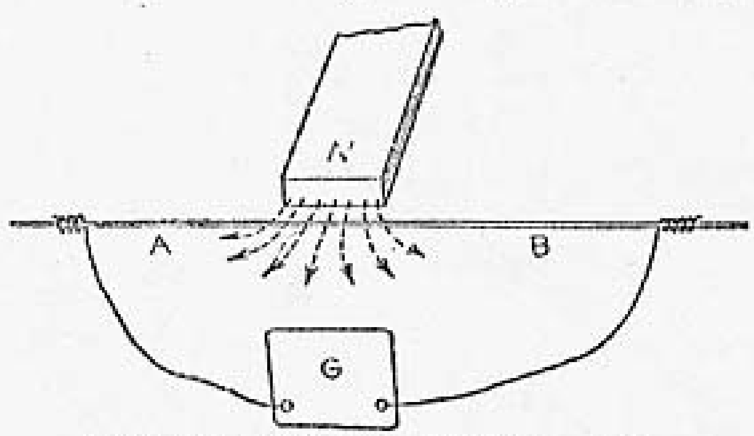


Fig. 1 — Wire Connected to Galvanometer

G, which will cause the magnetic needle suspended in the center of the coil to be acted upon by a magnetic force tending to move it from its initial position,

 GRANDDAD'S ELCTRICITY BOOK

or position of rest. It will be found that this induced electrical pressure will exist only as long as the conductor AB is moving with respect to the magnetic field of the magnet N, as there will be no deflection of the galvanometer needle when the motion of the conductor ceases, indicating there is no current in the galvanometer winding, and hence no induced electrical pressure. It will also be found that the direction in which the magnetic needle of the galvanometer is deflected changes as the direction of motion of the conductor changes with respect to the magnet, indicating that there is a change in the direction of the current in the winding of the galvanometer, and since the direction of this current is dependent upon the direction in which the induced electrical pressure acts, there must have been a change in the direction of this pressure due to a change in the direction of motion of the conductor. The same results can be obtained by moving the magnet, allowing the conductor AB to remain stationary, the only requirement being a relative movement of the conductor and the magnetic field created by the magnet.

It is not necessary that the magnetic field be created by a permanent magnet. It can be produced by a current

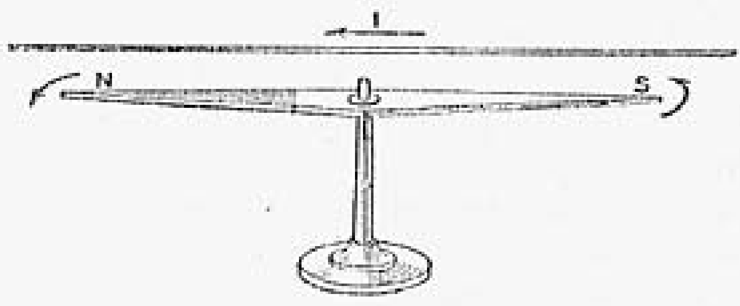


Fig. 2—Compass Needle Test

in a conductor. The fact that there is a magnetic field surrounding a conductor in which there is a current can be shown by a simple experiment, as illustrated in Fig. 2. If a wire be placed above a

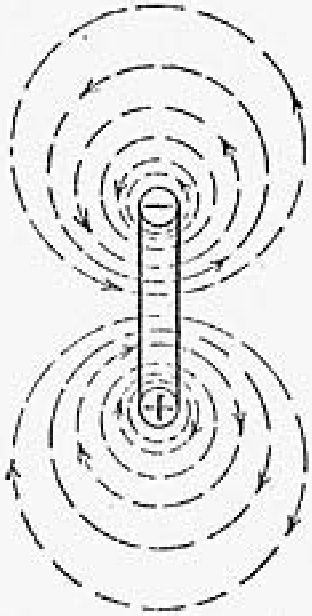


Fig. 4—Reversed Lines of Force

compass needle and parallel to the direction of the compass needle and a current be sent through the wire in the direction indicated by the arrow I, there will be a force acting on the compass needle tending to turn the needle at right angles to the wire. The amount the needle is turned will depend upon the value of the current in the wire. There is a definite relation between the direction of the current in the wire and the direction of the magnetic field surrounding the wire, because a reversal of current in the conductor will result in a reversal in the direction in which the compass needle is deflected. Remembering that the direction of a magnetic field can be determined by placing a magnetic needle in the field and noting the direction in which the N-pole of the needle points, this being taken as the positive direction, if one looks along a conductor in which there is a current and the current be from the observer, the direction of the magnetic field about the conductor will be clockwise. Imagine a conductor carrying a current and that you are looking at a cross-section of this conductor (see Fig. 3), and the direction of the current in the conductor is from you (this being indicated in the figure by the cross inside the circle), then the lines of force of the magnetic field will be concentric circles about the conductor, they being nearer together near the conductor, indicating the strength of the field is greatest near the conductor. A compass needle placed above the conductor would place itself in such a position that the N-pole would point toward the right and the S-pole toward the left. If the needle be placed below the conductor, the N-pole would point to the left and the S-pole to the right, indicating that the direction of the magnetic field above the conductor is just the reverse of what it is below the conductor.

The strength of the magnetic field produced by a current in a conductor can be greatly increased by forming the conductor into a coil. Figure 4 shows the cross-section of a coil composed of a single turn of wire. The current in the upper cross-section is just the reverse of what it is in the lower cross-section, as indicated by the cross and dash inside the two circles. As a result of the direction of current

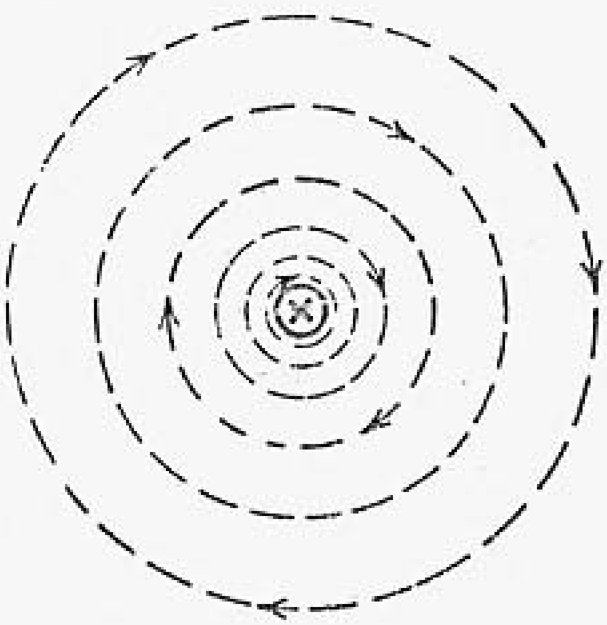


Fig. 3—Lines of Force

in the two cross-sections being different, the direction of the magnetic field about these two cross-sections will be different, one being clockwise, and the other counter-clockwise. It will be observed, however, that all the lines of force pass through the center of the coil in the same direction, or the magnetic field inside the coil is due to the combined action of the various parts of the conductor forming the complete turn. This magnetic field can be increased in value, without increasing the current in the conductor, by adding more turns to the coil.

A cross-section through a coil composed of eight turns placed side by side is shown in Fig. 5. The greater part of the magnetic lines created by each turn pass through the remaining turns as shown in the figure, instead of passing around the conductor in which the current exists that creates them. This results in the total num-

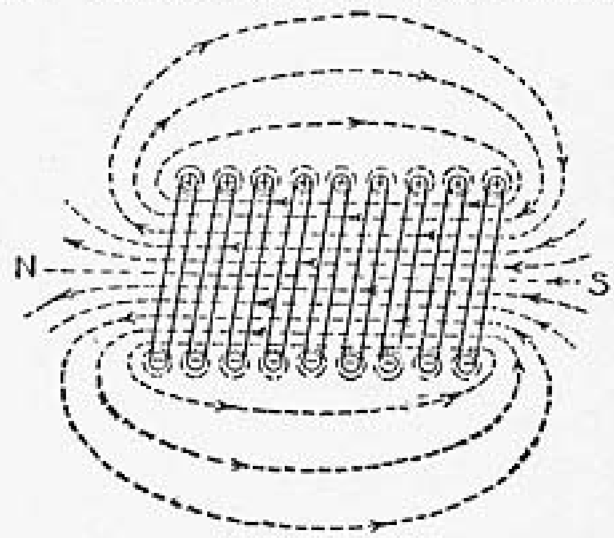


Fig. 5—Magnetic Lines Passing through Center

ber of lines passing through the coil per unit of cross-sectional area being greater than it was for a single turn, although the value of the current in the conductor has remained constant, the only change being an increase in the number of turns forming the coil.

If a conductor be moved by the end of a coil similar to that shown in Fig. 5, when there is a current in the winding of the coil, there will be an electrical pressure induced in the conductor, just the same as though it were moved by the end of a permanent magnet. The polarity of the coil is marked in Fig. 5. The magnetic lines pass from the S-pole to the N-pole through the coil and from the N-pole to the S-pole outside the coil, just as they do in a permanent magnet.

In Two Parts—Part II

If two coils of wire be placed parallel to each other as shown in Fig. 6, and a current be passed through the winding of one of them, say A, a part of the magnetic lines of force created by this current will pass through the other coil B. These lines of magnetic force must cut across the turns of wire of the coil in which there is no current as the magnetic field is being created, and as a result there will be an electrical pressure produced in the winding of the coil carrying no current. When the current in coil A is discontinued, the magnetic field created by this current is destroyed or it contracts to zero, and the magnetic lines again cut the various turns composing the winding of coil B. The direction in which the magnetic lines of force and the winding of coil B move with respect to each other is just the reverse, when the current in the winding of coil A is increasing, to what it is when the current in the winding of the coil A is decreasing. Any change in the value of the current in the winding of coil A will result in a change in the number of magnetic lines of force linked with the winding of the coil B, and as a result of this change in the number of lines linked with the winding of coil B there will be an induced electrical pressure set up in coil B. The direction of this induced electrical pressure will depend upon whether the current in the winding of coil A is increasing or decreasing in value. When the current in the winding of coil A is increasing in value, the electrical pressure induced in the winding of coil B will be in such a direction that the current produced by this induced electrical pressure will pass around the winding of coil B in the opposite direction to that in which the current passes around the winding of coil A. Or the current produced by the induced electrical pressure tends to produce a magnetic field opposite in direction to the one created by the current in the winding of coil A. When the current in the winding of A is decreasing in value, the induced pressure in the winding of the coil B is just the reverse of what it was in the previous case and the current produced by this induced pressure passes around the winding of the coil B in the same direction as the current passes around the winding of coil A. The current produced by the induced electrical pressure aids the current in the winding of coil A in producing a magnetic field. In general the current resulting from the induced pressure always passes around the circuit in such a direction as to produce a magnetic effect which will oppose a change in the value of the magnetic field causing the induced electrical pressure.

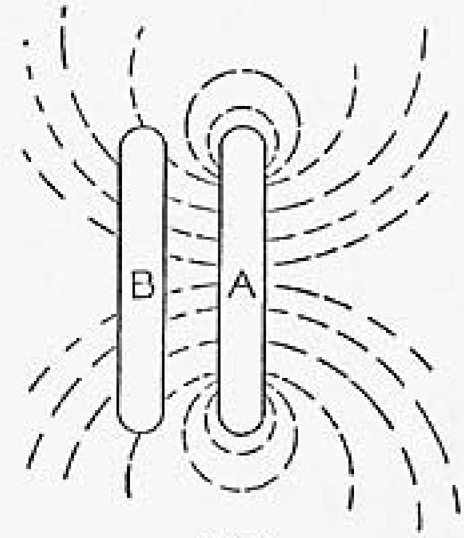


Fig. 6

There will be an induced pressure in the winding of coil B, due to a change in the value of the current in the winding of coil A, as long as the coil B remains in the magnetic field of the coil A and its plane is not parallel to magnetic lines; or, in other words, coil B must always be in such a position that some of the magnetic lines created by the current in coil A will pass through the winding of coil B.

If a telephone transmitter and a battery be connected in series with the winding of coil A, a fluctuating or varying current can be made to pass through the winding by causing the diaphragm of the transmitter to vibrate by speaking into the mouthpiece of the transmitter. This varying current will set up a varying magnetic field and there will be an induced electrical pressure set up in coil B, if it be properly placed with respect to coil A. A receiver connected in series with the winding of coil B will be subjected to the action of a varying current due to

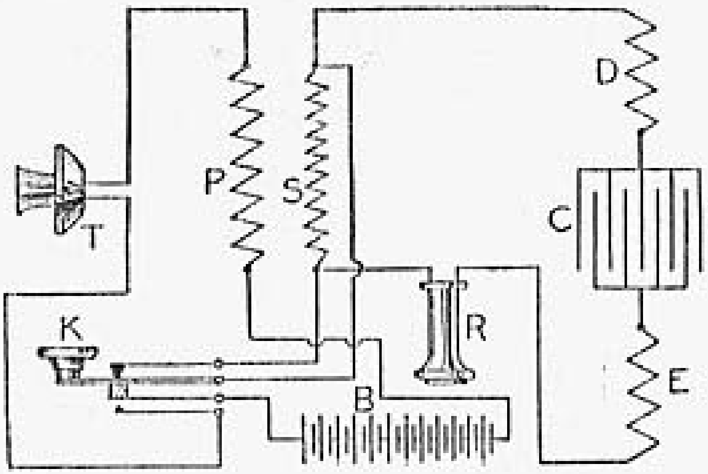


Fig. 7—Sending and Receiving Equipment

the induced electrical pressure in the winding of coil B and as a result, the diaphragm of the receiver will vibrate in unison with that of the transmitter, and speech can thus be transmitted. The connection just described should be somewhat modified and a little more equipment used in order to give the best results.

Figure 7 shows the complete sending and receiving equipment, a complete outfit of this kind being required for each station. The transmitter T and the receiver R may be an ordinary local battery transmitter and receiver, although a high-resistance receiver will give better results. The induction coil with the windings, marked P and S, may be any commercial type of induction coil as used in a magneto telephone instrument, but a coil with a high-wound secondary will give better results. The push button K is to be used in closing the transmitter circuit when the set is being used for transmitting, the key being depressed, and for shorting out the high resistance secondary winding when the set is used in receiving, the key being in the normal position. Ten dry cells should be connected in series and used to supply current to the transmitter circuit, as shown by B in the figure. The receiver R, secondary winding of the induction coil S, and the winding of coil A used in transmitting and receiving the magnetic effects, are all connected in series. The winding of the coil A consists of two parts, D and E, as shown in the figure, with two of their ends connected together by means of a condenser, C, having a capacity of about 2 micro-farads. Each of these parts should consist of about 200 turns of No. 22 gauge silk-covered copper wire, wound on an ordinary bicycle rim. The inside end of one winding should be connected to the outside of the other by means of the condenser, the two coils being wound in the same direction. The condenser C can be procured at a small cost from almost any telephone company.

To talk, two of the instruments are placed 25 or 30 ft. apart, and they may be placed in different rooms as walls and other ordinary obstructions that do not interfere with the production of the magnetic field about the transmitting coil, have no effect upon the operation. Pressing the button K at the transmitting station, closes the transmitter circuit and removes the shunt from about the secondary winding of the induction. Any vibration of the transmitter will cause a varying current to pass through the primary winding P, which in turn induces an electrical pressure in the secondary winding S, and this pressure causes a varying current to pass through the coil A. The varying current in the winding of the coil A produces a varying magnetic field which acts upon the receiving coil, inducing an electrical pressure in it and producing a current through the receiver at the receiving station.

A filing coherer, adapted to close a local relay circuit and ring an ordinary bell, may be used with the sets just described for signaling between stations.

An Electric Incubator

THE BOY MECHANIC -- 1915

Where electric current is available, it can be used to heat an incubator much better and cleanlier than the kerosene lamp. The materials are inexpensive and the cost should be no more than for the ordinary kind of heater.

First of all the box part must be made of very dry wood, ½ in. thick. The material should be matched, as the cost of the operation depends upon the construction of the box. The proper size for an 80-egg incubator is 2 ft. square and 1 ft. high. If a larger one is desired, the dimensions may be varied to suit, but it is not necessary to make it any higher for a larger one. If it is desired to have a window in the door, care must be taken to make it a good fit. The top, as shown in the sketch, is made without hinges so that it can be readily set on and removed. This makes it handy in case of repairing the heater and cleaning the box. The inside of the box, with the exception of the bottom, should be covered with asbestos paper.

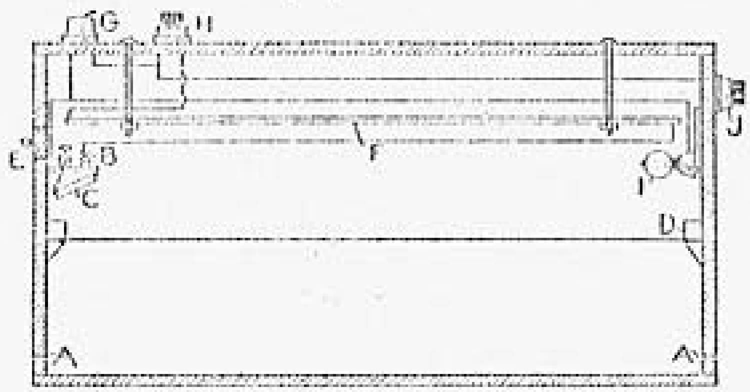


Fig. 1—Box Details

After the box is finished, fit it with a tray, 1½ ft. by 1 ft. 10¾ in. A tray having these dimensions will slide easily in the box. This is an essential feature of the hatching. The frame of the tray D, Fig. 1, consists of wood, ¾ by ¾ in., with a bottom made of wire mesh. The mesh should be firmly

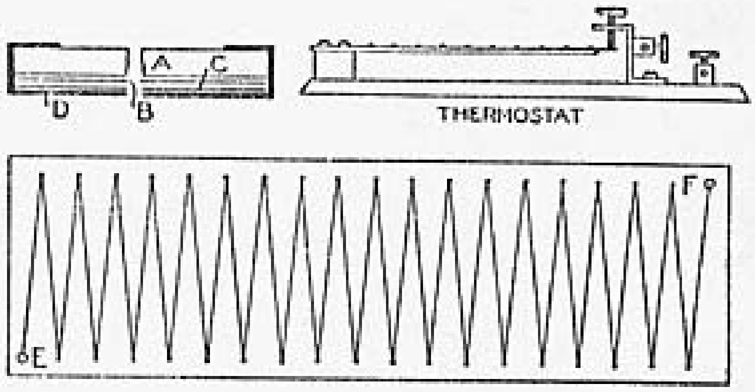


Fig. 2—Heater Details

attached, so that it will not give away when full of eggs. Runners for the tray are placed 4½ in. from the bottom of the box. When the tray is put in place, it will not touch the back. This small space is left for the chicks to fall into the nursery below. About 4 in. below the tray four holes are bored, A A, ⅛ in. in diameter, one on each side of the box. These holes admit fresh air to the eggs.

The electric heater is just large enough to allow a space about ½ in. on all edges. This makes it 23 in. square. A piece of ¼-in. asbestos of the above size should be secured, on which to place the heating wire. The amount of wire depends on the size and kind. As it is not necessary to heat the wire very hot, iron or steel wire may be used. The length of wire may be determined by the following method:

Wind the wire on a long stick, making sure that no one coil touches its neighbor. Connect one wire of the current supply at one end of the coil and run the other end of the current supply along the coils, starting at the extreme opposite end and drawing toward the center until the iron wire gets too hot to hold with the bare hand. This will be the right length of wire to use. The length being known, a number of tacks are placed in the asbestos board to hold the wire, as shown in Fig. 2. Cover the wire with a sheet of asbestos and attach binding-posts, E and F, at each end.

The asbestos inclosing the heating wires is covered with a thin piece of sheet iron, which is made to fit tightly over the bottom and sides. This will spread the heat evenly. Be careful to have the binding-posts insulated from the sheet metal. In the cross section of the heater, Fig. 2, A represents the 1/4-in. asbestos board; B, the heater wire; C, the asbestos paper, and D the sheet-metal covering.

The most important part of the incubator is the thermostat which regulates the current to maintain a steady heat. It is not advisable to make this instrument, as a good one can be purchased for less than $1. Place the thermostat in the end of the box at B, Fig. 1. A small door, E, is made in the box for easy adjustment of the thumbscrews.

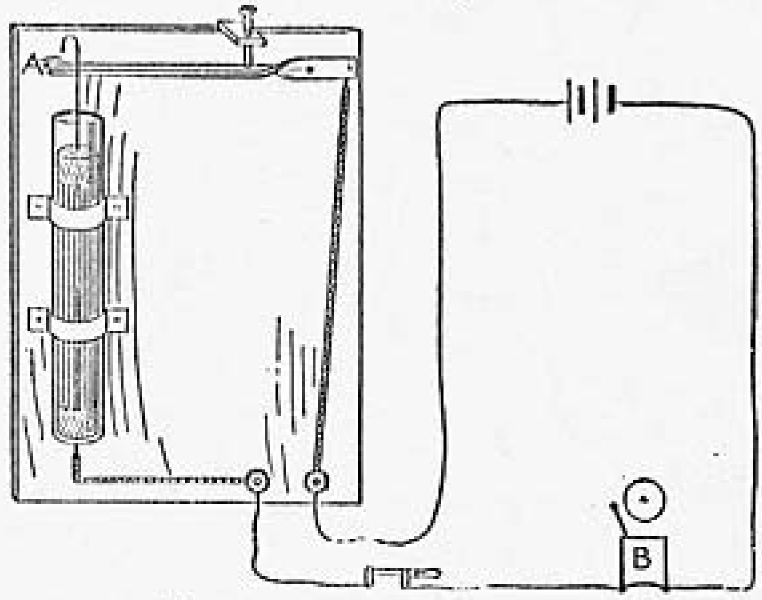
Suspend the heater from the cover of the box with bolts 2 3/4 in. long, as shown in Fig. 1. A base receptacle, G, and a snap switch, H, are fastened on top of the cover and connected up to the thermostat B, the condenser C, the heater F, and lamp I, as shown. Another snap switch, J, is used on the light only. The condenser C is to prevent sparking, thus saving the platinum points on the screws. Do not use more than a 2-cp. lamp for lighting purposes, as a brighter light blinds the young chicks.

The incubator should be run for a day or two so that the current may be well regulated before placing the eggs in the tray. The incubator is operated the same as with lamp heat.—Contributed by M. Miller, Lansing, Mich.

THE BOY MECHANIC – 1915

Temperature Alarm

The falling temperature of a room during the night may result in a very bad cold for the occupant. This may be prevented by the use of an alarm to awaken the sleeper and warn him to close the window. An alarm can be made as follows: Take a glass tube about 4 in. long and 1/4 in. in diameter and close one end, used for the bottom, with sealing wax, in which



The Alarm and Wiring Diagram

the bare end of a No. 20 gauge magnet wire is inserted. The tube is almost filled with mercury. On the mercury a float of wax is placed in which a bare piece of the same magnet wire is inserted and bent as shown in the sketch. The tube of mercury is fastened to a base with two clips of metal. At the upper end of this base the adjustable lever A is attached. The electric connections are made as shown in the sketch.

Should the temperature fall during the night, the mercury will contract, the float descend and the circuit close, so that the bell will ring. The adjustable lever allows setting the alarm for various differences of temperature.—Contributed by Klyce Fuzzelle, Rogers, Ark.

THE BOY MECHANIC – 1915

Construction of a Small Bell-Ringing Transformer

By A. E. ANDREWS

Part I—Fundamental Principles

The transformer in its simplest form consists of two separate and electrically independent coils of wire, usually wound upon an iron core.

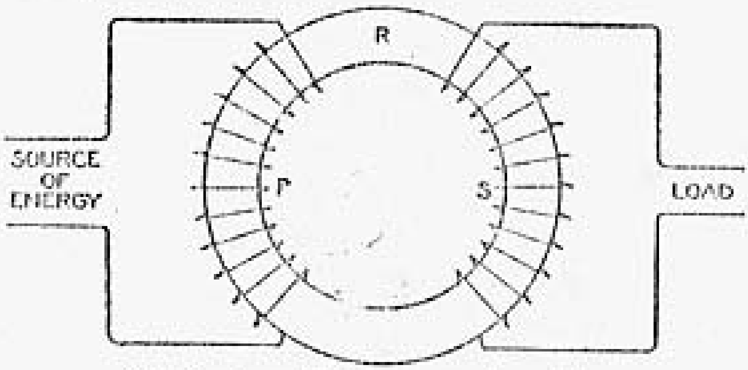


Fig. 1—Two Coils on an Iron Ring

Figure 1 shows two coils, P and S, placed upon an iron ring, R. One of these coils is connected to some source of energy, such as an alternating-current generator, or an alternating-current lighting circuit, receiving its energy therefrom. The other coil is connected to a load to which it delivers alternating current. The coil of the transformer that is connected to the source of energy is called the primary coil, and the one that is connected to the load, the secondary coil.

The electrical pressure (voltage) at which current is supplied by the secondary bears a definite relation to the electrical pressure at which current is supplied to the primary. This relation, as will be explained later, is practically the same as the relation between the number of turns in the secondary and primary coils. If there are a smaller number of turns in the secondary coil than there are in the primary, the secondary voltage is less than the primary, and the transformer is called a step-down transformer. If, on the other hand, there are a larger number of secondary turns than of primary, the secondary voltage is greater than the primary voltage, and the transformer is called a step-up transformer.

The transfer of electrical energy from the primary coil to the secondary coil of a transformer is based upon the fundamental principles of electromagnetism and electromagnetic induction, and it will be necessary to investigate these principles before we can understand the operation of the transformer.

A magnet is a body, which, when freely suspended, assumes approximately a north and south position. The end of the magnet that points north is called the north pole, while the end that points south is called the south pole. The region surrounding a magnet is called a magnetic field. In this field the magnetism is supposed to flow along a large number of imaginary lines, called lines of force, and these lines are all supposed to emanate from the north pole of the magnet, pass through the medium surrounding the magnet and enter the south pole. The magnetic field surrounding a bar magnet is shown in Fig. 2. The strength of any magnetic field depends upon the number of these lines of force per unit area (square centimeter), the area being taken perpendicular to the direction of the lines.

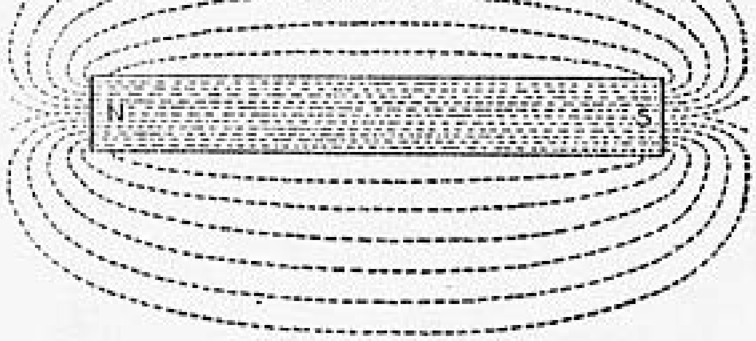


Fig. 2—Magnetic Field

In 1812, Oersted discovered that a compass needle, which is nothing but a permanent magnet freely suspended or supported, when placed near a conductor in which there was a direct current, was acted upon by a force that tended to bring the needle into a position at right angles to the conductor. This simple experiment proved to Oersted that there was a magnetic field produced by the current in the conductor. He also found that there was a definite relation between the direction of the current in the conductor, and the direction in which the north pole of the compass needle pointed. If the compass needle is allowed to come to rest in the earth's magnetic field, and a conductor is placed above it, the conductor being parallel to the needle, and a current then sent through the conductor, the needle will be deflected from its position of rest. Reversing the current in the conductor, reverses the direction in which the needle is deflected. If the needle be allowed to come to rest while there is a current in the conductor, and this current is then increased, it will be found that the deflection of the needle will be increased, but not in direct proportion to the increase in the current. Hence the strength of this magnetic field surrounding the conductor depends upon the value of the current in the conductor, and the direction of the field depends upon the direction of the current.

If a conductor be passed through a piece of cardboard, as shown in Fig. 3, and a current sent through it in the direction indicated by the arrow A, a compass needle, moved about the conductor in the path indicated by the dotted line, will always assume such a position that the north pole points around the conductor in a clockwise direction as you look down on the cardboard. If the current be reversed, the direction assumed by the compass needle will be reversed. Looking along a conductor in the direction of the current, the magnetic field will consist of magnetic lines encircling the conductor. These lines will be con-

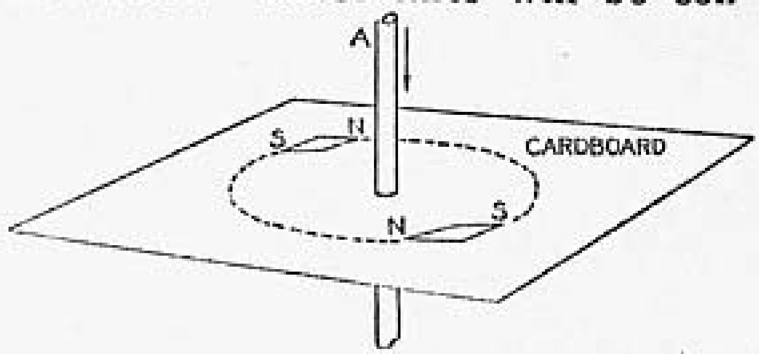


Fig. 3—Magnetic Field around Conductor

centric circles, as a general rule, except when they are distorted by the presence of other magnets or magnetic materials, and their direction will be clockwise.

The strength of the magnetic field at any point near this conductor will depend upon the value of the current in the conductor, and the distance the point is from the conductor. The magnetic field surrounding a conductor is shown in Fig. 4. The plus sign in-

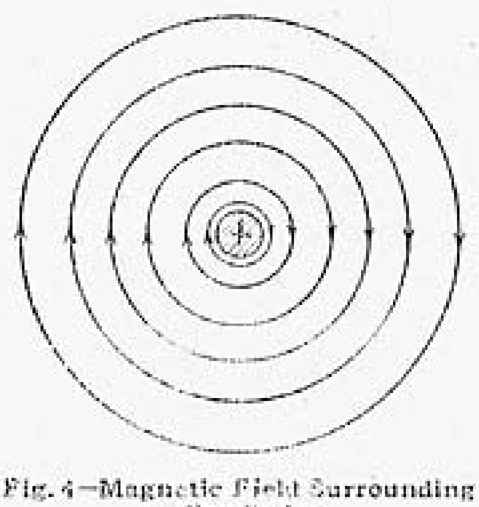


Fig. 4—Magnetic Field Surrounding a Conductor

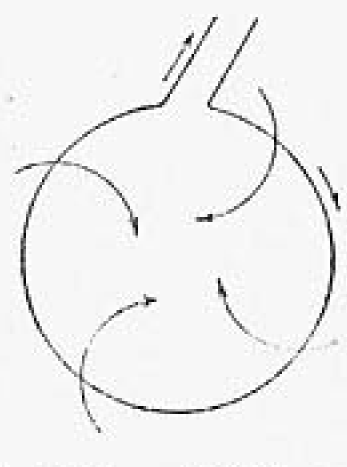


Fig. 5—Magnetic Field about a Coil

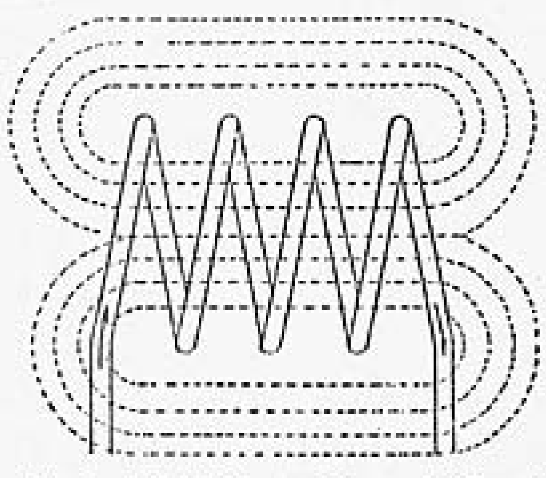


Fig. 6—A Coil about a Magnetic Circuit through Iron and Air

dicates that the direction of the current is from you. The strength of a magnetic field due to a current in a conductor can be greatly increased by forming a coil of the conductor. Each turn of the coil then produces a certain number of lines, and the greater part of these lines pass through the center of the coil, as shown in Fig. 5. The field strength inside such a coil is dependent upon the number of turns in the coil, and the value of the current in these turns. Increasing the number of turns in the coil increases the number of magnetic lines passing through the center of the coil, as shown in Fig. 6. If the current be decreased in value, the field strength is decreased, and if the current be reversed in direction, the magnetic field is reversed in direc-

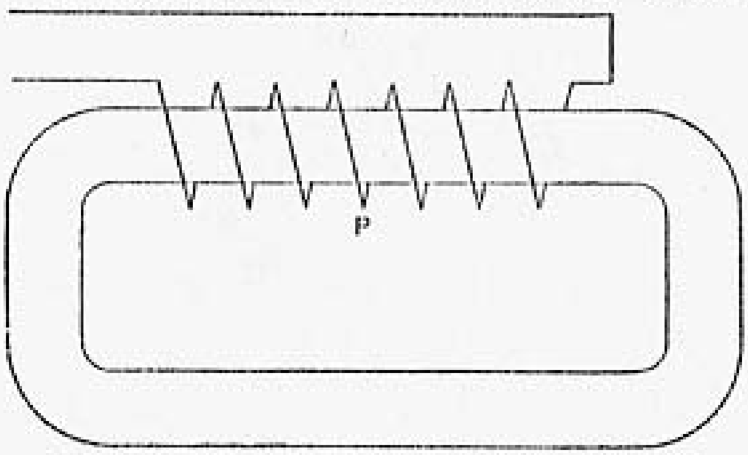


Fig. 7— A Coil about a Magnetic Circuit through Iron

tion. The number of magnetic lines passing through the solenoid depends also upon the kind of material composing the core of the solenoid, in addition to the number of turns and the value of the current in these turns. The number of lines per unit area inside a solenoid with an air core can be multiplied several times by introducing a soft-iron core. If this core be extended as shown in Fig. 7, the magnetic circuit (the path through which the magnetic lines pass) may be completed through it. The larger part of the total number of lines will pass through the iron, as it is a much better conductor of magnetism than air.

In 1831, Michael Faraday discovered that there was an electrical pressure induced in an electrical conductor when it was moved in a magnetic field so that it cut some of the lines forming the field. If this conductor be made to form part of a closed electrical circuit, there will be a current produced in the circuit as a result of the induced electrical pressure. The value of this induced electrical pressure depends upon the number of magnetic lines of force that the conductor cuts in one second. If 100,000,000 lines are cut in one second, an electrical pressure of one volt is produced. The direction of the induced pressure depends upon the direction of the movement of the conductor and the direction of the lines of force in the magnetic field; reversing either the direction of the magnetic field or the motion of the conductor, reverses the direction of the induced pressure. If both the direction of the magnetic field, and the direction of the motion of the conductor be reversed, there is no change in the direction of the induced pressure, for there is then no change in the relative directions of the two. The same results can be obtained by moving the magnetic field with respect to the conductor in such a way that the lines of force of the field cut the conductor.

If a permanent magnet be thrust into a coil of wire, there will be an electrical pressure set up in the coil so long as the turns of wire forming the coil are cutting the lines of force that are produced by the magnet. When the magnet is withdrawn, the induced electrical pressure will be reversed in direction, since the direction of cutting is reversed. A magnetic field may be produced through a coil of wire by winding it on the magnetic circuit shown in Fig. 8. Now any change of current in the coil P will cause a change in the number of magnetic lines passing through S and hence there will be an induced electrical pressure set up in S so long as the number of lines passing through it is changing. The pressure induced in

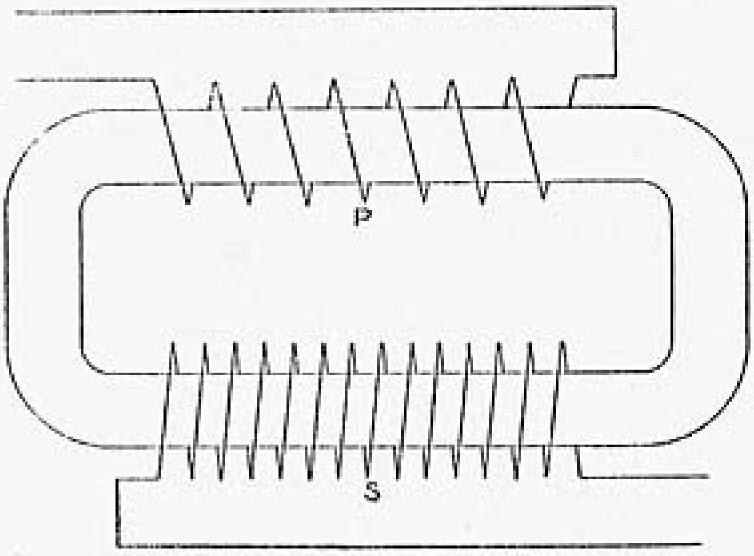


Fig. 8—Two Coils about a Magnetic Circuit through Iron

each of the turns comprising the coil S depends upon the change in the number of magnetic lines through it.

Let us now consider a condition of operation when there is no current in the secondary coil and the primary coil is connected to some source of electrical energy. When this is the case the current in the primary coil is not determined by Ohm's law, which states that the current is equal to the electrical pressure divided by the resistance, but is considerably less in value, for the following reason. The magnetic lines of force produced by the current in the primary induces an electrical pressure in the primary winding itself, the direction of which is always opposite to the impressed pressure, or the one producing the current. As a result of this induced pressure being set up in the primary, the effective pressure acting in the circuit is decreased. At the same time there is an electrical pressure induced in the secondary winding in the same direction as that induced in the primary.

If the secondary circuit be connected to a load, there will be a current in the secondary winding, which will pass around the magnetic circuit in the opposite direction to the primary current, and as a result will decrease the number of lines passing through the primary coil. This will in turn decrease the electrical pressure induced in the primary coil, and a larger current will exist in the primary winding than there was before any current was taken from the secondary coil. The decrease in induced pressure is small, but it is always ample to allow the required increase in primary current. There is, at the same time, a small decrease in the secondary pressure.

When the transformer is operating on no load, with no current in the secondary coil, the induced pressure in the primary coil is practically equal to the impressed pressure and hence a very small current will be taken from the source of energy. It is apparent now that if the primary and secondary coils have the same number of turns, the induced electrical pressure in each of these coils will be the same, assuming, of course, that all the magnetic lines that pass through the primary also pass through the secondary coil, and vice versa, or the secondary pressure is practically the same as the pressure impressed on the primary. If the number of turns in the secondary coil is greater or less than the number of turns in the primary, the magnetic lines will be cut a greater or less number of times by the secondary coil, and hence the induced pressure will be greater or less, depending upon the relation of the number of turns in the two coils.

PART II—Construction

Transformers may be divided into two main groups, the classification being made according to the relation between the magnetic circuit of the transformer and the primary and secondary windings. When the two windings surround the magnetic circuit of a transformer, as indicated in Fig. 9, the transformer is said to be of core type. If the magnetic circuit surrounds the windings, as indicated in Fig. 10, the transformer is said to be of the shell type. The following in-

 GRANDDAD'S ELCTRICITY BOOK

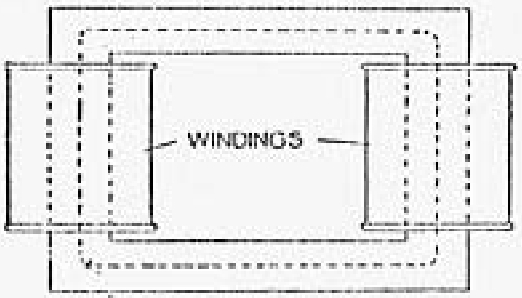


Fig. 9 — Core-Type Transformer

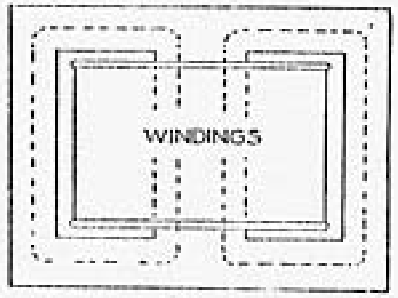


Fig. 10 — Shell-Type Transformer

structions are for a shell-type transformer.

Any mass of magnetic material, such as a piece of soft iron, when placed in a magnetic field that is produced by an alternating current, will be rapidly magnetized and demagnetized, the rapidity of the change depending upon the frequency of the current producing the field. When a piece of iron is magnetized and demagnetized, as just stated, there will be a certain amount of heat generated in it and this heat represents energy that must come from the electrical circuit producing the magnetic field in which the iron is placed.

The heat that is generated in the iron is due to two causes: First, the hysteresis loss which is due to a property of the iron that causes the magnetism in the iron to lag behind the magnetizing influence, or the changes that are constantly taking place in the field strength due to the alternating current. This loss cannot be entirely eliminated, but it may be reduced to a very low value by using a soft grade of iron, or one having what is called a low hysteretic constant. Second, the eddy-current loss which is due to the circulation of currents through the mass of metal. These currents are due to unequal electromotive forces set up in the different parts of the piece of metal when there is a change in the strength of the field in which the metal is placed. This loss cannot be entirely eliminated, but it can be greatly reduced by breaking the mass of metal up into parts and insulating these parts from each other, which results in the paths in which the eddy currents originally circulated being destroyed to a certain extent.

The breaking up of the metal is usually made in such a way that the joints between the various parts are parallel to the direction of the magnetic field. When the joints are made in this way, they offer less opposition to the magnetizing force. This is one of the principal reasons why induction-coil cores are made up of a bundle of wires instead of a solid piece. These wires are annealed or softened to reduce the hysteresis loss that would occur. The combined hysteresis and eddy-current losses, which are spoken of as the iron losses, will of course be very small in the transformer you are going to construct, but the above discussion is given to show why the magnetic circuits of transformers are built up from sheets of soft iron, called laminations. The core is said to be laminated.

The dimensions of the complete magnetic circuit, of the transformer you are going to construct, are given in Fig. 11. The primary and secondary windings are both to be placed about the center portion C, and it is apparent that the winding of these coils would be very tedious if the wire had to be passed back and forth through the openings A and B. This procedure in winding can be prevented by first forming the part of the magnetic circuit upon which the windings are placed; then wind on the coils and, after they are completed, finish build-

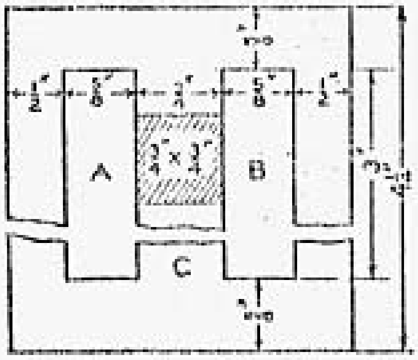


Fig. 11 — Complete Magnetic Circuit

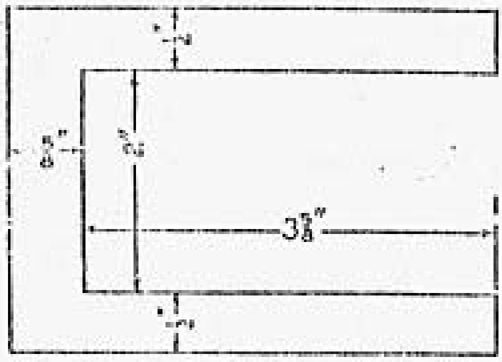


Fig. 12 — Outer Portion of the Magnetic Circuit

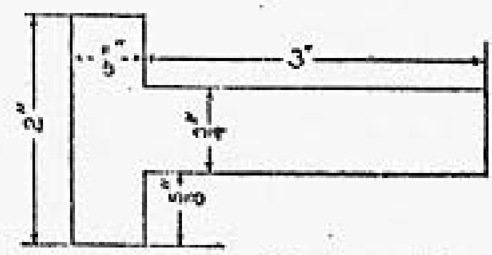


Fig. 13 — Inner Portion of the Magnetic Circuit

ing up the magnetic circuit with pieces cut to the proper size and shape.

Procure a small quantity of soft, thin sheet iron and cut out a sufficient number of rectangular pieces, 3 in. by 4¼ in., to make a pile ¾ in. in height when firmly pressed together. Now cut a rectangular notch in each of these pieces, 2 in. wide and 3⅝ in. long. The sides of this notch can be cut with a pair of tinner's shears, and the end can be cut with a sharp cold-chisel. Be careful not to bend either piece any more than you can help. The outside piece, or the one in which the notch is cut, should have dimensions corresponding to those given in Fig. 12. When all of these pieces have been cut, as indicated above, the rectangular pieces, 2 in. by 3⅝ in., that were cut out to form the notch in the larger pieces, should have two of their corners cut away, so as to form pieces whose dimensions correspond to those given in Fig. 13. These last pieces are to form the core and part of the end of the transformer. Now make sure that all the edges of the pieces are perfectly smooth and that they are all of the same size; then give each one a coat of very thin shellac.

Now cut from a piece of insulating fiber, that is about $\frac{1}{16}$ in. thick, two pieces whose dimensions correspond to those given in Fig. 14. When these pieces are completed, the core of the transformer can be assembled as follows: Place the T-shaped pieces, whose dimensions correspond to those given in Fig. 13, through the openings in the pieces of insulation, alternate pieces being put through the openings from opposite sides. The distance from outside to outside of the pieces of insulation should be exactly the same as the length of the vertical portion of the T-shaped pieces forming the core, or 3 in.

Cut from some soft wood four pieces having cross sections whose dimensions correspond to those given in Fig. 15, and of such a length that they will just slip down between the two pieces of insulation. These pieces should now be placed on the four sides of the iron core and covered with several layers of heavy insulating cloth. Each layer of the cloth should be shellacked as it is put on, which will increase the insulation and at the same time help in holding the wooden pieces in place. You are now ready to start winding the transformer.

The secondary, which is the low-voltage side in this case, as you are using the transformer to reduce or step down the voltage, will have the smaller number of turns, and larger wire should be used in winding it than in the primary, as it will carry a larger current. On account of the secondary being of larger wire, it will be placed on the core first. For this winding you will need a small quantity of No. 26 B. & S. gauge, single cotton-covered wire. Drill a small hole through one of the insulating washers, down close to the cloth covering the core, being careful at the same time to keep the hole as far from the metal part of the core as possible. Pass the end of a short piece of No. 18 or 20 B. & S. gauge, double

 GRANDDAD'S ELCTRICITY BOOK

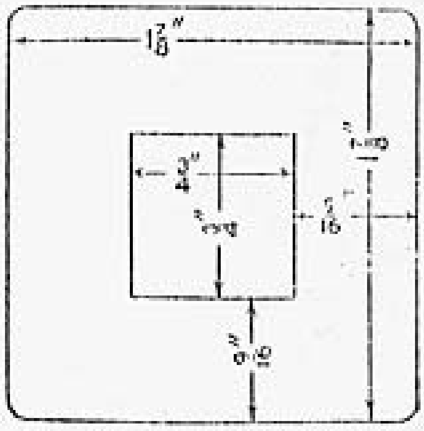


Fig. 14—Insulating Washer

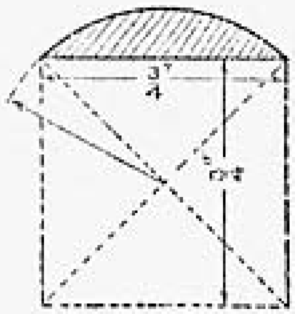


Fig. 15—Wood Filler

cotton-covered wire through this opening and solder it to the end of the No. 26 wire. Insulate the joint with a piece of paraffin paper or cloth, and bind the piece of heavy wire to the core of the transformer with a piece of linen thread.

Now wind the No. 26 wire on the core as evenly as possible, to within about ⅛ in. of the end of the spool. Place over the first layer two layers of paraffin paper and wind on a second layer of wire. Three layers should give you the required number of turns in the secondary winding and a resistance of approximately 3½ ohms. The end of the secondary winding should be terminated in the same way as the winding was started. Outside of the completed secondary winding place at least six layers of paraffin paper, or several layers of insulating cloth. The paraffin paper used should be approximately five mills in thickness. You can make your own paraffin paper by taking a good quality of writing paper about two mills thick and dipping it into some hot paraffin, then hanging it up by one edge to drain.

The primary winding is to be made from No. 34 B. & S. gauge, single silk-covered copper wire. The inside end of this winding should be started in the same way as the secondary, but at the end opposite to the one where the secondary terminated. Wind about 240 turns on each layer and place one layer of paraffin paper between each layer of wire. The primary winding should have at least 12 layers, and the outside end should be terminated as the inside end. Outside of the completed windings, place several layers of insulating cloth to serve as an insulation, and at the same time provide a mechanical protection for the windings.

The outside part of the magnetic circuit can now be put in place. When the U-shaped pieces are all in place, the magnetic circuit will have the form and dimensions shown in Fig. 11. A clamp should now be made for each end of the transformer, to hold the pieces forming the magnetic circuit together, and at the same time give an easy means of mounting the transformer. Cut from a piece of sheet iron, about $\frac{1}{16}$ in. in thickness, two pieces whose dimensions correspond to those given in Fig. 16, and two pieces whose dimensions correspond to those given in Fig. 17. Drill the holes in these pieces as indicated, and bend the larger ones into the form shown in Fig. 18. These pieces can now be clamped across the ends of the transformer with small bolts, as shown in Fig. 19.

A box should now be made from sheet iron to hold the transformer. The box should be of such dimensions that it will be at least ⅛ in. from the transformer at all points. This box should be provided with a cover that can be easily removed.

Now mount the transformer in the box by means of small bolts, that pass through the holes in the supports and holes in the bottom of the box. Two binding-posts can now be mounted on one end of the box, and insulated from it, to serve as terminals for the secondary winding. Two pieces of stranded No. 14 B. & S. gauge, rubber-covered copper wire should now be soldered to the terminals of the primary circuit and passed out through insulating bushings mounted in holes cut in the end of the box opposite to the one upon which the binding-posts were mounted. These heavy wires should be firmly fastened to the iron

Fig. 16.—Upper Clamping Pieces

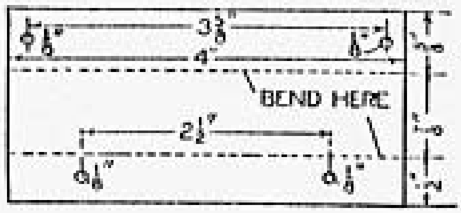


Fig. 17—Lower Clamping Pieces and Mounting Supports

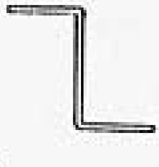


Fig. 18—Shape of Support

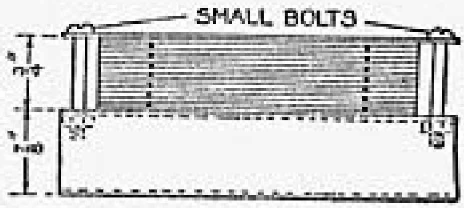


Fig. 19—Method of Clamping Transformer Together

part of the transformer inside the box, so that any outside strain placed upon them will not, in time, break them loose from the smaller wires. Be sure to insulate all joints and wires well inside the box.

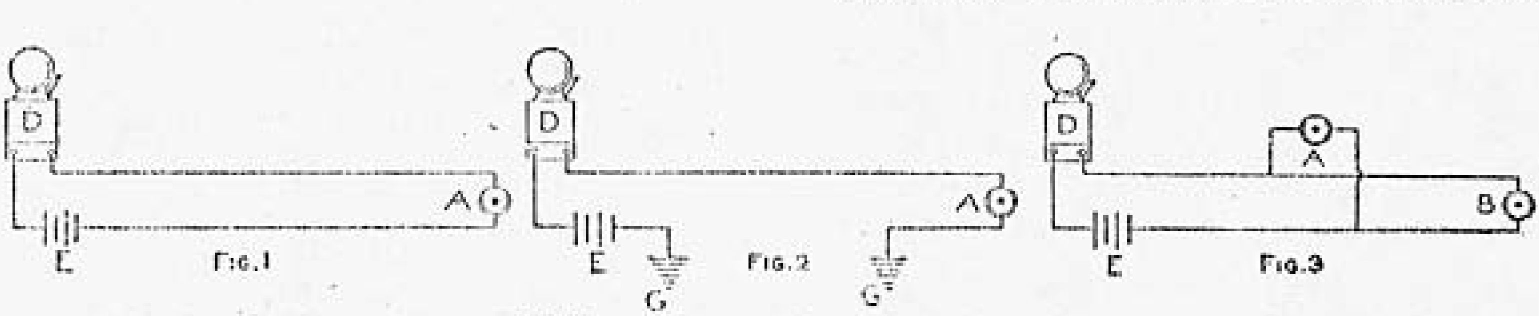
A circuit can now be run from a 110-volt lighting or power circuit, observing the same rules as though you were wiring for lights, and connected to the heavy wires, or primary circuit. The binding-posts, or secondary winding should be connected to the bell circuit and the transformer is complete and ready to operate. You may have to change the adjustment of the bells, but after a little adjustment they will operate quite satisfactorily.

THE BOY MECHANIC – 1915

Simple Methods of Connecting Call Bells

The following diagrams will indicate a few of the various methods that may be employed in connecting up electric bells for different purposes, A, B and C representing the push buttons; D, the bells; E, the batteries, and G, the ground. The simplest possible connection is shown in Fig. 1, the bell D, battery E, and push button A, are all connected in series. The operation of the bell is independent of the order in which the bell, battery, and push button are placed, so long as there is a complete circuit when the push button is pressed. One of the wires in this circuit may be done away with by completing the circuit through the ground, as shown in Fig. 2. Connecting a bell as shown in this diagram often results in quite a saving of wire. The proper connections for operating one bell from either of two push buttons, A or B, is shown in Fig. 3. Two bells, D, operated from a single push button, C, are connected as shown in Fig. 4. The two bells, D, are shown connected in parallel, which requires more wire than if they were connected in series. If they be connected in series, one or the other should have its make-and-break contact closed. The bell whose circuit remains unchanged will intercept the current for the other bell in series with it. The operating of the bells is more satisfactory, however, when they are in parallel, and each taking current from the battery independent of the other.

The diagram, Fig. 5, shows the proper connections for operating two bells from two independent push buttons, each push button operating a particular bell. Any number of bells operated from any number of push buttons, all of the bells being rung from any one of the push buttons, are



Wiring Diagrams for a Single Bell

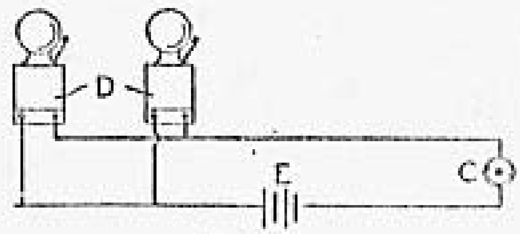


FIG. 4

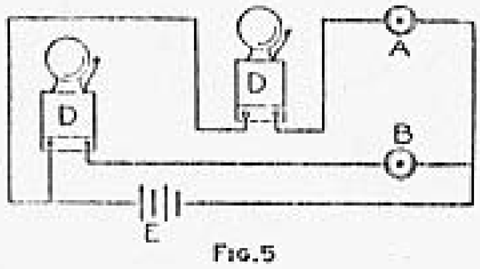


FIG. 5

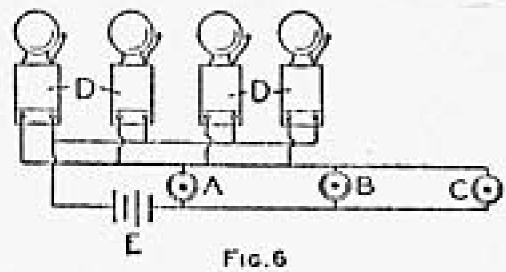


FIG. 6

Wiring Diagram for Two or More Bells

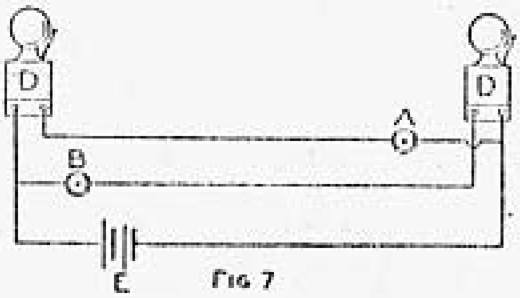


FIG. 7

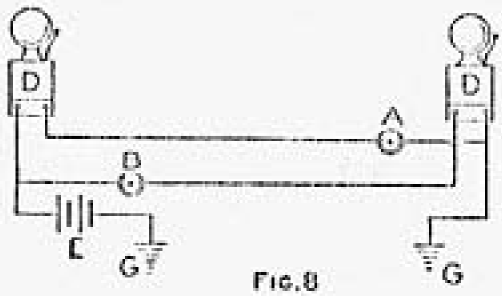


FIG. 8

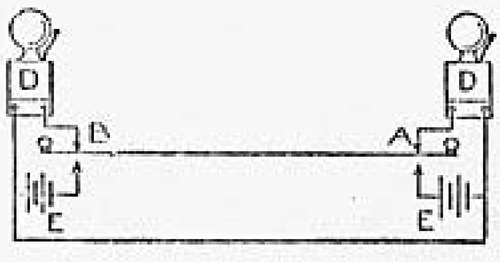


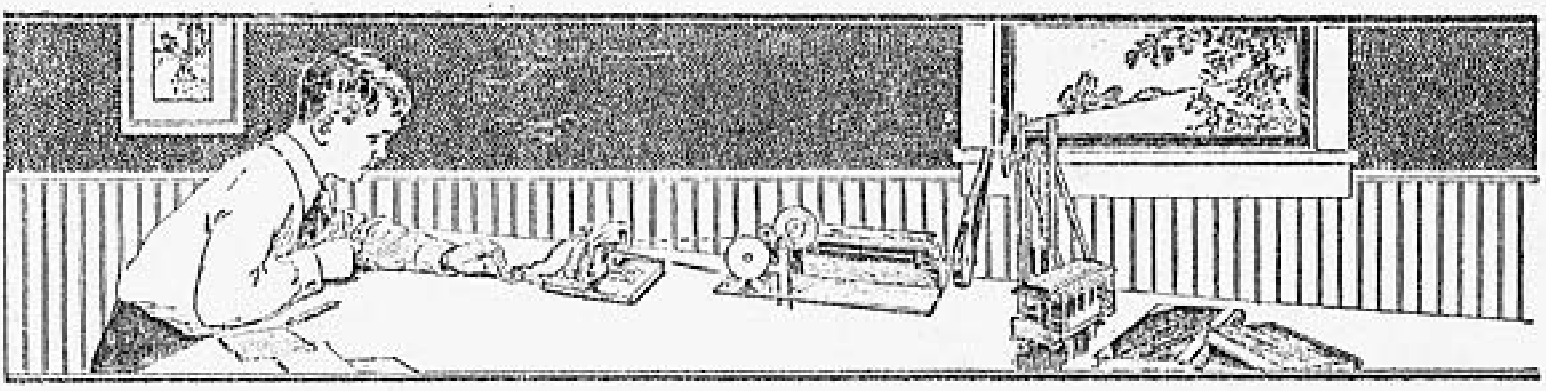
FIG. 9

Wiring Diagrams for Return-Call Bells

connected as shown in Fig. 6. Such a circuit can be used as a fire alarm or time call in a factory, the operation of the circuit being controlled from any one of a number of different points.

The proper connections for what is called a return-call circuit is shown in Fig. 7. The circuit is so arranged that the bell at one end is controlled by the push button at the other end. Such a circuit can be used in transmitting signals in either direction. A ground return-call circuit is shown in Fig. 8. In the circuits shown in Figs. 7 and 8, only one battery is needed.

The connections of a two-wire metallic return-call circuit are shown in Fig. 9. A special push button must be used in this circuit, and in this case two batteries are used instead of one, as in Figs. 7 and 8. This circuit may be changed to a ground return-call circuit by using the earth as a conductor instead of either wire. There are, of course, numerous other methods that may be used in connecting call bells, but the connections shown in the diagrams are perhaps the most common.



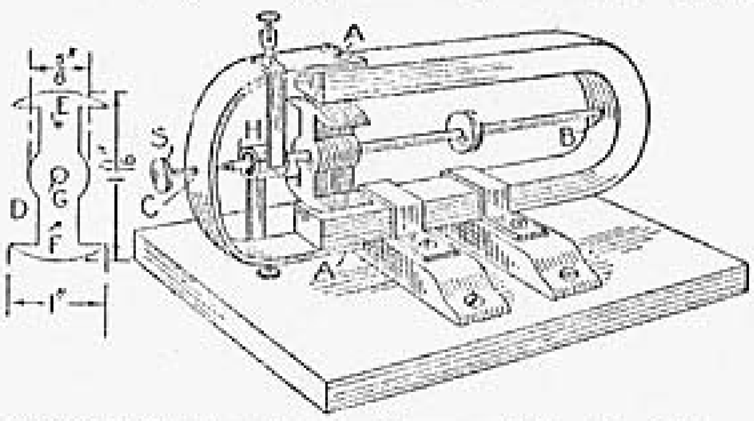
How to Build a Simple Electric Motor

By A. G. McCLURE THE BOY MECHANIC – 1915

An exceedingly simple and inexpensive motor that may be used in operating small toys can be constructed as follows: First procure a good permanent magnet, about 5 in. long and about 1½ in. between the inside edges at the open end. This magnet should be at least ½ in. thick, and if it cannot be had in one piece, two or more may be placed side by side, like poles being placed together. The writer was unable to procure ready-made magnets, so one was formed and magnetized. Obtain a piece of tungsten or some other good-grade steel, ½ in. by ½ in., and about 11 in. long. Bend this piece into the form of a U, with the inner edges 1¾ in. apart. Square off both ends and drill two small holes in the outside surface of each end, at AA, about ⅜ in. from the end. Tap these holes for small machine screws. Drill the hole B with a small drill, about 1/16 in., in the center of the lower portion of the U and ream it out. The piece should now be clamped with a good pair of blacksmith's tongs,—a block of iron being placed between the ends to keep the pressure of the tongs from drawing them together—heated to a cherry red and then plunged into a bath of oil. It can then be magnetized by placing it in contact with a permanent magnet.

Next obtain a piece of ⅛-in. brass, about ½ in. wide and 5½ in. long. Drill two holes in each end of the piece to match those drilled in the ends of the magnet, also one in the center, and tap it for a ⅛-in. machine screw. Now bend this piece into the form shown. Provide a machine screw, S, for the hole C and drill a small tapered hole in the end of the screw.

Obtain a small quantity of soft sheet iron and cut a sufficient number of pieces similar to that shown at D to make a pile ½ in. high. Cut two



Detail of Armature Laminations, and Completed Parts Assembled, but without Armature Windings

pieces of the same size from some thin sheet brass. Now place all of these pieces in a pile, the brass pieces being on the outside, and clamp them securely, then drill the two small holes, E and F. Place two small copper rivets in these holes and rivet the heads down before removing the clamp. Drill a ⅛-in. hole, G, through this piece, the armature, for the shaft to pass through. Procure a piece of ⅛-in. steel rod, about 6 in. long. Sharpen one end so that it will enter the hole B, then cut the other end off and sharpen it so that it will enter the opening made in the end of the screw S. The armature may now be soldered to this shaft, its left-hand surface being flush with the ends of the magnet.

A small commutator, H, should now be made as follows: Obtain a piece of thin brass tubing about ⅝ in. in diameter. Turn down a piece of hard rubber so that the tube will fit tightly on it. Drill a hole in this piece of rubber of such a size that it will have to be forced on the steel shaft. Saw two longitudinal slots in the brass tube diametrically opposite each other and then bind these two pieces in place on the piece of rubber with some heavy linen thread wrapped around each end. The armature is now ready to wind. Get a small quantity of No. 22 gauge cotton-covered wire, solder one end to one of the segments of the commutator, then wind one end of the armature full and cross over and wind the other end full, soldering the end of the wire to the second commutator segment. Make sure to wind both ends of the armature in the same direction so the current in both parts of the winding produces magnetizing effects in the same direction. Insulate the winding from the core and the different layers from each other with a good quality of thin writing paper.

Two small brushes should now be made from some thin spring brass and mounted on the brass piece as shown. These brushes should be insulated from the piece of brass and two small binding posts should be provided for making connections to them. The position of the commutator and brushes

 GRANDDAD'S ELCTRICITY BOOK

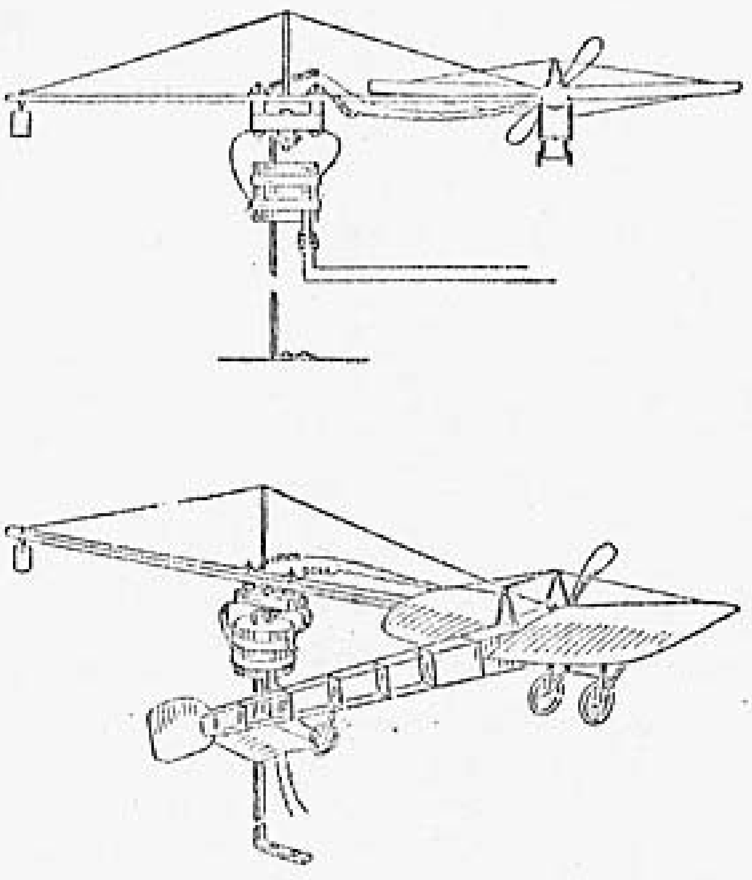
should be such that the brushes move from one segment to the other when the ends of the armature are directly in line with the ends of the permanent magnet.

A small pulley should be mounted upon the shaft to be used in transmitting the power. The whole device may be mounted in a horizontal position on a wooden base as shown, and the motor is complete.

THE BOY MECHANIC – 1915

Flying Model Aeroplane for a Display

A novelty for a window display is made of a model aeroplane flying by its own power. To control the direction and make the model fly in a circle



Detail of Parts Showing Wire Connections and Model in Flight around the Central Axis

it is fastened to a long stick or beam which is pivoted in the center. The one shown was pivoted to a roller-skate wheel which in turn was fastened to a metal standard. The beam was attached to the skate wheel with two small bolts which were insulated and carried two brushes as commutator contacts.

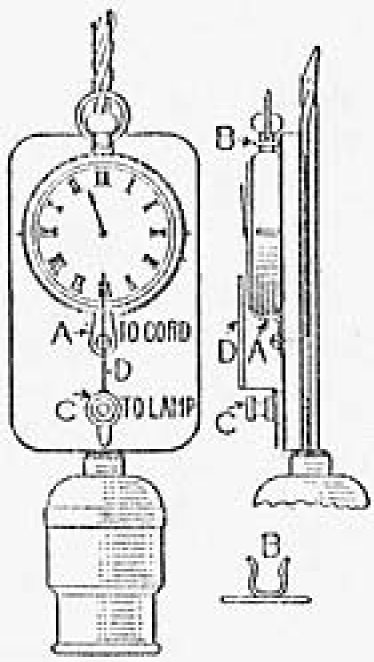
The commutator rings were made of heavy brass strips, fastened to a round piece of wood which was attached to the metal standard. The wires from the current supply were connected to the commutator rings. From the brushes connecting wires were carried along the beam to the aeroplane motor which was a small battery motor with propeller.

The opposite end of the beam was weighted to balance it. The first sketch shows the parts and the manner of making the connections. The aeroplane is driven in a circular path by its own power in a realistic manner.

THE BOY MECHANIC – 1915

An Electric Time Light

Although the modern alarm clock is a wonderfully effective piece of mechanism, it is, to say the least, very abrupt in its manner. It seldom confines its efforts to the chamber of its owner, but spreads its disturbance all over the building. It is very easy for a person to arise early in the summer and no greater difficulty should be experienced in winter, if the bedroom is brightly lighted at the proper hour. To do this simply and automatically became the problem.



The first thought was to obtain one of those clock-actuated electric-light switches, such as the stores use, but this would not do, because it meant some unsightly wiring around the room. It was then remembered how, in the course of some experiments, an ordinary incandescent light was operated through a piece of No. 36 gauge wire without any sign of heating. If, then, a wire only 1/200 in. in diameter were of ample carrying capacity, surely a dollar watch would be sufficient to make the connection. Such being the case, the whole mechanism could readily be attached to the drop cord of a lamp directly above the socket, thus obviating any additional wiring. This all proved to be true, and the whole was made and attached in the course of a couple of hours.

While one might feel enthusiastic about this small and easily contrived affair, it is scarcely to be presumed that it would operate so effectively on one who had spent the larger part of the night tripping the "light fantastic," or in undue conviviality. An ordinary 16-cp. globe has thus far operated perfectly, and a 40-watt tungsten lamp would, if not too far away, surely awaken the hardest sleeper of sober habits.

The base of the mechanism is a small piece of ¼-in. hard wood, upon which is fastened a small brass bracket, A, bent so as to hold the watch from slipping down. A small clip, B, was then arranged so as to grip the neck of the watch after its lower edge had been placed against A, and a small brad at either side prevented lateral movement. In this way the watch was held firmly, yet in a manner that would permit its being taken out instantly when necessary. The glass and minute hand were removed. The brass bolt from an exhausted dry cell was placed at C, so as to clamp a small copper washer to which was soldered a narrow strip of copper, D, about $\frac{1}{16}$ in. wide and cut from a leaf of an old dynamo brush. This strip is arranged so as to wipe the hour hand as it travels past, but being so thin, it has no appreciable effect on the time keeping. As illustrated, the device is set for six o'clock, but by loosening the nut C an hour's adjustment either way may be had. It is a very simple matter, however, to arrange the device so it will operate at any hour. In connecting up, one end of the drop cord is removed from the socket and attached to A, which throws the current through the watch, thence along the hand and down D to C, from where it is carried by a short piece of wire to the socket again. As there are so many circuits through the watch, the small current required for one light does not affect it in any way. Thus far, no trouble has been experienced in making this delicate connection with 110 volts, but if any should develop, the contacts may be tipped with the small pieces of platinum taken from a burned-out globe.

THE BOY MECHANIC – 1915

A Small Shocking Machine

AN amusing as well as instructive shocking machine, usually called

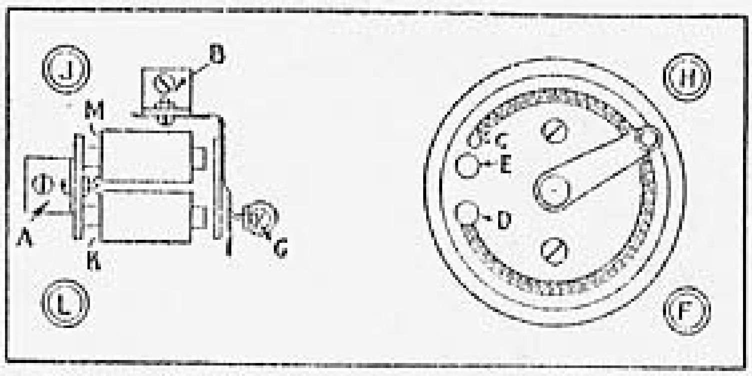


Fig. 1

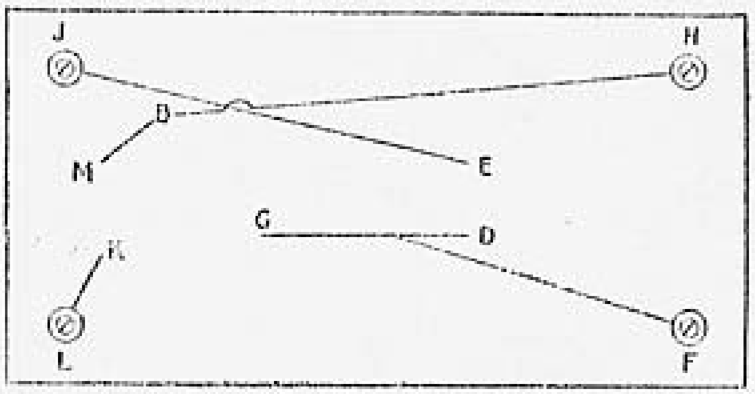


Fig. 2

The Base upon Which the Buzzer and Rheostat are Fastened, and the Electrical Connections

a medical coil, can be easily constructed from a discarded buzzer or electric bell, four binding posts, some pieces of insulated wire, two carbon rods, and a rheostat.

A base for attaching the

parts is made of a piece of poplar, 10 in. long, 5 in. wide, and ½ in. thick, which can be finished as desired, but a good method is to shape the edge like molding and give it a mahogany stain, and when dry apply a coat of white shellac, which should be allowed to dry a day, whereupon the surface is rubbed with prepared wax. When the base is ready, mount the buzzer at one end. This can be easily done by making an L-shaped piece of metal, A, which is fastened to the base with a screw, and to the yoke of the magnet coil with a small bolt. If the armature and its connections are also used from the buzzer, the height of the coils must be taken in consideration. These parts are fastened in position as shown, using an L-shaped piece of metal, B, for the spring end. The screw holding the armature spring to the base, as well as the vibrator screw, should be of such a length that it will enter the base far enough to permit a connection for a wire in a countersunk hole bored in the base from the under side. Binding posts are placed in the corners of the base in holes countersunk from the under side for the screw heads.

The Shocking Coil as It is Used for Amusement, or in the Manner a Current is Given a Patient

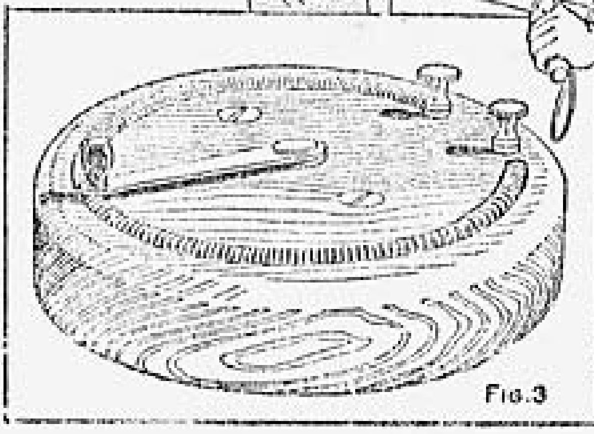


Fig.3

Left: The Rheostat That is Used to Regulate the Flow of Current in the Carbon Hand Pieces

The rheostat is of the miniature-battery type, which has a round base and a coil of resistance wire with a lever passing over the coil. Such a rheostat can be purchased from an electrical store, but if the person constructing the shocking machine desires to make one, it is not difficult if a lathe is at hand.

To make the rheostat, turn up a disk, about 3 in. in diameter, from a piece of hard wood, such as oak, maple, or walnut, and form a circular groove in the upper surface, about ⅜ in. inside of the circumference. The groove is to admit a circular coil of resistance wire, and in making it, be sure to have it the proper size to take the coil snugly. The coil can be of any size, and to make it, resistance wire is wound around a piece of wire used as a mandrel. If the coil is ¼ in., or a trifle smaller, in diameter, it will make a good size. Be sure that the depth of the groove is such that it will allow a part of the coils of the resistance wire to project above the surface of the wood disk. The coil of wire should be just long enough to fit in the groove and allow a 1-in. space between the ends, one of which is anchored to the base, at C, the other being attached to the binding post D. Drill a hole through the center of the disk and fasten a lever, taken from a switch, or one made of a piece of sheet brass, that will extend from the center to the outside of the disk, or over the resistance-wire coil. A small handle is attached to the outer end. A connection is made from the center support of the lever to the binding post E.

The connections for the buzzer and rheostat are made on the under side of the base, where grooves are cut to run the wires in, so that they will be below the surface of the wood. In the diagram, the binding post F is connected to the binding post D of the rheostat, which in turn is connected to the screw of the make-and-break point G. The other binding post H is connected to the bracket B supporting the armature spring. The binding post E of the rheostat is connected to the base binding post J. The magnet coils are connected, as shown, from K to L, and from M to B.

The two pieces of carbon, which are used for the hand pieces, are connected with silk-insulated wire. These connections are made to the binding posts F and H. The other two binding posts, J and L, are connected to a battery. The carbons used may be purchased, or taken from an old battery. Two or more dry cells are used for the current. The rheostat controls the amount of current passing through the hand pieces.—Contributed by Gilbert Crossley, Erie, Pa.

THE BOY MECHANIC – 1915

An Electric Anemometer

By WM. H. DETTMAN

The construction of this instrument is so simple that any amateur can make one, and if accurate calibrations are desired, these can be marked by comparison with a standard anemometer, while both are placed in the wind.

The Indicator

The case of the indicator is built of thin wood—the material of an old cigar box will do—9 in. long, 6 in. wide and 1½ in. deep. If cigar-box material is used, it must first be soaked in warm water to remove the paper. If a cover is to be used on the box, a slot, on an arc of a circle, must be cut through it to show the scale beneath. The arc is determined by the length of the needle from a center over the axis on which the needle swings. When the box is completed, smooth up the outside surface with fine sandpaper and give it a coat of stain.

The core of the magnet is made by winding several layers of bond paper around a pencil of sufficient size to make an inside diameter of slightly over ¼ in., and a tube 2 in. long. Each layer of the paper is glued to the preceding layer.

Two flanges or disks are attached to the tube to form a spool for the wire. The disks are cut from thin wood, 1¼ in. square, and a hole bored through their centers so that each will fit on the tube tightly. One of them is glued to one end of the tube and the other fastened at a point ½ in. from the opposite end. The space between the disks is filled with seven layers of No. 22 gauge insulated magnet wire, allowing sufficient ends of the wire to project for connections. The finished coil is located in the box, as shown at A, Fig. 1.

The core for the coil is cut from a piece of ¼-in. iron rod, 1¼ in. long, and a slot is cut in each end, 1/4 in. deep, into which brass strips are inserted and soldered, or otherwise fastened. The strips of brass are 3/16 in. wide, one 1 1/2 in. long and the other 3/4 in. Two 1/16-in. holes are drilled in the end of the long piece, and one 1/16-in.

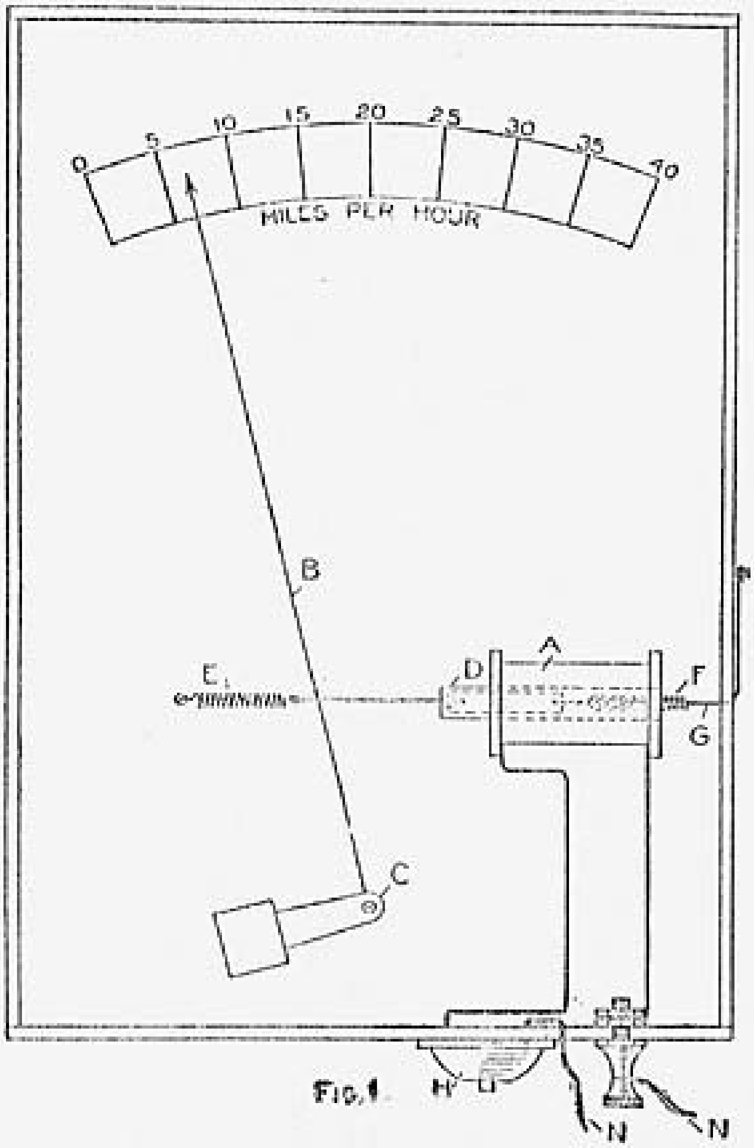


FIG. 1

The Indicator Box with Coil, Needle and Scale, as It is Used in Connection with the Anemometer

hole in the end of the short piece. The complete core with the brass ends is shown in Fig. 2.

The needle B, Fig. 1, is made of a copper or brass wire, about 6 in. long, and is mounted on an axis at C. The detail of the bearing for the axis is shown in Fig. 3. The axis D is a piece of wood fitted in the U-shaped piece of brass and made to turn on brads as bearings, the center being pierced to receive the end of the needle. After locating the bearing for the axis C, Fig. 1, it is fastened in place so that the upper end or pointer of the needle will travel over the scale. The needle is then attached to the bearing after having been passed through the inner hole of the longer brass strip of the core, and the coil is fitted with the core in the manner shown at D. A light brass coil spring is attached to each end of the core, as shown at E and F, the latter being held with a string, G,

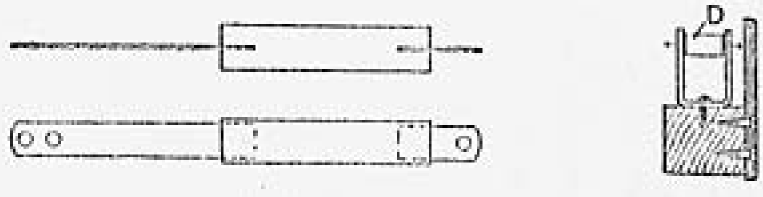


FIG. 2 FIG. 3

The Metal Core for the Coil and the Bearing Block for the Axis of the Needle

whose end is tied to a brad on the outside of the box, for adjustment. A better device could be substituted by attaching the end of the spring F to a nut and using a knurled-head bolt passed through the box side. One of the wires from the coil is attached to a push button, H, to be used when a reading of the instrument is made. The connections for the instrument consist of one binding post and a push button.

The Anemometer

The anemometer resembles a miniature windmill and is mounted on top of a building or support where it is fully exposed to the air currents. It differs from the windmill in that the revolving wheel is replaced by a cupped disk, A, Fig. 4, fitted with a sliding metal shaft, B, which is supported on crosspieces, CC, between the main frame pieces DD. The latter pieces carry a vane at the opposite end. The frame pieces are 1/2 in. thick, 2 1/4 in. wide and 36 in. long, and the crosspieces have the same width and thickness and are 4 in. long.

A variable-resistance coil, E, is made as follows and fastened in the main frame. The core of this coil is a piece of wood, 2 in. square and 4 in. long, and wound with No. 18 gauge

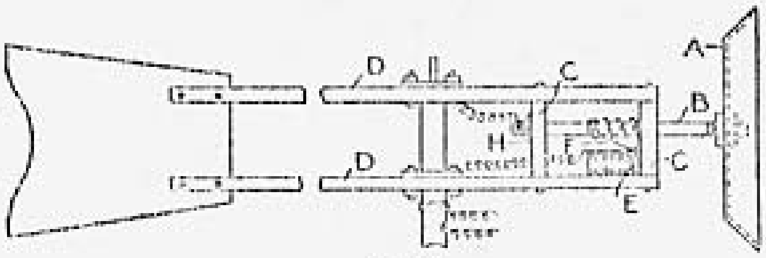


Fig. 4

The Anemometer as It is Mounted on a Standard Similar to a Small Windmill Weather Vane

single-wound cotton-covered german-silver wire. The winding should begin ¼ in. from one end of the core and finish ¼ in. from the other, making the length of the coil 3½ in. The ends of the wire are secured by winding them around the heads of brads driven into the core. A small portion of the insulation is removed from the wire on one side of the coil. This may be done with a piece of emery cloth or sandpaper. A sliding spring contact, F, is attached to the sliding shaft B, the end of which is pressed firmly on the bared portion of the wire coil. One end of a coil spring, which is slipped on the shaft between the pieces CC, is attached to the end crosspiece, and the other end is fastened to the sliding shaft so as to keep the shaft and disk out, and the flange H against the second crosspiece, when there is no air current applied to the disk A.

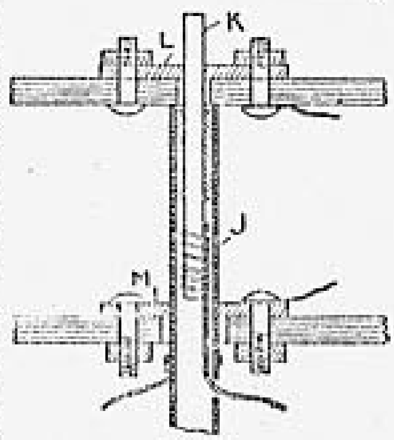


Fig. 5

The insulation of the standard upon which the anemometer turns is shown in Fig. 5. The standard J is made of a piece of ½-in. pipe, suitably and rigidly attached to the building or support, and the upper end, around which the anemometer revolves to keep in the direction of the air currents, is fitted with a plug of wood to insulate the ¼-in. brass rod K. A bearing and electric-wire connection plate, L, is made of brass, ⅛ in. thick, 2 in. wide and 4 in. long. The bearing and connection plate M are made in a similar manner. The surface of the holes in these plates, bearing against the pipe J and the brass rod K, make the two connections for the wires from the variable-resistance coil E, Fig. 4, located on the main frame, to the wire connections between the two instruments. These wires should be weather-proof, insulated, attached as shown, and running to and connecting the indicator with the anemometer at NN, Fig. 1.

Two or more dry cells must be connected in the line, and when a reading is desired, the button H, Fig. 1, is pushed, which causes the current to flow through the lines and draw the magnet core D in the coil, in proportion to the magnetic force induced by the amount of current passing through the resistance in the coils on E, Fig. 4, from the contact into which the spring F is brought by the wind pressure on the disk A.

THE BOY MECHANIC – 1915

How to Make an Electric Lamp Flasher

Procure two pieces of metal, one of brass and the other of sheet iron, 5 in. long, ½ in. wide, and $\frac{1}{32}$ in., or just a little more, in thickness. Bend the brass strip into the form shown in Fig. 1, then place the brass piece on top of the iron and drill the holes A and B indicated in Fig. 2. After the brass piece has been bent, as shown in Fig. 1, it will of course be shorter than the iron strip and the iron strip must be cut off, or a brass strip a little longer than 5 in. can be secured and cut the same length as the iron strip after it is bent. The holes A and B should be $\frac{3}{32}$ in. in diameter. The next thing to do will be to wind a heating coil about the brass strip. Wrap a very thin layer of sheet asbestos about the brass strip, and wind on the strip 18 ft. of No. 34 gauge bare superior resistance wire. Use a thread about .006 in. in diameter

 GRANDDAD'S ELCTRICITY BOOK

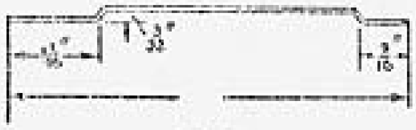


Fig. 1

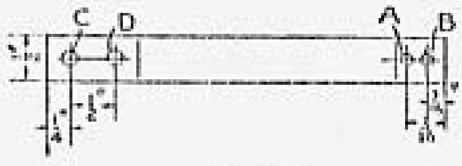
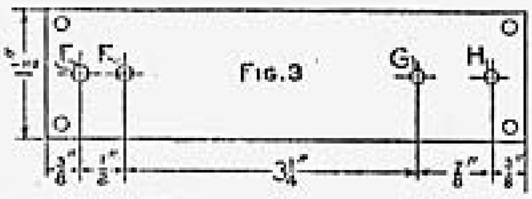


Fig. 2



Dimensions of the Brass Strip and Mounting Base, Showing the Location of the Holes and the Shape of the Brass Strip to Receive the Coil of Wire

to separate the various turns. This thread can be removed after the winding is completed and the ends have been fastened. Rivet the iron and brass pieces together with a small brass rivet in the hole A, Fig. 2. After the two pieces are riveted together bend them into the form shown in Fig. 4 and then drill the two 1/8-in. holes C and D, as shown in Fig. 2. Tap the hole B, Fig. 2, to take a small machine screw.

The base is constructed as follows: Procure a piece of slate, 5 3/8 in. long, 1 1/2 in. wide, and 1/2 in. in thickness. Drill the holes indicated in Fig. 3. The four corner holes are for mounting the flasher in its containing case, and should be about 1/8 in. in diameter. The holes E, F, G, and H should be 1/8 in. in diameter and countersunk with a 3/8-in. square-ended drill, on the under side, to a depth of 3/16 or 1/4 in. Cut from some 1/16-in. sheet brass a piece 1 3/8 in. long, and 1/2 in. wide. Drill two 1/8-in. holes in this piece, 7/8 in. apart and equally spaced from the ends. Procure four 1/8-in. brass bolts, two 1/2 in. in length, and two 1 in. in length. Secure four small washers and two additional nuts. Mount the combined iron and brass strip on the slate base, using a long and short bolt as shown in Fig. 4. One terminal of the winding should be placed under the head of the bolt J. Place a washer, K, between the head of the bolt and the wire. The brass strip L can now be mounted in a similar manner, as shown in Fig. 4. Place the other end of the winding under the head of the bolt M.

Obtain a small screw, N, Fig. 4, of such a length that its point will reach the brass strip L when the screw is placed in the hole B, Fig. 2. A lock nut, O, should be provided for this screw so that it will remain in adjustment. The point of the screw and the point on the brass plate where the screw touches should be of platinum, as the brass will not withstand the high temperature of the arc formed when the circuit is broken.

A metal box should now be provided to serve as a containing case and the flasher is complete. This box should be of such design and construction that it will comply with the requirements of the electrical inspection department having jurisdiction over the locality where the flasher is to be used.

The flasher should be connected in series with the lamp, the wires being fastened under the nuts on the bolts P and R, Fig. 4, and the screw N adjusted so that it lacks a small fraction of an inch of making contact with the brass plate when there is no current in the winding. When the switch is turned on there will be a current through the lamp and winding in series. The brass strip will be heated more than the iron and it will expand more, thus forcing the point of the screw N down upon the brass plate, which will result in the winding about the brass strip being shorted and the full voltage will be impressed upon the lamp, and it will burn at normal candlepower. When the coil is shorted there will of course be no current in its winding and the brass strip will cool down, the screw N will finally be drawn away from contact with the brass plate, and the winding again connected in series with the lamp. The lamp will apparently go out when the winding is in series with it, as the total

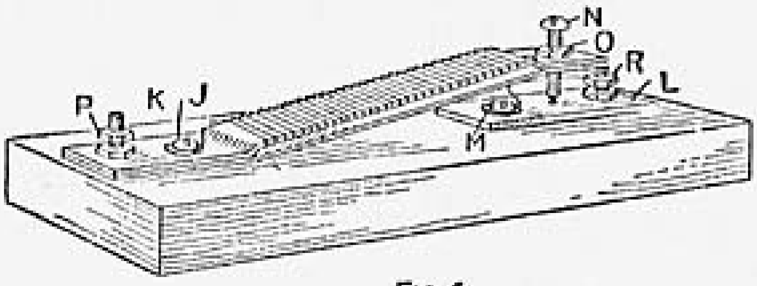


FIG.4
The Assembled Parts Showing the Complete Flasher and Electric Connections with Adjusting Screw

resistance of the lamp and winding combined will not permit sufficient current to pass through the lamp to make its filament glow. The time the lamp is on and off may be varied to a certain extent by adjusting the screw N.

THE BOY MECHANIC – 1915

A Rotary Tuning Coil

The rotary tuner shown in the sketch was designed by a correspondent of Modern Electrics. The circle is cut from ¾-in. stock, 1 in. wide and well covered with insulating material. It is then wound with No. 24 single cotton-covered copper wire so that the coils will lie flat. All the arms are of ¼-in. square brass. The supports are smaller in section. Sliders are mounted on the ends of the long arms and are kept in place by setscrews.

The insulation on the wire is removed with a small piece of sandpaper pasted on a block of wood. This should be temporarily fastened to the revolving lever at the point where the contact is wanted, then the lever is turned until the insulation is removed. The wiring diagram shows the location of the tuning coil in the line.

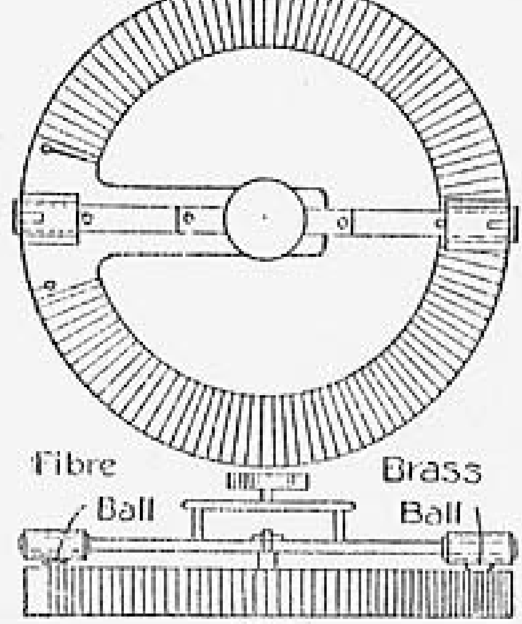


FIG.1

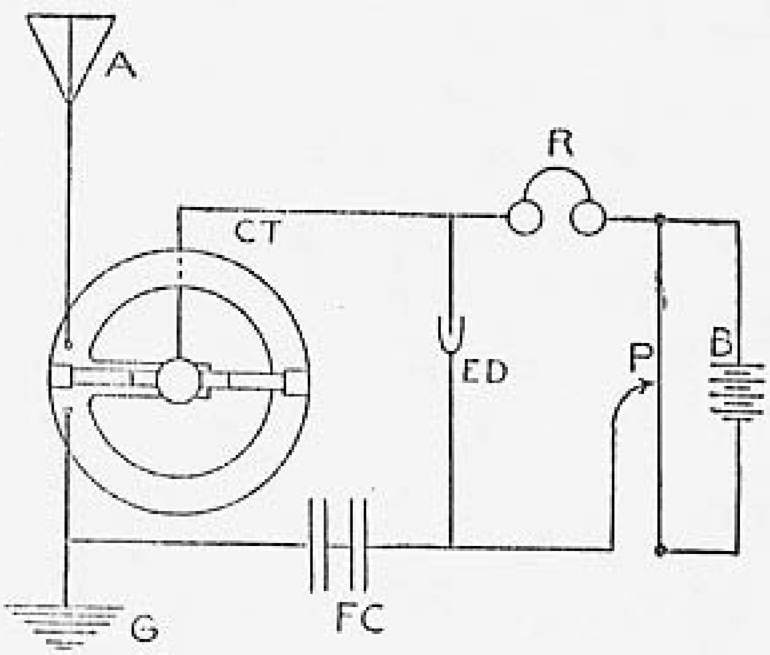


FIG.2

Tuning Coil and Wiring Diagram

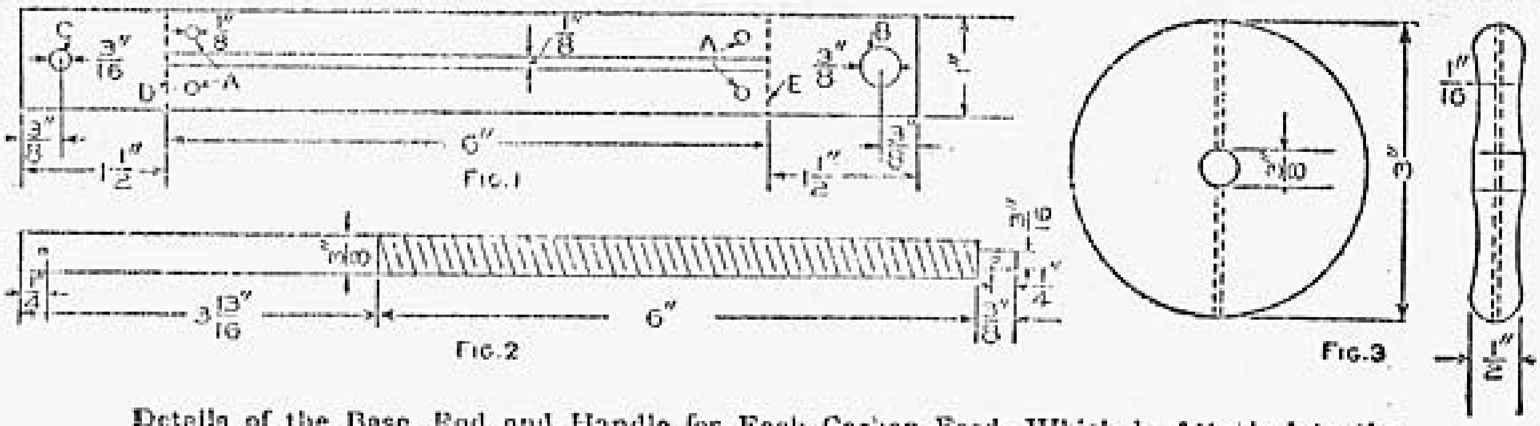
THE BOY MECHANIC – 1915

How to Make an Electric Furnace

A small electric furnace that will be very serviceable in a laboratory may be made as follows:

First procure a small clay flowerpot, about 4 in. in diameter at the bottom, and also a small clay crucible, about 2 in. in diameter at the bottom and at least 1 in. less in height than the flowerpot, and having as nearly as possible the same slope to its sides as the pot. Now obtain a small quantity of asbestos compound and pack it around the small crucible inside the flowerpot. Make sure the crucible is in the exact center of the flowerpot and that their tops are even with each other. Assuming that ordinary electric-light carbons are to be used, which are about ½ in. in diameter, drill two ⅝-in. holes, exactly opposite each other,

 GRANDDAD'S ELCTRICITY BOOK



Details of the Base, Rod and Handle for Each Carbon Feed, Which is Attached to the Large Base on One Side of the Furnace

through the walls of the flowerpot and asbestos compound so that they enter the crucible about $\frac{3}{4}$ in. above its bottom on the inside. A suitable lid for the furnace may be made from $\frac{1}{4}$-in. sheet asbestos and should be large enough to cover the top of the flowerpot.

The feeds and supports for the carbon electrodes are constructed as follows: Procure two pieces of $\frac{1}{8}$-in. brass, 1 in. wide and 9 in. long. Cut a $\frac{1}{8}$-in. groove lengthwise in the center of these pieces to within $1\frac{1}{2}$ in. of each end, as shown in Fig. 1. Drill four $\frac{1}{8}$-in. holes, AA, in each piece, a $\frac{3}{8}$-in. hole, B, in one end and a $\frac{3}{16}$-in. hole, C, in the other end. Now bend the ends up at right angles to the remainder of the piece along the dotted lines shown at D and E. Next obtain two $\frac{3}{8}$-in. rods, $10\frac{3}{16}$ in. long. Turn one end of each down to a $\frac{3}{16}$-in. diameter for a distance of $\frac{3}{8}$ in. From that point thread the same end of the rods for a distance of 6 in. Drill a $\frac{1}{16}$-in. hole in each end of the rods a little less than $\frac{1}{4}$ in. from the ends. The dimensions of the rods are given in Fig. 2. Two small rubber or wooden handles, similar to the one shown in Fig. 3, should now be made and fastened to the large ends of the rods by means of $\frac{1}{16}$-in. steel pins. Obtain two pieces of brass of approximately the following dimensions: 1 in. by 1 in. by 3 in. Drill four holes in each of these pieces as shown in Fig. 4. The hole H should be just large enough to allow the carbon to enter, or about $\frac{1}{2}$ in. in diameter. The hole G should be tapped to take a $\frac{1}{4}$-in. machine screw, the hole F should be threaded so that the threaded rods will enter, and a small binding post should be mounted on a lug fastened in the hole J. Cut away one end of this piece as shown in Fig. 4 until it is a little less than $\frac{1}{8}$ in. in thickness, or so it will enter the grooves cut in the brass strips.

The parts of the furnace are now ready to assemble, which may be done as follows: Procure a piece of well seasoned board, hard wood if possible, about 1 in. thick, 8 in. wide and perhaps 20 in. long. Cover one side of this board and the edges with some $\frac{1}{8}$-in. sheet asbestos. Now place the flowerpot in the exact center and then mount the grooved brass strips one on either side of it with the longest dimension parallel to the longest dimension of the board and the inside end about 1 in. from the side of the pot. The end with the $\frac{3}{16}$-in. holes should be next to the pot. Assemble the parts of the carbon feeds and then cut out some circular disks of asbestos to place under the flowerpot so as to raise it to such a position that the holes in its sides will be on a line with the carbon rods. Three long screws should now be placed in the board, forming the base, in such a position as to hold the flowerpot always in place. This completes the furnace proper, which is

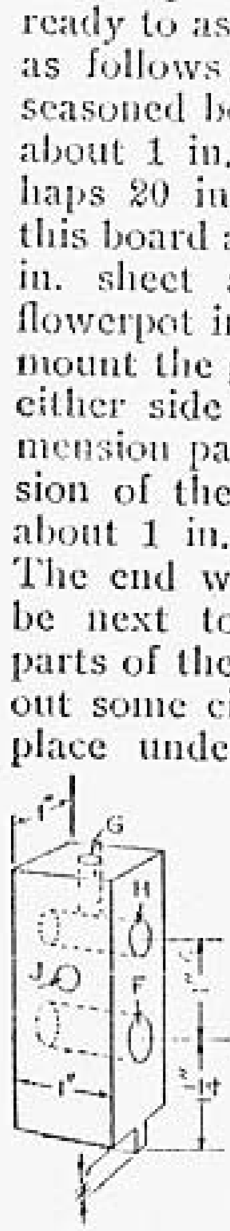


Fig. 4

 GRANDDAD'S ELCTRICITY BOOK

shown in Fig. 5. The furnace can now be put into operation provided there is a suitable current rheostat to connect in series with the carbon arc to prevent an excessive current being taken from the line. If such a rheostat is not available, a serviceable one may be made as follows:

Obtain two pieces of $\frac{1}{16}$-in. sheet iron, 6 by 6 in., that are to form the end plates. Cut off the corners of one piece so as to form an octagon and drill a number of ⅛-in. and ¼-in. holes in it, as shown in Fig. 6. Bend the corners of the other piece down along the dotted lines marked L, Fig. 7, and then make a second bend in each corner along the dotted lines K, so that the outermost portion of the corner is parallel to the main portion of the piece. Drill a number of ⅛-in. holes in this piece as indicated. A 3-in. opening should be cut in the center of this piece to give access to the interior of the completed rheostat. Now obtain eight ⅜-in. iron rods, 10 in. long. Drill and tap each end of these rods to accommodate a ⅛-in. machine screw. Wrap several layers of thin sheet asbestos around each rod and tie it in place with some thread. These rods should now be fastened between the end plates by means of a number of

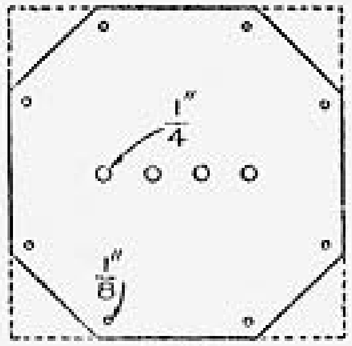


Fig.6

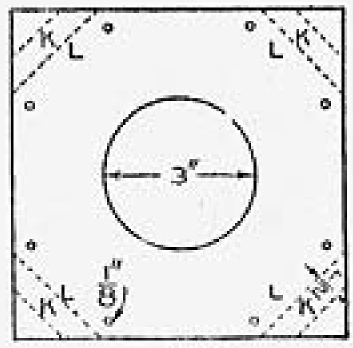


Fig.7

Detail of the Upper and Lower End Plates That are Used in Making a Rheostat

iron machine screws. Mount four back-connected binding posts on the plate shown in Fig. 6, making sure they are insulated from the plate by means of suitable bushings and washers.

Procure a small quantity of No. 14 gauge iron wire. Fasten one end of the wire under the head of the screw holding one of the binding posts in place and then wind it around the rods about 20 times, making the distance between the turns equal to the diameter of the wire. After winding on the 20 turns, attach a short piece of wire to the main wire and fasten the free end of the short piece to one of the other binding posts. Wind on 20 more turns, and make another connection to the third binding post, then complete the winding and attach the end to the remaining binding post. Different amounts of this resistance can now be

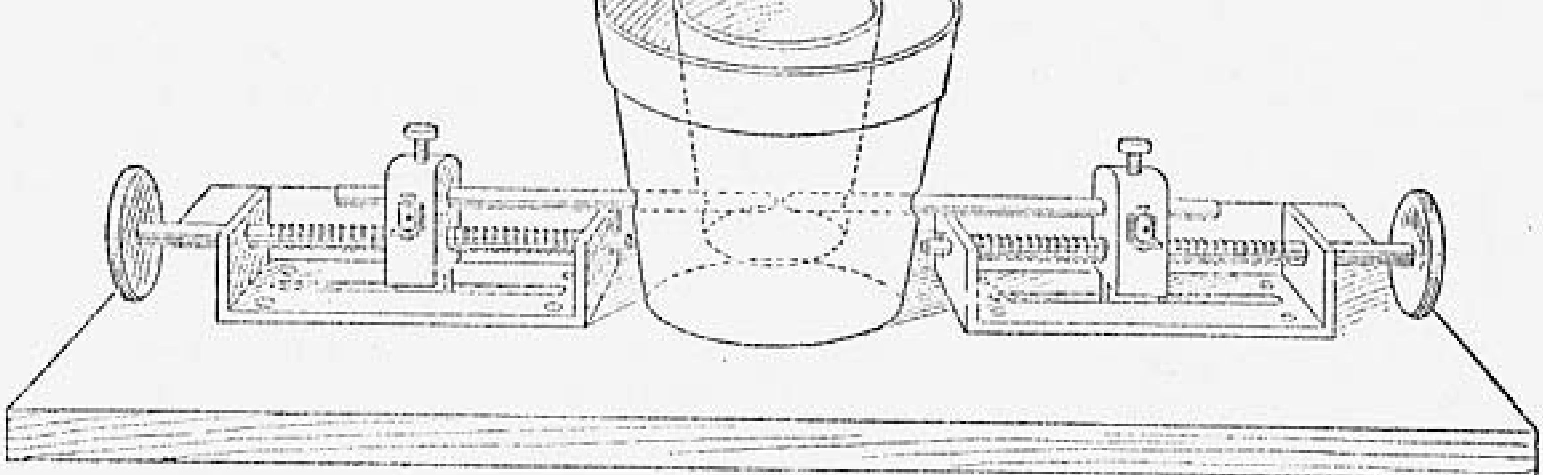


Fig.5

The Furnace Consists of a Flowerpot in Which a Crucible is Set, and on Either Side the Carbon Holders are Fastened to the Base connected in series with the arc by changing the connections from one binding post to another. The rheostat may be located on a bracket fastened to the wall, but care must be taken not to place it in such a position that it will come into contact with inflammable material. As an extra precaution, the circuit should be properly fused.

THE BOY MECHANIC – 1915

An Electric Gas Lighter

A very simple and inexpensive electric gas-lighting device is shown in the accompanying illustration. The gas is ignited by means of an electric spark which is produced between the two parts A and B of an electric circuit. This circuit is composed of a source of electrical energy, such as a number of dry cells, a kick coil, the connecting leads, and a special operating switch for opening and closing the circuit to produce the spark. The circuit is normally open, but as the lever controlling the gas valve is moved from one position to the other, by pulling the chains, the lever C is caused to move through a certain arc. Now, as this lever C moves, its upper end passes the projecting point B, which is attached to the upper portion of the burner, and the electric circuit will be completed and broken. Just as the point A leaves contact with the point B an arc will be produced. This arc is greatly intensified by the kick coil, which acts as a sort of reservoir in which energy is stored while the circuit is closed, and upon opening the circuit this stored energy is given out by the kick coil and increases the size of the arc.

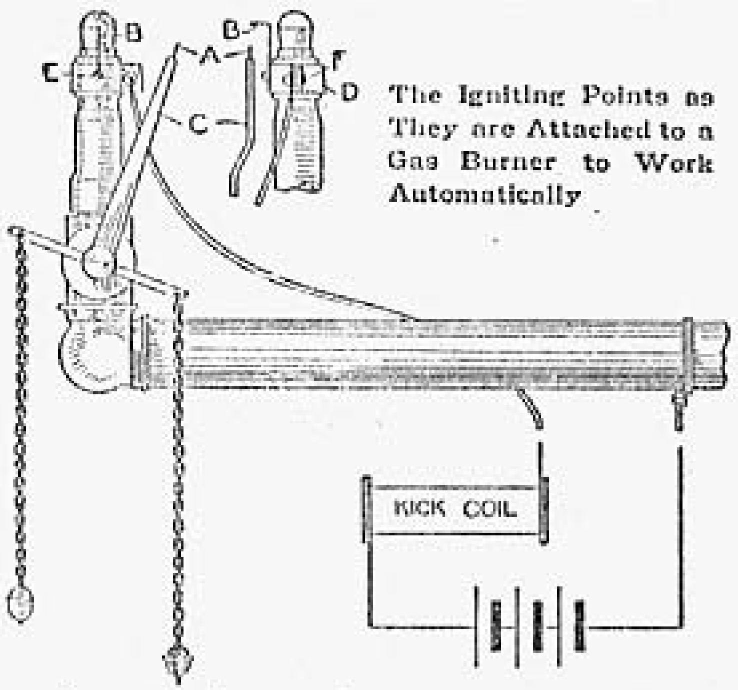
The points A and B should both be made of platinum, as other metals will not withstand the extremely high temperature of the arc. Pieces of platinum that will serve very nicely for the purpose may be obtained from an old incandescent lamp. The piece B is mounted on a brass collar, D, by means of a small screw, E. The brass collar D is held in place by the screw F, which draws the two ends together. This collar must be insulated from the stem or fixture by some thin sheets of mica. The upper end of the piece of platinum B should be just high enough to come within the lower edge of the gas flame.

Now mount an arm, C, on the valve stem so that it stands in a vertical position when the lever to which the chains are attached is in a horizontal position. Bend this arm into the form shown in the figure and cut its upper end off so that it is about ½ in. below the outwardly projecting end of the piece of platinum B. Drill a small hole in the upper end of C, and insert a piece of platinum and run some solder around it.

Then the complete burner and valve are mounted on the gas fixture, and from the collar D an insulated wire is run to the point where the battery and kick coil are to be located. The gas fixture itself is to form one side of the electric circuit, and one terminal of the battery should be connected to the gas pipe as shown in the figure.

A kick coil may be made as follows: Procure a small quantity of rather small soft-iron wire and cut a sufficient number of 8-in. lengths to make a bundle about ⅞ in. in diameter. From some good writing paper make a tube, 8 in. long and ⅞ in. in outside diameter. Use at least six layers of paper and glue the various layers together in forming this paper tube. After the tube has dried thoroughly, fill it with the pieces of iron wire until it is perfectly hard. Cut from some ½-in. hard wood, two pieces, 3 in. square, and drill a ⅞-in. hole in the center of each of these to a depth of ⅜ in. Now glue these pieces to the completed core and the winding can begin as soon as the glue is dry. Wind on this spool six layers of double cotton-covered No. 18 gauge wire, insulating the various layers from each other with several thicknesses of good writing paper. This coil is then mounted on a wooden base and suitable terminals provided.

At least four dry cells will be required to give satisfactory results. Bear in mind that the gas must be escaping from the burner when the arc is formed. The adjustment of the arm A, as given above, may result in the gas valve being closed when the arc is formed, and the device will then fail to operate. If this is the case, the arm C should be loosened and moved back so that the circuit is broken at a later time while the valve is being moved from the "off" to "on" position. The circuit should be closed for some little time before it is opened so that some energy may be stored in the kick coil. If the wire A is made long enough to



The Igniting Points as They are Attached to a Gas Burner to Work Automatically

project a short distance above B, it will result in the circuit being closed for a longer time than it would if they just touched.

THE BOY MECHANIC – 1915

Reversing Switch for Small Motors

A reversing switch made as follows will be found very serviceable in reversing the direction of the rotation of small motors, changing the polarity of electromagnets, etc.

A diagram of the connections to the switch and on the switch base is given in the sketch, and in this particular case the switch is shown connected to a small toy motor. The field of the motor is represented by A, the armature by B; and C, D, E, and F are four binding posts mounted on the base of the switch; G, H, and I are three contacts; J and K are terminals of the switch blades, and L a single-pole switch. The two blades of the reversing switch have their lower ends fastened to the terminals J and K, and their upper ends, which are indicated by arrow heads, may be moved over the contacts G, H, and I. For the position of the reversing switch shown by the full lines, J is connected to G and K to H. When the switch is thrown to the right-hand position, as shown by the dotted lines, J is connected to H and K to I. It is obvious that the direction of the current through the armature B will be reversed when the reversing switch is thrown from one position to the other. The direction in which the armature rotates will change, due to the reversal in direction of the current through it. The same results could be obtained by reversing the current in the field winding A. But it must always be borne in mind that in order to reverse the direction of rotation, the current must be reversed in the armature only or in the field only, not in both.

The above switch may be constructed as follows: First, procure a piece of well-seasoned hard wood, say maple, ½ in. thick, 2½ in. wide and 4 in. long. Round off the corners and the edges of this piece on one side and drill the holes indicated in the sketch. The four corner holes should be of such a size as to accommodate the screws used in mounting four small back-connected binding posts. The remaining holes should be ⅛ in. All these holes should be countersunk with a ⅜-in. bit to a depth of ¼ in. on the under side.

Cut from some $\frac{1}{16}$-in. sheet brass two pieces, 2¾ in. long, ½ in. wide at one end and ¼ in. at the other, and round their ends. Drill a ⅛-in. hole through the larger end of each of these pieces, ¼ in. from the end, and also a hole through each, 1¼ in. from the narrow end. The last two holes should be threaded for ⅛-in. machine screws. Obtain five ⅛-in. brass bolts, ½ in. long. File the heads of three of these bolts down to a thickness of approximately 1/16 in. and mount them in the holes G, H and I. Before mounting anything on the base the grooves indicated by the heavy dotted lines should be cut in the under side so that the various points may be properly connected by conductors placed in the grooves. Now mount the two pieces of sheet brass upon the base by means of the remaining two bolts, which should pass through the holes J and K. A 1/16-in. washer should be placed between the pieces of brass and the wooden base.

Procure a piece of ⅛-in. fiber, 1¼ in. long and ⅜ in. broad. Drill two ⅛-in. holes in this piece, one in each end, so that they are 1 in. apart. Drill a third ⅛-in. hole in the center and fasten a small handle to the piece of fiber. Now mount this piece upon the two pieces of brass that form the blades of the switch by means of two small ⅛-in. brass machine screws.

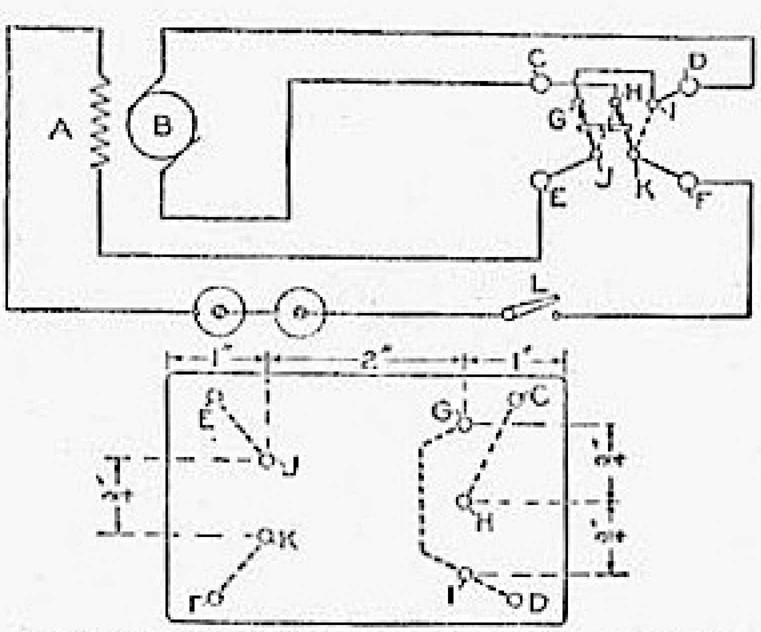


Diagram of the Wiring to a Small Motor and the Details of the Switch

Two small brads should be driven into the wooden base so as to prevent the possibility of the switch blades moving beyond their proper position. Two pieces of 1/16-in. fiber should be placed between the heads of the screws G and H, and H and I, to prevent the ends of the switch blades from dropping down on the wooden base.

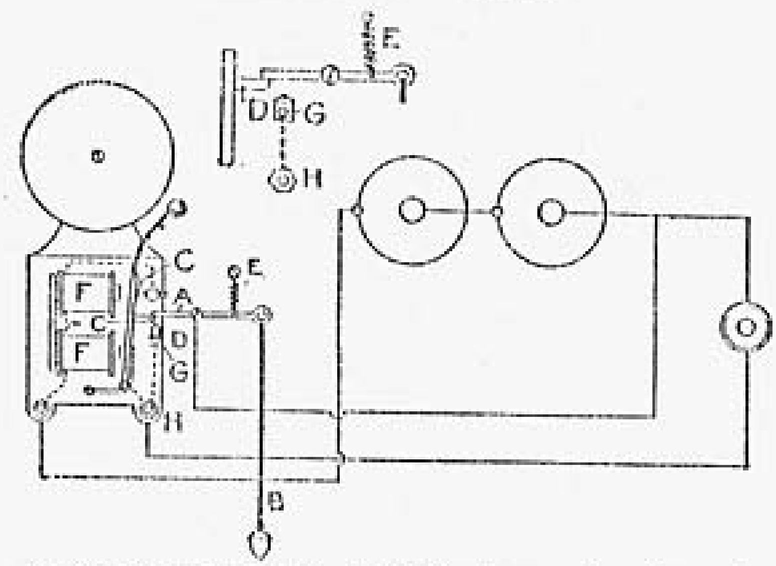
THE BOY MECHANIC – 1915

How to Make a Continuously Ringing Bell

The bell shown in the accompanying diagram is known as the continuously ringing type, and has quite a field of usefulness in connection with burglar alarms, door-bell signals, telephone signals, etc. The operation of the bell proper is identical with that of the ordinary vibrating bell and, in addition, there is a circuit controlled by the armature of the bell, which is normally open, but becomes closed as soon as the armature is drawn over. The closing of this circuit by the operation of the armature amounts to keeping the push button in the bell circuit depressed, and the bell will continue to ring until the latch A is restored by pulling the cord B.

Any ordinary vibrating bell may be converted into a continuously ringing bell as follows: In the armature, C, mount a short metal pin, D, and round off its under side slightly. A latch, A, should now be constructed similar to the one shown in the sketch and mounted in such a position that its left end will rest on the outer end of the pin D when the armature, C, of the bell is in its extreme outer position. The length of the latch should be such that its left end will drop off the end of the pin D, due to the action of the spring E, when the armature C is drawn over by the electromagnets F, thus allowing it to come into contact with a spring G, which is electrically connected to the terminal of the bell marked H. The latch A is connected to one side of

 GRANDDAD'S ELCTRICITY BOOK



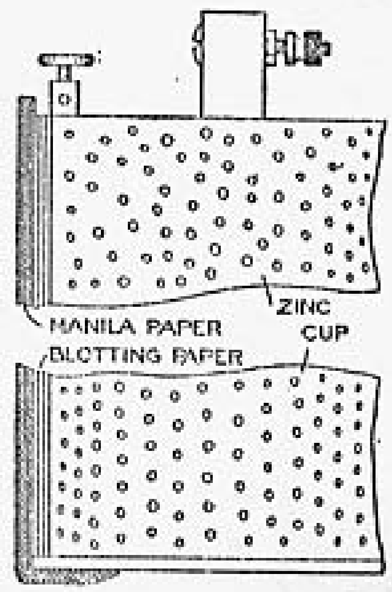
An Ordinary Vibrating Bell Used as a Continuously Ringing Bell, and the Wiring Diagram

the line, as shown in the sketch, so as to include the bell winding and battery in a local circuit that is formed by the latch coming in contact with the spring G. The end of the latch should not interfere with the free operation of the armature when it is resting on the spring G. A cord, B, attached to the outer end of the latch, is used in restoring it, and at the same time stopping the bell from ringing. The tension in the spring E should be so adjusted that the operation of the latch is sure and firm, yet not too stiff.

THE BOY MECHANIC – 1915

Renewing Dry Batteries

It is a well-known fact that dry cells commence to deteriorate from the time they are manufactured, and it is a matter of considerable uncertainty in purchasing cells to know whether they will continue to be efficient for their supposed natural life under the existing conditions of service, or for only a small part of this period. When the voltage of a dry cell falls below a certain value it is usually discarded and replaced by a new one, which often means quite an expense. The following simple suggestion will enable one to renew the prematurely exhausted cell with very little trouble and slight expense, so that its period of usefulness will be extended for a length of time, at least equal to that for which it could be used if put into service immediately after its manufacture.



The procedure in renewing the cell is as follows: A casing is placed outside of the zinc-containing case, having inside dimensions a little greater than the zinc cup. The space between the zinc cup and case is filled with a dry electrolyte, which, upon the addition of moisture, sets up a chemical action with the exterior surface of the zinc, and the latter having been perforated, causes electrical action to be again produced.

The casing, or cup, to be used outside the zinc cup should be made of a waterproof material. The electrolyte instead of being placed between this cup and the zinc in a powdered form, as might be expected, should be held by several layers of blotting paper, formed into a cylinder of the proper diameter to fit snugly on the outside of the zinc cup. This porous cup should be impregnated with a solution containing the following materials in the approximate amounts given: Muriate of ammonia, 10 parts; bichromate of potash, 4 parts, and chloride of sodium, 4 parts. After the porous cup has thoroughly soaked in the above solution it should be dried by passing a roller over its external surface when it is mounted on a wooden cylinder of proper diameter. The moisture-proof cup may be formed outside the porous cup by covering the latter with several coats of waterproofing paste and winding on several thicknesses of common manila paper, each layer of paper being treated with the paste. A disk of cardboard, properly treated, should be placed in the end of the cylinder to form the bottom, and the edge of the manila paper folded in over it and pasted in place.

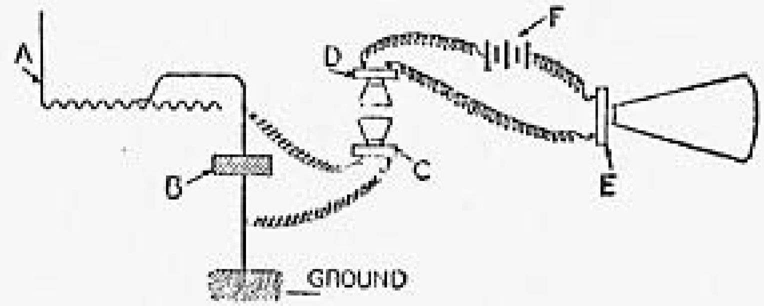
The pasteboard covering surrounding the zinc cup of the cell, should be removed and the surface of the zinc thoroughly cleaned. The coal tar in the top of the zinc cup should be removed by tapping around the edge with a hammer, and a large number of small holes should be made in the walls of the cup with a sharp instrument. Then put the cell within the porous cup and fill the top with clear water, preferably rain water. A chemical reaction will immediately take place between the outer surface of the zinc and the chemicals contained in the material forming the porous cup, and the terminal voltage of the cell will be practically the same as it was when the cell was new. The water, of course, must be replenished from time to time on account of evaporation, and the useful life of the cell can be prolonged for a considerable time. A part cross section of a cell treated as described above is shown in the accompanying sketch.

THE BOY MECHANIC – 1915

Sounder for Wireless-Telegraph Messages

The owner of an amateur wireless outfit often has reason to regret that he cannot let some of his friends listen to a message at the same time as he himself. The magnifier described in the following permits all those present in the room to hear the message, provided, of course, they are able to interpret the Morse alphabet by sound.

A very simple means, making the message audible at a distance of about 10 ft., is to attach a phonograph horn, or a horn of cardboard or metal, to the telephone receiver, but a much better arrangement can be made as shown in the diagram, in which A represents the antenna or aerial; B, the detector, and C, the receiver. Procure a small microphone, D, placing its mouthpiece



The Phonograph Horn as It is Connected to a Detector for Transmitting the Messages

closely against the receiver—for the sake of clearness the two are separated in the diagram—and connect the former with a battery, F, of two or three dry cells, in series with the microphone of an ordinary telephone transmitter provided with a large horn. The effect obtained by this simple means will be surprising.

THE BOY MECHANIC – 1915

An Electric Shaving Mug

The general use of electricity in the home has opened up a new field in the way of heating and cooking utensils. While these utensils are sold by electric-supply houses, some of them can be easily made at home and answer the purpose just as nicely. One of these is the electric shaving mug.

A mug that will stand heat is the first thing required, and an aluminum cup of standard shape and design, which can be bought in almost every town, will do perfectly well. These cups are spun from a flat sheet and have no seams to open and leak, and it is necessary that no holes be drilled in the cup as it is impossible to make such a hole watertight. The heating element must be fastened to the mug with a clamp. The clamp will also allow the heating coil to be removed for repairs without injury to the mug. The bottoms of these mugs have a flange which makes a recessed part and in this the heating element is placed.

The legs of the mug are made of sheet brass as shown in Fig. 1, one of

 GRANDDAD'S ELCTRICITY BOOK

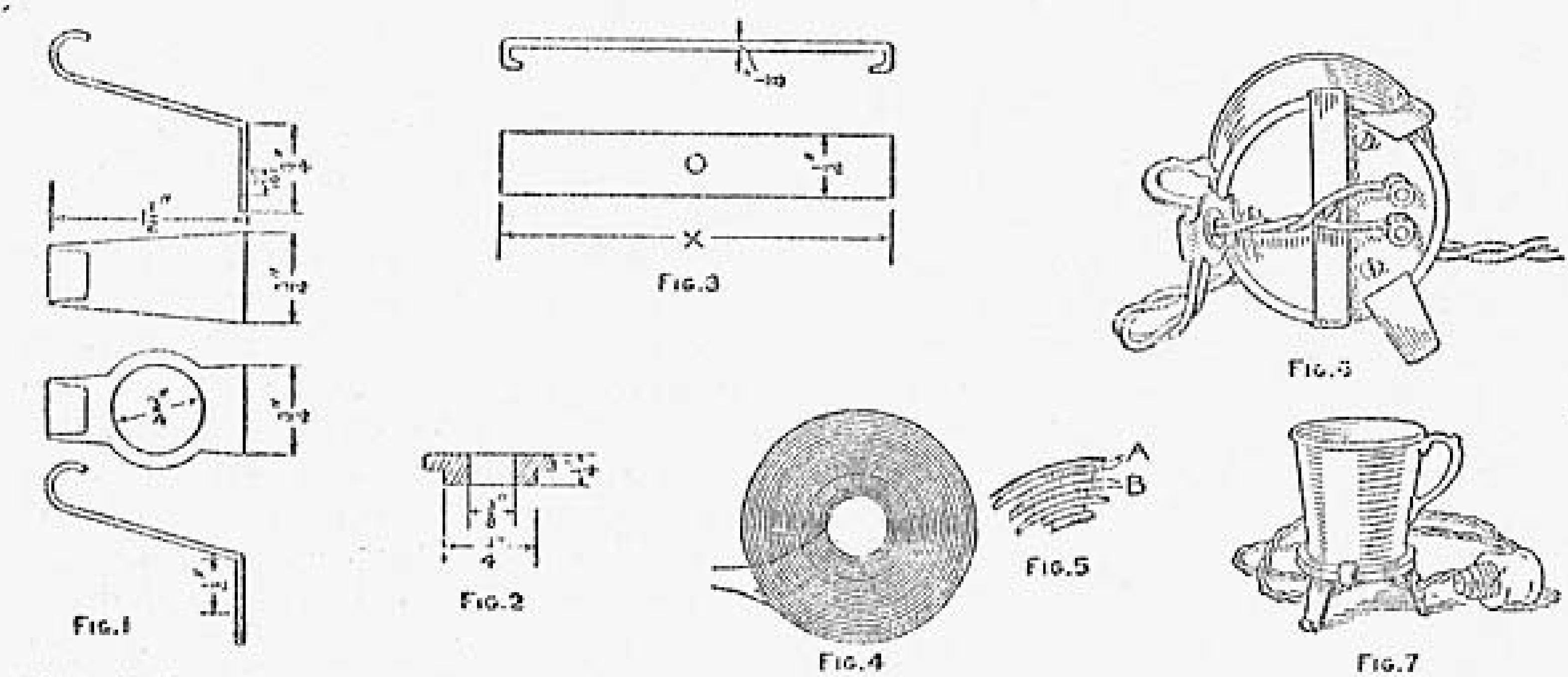
the three having an enlargement near its center with a hole for an insulating button (Fig. 2), of "transite" or some other material, to hold the supply cord in place.

The clamp for holding the heating coil in place is shown in Fig. 3. This clamp has a screw in the center to tighten it in place. The legs and clamp may be nickelplated if desired.

The heating coil is shown in Fig. 4 which is a coil of flat "Nichrome" wire, or ribbon as it is called, 12 ft. long, $\frac{1}{16}$ in. wide and 3/1000 in. thick. This is equal in cross section to a No. 26 gauge wire. To wind this coil, procure a block of wood, ⅞ in. thick and about 4 in. square, with a ½-in. hole in the center for an axis or pivot. Clamp a ½-in. rod in a vise so that the block can be rotated about it. Begin at the center and fasten one end of the ribbon to the block, leaving about 2 in. projecting for a connection, then proceed to wind the ribbon in a spiral coil, separating each turn from the preceding one with a strand of asbestos cord. A small section of the coil is shown in Fig. 5, in which A, or the light part, represents the asbestos insulation, and B, or the black lines, the heating element. The insulation may be obtained by untwisting some ⅛-in. round asbestos packing and using one of the strands. This cord insulates each turn of the ribbon from the other and the current must travel through the whole coil without jumping across from one turn to the other. The whole coil must be closely wound to get it into the limited space at the bottom of the mug.

Before taking the coil from the block, rub into its surface a little asbestos retort cement, or a cement composed of a mixture of silicate of soda and silica, or glass sand. This mixture, when dry, will tend to hold the coil together and the current may be passed through the coil to test it as well as to bake it in its coiled shape.

The support for the heating coil is made of a piece of $\frac{5}{16}$-in. asbestos wood or transite. Cut it to fit into the recessed bottom of the mug, then with a chisel remove the material in the top to form a depression $\frac{1}{16}$ in. deep to receive the coil with its top flush. The leads of the coil are run through the disk. The surface of the coil is then plastered evenly with retort cement. The legs are fastened to a second piece of insulating material with roundhead brass machine screws, ½ in. long, with nuts. The heads of these screws are shown in Fig. 6, the nuts being above the brass and between the two insulating pieces.



Detail of the Parts for the Construction of an Electric Shaving Mug. The Heating of Sufficient Water for a Shave can be Accomplished at a Nominal Cost

The ends of the heating ribbon are brought through the lower insulating disk and attached to binding posts as shown. The leads may be covered with tape to prevent any short circuit.

The mug uses 3½ amperes at 110 volts, either direct or alternating current, and it will cost about 3 cents an hour to operate it. Care should be taken to use a separable attachment for connecting, as an ordinary lamp socket may be burned out by turning off the current, it being adapted only to a small capacity.

In assembling the parts, several pieces of mica should be placed between the coil and the metal of the mug to insulate the coil from the mug.

THE BOY MECHANIC – 1915

How to Construct a Simple Galvanometer

A galvanometer is an instrument used to detect the presence of an electrical current in a circuit or to measure the value of the current in amperes. The operation of practically all galvanometers is based upon the same principle, and they differ chiefly in mechanical construction and the relative arrangement of their different parts.

A very simple galvanometer, that will give quite satisfactory results, under favorable conditions, may be constructed as follows: Turn from a piece of hard wood a ring having dimensions corresponding to those given in the cross section, Fig. 1. Fill the groove in this ring to within ⅛ in. of the top with No. 18 gauge double-cotton-covered copper wire, insulating the different layers from each other by means of a layer of good bond paper. The winding may be started by drilling a small hole through the side of the groove, as close to the bottom as possible, and allowing about 6 in. of the wire to protrude through it. The outside end may be terminated in a similar manner, and the two ends should be on the same side of the ring, or as near each other as possible. A protecting covering of bookbinder's paper is placed over the winding and the completed ring given a coat of shellac. The electric current to be detected or measured is to pass around the winding of this coil and produce an effect upon a compass needle mounted in its center. In order that the current may produce a maximum effect upon the needle, the coil should be mounted in a vertical position.

The base upon which the ring is to be mounted may be cut from some ½-in. hard wood. It should be circular in form and about 5 in. in diameter, and have its upper edge rounded off and shellacked to improve its appearance. The ring is mounted in a vertical position on this base, which may be done as follows: Cut a flat surface on each of the flanges of the ring so that it will stand in a vertical position and the terminals of the winding will be as near as possible to the

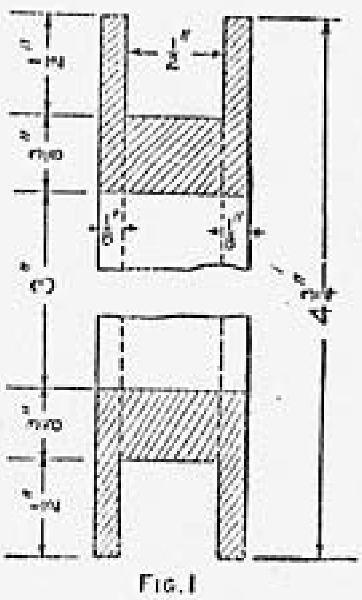


Fig. 1

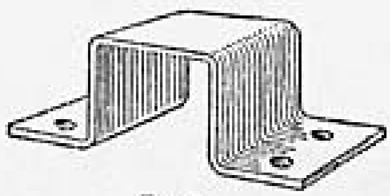


Fig. 2

The Wood Ring for the Coil and Its Holding Stirrup

surface upon which the ring rests. Then form a stirrup from some thin sheet brass, similar to that shown in Fig. 2, so that it will fit tightly over the ring and its outwardly projecting ends will rest upon the base of the instrument. Small wood screws are used in fastening the stirrup to the base. The fastening may be made more secure by cutting a groove across the inside of the ring for the stirrup to fit in, Fig. 3, thus preventing the possibility of the ring moving through the stirrup. Two holes should be drilled in the base for the terminals of the winding to pass through, and it would be best to cut two grooves in the side of the ring for these wires so as to prevent their coming into contact with the metal stirrup. Two back-connected binding posts, A and B, Fig. 3, are mounted on the base and the ends of the winding attached to them. The wires should be placed in grooves cut in the under side of the base, and the screws used in fastening the binding posts should be countersunk.

A short compass needle is then mounted on a suitable supporting pivot in the center of the coil. This compass needle will always come to rest in an approximate north and south position when it is acted upon by the earth's magnetic field alone. If now the plane of the coil be placed in such a position that it is parallel to the direction of the compass needle (no current in the coil), the magnetic field that will be produced when a current is sent through the winding will be perpendic-

Galvanometer as It is Used to Detect the Presence of an Electrical Current

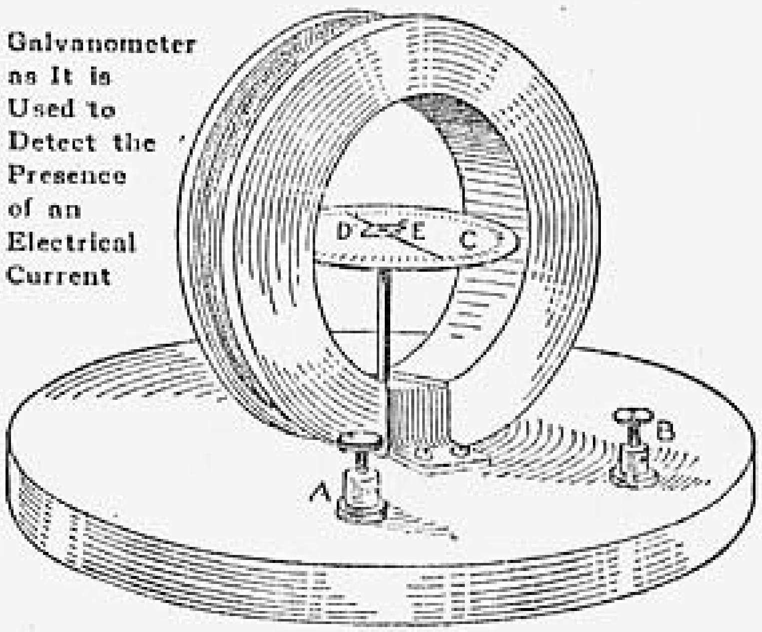


Fig. 3

ular to the magnetic field of the earth and there will be a force, due to this particular current, tending to turn the compass needle around perpendicularly to its original position. There will be a deflection of the needle for all values of current in the coil, and this deflection will vary in value as the current in the coil varies. The mere fact that the compass needle is deflected due to a current in the coil gives a means of detecting a current in any circuit of which the coil is a part, and the degree of this deflection affords a means of measuring the current, the value of the different deflections in terms of the current in the coil having been experimentally determined by sending a known current through the coil and noting the positions of the compass needle for each value of current used.

In order to determine the deflection of the needle, a scale, C, Fig. 3, must be mounted directly under the compass needle and a pointer, D, attached to the compass needle so that any movement of the needle results in an equal angular displacement of the pointer. The compass needle, E, should be short and quite heavy, say, 5/8 in. in length, 1/16 in. in thickness and 1/4 in. in width at its center, and tapering to a point at its ends. It should be made of a good grade of steel, tempered and then magnetized by means of a powerful electromagnet. The reason for making the compass needle short is that it will then operate in practically a uniform magnetic field, which exists only at the center of the coil. On account of the needle being so short and in view of the fact that it comes to rest parallel to the coil for its zero position, it is best to use a pointer attached to the needle to determine its deflection, as this pointer can be made much longer than the needle, and any movement of the needle may be more easily detected, as the end of the pointer moves through a much larger distance than the end of the needle, and since it may be attached to the needle, at right angles to the needle's axis, the end of the pointer will be off to one side of the coil and its movement may be easily observed. The pointer should be made of some nonmagnetic material, such as aluminum or brass, and it should be as long as it may be conveniently made. A suitable box with a glass cover may be provided in which the needle, pointer and scale may be housed. The construction of this box will be left entirely to the ingenuity of the one making the instrument.

In order to use this instrument as an ammeter, it will be necessary to calibrate it, which consists in determining the position of the pointer for various values of current through the

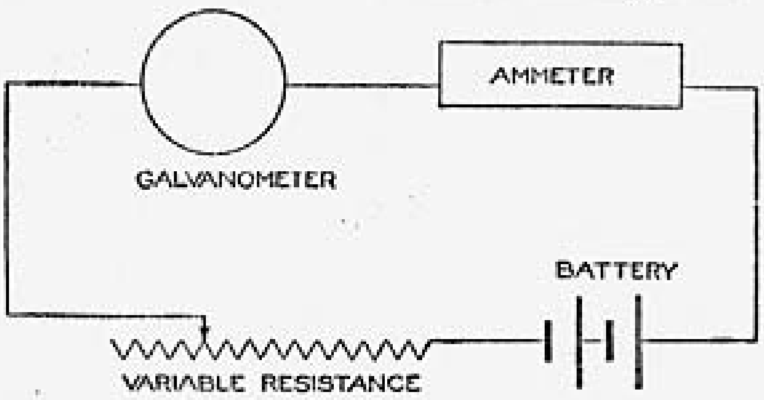


Fig. 4
The Electric Circuit, Showing Connections for Finding the Value of a Current in Calibrating

coil. It will be necessary to obtain the use of a direct-current ammeter for this purpose. The winding of the galvanometer, ammeter, battery and a variable resistance of some kind should all be connected in series as shown in the diagram, Fig. 4. Allow the compass needle to come to rest under the influence of the earth's magnetic field and then turn the coil into such a position that it is as nearly parallel with the needle as possible. This corresponds to the zero position, and the instrument must always be in this position when it is used. The position of the ends of the pointer is now marked on the scale for different values of current, first with the current in one direction and then in the opposite direction. The deflection of the needle will, of course, reverse when the current is reversed.

The effect produced by any current upon the compass needle can be changed by changing the number of turns in the coil. In measuring a large current, a few turns of large wire would be required, and in measuring a small current, a large number of turns of small wire could be used. In other words, the size of the wire will depend upon the current it is to carry and the number of turns in the coil will depend upon the magnetic effect the current is to produce, which is proportional to the product of the number of turns and the current, called the ampere-turns.

THE BOY MECHANIC – 1915

How to Make a Small Rheostat

In operating small motors there is as a rule no means provided for regulating their speed, and this often is quite a disadvantage, especially in the case of toy motors such as used on miniature electric locomotives. The speed, of course, can be regulated by changing the number of cells of battery by means of a special switch, but then all the cells are not used the same amount and some of them may be completely exhausted before the others show any appreciable depreciation. If a small transformer is used with a number of taps taken off the secondary winding, the voltage impressed upon the motor, and consequently the speed, can be changed by varying the amount of the secondary winding across which the motor is connected.

But in both these cases there is no means of varying the speed gradually. This can, however, be accomplished by means of a small rheostat placed in series with the motor. The rheostat acts in an electrical circuit in just the same way a valve does in a hydraulic circuit. It consists of a resistance, which can be easily varied in value, placed in the circuit connecting the motor with the source of electrical energy. A diagram of the rheostat is shown in Fig. 1, in which A represents the armature of the motor; B, the field; C, the rheostat, and D, the source of electrical energy. When the handle E is in such a position that the max-

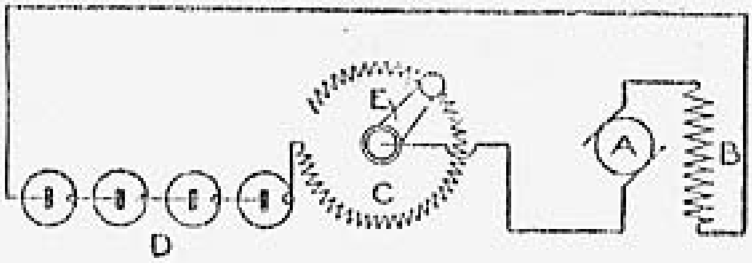


Fig. 1
Diagram Showing the Connections for a Small Motor Where a Rheostat Is in the Line

imum amount of resistance is in circuit there will be a minimum circuit through the field and armature of the motor, and its speed will be a minimum. As the resistance of the rheostat is decreased, the current increases and the motor speeds up, reaching a maximum value when the resistance of the rheostat has been reduced to zero value. Such a rheostat may be used in combination with a special switch

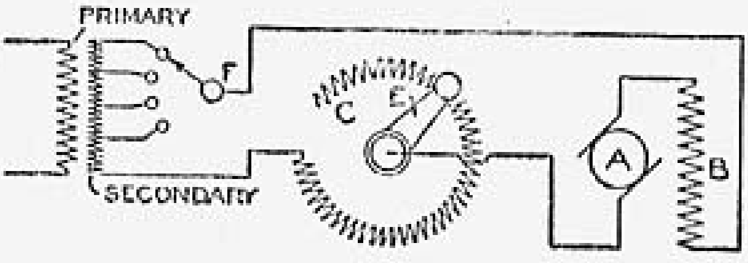


Fig. 2
Diagram of a Small Motor Where a Rheostat and Switch Are in the Line

F., as shown in Fig. 2. The switch gives a means of varying the voltage and the rheostat takes care of the desired changes in speed occurring between those produced by the variations in voltage.

A very simple and inexpensive rheostat may be constructed as follows: Procure a piece of thin fiber, about $\frac{1}{16}$ in. thick, ½ in. wide and approximately 10 in. long. Wind on this piece of fiber, after the edges have all been smoothed down, a piece of No. 22 gauge cotton-covered resistance wire, starting about ¼ in. from one end and winding the various turns fairly close together to within ¼ in. of the other end. The ends of the wire may be secured by passing them through several small holes drilled in the piece of fiber, and should protrude 3 or 4 in. for connecting to binding posts that will be mounted upon the base of the rheostat.

Now form this piece of fiber into a complete ring by bending it around some round object, the flat side being toward the object. Determine as accurately as possible the diameter of the ring thus formed and also its thickness. Obtain a piece of well seasoned hard wood, ½ in. thick and 4½ in. square. Round off the corners and upper edges of this block and mark out on it two circles whose diameters correspond to the inside and outside diameters of the fiber ring. The centers of these circles should be in the center of the block. Carefully saw out the two circles so that the space between the inside and outside portions will just accommodate the fiber ring. Obtain a second piece of hard wood,

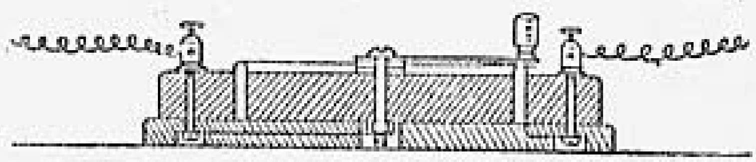


Fig. 3
A Cross Section of the Rheostat, Showing the Connections through the Resistance

¼ in. thick and 4¾ in. square, round off its corners and upper edges and mount the other pieces upon it by means of several small wood screws, which should pass up from the under side and be well countersunk. Place the fiber ring in the groove, but, before doing so, drill a hole in the base proper for one end of the wire to pass through. Two small back-connected binding posts should be mounted in the corners. One of these should be connected to the end of the winding and the other to a small bolt in the center of the base that serves to hold the handle or movable arm of the rheostat in place. These connecting leads should all be placed in grooves cut in the under side of the base.

The movable arm of the rheostat may be made from a piece of $\frac{1}{16}$-in. sheet brass, and should have the following approximate dimensions:

length, 2 in.; breadth ½ in. at one end, and ¼ in. at the other. Obtain a ⅛-in. brass bolt, about 1 in. long, also several washers. Drill a hole in the larger end of the piece of brass to accommodate the bolt and also in the center of the wooden base. Countersink the hole in the base on the under side with a ½-in. bit to a depth of ¼ in. On the under side of the piece of brass, and near its narrow end, solder a piece of thin spring brass so that its free end will rest upon the upper edge of the fiber ring. A small handle may be mounted upon the upper side of the movable arm. Now mount the arm on the base by means of the bolt, placing several washers between it and the upper surface of the base, so that its outer end will be raised above the edge of the fiber ring. Solder a short piece of thin brass to the nut that is to be placed on the lower end of the bolt, and cut a recess in the countersunk portion of the hole in the base to accommodate it. When the bolt has been screwed down sufficiently tight a locknut may be put on, or the first nut soldered to the end of the bolt. If possible, it would be best to use a spring washer, or two, between the arm and base.

The insulation should now be removed from the wire on the upper edge of the fiber ring with a piece of fine sandpaper, so that the spring on the under side of the movable arm may make contact with the winding. The rheostat is now complete with the exception of a coat of shellac. A cross-sectional view of the completed rheostat is shown in Fig. 3.

THE BOY MECHANIC – 1915

A Pocket Direct-Current Voltmeter

The assembled drawings of a very simple voltmeter are shown in Fig. 1, and its operation is as follows: The moving portion consists of a pointer, or needle, A; a small permanent magnet, or armature, B, and a counterweight, C, mounted upon a small steel shaft, D. The ends of this steel shaft are pointed and rest in bearings provided in the U-shaped piece of brass E, which is rigidly fastened to the fiber base F, by means of two screws. The permanent magnet B, carried on the shaft D, is at all times under the magnetic influence of the permanent horseshoe magnet, G, which is fastened, by means of thin brass straps, H H, and small screws, to the base F, so that the ends of the armature B are directly above the poles of the horseshoe magnet. The armature B will assume the position shown in the sketch when it is acted upon by the permanent magnet G alone and the moving system is perfectly balanced. A solenoid, J, is mounted in the position shown. When there is a current in its winding its soft-iron core will become magnetized and the magnetic pole produced at the lower end will produce a magnetic force upon the armature B, with the result that the armature will be rotated either in a clockwise or counter-clockwise direction, depending upon its polarity and the polarity of the end of the core adjacent to it. Thus, if the left end of the armature has north polarity, the right end south polarity, and the lower end of the core is magnetized to a south polarity the armature will be rotated clockwise, for the left end, or north pole, will be attracted by the lower end of the iron core, which is a south pole, and the right end will be repelled. This is in accordance with one of the fundamental laws of magnetism which states that magnetic poles of unlike polarity attract each other and those of like polarity repel each other. The amount the armature B is rotated will depend upon the relative effects of the pole of the solenoid and the permanent magnet G. The strength of the pole of the solenoid will depend upon the current in its winding and the number of times the current passes around the core, or the number of turns in the winding. In other words, the strength of the pole of the solenoid

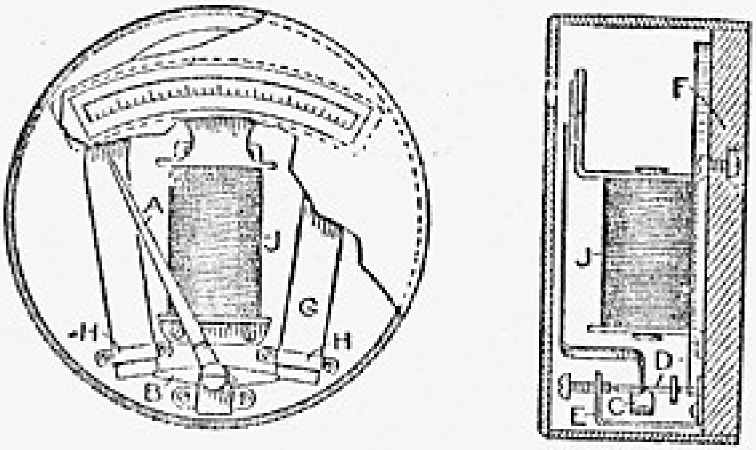


Fig. 1

The Parts as They are Assembled to Make a Pocket Voltmeter for Direct Currents

varies as the product of the current and the number of turns, which is called the ampere-turns. The same magnetic effect can be produced by a large current passing through a few turns or a small current passing through a relatively large number of turns. This simple relation of current and turns gives a means of adjusting the current capacity of the instrument so that a full-scale deflection of the needle will correspond to any desired maximum current. The instrument may be used as either a voltmeter or as an ammeter, and its operation will be identical in each case. The resistance of the voltmeter, however, will be many times the resistance of the ammeter, as it will be connected directly across the line, while the ammeter will always be in series in the circuit in which it is desired to measure the current. The following description and suggestion as to how to proceed in the construction of this instrument may be useful to those who undertake to build one. All the minor details and some of the dimensions will be omitted in the description, but these can be easily supplied.

Procure a piece of hard rubber or fiber, about ¼ in. in thickness and of sufficient size to cut from it a disk, 2½ in. in diameter. Make a small horseshoe magnet from a piece of the very best steel obtainable, and magnetize it to as high a strength as possible. This magnet is made of a piece of steel, ⅛ in. thick, about ⅜ in. in breadth, and of such length that the overall lengthwise dimension of the completed magnet will be about 1⅞ in. and the distance between the inside edges of the ends a little greater than ½ in. Fasten the completed magnet to the base F by means of two or three straps, made from some thin brass, and small machine or wood screws.

Then cut from some $\frac{1}{16}$-in. sheet brass a piece having the general appearance and dimensions shown at A, Fig. 2. Bend the ends of this piece over at right angles to the center portion along the dotted lines. Drill the hole at the upper end and thread it for a $\frac{1}{16}$-in. machine screw. By means of a pointed drill, make a small recess at the lower end directly opposite the first hole. This small recess is to form the lower bearing for the shaft supporting the moving system, while a small recess cut centrally in the end of a screw, mounted in the upper hole, will form the upper bearing. The screw placed in the upper hole need be only about $\frac{3}{16}$ in. long. The holes in the two wings are for mounting this piece upon the fiber base, as shown in Fig. 1.

The shaft for supporting the moving system is made of a piece of a hatpin. It is about $\frac{13}{16}$ in. long and its ends are pointed so that they will turn freely in the bearings provided for them.

The armature is cut from a piece of $\frac{1}{16}$-in. sheet steel. It is made about ¾ in. long, $\frac{5}{16}$ in. wide at the center, tapering to ⅛ in. at the ends. A hole is drilled in its center so that it may be forced onto the shaft. It is mounted so that its lower surface comes about ¼ in. from the lower end of the shaft.

Then cut from some very thin brass a piece, that is to form the needle, ¼ in. wide at one end and tapered to a point at the other, the total length being about 3 in. Drill a hole in the large end of this piece, the same size as the shaft and ½ in. from the end.

This piece is not fastened to the shaft until some of the other parts are completed.

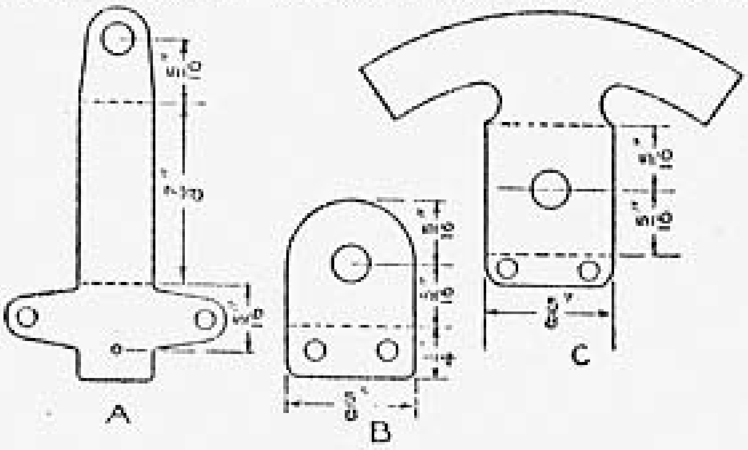
The spool upon which the winding is to be placed is made as follows: Procure a piece of very soft wrought iron, 1¼ in. long and ¼ in. in diameter, to form the core. The ends of the spool are made of thin brass and are dimensioned as shown in Fig. 2, at B and C. The piece shown at B is to form the lower end of the spool, and is bent at right angles along the dotted line. The two holes at the lower edge are for attaching the end of the spool to the fiber base. The piece shown at C forms the upper end of the spool and at the same time a back upon which the scale of the instrument is mounted. The holes in the lower edge are threaded for small machine screws, as it will be necessary to fasten this piece to the base by means of screws that pass through the base from the under side, as shown in Fig. 1. Bend the upper and lower portion of the piece over at right angles to the center portion along the dotted lines. Make sure that the large hole in the center of each end piece is of such size that it will fit very tight on the end of the wrought-iron core. Force the end pieces onto the ends of the core a short distance, say, $\frac{1}{16}$ in., and hammer down the edges of the core so that the end pieces cannot be easily removed. In fastening the ends to the core be sure that the parts that are to rest upon the base are parallel with each other and extend in opposite directions; also that the ends are at right angles to the core. Then insulate the inner portions of the completed spool with several thicknesses of onion-skin paper, or any good-quality, thin writing paper, and shellac. The winding will be described later.

Mount the spool and support for the bearings upon the base so that they occupy the positions, relative to each other, indicated in Fig. 1. A paper scale is then mounted upon the brass base provided for it by means of some thin shellac. The upper and lower lines for the scale can now be drawn upon the paper, using the center of the screw at the lower end of the needle as a center. These lines are best placed about ⅛ in. apart and not nearer the edge of the base than ¼ inches.

The needle is bent over at right angles $\frac{5}{16}$ in. from the center of the shaft. Another right-angle bend in the needle is then made so that the pointed end will be about $\frac{1}{16}$ in. above the surface of the scale when the large end of the needle is fastened to the shaft ⅜ in. from the upper end of the latter. Turn the needle on the shaft so that the pointer is at the left end of the scale when the moving system is at rest. The shaft must be exactly vertical when this adjustment is made. Cut the end of the needle down until its end is midway between the two scale lines. Solder the needle to the shaft, and then place a sufficient quantity of solder on the broad end to balance the system perfectly and allow it to come to rest in any position when the armature B is not influenced by any magnetic field.

A containing case for the instrument may be made as follows: Make a cylinder from some thin sheet brass, having exactly the same inside diameter as the base, and a height a little greater than the vertical distance from the lower surface of the base to the upper surface of the needle. Also a disk from some thin sheet brass, having a diameter ⅛ in. greater than the outside diameter of the cylinder. Round off the edges of this disk and cut a curved slot in it directly over the scale, about ⅜ in. wide and of the same length and form as the scale. Solder the disk to one end of the cylinder, placing the solder all on the inside. To prevent moisture from entering the case, fasten a piece of thin glass on the under side of the slot in the disk by means of some shellac and several pieces of brass soldered to the disk and bent down onto the glass. The case can now be fastened to the base by means of several screws, passing through its lower end into the edge of the base. Two small binding posts are mounted on the outside of the case, about 90 deg. apart and well insulated from each other and from the case, to serve as terminals for the instrument.

The instrument is now complete with the exception of the winding. Since this is to be a voltmeter and it



Details of the Supports for the Coil and for the Needle, or Pointer, Shaft

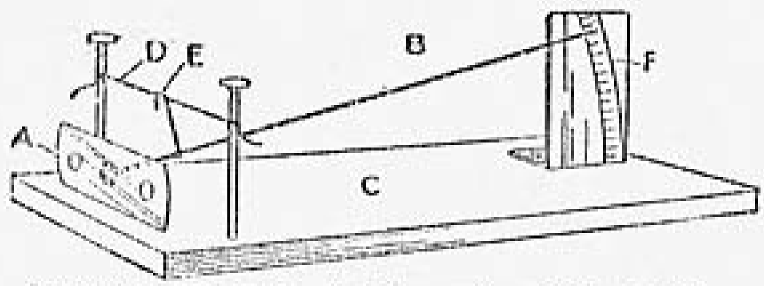
is always desirable that a voltmeter take as small a current as possible, the winding must consist of a relatively large number of turns of small wire, each turn carrying a small current. The difference in the construction of different instruments necessitates that their winding contain a different number of turns in order that a given voltage may produce a full-scale deflection. A little experimenting with different windings is the easiest means of determining the proper size of wire and number of turns to meet individual requirements. After adjusting the winding so that the maximum voltage it is desired to measure produces a full-scale deflection, the scale is calibrated by marking the positions of the needle in accordance with those of the needle of a standard instrument connected in parallel with it. In marking the scale of an ammeter, connect the instruments in series. Remember that if the instrument is to be used as an ammeter, it must have as low a resistance as possible and that to prevent undue heating, the wire must have ample cross section.

If difficulty is experienced due to the continuous vibration of the needle, although the current be practically constant, this trouble can be greatly reduced by mounting a paper wind vane on the moving system, which will tend to dampen its movement.

THE BOY MECHANIC – 1915

Wire Expansion Meter

When there is a current of electricity in an electrical conductor a certain amount of heat is generated due to the opposition or resistance of the conductor to the free passage of the electricity through it. The heat thus generated causes a change in the temperature of the conductor and as a result there will be a change in its length, it contracting with a decrease in temperature and expanding with an increase in temperature. The tempera-



Meter for Measuring the Expansion of Metal Wires Which are Heated by Electricity

ture of the conductor will change when the current in it changes, and hence its length will change, and it will reach a constant temperature or a constant length when the current in it is constant in value and the rate at which it is giving off heat is exactly equal to the rate at which heat is being generated in it.

The fact that there is an actual change in the length of the conductor due to a change in current in it constitutes the fundamental principle of the following simple instrument.

The parts needed in its construction are as follows: An old safety-razor blade; one 8-in. hatpin; two medium-size nails; a short piece of German-silver wire; a small piece of sealing wax; a ½-in. board for the base, approximately 3½ in. by 10 in., and a small piece of thin sheet brass. Remove the head from the hatpin and fasten the blunt end in the center of the safety-razor blade A with a piece of sealing wax so that the pin B is perpendicular to the blade as shown. Now drive the two nails into the board C, so that they are about ¼ in. from the edges and 1½ in. from the end. Fasten the piece of German-silver wire D to these nails as shown. The size of this wire will depend upon the value of the current to be measured. Make a small hook, E, from a short piece of rather stiff wire and fasten it to the hatpin about 1 in. from the razor blade. The length of this hook should be such that the pointed end of the hatpin will be at the top of the scale F when there is no current in the wire, D. The scale F is made by bending the piece of sheet brass so as to form a right angle and fastening it to the base. A piece of thin cardboard can be mounted upon the surface of the vertical portion of the piece of brass and a suitable scale inked upon it. The instrument is now complete with the exception of two binding posts, not shown in the sketch, that may be mounted at convenient points on the base and connected to the ends of the German-silver wire, thus serving as terminals for the instrument.

The completed instrument can be calibrated by connecting it in series with another instrument whose calibration is known and marking the position of the pointer on the scale for different values of current.

The Electric Globes, as They Light beneath the Spray, Illuminate the Top, and the Light Follows the Streams of Water So That They Appear Like Streams of Light

An Electric Fountain

THE BOY MECHANIC – 1915

By WALTER P. BUTLER

To make the grounds as attractive as possible for a lawn party given one night, I constructed an electric fountain which at first appeared to be an expensive proposition, but when completed the desired effect was produced without any expense whatever, as I had the things used in its construction on hand.

A light frame, 9 in. square, was

 GRANDDAD'S ELCTRICITY BOOK

made, of ¾-in. material, as shown in Fig. 1, and a grooved pulley was attached exactly in the center on the under side of the crosspiece. A turned stick, A, 2 in. in diameter and 2½ in. long, was fastened to the face of the pulley so that it turned true as the pulley and frame revolved. A hole was then bored centrally through the three parts, the frame crosspiece, the pulley, and the turned stick, of a size to fit a spindle about ⅜ in. in diameter.

A box was procured, large enough for the frame to turn in freely, and a block of wood was fastened centrally in its bottom, which had a ⅜-in. pin set in a hole bored in the center. The pin may be of hard wood, but it is better to use metal. A bolt, or piece of rod, will answer the purpose of a pin very well.

A small battery motor—I had one on hand and did not need to purchase one—was fastened to one side of the box so that its pulley was in line with the pulley on the lower surface of the frame. The batteries to run the motor were placed in the corner of the box, where the revolving frame would not touch them. The motor may be of larger current capacity, however, and run direct on the current used for the lamps.

About ½ in. from the lower end of the turned piece A, a brass strip was fastened around it. This work should be neatly done, and the joint soldered and smoothed, so that the outer surface will not catch on the brush used to make the contact. This ring can be better made by cutting the width from a piece of brass tubing of a size to fit on the turned stick A. About 1½ in. from the lower end four segments of a circle were fastened so as to make a space of about ¼ in. between their ends. This construction is clearly shown in Fig. 2. A cross section, showing the wire connections from the brass ring and segments to the lamps and where they lead out on top, is shown at B. The contact brushes

THE BOY MECHANIC – 1915

How to Make a Small Series Motor

The motor here described has been constructed and found to give very good results. It is simple to build and the materials required can be easily obtained. The armature core and field, or frame, are made of laminated iron, instead of being cast as is often done by the manufacturers, which is a decided advantage, as certain losses are thereby reduced, and its operation will be improved by this type of construc-

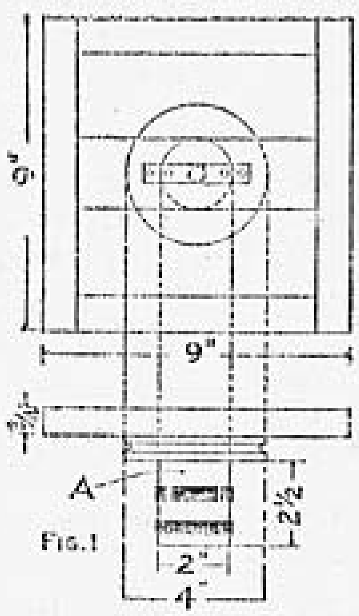


Fig.1

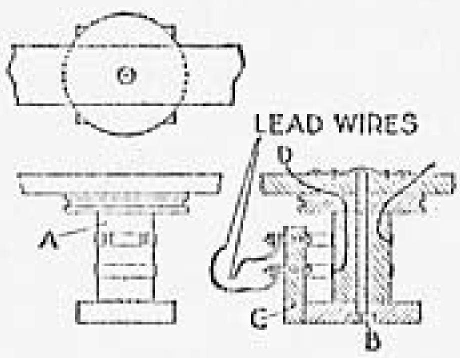


Fig.2

Details of the Different Parts to Construct the Electric Fountain

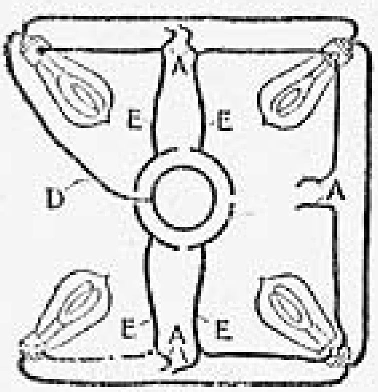


Fig.3

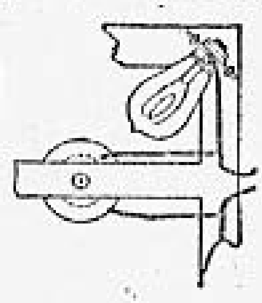


Fig.4

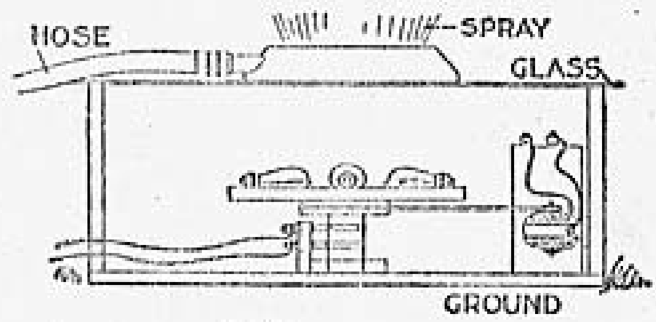


Fig.5

tion especially if used on an alternating-current circuit.

The machine will be divided into three main parts, the construction of each of which will be taken up in turn and the method of procedure discussed in detail. These parts are the completed armature, the field and bearings, and the brushes together with suitable terminals and connections.

The armature core is constructed from a number of pieces, having dimensions that correspond to those given in A, Fig. 1. These pieces are cut from thin annealed sheet iron, in sufficient number to make a pile, 3/4 in. high, when placed on top of each other and firmly clamped. It would, no doubt, be best to first lay out one of these pieces very carefully and then cut it out and mark out the other pieces with the first one as a pattern, being careful to file off all the rough edges on each piece.

Now obtain a piece of 1/4-in. iron or brass rod, 3 1/4 in. long, that is to serve as a shaft upon which to mount the armature and commutator. This rod is threaded for a distance of 7/8 in. on one end and 1 7/8 in. on the other. Procure five brass nuts, 1/8 in. in thickness, to fit the threads on the rod. If possible have the ends of the rod centered before the threads are cut, for reasons to be given later. Place one of the nuts on that end of the shaft that is threaded for 7/8 in., and in such a position that its inner surface is 3/4 in. from the end of the rod. Solder this nut to the rod when it is in the proper place and remove all extra solder. Drill a 1/4-in. hole in each of the armature stampings and place them on the shaft, clamping them together with three small clamps, one on each extension or pole. Then place a second nut on the shaft and draw it up tight against the last stamping placed in position, and solder it to the shaft. Next wind two or three layers of good strong tape around each of the rectangular portions of the armature and

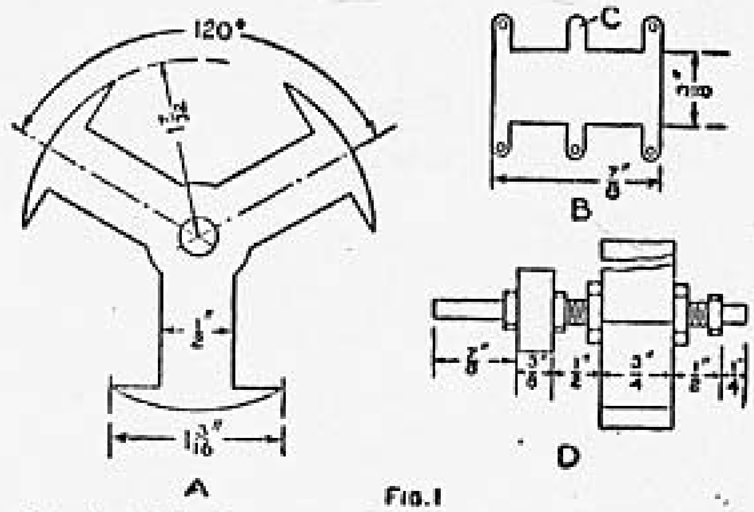


Fig. 1
Details of the Armature Laminations and the Commutator Segments, and the Method of Mounting Armature Core and Commutator

then remove the clamps. Make sure that all the edges of the different laminations are perfectly even before applying the tape.

The shaft is then placed between two centers to determine whether the core is approximately balanced and runs true. If the armature core is unbalanced or not true, the trouble should be corrected before proceeding with the remainder of the armature construction. The armature winding is not to be put on the core until the commutator has been constructed and mounted on the shaft.

The commutator consists of three pieces of thin sheet brass similar to that shown at B, Fig 1, mounted on the surface of a cylinder of insulating material, 3/8 in. long and 7/8 in. in diameter. A 1/4-in. hole is drilled lengthwise through the cylinder of insulating material. Bend the pieces of brass around the outside of the cylinder, and turn all the lugs, except the center one, marked C, over at right angles and put a small nail or screw through the holes in the ends of the lugs into the cylinder. These pieces of brass are equally spaced around the cylinder so that all the lugs, not turned down, project in the same direction. Now place a nut on the end of the shaft that extends the greatest distance through the armature, so that its outside surface is 1/2 in. from the surface of the end of the armature core next

 GRANDDAD'S ELCTRICITY BOOK

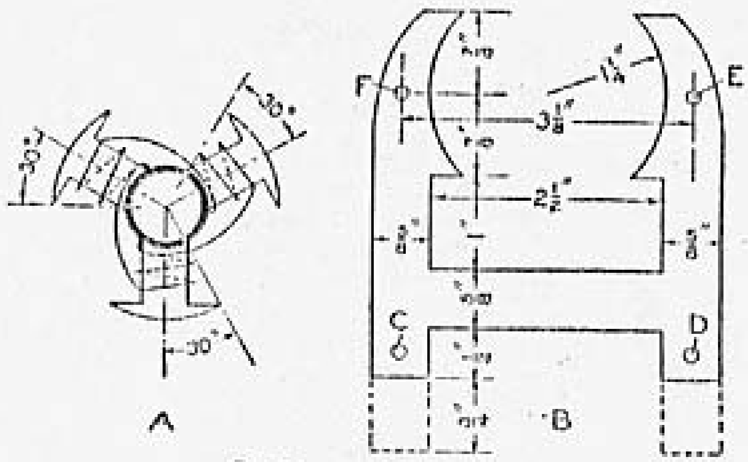


Fig. 2

Diagram of the Winding on the Armature and Detail of the Field Laminations

to it, and solder the nut to the shaft. Place the commutator on the shaft so that the projections on the pieces of brass are toward the armature core and the spaces between the ends of the pieces occupy the position relative to the cores, shown at A, Fig. 2. Another nut is then placed on the shaft and drawn up tight against the cylinder. The proper spacing of the various parts on the shaft of the machine is shown at D, Fig. 1. Another small nut is placed on the end of the shaft, away from the commutator, so that its outside surface is ½ in. from the surface of the end of the armature core.

The threads on that part of the shaft extending beyond the last nut on each end are now filed off, which can be easily done by placing the shaft between the centers of a lathe and revolving it quite rapidly, the file being applied to the parts that are to be cut down.

Obtain a small quantity of No. 22 gauge single-cotton-covered copper wire and wind four layers on each of the three legs, or poles, of the armature core, insulating the layers from each other and the entire winding from the core by means of paper and shellac. The three coils are wound in the same direction about their respective cores and each winding is started at the center of the armature with 2 or 3 in. of wire extending out toward the commutator. The outside end of each winding will terminate at the end of the coil toward the center of the armature, if an even number of layers is wound on, and is securely fastened by means of two or three turns of heavy thread. The inside end of one coil is then connected to the outside end of the next one, and so on. These connections can be easily made, and at the same time the proper connections made to the commutator, by cutting the inside end of one coil and the outside end of the next so that they will reach the lug on the nearest segment of the commutator, with about ¼ in. to spare, then removing the insulation from each for about ⅛ in. and soldering them both to the same lug. The arrangement of the winding is shown at A, Fig. 2. Connect all of the coils and segments in this manner, and the armature of the motor is complete.

The field or frame of the machine is made from a number of laminations whose dimensions correspond to those given in B, Fig. 2. As many laminations are used in the construction of the frame as the number of pieces in the armature, if iron of the same thickness is used. Four of the laminations have extensions at their lower corners to correspond to the parts shown by the dotted lines in B, Fig. 2. Place all of these laminations in a pile and clamp them rigidly together, then drill the four holes, indicated by the letters C, D, E and F, with a $\frac{3}{16}$-in. drill. Two of the pieces with the extensions on them are placed in the bottom of the pile and the other two on top.

Place a $\frac{3}{16}$-in. bolt through each of the lower holes and draw up the nuts on them tight. Procure two pieces of $\frac{3}{16}$-in. rod, 1½ in. long, and thread each end for a distance of ½ in. Get 8 nuts for these rods, about ⅛ in. thick and ⅝ in. across the face, if possible. Both sides of these nuts are filed down flat. Put the threaded rods through the two upper holes in the field frame and place a nut on each end and draw them tight, leaving an equal length of rod protruding from each side.

Obtain two pieces of 1/8-in. brass, 5/8 in. wide, one 4 3/4 in. long and the other 5 3/4 in. long. Bend these pieces into the forms shown at A, Fig. 3. Drill a 7/16-in. hole in each end of both pieces so that they may be mounted upon the ends of the rods protruding from the field frame. The exact center of the space the armature is to occupy is then marked on each of these pieces, and a hole is drilled in each, having the same diameter as the ends of the armature shaft.

The extensions on the outside laminations are bent over at right angles to the main portion of the frame, thus forming a base upon which the motor may rest. Holes may be drilled in the extensions after they are bent over to be used in mounting the frame upon a wooden base.

Procure about 1/2 lb. of No. 18 gauge single-cotton-covered copper wire and wind it on the lower center portion of the frame until the depth of the winding is about 1/2 in. Be careful to insulate the winding well and, to insure mechanical protection, place a layer of adhesive tape outside. About 4 or 5 in. of wire is allowed at each end for making connections. It is best to have these ends terminate on the commutator side of the frame.

The brushes for the machine are made from some thin sheet copper or brass, and are shaped and dimensioned approximately as shown at B, Fig. 3. Two pieces of hard rubber, or fiber, 1/2 in. square and 7/8 in. long, serve as mountings for the brushes. These pieces of insulation are mounted in the corners of the armature support, at the commutator end, by means of two small screws in each. Mount the brushes on these pieces so that their free ends bear on the commutator exactly opposite each other. One brush is mounted on the upper end of its support and the other brush on the lower end of its support. This is shown at C, Fig. 3. Two small binding posts are mounted at the same time as the brushes, and are electrically connected to the brushes, thus affording an easy means of making a connection to the

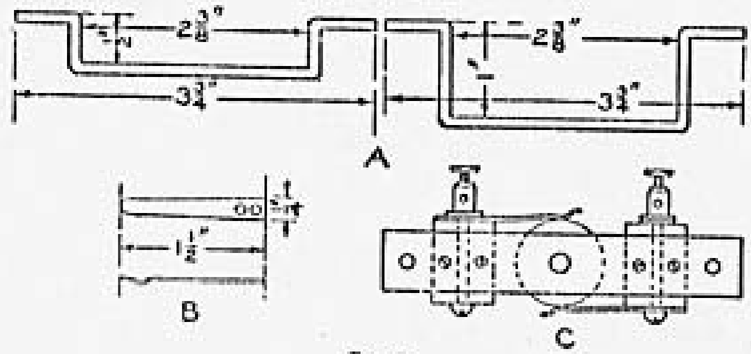


FIG. 3

Detail of the Armature Supports and the Brushes, and the Manner of Mounting the Brushes

armature. The brushes are so mounted as to bear firmly upon the commutator.

To operate the motor, connect the armature and field windings in series, and the combination to a source of electromotive force of several volts. If it is desired to reverse the direction of rotation, reverse the connections of either the armature or field windings, but not both. The motor may be mounted on a neat wooden base and the connections all brought down to a reversing switch, which may also be mounted on the same base as the motor. The speed can be varied by changing the impressed voltage, or by connecting a variable resistance in the armature circuit, such as a wire rheostat.

A small pulley may be made and attached to the armature shaft so that the motor may be used in driving various kinds of toys.

THE BOY MECHANIC – 1915

How to Make an Electric Heater

The electric heater described in this article is very simple to construct, its operation exceedingly satisfactory, and the necessary material easily procured at a small cost at most electrical-supply stores. The few tools needed are usually found about every home, and the heater may be constructed by any ingenious person.

 GRANDDAD'S ELCTRICITY BOOK

Procure 6 porcelain tubes, 20 in. long and approximately $\frac{13}{16}$ in. in diameter. On each of these tubes wind 25 ft. of bare No. 26 gauge "Climax" resistance wire. The various turns should be uniformly distributed along the tubes and not allowed to come into contact with each other, which can be prevented by placing a thin, narrow coat of plaster of Paris along the side of each of the tubes immediately after the winding has been put on. Several inches of free wire should be allowed at each end, for making connections, and the first and last turns on each tube should be securely fastened to the tube by several turns of binding wire. It would be best not to extend the winding nearer the ends of the tubes than ¾ in.

Cut from some heavy tin, or other thin sheet metal, two disks, 6 in. in diameter, and punch six $\frac{5}{16}$-in. holes in each of the disks at equal distances and within ¾ in. of the outer edge. Punch two ⅛-in. holes in one of these disks, to be used in mounting a porcelain socket, and also one ½-in. hole through which the wires may be led to the socket, as shown in Fig. 1. In the other disk punch four ⅛-in. holes, for mounting two porcelain single-pole snap switches, and two ½-in. holes, for leading the wires through to the switches, as shown in Fig. 2.

Cut off six lengths of $\frac{5}{16}$-in. iron rod, 22 in. long, and thread both ends of each piece for a length of 1¼ in. Fasten the porcelain tubes between the metal disks, by placing one of the rods through each of the tubes and allowing the ends to extend through the $\frac{5}{16}$-in. holes in the outer edge of the disks. A nut should be placed on each end of all the rods and drawn up so that the length of rod protruding at each end is the same. Obtain two single-pole snap switches and a porcelain socket, and mount them on the ends by means of some small stove bolts.

The windings on the porcelain tubes should be connected as follows: Let

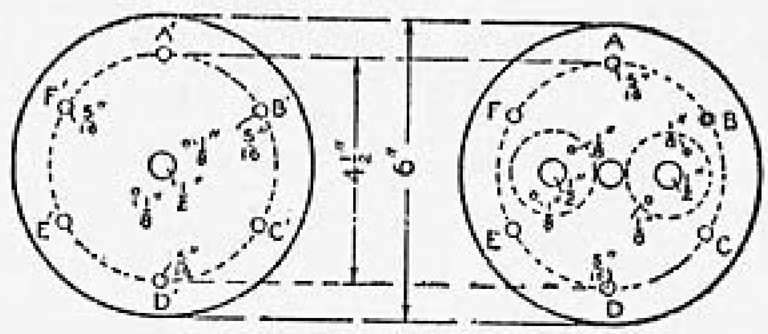


FIG. 1 FIG. 2

Detail of the Two Ends on the Heater Giving Dimensions and the Location of Parts

the windings be designated by the letters A, B, C, D, E, and F, and their position be that indicated in Figs. 1 and 2. The primes indicate the ends of the windings at the socket end, and the letters without the primes indicate the ends of the windings at the switch end of the heater. The ends A and D should be connected directly together. The ends B and C to the clips of the right-hand snap switch, and E and F, to the clips of the left-hand snap switch. The ends F′, A′, and B′ should be connected to one terminal of the socket, and C′, D′, and E′ to the other terminal of the socket. Electrical connection is made to the winding by means of a plug and piece of lamp cord. It is obvious that the windings A and D will be connected as soon as the plug is screwed into the socket, if the circuit is closed at all other points, and the windings B and C, and E and F are controlled by the right and left-hand snap switches, respectively. Make sure all the connections are properly insulated, and that there is little chance of a short circuit occurring.

After the socket and snap switches have been connected to the windings, two more thin disks, the same diameter as the first, may be fitted over the ends and held in place by two units on the end of each rod, a nut being placed on each side of the disks. A better way of mounting these disks would be by small machine screws that enter threaded holes in the ends of the rods. These last disks are not absolutely necessary, but they will add some to the

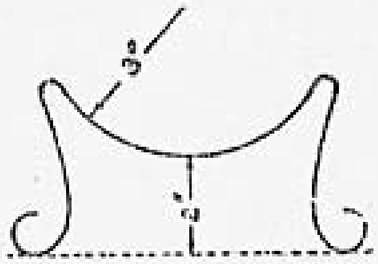


Fig.3

appearance of the completed heater. Four small ears, about 5/8 in. square, should be cut on the outer edge of the outside or inside disks and bent over at right angles to the main portion, to be used in mounting the outside case of the heater.

Cut from a sheet of 1/8-in. asbestos a piece just long enough to fit between the inside disks and wide enough to cover the three lower windings C, D, and E. The object of this piece of asbestos is to protect the surface upon which the heater will stand from excessive heat, since it is to rest in a horizontal position.

Obtain a piece of perforated, thin sheet metal, 19½ in. wide and long enough to reach from one outside disk to the other. Bend this into a cylinder and fasten it to the lugs on the disks by means of small screws or bolts.

The legs may be made of 1/8-in. strap iron, 5/8 in. wide, bent into the form shown in Fig. 3. These pieces may be attached to the perforated cylinder, before it is mounted on the heater proper, by means of several small bolts. The piece of asbestos should be wired to the cylinder after the heater is all assembled, so that it will always remain in the lower part of the cylinder and serve the purpose for which it is intended.

The heater, as described above, is constructed for a 110-volt circuit, which is the voltage commonly used in electric lighting. The total consumption of the heater will be approximately 600 watts, each part consuming about 1/3 of the total, or 200 watts. If it is desired to wind the heater for a 220-volt circuit, 25 ft. of No. 29 gauge "Climax" resistance wire should be used on each tube.

THE BOY MECHANIC – 1915

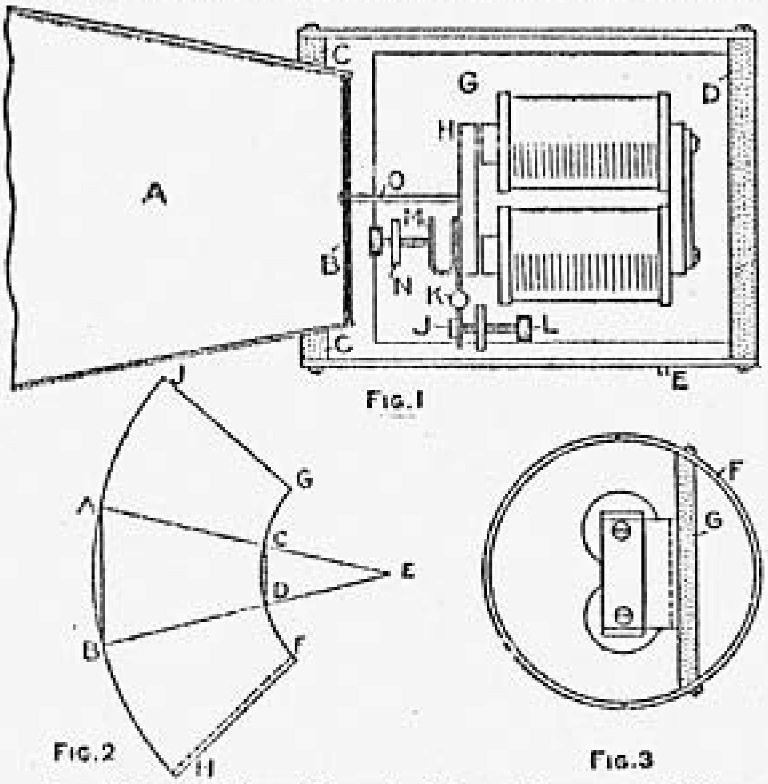
An Electric Horn

A simple electric horn for use on a bicycle, automobile, or for other purposes, can be constructed as shown in Fig. 1. The size will of course depend somewhat on the use for which it is intended, but one with the diaphragm 1¾ in. in diameter and the horn 5 in. long and 4 in. in diameter, at the large end, will be sufficient for most purposes. This will make the instrument 7½ or 8 in. in over-all length.

The horn proper, A, Fig. 1, is constructed first. This can be formed from sheet brass. To lay out the metal to the desired size draw a cross section, as ABCD, Fig. 2, then project the lines AC and BD until they meet at E. Strike two arcs of circles on the brass sheet, using EC as radius for the inner one and EA for the outer. Measure off FG and HJ equal to 3¼ times DC and AB, respectively, and cut out FGJH. Roll and lap ¼ in. at the edges and solder the joint neatly.

After smoothing the edges on the ends, solder a very thin disk of ferrotype metal, B, Fig. 1, to the small end of the horn. This is used for the diaphragm. Cut out a ring, C, from ¼-in. hard fiber and bevel it on the inside edge to fit the horn. Also make a disk of fiber, D, having the same outside diameter as the ring C. These parts form the ends for a brass cylinder E, which is made in two parts or halves joined on the lines shown in Fig. 3. Fasten one of the halves, F, Fig. 3, to the fiber ring C and disk D, Fig. 1, with small screws, the other half to be put in place after the instrument is completed and adjusted.

A small support, G, is cut from fiber and fastened in as shown. A pair of magnets of about 50 ohms are mounted on this support. The parts from an old bell or buzzer may be used, which consist of a soft-iron armature, H, Fig. 1, having a strap of spring brass, J, attached by soldering and pivoted at K, with an adjusting screw, L, to set the tension. Another U-shaped spring-brass strip, M, constitutes the current breaker, which has an adjusting screw, N. The points of contact on the current breaker should be tipped



An Electric Horn Operated in a Manner Similar to an Electric Bell on a Battery Circuit

with platinum. A piece of brass wire, O, is soldered to the diaphragm disk B and the soft-iron armature H, to connect them solidly. The tone of the horn can be adjusted with the screws L and N. The faster the armature vibrates, the higher the tone, and vice versa. The connections are the same as for an electric bell.—Contributed by James P. Lewis, Golden, Colo.

THE BOY MECHANIC – 1915

How to Make a Fire and Burglar Alarm

A very serviceable fire and burglar alarm may be installed by anyone who can work with carpenters' tools and who has an elementary knowledge of electricity. Fire and burglar alarms are divided into two general types, called "open circuit" and "closed circuit," respectively.

In the open-circuit type of alarm all the windows, doors, and places to be protected are equipped with electrical alarm springs which are in circuit with an ordinary vibrating bell and battery, and these alarm springs are all normally open. When a window or door is disturbed or moved more than a predetermined amount, the bell circuit is closed and the alarm sounded. The arrangement of such an alarm is shown in Fig. 1. A switch, A, is placed in circuit so that the alarm may be disconnected during the day and the opening and closing of doors and windows will not operate the bell. It is best not to place a switch in the fire-alarm circuit as this circuit should be in an operating condition at all times.

The alarm switch controlled by the window consists of a narrow metal plate, B, and a spring, C, mounted in a recess cut in the side of the window frame. The spring C is bent into such a form that its upper end is forced into contact with the plate B, when the window is raised past the outwardly projecting part of the spring C, and the bell circuit is thus closed. The position of the alarm switch can be adjusted so that the window may be opened a sufficient distance to permit the necessary ventilation but not allow a burglar to enter.

The alarm switch controlled by the door is arranged in a different manner. In this case the free end of the spring D is held away from contact with the spring E by the edge of the door, which forces the spring D back into the recess cut in the door jamb. When the door is opened the spring E is permitted to move out and come into contact with the spring or plate E, and the alarm circuit is thus closed. The form of the spring D can be so adjusted that the door may be opened some distance, but not enough to allow a person to enter, before the alarm is sounded.

An alarm switch, identical with that

 GRANDDAD'S ELCTRICITY BOOK

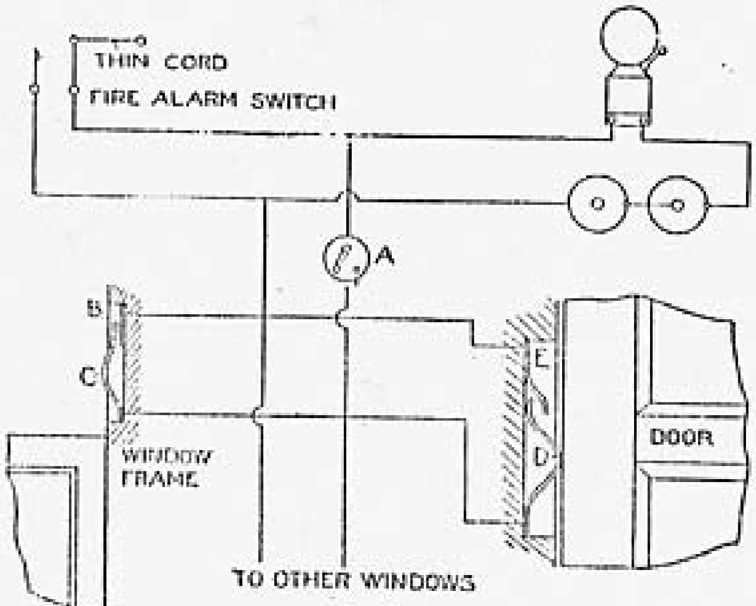


FIG. 1

Connections and Wiring Diagram Showing an Open-Circuit Fire and Burglar Alarm

just described for the door, should be mounted in the upper part of the window frame to take care of the upper sash. This alarm switch may be located low enough to permit the window to be lowered for the purpose of ventilation without sounding the alarm.

The wires for these various alarm switches should be run as near completely concealed as possible to prevent them being tampered with by curious parties, who may unintentionally break one of the conductors and thus make some part of the system inoperative. It might be best to test the system occasionally, to make sure all switches are in operating condition.

The fire-alarm switch consists of two springs that are held from contact with each other by means of a thin cord. This switch is placed in the location to be protected, or wherever a fire is most likely to break out, such as over the furnace, in the coal bin, etc. When the cord is destroyed the springs make contact and the alarm is sounded. A metal having a very low melting temperature may be used instead of the cord, and the alarm will be sounded when the temperature exceeds a certain amount and the actual occurrence of a fire thus prevented. In some cases, the fire-alarm switch may be completely destroyed and the alarm

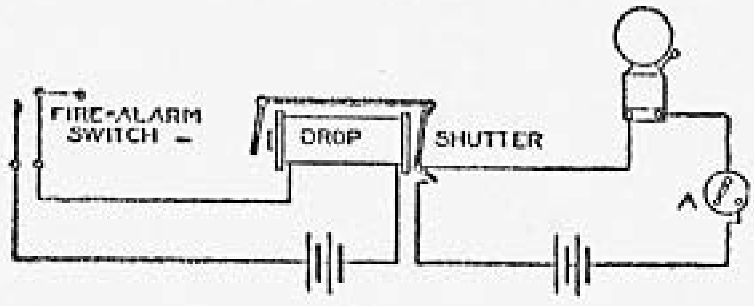


FIG. 2

Circuit Equipped with Drop to Ring the Bell in Case the Switch is Destroyed

circuit will then be opened and the bell will cease ringing. To prevent this trouble a small electric drop may be placed in the circuit, the arrangement being similar to that shown in Fig. 2. When the shutter of the drop falls, due to the closing of the alarm circuit, there is a second circuit closed, and this second circuit remains closed until the shutter is restored to its vertical or normal position, or the switch, A, is thrown to the open point. The addition of the drop in the burglar-alarm circuit may prove to be an advantage, as a burglar cannot stop the alarm, after he has once closed any of the alarm switches and operated the drop, by simply restoring the window or door to its original position.

In the closed-circuit type, the alarm

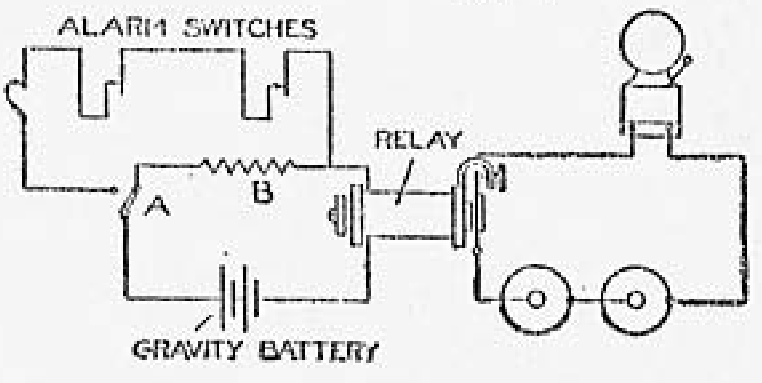


FIG. 3

Wiring Diagram Showing Connections for a Closed-Circuit Burglar and Fire Alarm

switches are all normally closed and the alarm is sounded by opening the circuit at some point. The arrangement of such an alarm is shown in Fig. 3. The alarm switches are all connected in series in this case and in circuit with a closed-circuit battery and relay or drop. The drop or relay controls a local circuit composed of an open-circuit battery and an ordinary vibrating bell.

The operation of a drop on a closed circuit is a little different from its operation on a normally open circuit. The drop for the closed circuit must be so constructed that its latch holds the shutter in a vertical position when there is a current in the drop winding, but allows it to fall as soon as the drop circuit is opened.

An ordinary telegraph relay may be used in connection with the closed-circuit alarm. The connections to the relay are such that the bell circuit is normally open and remains so until the armature of the relay is released, which does not occur until the circuit of which its winding is a part is opened at one of the alarm springs. A special switch, A, and resistance, B, are shown connected in circuit in Fig. 3, the object of which is as follows: When it is desired to disconnect the alarm springs or make them inoperative they must be replaced by another circuit which will permit a sufficient current to pass through the relay winding at all times, to prevent its armature from being released and sounding the alarm. The switch A is so constructed that either the alarm switches or the resistance B is in series with the battery and relay winding at all times, there being no open-circuit position for the switch.

The fire-alarm switch for this type of signal may be made from a narrow piece of tin foil, or some metal having a low melting temperature, mounted between two insulated clips that are connected in the alarm circuit.

Strips of gold or silver foil may be placed on windows and connected in the alarm circuit, which will give a protection from theft by breaking the glass.

Two or three gravity cells will serve very nicely for the closed-circuit battery, while several dry cells will do for the open-circuit or bell battery.

All types of alarm switches can be purchased at any up-to-date electrical supply house, but their construction and operation is so simple that they may be easily made by almost anyone. A detailed description of the construction of the various parts of the above circuits will not be given here, but such details can be safely left to the ingenuity of the person installing the system.

It is easily seen from the above description that a burglar who might discover that a house was wired for alarm would be greatly perplexed to know what to do, for the very thing that would prevent one kind of alarm from ringing would cause the other to ring.

A D'Arsonval Galvanometer

A galvanometer in which the moving part of the instrument is a permanent magnet controlled by the action of the earth's magnetic field and the magnetic effect of a current in a coil of wire, that usually surrounds the magnet, has the great disadvantage of having its indications changed, although the current itself may remain constant, due to a change in the strength of the magnetic field in which the instrument operates. The operation of instruments of the above type is satisfactory only in localities where there is a practically constant magnetic field for them to operate in, which it is almost impossible to have, due to the presence of permanent and electric magnets and magnetic materials such as iron and steel.

An instrument constructed as follows will not have the above disadvantage and its operation will be a great deal more satisfactory, as its indications will be practically independent of outside disturbances. In this instrument, the moving part is the coil carrying the current, and it moves in a permanent magnetic field so strong that other disturbing magnetic effects can be neglected. The coil is hung by

 GRANDDAD'S ELCTRICITY BOOK

means of a fine wire and the twist in this wire is the only force acting to bring the coil back to its zero position, after it has been deflected, and maintain it there.

The construction of the magnet and containing case for the instrument will be taken up first. Obtain a piece of Norway iron, ½ in. square and about 9 in. long. Bend this piece into the form shown in Fig. 1, and file off the inner edges until they are parallel and about ⅞ in. apart. Drill four ⅛-in. holes in the ends of this piece, two in each end, as indicated. This piece of iron is first tempered and then magnetized by placing it in contact with a powerful electromagnet. Cut a second piece from some soft iron with dimensions corresponding to those given in Fig. 2. Drill two ⅛-in. holes, A and B, in this piece as shown in the sketch. This second piece is mounted between the poles of the magnet, as follows: Cut from some $\frac{1}{32}$-in. sheet brass a piece similar to the one shown in Fig. 3. Drill the holes indicated and thread those designated by A, B, C, D, E, and F to take a ⅛-in. machine screw. Bend the upper end of the piece over at the point indicated by the dotted line until it is perpendicular to the lower part. The center of the hole in the projecting part K, when it is bent over, should be about ¼ in. from the outer surface of the main part of the piece. The small piece of iron is then fastened to the piece of brass with two round-headed screws that pass through the two holes in it and into the holes A and B in the brass piece. The magnet is mounted, also with small brass screws, so that the main part of the magnet and the piece of brass extend in opposite directions, as shown in Fig. 1. The assembled parts are then mounted on a wooden board, whose dimensions are given in Fig. 1, with three brass screws that pass through the holes G, H, and J, as shown.

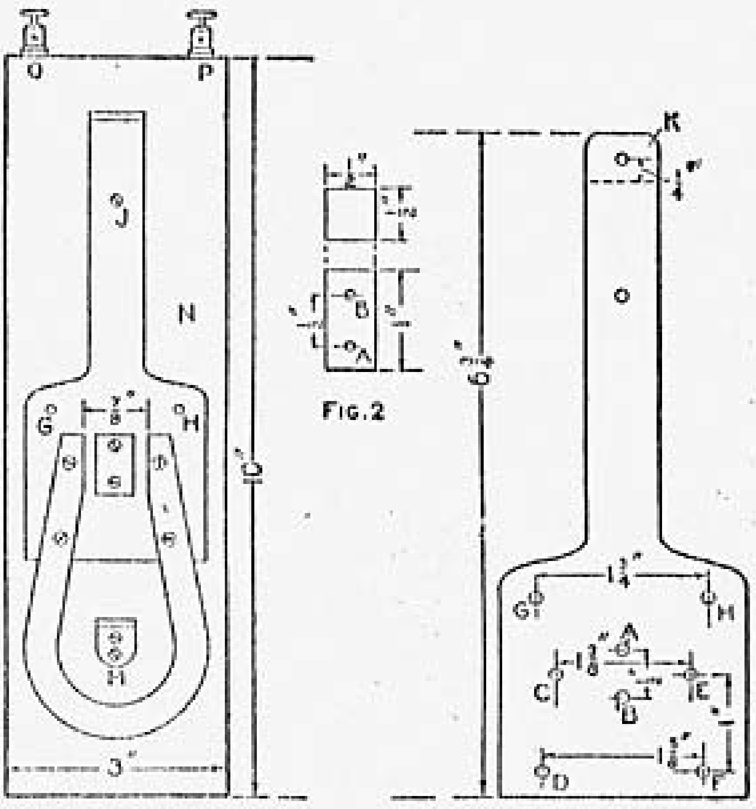


Fig. 1 Fig. 3
The Permanent Magnet and Its Brass Support, and Their Position on the Base

The moving coil of the galvanometer is constructed as follows: Cut from some ⅛-in. pine a piece 1⅛ in. long and ⅝ in. wide. Cut two other pieces whose dimensions, except their thickness, are ¼ in. larger than the first piece. Then fasten these two pieces to the sides of the first, with three or four small screws through each of them, thus forming a small spool. Saw about 16 slots with a very fine saw in the edges of the projecting pieces and a short way into the edge of the center piece. Wind on this spool about 300 turns of No. 38 gauge silk-covered copper wire. Start with the terminal of the wire in the center of one end of the spool, with a few inches of free wire for making connections,

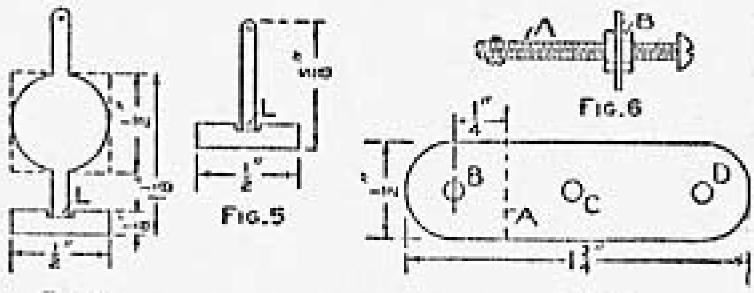


Fig. 4 Fig. 7
Upper and Lower Connections to the Coil and Supports, and the Supports for Suspension

 GRANDDAD'S ELCTRICITY BOOK

and end up with the terminal in the center of the opposite end of the spool. A small thread is then passed through the slots under the coil and tied, thus serving to hold the various turns of wire together when the coil is removed from the form. The coil should be given a coat of shellac as soon as it is removed from the form.

Two pieces must now be attached to the top and bottom of the coil to be used in making electrical connections and suspending the coil. Cut from some very thin sheet brass two pieces whose dimensions correspond to those given in Figs. 4 and 5. Drill a small hole in the center of each of these pieces. Bend the lower part of each piece over at the dotted lines L until it is perpendicular to the main portion of the piece. The bent-over portions of these two pieces are then fastened to the ends of the coil with some fine thread, making sure that they are in the center of the ends before they are fastened. The terminals of the coil are now soldered to these pieces. It would be best to place a sheet or two of thin paper between the brass pieces and the coil, to prevent any part of the coil, except the ends, from coming into contact with the brass pieces. Obtain a small piece of thin mirror and mount it with some glue, as shown by the dotted lines in Fig. 4.

The upper support for the suspension is shown in Fig. 6 and consists of a ⅛-in. threaded screw, A, that passes through the hole in the part K, Fig 3, and is provided with two lock nuts, B. The lower end of this screw should be slotted a short distance, and a small screw put through it, perpendicular to the slot, so that a wire can be easily clamped in the slot by turning up the screw. Next, take a piece of $\frac{1}{32}$-in. brass, as shown in Fig. 7, and bend it at the dotted line A until it forms a right angle. The hole B should be threaded to take a ⅛-in. screw. The holes C and D are for mounting the piece on the back of the instrument. Slot the end of a ⅛-in. screw, about ½ in. long, and put a screw through the end as for the upper support for the suspension. This piece is mounted below the position the coil is to occupy, as shown by M, Fig. 1.

A case should be made for the galvanometer whose inside dimensions correspond to those of the piece N, Fig. 1, and whose depth is about ¾ in. more than the thickness of that piece. Four pieces of wood can be fastened in the corners that will allow the case to slip just far enough on the piece N to make the edge of the case and the back surface of the piece N flush. Cut an opening in the front of this case, about 2 in. long and 1 in. wide, in such a place that the center of the opening is about level with the ends of the magnet. Fasten, back of this opening, a piece of thin glass with four small screws whose heads rest upon the edge of the glass. The interior of this case and all the parts should be given a coat of lampblack mixed with a little vinegar. Two small binding posts, O and P, are mounted on the upper end of the piece N and connected to the upper and lower supports for the suspension of the coil.

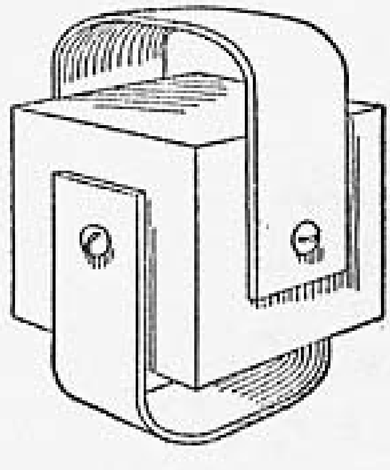


FIG. 8

This galvanometer will work best, of course, when it is in an exactly vertical position and the following simple device, when attached to it, will allow it to assume this position independent of the level of the surface its base may rest upon. Cut from some ⅛-in. brass two pieces, ½ in. wide and 2½ in. long. Drill a ⅛-in. hole in the center of each end of them, ¼ in. from the end, and a ¼-in. hole through the center of each. Bend these pieces to a ¾-

in. radius. Cut from some ½-in. hard wood a block, 1¼ in. square. Fasten the two pieces of brass to the wooden block with ⅛-in. screws, as shown in Fig. 8. One of these pieces is fastened to the upper end of the piece N, Fig. 1, so that the galvanometer will hang vertically. The other piece is fastened to a bracket from which the galvanometer is suspended. A suitable bracket for this purpose can be easily made. When the galvanometer is hung in this way, two binding posts are mounted on the bracket, and connected to the two on the galvanometer. In this way the galvanometer will not be disturbed when making connections.

The suspension is made as follows: Take a piece of small copper wire and roll it out flat. Solder one end of a piece of this wire in the hole in the piece of brass, with the mirror mounted on it. Fasten a piece of the same wire to the lower brass piece, attached to the coil. The upper piece of wire is then clamped in the end of the screw A, Fig. 6, so that the coil hangs perfectly free about the iron core. The lower piece of wire is bent around a small rod several times and its end fastened in the slot in the lower screw.

The deflection of the instrument is read by causing a beam of light from a lamp or candle to be reflected from the mirror to a scale located in front of the instrument. If the light from the lamp is allowed to shine through a small slit in a piece of dark paper, there will be a streak of light reflected upon the scale, instead of a spot.

To use this instrument in measuring larger currents than it will safely carry, connect it in parallel with another resistance which will carry the larger part of the total current. The galvanometer can be calibrated with this resistance, which is known as a shunt.

THE BOY MECHANIC – 1915

How to Make an Electrotype Stamp

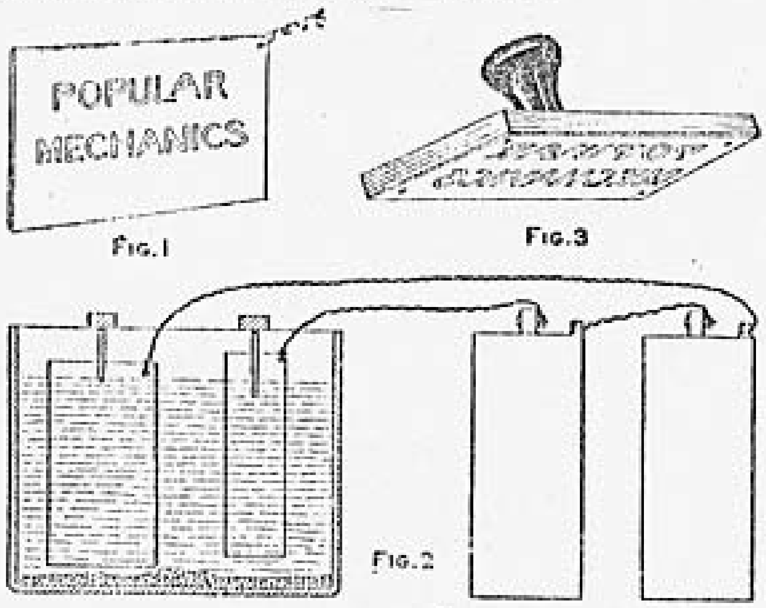
The method described in the following produces a very good metal stamp for any name, initial, drawing, etc.

Procure a smooth and perfectly level sheet of brass about $\frac{1}{16}$ in. thick and about 3 by 4 in. in size. Nickelplate the brass so that the copper deposit will not stick to it. If a small plating outfit is not at hand the piece may be plated at a local plating works for a nominal price. Dip the plate in melted paraffin until the coating is about $\frac{1}{16}$ in. thick and see that no metal is exposed. Drill a hole in one corner and attach a wire.

Draw the letters or sketch desired, using a metal stylus having a sharp point, taking care to make the lines scratched in the wax clean and open to the surface of the metal (Fig. 1).

A large open-mouthed bottle or glass tank will be required for the plating solution, which is made by dissolving copper sulphate in water until the solution is saturated with the sulphate and then adding a few drops of sulphuric acid. Immerse the plate in the solution as shown in Fig. 2 and connect with the zinc pole of the battery. Put a piece of pure copper in on the opposite side of the jar and connect with the carbon pole of the battery, using care in each case to keep the connection of the wire and the upper part of the plate above the surface. One or two dry cells will be sufficient. If the current is right, the deposit on the waxed plate will be a flesh pink; if too strong, it will be a dirty brick color and the plate will have to be washed and the current reduced. When the desired thickness of metal is deposited, remove the plate and pour boiling water on the back. This will remove the thin copper shell and the nickeled plate may be laid away for future use.

Procure a flat pan and after placing the shell in it, face down, sprinkle a little resin or soldering flux on the back. Lay three or four sheets of the lead from tea packages on the back of



Making the Copper Shell

the shell and heat it over a spirit lamp or on the stove until the lead melts and runs into the crevices on the back of the copper, thus making it solid and suitable for mounting. Mount as shown in Fig. 3 with small brass screws and after polishing the surface to remove dirt, etc., the stamp is ready for use.

An ordinary stamp pad will do for inking, but the best ink to use is printer's slightly thinned, as the ordinary rubber stamp ink is not suitable for a metal stamp.—Contributed by S. V. Cooke, Hamilton, Ont.

THE BOY MECHANIC – 1915

How to Make a Dry Cell

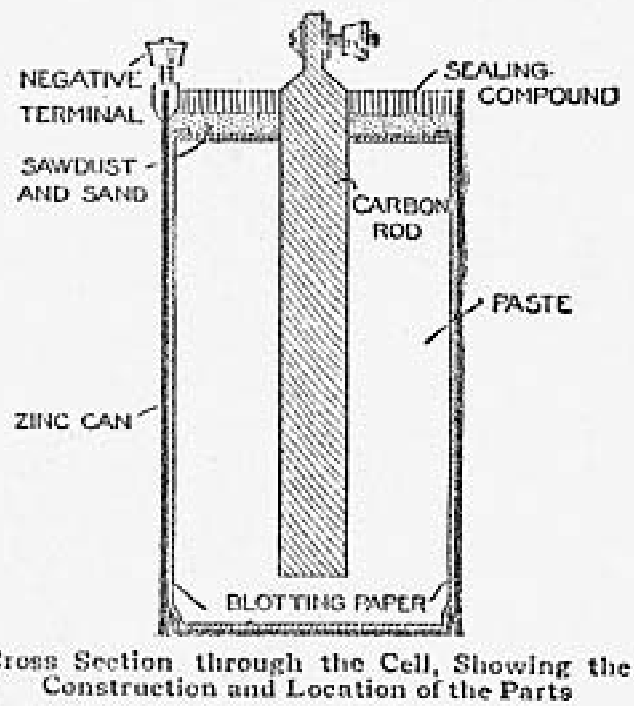
The containing vessel for the cell should be made from sheet zinc. It should be cylindrical in form, approximately 2½ in. in diameter and 6 in. long. This vessel is to form the negative terminal of the cell and a suitable connecting device, similar to the one shown in the sketch, should be provided and securely fastened to the upper edge of the vessel. The vessel should be lined with some heavy blotting paper, both sides and bottom.

Place into a glass jar a small quantity of chloride-of-zinc crystals, and pour over them ½ pt. of distilled water. Allow the crystals to dissolve at least one-half hour. If the crystals all dissolve, add more until some remain in the bottom of the jar, or until the liquid is saturated. Pour off the solution and dilute it by adding an equal part of distilled water. Add to this solution sal ammoniac, in the proportion of 1 lb. of sal ammoniac to every 2 qt. of liquid. Fill the dry-cell vessel with this solution and allow it to remain until the blotting paper is completely saturated.

Obtain a good size electric-light carbon, about ⅝ in. in diameter, and file one end down as shown. Drill a hole through the carbon and mount a terminal.

Make a mixture of equal parts of finely powdered carbon and manganese dioxide of sufficient amount to almost fill the vessel. Add to this mixture some of the solution and thoroughly mix them. Continue adding solution until a thick paste is formed.

Pour the solution out of the vessel and allow the latter to drain for a few minutes in an inverted position. Place the carbon rod in the center of the vessel and pack the paste down around it, being careful not to move the carbon rod from its central position. The vessel should be filled with the paste to within about ⅝ in. of the top. The lower end of the carbon rod should not be nearer the bottom of the vessel than ½ in. Over the top of the paste place

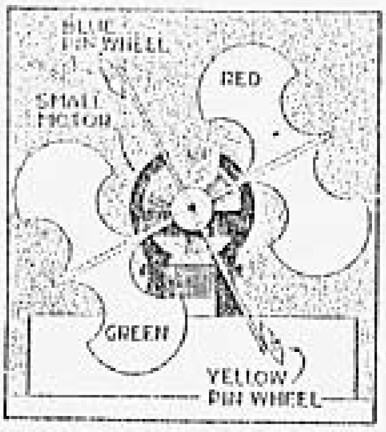


Cross Section through the Cell, Showing the Construction and Location of the Parts a mixture of equal parts sand and fine sawdust and then, over this, a layer of pitch, which acts as a seal for the cell. A layer of blotting paper should be placed between the sand-sawdust mixture and the carbon-manganese mixture. The side lining of the vessel should be turned in before the sand-sawdust mixture is placed in the top of the cell. The outside of the cell should be covered with some heavy pasteboard, which will serve to insulate the negative terminal from the surface upon which the cell rests.

THE BOY MECHANIC – 1919

Motor-Driven Entertainer for the Baby

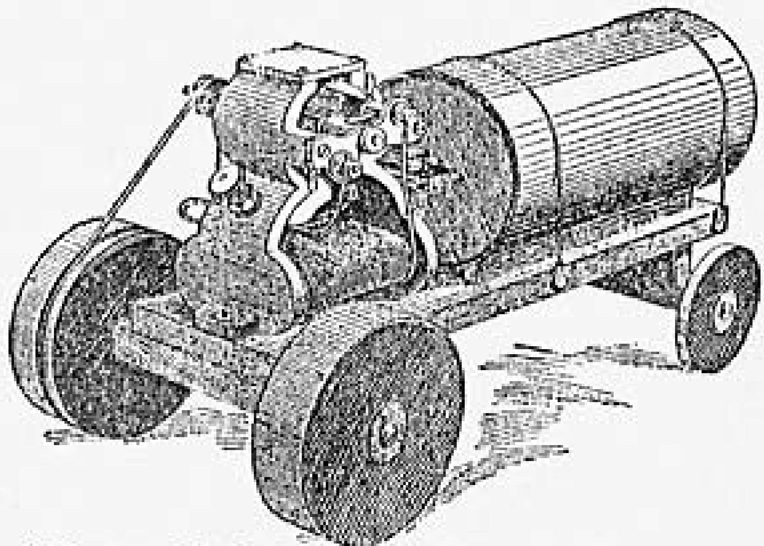
A contrivance that keeps the baby entertained, by the hour, at intervals, and is a big help to a busy mother, was made in a short time. I mounted four wooden arms on a small motor, as shown. On the ends of two of the arms, I fixed small pin wheels, one blue and the other yellow. The other arms hold curious-shaped pieces of bright cardboard, one red and the other green. The driving motor is run by one two-volt cell. The revolving colored pin wheels amuse baby in his high chair, and the device has well repaid the little trouble of making it.—A. H. Lauge, St. Paul, Minn.



THE BOY MECHANIC – 1919

A Toy Tractor Built with Dry Cell and Motor

An ordinary two-volt dry cell, a small motor, and the necessary wooden parts, as shown in the illustration, are all that is needed for the making of a toy tractor that will give its builder a great deal of fun. A good feature is that the parts can be taken down quickly and used for other purposes when desired. A base, ½ by 3 by 9 in. long, is made of wood, and two axles



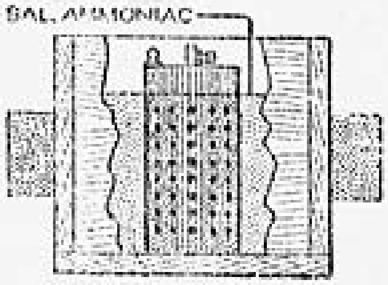
A Boy can Make This Simple Electric Tractor in a Short Time, and will Get Much Fun Out of It

of the same thickness are set under it, as shown. The wheels are disks cut from spools, or cut out of thin wood for the rear wheels, and heavier wood for the front ones. They are fastened with screws and washers, or with nails. The dry cell is mounted on small strips and held by wires. The motor is fastened with screws and wired to the dry cell in the usual manner. One of the front wheels serves as the driver, and is grooved to receive the cord belt.—J. E. Dalton, Cleveland, O.

THE BOY MECHANIC – 1919

Renewing Dry Batteries with Sal Ammoniac

Finding that dry batteries had increased in price, and requiring a number for experimental purposes, I devised the following method by which I was able to use the old batteries for a considerable period: When the dry cells were nearly exhausted, I punched holes through the zinc covering with a nail, as shown in the sketch. The holes were placed about 1½ in. apart, and care was taken not to punch them near the upper edge of the container, or the



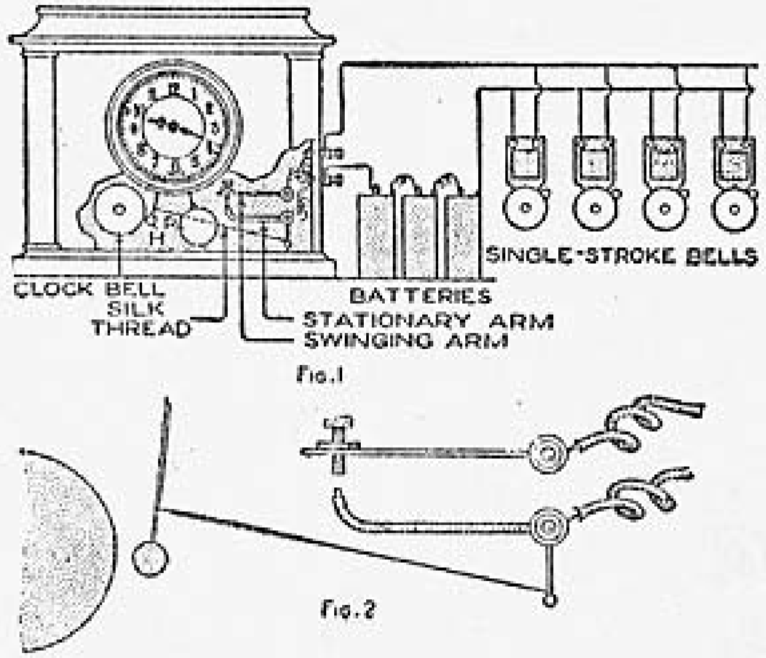
black insulation might thus be injured. The cells were then placed in a saturated solution of sal ammoniac. The vessel containing the liquid must be filled only to within ½ in. from the top of the cell, otherwise the binding posts will be corroded, and the cell probably short-circuited. The cells were left in the solution six hours, and then became remarkably live. They must not be connected or permitted to come into contact with each other while in the solution.—H. Sterling Parker, Brooklyn, N. Y.

THE BOY MECHANIC – 1919

Electrical Device Transmits Striking of Clock

Converting an ordinary parlor, or mantel, clock into a master clock, from which the striking of the gong is transmitted to various parts of the home, may be accomplished by fitting it with a simple electrical device, as shown in the sketch. The general arrangement of the batteries, single-stroke bells, and the contact device within the clock case is shown in Fig. 1; a detail of the silk cord and other connections of the contact key and the gong hammer, is shown in Fig. 2. This arrangement has been in operation for several years, and has been found practical.

The various rooms to which the striking of the gong is to be transmitted are wired with No. 18 annunciator wire, run carefully behind picture moldings and in corners. Where the wires must be carried through a partition, a ¼-in. hole is sufficiently large for the purpose. The single-stroke bells are wired up as shown in the sketch. The number of dry batteries necessary varies with the number of bells in the circuit, and also depends



The General Arrangement of the Apparatus for Transmitting the Striking of a Clock Gong is Shown in Fig. 1, and a Detail of the Contact Device in Fig. 2

on the length of wire through which the current is carried. A trial should be made with several batteries and more added until the bells are rung properly.

The connecting device may be fitted into the clock case without defacing it by boring holes in its side, and the binding posts are fixed into place neatly. The two sections of the contact key, shown in detail in Fig. 2, are fastened to the back of the clock case with bolts. The upper member is fitted with an adjustable thumbscrew and is stationary on the bolt fastening. The lower arm is made of covered wire and is pivoted on the supporting bolt. Attached to its lower edge, at the pivot, is a small lever arm. This is connected to the hammer rod of the gong with a silk cord. The length of the cord must be determined by careful adjustment so that it will not hinder the action of the hammer H, but will bring the swinging arm into proper contact with the thumbscrew. The contact should be made at the instant the hammer strikes the bell. The contact of the platinum point of the thumbscrew and the swinging arm must be close, but not too strong. Metal posts or tubes fitted over the bolts, at the points where the arms are attached to the back of the clock case, may be used to bring the arms the proper distance forward in the case, so that they will be in alinement with the hammer rod. The silk cord must not interfere with the action of the pendulum P. To hold the silk cord in place on the hammer rod, drop a small piece of melted sealing wax or solder on the rod.—W. E. Day, Pittsfield, Mass.

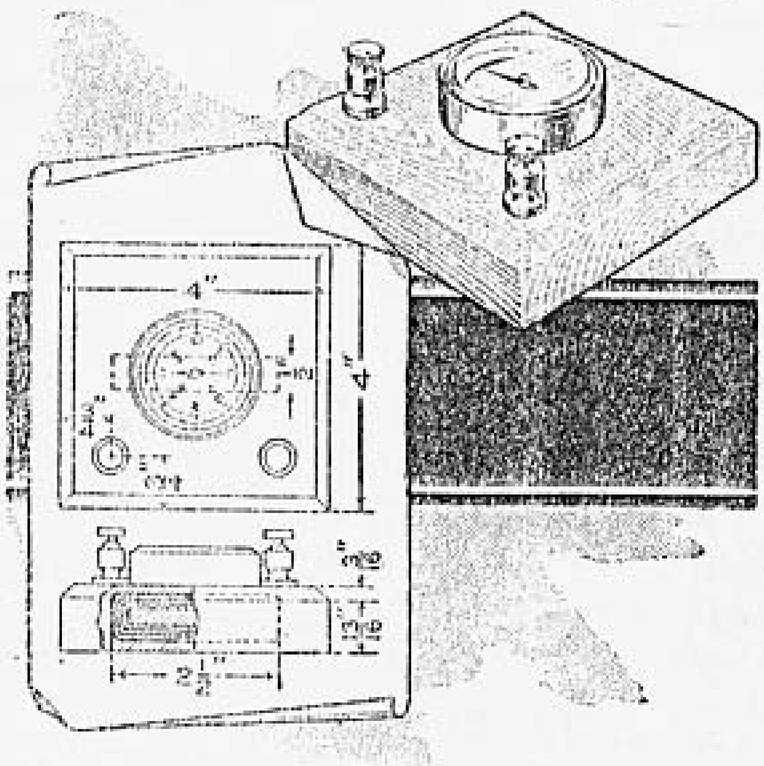
THE BOY MECHANIC – 1919

A Compact Galvanometer

A small portable galvanometer is one of the most useful instruments to the electrical experimenter. There are continually arising instances where it is necessary to test through and identify certain wires, for which purpose a small galvanometer and a dry cell are quite sufficient. For comparing the resistances by the well-known Wheatstone-bridge method, a galvanometer is, of course, indispensable. If the winding is made suitable, or by placing a shunt across the terminals to reduce the deflection, a small galvanometer will roughly indicate the current passing and thus enable one to compare his dry cells and eliminate the weak ones. Rough voltage comparisons may also be made by placing a resistance in series with the galvanometer.

For constructing this instrument, a good pocket compass, of about 2-in. diameter, must be procured. Prepare a neat little box with the four edges accurately beveled off. On the under side of this, carefully cut a channel, about ½ in. wide and 2½ in. long, to a depth that will bring the bottom of the slot within ⅛ in. of the top of the base block. Place two binding posts on the base, as indicated, and secure the compass in place with cement, or by two very small nails put through the bottom. If the glass cannot be removed, it will be necessary to solder the nail heads to the bottom of the compass box, after having carefully removed the lacquer.

The correct wiring will depend on the strength of the current handled. It is, however, very easy to get an idea of what the deflection will be under certain conditions by merely making a preliminary trial, after winding a few



Galvanometer Made of a Compass Set on a Wood Base, with Coil and Wire Connections

turns of any magnet or bell wire at hand around a small piece of wood, and slipping the coil so formed into the slot on the under side of the base block. The winding may be from two or three turns of heavy wire up to several hundred turns of fine magnet wire, but after one or two trials, the maker will have no trouble in determining his particular requirements.

The final coil should be wound lengthwise on a wood core, and the whole packed neatly into the slot. Connect up the ends to the binding posts, and then glue in a thin piece to hold the coil in place.

By drilling a small horizontal hole through the base, as indicated by the two dotted lines in the top view of the working drawings, and inserting a small bar magnet, ⅛ in. in diameter, or less, the instrument may be rendered independent of the earth's magnetism and used without reference to the north point. Such a controlling magnet re-

 GRANDDAD'S ELCTRICITY BOOK

duces the time required to bring the needle to rest after it has been violently deflected.

THE BOY MECHANIC – 1919

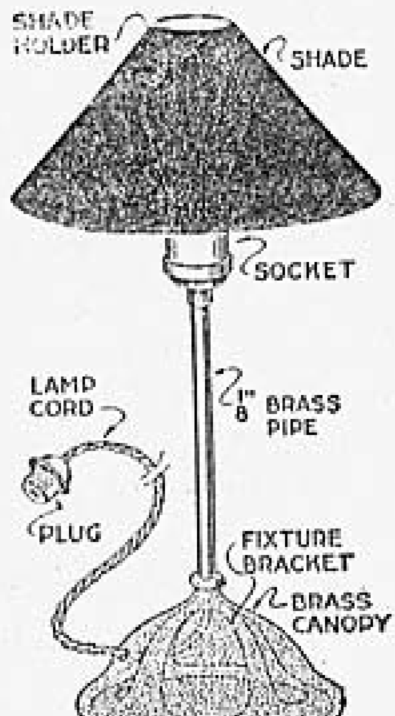
An Electric Lure for Fish

Every good fisherman knows that a light will attract fish. A simple light can be made by taking a pint fruit jar, cutting a 1/4-in. hole in the top of the cover, inserting a piece of gas pipe in the hole and soldering it to the cover. Insulated wires are run through the pipe, and a small electric globe is attached to the ends in the jar. The other ends of the wires are attached to a pocket battery. The jar is placed under water and the light turned on, which attracts the fish.

THE BOY MECHANIC – 1919

Inexpensive Table Lamp Made of Electrical-Fixture Parts

A small table lamp that is light and easily portable, can be made at a cost of less than $1 from electrical-fixture parts, either old or purchased at a supply store for the job. The base is a bracket, with its brass canopy inverted, as shown. The upright is a 1/8-in. brass pipe, and it is fitted to a standard socket. The shade holder can be made complete from a strip of tin and two wires; or adapted from a commercial shade holder used for candlesticks. Various types of shades, homemade if desired, can be used.



THE BOY MECHANIC – 1919

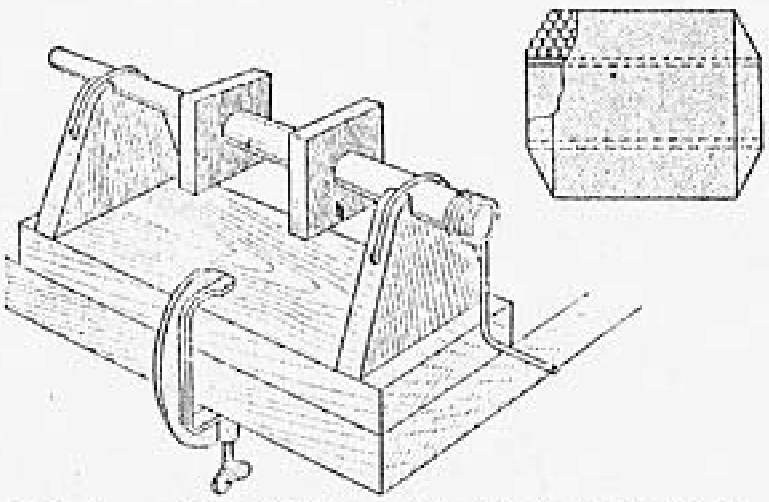
How to Wind Wire on Electrical Apparatus

When a beginner, it was the despair of the writer to try to produce in his homemade apparatus the mathematical regularity and perfection of the winding on the coils of electrical instruments in the supply stores, but when he found that this professional and workmanlike finish could be obtained by means of a simple contrivance, and a little care and attention to details before beginning, experimental work took on a new interest.

At the outset let it be stated that wire should never be wound directly on the iron core, not only because it cannot be done satisfactorily in that manner, but for the reason that it is often desired to remove a coil from a piece of apparatus after it has served its purpose. It is therefore advisable to make a bobbin, which consists of a thin, hard tube with two ends. The tube may be easily formed by wrapping a suitable length of medium-weight paper on the core, having first coated it with ordinary fish glue, excepting, of course, the first 2 or 3 in. in direct contact with the core. Wind tightly until the thickness is from 1/32 in. to 1/16 in., depending upon the diameter of the core, and then wrap with string until the glue hardens, after which the tube may be sandpapered and trimmed up as desired.

Where the wire is not of too small a gauge and is not to be wound to too great a depth, no ends will be necessary if each layer of wire is stopped one-half turn before the preceding one, as indicated in the accompanying sketch, and is also thoroughly shellacked. With ordinary care magnet wire may be wound in this manner to a depth of over one-half inch.

The tube having been made ready, with or without ends as may be necessary, the small winding jig illustrated is to be made. All that is essential is to provide a suitable means for rotating by hand a slightly tapering wood spindle, upon which the tube is to be pushed. The bearings can be just notches made in the upper ends of two standards, through each of which a hole is drilled at right angles to the length of the spindle, so that some string or wire may be laced through in order to hold the spindle down. A crank may be formed by winding a piece of heavy wire around the larger end of the spindle. A loop of wire, or string, is to be attached at some convenient point, so that the crank may be held from unwinding while adjusting matters at the end of each layer, or while making a connection. There should also be provided a suitable support for the spool of wire, which is generally placed below the table to good advantage. Much depends, in this sort of work, upon attention to these small details, after which it will be found that



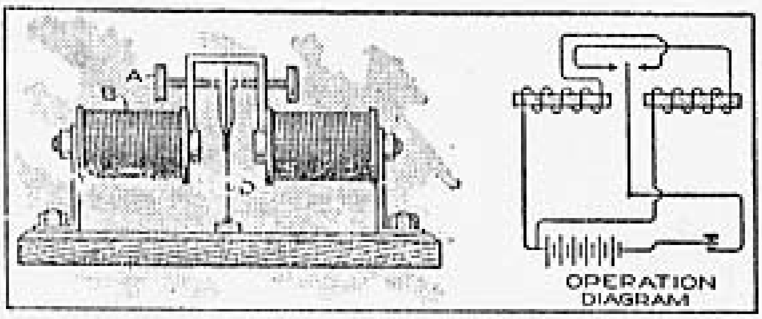
Winding a Coil of Wire so That the Layers will be Even and Smooth

the actual winding will require very little time.—Contributed by John D. Adams, Phoenix, Ariz.

THE BOY MECHANIC – 1919

A Double-Contact Vibrator

A double-contact vibrator, which eliminates sticking contacts, spring troubles, and other sources of annoyance, in addition to producing a fine, high tone, is shown in the sketch. It is an instrument easy to construct, by reason of its simplicity. Special care in making the vibrator D will insure good vibration. The springs, holding the contacts, are of phosphor bronze. The contacts may be made of silver, platinum, or other metals, which will not burn and break contact. The coils



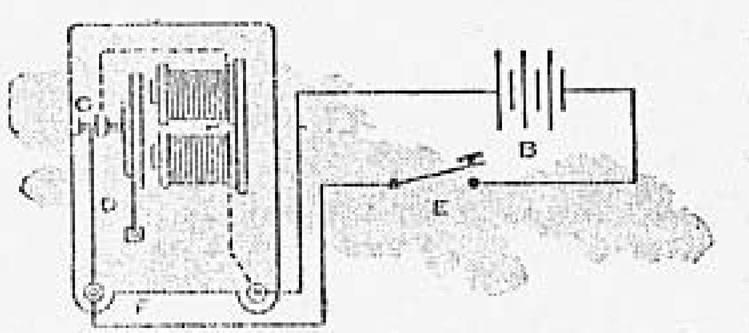
When the Vibrator Touches One Contact, the Coil on the Opposite Side Attracts the Vibrator, This Process being Repeated Alternately

B are of the common bell-ringing type. The springs on the vibrator should not be too long, nor too weak; experimenting will determine the length at which they will work best. The adjustment is made at the thumbscrews A. The coils are supported on metal brackets, bolted to a wooden base. The method of hooking up the vibrator in the key circuit is shown in the diagram.—J. L. Taylor, Barker, N. Y.

THE BOY MECHANIC – 1919

Battery Buzzer Converted into a Telegraph Sounder

An ordinary battery buzzer may readily be converted into a telegraph sounder for use in practicing the Morse code. All that is necessary is to connect the vibrator contact C of the buzzer to the binding post that is not insulated from the frame. The other connections of the key and battery are the same as in any ordinary telegraph or buzzer circuit. In the diagram, C rep-

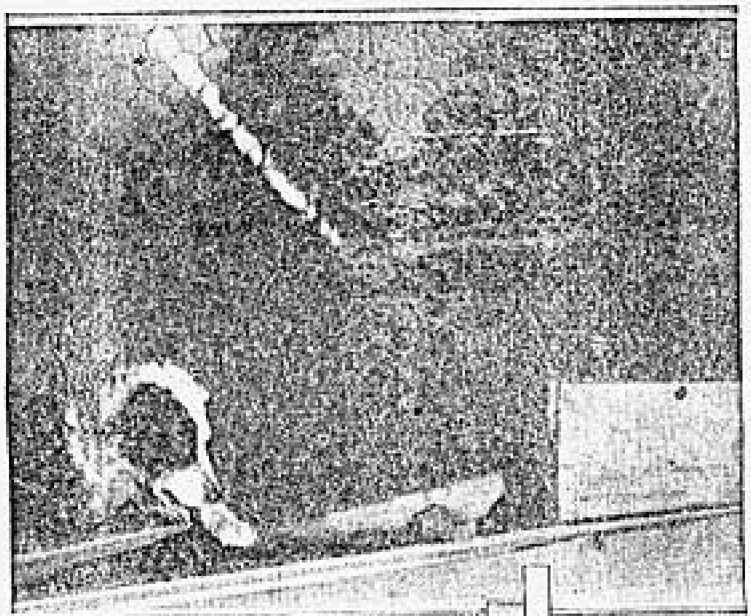


The Amateur can Practice the Morse Code Handily on This Sounder, Made from a Buzzer resents the vibrator contact; D, the wire connecting the contact and the uninsulated binding post, and F, the uninsulated binding post; E is the telegraph key, and B, the dry cells.—Clarence F. Kramer, Lebanon, Ind.

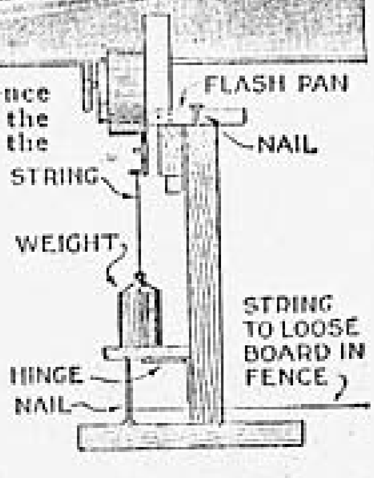
THE BOY MECHANIC – 1919

Automatic Flash Light Snaps Chicken-Coop Marauder

After the wire fence around the chicken house had been torn up, and



This Photographic Evidence Was Proof Positive as to the Identity of the Thief in the Night



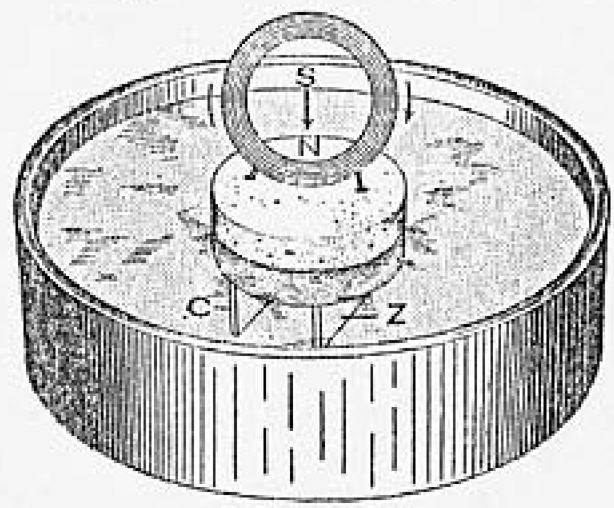
the place entered 13 nights in two weeks, I decided on more preparedness. Various ways and means failed, so I used a comparatively slight knowledge of photography in the process.

I mounted my flash lamp on a piece of board, 1 by 4 by 8 in. long, and fastened this to a base, as shown. I attached a weight to the lamp, which was supported by a hinged drop, halfway down the upright board, which in turn was supported by a nail, to which was attached a string. The flash was set off by a slight pull of the string, which dropped the weight. This contrivance I concealed in the chicken yard, and the camera in the chicken house. That night I opened the lens of the camera in the dark, and attached the string to a loose board in the fence. The next morning, before daybreak, I closed the lens again. The flash had been set off during the night. Also there were drops of blood on the ground. I could hardly wait until the plate was developed. The result, as reproduced, was hardly what I expected.—H. U. Scholz, Medford, Ore.

THE BOY MECHANIC – 1919

Simple Experiment in Electromagnetism

The following simple experiment, which may be easily performed, will serve to prove the theory that there



A Small Coil of Wire Mounted on a Cork Floating in Dilute Sulphuric Acid

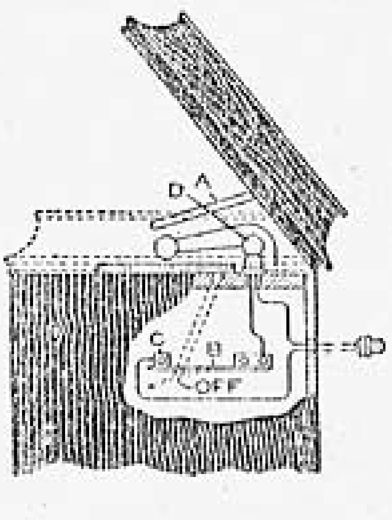
is a magnetic field produced about a conductor carrying a current, and that there is a definite relation between the direction of the current in the conductor and the direction, or polarity, of the magnetic field produced by the current. The current in the experiment is to be produced by a battery consisting of a small copper and zinc plate fastened to the under side of a large flat cork, as shown in the sketch, the whole being placed in a glass or rubber vessel partly filled with diluted sulphuric acid. A small coil of wire is formed and mounted on top of the cork, and its terminals are connected to the copper and zinc plates. The electromotive force generated will cause a current to circulate through the coil from the copper plate to the zinc plate. If the poles of a permanent magnet be presented in turn to the same side of the coil it will be found that there is a force of attraction between one pole of the permanent magnet and the coil, and a force of repulsion between the other pole and the coil. If the same operation be performed on the opposite side of the coil, it will be found that the force between the poles of the magnet and the coil are just the reverse of what they were in the first case; that is, the pole that attracted the coil in the first case will now repel it, and the one that repelled it, will now attract it. Applying one of the fundamental laws of magnetism—like poles attract and unlike repel each other—it can be readily seen that the two sides of the coil are of opposite magnetic polarity.

If the direction of the current around the coil be changed, the action between the coil and the magnet will be opposite to what it was originally, and if the plates be placed in clean water, there will be no current and no attraction or repulsion between the coil and the poles of the magnet.

THE BOY MECHANIC – 1919

Automatic Electric Light on Talking-Machine Cabinet

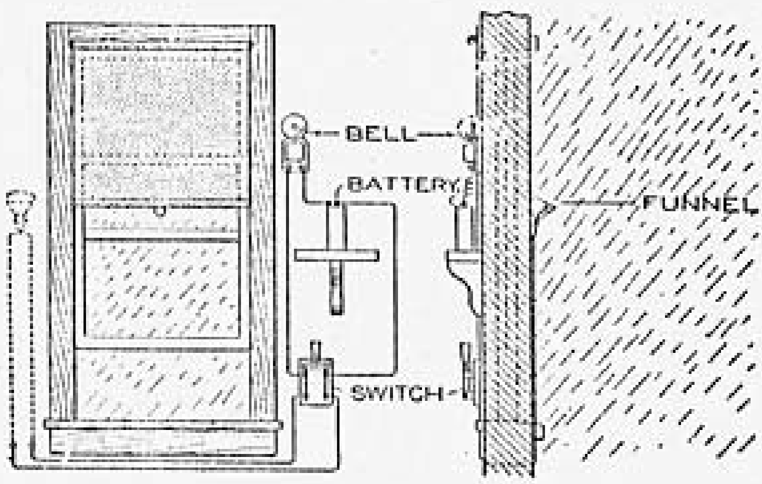
In many homes the phonograph is placed where little light is available in changing the records, setting the needle, etc. An electric light which is lighted only while the cover of the phonograph is raised, is well worth installing. A metal arm, A, supports the open cover of the cabinet. When the cover is closed, this arm passes through a slot and takes the position shown by the dotted line. A strip of spring brass, B, is fastened to the inside wall of the cabinet, in the path of the arm, so that it will be pushed down to the off position, as indicated. When the arm releases the strip B, the latter presses against the contact C. A small electric lamp, D, is set in the corner, and electrical connection made to it through B and C, the plug connections passing through the back of the cabinet. When the cover is down, the electric circuit is open, and the moment it is raised, connection is made at C, and the lamp lights. The backs of most phonograph cabinets may be removed easily to make these changes.—M. C. Ball, Kansas City, Mo.



THE BOY MECHANIC – 1919

Rain Alarm with Drop-of-Water Contact

An annunciating device, which awakens a person sleeping in a room with the window open and warns him that it is raining, so that he may close the window, is an interesting bit of electrical construction. On the outside of the house, as detailed, is a funnel fixed to the wall. At its small end, two separate wires have their terminals. The wires enter the room at the frame of the window, and connect to an electric bell, and a dry cell. A drop of water entering the funnel, flows down to the small end, falling on the terminals of the wires, and acting as a conductor, completes the circuit, ringing the bell. A



A Drop of Rain Water Completes the Bell Circuit, Thus Giving Warning of the Rain

 GRANDDAD'S ELCTRICITY BOOK

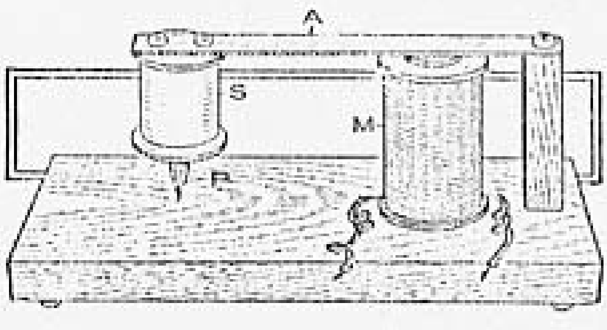
switch inside cuts out the circuit, stopping the bell's ringing.—John M. Chabot, Lauzon, Quebec, Can.

THE BOY MECHANIC – 1919

Telegraph Recorder with Spool-and-Pencil Indicator

A simple substitute for the somewhat complicated telegraph recorders of the inking type may be constructed of materials readily available to a boy. The instrument shown in the sketch was made in a short time and with no special outlay. The base and the upright support are of wood. The armature A was made of a strip cut from a tin box, and folded to a length of 4 in.

The recording device consists of a short piece of pencil, P, set in a spool, S. The electromagnet M is fixed to the base, and the armature A is actuated when current is permitted to pass through the magnet, causing the recording pencil to move vertically. A strip of paper is moved slowly under the pencil, and in order to make the



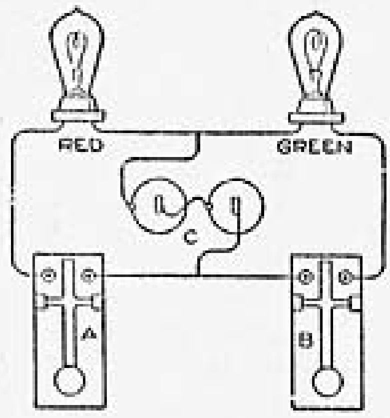
The Telegraph Recorder was Made of Materials That may be Gathered Easily by Boys

record regular a small channel-shaped guide of metal may be arranged under the pencil.—William Warnecke, Jr., New York City.

THE BOY MECHANIC – 1919

Signal Telegraph with Green and Red Lights

By arranging a circuit with batteries, lights, and keys, as shown in the diagram, a signal telegraph may be made that will afford much pleasure to boys

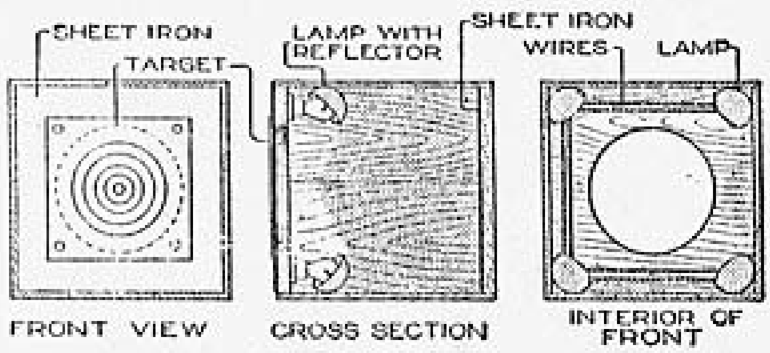


and may be used for practical purposes. The keys A and B are wired into the circuit with a battery C and a red and a green incandescent lamp. A simple set of signals may be devised easily so that messages may be sent in the code.—James R. Townsend, Itasca, Texas.

THE BOY MECHANIC – 1919

An Illuminated Indicating Target Box

The joys of target practice are often hampered by the delays in the settlement of hits. It takes time and is annoying to be constantly advancing to the target to examine it. To do away with this, an illuminated target was constructed that enables the shooter to locate every hit without leaving his post. To make the device, a square wooden box of convenient size is obtained. In one side of this, cut a round hole as large as the largest ring on the targets used. The side opposite this is



The Location of Hits is Recorded by a Beam of Light Streaming through the Hole Shot in the Paper Target

fitted with a piece of sheet iron to stop the bullets. Paint this iron and the interior white. Inside the box, arrange four electric lights so their rays will be thrown on the hole, as shown. Candles may be used, if necessary. The lamps must be out of range of the bullets, that hit the target, and protected by an iron plate. The targets,

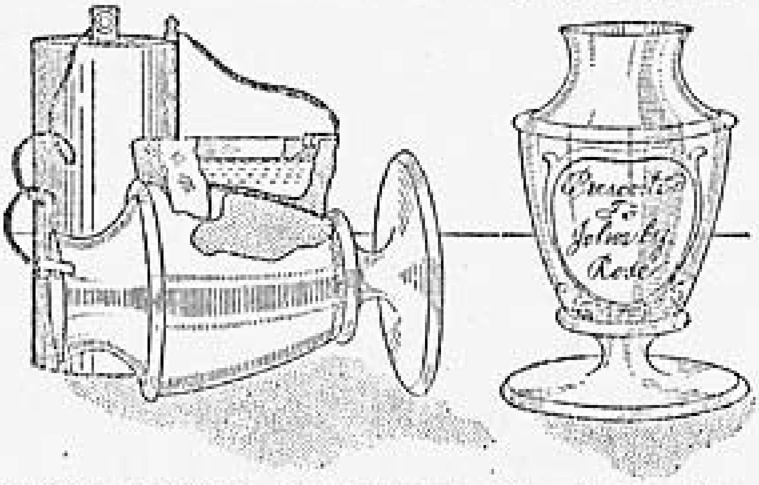
 GRANDDAD'S ELCTRICITY BOOK

painted on thin paper, are fastened over the front of the hole, and the lights are on, while shooting. Each shot punctures the paper, and the light streaming through the hole will show the location of the hit.

THE BOY MECHANIC – 1919

Onlaying Script on a Trophy Cup

A novel method of inscribing names or other indications on trophy cups or



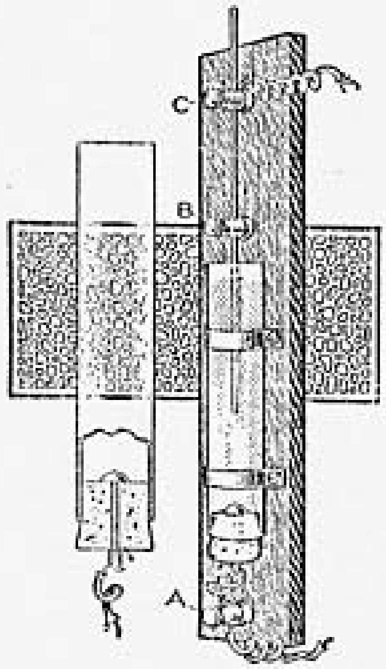
Copper or Other Metal may be Deposited on the Surface of the Cup, Making an Effective Inscription

medallions is to onlay copper, or other contrasting metal, upon the surface by the process illustrated. Beeswax, or paraffin, is fixed to the side of the cup and formed into a dish shape, the surface on which the onlaying is to be done being covered with only a thin layer of the wax. With a needle or other suitable instrument, scratch the markings desired through the thin layer of wax to the surface of the cup. Pour copper sulphate into the wax cavity, if the onlay is to be of copper, and suspend a small piece of pure copper in the liquid, connected with the positive pole of a storage battery, or other similar electrical source. Attach a wire from the negative pole of the battery to the cup. The copper will be deposited on the surface of the cup where the thin layer of wax has been scratched off, exposing the metal. The thickness of the deposit will depend on the length of time that the current is permitted to flow. Ten hours of action will permit the depositing of a satisfactory onlay.—M. H. Edwards.

THE BOY MECHANIC – 1919

Water Rheostat for Small Electrical Devices

The rheostat shown in the illustration can be made quickly and at small expense. The base consists of a piece of wood, ½ by 2 by 12 in. A glass tube, 1 in. in diameter and 6 in. long, is fastened to this with strips of sheet metal. A large brass tack is driven into a cork, and the cork is inserted in the lower end of the tube. A wire runs from the brass tack to the binding post A. The lower part of the tube should be paraffined to make it water-tight. A brass or copper rod is placed through the binding posts B and C. The resistance can be changed by sliding the rod up or down. The tube is nearly filled with water having a small quantity of salt dissolved in it. The amount will depend upon the current to be reduced. The rheostat should be fastened to a wall, or other support, and may be used to regulate the speed of small motors and other electrical devices.

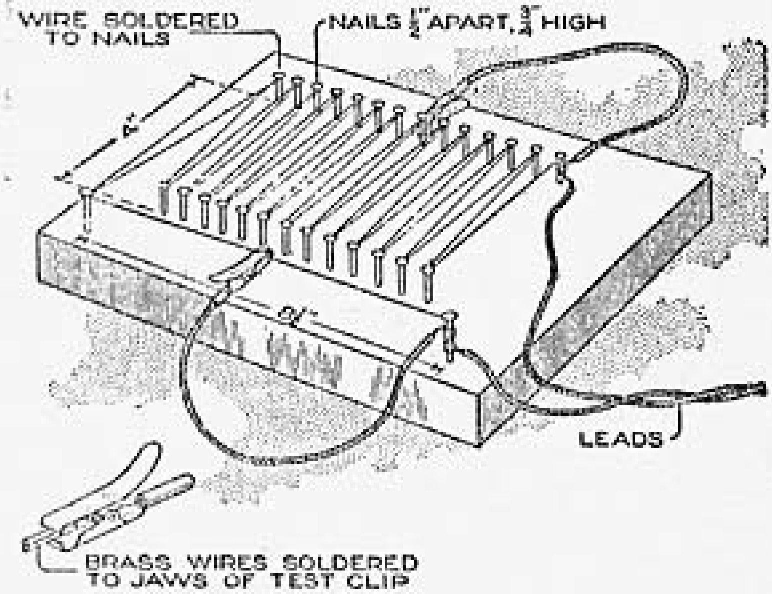


THE BOY MECHANIC – 1919

A Small Rheostat for Experiments and Testing

A rheostat made as shown in the sketch has been used successfully for calibrating a large number of ammeters and wattmeters. One of the general designs suggested will be useful for many other purposes. The dimensions given were used for obtaining a variation of from ½ to 5 amperes with a 6-volt source of electromotive force. For other capacities the proportions may be increased or decreased proportionately. A piece of pine, 7 by 9½ in., forms the base. For resistance wire No. 16 gauge "Climax" was used, but wire of any material which will carry the maximum current without excessive oxidation may be employed instead. Nails support the resistance wire, which should be soldered to the nails to insure good electrical contact. Leads of flexible cord are arranged as shown. These are soldered to the first and last nails in the series. To provide connection between the free ends of the cord and the resistance wire or the nails, 5-ampere test clips are soldered to the cord ends. The teeth of the clip jaws are filed off, and in their stead a short piece of brass wire is soldered to each jaw, as indicated in the detailed view. A nick is filed in each of the brass wires so that they will hold firmly onto the resistance wire or nail. Suspender or display-case clips, suitably modified, may be substituted for the commercial test clips.

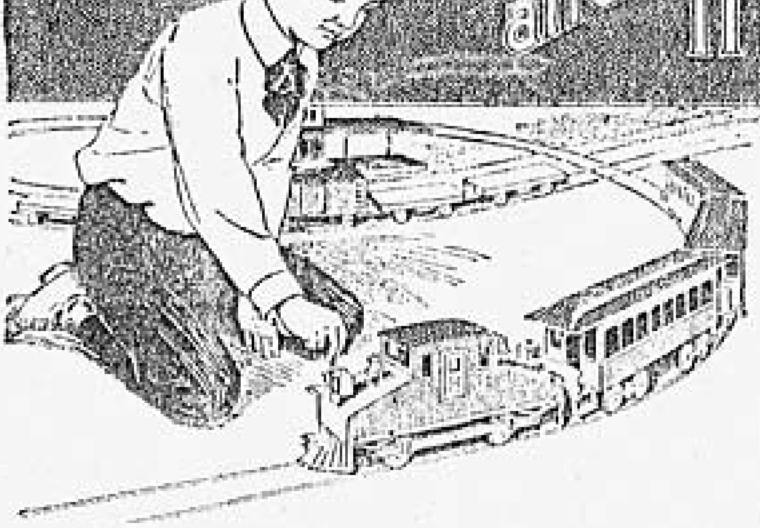
In using the device, one clip is moved along the front span. The other is gripped to a nail in the rear row. Sliding the front clip along the span wire insures a fine adjustment of resistance. Gripping the rear clip on the different



This Homemade Rheostat Has a Capacity of One-Half to Five Amperes, on a Six-Volt Circuit

nails provides the coarse adjustment. —R. F. Binney, La Vina, Calif.

Homemade Electric Locomotive Model and Track System



THE BOY MECHANIC – 1919

By A. E. ANDREW

PART I—The Motor

THE electric locomotive described may be constructed by boys having average mechanical ability and the necessary tools. However, in any piece of mechanical construction care must be taken to follow the instructions. The material required is inexpensive, and the pleasure derived from such a toy is well worth the time used in its construction.

The making of the outfit may be divided into three parts, the first of which is the motor; second, the truck, which is to carry the motor and the body of the car, and third, the track system upon which the engine is to operate. A side view of the locomotive is shown in Fig. 1.

The motor is of the series type, having its field and armature terminals connected to the source of electrical energy through a special reversing switch. By this means the rotation of the armature may be reversed to make the locomotive travel forward or backward. The armature and field are constructed of sheet-iron stampings, riveted together.

The detailed construction of the armature and its dimensions are shown in Fig. 2. The shaft upon which the armature core and commutator are to be rigidly mounted is made of a piece of steel rod, 7/32 in. in diameter. A portion of this rod, 2 1/4 in. long, is threaded with a fine thread, and two small brass, or iron, nuts are provided to fit it. The ends of the rod are turned down to a diameter of 1/8 in. for a distance of 1/8 in. These are to fit in the bearings that are to be made later.

Cut from thin sheet iron a sufficient number of disks, 1 1/8 in. in diameter, to make a pile exactly 5/8 in. thick when they are securely clamped together. Drill a hole in the center of each of these disks, of such a size that they will slip on the shaft snugly. Remove the rough edges from the disks and see that they are flat. Cut two disks of the same size, from a piece of 1/16-in. spring brass, and drill a hole in the center of each, so that they will slip on the shaft. Place all these disks on the shaft, with the brass ones on the outside, and draw them up tightly with the nuts provided. Be sure to get the laminated core in the proper position on the shaft by observing the dimensions given in the illustration, Fig. 2.

After the disks have been fastened, clamp the shaft in the chuck of a lathe and turn down the edges of all the disks so that they form a smooth cylinder, 1 1/16 in. in diameter. Draw a circle on the side of one of the brass disks, 3/32 in. from the edge, while the shaft is held in the chuck. Divide this

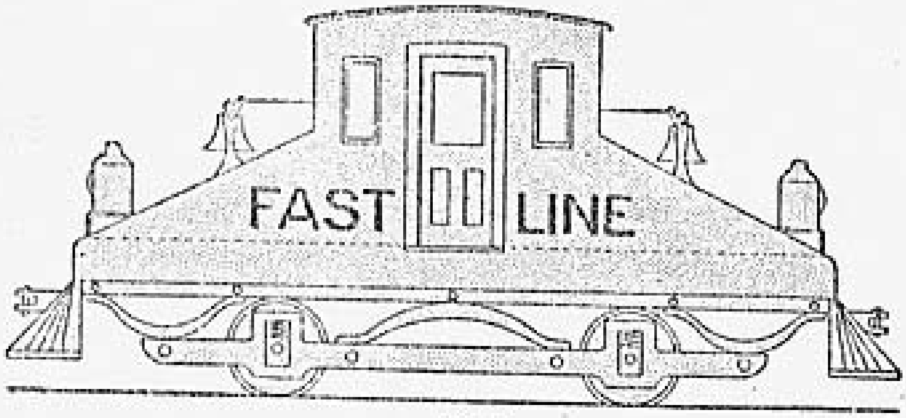


FIG. I
Side View of a Locomotive Designed to be Operated with Either End Forward

circle into eight equal parts and make a center-punch mark at each division. Drill eight holes through the core lengthwise with a 3/16-in. drill. If the centers of the holes have been properly located, all the metal on the outside will be cut away, as shown in the end view, at the right in Fig. 2. The width of the gaps, F, G, H, etc., thus formed, should be about 1/16 in. Smooth off all the edges with a fine file after the holes are drilled.

A cross-sectional view of the commutator is shown at the extreme left, Fig. 2. It is constructed as follows: Take a rod of copper or brass, 7/8 in. in diameter, and 1 1/4 in. long; clamp one end in the chuck of a lathe. Turn the other end down to a diameter of 3/4 in., and drill a 1/2-in. hole through it at the center. Cut away the metal from the end to form a disklike recess.

Cut off a disk, 5/16 in. thick, measuring from the finished end, from the piece of stock. Place this disk in a chuck, with the unfinished end exposed, and cut away the metal in a dish form, as shown at B. Cut small slots, into which the ends of the wires used in winding are to be soldered, as shown at 1, 2, 3, etc., in the right-hand view of Fig. 2. Obtain two brass nuts, about 1/4 in. in thickness, and turn their edges down so that they correspond in form to those shown at C and D. Divide the

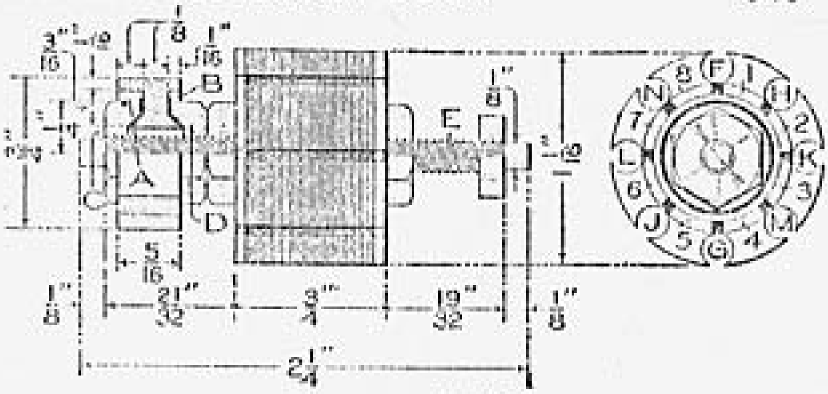


Fig.2

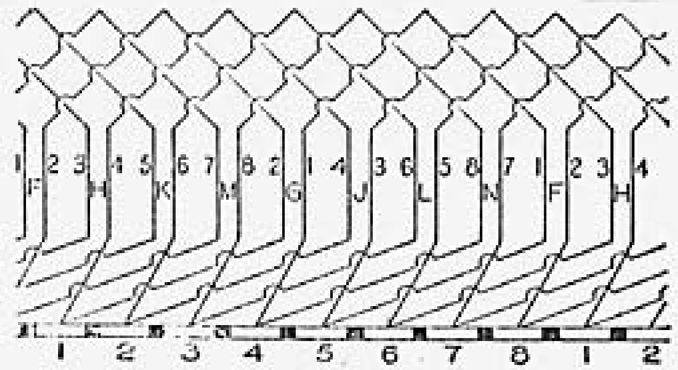


Fig.3

How the Armature Core is Made of Soft-Iron Disks for the Lamination, at the Left. Diagram for the Winding of the Armature Coils and Their Connection to the Commutator, at the Right

disk ring, just made, into eight equal parts, by lines drawn across it through the center. Cut eight slots at these points, in the rim of the disk. These cuts should be through the rim. Fill each of the slots with a piece of mica insulation.

Place one of the nuts on the shaft, and then a washer of mica insulation, shown by the heavy lines, near A and B; then the ring, a second piece of mica, and last the nut, C. The latter should be drawn up tightly, so that the insulation in the slots in the disk are opposite the drilled slots in the armature core, as shown in the right-hand view of Fig. 2. After the disk has been fastened securely, test it to learn whether it is insulated from the shaft. This is done by means of a battery and bell, connected in series, one terminal of the circuit being connected to the disk, and the other to the shaft. If the bell rings when these connections are made, the ring and shaft are not insulated. The disk must then be remounted, using new washers of mica insulation. Mica is used because of its ability to withstand a higher degree of heat than most other forms of insulation.

Each of the eight segments of the dished disk should be insulated from the others. Make a test to see if the adjacent commutator segments are insulated from each other, and also from the shaft. If the test indicates that any segment is electrically connected to another, or to the shaft, the commutator must be dismantled, and the trouble corrected.

The armature is now ready to be wound. Procure 1/8 lb. of No. 26 gauge insulated copper wire. Insulate the shaft, at E, with several turns of thin cloth insulation, and also insulate similarly the nuts holding the armature core and the inside nut holding the commutator. Cut several pieces from the cloth insulation, wide enough to cover the walls of the slots in the core, and long enough to extend at least 1/16 in. beyond the core at the ends. Insulate slots F and G thus, and wind 15 turns of the wire around the core lengthwise, passing the wire back through the slot F, across the back end of the core, then toward the front end through slot G, and back through F, and so on. About 2 in. of free wire should be provided at each end of the coils.

In passing across the ends of the armature, all the turns are placed on one side of the shaft, and so as to pass on the left side, the armature being viewed from the commutator end. The second coil, which is wound in the same grooves, is then passed on the right side, the third on the left, and so on. After this coil is completed test it to see if it is connected to the armature core. If such a condition is found, the coil must be rewound. If the insulation is good, wind the second coil, which is wound in the same slots, F and G, and composed of the same number of turns. Insulate the slots H and J, and wind two coils of 15 turns each in them, observing the same precautions as with the first two coils. The fifth and sixth coils are placed in slots K and L, and the seventh and eighth, in slots M and N.

The arrangement of the half coils, slots, and commutator segments is given in detail in Fig. 3. Each coil is reduced to one turn in the illustration, in order to simplify it. From an inspection of this diagram it may be seen that the outside end of the second coil in the upper row of figures, at the left end, is connected to the inside end of the fourth coil at segment 1, in the lower row of figures, representing the segments of the commutator. The outside end of the fourth coil is connected with the inside end of the sixth coil, at segment 2; the outside end of the sixth coil is connected with the inside end of the eighth coil at segment 3; the outside end of the eighth coil is connected to the inside end of the coil 1 at segment 4; the outside end of the coil 1 is connected to the inside end of the coil 3 at segment 5; the outside

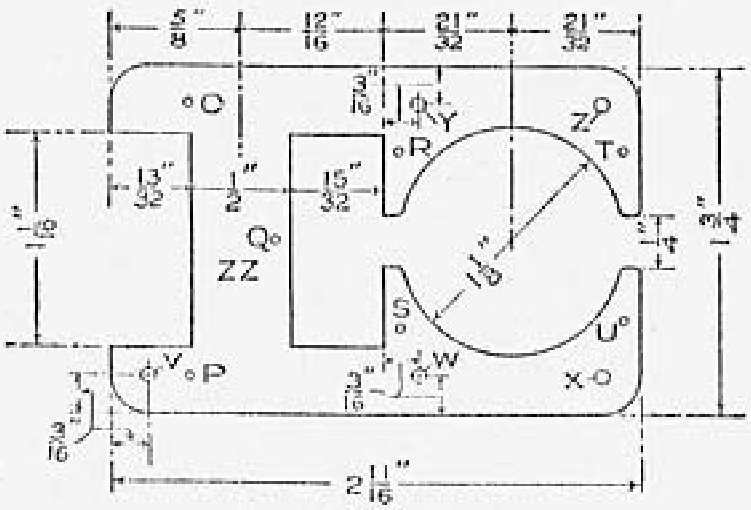


FIG. 4

Pattern for the Field Stampings, Several Pieces being Used to Make the Desired Thickness

end of the third coil is connected to the inside end of the fifth coil at segment 6; the outside end of the fifth coil is connected to the inside end of the seventh coil at segment 7; the outside end of the seventh coil is connected to the inside end of the second coil at segment 8, and the outside end of the second coil is connected to segment 1, completing the circuit.

In winding the coils on the core, their ends should be terminated close to the commutator segments to which they are to be connected, in order to simplify the end connections. After all the coils are wound and properly tested, their ends may be connected as indicated. They are then soldered into the slots in the ends of the commutator segments. The completed winding is given a coating of shellac.

The dimensions and form of the field stampings are given in Fig. 4. A number of these cut from thin sheet iron to make a pile 5/8 in. thick when clamped together is needed. The dimensions of the opening to carry the armature should be a little less than that indicated in the sketch, as it will be necessary to true it up after the stampings are fastened together. Use one of the stampings as a pattern, and drill seven small holes in each, as indicated by the letters O, P, Q, R, S, T, and U. Fasten them together with small rivets, and true up the opening for the armature to a diameter of 1 1/8 in. Drill five 1/8-in. holes, as indicated by the letters V, W, X, Y, and Z, to be used in mounting the pieces, which are to form the armature bearings, brush supports, and base of the motor.

Cut two rectangular washers from a piece of thin fiber insulation, with outside dimensions of 1 1/8 in. and 1 1/4 in., and an inside opening, 1/2 in. by 5/8 in. Cut open these washers and slip them in position on the portion of the field marked ZZ. Wrap two turns of the cloth insulation about this part, which is to form the field core, and wind the space full of No. 18 gauge enamel-

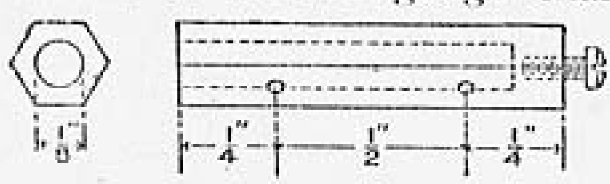


FIG. 7

Detail of the Brush Holders, One Inch Long, with Holes as Shown

insulated copper wire. Give the completed winding a coat of shellac. The terminals of this winding should be

 GRANDDAD'S ELCTRICITY BOOK

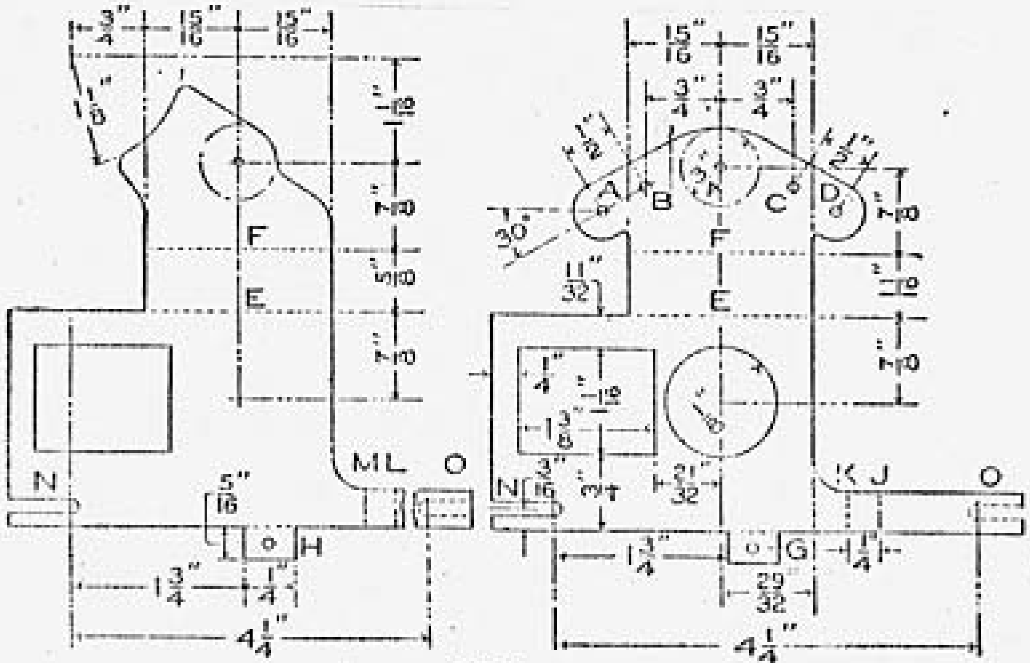


FIG. 5

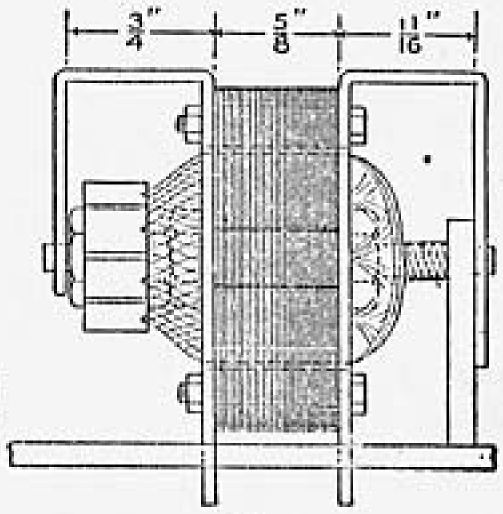


FIG. 6

Detail of the Field-Structure Supports, One Being for the Left Side and the Other for the Right. The Supports are Shown in Place at the Right

brought out through two holes drilled in one of the fiber washers, one near the core and the other near the outer edge. It is better to have the field terminals at the lower end of the part ZZ than at the upper end.

Now cut two pieces from 1/16-in. sheet brass, similar to those shown in Fig. 5. Place them on opposite sides of the laminated field structure, shown in Fig. 4, and carefully mark the position of the holes, V, W, X, Y, and Z, as indicated in Fig. 4, and drill 1/8-in. holes, where the marks were made. Lay out and drill 1/8-in. holes, A, B, C, and D, Fig. 5. Bend the upper portion of the pieces at right angles to the lower portion, along the dotted lines E, and then bend the end of the horizontal portions down along the dotted lines F, until they are parallel with the main vertical parts of the pieces. The latter should be bent so that one forms the left support and the other the right, as shown in Fig. 6.

Bend the projections G and H at right angles to the vertical main parts. The parts at the bottom are bent, one back along the dotted line J and forward on the line K; the other forward on the line L and back on the line M. The pieces are then mounted, on the side of the field structure, as shown in Fig. 6. The supports are fastened in place with five small bolts. The grooves N and O, in Fig. 5, are used in mounting the motor on the axles of the truck. They will not be cut until after the truck is constructed.

The brush holders are made of two pieces of hexagonal brass, each 1 in. in length, having a 1/8-in. hole drilled in one end to a depth of 7/8 in., and a threaded hole in the other end, for a small machine screw, as shown in Fig. 7. Two holes are drilled and threaded in one side of each of these pieces. These holders are to be mounted, by means of screws, through the holes A, B, C, and D, Fig. 5. Each holder must be insulated from its support. The distance of the holder from its support should be such that the opening in its end is in the center of the commutator. The brushes are made of very fine copper gauze, rolled to form a rod. They are made long enough to extend about 1/2 in. into the holder, when they are resting on the commutator. A small spiral spring is placed in the holder, back of the end of the brush, and which will serve to keep the latter in contact with the commutator.

Temporary connections are made and the motor is tested with a six-volt battery. The construction of the motor may be modified as to the length of shaft, and other minor details, and may be used for other purposes by fitting it with pulleys, a countershaft, or other transmission devices.

PART II—Construction of the Locomotive Truck and Cab

SUCCESSFUL operation and construction that is feasible, yet of a reasonable standard of workmanship, are the essentials of the locomotive truck and cab described as the second feature of the locomotive and track system under consideration. The materials suggested are those found to be satisfactory, but substitutes may be used if caution is observed. The completed locomotive is shown in Figs. 1 and 2. The outward aspect only is presented, and, for the sake of clearness, the portions of the motor and driving rigging attached to it, that project below the cab, are omitted. These parts are shown assembled in Fig. 12, and in detail in the succeeding sketches.

The locomotive, apart from the motor, consists of two main portions, the truck and the cab. Consideration will be given first to the building of the truck and the fitting of the motor into it. The mechanical and operative features are to be completed before beginning work on the cab, which is merely a hood fixed into place with screws, set into the wooden cab base.

Begin the construction with the wheels, shown in Fig. 3. Make the axles of ⅛-in. round steel rod, cut 3³⁄₁₆ in. long.

Turn four wheels of ⅜-in. brass. Drill a ⅛-in. hole in two of them so that they may be forced on the slightly tapered ends of the axle. Drill a ¼-in. hole in each of the other wheels, and solder a collar, A, Fig. 3, on the inside surfaces of them. Two fiber bushings, B, should be provided to fit in the ¼-in. openings in the wheels and to fit tightly on the ends of the axles. This insulates the wheels on one side of the truck from those on the other. If the rails forming the track are insulated from each other, the current supplied to the motor may pass in on one rail to the two insulated wheels, then to a brush, which bears on the brass collar A, through the windings of the motor, through the reversing switch to the other set of wheels, and back to the source of energy over the other rail, as shown in Fig. 15.

The wheels of the truck should fit on the axles tightly, since no means other than the friction will be employed in holding them in position. If the ends of the axles are tapered slightly, the wheels may be forced into place and will stay firmly. Do not force them on until the truck is finally assembled.

The truck frame should be constructed next, and its details are shown in Figs. 4 and 5. Make two sidepieces of ¹⁄₁₆-in. brass, 9¾ in. long and 1⅝ in. wide, cutting out portions, as shown, in order to reduce the weight. This also gives the appearance of leaf springs.

The two rectangular openings are to accommodate the axle bearings. They should be cut to precise dimensions, and their edges should be squared off. Extensions, ¹⁄₁₆ in. wide, are provided at the middle of the upper edges of each of these openings. They are to hold the upper end of the coil springs, which are to rest in the holes cut into the bearings, as shown at G, Fig. 7, and also in assembled form, Fig. 6.

Next drill four ⅛-in. holes in each of the sidepieces, as indicated at the letters H_1 to H_4, Fig. 5. For the cross supports use four pieces of brass rod, ¼ in. square, and square off the ends to a length of 2¾ in. Drill holes in the center of the ends and tap them for ⅛-in. machine screws. Join the side and crosspieces as shown in Fig. 4. Two fiber washers about ¹⁄₁₆ in. thick should be placed on each axle at E and F, to hold the wheels from contact with the sidepieces.

Details of a bearing for the axles are shown in Fig. 7. The hole G carries the lower end of the coil spring, and the hole J is the bearing socket for the axle. Four spiral springs, having an outside diameter of 1/8 in. and a length of 1/2 in. when extended, should be provided. The extensions on the sides of the bearings fit against the inner faces of the sides of the truck. They hold the bearings in position and prevent them from falling out.

The base of the cab is made of wood, dimensioned as in Fig. 10. The center of the piece is cut away so as to provide a space for the motor, which extends above the upper edge of the truck, as shown in Fig. 12. This block is fastened in place by four screws through the upper crosspieces at the ends of the truck. The base should be made and fitted into place temporarily so as to be available in observing how the motor and its fittings are placed in relation to it. For convenience in assembling the parts of the truck and setting the motor, it may be removed readily.

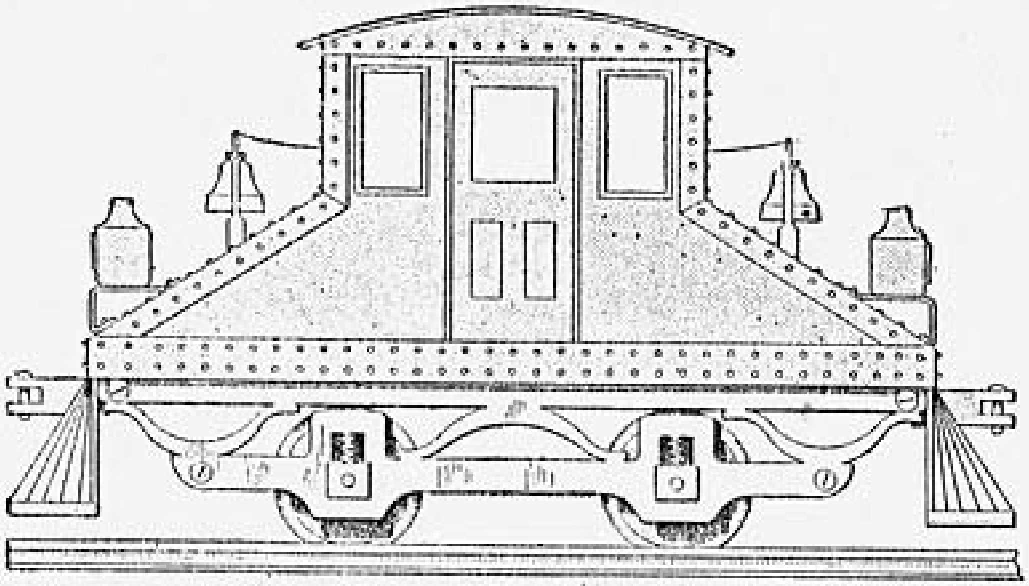
Assembling the truck, including the motor, probably requires the most painstaking effort of any part of the construction of the locomotive. Too great care cannot be taken with it, as the dimensions are carefully worked out and failure to observe them may cause errors sufficient to make the locomotive unserviceable. Before undertaking this work it would be well to examine carefully the arrangement of the parts as shown in Fig. 12. The upper view shows the relation of the driving gears in mesh and the lower view shows the machinery of the truck as seen from above.

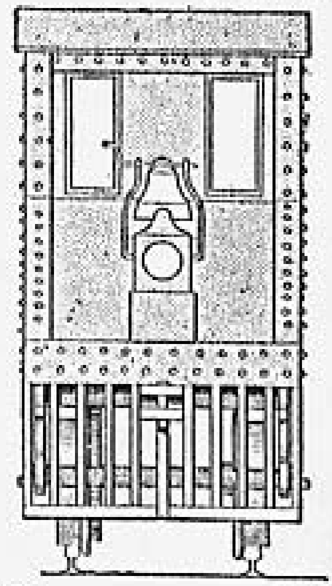
The power from the motor is transmitted to one set of wheels by means of a small gear on the armature shaft engaging an intermediate gear, which in turn engages a large gear attached to the inside of one of the truck wheels. The center of the armature shaft is 1 5/16 in. from the center of the power axle, when both axles are in the slots provided in the motor frame, Fig. 12. The gears for the transmission may now be selected. The gear on the armature shaft should be as small, and that on the axle as large, as practicable. The intermediate gear should be of such a size that it will close the space between the small gear on the armature shaft and the large one on the axle. Gears suitable for the transmission may be purchased at a clock store for a small sum. If gears of exactly the proper size cannot be obtained readily, the position of the intermediate gear may be adjusted to produce a proper meshing of the gears.

Mount the small gear on the end of the armature shaft away from the commutator, so that there will be about 1/16-in. clearance between the outside surface and the shoulder at the end of the shaft. Fit it on tightly so that no other means of fastening will be necessary. Mount the large gear on the inside surface of one of the truck wheels, as shown in Figs. 3 and 12. Place the axle of the truck into the proper grooves in the motor frame, and mark the position of the center of the intermediate gear, when it engages the other gear. Drill a hole in the extension on the motor frame, provided as a support, to fit a small bolt with which the intermediate gear is fastened.

Place a washer between the gear and the piece upon which it is mounted, and a locknut on the threaded end of the bolt, drawing it up so that the gear has only sufficient play.

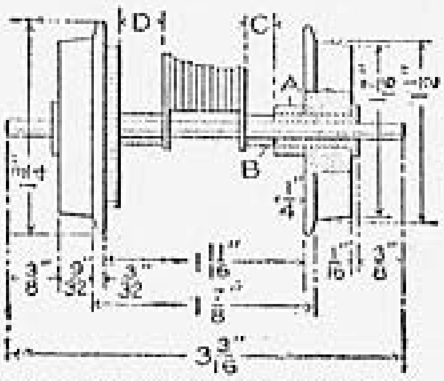
The slots in the motor frame to fit the free axle may now be cut, as shown in Fig. 12. Place the motor in position on the axle so that the gears all mesh properly. Fit tubes of insulating material with an outside diameter of 3/8 in. at C and D, Fig. 3, and as also shown in Fig. 12. Insulation tubes should be provided for the sec-





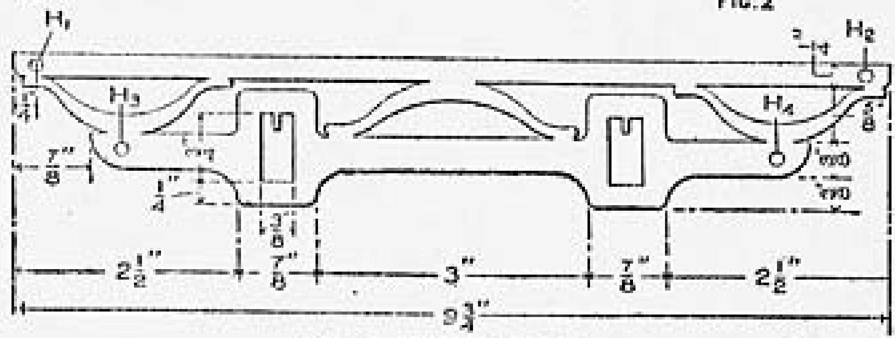
SIDE AND FRONT VIEW OF COMPLETED LOCOMOTIVE

Fig. 1 Fig. 2



CONSTRUCTION OF WHEELS

Fig. 3



SIDE OF TRUCK

Fig. 5

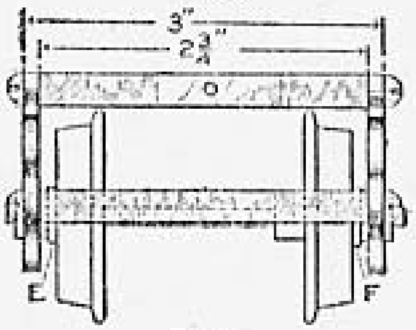


Fig. 4

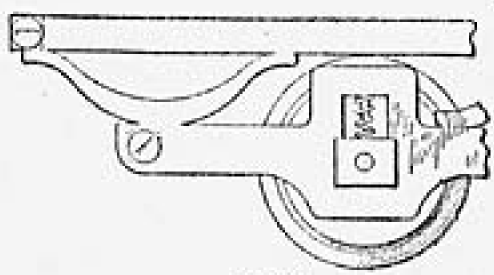
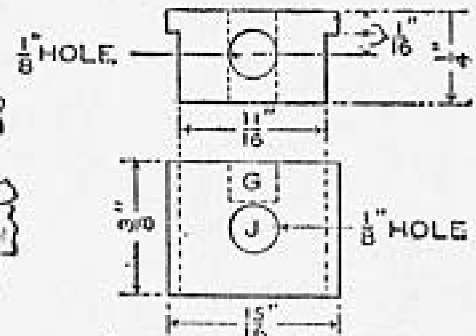


Fig. 6



TOP AND SIDE VIEW OF BEARING

Fig. 7

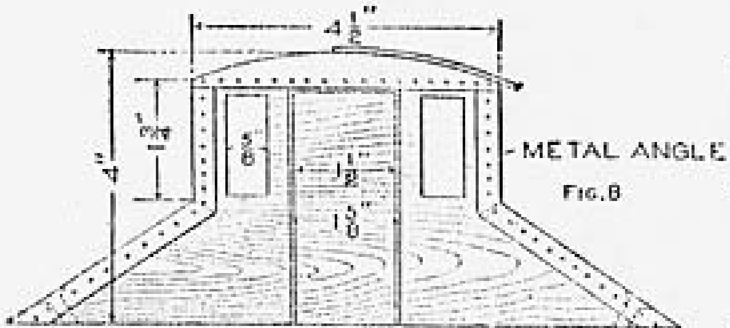


Fig. 8

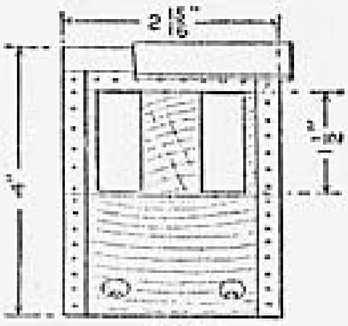
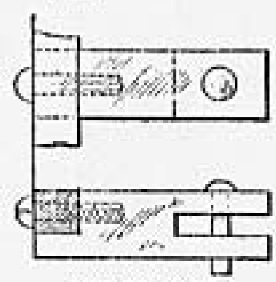
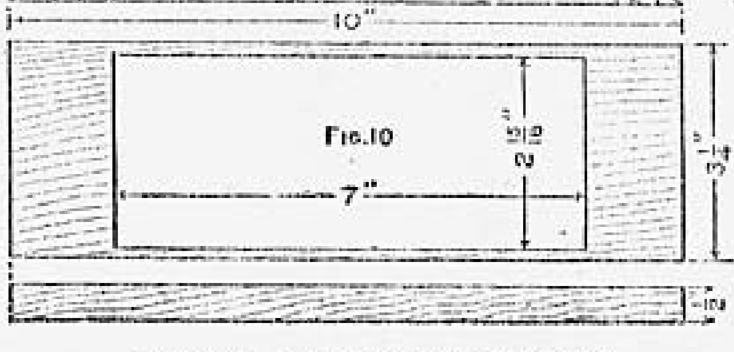


Fig. 9



COUPLING

Fig. 11



BOTTOM OF LOCOMOTIVE CAB

Successful Operation, Based on Feasible Construction and a Reasonable Standard of Workmanship, Is the First Consideration in the Locomotive. The Dimensions should be Observed Closely in Order That the Parts may be Assembled Satisfactorily. The Construction of the Cab Is Suggestive Only, and the Inventive Builder may Design One in Conformity with the Materials Available or the Individual Taste

 GRANDDAD'S ELCTRICITY BOOK

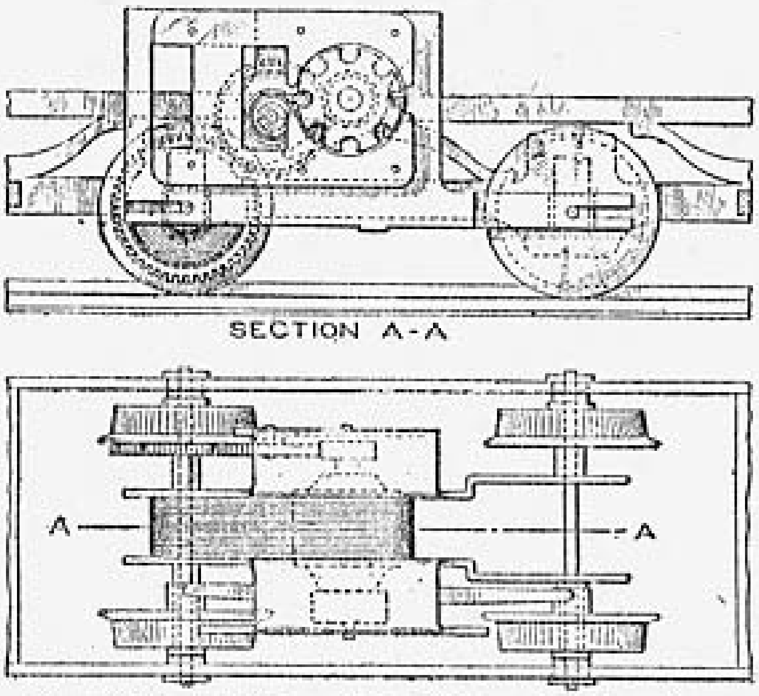


Fig. 12, Installation of the Motor, Showing Gears and Switch Contact Spring

ond axle so as to hold the motor in position, and to keep the wheels in line. In mounting the various parts sufficient play should be allowed to prevent excessive friction.

The reversing switch, which is to be mounted on the under side of the motor frame, is shown in Figs. 13 and 14. It is provided with a control lever which projects out from under the

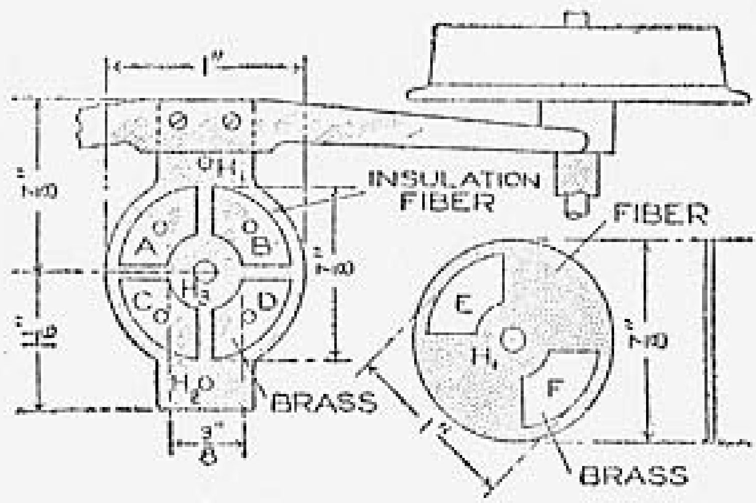


Fig. 13, Details of the Switch, Shaded Portions Being of Fiber Insulation

truck frame. A small movement of the lever will produce the necessary changes in the connections. The operation of the switch may be understood readily from the diagram shown in Fig. 15. The moving element of the switch carries two pieces of copper, E and F, which connect the four stationary pieces of copper, A, B, C, and D, when the lever attached to E and F is moved to either side of its central position. The pieces of copper which are moved—E and F—are shown outside of the stationary pieces in Fig. 15 for purposes of a diagram only, and are actually directly over the ring formed by the stationary pieces.

The operation of the switch is as follows: Assuming that the current enters at the terminal marked 1 and leaves at the terminal marked 2, then the direction of the current in the armature and series field will be as indicated in the diagrams. The direction of the current in the series-field winding is different in the two cases, which will result in opposite rotation of the armature.

The base of the switch is made of 1/16-in. fiber insulation; its dimensions are shown in Fig. 13. It is to be mounted on the two pieces projecting outward on the under side of the motor frame, as shown in Fig. 14. Drill a small hole in each of these projections, as indicated by the letters H_1 and H_2, and tap them to take a small machine screw. Next drill two holes, H_1 and H_2, Fig. 13, in the piece of insulation, with centers the same distance apart as those drilled in the projections. One end of this piece of insulation is extended to form a mounting for a thin brass spring, the ends of which bear on the brass collars insulated from the axles, as shown in Figs. 12 and 13. The form of this spring and the method of mounting it are also shown in Fig. 13.

The sections which come into contact in the switch are made as follows: Mount four pieces of thin copper or brass on the fiber base with rivets having their heads countersunk. Cut a disk, 1 in. in diameter, from a piece of sheet insulation and drill a hole H_1 in the center of it. Also drill a similar hole H_3 in the center of the switch base. Mount two pieces of copper or brass, E and F, on the under side of this disk. The edges and ends of all

 GRANDDAD'S ELCTRICITY BOOK

six pieces of metal should be rounded off so that the pieces E and F will move freely over those on the base. The disk, or upper part of the switch, may be attached to the base by means of a small bolt placed through the holes at the center. A small spiral spring should be placed between the disk and the lower end of this bolt so as to keep the pieces of metal on the disk in contact with those on the base. Attach a small handle to the disk so that it will extend out on one side of the truck. Fix the switch into place by bolts through the holes H_1 and H_2, Fig. 14, on the bottom of the motor frame. The electrical connections should be made as shown in Fig. 15.

The detail of the couplers is shown in Fig. 11. They are made of brass, fitted to the upper crosspieces and fixed to them by machine screws. "Cowcatchers" may be made for the ends of the locomotive. Sheet metal, corrugated appropriately and bent to the proper shape, will afford the easiest method of making them. Those shown in Figs. 1 and 2 are made of strips soldered together, and also to the upper crosspieces; they are strengthened by a cross strip at the bottom, opposite the point.

The cab is to be made apart from the truck and is to fit upon the base,

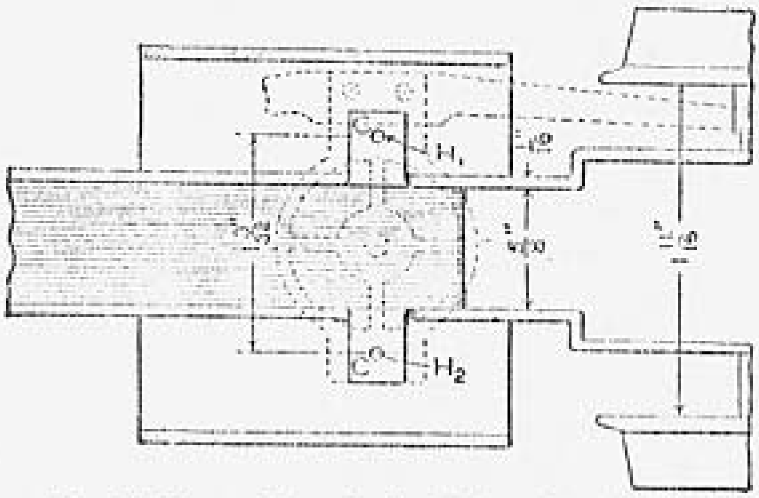


Fig. 14. View of the Under Side of the Motor, Showing How Switch is Fixed into Place

as shown in Figs. 1 and 2. It is fixed into place by four screws and can be removed easily for examination of the locomotive mechanism. The dimensions for the cab are shown in Figs. 8 and 9, and may be varied by the builder.

Sheet metal or wood may be used

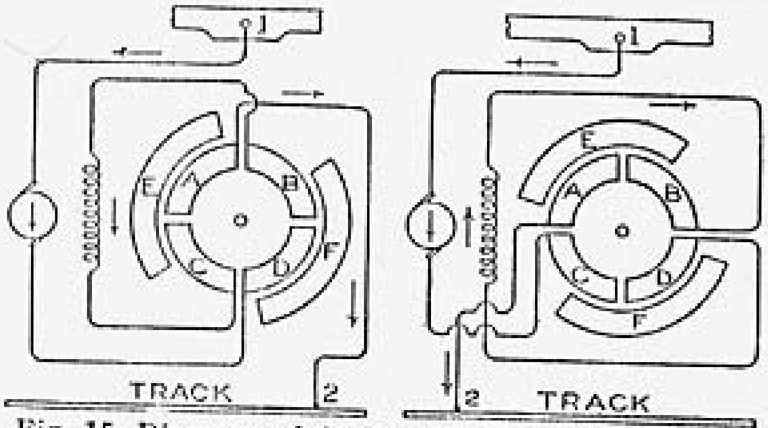


Fig. 15, Diagrams of the Reversing of Motor by Shifting Switch to Form Contact between Pairs of Brass Sectors Set in the Fiber Switch Base

in the construction, and the joints soldered on the inside or riveted, as shown in the illustration. The window and door openings may be cut out or painted on. Small bells may be mounted on the ends of the cab, adding to its appearance. The headlights shown in Figs. 1 and 2 may be cut from wood or made of sheet metal. Light bulbs may be installed, and their voltage should correspond to that of the motive energy. The terminals for the sockets of the headlight lamps should be connected to the frame of the truck and to the spring, which bears upon the brass collars on the wheels, which are insulated from the axles, as shown at A, Fig. 3.

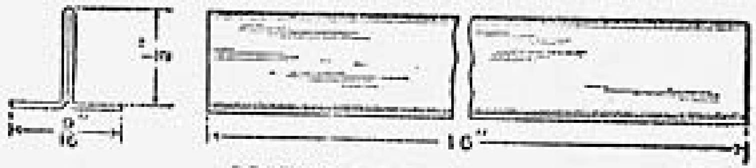
This completes the locomotive in all essential details and it is ready to be placed upon the track to be tested.

PART III—Construction of the Track System

OPERATION of the electric-locomotive model described in the previous articles is feasible only with a properly constructed track system. This equipment, including curves and switches, is to be described in this, the final, article. Two functions are to be performed by the track system: It must serve as a support and guide for the locomotive and provide a path over which the current from the source of energy is supplied to the motor within the locomotive and returned to the source. On this basis, then, the construction may be divided into two parts: the mechanical and the electrical features. If the mechanical construction is not practical and accurate, the locomotive will not operate satisfactorily. The electrical connections must be given due care also.

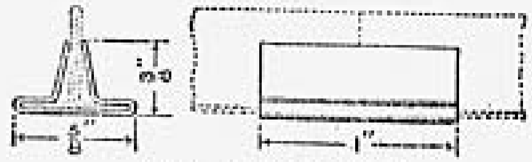
The track should be of uniform gauge; the joints should be solid and free from irregularities, which cause "bumping" in passing over them. The material used should be stiff, so that it will retain its form, and preferably nonrusting. The rails must be insulated from each other, and proper means must be provided for making suitable electrical connections between the various sections. The construction of a straight and a curved section of track, together with a switch and signal, adaptable to various places on the system, will be considered in detail.

The straight sections may be made any suitable length; sections 16 in. long will be found convenient, as the metal pieces forming the rails may be bent into shape easily when they are short rather than long. The possibility of various combinations of straight and curved sections in a given area is increased by having the sections shorter. The rails may be made from tinned sheet-metal strips, by taking pieces, 16 in. long and 1½ in. wide, and bending them into the form shown in Fig. 1. The rails should be mounted on small wooden sleepers, ½ by ½ by 4 in., by means of small nails, or preferably small screws. The distance between the centers of the rails should be 2 in. The sections of track may be fastened together at the ends by means of a special connector, shown in Fig. 2, made from thin metal, preferably spring brass. The type of connector shown in Fig. 2 will not prevent the sections from pulling apart, and to prevent this, a second connector, similar to that



SECTION OF RAIL

Fig. 1

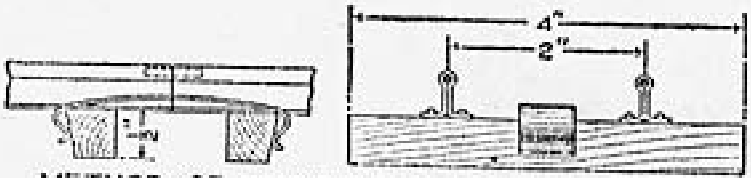


RAIL CONNECTION

Fig. 2

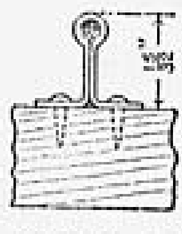
Shape the Rails from Sheet-Metal Strips, 1½ Inches Wide and 16 Inches Long, to the Form Shown in Fig. 1. The Rail Connections are Formed as Shown in Fig. 2

shown in Fig. 3, should be made. The sleepers at the ends of each section should have one side beveled, as shown, and these edges should be exactly one inch from the end of the rails. A spring clip should be made, similar to that shown, which will slip down on



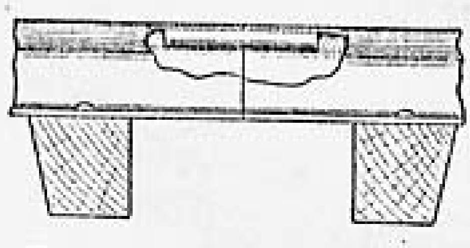
METHOD OF CONNECTING TRACK SECTIONS

Fig. 3



SECTION OF RAIL

Fig. 4



END CONNECTION OF RAILS

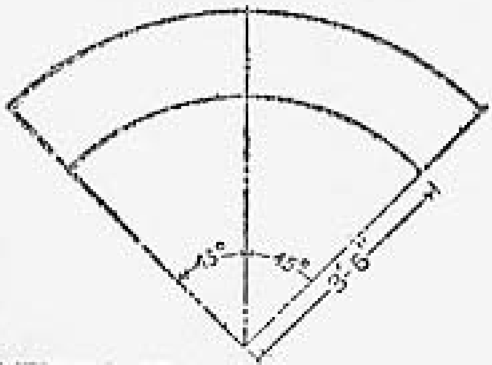
Fig. 5

A Spring Clamp for the Joints in the Sections is Shown in Fig. 3. An Improved Form of Rail is Shown in Fig. 4, and in Fig. 5 is Indicated the Method of Joining Its Sections

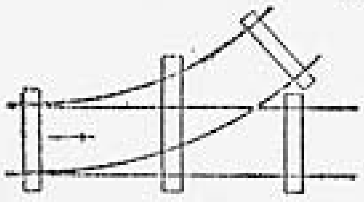
the inside of the end sleepers and hold the sections together.

A better form of rail is shown in Figs. 3 and 4, but it is somewhat more difficult to construct. In this case, instead of bending the piece of metal forming the rail over on itself and closing the space entirely, the metal is bent over a round form, such as a piece of wire, which may be removed, leaving an opening through the upper part of the rail from end to end. This gives a better form to the tread of the rail and

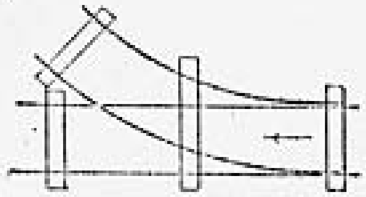
 GRANDDAD'S ELCTRICITY BOOK



METHOD OF LAYING OUT CURVED SECTION
Fig. 6



LEFT SWITCH
Fig. 7



RIGHT SWITCH
Fig. 8

Lay Out the Switches and Curves, Full Size, and Fit the Rails to the Curves Accurately

at the same time provides an easy means of connecting the ends of the rails, as shown in Fig. 5. Small metal pins, about 1 in. long, and of such a diameter that they will just fit the circular opening in the top of the rail, are provided. One of these pins should be fastened in one rail at each end of a section, making sure that no rail has more than one pin in it, and that the arrangement of pins and rails corresponds in all sections. With proper care the various sections should fit together equally well, and they may be held together as shown in Fig. 3.

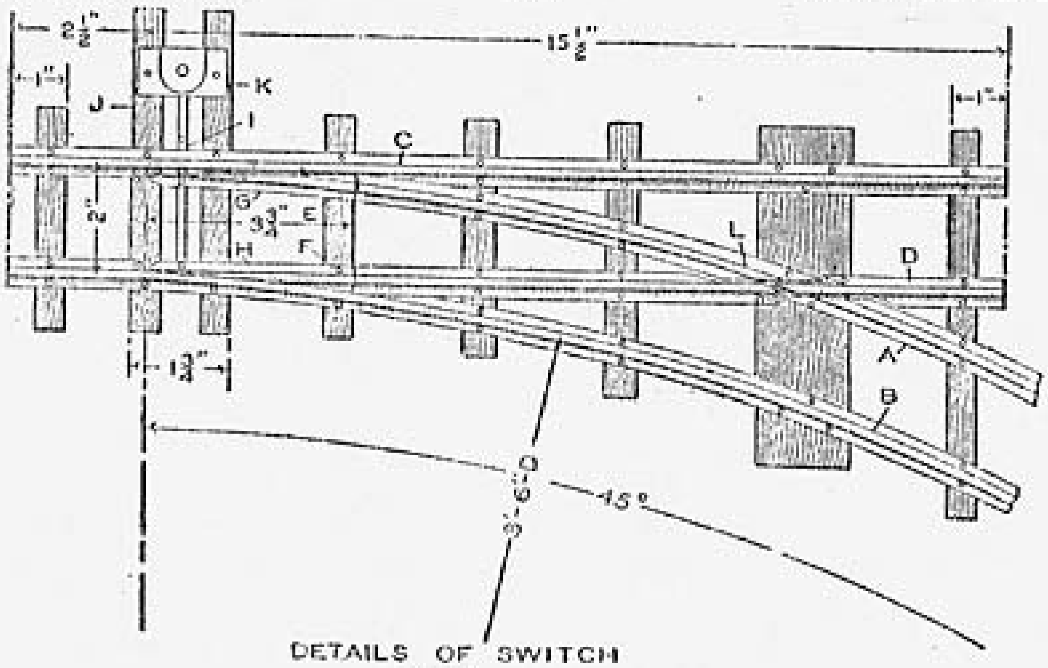
The curved sections may be made from rails similar to those described above, but some difficulty will be experienced in bending them into a curve because of the necessity of bending the lower flange on edge. The difficulty may be overcome by crimping in the inner edge of the lower flange and expanding the outer edge by hammering it on a smooth surface. The radius of the curve to which the inner rail should be bent in order to give a section of convenient length, and not too abrupt a curve, is 21 in. The circumference of such a circle is approximately 132 in., which, divided into eight sections, gives 16½ in. as the length of the inner rail of each section. Since the tread of the track is 2 in., the radius of the curve of the outer rail will be 23 in. The circumference of the circle formed by the outer rail is 145 in., which divided into eight sections gives 18⅛ in. as the length of the outer rail of each section. These curved rails may be mounted on sleepers, their ends being held in place, and the various sections fastened together, just as in the case of the straight sections.

Some trouble may be experienced in getting the curved rails properly shaped, and it would be a good plan to lay them out full size by drawing two circles on a smooth surface having diameters of 42 and 46 in., respectively, and divide each of the latter into eight equal parts. The form of the curve between these division lines and the lengths of the curves will correspond to the shape and lengths of the rails forming the curved sections of the track. The pieces should be cut slightly longer than required, and after they are bent into shape their length can be determined precisely and extra portions cut off. Each curved section will correspond to ⅛ of the complete circle, or 45°, as shown in Fig 6.

The switches for the track may be of two kinds: left and right. They are named according to whether the car is carried to the left or right of the main track with reference to the direction in which the car moves in entering the switch. A left switch is shown in Fig. 7, and a right switch in Fig. 8, the direction of movement being indicated by the arrows.

A detailed drawing of a right switch is shown in Fig. 9. Rail A corresponds in form and length to the outer rail of one of the curved sections previously described; rail B cor-

 GRANDDAD'S ELCTRICITY BOOK



DETAILS OF SWITCH
Fig. 9

The Crossings of the Rails must be Fitted Carefully, and the Movable Sections G and H Arranged to Make the Proper Contacts

responds to the inner rail of one of the curved sections, except that 2½ in. of straight rail is added at the left end. Rail C is a straight portion of rail, 18 in. in length, with a part of the base cut away at the switch, and rail D is a section of straight rail, 15½ in. in length, with the base cut away where it crosses rail A. The ends of rails D and A are hinged at the points E and F, 3¾ in. from the left end, with pins driven into the ties. The outside edges of the pieces G and H are filed off so they will fit up against the rails C and B respectively. Both the pieces G and H are attached to a strip of fiber insulating material, I, at their left-hand ends, in such a way that when the piece H is against the rail B, the piece G is away from the rail C about $\frac{3}{16}$ in.; when the end of the piece G is drawn over against the rail C, the end of the piece H is drawn away from the rail B about $\frac{3}{16}$ in. With these two combinations the car may be made to move along the main track or to the right on the curved track. The two long sleepers J and K are to provide a mounting for the switch-control lever and signal.

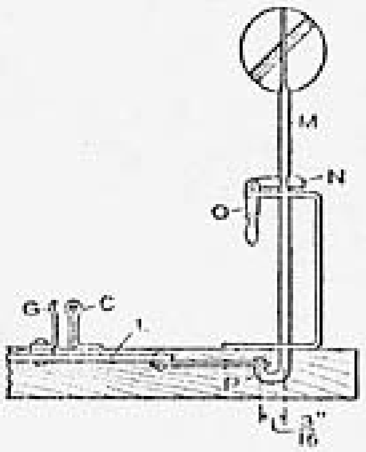
The rail A is not continuous where the rail D crosses it, but is broken as shown in the figure. A small notch should be cut in the surface of the rail D where it crosses the rail A, for the flange of the car wheels to roll through when the car is moving onto or off the switch. The sections of the rails A and D must be connected electrically. Rail A must be connected to rail C, and rail B to rail D.

It is obvious from an inspection of Fig. 9, at L, that rail D will be connected to rail A when the car is on the switch, the car wheels passing over the point L, and a short circuit will result. This may be prevented by insulating the short section of the rail D at this point from the remainder of the rail, but the length of the insulated section must not be greater than the distance between the wheels on one side of the car; otherwise the circuit through the motor would be broken. If this is the case, and the car stops on the main track with both wheels on the insulated sec-

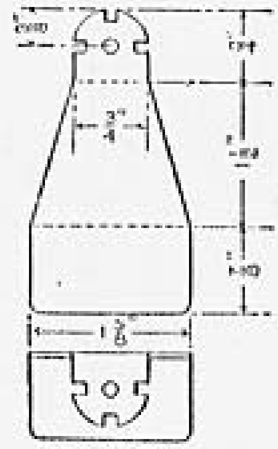
 GRANDDAD'S ELCTRICITY BOOK

tion, it would be impossible to start the locomotive until one wheel was moved to a live part of the rail.

The switch control is shown in Fig. 10, and the letters C, G, and I correspond to those given in Fig. 9. A ⅛-in. rod, about 4 in. in length, is bent into the form shown at M. It is mounted in a frame, the details of which are shown in Fig. 11. A small arm, N, with a hinged handle, O, is



SWITCH CONTROL
Fig. 10



TOP VIEW
SWITCH FRAME
Fig. 11

The Signals Indicate the Open or Closed Condition of the Switch by the Small Disk, Which is Regulated by the Lever Switch Control

soldered to the rod, after it is placed in position in the switch frame. The arm N and the lever P should be parallel with each other. If properly constructed, the handle O will drop into the notches in the top of the switch frame, and prevent the rod M from turning. A connection should be made from the lever P to the end of the piece I, which will result in the switch being operated when the rod M is rotated one-fourth of a turn. After this connection is made, the frame of the switch should be fastened to the ends of the long sleepers, which were provided when the track part of the switch was constructed. Two small disks, mounted at right angles to each other, will serve as signals when properly painted, or as an indication of the open or closed position of the switch.

The speed of the car on the track may be controlled by inserting resistance in series with the battery or source of electrical energy, or by altering the value of the voltage between the rails, by changing the connections of the cells forming the battery. The direction of movement of the locomotive cannot be changed unless the car is turned end for end, or the connections of the armature or field winding—not both—are reversed. The switch on the bottom of the locomotive reverses these connections.

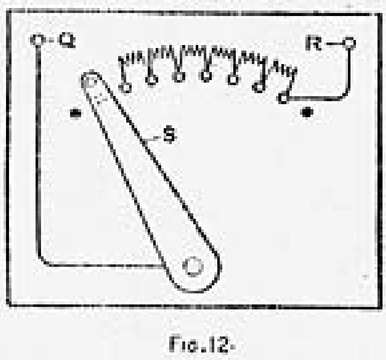


Fig. 12

A small rheostat, which will give the desired resistance, may be constructed as follows: Obtain a piece of hard wood, 4 by 5 in., and ⅜ in. in thickness. Lay out a curve on this piece, as shown in Fig. 12 by the row of small circles. Procure eight round-headed brass machine screws, about ⅛ in. in diameter and ¾ in. in length, and 16 nuts to fit them. Drill eight ⅛-in. holes along the curve, spacing them ⅜ in. apart. File the heads of the screws off flat and mount the screws in these holes. Make a metal arm, S, and mount it on a small bolt passing through a hole drilled at the center from which the curve was drawn, along which the screws were mounted. This arm should be of such a length that its outer end will move over the heads of the screws. Mount two binding posts, Q and R, in the upper corners of the board and connect R to screw No. 8, and Q to the bolt holding the arm S in place. Connect small resistance coils between the screws, starting with screw No. 2; screw No. 1 corresponds to an open circuit and is shown in contact with the arm S. Two stops, indicated by the black spots, should be provided, to prevent the arm from moving back of screw No. 1 or beyond screw No. 8. The board may now be mounted on a suitable hollow base, and the rheostat is complete.

Two binding posts should be mounted on the ties of one section of the track, and one of them electrically connected to each of the two rails, which will give an easy means of making the necessary electrical connections to the source of energy. After careful examination, to make certain that the locomotive is in running order, a test run may be made. If the locomotive operates properly and difficulty is experienced when it is placed upon the track, check up thoroughly on all rail connections, insulations, and other elements in the electrical equipment. Cars of a proper gauge may be coupled to the locomotive, and "runs" made as extensively as the track system will permit.

THE BOY MECHANIC – 1919

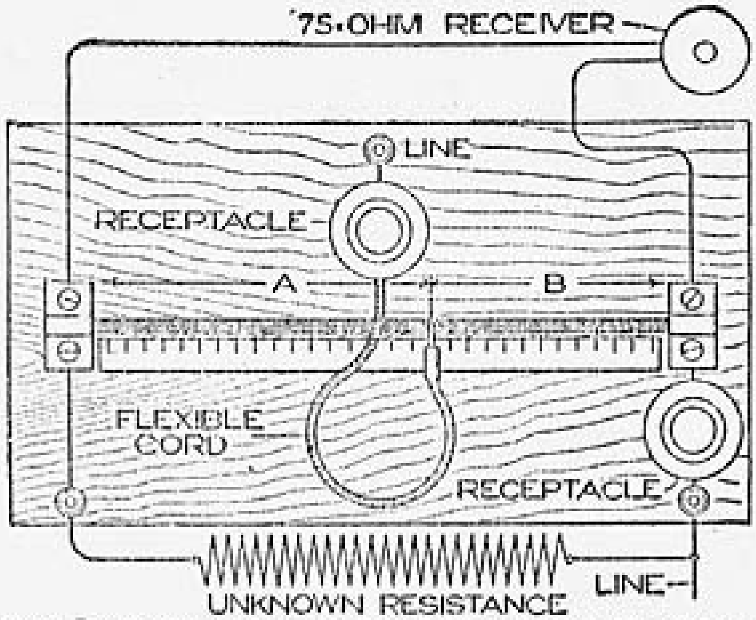
Measuring Resistance with a Lead Pencil

THERE are very few electrical experimenters who can afford a Wheatstone bridge for measuring resistances, and yet, if one is to gain any knowledge from his experiments, it is very necessary to know what resistance is being used, particularly in handling 110 volts. The amateur will find the following method very useful.

There are several brands of lead pencils, the leads of which have a resistance of 200 to 300 ohms, while others have comparatively little resistance. Soak several pencils—preferably the large kind carpenters use—in water over night so that the leads may be removed without breaking. Connect up two 40-watt lamps in series and note how they burn. Then replace one lamp with a lead and note the relative intensity with which the remaining lamp burns. If the lead is of a sufficiently high resistance it will cut down the illumination about as much as the additional lamp.

Having selected a lead, mount it on a suitable board, holding it in place by clamping each end under a strip of brass held down with wood screws. Next screw in place two porcelain receptacles and place three binding posts in position, all as shown in the sketch. Connect up as indicated, and attach a short length of flexible cord, with a metal tip on the free end, to one terminal of the central receptacle. Procure a cheap 75-ohm receiver and connect it to the two ends of the pencil lead. Finally glue on a paper scale.

To operate, place a high-resistance lamp in the center receptacle—say, a 15-watt lamp—to prevent heating, and almost any lamp of known wattage in the other receptacle. From the rating of this lamp the resistance may at once be determined by Ohm's law. Thus, at 110 volts, a 25-watt lamp will have a resistance of 484 ohms; a 40-watt



The Lead Taken from a Lead Pencil and Used as a Means of Measuring Resistance

lamp 300 ohms, and a 60-watt lamp, 200 ohms. Connect the unknown resistance, as shown in the drawing, and move the metal tip on the end of the flexible cord back and forth along the pencil lead until a point is reached where no sound is emitted by the receiver. This point will be very well defined, and as the connection is moved away from it in either direction the sound will increase rapidly. Note the reading on the scale, and then if a 40-watt lamp is used in the end receptacle, the unknown resistance will be $= \frac{300\,A}{B}$. The resistance of the center lamp does not enter into the computation, but by changing the lamp in the end receptacle, another set of figures may be obtained, and a means had to secure increased accuracy.

THE BOY MECHANIC – 1919

A Simple Motor Controller

The controller described is very similar in operation to the types of controllers used on electric automobiles, and its operation may be easily followed by reference to the diagrammatic representation of its circuits, and

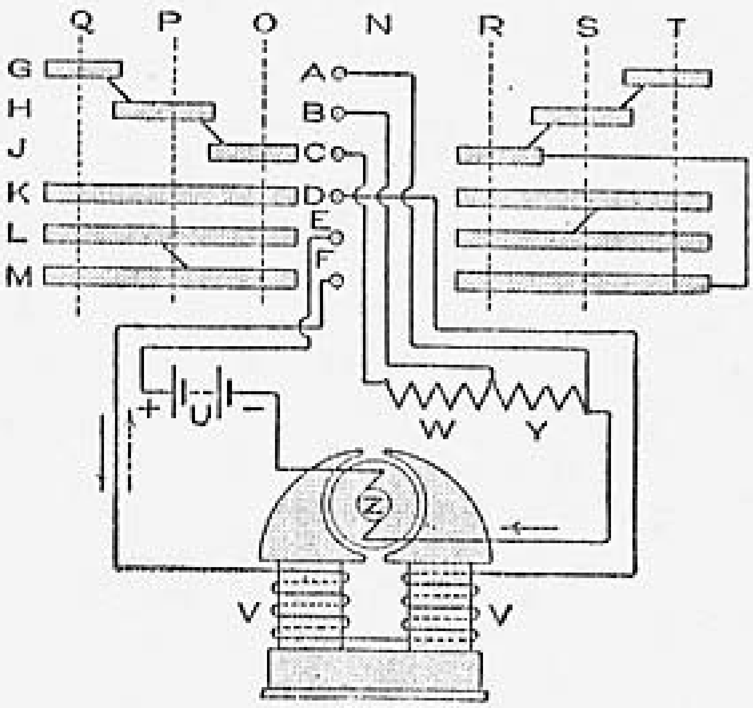


FIG. 1

Diagram of the Electrical Connections of a Controller to a Two-Pole Series Motor

those of a two-pole series motor to which it is connected, as shown in Fig. 1. The controller consists of six flat springs, represented as small circles and lettered A, B, C, D, E, and F, which make contact with pieces of narrow sheet brass mounted on a small wood cylinder, so arranged that it may be turned by means of a small handle located on top of the controller case in either direction from a point called neutral, which is marked N. When the cylinder of the controller is in the neutral position, all six contact springs are free from contact with any metal on the cylinder. The contacts around the cylinder in the six different horizontal positions are lettered G, H, J, K, L, and M. There are three different positions of the controller in either direction from the neutral point. Moving the cylinder in one direction will cause the armature of the motor to rotate in a certain direction at three different speeds, while moving the cylinder in a reverse direction will cause the armature to rotate in the opposite direction

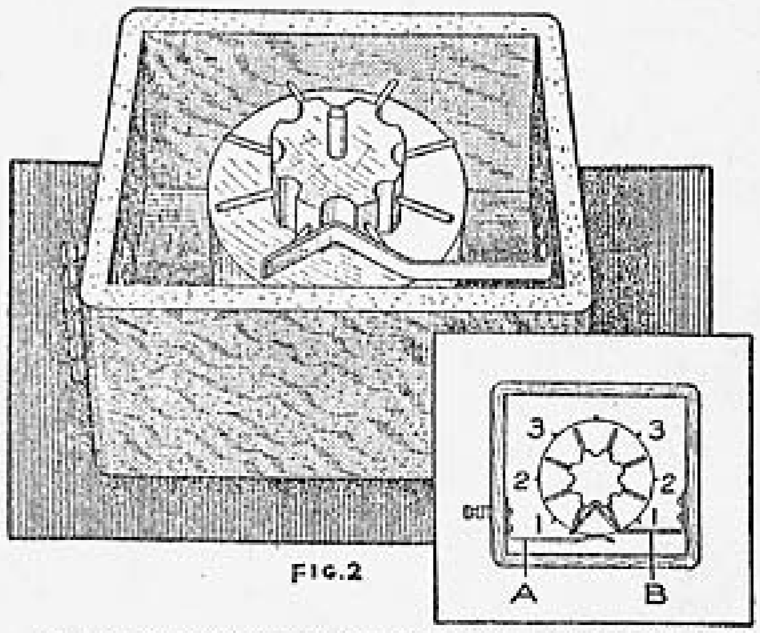


FIG. 2

Upper-End View of the Controller, Showing the Manner of Attaching the Springs

at three different speeds, depending upon the exact position of the cylinder. These positions are designated by the letters O, P, and Q, for one way, and R, S, and T, for the other.

Supposing the cylinder to be rotated to the position marked O, the circuit may be traced from the positive terminal of the battery U, as follows: To contact spring E, to strip of brass L, to strip of brass M, to contact spring F, through the field windings VV, to contact spring D, to strip of brass K, to strip of brass J, to contact spring C, through resistance W and Y, to armature Z, through armature to the negative terminal of the battery. Moving the cylinder to the position P merely cuts out the resistance W, and to the position Q, cuts out the remaining resistance Y. The direction of the current through the armature and series field, for all positions of the cylinder to the left, is indicated by the full-line arrows. Moving the controller to the positions marked R, S, and T, will result in the same changes in circuit connections, as in the previous case, except the direction of the current in the series field windings will be reversed.

The construction of the controller may be carried out as follows: Obtain a cylindrical piece of wood, 1¾ in. in diameter and 3⅛ in. long, preferably hard wood. Turn one end of this cylinder down to a diameter of ½ in., and drill a ¼-in. hole through its center from end to end. Divide the circumference of the small-diameter portion into eight equal parts and drive a small nail into the cylinder at each division point, the nail being placed in the center of the surface lengthwise and perpendicular to the axis of the cylinder. Cut off all the nail heads so that the outer ends of the nails extend even with the surface of the outer, or large-size, cylinder. Divide the large part into eight equal parts so that the division points will be midway between the ends of the nails, and draw lines the full length of the cylinder on these points. Divide the cylinder lengthwise into seven equal parts and draw a line around it at each division point. Cut some ⅛-in. strips from thin sheet brass and mount them on the cylinder to correspond to those shown in Fig. 1. Any one of the vertical division lines drawn on the cylinder may be taken as the neutral point. The pieces may be mounted by bending the ends over and sharpening them so that they can be driven into the wood. The various strips of brass should be connected electrically, as shown by the heavy lines in Fig. 1, but these connections must all be made so that they will not extend beyond the outer surface of the strips of brass.

A small rectangular frame is made, and the cylinder is mounted in a vertical position in it by means of a rod passing down through a hole in the top of the rectangle, through the hole in the cylinder and partly through the bottom of the rectangle. The upper part of the rod may be bent so as to form a handle. The rod must be fastened to the cylinder in some convenient way.

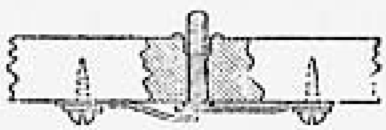
Make six flat springs similar to the one shown at A, Fig. 2, and mount them on the inside of the rectangle so that they will correspond in their vertical positions to the strips of brass on the cylinder. Six small binding posts mounted on the outside of the box and connected to these springs serve to make the external connections, and they should be marked so that they may be easily identified.

A flat spring, ¼ in. wide, is made

THE BOY MECHANIC – 1919

Miniature Push Buttons

A very neat and workmanlike push button may be made in the following manner: Procure an unused tan-shoe eyelet with an opening about $\frac{3}{16}$ in. in diameter, and at the



proper point drill a hole into the board in which the button is to be set. Force the eyelet in flush, using a little shellac to hold it in tightly. For the button proper, polish off and round one end of a piece of brass rod of a diameter that will move freely up and down in the eyelet. Solder a small piece of sheet brass across the lower end to keep it from coming out, then adjust and fasten on the two contact pieces, all as indicated in the sketch. The larger piece should be quite springy so as to bring the button back each time. The connections may be made by slipping the wires under the heads of the two wood screws that hold the contact pieces in place.

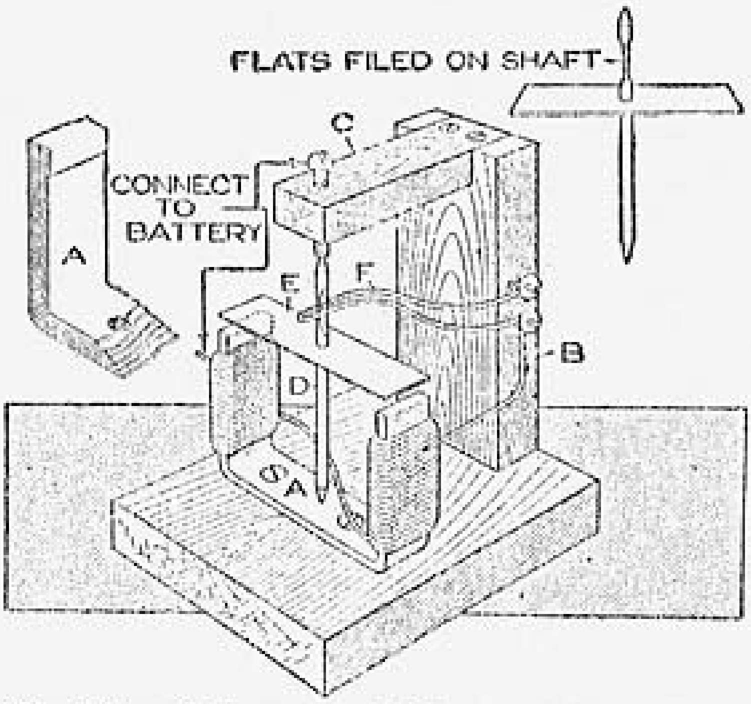
As every experimenter knows, it is

almost impossible to drill a hole in the varnished base of an instrument without leaving a raw edge. Under such circumstances, when it is desired to make an opening for conducting cords, and the like, simply drill a hole with an ordinary drill and then set in a small shoe eyelet, which immediately presents a very finished appearance.

THE BOY MECHANIC – 1919

A Quickly Made Toy Electric Motor

The illustration shows a small electric motor of such simple construction that it can be easily made from odds and ends to be found in any amateur



The Motor is Constructed of Pieces of Tin, a Nail, and Some Wood Blocks

workshop. Cut six strips, ½ in. wide and 3½ in. long, from an old tin can, and bend them together into a U-shape. This forms the magnet A. The outside piece should be a trifle longer than the others so that its ends can be turned over the other ends to keep them all in place. Screw this down on a small wood base. At one side of the wood base, fix an upright, B, and on top, a light wood bracket, C, to take the upper bearing of the motor. The shaft D is simply a wire nail with the head filed off and filed to a point. Drive it through a 1½-in. length of the same kind of material as used for the magnet. This forms the rotating armature E.

Make a slight indentation with a center punch, or strong nail, exactly in the center of the base portion of the magnet to take the lower end of the shaft. For the upper bearing file the end of a brass screw off flat and make a similar indentation with a center punch, or by a few turns of a small drill. This screw should be adjusted in the bracket until the shaft rotates freely with the armature just clearing the tips of the magnet. Wind about 40 turns of fairly thin cotton-covered copper wire—No. 24 or 26 gauge is suitable—around each limb of the magnet, first covering the latter with paper, to prevent the possibility of short-circuiting. The windings should be in opposite directions so that the connecting piece of the wire from one coil to the other passes across diagonally as shown in the illustration.

The brush F is formed by doubling up one of the free ends of the windings after removing the cotton covering and fixing it firmly with two screws to the side of the upright. After attaching, it should be bent until the outer end bears lightly on the shaft. Remove the shaft and at the point where the brush touched, file two flat surfaces on opposite sides of the nail in a direction at right angles to the longitudinal center line of the armature. On replacing the shaft the brush should be adjusted so that it makes contact twice in a revolution and remains clear at the flat portions. Connect up to a battery, one wire to the screw at the top of the motor and the other end to the open end of the windings. Give the armature a start and it will run at a terrific speed. —Contributed by Morris G. Miller, New Rochelle, N. Y.

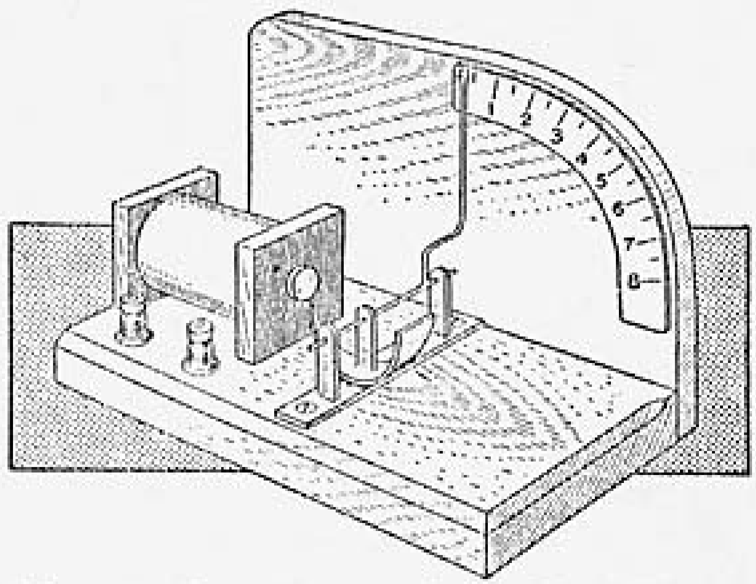
THE BOY MECHANIC – 1919

A Homemade Ammeter

WHERE a high degree of accuracy is neither desired nor necessary, a very satisfactory ammeter may be made at the cost of a few cents, and without using hairsprings, permanent magnets, or other articles usually not at hand.

The actuating device consists of a small coil of coarse, insulated wire, with a bundle of soft-iron wires for a core, which attracts a curved, soft-iron, wedge-shaped armature. The moving system is so balanced that the armature will hang as illustrated when no current is passing. On account of its shape, the higher the armature rises, the more iron it presents to the influence of the magnet, and, on the other hand, the greater will be the effect of gravity. The advantage of this type of control is the elimination of the irregular readings of the scale, due to the law of inverse squares, that usually follow when any method depending upon a variable distance is used. Further, the readings can be had as desired by altering the taper of the armature, its thickness, or its distance from the magnet, and also by adding a small weight of nonmagnetic material at the bottom. As most commercial circuits supply alternating current, the friction of the bearings does not affect the readings, since the alternations set up a decided vibration in the entire moving system, thus eliminating static friction.

In view of the variations above referred to, it will be evident that it is not very essential of what dimensions the apparatus is made. The instrument that I use has a base measuring 2½ in. by 5 in. The coil is built on a tube of glued paper, and contains about 15 ft. of No. 16 gauge wire. The terminals consist of the brass bolts taken from discarded dry cells. A steel sewing needle serves as a shaft, and a piece of wire for the pointer. The various joints are made with soft solder, and suitable stops are provided to keep the armature from shifting laterally. In calibrating, a blank scale should be glued in position and as many 55-watt lamps as possible ar-



A Very Satisfactory Ammeter for Use Where Accuracy is Not Desired or Necessary

ranged so that they can be placed in the circuit, one at a time. On a 110-volt line, each lamp added will mark a half-ampere point. If a sufficient number of lamps to carry the scale high enough cannot be secured temporarily, a resistance of some 20 or 30 ohms should be placed in the circuit without any lamps. Note the reading in amperes on the scale thus far constructed, and then begin adding the lamps again, making a mark on the scale as each lamp is added. In this manner a scale may be built up sufficiently accurate for all practical purposes.

If two identical coils are made in place of one, the additional coil can be placed in parallel with the instrument as a shunt, thus doubling its capacity and making it necessary, of course, to multiply all readings by two.

THE BOY MECHANIC – 1919

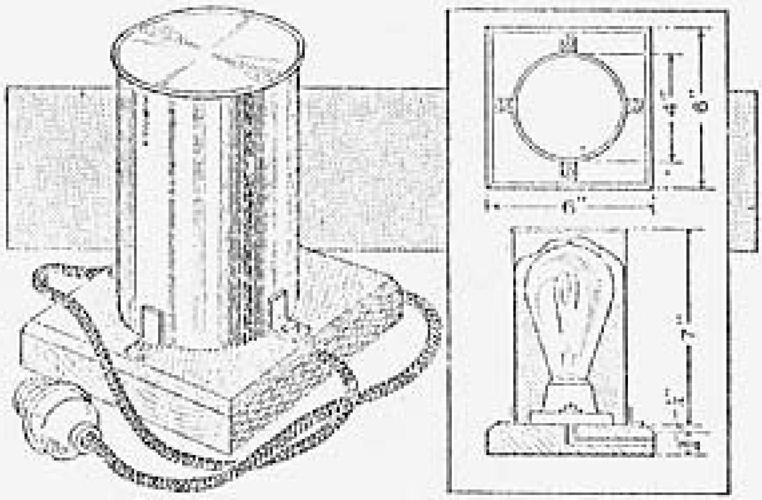
A Fifty-Cent Electric Stove

Few persons realize what an intense heat may be developed when the globe of an ordinary incandescent lamp is tightly inclosed, largely eliminating the loss of heat. When the lamp is inclosed, the temperature will increase until the rate of radiation is equal to that at which the heat is generated. A good reflector is a poor radiator, hence, when the metal wall surrounding the lamp is bright and shiny, both inside

 GRANDDAD'S ELCTRICITY BOOK

and out, the heat is reflected inward.

To make a small stove that will keep liquids warm, melt paraffin, dissolve glue, etc., procure an ordinary 16-cp. carbon lamp, a porcelain receptacle, and a bright, clean tin can, about 4 in. in diameter and 7 in. long. Thoroughly blacken the bottom on the inside, and then solder on four small brackets, cut from sheet brass or copper, so that the can may be held down firmly, when inverted on the base. The latter should preferably be made of hard wood, with the upper edges beveled, as shown. Next bore the hole for the wire or flexi-



A Handy Electric Stove can be Made at an Outlay of 50 Cents

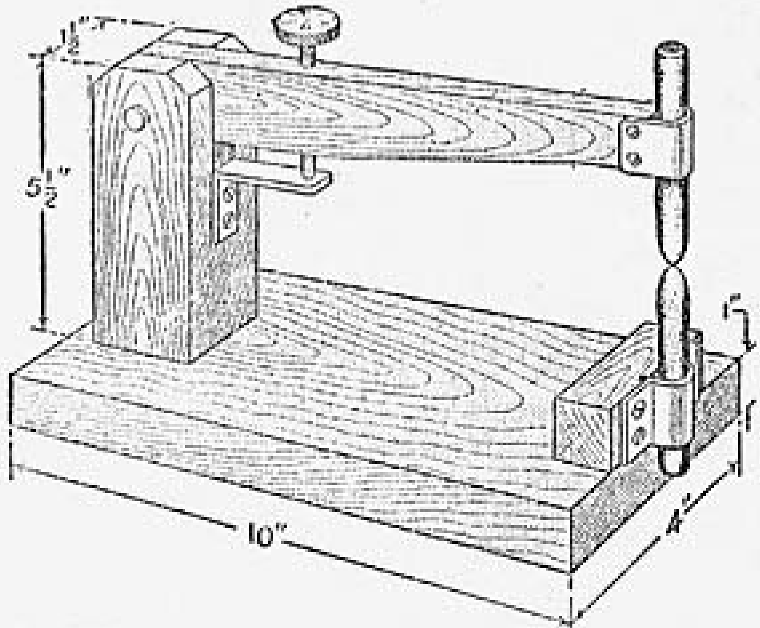
ble cord. Fasten down the porcelain receptacle, connect the wiring, screw in the globe, and screw down the tin can; the stove is then ready for operation.

THE BOY MECHANIC – 1919

Homemade Arc Light

Those who wish to produce an arc light for experimental purposes, or for the brief periods required by photography, will find the method of construction shown in the sketch very simple and inexpensive. Using the short lengths of carbons discarded by moving-picture operators, there is no difficulty in maintaining a good arc for 15 minutes, or more, without once manipulating the adjusting screw at the top.

Only three pieces of wood are necessary besides the base, and in the preparation of these no particular care is necessary except to have the top arm swing freely up and down without any appreciable side movement. The carbon holders are merely strips of heavy tin, which need only be screwed up sufficiently tight to hold the carbons in place and yet permit their being pushed up when the top adjusting screw will no longer operate. This adjustment may be readily taken care of by means of a long, slender wood screw with the point filed off and a metal



An Efficient Arc Light for Purposes Where a Light is Required for a Short Time

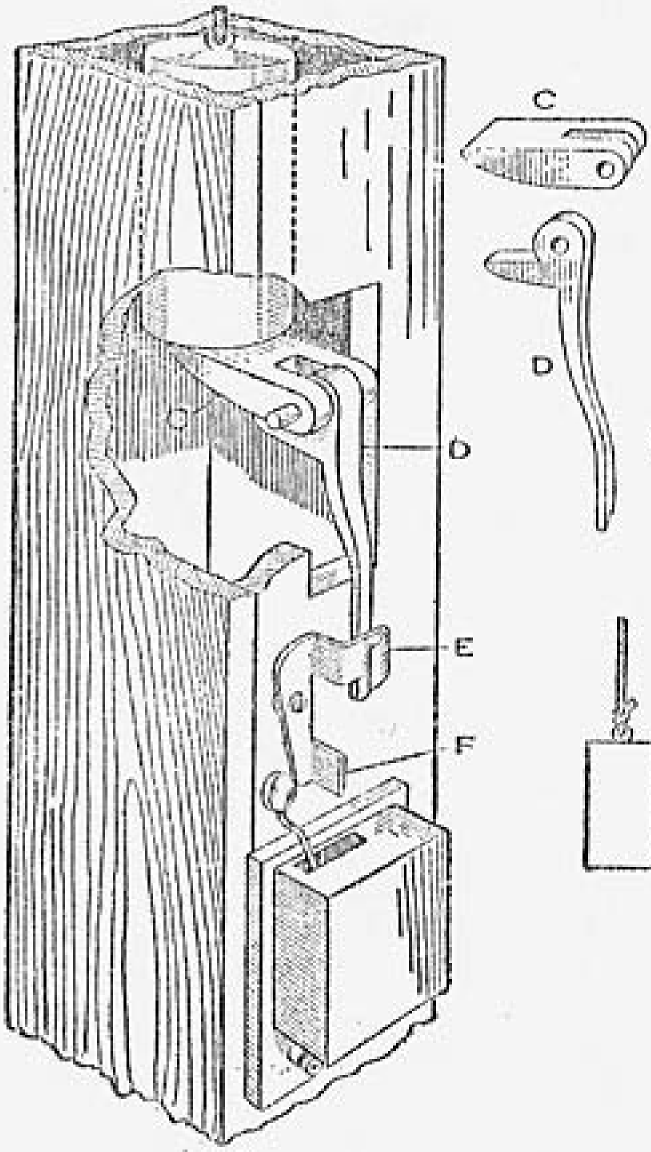
disk soldered to the top. Connections are made to the carbon holders either under a screw head or by soldering the wires to the metal.

In operating any arc light on the commercial 110-volt current some resistance must be placed in the circuit. An earthen jar of water with two strips of tin or lead for electrodes, will answer every purpose.

THE BOY MECHANIC – 1919

An Automatic Window Closer

The window closer consists of a weight, A, attached to one end of a cord, B, which runs through several pulleys and has its other end attached to a hook in the center of the window sash, as shown in Fig. 1. The weight A is held in an elevated position by a small trigger which is operated with an electromagnet.



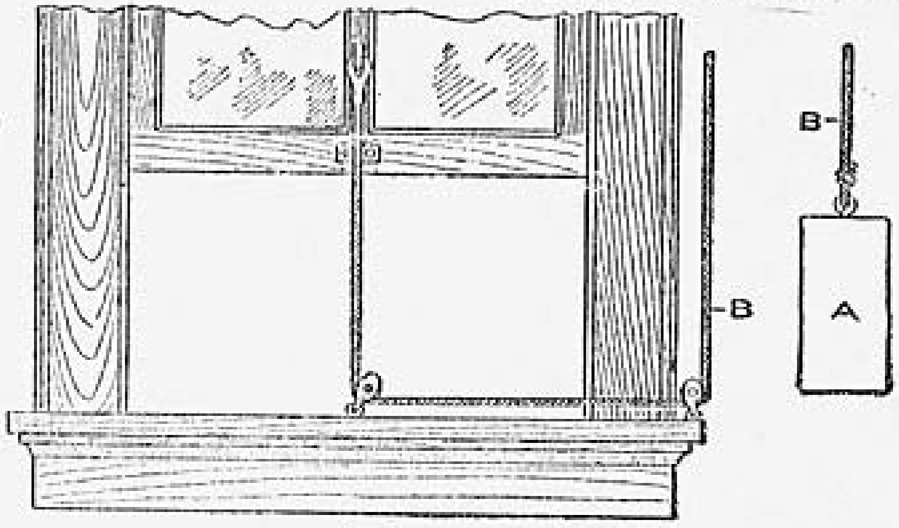


Fig. 1

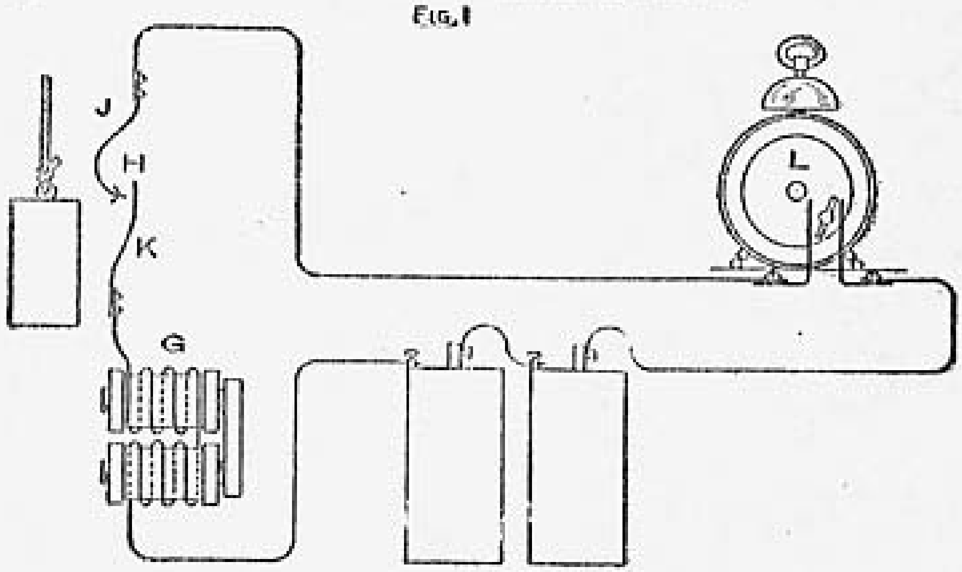


Fig. 3

Fig. 2

The Window is Automatically Closed by a Weight at the Time Set on the Alarm Clock When the Key Closes the Electric Circuit, Causing the Magnet to Release the Latch

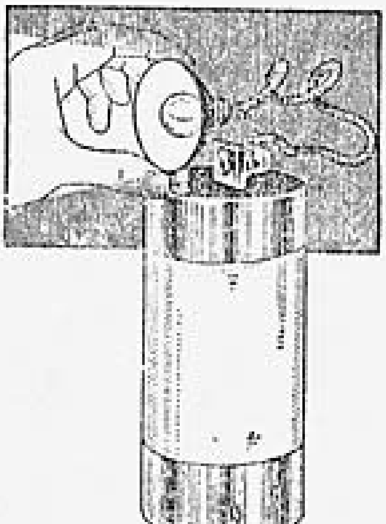
The arrangement of the weight and its control is shown in Fig. 2. The latch C is held in a horizontal position by an extension on the arm D, which in turn is held by a latch, E. The latch C is mounted on the same supporting shaft as the arm D, and they are connected with a coil spring having the tension in such a direction that it holds the latch C down on the extension of the arm D. When the weight moves up through the box the latch C will rise and allow it to pass down beside it. The latch holding the lower end of the arm D may be released by means of an ordinary vibrating bell arranged so that its clapper will strike the extension F on the latch and thus cause its upper end to move from the engagement with the arm D. A small coil spring is attached to the arm D so that it will be returned to its vertical position when the weight has passed C and thus make it ready for the next operation without any adjustment except raising the weight and setting the clock.

A diagram of the electrical circuit is shown in Fig. 3, in which G represents the electromagnet to trip the trigger that supports the weight, and H the contact which remains open until the weight is raised to the upper position, when the spring J is forced against the spring K and closes the circuit. The circuit still remains broken until the contact L is closed by the key on the alarm clock, which is set in a vertical position between two springs representing the terminals of the wire. The contact H should be so located on the housing for the weight that it will be closed only when the weight is resting on the latch C. The circuit is then opened as soon as the latch C is released, and the clapper will stop vibrating.

THE BOY MECHANIC – 1919

Testing Dry Cells with Light Bulb

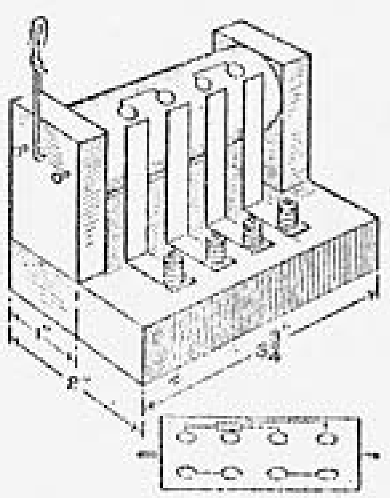
Tests of batteries for telephones, doorbells, and similar appliances, may be made by the use of a lamp from a pocket flash light. Remove the reflector and lamp and connect them with the poles of each cell to be tested, as shown in the sketch. The glow of the lamp is proportional to the amount of life in the cell. Very often but one dead cell will be found to cause trouble. By testing carefully, the good cells may be retained and new ones substituted for those worn out.



THE BOY MECHANIC – 1919

A Cylinder Reversing Switch

A cylinder reversing switch for small battery motors may be constructed cheaply, from a 3-in. length of broom handle and ½-in. boards, as shown. The four brushes are strips of copper. The contacts on the moving cylinder are eight brass tacks, connected as indicated in the diagram. The wires are insulated with paper where they cross. The handle is of heavy wire, and two tacks limit its motion, as shown. The method of connecting the switch is as follows, for either a series or shunt motor: Remove the two wires from the motor brushes, and connect the two middle brushes of the switch to the motor brushes. Connect the wires removed from the motor brushes to the outer brushes of the switch.—Claude Schuder, Sumner, Ill.



THE BOY MECHANIC – 1919

A Recording Annunciator Target

In rifle practice it is often desirable to provide a target which will indicate to the marksman when the bull's-eye is struck. The device shown in the sketch, arranged behind an ordinary card target, has given satisfactory results on a private range, and can easily be adapted for other uses.

Referring to Fig. 1, A indicates a wooden base, 4 by 8 by ½ in., on which is mounted a strap hinge, B, 6½ in. long, by means of a block, 1⅜ in. high. An opening, C, 1½ in. in diameter, is provided in the base, and a plate, D, 1¾ in. square, is riveted to the strap hinge opposite to the opening. An electromagnet, E, obtained from an electric bell, is mounted upon the base under the small end of the hinge. A standard, F, provided with a cross arm, G, is secured upon the base between the opening and the magnet. A thumbscrew with a locknut extends through the cross arm, engaging the rear side of the strap hinge, and permits an adjustment of distance between the core of the magnet and the surface of the hinge. A bell or buzzer, H, is connected as indicated, through the battery circuit. The electromagnet is connected through the battery and push button J.

The strap hinge normally rests against the electromagnet. The force of any projectile passing through the opening against the plate closes the bell circuit and indicates to the marksman that the bull's-eye has been hit. By the closing of the magnet circuit, the strap hinge is drawn again into normal position and the bell circuit is

 GRANDDAD'S ELCTRICITY BOOK

broken. Figure 2 shows a front view of the circuit-closing device. The device may be mounted in any suitable box, as suggested in Fig. 3. The front

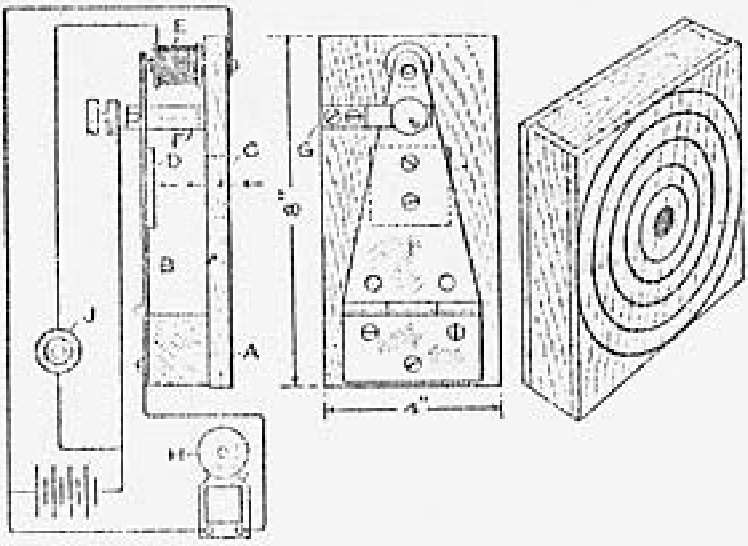


Fig. 1 Fig. 2 Fig. 3

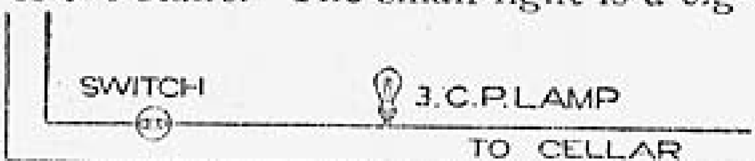
The Bullet Forces the Hinge against the Thumbscrew, Causing the Bell to Ring

of the box is covered with sheet metal, 1/16 in. thick, and the standard target card is mounted thereon.—John B. Brady, Washington, D. C.

THE BOY MECHANIC – 1919

Signal for Lighted Lights in Basement

To avoid the loss of electric current by forgetting to turn out the light in the basement, I placed a 3-cp. lamp in the circuit near the switch at the head of the stairs. The small light is a sig-



The Small Lamp near the Switch in Circuit Glows When Lights Are On in the Basement

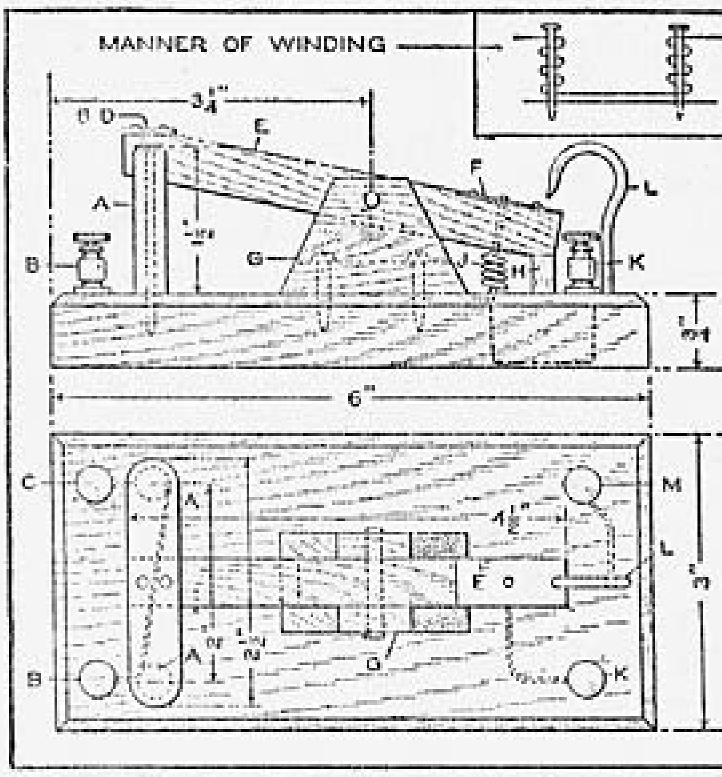
nal that the light is still turned on in the basement.—Contributed by A. MacCunn, Toronto, Can.

THE BOY MECHANIC – 1919

Homemade Relay of Inexpensive Materials

A practical relay was made of odds and ends gathered in the workshop. The base is of wood, 3/4 by 3 by 6 in. The magnets A are made of two wire nails driven into the base, the heads projecting 1½ in. They are wound with six layers of fine insulated No. 25 gauge wire, as shown in the small sketch. The ends of these magnet wires are carried to the two binding posts B and C, taken from dry-cell carbons.

The armature D is a piece of soft iron, ½ by 2½ in., screwed to the armature lever E, which is a ½ by 4½-in. piece of wood. A piece of tin is tacked to the opposite end F, and a 1/8-in. hole is bored through the lever, 2½ in. from the front end. Nail a wooden block, G, to the base, slotted to accommodate the lever, so that when the latter is pivoted in the slot, the armature will lie directly over the magnet heads. Fit a wooden stop, H, under the end of the lever, so that the armature is held 1/8 in. above the magnets, by a brass spring, J, connected to the tin, F, and the binding post, K, with copper wire. Arrange the brass hook, L, so it comes in contact with F when the armature bears down upon the magnets. Connect this hook to the binding post, M. When current flows through the magnets, the armature is pulled down and the contact of the



Nails, a Screw Hook, and Similiar Common Materials, were Used in Making This Relay

hook, L, with the tin, F, completes a secondary circuit.—L. R. Hardins, Harwich, Mass.

THE BOY MECHANIC – 1919

A Small Variable Condenser

The condenser shown in the diagram combines the large capacity of a fixed condenser with the gradual capacity

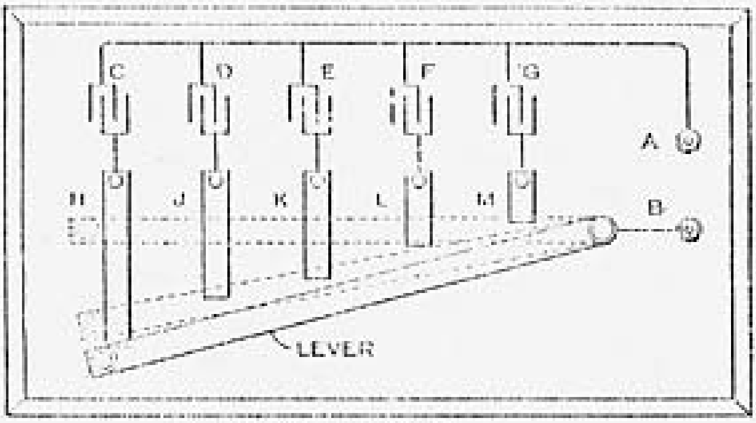


Diagram for a Small Variable Condenser

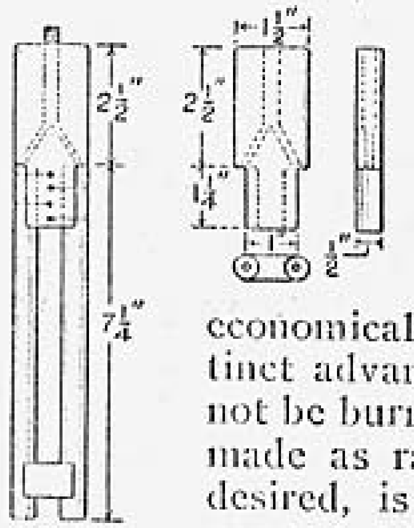
variation of a variable one. It is suitable for a wireless receiving circuit, or to shunt around the vibrator of an induction coil, by making the units considerably larger. It is made up of several fixed condensers, connected in parallel, a lever being the means whereby the capacity is varied. Five or more units may be used, each being a small condenser, built up of 10 sheets of waxed paper and nine sheets of tin foil. A convenient size for the tin foil is 6 by 4 in., and for the paper, 5½ by 4½ in. The latter should be a good grade of very thin linen paper and should be carefully prepared by dipping it in hot paraffin. The sheets of tin foil and paper in each unit are piled up alternately, allowing about ½ in. on each tin-foil strip to project beyond the paper for making connections. The pile is covered with heavy paper, and a heated flatiron is passed on the top of each unit until the paraffin begins to melt. Upon cooling, the units are compact.

The connections necessary are shown in the diagram. The condenser units C, D, E, F, G, each have one side connected to a common terminal A. The other sides of the condensers are connected to the copper strips H, J, K, L, M. They are ½ in. wide and 1/16 in. thick. A copper lever, ⅛ by ½ by 8 in., is pivoted on one end so that it will connect two or more of the condensers in parallel. The pivoted end is connected to the terminal B. The dotted line shows different positions of the lever. The apparatus is mounted in a wooden box.

THE BOY MECHANIC – 1919

A Carbon Electric Water Heater

The water heater illustrated is for use on a 110-volt circuit without added resistance. It consists of two electrodes which are immersed directly in the water; and while it is not as artistic as the usual nickel-plated heater, it is usually more economical and has the distinct advantage that it cannot be burnt out. It may be made as rapid in action as desired, is inexpensive and very convenient where water is required for experimental or industrial purposes.



For the electrodes, procure two ½ in. uncoppered carbons, and drill a hole in the top of each of these so that feed wires can be attached. The handle is shaped from a piece of hard wood. The lower end is hollowed out half round at either side, so that the carbons will fit in snugly. Four small holes are then drilled through from side to side, for binding wires, and a large hole is made in the center for the feed wires. Two smaller branch holes are then drilled to join the center hole, so that the double feed cord may be branched out to reach both electrodes. The outer edge of the handle is neatly rounded off and boiled in paraffin so as to render it impervious to moisture.

Remove sufficient insulation from the feed cord to make a good connection with the carbons. Fish the wire through the handle from the upper end.

Pull each of the two ends pretty well through, so that they can be securely leaded into the holes previously made in the carbons. Have the latter quite hot and run in as much solder as possible, forcing it in with the end of a match as it becomes plastic. Remove all traces of the flux, and paint the connection with some melted pitch, taken from the top of a discarded dry cell. The feed cord may then be pulled up tightly, which will draw the carbons in place. They are then bound by threading through several strands of copper wire. If the holes in the wood are slightly countersunk, and two small grooves filed around each carbon at the right places to let the holding wires in, the binding feature may be disposed of very neatly.

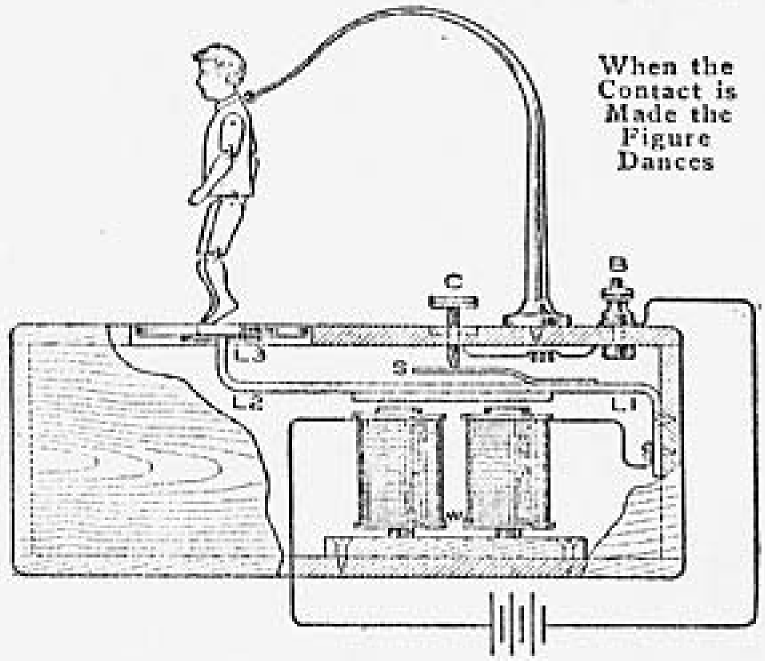
In some localities the water is so free from all mineral salts that it will not carry the current freely, which means that the electrodes must be placed closer together, or else a small pinch of common salt may be added to the water. Although, in sterilizing instruments, boiling eggs, or something of that sort, this would be of no advantage, the salt greatly hastens the boiling.

THE BOY MECHANIC – 1919

An Electrical Dancer

The modification of the well-known mechanical dancer shown in the illustration is based on the principle of the electric bell. While the amusing antics of the mechanical dancer are controlled by the hand, the manikin shown is actuated by the electromagnet.

The mechanism is contained in a box. It consists of an electromagnet with a soft-iron armature carried by a spring. A wire from the battery goes to the magnet. The other terminal of the magnet connects with the armature spring at L 1. The spring is bent at a right angle at its other end, L 2, and carries a platform, L 3, strengthened by a smaller disk underneath.



When the Contact is Made the Figure Dances

The dancer performs upon this platform.

A contact spring, S, is carried by the armature spring. A contact screw, C, is adjustable in its contact with the spring S. A wire runs from the contact screw to the binding post B, to which the other battery wire is connected.

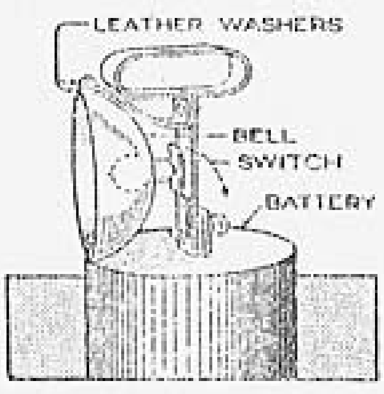
The current keeps the platform in constant vibration, causing the dancer to "dance." By means of the screw C, the action of the current may be varied, and the "dancing" will vary correspondingly.

The figure is made of wood with very loose joints and is suspended so that the feet barely touch the platform.—Contributed by Edward C. Connelly, Wilkesbarre, Pa.

THE BOY MECHANIC – 1919

A Homemade Trouble Lamp

By attaching a handle for carrying, and making suitable connections, a portable trouble light was made of a dry battery. A strip of iron was bent to the shape shown, for the handle, and fixed to the binding post on the carbon. A bell from an alarm clock was drilled and



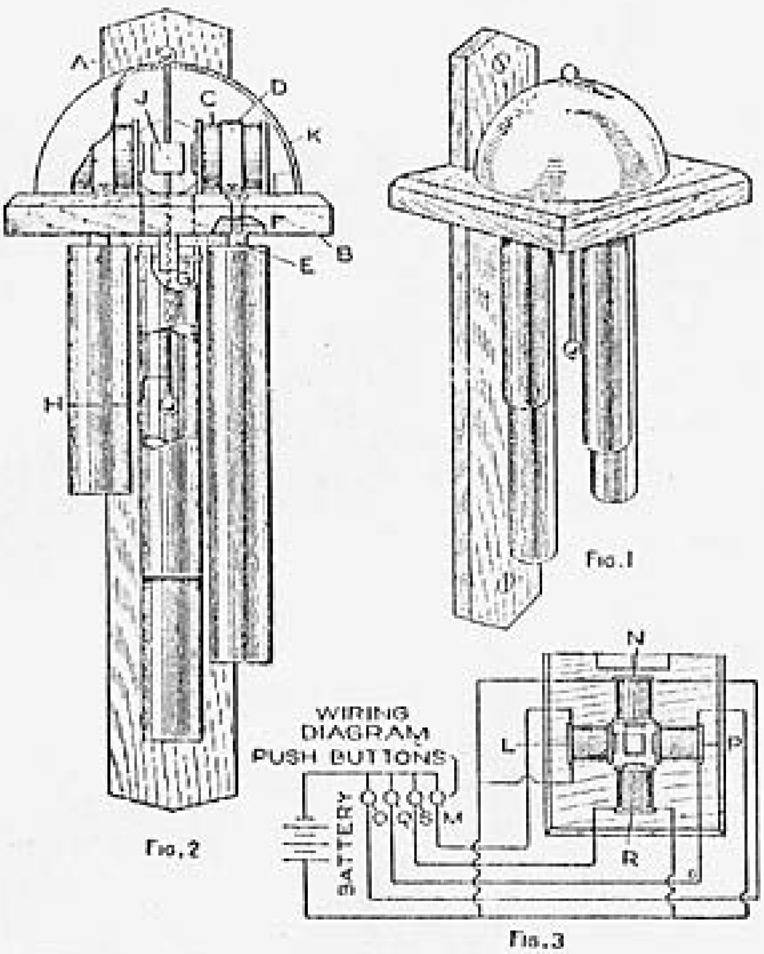
 GRANDDAD'S ELCTRICITY BOOK

tapped to fit a small light bulb, and fastened at the zinc post. The upper edge of the bell was bolted to the extension of the handle, as shown, leather washers insulating it. A small switch, riveted loosely to the iron strip, controls the light.—Carl A. Haberlein, McPherson, Kan.

THE BOY MECHANIC – 1919

A Set of Electric Chimes

A set of electric dinner chimes is a welcome and useful addition to many households, and may be made at a



When the Buttons are Pressed, Tones are Given Forth by the Electrically Operated Gongs

trifling cost by the average person handy with tools. The completed article is shown in Fig. 1, the details in Fig. 2, and the wiring diagram in Fig. 3. The woodwork is of ½-in. stock. The back A, Fig. 2, is 1½ in., by 9¾ in. long. The ends may be shaped to suit the builder's fancy. The shelf B is 4 in. square, and is fastened to the back piece 2¼ in. from the upper end. It supports the magnets C, which are made on cores, ⅜ in. in diameter and ¾ in. long, with ends 5/16 in. by 1 in. in diameter. The spools are wound full of No. 28 silk-covered copper magnet wire. These coils are mounted on the shelf by means of brass straps D. Four magnets are used, the forward one being omitted in Fig. 2.

The supports E, for the tubes, consist of ½-in. lengths of ¼-in. square brass rod. One end of the rod is drilled and tapped for an 8-32 screw which holds the support in place. Drill a small hole, ¼ in. from the end, for the pin G, made of steel wire. The tapper H is made from a 4½-in. length of stiff iron wire; 1¼ in. from one end a ⅜-in. cube of iron, J, is soldered, the wire passing through it. The ends of the wire are fitted with balls as shown. A nickeled gong, K, covers the four magnets. The end of the tapper is passed through the hole in the gong, and the ball riveted into place.

Four ¾-in. diameter tubes are used, respectively 3, 4, 5, and 6 in. long. When the apparatus is assembled as shown, and one of the magnets is energized, the latter will draw the iron cube J toward it, and the tapper will strike one of the tubes.

To control the current supplying the magnets, four small push buttons mounted on a wooden base are used. They are wired up with the battery and coils, as shown in Fig. 3. A wire from each of the coils runs directly to one terminal of the battery, the other wire from each coil being connected to a separate push button. The other sides of the push buttons are connected to the battery. By this means any of the magnets may be energized at will, the coils and corresponding push buttons being marked L and M, etc., alphabetically.

THE BOY MECHANIC – 1919

Testing Direct Current Polarity with Litmus Paper

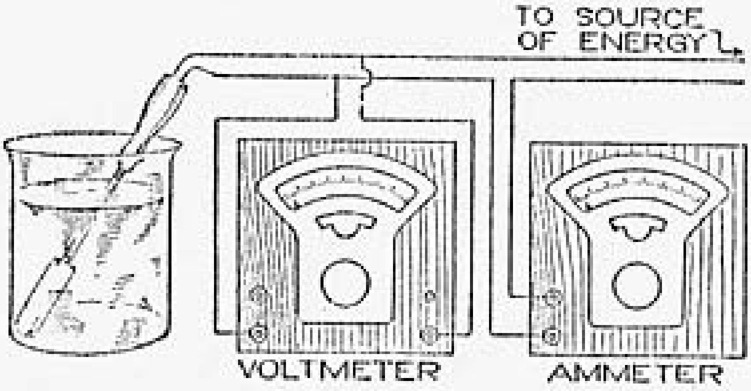
Litmus paper laid on glass, and

moistened with a weak solution of sodium sulphate can be used to test the polarity of a direct current. If the two conductors are touched on the moistened paper, the latter will turn red at the positive, and blue at the negative conductor.

THE BOY MECHANIC – 1919

To Determine the Efficiency of Electrically Heated Devices

The efficiency of any machine is defined as being the ratio of the output to the input expressed as a percentage, and both quantities must be measured



Connections to the Voltmeter and Ammeter for Measuring the Input to an Electric Heater

in the same units. For example, the output of a motor is 10 hp. when the power taken by the motor from the electric circuit to which it is connected is 9,325 watts. What is the efficiency? Since the output must be expressed in the same units it is necessary to change the 10 horsepower to watts or the 9,325 watts to horsepower. There are 746 watts in each horsepower. The 9,325 watts are equivalent to 9,325 ÷ 746 or 12.5 hp. The efficiency is then equal to 10 ÷ 12.5 or .8; that is, the output is .8 of the input or, when multiplied by 100 to change it to percentage, 80 per cent.

By way of an example, consider the efficiency of an electric heater, like the one shown in the illustration, which is immersed in water placed in a suitable vessel. The energy input to this heater in a given time may be easily determined by measuring the current passing through the heater circuit and the difference in pressure between the terminals of the heater. These measurements may be made, in case the heater is operated on a direct circuit, by means of any ammeter and voltmeter of suitable capacity, connected as shown. If the heater is operated on an alternating-current circuit, only alternating-current instruments can be used, as certain types of instruments will not operate when connected to such a circuit. In either case, the product of the ammeter reading in amperes and the voltmeter reading in volts will give the power taken by the heater in watts, assuming the heater winding to be noninductive. If the heater winding is not noninductive, then the current and the electrical pressure will no longer be in phase when the device is operating on an alternating-current circuit, and a wattmeter must be used. Practically all heating elements are wound noninductively so that the power may be measured by means of an ammeter and voltmeter.

The energy taken by a heater in a given time will be equal to the product of the average power and the time. For example, if the heater takes 300 watts for 30 minutes—½ hour—then the energy consumed is equal to 300 times ½ or 150 watt-hours, which is equal to .15 kilowatt-hour.

To determine the output of the heater is a little more difficult, but it may be approximated as follows: Since the object of the device is to convert electrical energy into heat energy the output must be measured in heat units. The unit of heat most commonly employed is the calorie, which is the heat required to raise the temperature of one gram of water one degree centigrade. Hence, if a certain weight of water has its temperature increased a definite number of degrees centigrade by the electric heater, then the total heat imparted to the water in calories will equal the weight of the water in grams multiplied by the change in temperature in degrees centigrade. Of course, the heat generated by the heater exceeds that obtained by the above calculation, due to the fact that some heat is imparted to the vessel containing the water and to the supports for the vessel, but it is only the heat imparted to the water that must be considered, as the other heat is not useful.

When the temperature of the water is raised to the boiling point and a part of the water is evaporated, the foregoing method of calculating the heat imparted to the water no longer holds good, and the following method must be used. Weigh the water before and immediately after the test to determine the amount of evaporation. For each gram of water evaporated there will be required approximately 536 calories, and the heat in calories imparted to the water to raise its temperature to the boiling point will be equal to the difference between 100 and the initial temperature of the water multiplied by the weight of the water at the start. To determine the efficiency, the input to the heating element in electrical units must be changed to heat units which may be done by multiplying the power in watts by the time in seconds and this product in turn by .24, giving the result in calories. The following example may serve as a help in performing such an experiment or test.

Weight of water at the start....	500.0	grams.
Weight of water at the end of test	474.5	grams.
Temperature of water at the start..	25	deg. C.
Average current taken by the heater	6.5	amperes.
Average pressure at the heater terminals	110	volts.
Time heater is connected..........	5½	minutes.
Change in temperature of the water	75	deg. C.
Heat developed in heater: 6.5 x 110 x 5½ x 60 x .24=.....	56,628	calories.
Heat absorbed by water in coming to boiling point: 500 x 75=..	37,500	calories.
Heat used in evaporating 25.5 grams of water: 536 x 25.5=.	13,668	calories.
Total heat absorbed by water..	51,168	calories.
Efficiency of heater: $\frac{51,168}{56,628} \times 100 =$	90.4	per cent.

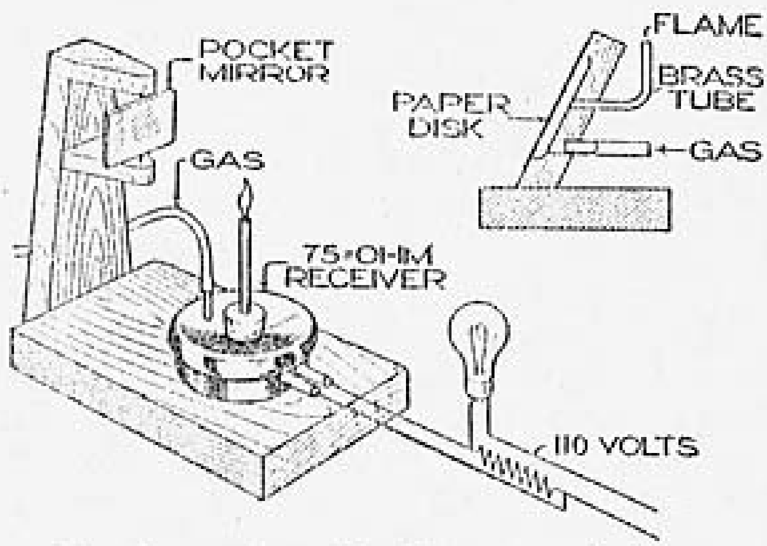
This value of efficiency may be increased by insulating the vessel with a nonconductor of heat and providing a covering for it, thus decreasing the losses to the air and surrounding objects.

The efficiency of an electric stove or electric iron, or, in fact, any electrically heated device, may be determined in a manner similar to the water heater. In the case of a stove, place a vessel filled with water on it and measure the heat imparted to the water in a given time, also the input to the heating element in the same time, from which data the efficiency may be calculated. In the case of an electric iron, dampened cloths may be ironed and the actual water evaporated by the iron, determined by weighing the cloths before and after the ironing, together with the increase in weight of the cloth on the ironing board, the time the iron is in use and the temperature of the cloths. The actual water evaporated is the difference in the weight of the cloths before and after ironing, minus the increase in weight of the cloth on the ironing board, which takes up some of the moisture from the cloths being ironed.

THE BOY MECHANIC – 1919

Seeing an Alternating Current in a Mirror

It will almost appear impossible to those unfamiliar with laboratory methods that one may watch the vibrations



The Alternations of the Current may be Seen by Looking in the Mirror

—3,600 per minute—of an alternating current in a little pocket mirror without the use of any apparatus other than a telephone receiver. The experiment is very interesting and instructive, one that may be performed at practically no expense.

Take an ordinary inexpensive watch-case receiver, drill a hole in the cover for a short piece of brass tubing, to make a gas connection, and then plug up the center opening with a cork, into which is tightly fitted a piece of 1/8-in. tubing. The upper end of this should be closed with a plug having a central opening about the size of a pin. Procure a small rectangular pocket mirror and remove the celluloid covering, and then, across the back, solder a piece of straight wire to form a vertical spindle, about which the mirror may be rotated. Connect any resistance, such as a magnet coil of 10 or 20 ohms, in series with an incandescent lamp, and then connect the receiver terminals to the ends of this resistance. In this manner an ideal alternating-current supply of a few volts to operate the receiver safely is secured. Turn on the gas only sufficient to produce a narrow pencil of flame, not over 1 in. long. Mount the mirror as shown, or hold the spindle between the thumb and forefinger of the left hand while rocking it back and forth with the right. Ordinarily only a streak of light will appear, but immediately upon turning on the current this streak will be broken up into a series of regular waves, flatter or sharper according to the speed with which the mirror is rocked. After carefully noting the wave form, connect the receiver with the primary of an ordinary medical coil, across the make-and-break, and note the marked difference in the waves.

By replacing the receiver with a block of wood having a circular depression, about 2 in. in diameter and 1/8 in. deep, over which is pasted a disk of smooth paper, the waves set up by the human voice may be observed if the talking is done loudly and close to the disk. The gas connection in this case is made from the back of the block, as shown. As the several vowels are sounded, the characteristic wave from each will be seen in the mirror. It is also interesting to increase the pitch of the voice and note how much finer the waves become.

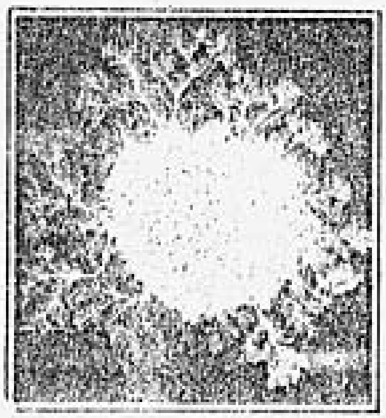
THE BOY MECHANIC – 1919

Photographing Electric Sparks

Electric sparks may be photographed with simple equipment, and the process offers a diversion from the common subjects for photography. The materials necessary are a spark coil and current source, a photographic plate, facilities for developing it, and a sheet of tin foil. The illustration shows a typical photograph of an electric spark, and the variety possible is unlimited.

The process, which must be performed in a dark room with a ruby light, is as follows: Over the mouth of a small glass bottle, partly filled with talcum powder, tie a piece of cheesecloth, to act as a sieve. Arrange the material on a table, the sheet of tin foil lying flat, and a photographic plate on top of it, coated side upward.

Spread a thin layer of the powder on the plate, through the sieve. Attach a needle to an electric wire and fix the other end of the wire to one of the secondary posts of the spark coil. Attach a second wire to the other post of the spark coil and to the sheet of tin foil. Care must be taken in handling



the needle that only the insulated portion, where it is joined to the wire, comes in contact with the fingers, or a shock may result. Place the point of the needle near the middle of the plate and turn on the current, permitting it to produce a spark of not more than

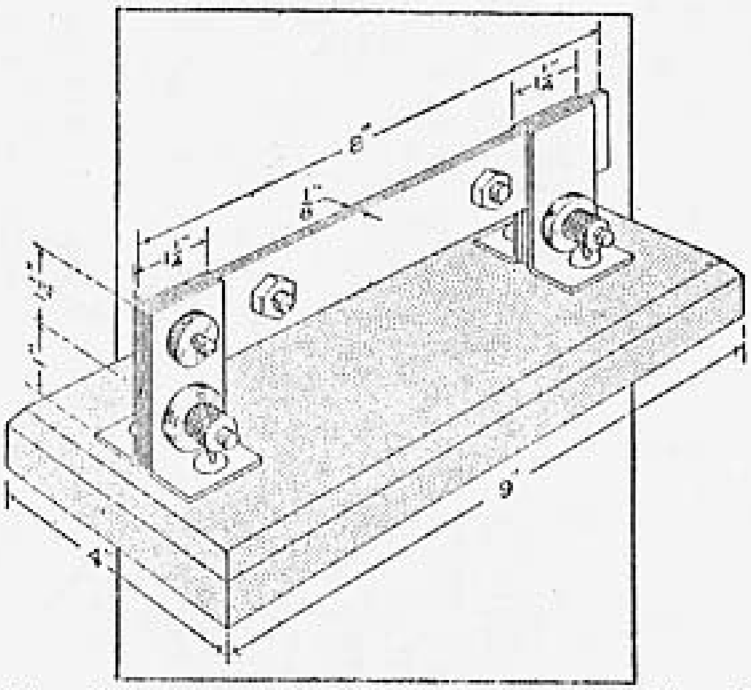
 GRANDDAD'S ELCTRICITY BOOK

one second's duration. If the exposure is longer than that the result will not be satisfactory. Wipe off the powder and develop the plate. If care has been taken in the process, a photograph similar to the one shown in the illustration will result.

THE BOY MECHANIC – 1919

Lightning Switch for Wireless Aerials

Amateur wireless operators often cannot afford to buy a lightning switch such as is required to ground the aerial



Discarded Copper Half-Tone Plates and a Piece of Marble were Used in Making This Lightning Switch for Wireless Aerials

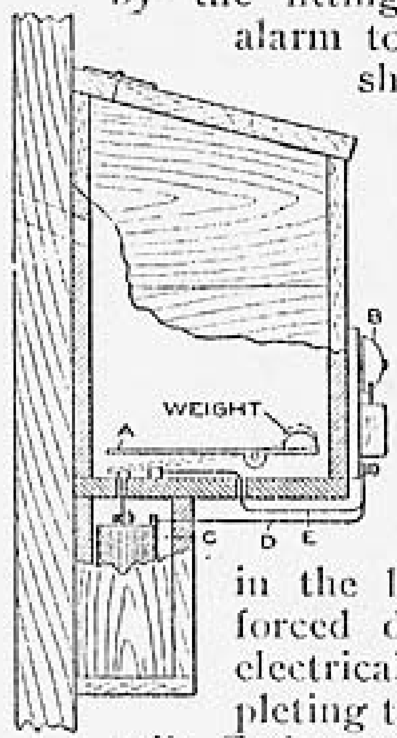
when not in use. The sketch shows such a device, which was made of a marble slab fitted with copper strips cut from discarded half-tone plates. The base was smoothed and polished to the size indicated, 4 in. wide and 9 in. long. The upper edges were beveled off, and holes were drilled near the ends through which bolts were passed to fasten the small brackets supporting the crossbar.

The copper pieces were made as follows: The plates of $\frac{1}{16}$-in. copper were cut into strips, $1\frac{1}{4}$ in. wide. Two were made 8 in. long; four, 3 in. long, and four, $\frac{7}{8}$ in. long. The 8-in. strips were fastened together with small bolts and a hole was drilled through one end of the joined pieces to fit the bolt which forms the pivot for the switch. The 3-in. strips were bent to form a $\frac{3}{4}$-in. angle, through which holes were bored for fastening to the base. The $\frac{7}{8}$-in. strips were clamped between the brackets at their lower ends to provide a slot for the crossbar. The bolts, by which the brackets were clamped together, were provided with binding nuts to which the wires were connected. A handle might be fixed to the crossbar, but this is not essential.

THE BOY MECHANIC – 1919

A Bell-Ringing Mail Box

The annoyance of watching for the arrival of the mailman was overcome by the fitting of an electrical alarm to the mail box, as shown in the sketch. A strip of metal, A, was pivoted in the box and weighted on one end. A bell, B, was wired to dry cells in the box below the container for the mail. When the mail is dropped in the box the end A is forced down, forming an electrical contact and completing the circuit from the cells C through the wire D and back through the wire E. When the mail is removed the weight raises the metal strip.—James E. Noble, Portsmouth, Canada.

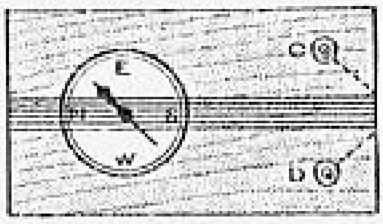


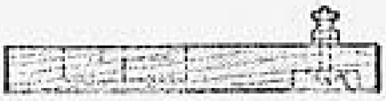
THE BOY MECHANIC – 1919

A Simple Polarity Indicator

An ordinary compass, fitted flush in a wooden frame as shown in the sketch, forms the basis for the polarity indicator described. The N, or north, and S, or south, points of the compass should run lengthwise with the frame, with the former on the end farthest from the binding posts, C and D. Five turns of No. 18 gauge, or any similar, wire are wound lengthwise around the frame and over the compass. The ends of the wires terminate at the two binding posts. Begin at C and wind toward the compass, binding the wire at D.

If the two ends of a wire are free, and it is desired to know whether there is any current present, and if so, its polarity, fasten one wire to the post C and the other to D. Before connecting the wires, hold the compass and frame in such a way that the needle is over the N point on the compass dial. If, after the wires are connected, the needle moves, there is a current flowing. If the needle is deflected toward the east, the negative wire is on C; if it is deflected toward the west, the positive wire is on C.





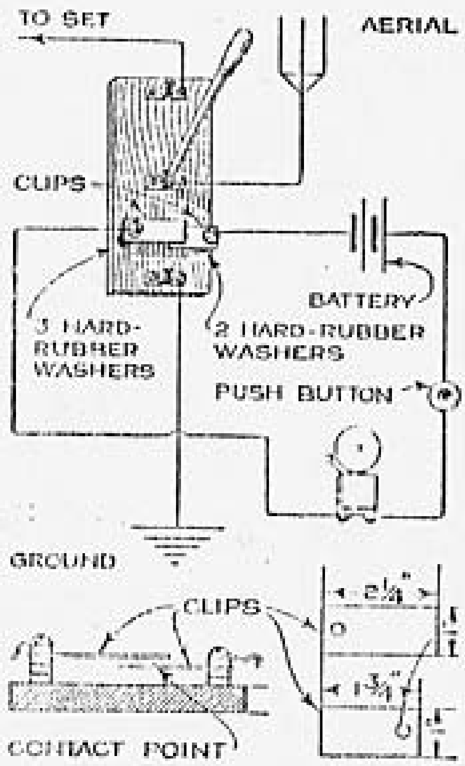
When it is desired to ascertain the polarity of a wire, which is covered by a floor, ceiling, or molding, hold the compass as explained, and either directly above or below the wire. Then turn on the current. If the instrument is above the wire, the wire extending parallel with it north and south, and the needle is deflected toward the west, the current is flowing from the north to the south end of the wire. If the wire runs east and west and the needle is deflected to the west, the current is running from west to east.

If the wire runs on a diagonal between the directions mentioned, and the needle is deflected toward the west, the current is flowing from the quadrant between N and W on the compass dial toward the quadrant between S and E. If the instrument is held over the wire and the needle is deflected toward E, the polarity is the opposite to that last indicated. Should the instrument be held below the wire, if the needle goes toward W, it is equivalent to going toward E when above the wire.—H. Sterling Parker, Brooklyn, New York.

THE BOY MECHANIC – 1919

To Tell When Aerial is Grounded

Aerial grounding switches should always be attached to the outside of the building, and this arrangement is particularly bothersome in bad weather, as the operator must open the window or make a trip outdoors to make certain that the switch has been thrown to ground the aerial.

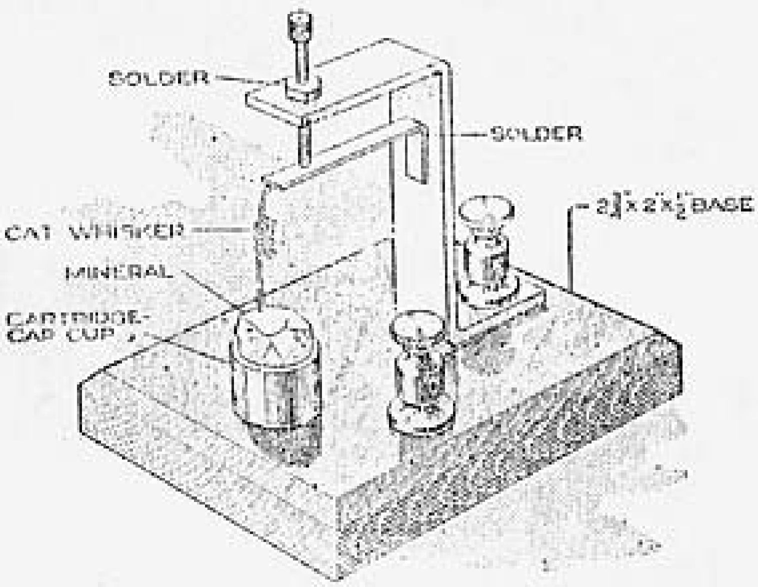


By providing the switch with contact clips and connecting them to a bell circuit in the manner indicated, this inconvenience is eliminated. A hole is drilled through the switch base on each side of the knife, midway between the ground clip and the knife base. A small bolt is provided for each hole, and the overlapping spring-brass contact clips are elevated from the base by hard-rubber washers, two being used under the lower clip and three under the upper one. The wires to the bell are soldered to these clips, and brought inside the house, and the bell and button are mounted in some place convenient to the instrument table. When the aerial is grounded, the contact clips are pressed together by the switch knife. This closes the break in the bell circuit, and to prove the establishment of a ground it is only necessary to press the bell button. If the bell does not ring it indicates the aerial has not been grounded.—F. L. Brittin, Chicago, Ill.

THE BOY MECHANIC – 1919

A Simple Wireless Detector

A cheap and serviceable wireless detector was made from odds and ends such as any amateur can obtain. The base was made of wood, saturated in paraffin. The mineral cup is a brass cap from a cartridge fuse. The upright was



This Neat Wireless Detector was Made of Materials Easily Gathered in the Boy's Workshop

made of a piece of copper, ½ by 4½ in. long, and is fastened to the base by an old-battery binding post. The spring which supports the cat whisker is made of a strip of copper, 1/32 in. by 3/16 in. wide. The cat whisker is soldered to the spring, and the spring is bolted to the upright. The setscrew, which regulates the pressure of the cat whisker upon the mineral, works in a nut, soldered over a hole in the top of the upright. The cat whisker is made of No. 22 gauge bare copper wire. The connection between the cup and the battery binding post, at the front edge, is made on the under side of the base. —Charles Brinkmann, Chicago, Ill.

THE BOY MECHANIC – 1925

Renewing a Radio Crystal

When the galena crystal of a small radio set has become dull and dirty, so that it is almost impossible to find a sensitive spot, a simple but very effective method can be used to renew it.

The mounted crystal should be held over a flame, in an old spoon, until the metal begins to run. The crystal can then be turned over with a piece of wire, thus exposing an entirely new sensitive area. A mold can be used to keep the melted metal in the original shape and size, so that it will fit in the detector cup. Care should be taken not to heat the metal too much beyond the melting point, as this will impair the sensitiveness of the crystal.

THE BOY MECHANIC – 1925

Neat Tips on Wires

In order to have the wiring look neat on a radio set, or other instrument being made, all wires with visible connection to binding posts should be wound with small bare wire to prevent the insulation from raveling out. Fig. 1 shows the insulation removed from the wire, the winding of the tip started with a piece of bare wire of small diameter, and the neat finished effect. Fig. 2 illustrates the method of making a tip for connecting to another style of binding post. The latter is a connection that is especially useful when the wire is to be frequently connected to or disconnected from a binding post.

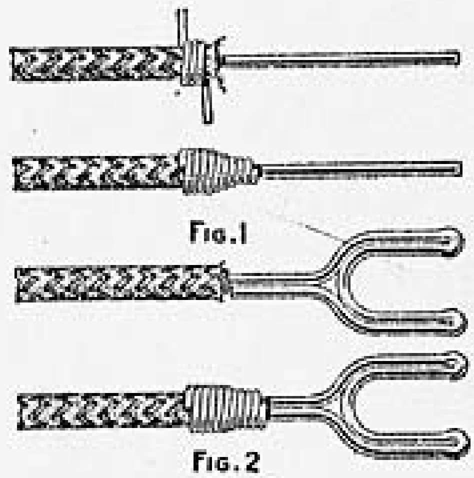


Fig. 1

Fig. 2

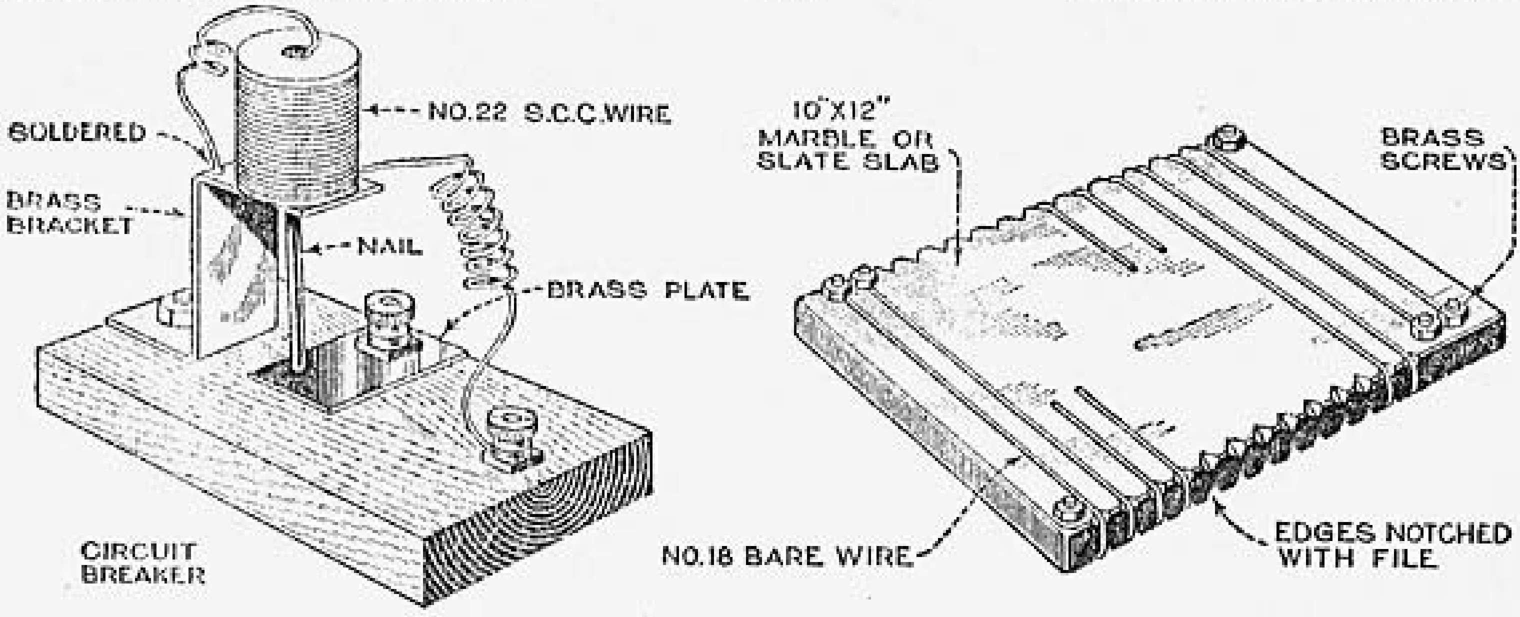
THE BOY MECHANIC – 1925

An Electric Insect Killer

By C. FISKE

ALTHOUGH the 110-volt house-lighting current is ordinarily not fatal to the human body, it is very effective for electrocuting small animals and insects, because the resistance of these bodies is much less than that of the human body. This explains the effectiveness with which the electric insect killer, shown in the illustration, disposes of roaches, flies, spiders, and other insects. Once the apparatus is set up, it requires little or no attention, as it is automatic in its action, and there is no danger in having it connected continually.

The killer consists of a 10 by 12-in. slab of slate or marble with copper wire wound on it. The edges are nicked with a file to hold the wire in place securely. Care must

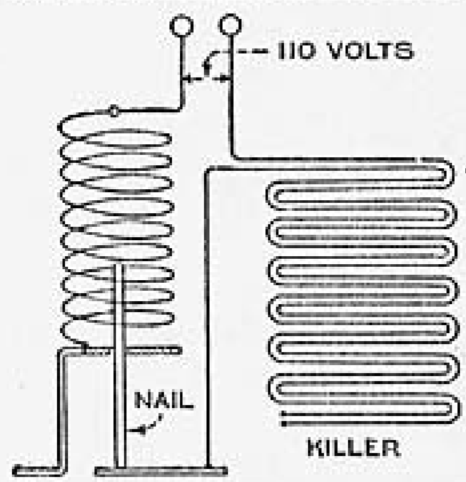


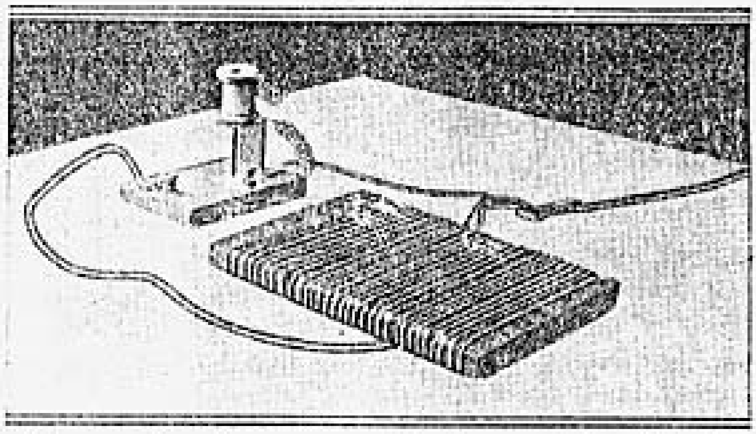
An Electric Insect Killer, Which Uses House-Lighting Current, and Has Been Found Very Effective. A Small Circuit Breaker Protects the Fuses in Case Too Much Current Flows

be taken to get the nicks about $\frac{1}{8}$ in. apart so that the wires will run close to each other but will not actually touch. The wire used for this purpose is preferably No. 18, and it must, of course, be bare. Two separate lengths are wound side by side so that the alternate wires will be of opposite polarity when connected to the circuit. The ends of the wires are securely fastened to a pair of $\frac{3}{4}$-in. brass screws at opposite corners of the slab to prevent the wires from unwinding. The heads of these screws project far enough below the slab to prevent the wires from touching the surface of the table upon which it is laid, and single screws are provided on the other two corners so that the slab will rest solidly.

As soon as an insect crawls or alights on the wired surface of this slab, on which sugar or other attractive bait is spread as a lure, it touches two wires of opposite polarity, and this allows a sufficient amount of current to flow through its body to kill it instantly.

It is not advisable to connect the wires of the slab directly to the lighting circuit as a small piece of metal, accidentally dropped on the wires, will blow a fuse. A small circuit breaker should be provided to prevent this. The construction of a simple one is shown in the lower left-hand detail. It consists of a solenoid made by winding an ordinary thread spool full of No. 22 single cotton-covered copper



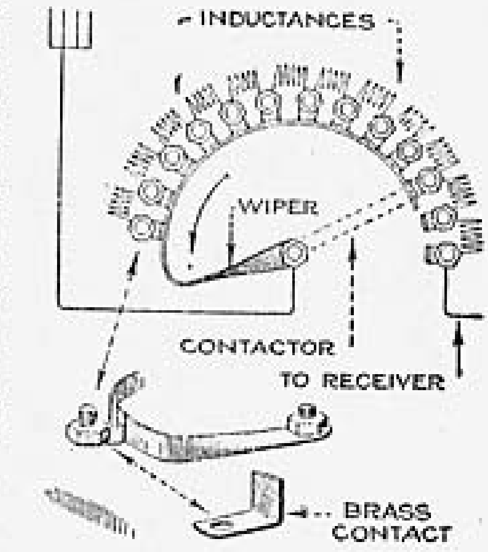


wire, and using a small wire nail, with the head clipped off, as a plunger. The solenoid is mounted on a brass bracket, which is bent to the shape shown, and screwed to a wooden base. Through this bracket, directly under the hole in the spool, a hole

THE BOY MECHANIC – 1925

Dead-End Switch for Inductances

The efficiency of a radio-receiving set can often be improved to a considerable extent by the use of a dead-end switch to short-circuit the unused turns of the inductance. The switch illustrated can be added to the set without disturbing the existing arrangement, and at a negligible cost. It consists simply of a piece of spring brass, bent as indicated, and soldered to the knob shaft, at the back of the panel. Small pieces of brass, bent to a right angle, are drilled and fastened under the head of each contact-point screw, to provide positive contacts for the spring-brass wiper. A little care is necessary to insure that each contact piece is placed correctly, and that the wiper is in the proper position, relative to the regular switch contactor, to short-circuit the unused turns and to touch all the contact pieces.

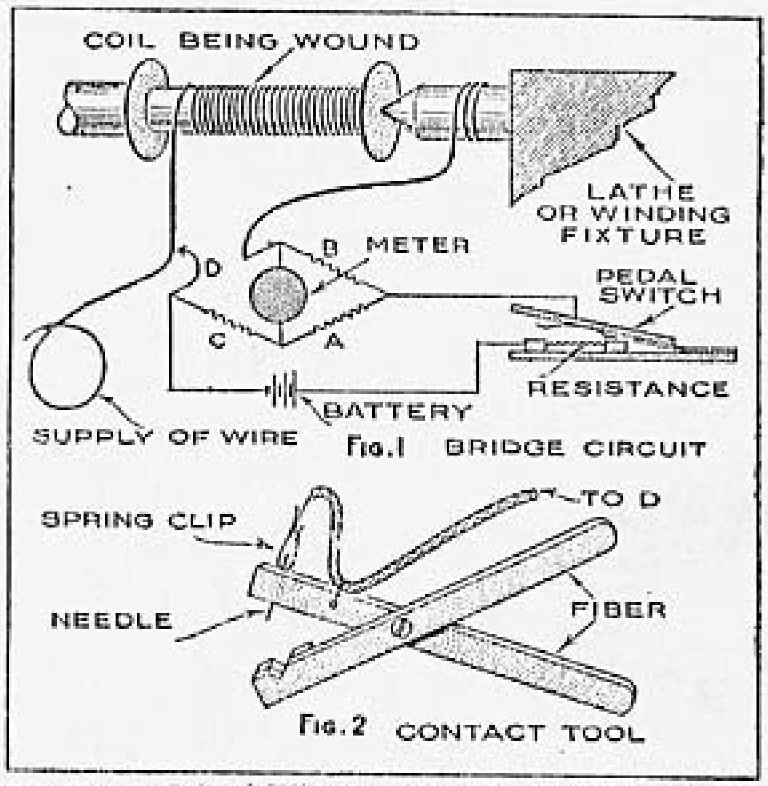


This switch can be used with any multipoint switch in which the points are arranged in an arc, and where contact is made by a rotating switch arm.

THE BOY MECHANIC – 1925

Wheatstone Bridge for Coil Winding

To wind electrical coils that must possess a certain resistance, or to wind a coil that will have the same resistance as another, are real problems to the experimenter unless he knows how to go about it. Almost every amateur is familiar with the Wheatstone bridge, by name at least; this is usually represented by four resistances in a diamond-shaped figure, with a battery connected at two of the points of the diamond and a galvanometer across the other two. When there is no current passing through the meter, it shows that the four resistances are balanced, and in proportion; that is, A is to B as C is to D. The voltage of the battery and the markings on the instrument need not be known or correct, as the accuracy of the result does not depend on them. Fig. 1 shows a method of applying the bridge principle to a coil as it is being wound, so that one may know just where to cut off the wire to get the right resistance. The galvanometer should, of course, be as sensitive as possible; it is not difficult to make one from a compass and a coil or two, or an excellent galvanometer can be obtained by removing the resistance coil from any good moving-coil voltmeter, or by connecting direct to the meter so as to bypass the resistance. The resistances A, B, and C must be of known value, if the coil is to be made a definite number of ohms, but if any one of them is of known resistance, two more can be made equal to it, by using ordinary bridge methods, so that only one known resistance is necessary at the start.



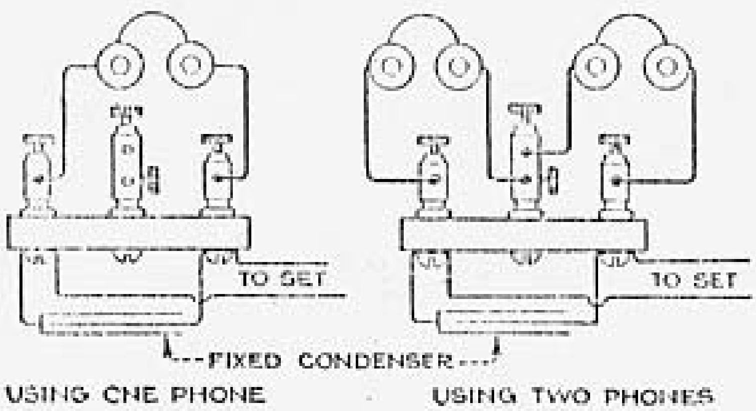
Winding a Coil of Wire to a Certain Resistance Is an Easy Task When the Wheatstone Bridge Illustrated is Used

In the figure, the coil being wound forms side D of the bridge; the inner end, or that next the meter, is grounded on the dead center of the lathe or winding fixture, and a temporary contact is made with the last turn wound by piercing the insulation. The pedal switch shown serves two purposes: It connects the battery in the circuit after the contact is made at D, and, as the pedal is further depressed, shorts out a resistance. This resistance is in series with the battery, and should be high enough to protect the meter from the high current which will result if the four sides of the bridge are much out of balance. When the first contact of the pedal switch closes and it is seen that only a small deflection appears on the meter, then the pedal can be pressed farther down, shortening out the resistance and giving greater accuracy in balancing the coil resistance against resistances A, B, and C. Fig. 2 shows a simple and handy tool for making the contact at D. Two pieces of fiber or hardwood are pivoted together at the middle; one is notched, and through the other a sharp steel needle is driven which is connected to the wire leading to the bridge. By laying the magnet wire in the notch and gently closing the needle point against it, the point will pierce the insulation sufficiently to make contact, but without damage of any importance to the cotton or enamel insulation.

THE BOY MECHANIC – 1925

Block for Multiple Radiophones

When more than one set of phones are used with a radio set, they should be connected in series; it is also best to shunt



Block for Connecting One or Two Sets of Ear Phones to the Radio Set: The Efficiency of the Phones is Increased by Shunting a Small Fixed Condenser across the Phone Circuit, as Shown

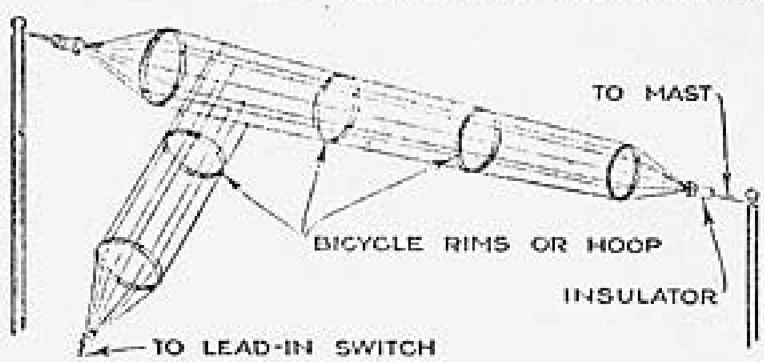
a small fixed condenser across the circuit, as in the diagram.

The block illustrated for connecting the two sets of phones is fitted with three binding posts, which are mounted in a straight line. The central post is of the two-hole type and is left "blind," not being connected in the circuit. The two end binding posts are of the ordinary type and are connected in the circuit in the usual manner. The posts are spaced about ¾ in. apart, and the fixed condenser is connected across the two outside ones. When only a single pair of phones is used, the tips are fastened in the end posts, as shown at the left, but when two sets are used, the connections are made as at the right.—W. C. Michel, Jersey City, N. J.

THE BOY MECHANIC – 1919

Cage-Type Aerial Highly Recommended to Amateurs

The cage type of aerial is gaining considerable favor with commercial and amateur operators, as it is easy to construct, economical in the number of insulators required, eliminates much trouble due to poorly soldered joints, occupies less space, and offers less resistance to the wind than the old flat-top type. Height is essential in this type, as the lead-in is also of the cage type, which adds to the capacity of the aerial. With this kind of antenna and lead-in it is possible to get greatly



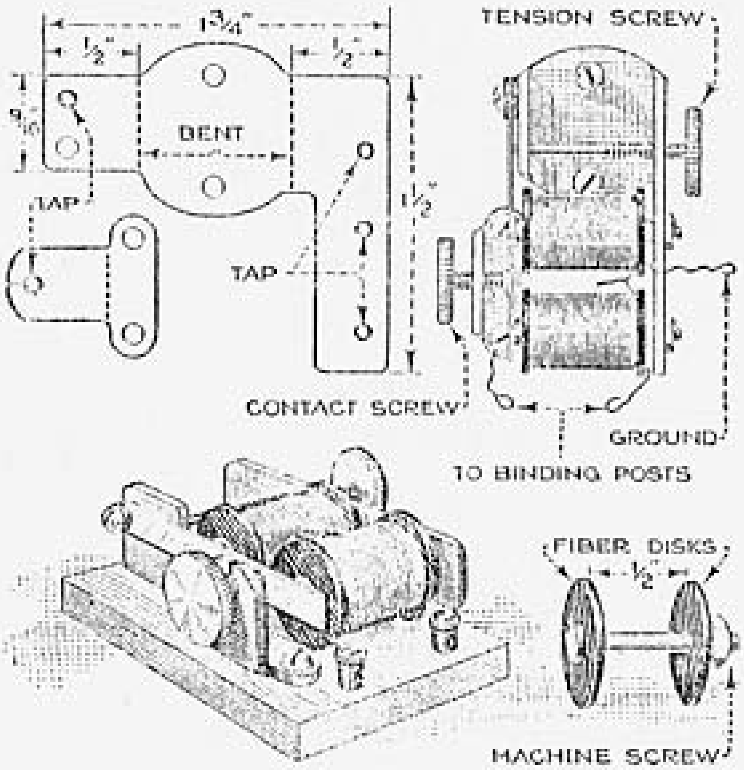
The Cage-Type Aerial is Highly Recommended to Amateurs, as It Is the Most Efficient Type for Stations Operating on a 200-Meter Wave Length

increased range of radiation on 200 meters. A good ground system is required, and good results cannot be obtained without giving as much attention to the grounding as to any other detail of the transmitting equipment. Either a suspended counterpoise or buried ground should be used, the latter being formed by burying 60-ft. lengths of No. 14 bare copper wire in the ground, the wires being laid to radiate fanwise under the aerial. This size bare copper wire is also used in the construction of the cage aerial, and a long insulator is used at each end of the cage; the spreaders or hoops are made of heavy wire, or discarded bicycle rims, which are light and strong, can be used, the separate wires forming the cage being secured to the hoops by several turns of wire, and then soldered. The ends of the wires are brought together, carefully soldered, and fastened securely to the insulators. The lead-in wires are soldered to the cage wires, and too much emphasis can hardly be placed on the necessity of careful soldering, as loose joints greatly reduce efficiency. All guy wires should be "broken up" with small insulators. The masts that support the aerial should both be of the same length so that each end of the aerial will be the same distance from the ground.

THE BOY MECHANIC – 1925

A-High-Tone Radio Buzzer

A buzzer with a clear, high-pitched tone is very desirable for radio-testing purposes, but, while it can be bought,



Operated by a Flat-Type Flashlight Battery, This Miniature Buzzer Produces the High-Pitched Tone So Desirable for Radio-Testing Purposes

such instruments are usually large, and cannot be used with a flashlight battery without exhausting it quickly. The home-made buzzer illustrated, however, is very small, and is particularly designed for flashlight-battery service.

The magnets are wound around cores made from 6-32 iron machine screws, 3/4 in. long, the hexagon heads of which are filed round. The spool ends are made from fiber disks, 7/16 in. in diameter, and holes are drilled through them to make a tight fit on the screws. A space, 1/2 in. long, is left between the disks for the winding, which is of No. 32 insulated wire; No. 30 wire, which is a trifle larger, can also be used, if necessary. Wind the space between the disks full, and, when finished, bring the ends out through small holes drilled in the disks, as shown. Then solder together the ends of the wires that begin the winding. One of the outside wires is grounded to the metal frame, and the other is connected to a binding post.

A piece of fairly stiff spring steel is used for the vibrator, which is mounted on the frame with a screw and two small washers. The tension screw merely presses against the vibrator. Contact points from spark coils, either new ones or old, which can be obtained for the asking at almost any garage, are soldered to the vibrator and the contact screw.

A piece of thick sheet brass or iron is cut to the pattern shown; then the necessary holes are drilled and tapped as indicated, a 8/32-in. tap being used for the threads. The screw holes at the center of the frame can be made to any convenient size; these holes are for the screws that fasten the instrument to its base. The bracket for holding the contact screw is made from a separate piece and mounted independently. After the hole for the contact screw has been drilled and tapped, a slot is cut through the bracket, and the ends squeezed together a little, to make a tight fit on the screw and prevent it from working loose. After all holes have been drilled and tapped, the frame is bent up as indicated by the dotted lines. Two binding posts are used for connecting the wires to the coils and contact-screw bracket.—Harry L. Gray, Independence, Ia.

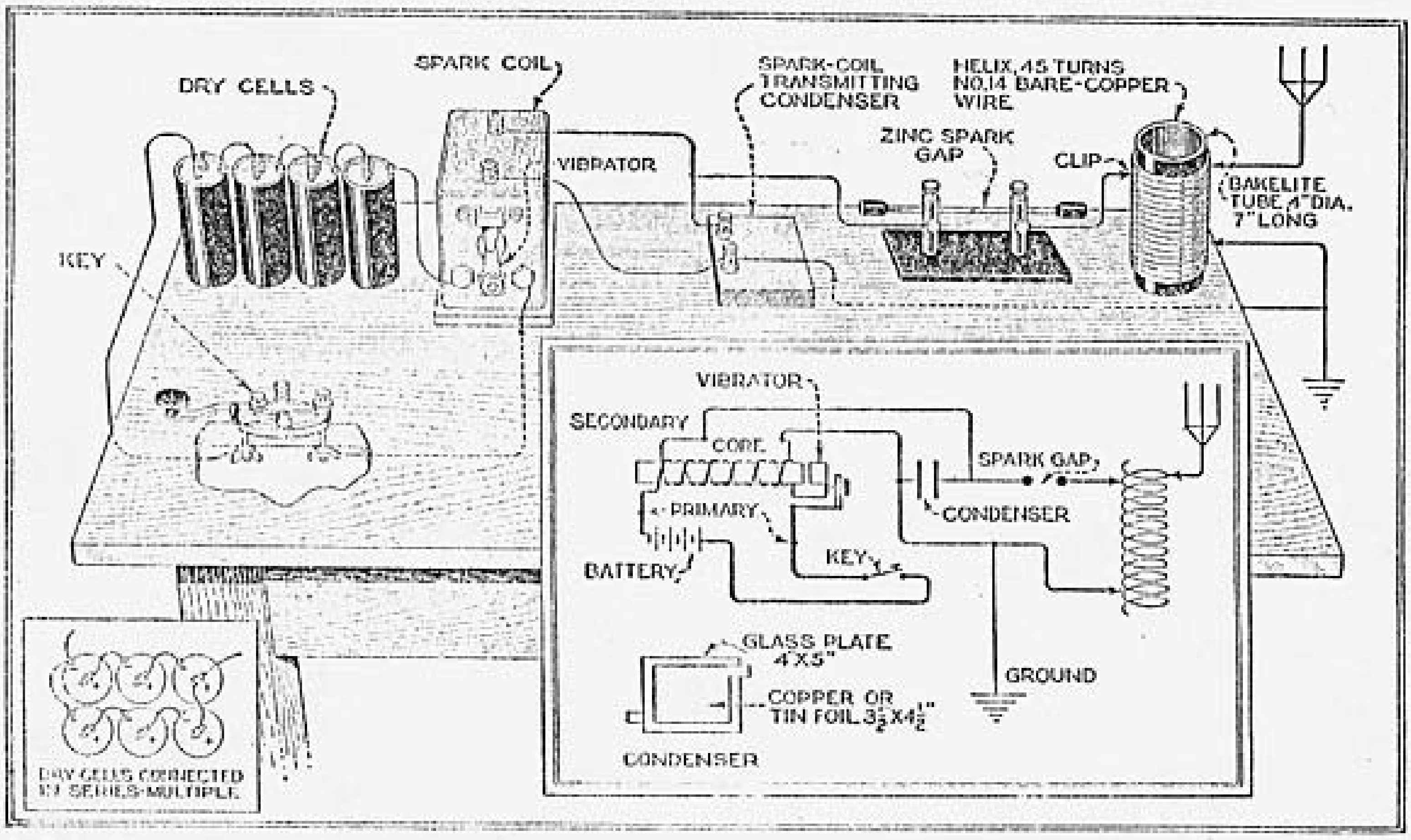
THE BOY MECHANIC – 1925

A Simple Radio-Transmitting Set

By F. L. BRITTIN

A SIMPLE spark-coil radio-transmitting set can be used where messages are to be sent over a short distance. The complete outfit can be put into a small suitcase, and is well adapted to the needs of outers in motor cars or boats, and for boy-scout field work.

The necessary instruments composing the set are the following: a high-tension jump-spark coil, of which different sizes can be purchased, good results having been obtained for distances up to 16 miles with the ignition coil from a standard light automobile; a key, an ordinary telegraph key answering the purpose, and a spark gap, which may be made from two zinc-battery electrodes mounted in two upright fiber posts. A condenser and helix will also be needed; the condenser stores up the energy, which is then discharged across the spark gap, and pro-



A Very Simple Transmitting Set for the Radio Amateur: It can be Packed into a Suitcase, Making It Suitable for Boy Scouts or Similar Organizations. All the Instruments may be Made at Home, if Desired, Making This a Very Cheap Set, and One Well Adapted to the Needs of the Beginner

duces the oscillations that are thrown into space from the antenna in the form of waves.

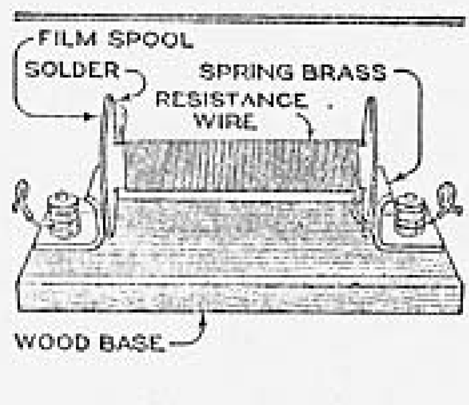
The condenser can be made from a number of glass plates with sheets of tinfoil between them. Old 4 by 5-in. or 5 by 7-in photographic negatives, from which the emulsion has been removed, will answer the purpose; the tinfoil sheets are cut ½ in. smaller than the plates, and a tab, or ear, is left projecting for connecting the lead wires to each sheet. In assembling the condenser, the tinfoil sheets are placed between the glass plates so that the tabs of alternate pieces will project from opposite sides. The condenser unit may consist of five sheets of foil and six glass plates. After assembling, bind the unit together and place in a cigar box, filling the surrounding space with melted insulating compound, or paraffin, to make a compact article for a portable set. If the transmitter is to be stationary, the condenser may be supported on wooden blocks in a pan, into which enough insulating or transformer oil to cover the unit is poured. Any desired capacity can be obtained by adding the proper number of condensers.

The helix consists of 45 turns of No. 14 bare-copper wire, which is wound around a grooved bakelite tube, 4 in. in diameter and 7 in. long. Spring clips are soldered to the wires from the aerial, ground, and spark gap, as shown in the diagram. Four dry cells give good results for short-distance work. When these are used, they may be connected in series, as shown in the upper part of the drawing; another method of connecting them is in series-multiple, as shown in the insert. This distributes the load, and makes the battery last longer.

THE BOY MECHANIC – 1925

Resistance Units from Film Spools

Fine resistance units for the use of electrical experimenters can be made from old film spools. The spools can be had from any photographer for the asking, and it is on these that the resistance wire is wound,

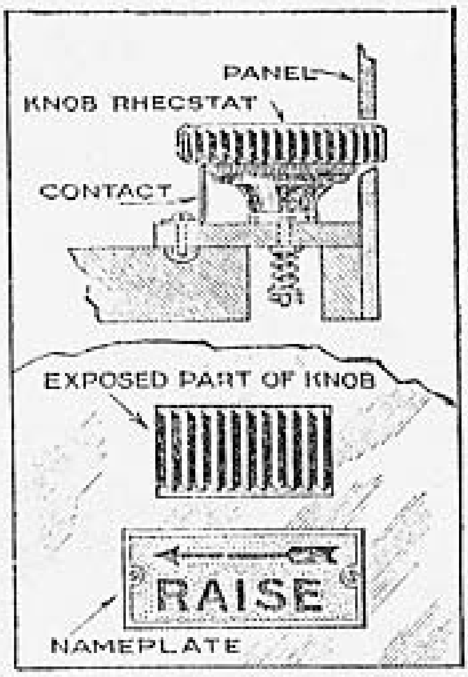


 GRANDDAD'S ELCTRICITY BOOK

the ends being soldered to the metal flanges of the spool. A holder, such as the one shown in the drawing, is used, and consequently all the resistance spools must be the same length. By winding a number of spools with a varying number of turns of resistance wire, and marking the known resistance on them, it is a very simple matter to substitute one spool for another by inserting it between the clips, in the same manner as a cartridge fuse. The ends of the spools bearing against the clips are polished bright, to provide a good contact, and the clips should press tightly against them.

Novel Radio-Rheostat Mounting

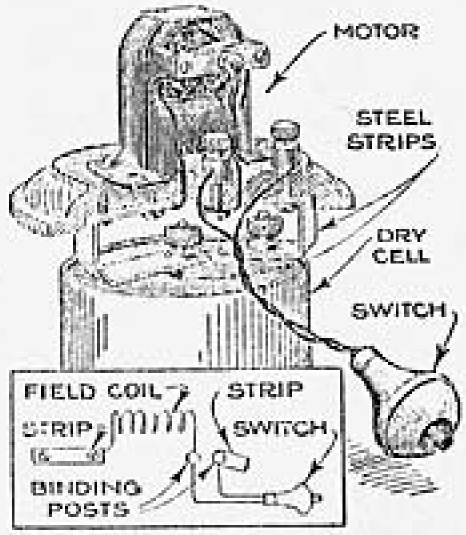
When making a radio set that was intended to be as compact as possible, it was discovered that it was out of the question to mount the panel-type rheostat in the usual manner. The difficulty was overcome by using a rheostat in which the resistance wire is molded into the knob and mounting it horizontally instead of vertically. A slot was cut in the panel, through which the rheostat knob projected about $\frac{1}{16}$ in. Thus the knob could easily be revolved with the thumb or forefinger to any desired adjustment.



THE BOY MECHANIC – 1925

Simple Mounting for Small Motor

When using a small electric-battery motor for different experiments in the amateur's laboratory, it is generally found that the units, when connected in the usual manner, are awkward to move



about. To combine the two, the motor is mounted on the top of the dry cell by means of two steel, brass, or copper strips, attached to the underside of the motor base, bent as shown, and clamped to the binding posts of the battery. A switch of the type illustrated, or of any other type desired, is connected to the binding posts on the base of the motor, so that the latter can be started and stopped as desired.—W. A. Saul, Cambridge, Mass.

THE BOY MECHANIC – 1925

A Small Electrically Heated Steam Boiler

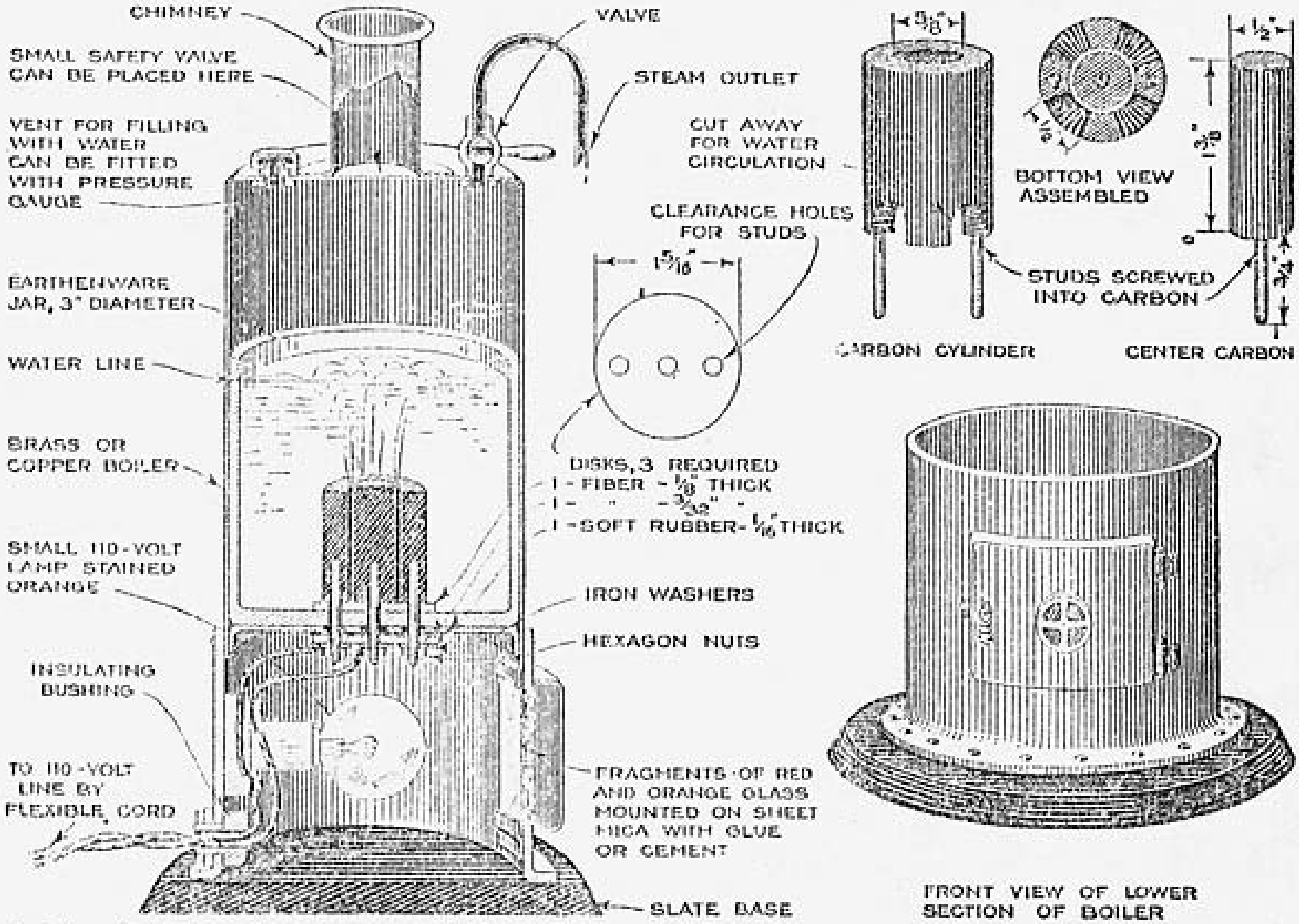
By A. N. Capron

A GREAT many amateur mechanics have frequent need of some apparatus that will supply steam under light pressure for the operation of model engines, turbines, and such incidental work as opening storage batteries; and it is for just such purposes that the electrically heated boiler shown in the drawing was designed.

First, an earthenware bottle, or jug, of the size required is obtained; this is cut off about $3\frac{1}{2}$ in. from the base, the operation being easiest performed on an emery grinder. Two pieces of hard carbon are required, which are drilled and formed to the dimensions shown in the drawing, the bottom of the larger piece being cut away, as indicated, to permit free circulation of water around and through the heating element. Both carbon pieces are drilled to take brass studs which may be made by threading short lengths of $\frac{5}{32}$-in. brass rod; these are screwed into the holes drilled for them, or they may be held by means of small metal pins.

The carbon heating elements are to be

 GRANDDAD'S ELCTRICITY BOOK



An Electrically Heated Steam Generator for the Amateur Mechanic's Laboratory Which will Supply Sufficient Steam for the Operation of Experimental Engines, without Fire Danger

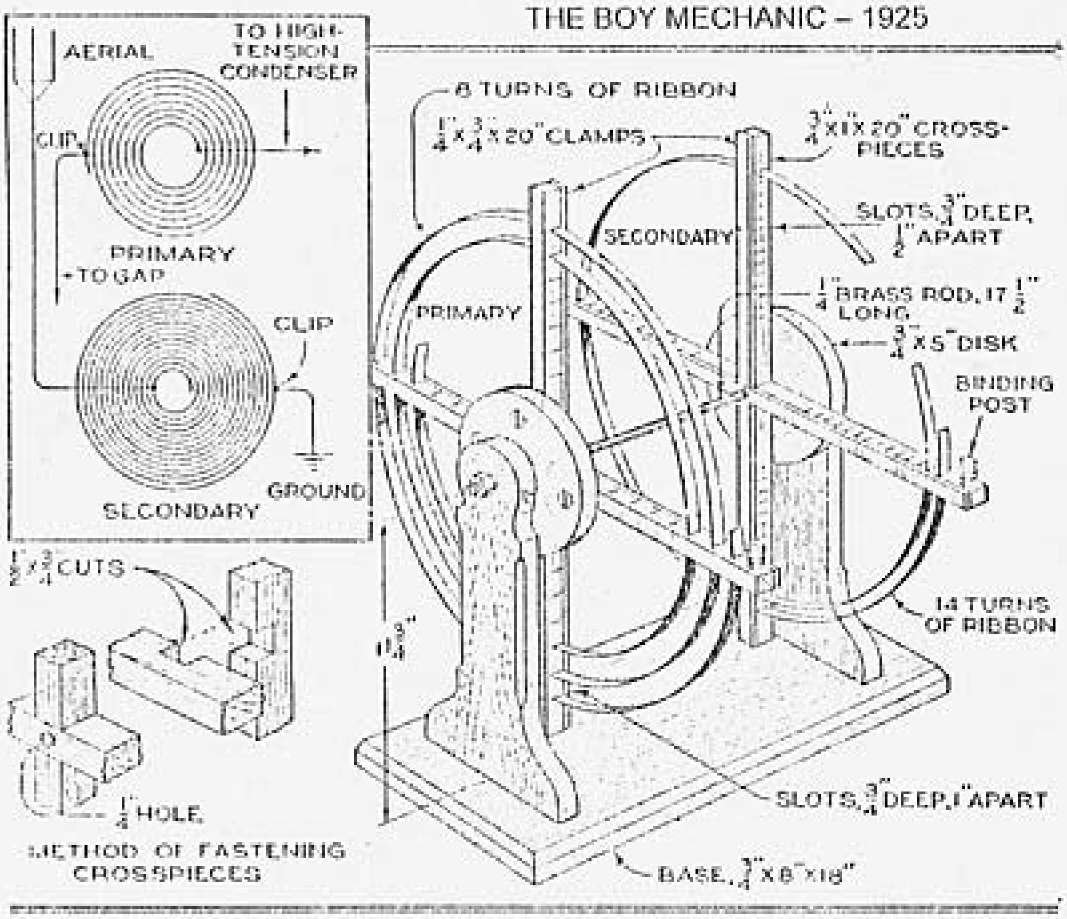
assembled together in the bottom of the earthenware cup so that there is 1/16 in. between them, and holes to accommodate the studs must be drilled through the bottom. This is accomplished by first chipping off the glaze and drilling the holes with a twist drill kept moistened with turpentine. The holes having been drilled, a boiler is made from sheet brass, copper, or iron to correspond with the dimensions of the earthenware jar, as shown in the drawing, with a horizontal support for the jar to rest upon.

This latter piece, which forms the top of the fire box, is drilled to give ample clearance for the studs and should be free from contact with them, as indicated. To prevent any possibility of the water or steam working its way between the earthenware jar and the boiler shell and out at the bottom, the seam should be silver-soldered, after the shell has been riveted in place, although brazing would be better. The heating element is then placed in position and insulated from the metal boiler with fiber disks, as indicated, a similar disk of soft rubber being used to prevent escape of steam or water. The top of the boiler is equipped with a steam valve, and the other necessary fittings, including a vent for filling the boiler, are brazed or riveted to the boiler shell. It will be impossible to rivet this piece in place unless it is concaved or "dished," with a flange around the edge for the rivets. To simulate the appearance of fire underneath the boiler a colored miniature lamp may be mounted in the fire box as indicated, or by placing the light behind a fire door that has openings covered with red and orange glass.

The efficiency of such a boiler is quite high; the water enters through the four open spaces in the bottom of the outer carbon and is heated as it ascends through the annular opening of the heating element. The water is heated to the boiling point by its own resistance to the passage of current through it. The fire danger that attends the usual alcohol lamp is eliminated, and if the boiler goes dry, the current is automatically shut off.

An Oscillation Transformer

The oscillation transformer is an important part of an efficient radio-transmitting set, and there are many types on the market; the best kind, for all practical purposes, however, is the so-called "pancake" type. This transformer is simple to make and inexpensive. The advantages of this type of transformer over the helix type are many, as it permits either direct or inductive coupling, insures a pure and sustained wave that can be sharply tuned at the receiving station, and cuts out interference. All parts of the winding are accessible to the clips, the primary and secondary slide along a horizontal brass rod that makes quick changes in coupling possible, and the full energy of the transmitter can be utilized without undue heating at the gap, as experienced with the old-style helix. The pancake transformer has made possible some remarkable records in amateur stations and nearly all of the record holders use it.



A Simple and Easily Made Oscillation Transformer, of the So-Called "Pancake" Type: All Material, with the Exception of the Ribbon, can be Picked Up around the Radio Laboratory

The woodwork may be any variety of wood, stained and finished to the satisfaction of the maker; poplar or birch will be found easy to work, and will take a mahogany finish well. The base and uprights are cut to the dimensions given, and assembled with 1¾-in. wood screws, driven through the bottom of the base. The brass rod is threaded and provided with a washer and nut at each end. Two wooden disks are screwed to the back of both primary and secondary crosspieces with 1-in. screws, and the crosspieces are slotted to take the required number of turns of ribbon. This ribbon may be of either copper or brass, about 1/16 in. thick by 3/4 in. wide; it may be made up from a number of short pieces soldered together, or bought in one length, from any dealer in radio supplies. Clamps, in the form of light wooden strips, for holding the turns in place are fastened over the slots, so that there is no possibility of the ribbon working out of position. A binding post may be used at each outside ribbon terminal if desired, the lead wires to the condenser and aerial being soldered to standard helix clips, or clips can be used at all points. The clips from an old knife switch make ideal contacts.—F. L. Brittin, Chicago, Ill.

THE BOY MECHANIC – 1925

Using Auto Battery as B-Battery

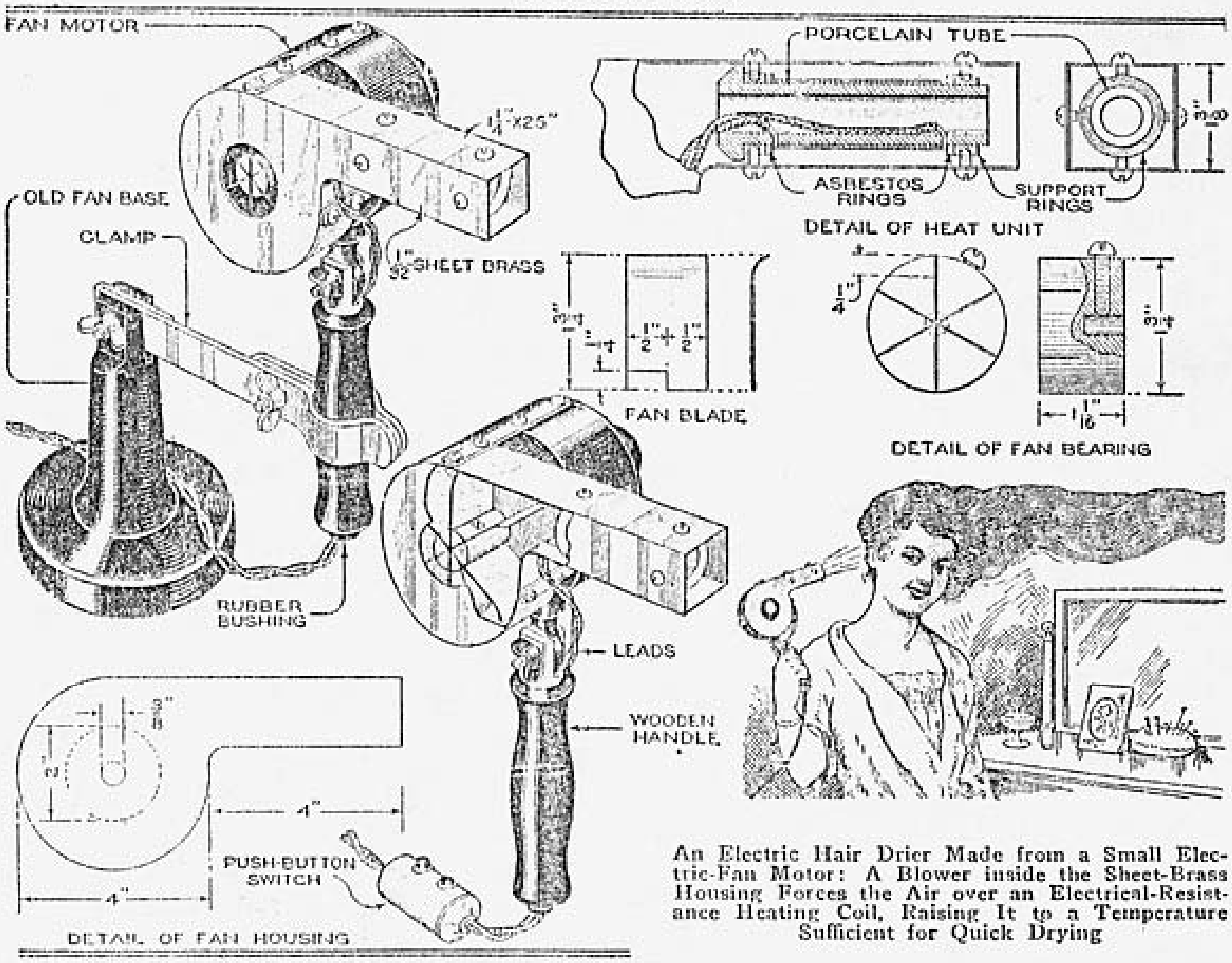
Knowing the inefficiency and weakness of the ordinary radio B-battery, and that the performance of the radio set depends largely upon this battery, an operator devised a method for tapping the 12-volt storage batteries of a truck and car that are housed in a near-by garage. Two sets of wires are run from the radio set to the garage, each set terminating, at the garage end, in a plug that will fit in the dash-lamp socket on the car and truck. The house ends of the wires are connected to the set in place of the B-battery. When the two motors are brought in in the evening, the dash bulbs are removed and the wires plugged in. This arrangement gives a 24-volt B-battery of great power. A rheostat is used to step down the voltage to that found to be the most efficient for the particular type of vacuum tube used. The amount of current drawn from the storage batteries is, of course, restored the next day, when the motors are running.—Philip A. Wall, Bedford, Massachusetts.

one end to accommodate the six brass blades. The blades are soldered into the slots, and, although supported for only half their width, as shown, are sufficiently rigid to stand without additional support. The combination blower and heater is held to the electric motor by strips screwed to the blower and to the motor shell.

To make the heating unit, obtain a

How to Make an Electric Hair Drier

By A. H. Scott



An Electric Hair Drier Made from a Small Electric-Fan Motor: A Blower inside the Sheet-Brass Housing Forces the Air over an Electrical-Resistance Heating Coil, Raising It to a Temperature Sufficient for Quick Drying

THE only parts of the electric hair drier illustrated that require to be made, are the blower and heating unit over which the air is driven to raise it to a temperature high enough for speedy drying.

Two pieces of sheet brass, as illustrated, will be required for the sides of the fan housing, as well as a strip of the same material to form the top and bottom. The fan hub, or bearing, is made from a piece of round brass or iron, slotted across

porcelain insulating tube such as used in ordinary house wiring, with an outside diameter of 1 in. This tube is cut off 3½ in. from the shoulder end, and used as a core for 32 turns of .025-in. German-silver resistance wire. Wind the wire tightly so that there will be a space of 1/32 to 1/16 in. between turns, to prevent short-circuiting. The ends of the first and last turns should be passed through 1/8-in. holes drilled through the tube.

When drilling the tube, it should be plugged with wood and held in a vise, the jaws of which are protected with wood; an ordinary twist drill is used. The leads connecting the heating unit to the circuit must be asbestos-covered.

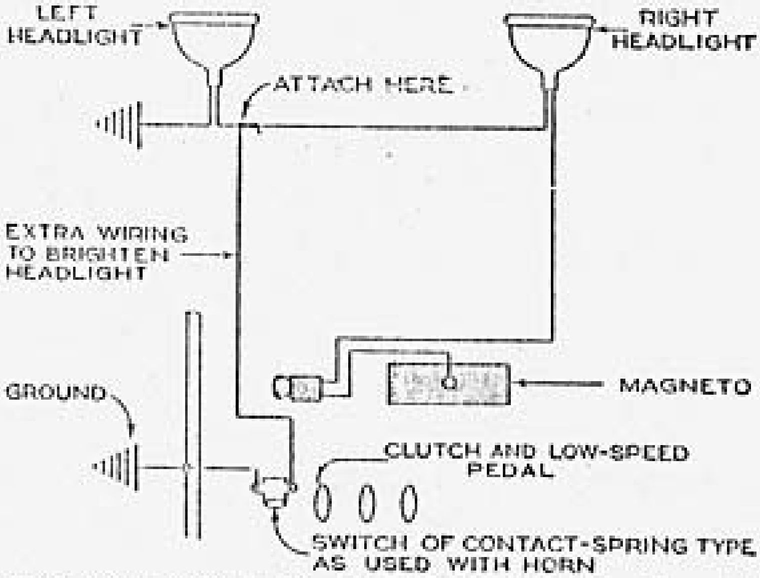
The heating unit should be centered out of contact with the blower housing. This is done with two brass rings, one at each end of the tube, cut from 1-in. brass pipe. These rings should fit snugly over the ends of the porcelain tube and be insulated from the winding by asbestos washers. The rings are tapped at opposite sides to receive four machine screws.

When assembling the blower, care should be taken to avoid projecting screws that would catch the blades. The finished drier can be provided with a wooden handle, and this can be clamped to an iron base in the manner illustrated, so that it can be used either in the hand or upon a table.

THE BOY MECHANIC – 1925

Switch to Brighten Auto Headlights

On a light automobile where the headlights are supplied with current generated by the magneto, the lamps usually burn



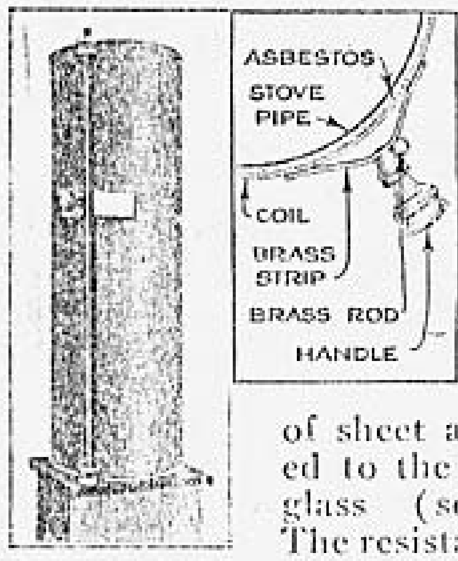
With This Wiring, One Headlight of a Light Car will Burn Brightly While the Car Runs at Slow Speeds

brightly when the car is running in high gear at slow speeds. For country driving, or wherever a bright light is desired with the car traveling at moderately slow speed, a simple arrangement for lighting one headlight brilliantly may be made by placing a push button, such as used for the horn, on the left side of the clutch pedal, running one wire from the button to a ground on the car frame, and another to the light, as shown in the diagram. When this button is pressed, the current flows only through the right lamp, causing it to burn brightly. The position of the button requires the use of the left foot to depress it, and consequently the car cannot be placed in low gear and the motor raced without releasing the pressure on the button, as otherwise the heavy current would burn out the bulbs.—G. A. Luers, Washington, D. C.

THE BOY MECHANIC – 1925

A Simple Electrical-Resistance Coil

A cheap resistance coil for arc lamps can easily be made by any amateur electrician from a length of stovepipe, suitably insulated and wound with resistance wire.

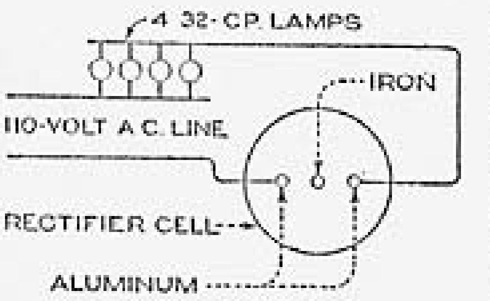


An 18-in. length of 5½-in. stovepipe is the foundation for the coil, and this is covered with a piece of sheet asbestos, cemented to the pipe with water glass (sodium silicate). The resistance is composed of about 125 turns of 1/16-in. iron wire, the turns being spaced about 3/32 in. apart. A brass rod, held at its ends in porcelain insulators, is spaced about 3/8 in. away from the winding. The insulators are secured to the opposite ends of the stovepipe by wire loops. The upper end of the rod is connected to one side of the arc-lamp circuit, and the upper end of the resistance winding connected to a binding post. A strip of stiff sheet brass, about ½ by 1 by 3 in., is bent to the form indicated, provided with an insulated knob, and pushed under the brass rod and against the coils. The resistance of the circuit is controlled by moving the brass slide up or down. About 250 ft. of wire will be required for the winding, and, when completed, the resistance can be mounted on a piece of asbestos, fiber, or plaster board.—Frank B. Howe, Los Angeles, Calif.

THE BOY MECHANIC – 1925

"Forming" Electrolytic Rectifier Plates

The operation of an electrolytic rectifier depends upon the formation of an insulating film on the aluminum plates when the current flows from the electrolyte to the plate, thus opening the circuit. A current from the plate to the solution will dissipate this film and permit the current to pass. It is necessary that the plates be "formed" before the rectifier is permanently connected in the circuit. The electrolytic rectifier, described on page 459 of the March, 1920, number, has the plates connected to the line, hence excessive current will flow until the plates are formed. The formation may be brought about by the heavy current in due course, but the preferred method is to connect the device as shown in the diagram.



The cell is left connected, as shown, until the lamps go out, indicating that the film is formed and the circuit is open. The length of time required for this formation varies greatly, depending upon the grade of aluminum used. Some plates will form at practically the first surge of current, others take an hour or more; the formation can be hastened by scratching the surface of the plates with a wire brush.

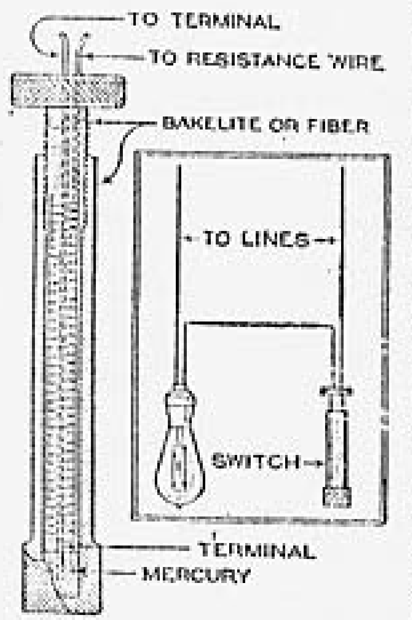
When in use, the device will pull a little over four amperes, and the more perfect the plate formation, the closer the current will be to this figure. After the plates have been formed, the rectifier is connected in the circuit according to the diagram shown in the previous article.

Owing to the fact that alloys of aluminum are sometimes sold as pure aluminum, a set of plates may not function properly. Should this happen, and the plates not form within an hour, it is advisable to try another electrolyte. A common one consists of a saturated solution of ammonium phosphate, to which is added a few drops of acid to reduce the resistance. The plates should also be formed in this solution. There is no question of the rectifier working properly once the plates are formed.

THE BOY MECHANIC – 1925

A Simple Dimming Switch

The drawing shows a very sensitive and simple dimming switch for use with an electric incandescent lamp, in locations where a dim light must be kept burning constantly. A hard-fiber, or bakelite, rod is turned down, as shown, to form a plunger, leaving enough of the original diameter to form a head, which is then knurled. A portion of the length of this rod, at the upper end, is threaded to fit the tapped hole in the mercury container. The latter consists of another piece of rod which is bored and tapped, the diameter of the hole below the thread being slightly larger than the plunger. The plunger is drilled, along the vertical axis, with a 1/16-in. drill, a copper wire being run through the hole, and projecting through the bottom of the plunger.



Resistance wire is then wound around the outside of the plunger, being firmly fastened at the bottom and led in at the top through another 1/16-in. hole paralleling the center one. At the bottom of the container, a small quantity of mercury is placed; as the container is screwed upward, the mercury rises in the annular space between plunger and container, so that the current flows through less of the resistance wire, thus increasing the current strength until full light is obtained. Screwing the container downward, of course, reverses this process. This type of switch has been successfully used on small motors and baking ovens, in addition to lamps.—W. Burr Bennett, Honesdale, Pennsylvania.

THE BOY MECHANIC – 1925

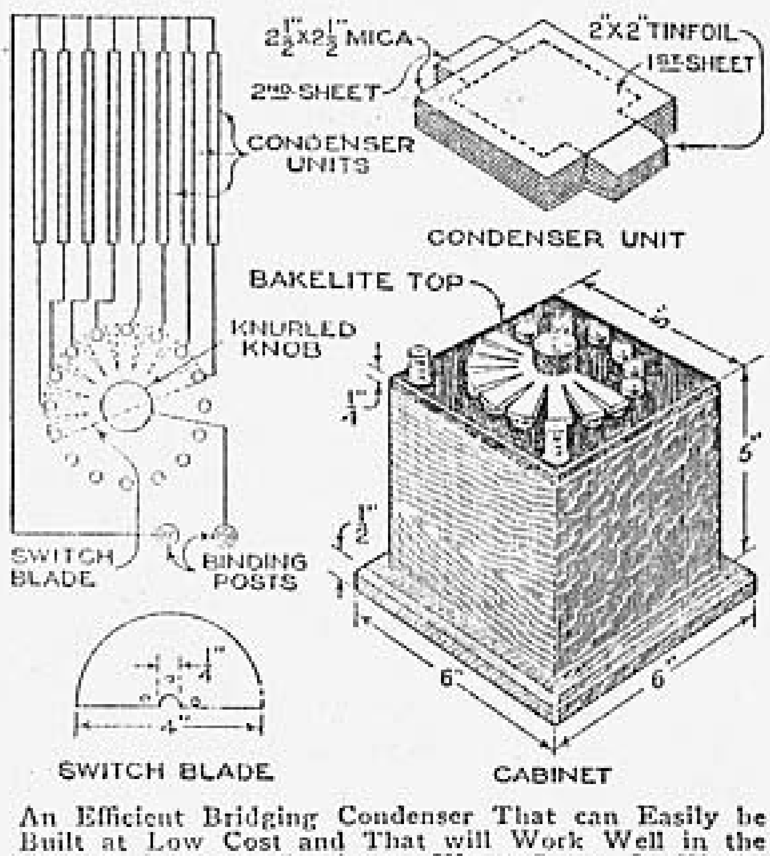
How to Build an Adjustable Bridging Condenser

An adjustable bridging condenser for wireless work, that will serve as well as the high-priced manufactured articles on the market, can be built easily and economically. It will work in the ground lead in C. W. transmission sets, but when used for this purpose, the mica should be of the best quality, and all units, when clamped together, should be tested out with 500 volts of direct current before installation. This condenser works nicely in receiving sets, and can be made in various capacities, which are cut into and out of the circuit by the fan switch.

The eight condenser units are made up of 2-in. squares of tinfoil, clamped between 2½-in. square mica sheets. Make one unit with five sheets of foil and the remaining seven with three sheets of foil each. The foil sheets are cut out with a tab at one edge which projects beyond the mica plates.

In assembling the first unit, a mica sheet is laid on the table, a tinfoil sheet placed on it with the tab projecting to the right, another mica sheet placed on top, and the next tinfoil sheet placed with the tab pointing to the left, and so on until the five sheets of foil and six sheets of mica are assembled. The remaining units are assembled in the same manner, the tabs of the alternate sheets being brought out at opposite sides.

After assembling each unit, bind it with electrician's tape, or bolt the whole number of units together between metal plates and impregnate with paraffin. The foil tabs are all brought together at the



An Efficient Bridging Condenser That can Easily be Built at Low Cost and That will Work Well in the Ground Lead of Continuous-Wave Sets: It Works Nicely in Receiving Sets and can be Made in Various Capacities

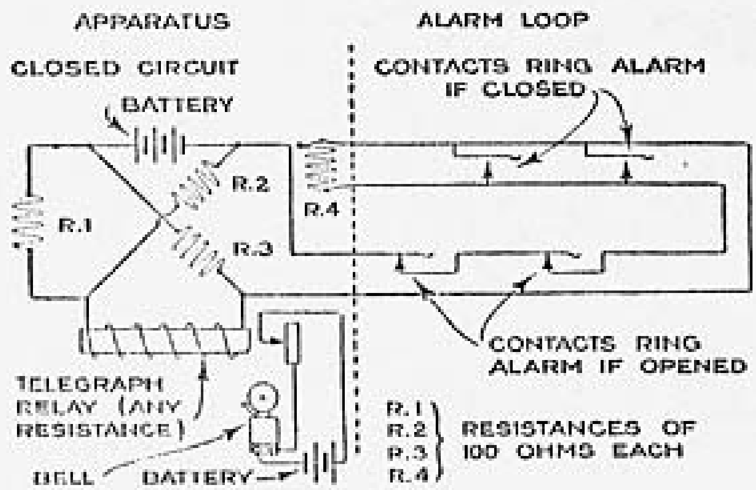
ends and a lead wire soldered to each, the whole being bridged at the back, as shown, and the leads brought out to contacts in the bakelite top of the cabinet; 16 points are used, eight of these are idle or dead taps, and merely serve to carry the switch blade smoothly. The switch blade is formed from sheet aluminum and screwed to the underside of the switch knob. If sheet aluminum is not to be had, use one of the fixed plates of an ordinary variable condenser, and saw out the radial teeth, as shown. The five-sheet unit is connected to the first point, shown at the left in the wiring diagram.

The cabinet is made from ¼-in. stock to the dimensions given, and the lead wires are brought to binding posts in the top. The cabinet should be finished to correspond to the finish of the other instruments. This condenser can also be back-mounted on the panel, instead of making it into a separate unit, if so desired.—F. L. Brittin, Chicago, Ill.

THE BOY MECHANIC – 1925

Burglar-Alarm Circuit

The burglar-alarm circuit shown in the drawing cannot be put out of order without giving an alarm. The only special



A Burglar-Alarm Circuit That cannot be Tampered With without Giving an Alarm; Short-Circuited or Broken Wires Cause the Bell to Ring

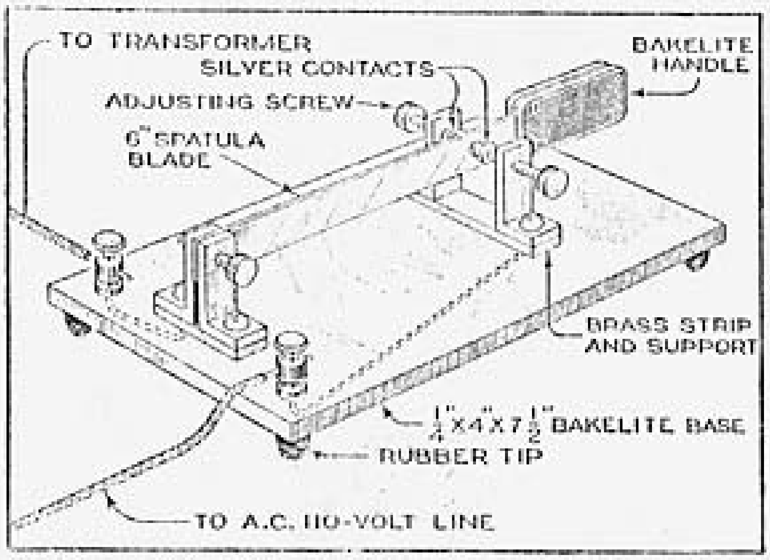
apparatus required are a relay, which may be of most any type, four coils of equal resistance, and the closed-circuit battery.

With the alarm circuit completely connected as shown, the relay will remain inoperative because both sides of the battery, positive and negative, are connected to each end of the relay winding through equal amounts of resistance. The relay is in a neutral position with respect to the battery and receives no current. Now, should the side of the bridge forming the alarm loop become unbalanced, short-circuited, or broken, the current would flow through the relay winding, causing it to operate and ring the bell, or other alarm device.—C. M. Crouch, Minneapolis, Minn.

THE BOY MECHANIC – 1925

How to Make a High-Speed Key

The "bug" or vibrating key has become quite popular with radio amateurs, and can no longer be considered the exclusive



A Vibrator-Type Transmitting Key for the Amateur Radio Operator, Which is Built Up from Easily Obtainable Parts, Makes It Possible to Develop Great Sending Speed

property of the commercial or professional operator. This type of key was first used by wire-telegraph operators to attain great speed, and, as it is easy to build and easy to operate, it is really a great improvement over the old-fashioned type of key. The movement of the key is from side to side instead of up and down, and with a little practice amazing speed in sending can be acquired. However, the operator should exercise some judgment, and not use so great a speed that he cannot transmit correctly.

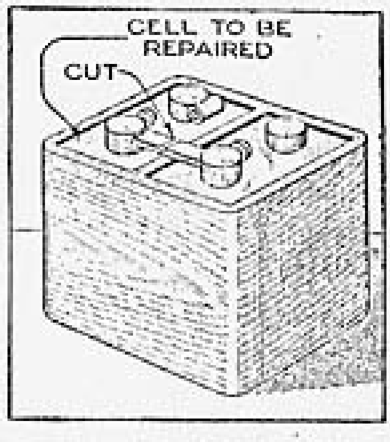
The base, which is made of ¼-in. bakelite, is supported on rubber feet to permit the wires to be run on the underside, as shown by the dotted lines on the drawing. The vibrator, or blade, can be made from any of various materials, such as a thin, flexible nail file, hacksaw blades, and the like, although an artist's spatula, as shown in the drawing, makes an ideal blade. The original handle of the spatula is removed, and two strips of bakelite are cut to form an insulating handle, which is held together by small machine screws, so placed as not to come into contact with the blade. A ⅛-in. hole is drilled near the other end of the blade, which is supported between brackets of the type shown; these are formed from ⅛-in. sheet brass, and the blade is securely fastened between them by a screw. Machine screws are used for attaching the brackets to the base. The front brackets, near the handle, are made of the same material and to the same dimensions as those holding the blade at the rear. These brackets are mounted on a brass strip, and each is provided with a knurled-head screw, as indicated. Coin-silver contacts are soldered to the tips of these screws and to the blade, at the points where it makes contact with the screws.

Adjustments are easily made when the blade is in position, by merely turning the thumbscrews. When the key assembly is completed, one wire is led from the base of the contact-point brackets to one of the binding posts, and another is led from the supporting brackets at the end of the blade to the second binding post. Owing to the fact that the steel blade always tends to straighten itself no switch is needed, because, if the contact points are adjusted to a uniform distance from the blade, it will not come into contact with them when not in use. After the wiring is completed, and the terminals soldered, the key is ready to be connected in series with the supply line leading to the transformer.—F. L. Brittin, Chicago, Ill.

THE BOY MECHANIC – 1925

Repairing Storage Batteries

Storage batteries may be repaired without the trouble of removing the jars from the case, and without melting the crossbars in order to remove a set of plates. A diagonal cut is sawed in the connecting bar, as shown, and the plates of the defective cell are lifted out after the sealing compound has been sufficiently softened. After the plates have been repaired or the separators renewed, the crossbar is carefully soldered

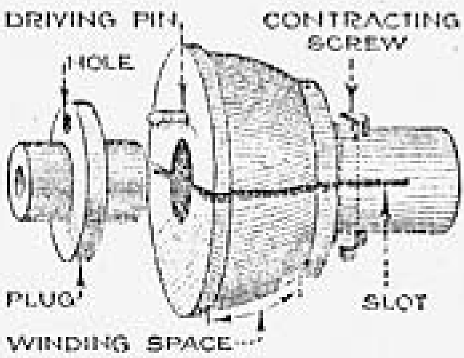


together. To facilitate soldering, the ends are pried up slightly and a piece of wood, or a piece of an old separator, is slid under the cut, which is then cleaned, fluxed, bent back into place, and soldered.

THE BOY MECHANIC – 1925

Variometer-Winding Form

Amateurs who wish to build their own radio instruments will find the stator-coil winding form illustrated a great convenience. The larger piece is the form proper; it is made of hardwood, the radius of the section on which the wire is wound being the same as the radius of the winding seat in the stator half, less twice the over-all thickness of the wire used. A cylindrical section, a few inches long, is turned on the smaller side of the form, and the face on the larger side is recessed to take the plug shown. This plug may be of hardwood or metal, as preferred; it is drilled to fit a driving pin driven into the form, and is centered, as is the opposite end of the form, to permit winding between lathe or other centers. The form is slotted, as shown, for a portion of its length, and fitted with a screw and nut. When the form has been wound, and the stator half coated with adhesive, the form is dropped into place and weighted or clamped until the cement is dry. Then the contracting screw is tightened, and the form can be removed very easily.—H. F. Lowe, Washington, District of Columbia.

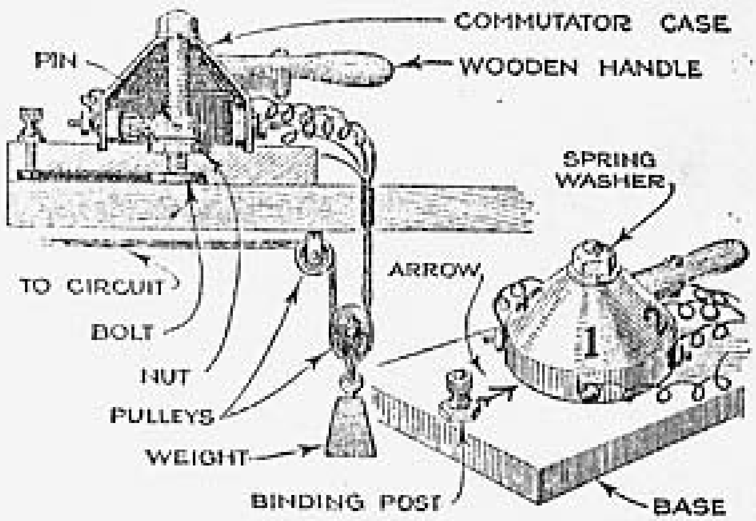


THE BOY MECHANIC – 1925

Four-Way Switch Made from Old Automobile Timer

For low-voltage circuits, where there are not more than four different lines over which the current is to be distributed, an old timer from a light automobile can easily be converted into a four-way switch.

Make a base of some insulating material, about 8 in. square and 1 in. thick, and drill a hole through the center as large as the end of the shaft over which the timer roller fits. Counterbore this hole large enough to take a bolt head, and cut a similar depression in the top of the base; both should be concentric with the hole. Get a bolt over which the timer roller will just slip, and ½ in. longer than the distance between the bottom of the base and the top of the timer shell when the latter is set on the base. Cut the threads the entire length of the bolt, file the head down to a thickness of about ¼ in., and drill a small hole 1½ in. from the head. Push this bolt through the



Four Electrical Circuits Controlled from One Switch: The Switch is Made from a Timer Taken from a Light Automobile

hole from the bottom of the base, and run on a locknut to hold it securely in position. Then put on the roller, and pin it to the bolt through the small hole. Be sure the roller points exactly toward one side of the base, and then lock the bolt in that position. Connect the bolt head to a large binding post in the base, just forward of the roller; this is the ground-wire post. Paint an arrow pointing from this post toward the center. Drill a hole, to fit the bolt, through the shell, place it in position, and run a pencil around it to mark its outline on the base. Scribe a second circle inside the first, ⅛ in. away from it. A circular groove, ⅛ in. deep, is cut out to serve as a track for the edge of the shell. Cut a wooden handle to fit over the timer-rod arm, and bolt it in position. Paint numerals on the shell in the order shown, opposite the terminals. Finally, slip the shell over the bolt, put on a spring washer, and run on the nut, turning the latter down just enough to hold the shell in the track and allow it to be turned around easily with the handle.

Fasten the base to the table, or bench, and drill a hole in it, one on each side of the base.

Connect flexible cords to the timer terminals, allowing plenty of slack, and run them through the holes, where they are looped over the weighted pulley shown. Each cord is then fastened to the underside of the bench. Set a knife switch in the ground line beyond the base.

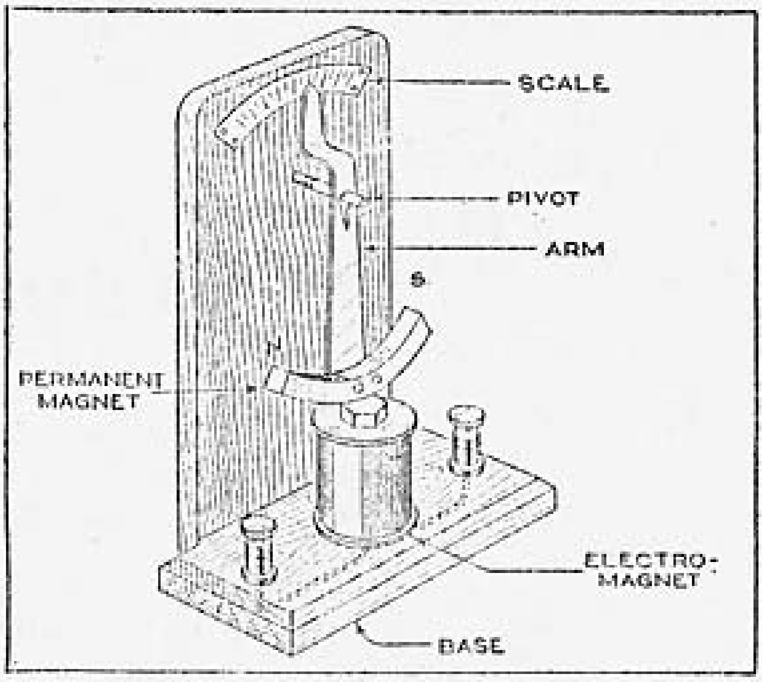
To operate, open the ground switch, swing the number of the circuit desired around toward the arrow, throw in the switch again, and only that circuit will be in operation.—L. B. Robbins, Harwich, Massachusetts.

THE BOY MECHANIC – 1925

How to Make a Simple Ammeter

Sometimes, for experimental purposes or in order to get a rough idea of comparative amounts of current flowing through a circuit, a simple ammeter is necessary; where a regular ammeter is not available, the one shown in the drawing will answer all requirements.

It is based on the well-known physical



A Homemade Ammeter by Means of Which the Electrical Experimenter Is Able to Make Reasonably Accurate Readings of the Amount of Current Flowing through a Circuit

principle that an electromagnet will attract either the north or south pole of a permanent magnet, according to the direction in which the current is flowing through the electromagnet.

Make a suitable wooden base and attach to one edge an upright board, about 6 by 10 in. In the center of the base, and close to the vertical piece at the back, place an electromagnet, either bought for the purpose or made by winding a number of turns of wire around an iron bolt; this need not be elaborate so long as it creates magnetism.

Next, cut out an arm about 6 in. long, of stiff brass; point one end and cut an opening in the arm, wide enough, and of such a shape as to permit the arm to swing without sliding, 4 in. from the lower end. The bottom, or blunt end, of the pointer is fastened to the center of a piece of magnetized steel, formed in the shape of an arc with a 4-in. radius. Then hang the arm in position by placing the slot over a screw driven into the back board, in such a position that the steel magnet will swing about 1/8 in. above the coil. The screw should have its top surface filed down to a knife-edge so that the pointer can swing with the least possible amount of friction.

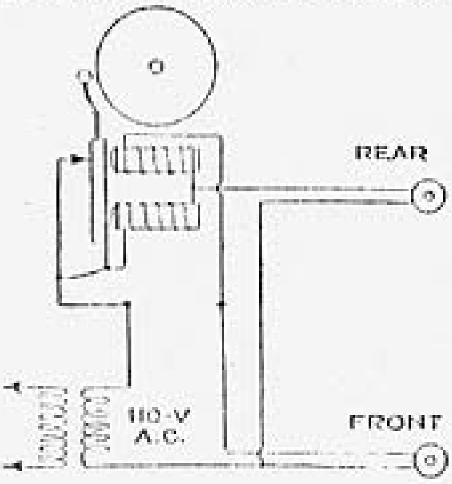
Connect the electromagnet to the two binding posts and then make a scale which can be tacked to the back under the end of the pointer. The instrument should be tested with a regular ammeter and the readings marked accordingly on the scale.

When using, set the instrument in a steady position so that the pointer will be at the center of zero point of the scale, and connect the magnet to the source of current; the action of the electromagnet will then pull one end or the other of the magnet down to it, which will swing the pointer either to the right or left and indicate the amount of current.—L. B. Robbins, Harwich, Mass.

THE BOY MECHANIC – 1925

Bell Gives Two Distinct Signals

In the installation of doorbells it is customary to use both a bell and a buzzer, in order to distinguish between signals from the front and rear doors. By the arrangement described, the buzzer is eliminated, and the bell circuit so modified that one bell will give two distinct signals, a ring when the button at the front door is pushed, and a buzz when the button at the



back door is operated.

A tap is taken from the bell winding at the point where the ends from the two coils are connected together. This tap, of insulated wire, is brought out through a hole in the base, or a slit under the cover of the bell, and the circuit is wired as in the drawing. The clapper is adjusted so that the hammer is ⅜₂ in. from the bell when the armature is at rest.

Current flows through only one coil of the bell when the button at the back door is pressed. While the magnetic energy of this single core will be sufficient to operate the armature, the clapper is not brought up forcibly enough to have the ⅜₂-in. overthrow necessary to strike the bell. Consequently, instead of ringing, the bell simply buzzes. If, however, the button at the front door is pushed, both of the bell coils receive current in the usual manner and the magnetic effect of the cores is, in this case, sufficient to cause the armature to operate with such force that the clapper strikes the bell.

If batteries are used in place of a transformer, the circuit is the same as shown, with the exception that the interrupter contacts are not short-circuited.—H. H. Schneckloth, Omaha, Neb.

THE BOY MECHANIC – 1925

Tested Radio Grounds

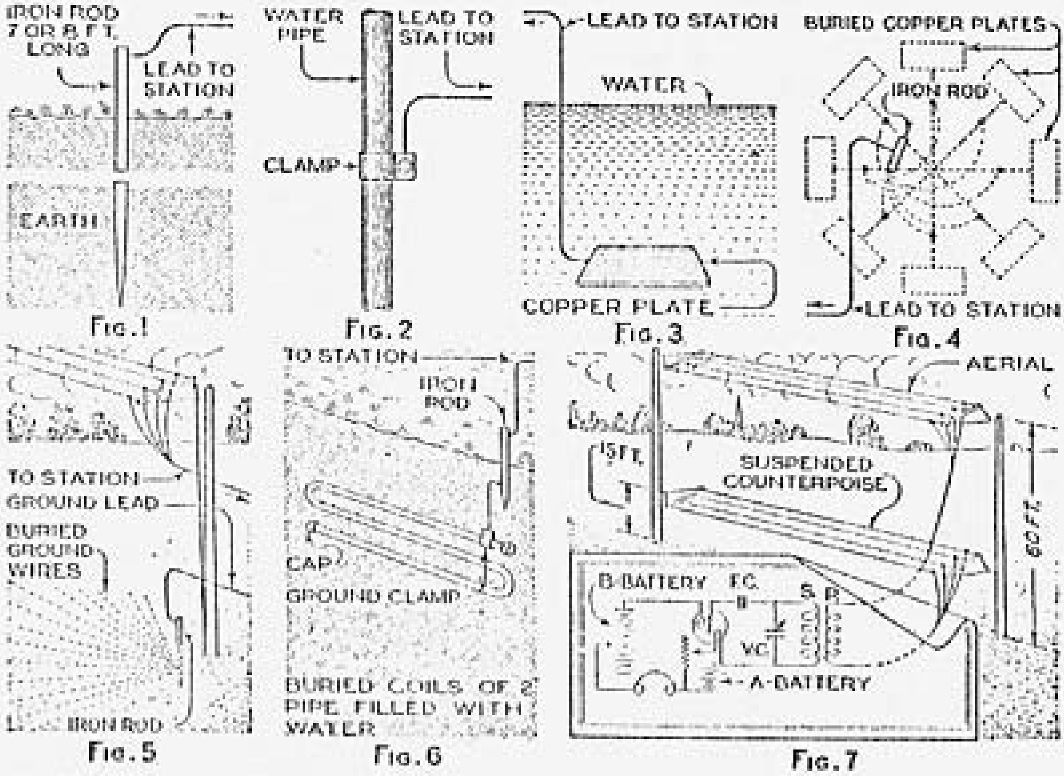
BY F. L. BRITTIN

A GOOD ground system makes great things possible for the radio enthusiast. The grounds of the government and commercial stations are very complex and cover large areas. The average amateur does not give enough attention to his ground system; this is a mistake, as no matter how good the apparatus may be, its efficiency is no greater than that of its weakest point.

Soldered joints and a fairly heavy ground lead, preferably of the seven-strand, rubber-insulated type, should be used, and in choosing the best method for grounding the station, the fact that the wave length is governed by the length of the ground lead as well as by the length of the aerial must be taken into consideration. The total length of the aerial is always measured from the far end of the aerial to the ground; after reaching the ground, the main thing is to get a good "hold" on it.

Many methods are in use, but those shown in the drawing give the best results. Figure 1 shows the most common method, consisting of a 7 or 8-ft. iron rod driven into the earth with the lead to the aerial switch securely soldered to it. A hole should be drilled through the upper end at the point of connection so that the wire may be threaded through it before soldering, thus insuring a tight joint. The method shown in Fig. 2 is another much used system, and consists in grounding to a water pipe by means of a clamp. The pipe should be scraped free of all paint before the clamp is applied. The water ground illustrated by Fig. 3 is very efficient, although not a common one, as the water is not usually at hand; a near-by well or cistern can be used by soldering a metal plate, preferably copper, to the end of the lead, and dropping the plate into the water.

The buried-plate ground is shown in Fig. 4, and consists of a number of copper plates buried in the ground, the leads being connected at a common point. One of the best systems in use is the buried-counterpoise type, shown in Fig. 5. A number of trenches, about 10 or 15 in. deep, are dug, radiating in all directions under the aerial, and No. 12 bare copper wire is buried in them and brought together to a common point, whence the lead is taken to the aerial or so-called lightning switch. Twice as much wire is buried as there is in the aerial; this makes the best ground known, especially when used in connection with the water ground



A Number of Different Methods of Grounding Amateur Wireless Stations, by Means of Which the Efficiency of the Average Apparatus may be Materially Increased

in Fig. 3. A type of ground that has been used with excellent results is shown in Fig. 6 and consists of a coil of 2-in. pipe, filled with water, and buried 5 ft. under ground. A suspended counterpoise is illustrated in Fig. 7; this consists of a second aerial suspended directly underneath the aerial proper and connected to the instruments in the manner indicated. The results from this method are good when the counterpoise is suspended about 15 ft. above the ground.

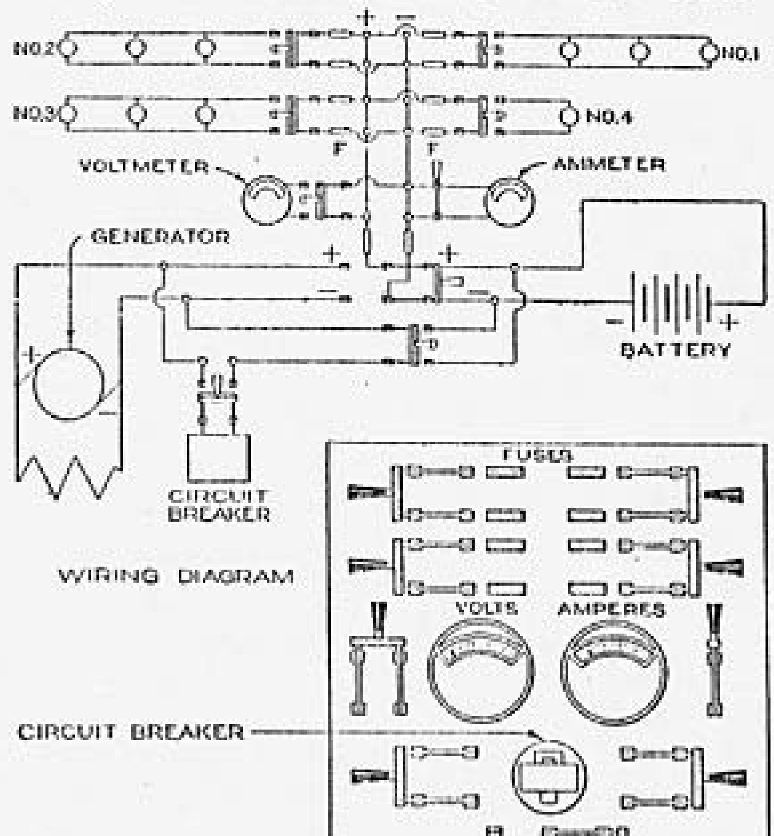
Whenever the ground or aerial is changed or altered, the operator should use his wave meter to be sure that he is keeping within the 200-meter limit, and should retune his transmitter.

Apropos of the 200-meter wave limit, all amateur stations should make an effort to get down to this wave length. Nothing will hurt the amateur radio enthusiasts all over the country so much as disobeying government regulations. The amateur generally seems to be under the impression that his infraction of this rule passes unnoticed; this is not so, and, if present regulations are not adhered to, the result will be that stricter laws will be passed and enforced.

THE BOY MECHANIC – 1925

Motorboat Illumination

Because electricity lacks the dangerous and disagreeable characteristics of oil, it is only natural that its use on motor craft



A Neat Arrangement for the Electric-Lighting System of a Motorboat or Cruiser: An Automobile Generator may be Used to Furnish All the Current Required, While a Storage Battery Takes Care of Emergency Demands

of various styles is becoming more and more common.

The electrical system shown can be easily installed, and advantage is taken of the efficiency of tungsten lamps operated from a six-volt current. Also, on account of the low voltage, No. 14 gauge rubber-insulated wire can be used without the trouble and expense of putting it in metallic conduit.

A generator having an output of from 6 to 8 volts, and an amperage of from 6 to 10, is needed to furnish the charging current. This is about the capacity of the average automobile generator, and as these can be picked up cheaply from wreckers and secondhand dealers, the cost will not be great. Such generators are usually designed to be driven by a silent chain, and this arrangement should preferably be adhered to, as the drive is more positive than a belt drive. The storage battery for emergency purposes can be concealed in some accessible locker from which the corrosive acid fumes can be carried away by ventilation.

The drawing shows the appearance of the small switchboard and its wiring arrangement for use with such a system; it is divided into four circuits, with a volt and ammeter, a main switch, and a small circuit breaker. It might be mentioned that the knife switches shown can be replaced by the smaller and neater snap switches. Circuit No. 1 takes care of the three running lights, port, starboard, and mast; circuit No. 2 is connected to the toilet, galley, binnacle, or an engine-trouble lamp as desirable, while circuit No. 3 controls the cabin lights, and circuit No. 4 takes care of the searchlight. Naturally, the circuits and their arrangement are merely suggestive, but represent typical practice.

All the running lights should be controlled directly from the switchboard, but the others may be placed in key sockets.

During charging, it will be seen that both volt and ammeters can be used, provided all the lighting circuits are open. The circuit breaker should be set for the correct charging current, and will take care of this automatically. However, the circuit breaker can be dispensed with by frequently observing the fluctuations of the voltmeter. Fuses in each circuit are inserted to prevent the battery from injury through a short circuit.

THE BOY MECHANIC – 1925

Removing Enamel Insulation

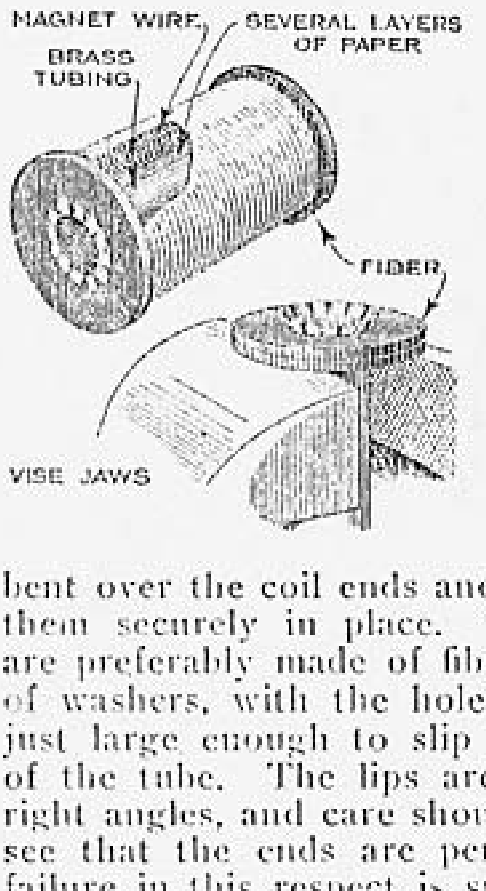
Amateur electricians have their troubles winding coils with enamel-coated wire, particularly with the finer sizes, as it is very difficult to scrape off the insulation without breaking the wire. By passing the wire through the flame of a gas burner several times, the enamel will be melted, and will drop off.—Paul I. Schmidt, Meno, Oklahoma.

THE BOY MECHANIC – 1925

Handy Spools for Coil Winding

A good substantial spool is the first step in winding any coil for an electromagnet, if it is to be prevented from collapsing or "loosening up."

Get a piece of brass tubing a little longer than the finished coil is to be; thin brass tubing is best, but if it cannot be had it is entirely possible to make one from a piece of sheet brass. The joint need not be soldered, although this is advisable.



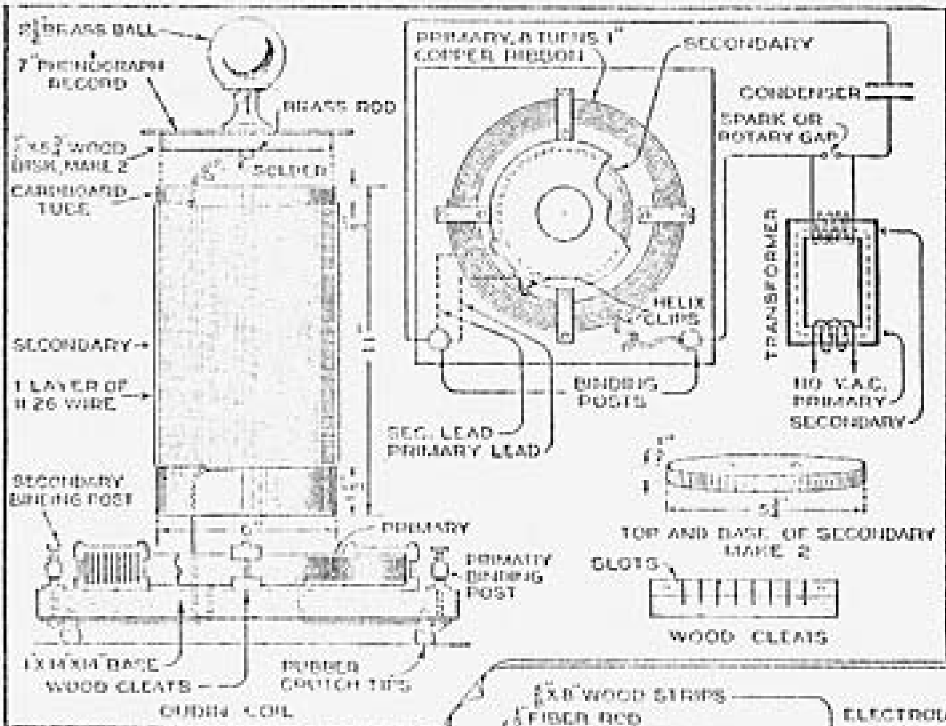
The ends of the tube are slotted for a short distance with a hacksaw, as shown in the drawing, to form lips which are bent over the coil ends and serve to hold them securely in place. The coil ends are preferably made of fiber in the form of washers, with the hole at the center just large enough to slip over the ends of the tube. The lips are bent over at right angles, and care should be taken to see that the ends are perpendicular, as failure in this respect is sure to make it difficult to wind the coil evenly.

Several layers of paper are glued or pasted around the core, shellacked, and allowed to become thoroughly dry before starting the winding, and the coil, when wound, should also be wrapped with one or two layers of shellacked paper to protect the wires from injury.—Curtis Ralston, Springfield, Ohio.

Making High Frequency Oudin and Tesla Coils

By F. L. Brittin

HIGH-FREQUENCY coils are easy to make, and the materials are, for the most part, to be found around the average radio laboratory. Most experimenters want either an Oudin or a Tesla coil, and as they usually have all other necessary equipment on hand, such as transformers, high-tension condenser, and rotary gap, it is comparatively easy to gratify their ambition.



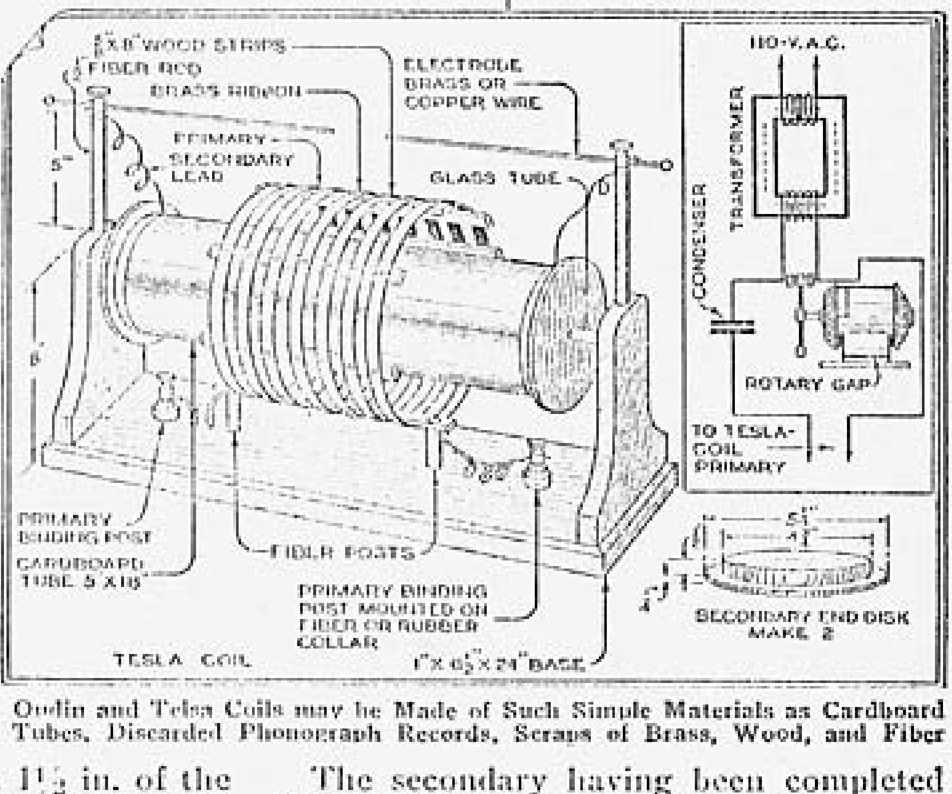
The Amateur Radio Operator of Limited Means need Not Deny Himself Necessary High-Frequency Coils

To make an Oudin coil, a cardboard tube, 6 by 11 in., is needed for the secondary; this is given two or three coats of shellac, and when the last coat has dried, a single layer of No. 26 double silk-covered magnet wire is wound on. Start the winding $1\frac{1}{2}$ in. from the upper end of the tube, first fastening the end and allowing a loose end, of about 8 in., for connecting to the brass rod. Wind to within $1\frac{1}{2}$ in. of the lower end. Small holes are made in the tube at the start and finish of the winding, and the loose ends of wire are pulled through and fastened. When the winding has been finished, it is given a coat of shellac, which is allowed to dry thoroughly before proceeding further.

The wooden disks, as shown in the drawing, are made to fit into the ends of the secondary; the bottom disk is screwed to the base, and the top one is drilled through the center to accommodate the brass rod leading to the ball, and is then attached to the tube. A neat cap for the coil is made from a 7-in. phonograph record; the hole at the center being enlarged to take the brass rod, and small holes being drilled at opposite points for the small round-head wood screws which are used to fasten it to the wooden disk.

Almost any junk yard will yield the brass ball, which is of the type commonly used on metal bedsteads.

The base is preferably made of hard wood, which may be finished as desired; it is supported and, at the same time, insulated by rubber crutch tips, which are fitted over wooden pegs, one at each corner.



Oudin and Tesla Coils may be Made of Such Simple Materials as Cardboard Tubes, Discarded Phonograph Records, Scraps of Brass, Wood, and Fiber

The secondary having been completed and connections made, the maker must direct his attention to the primary winding. This winding consists of eight turns of 1-in. copper ribbon, which is held to the base by four wooden cleats, as indicated; these cleats are slotted, to separate the individual turns from each other. Flexible leads, with helix clips attached to one end, are connected to the binding posts, as indicated, to complete the instrument. Using a ½-kw. transformer and a regular single-unit, oil-immersed, high-tension type condenser, sparks from 10 to 16 in. long can be drawn from the coil, which is connected in circuit as shown in the diagram.

The Tesla-type coil is simple to make and operate, and consists of a secondary winding of a single layer of No. 28 single cotton-covered magnet wire over a well shellacked 5 by 18-in. cardboard tube. After the winding has been applied, it is given two coats of shellac, each of which is allowed to become thoroughly dry. The wire is wound around the tube to within 1 in. of each end, and two small holes are punched through the cardboard at the terminals, for drawing the wire through and fastening it. After the wires have been looped and made fast to the tube, the ends are brought to the binding posts and soldered. The secondary end disks are turned to fit the ends of the tube snugly, and are drilled through their centers to receive the ¾-in. glass rod, or tube, which is supported in blind holes in the endpieces; this glass support is 21 in. long; if glass cannot be obtained, a wooden rod of the same dimensions will answer as well. The end blocks supporting the coil are drilled at the center of their upper edges to take ½-in. rods of fiber, to the upper ends of which the secondary binding posts are screwed, as shown.

Seven turns of 1/16 by ⅝-in. brass ribbon form the primary, the separate turns of which are held apart by means of wooden strips, or cleats, to which the ribbon is fastened with small tacks or screws. The terminals of the primary are brought out and fastened to the bases of binding posts, which are elevated from the wooden base on short posts of hard rubber or fiber. Similar fiber posts, fastened to one of the cleats, are used to support the primary, and keep it properly spaced with relation to the secondary. The wooden parts of the instrument are made from yellow pine to the dimensions shown in the drawing, and finished with black asphaltum paint. The wire electrodes slide back and forth through the secondary binding posts, and regulate the length of spark as desired. A Tesla coil of this type is very powerful, and with it many interesting experiments with currents of high frequency can be performed without difficulty. The circuit in which a coil of this kind is used requires the same type of condenser as that shown in the wiring diagram of the Oudin coil.

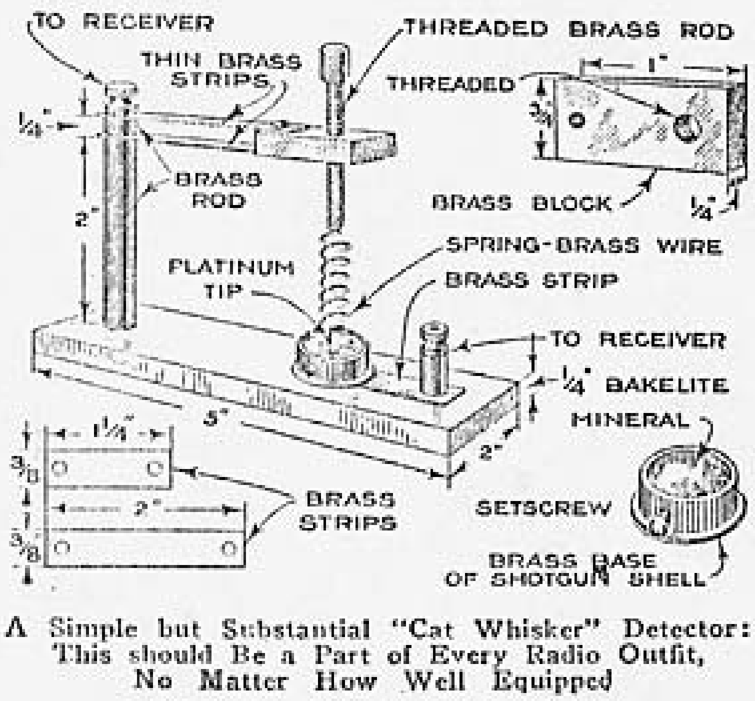
THE BOY MECHANIC – 1925

How to Make a Good Mineral Detector

By F. L. Brittin

A MINERAL detector should be a part of every radio amateur's equipment, as one never knows when the audion tube may burn out, and this sometimes happens right in the middle of an important message; it is then very handy to be able to switch the mineral detector into the circuit and continue receiving. A good mineral detector is a part of almost all commercial sets, where traffic must go on regardless of accidents. The detector described here is simple to build, and can be constructed from odds and ends about the station.

The base is of bakelite, or may be of any insulating material, ¼ by 2 by 5 in.; the upright post is of ⅜-in. brass rod, the lower part, 2 in. long, drilled and threaded at each end to take a ⅛-in. brass machine screw, the upper part being ¼ in. long, drilled through to clear the upper binding screw. This screw is 1½ in. long and



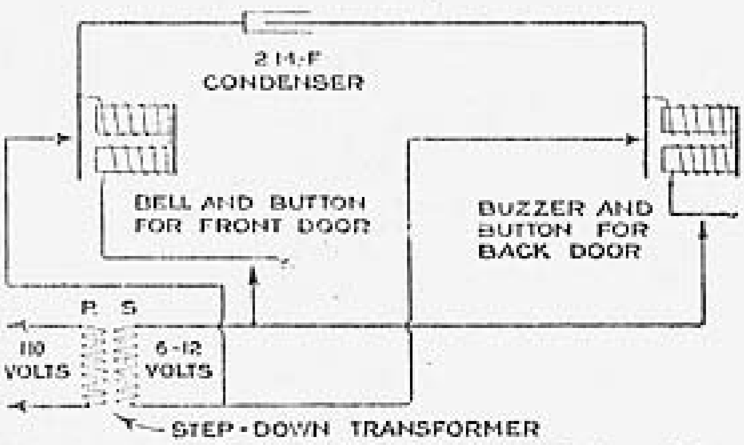
A Simple but Substantial "Cat Whisker" Detector: This should Be a Part of Every Radio Outfit, No Matter How Well Equipped serves to hold the two brass strips in place in addition to acting as a binding post, as shown in the drawing.

The small brass block is drilled to take a small bolt, which clamps the brass strips loosely, allowing a side swing to the block. The block is also drilled and threaded to take the knurled-head screw to which the spring wire is soldered; the

THE BOY MECHANIC – 1925

Eliminating Spark on Bell Contacts

After installing a small step-down transformer to operate the bells in my house, I found that the contacts on the bells were sparking badly, and would soon burn out. Shunting a condenser across the contacts to absorb the spark is a common practice, and I decided to do this for each bell. To avoid the necessity of buying another condenser, I devised the method of wiring shown in the drawing; this allows one condenser to serve both bell and buzzer. When the front-door bell is rung, the condenser is connected across its contacts through the contacts on the buzzer, and vice versa. This arrangement does not



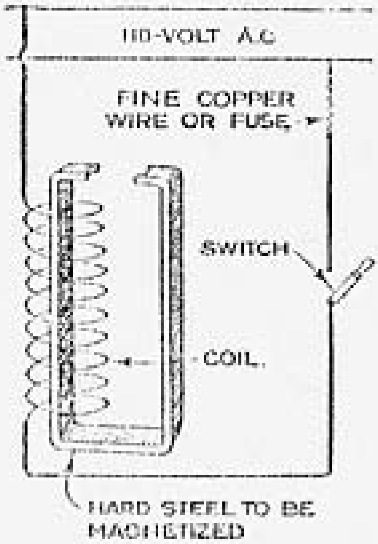
The Condenser Connected across Both Bell and Buzzer, as Shown, Stops Sparking at the Contact Points, Thus Preventing Undue Wear

interfere with the simultaneous use of both bell and buzzer.—C. M. Crouch, Minneapolis, Minn.

THE BOY MECHANIC – 1925

Making Permanent Magnets by Use of Alternating Current

In the amateur's laboratory it often happens that he desires permanently to magnetize steel parts, but is not able to do so without means of rectifying the commonly used alternating current.

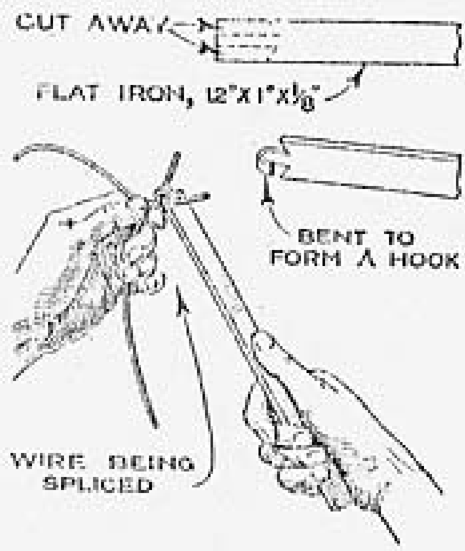


This difficulty can be easily overcome if the coil used to magnetize the parts is placed in circuit with a fairly heavy fuse, of 5 or 10 amperes, or with a piece of light copper wire, as shown in the sketch. When the switch is closed, the fuse, of course, is blown, but the instantaneous surge of current in the coil is very great, and the break so sudden that the steel is left magnetized. The result is secured only if the current happens to break near the peak of a wave, or alternation; if not successful the first time, the process must be repeated.—A. Swenson, Okmulgee, Okla.

THE BOY MECHANIC – 1925

A Wire-Splicing Tool

In splicing fence, telephone, and other wires, the simple little tool shown in the drawing will prove its value. It is made from a piece of flat iron of a convenient size, and formed as indicated. A hacksaw, or file, is used for cutting out sections 1/4 in. wide by 1 1/4 in. long, on each side, leaving a projecting tongue which is bent over into the form of a hook.



To use, cross the wires to be joined, hook the tool over one piece, and let the other wire fit into one of the notches. The tool is then turned until the wire is securely wrapped, the operation being repeated with the remaining end of the wire.—G. A. Tibbans, Galena, Kan.

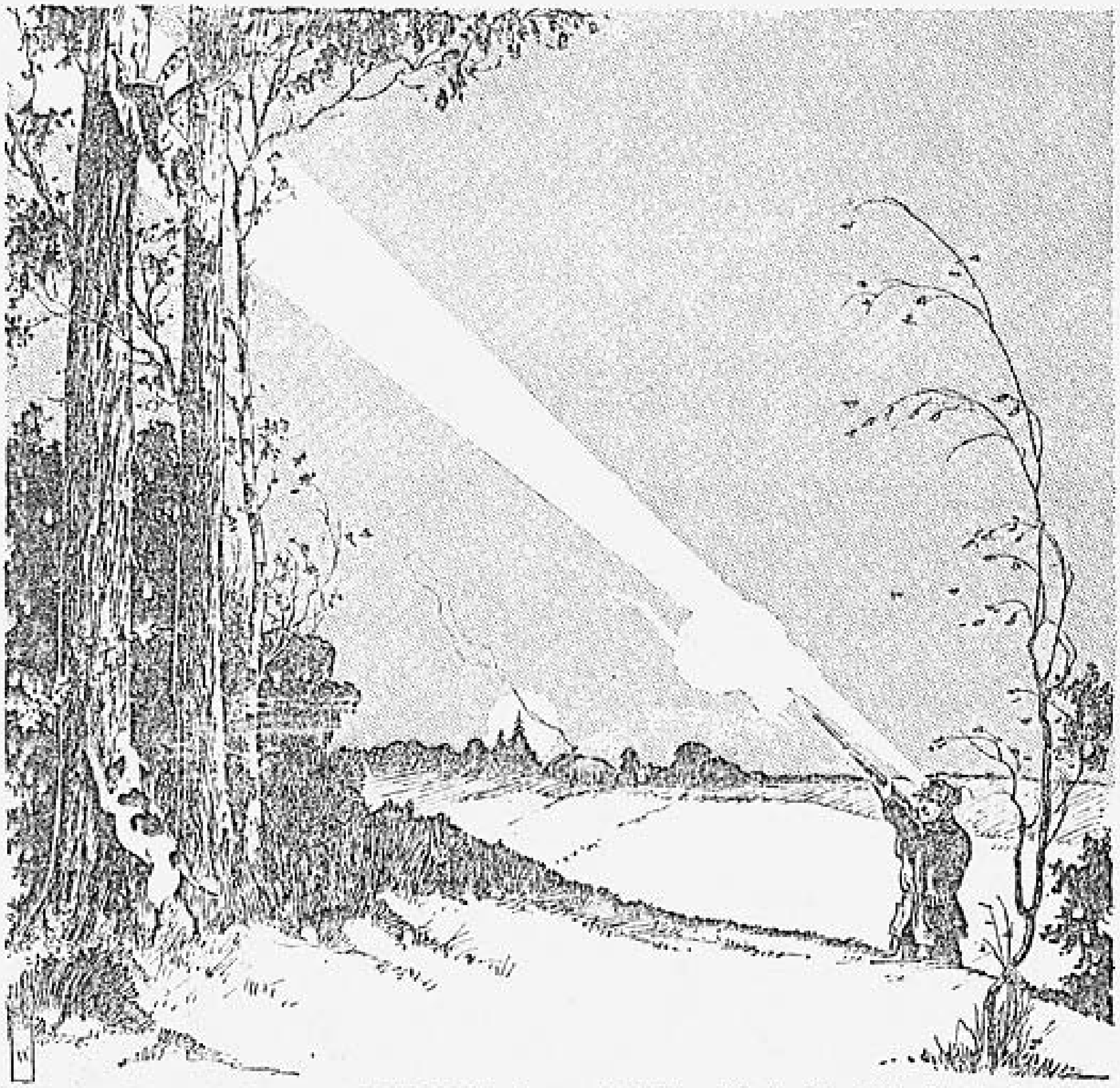
Electric Spotlight for Night Hunting

By AVERY E. GRANVILLE

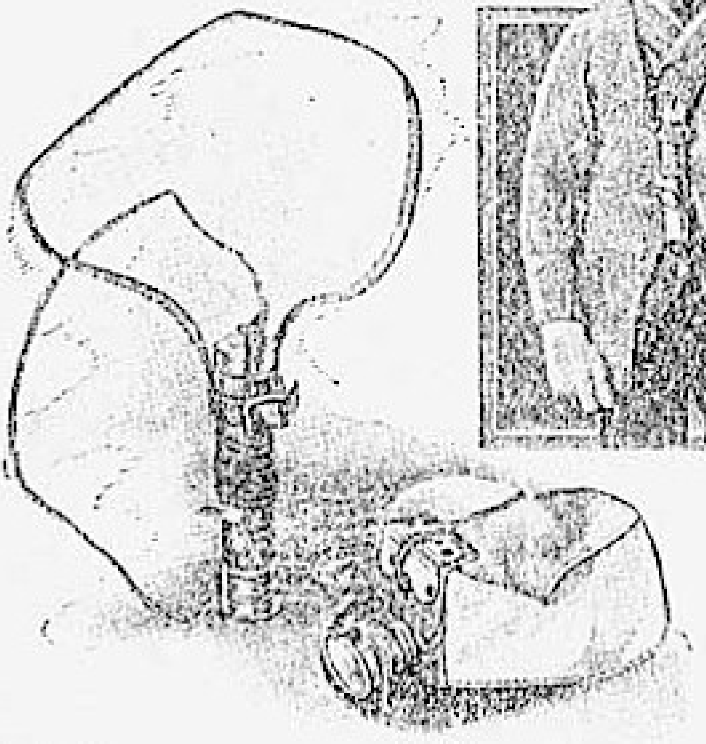
THE BOY MECHANIC – 1925

FOR night hunting, such as trailing raccoons, opossums, skunks and the like with dogs, one needs a light that will leave the hands free as well as throw a powerful beam. A cap light of some kind is the most logical one to use, for a light over the hunter's eyes that throws a beam straight ahead enables him to see an animal's eyes much better than one held anywhere else, the reflection coming direct from the animal's eyes to the hunter's. Such a light will often enable him to see his game up a tree or amid dense foliage when it could not be detected otherwise. The right kind of a cap light is also excellent to shoot by, and one can hit almost as well as by daylight—sometimes better.

Many hunters use carbide lights of the miner's type, but these, while much better than oil lamps of any kind, diffuse the light too much for best results. Some carbide lamps are equipped with bull's-eye lenses, but even then they do not approach the efficiency of a first-class electric spotlight. To have a lamp that would throw a spotlight beam a long distance, and at the same time be convenient to carry and handle, I made the outfit shown in the illustrations. I used parts from two spotlights, one new and the other a broken one. The cap was a common miner's cap with fiber and metal plates in front to hold the light in place. The part attached to the cap was the lamp end of



Hunting 'Coons and 'Possums at Night Is Made Comparatively Easy with the Aid of This Electric Spotlight, Mounted on the Cap the new spotlight, the screw cap from the old one being fitted to it at the back. Brass binding posts were soldered in place for the connecting wires, and the lamp terminals connected to them. The bulb was focused in the reflector so as to throw a beam as far as possible, and it was then fixed in that position, so



Left, Closeups of the Battery and Light on Cap: Right, Light and Battery in Place, Ready for Use

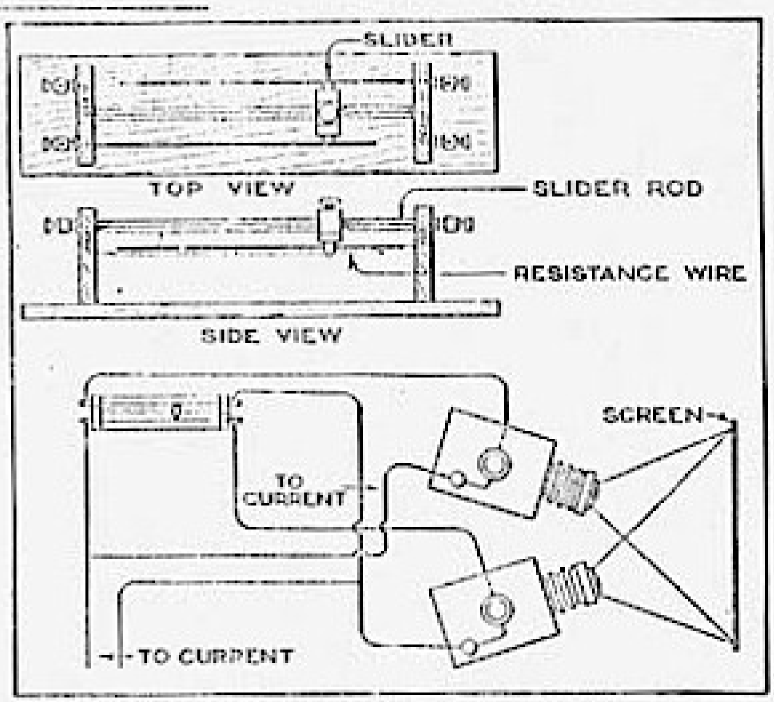
that no amount of jarring would change the setting. A screw at the back fastened the lamp to the support on the cap, and a heavy cord was used to anchor it to the visor, to prevent it from tilting upward when in use. To get the light in the proper position, I shift the cap.

A double wire runs from the binding posts on the lamp to the battery, which is suspended by a strap around the neck. The strap is just long enough to bring the battery well down on the chest, where the switch can be operated easily. The battery is the regular three-cell type, the case being that of the new spotlight with the lamp end replaced by a plain screw cap, into which a binding post has been soldered. The lower binding post of the switch is connected to the lower screw cap by a short piece of insulated wire, securely soldered in place. Thus, when the switch is closed, the current has a free passage, and lights the lamp on the cap. The switch used is a cheap knife switch which can be bought at any electrical-goods store, and is fastened to the battery case by drilling holes and running the binding-post screws through both the case and the switch ends. This type of switch will be found much more satisfactory than the switch originally on the case, as I have found that the sliding switch is too apt to go wrong at a critical time.

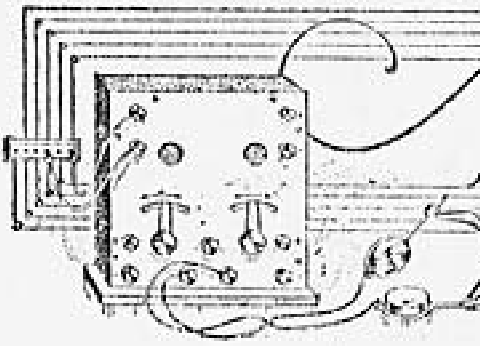
With this light I can spot a 'possum or a 'coon 200 ft. away, or up a tree amidst the densest foliage or tangle of limbs and brush, and every hunter knows that when once the animal is located the rest is easy.

A Switch for Producing Dissolving Views

Many persons who operate postcard projectors find the alternate lighting and darkening of the screen tiring to the eyes. The drawing shows a simple switch by means of which a dissolving effect is obtained. The switch, as illustrated, is made from parts of an old tuning coil of the double-slider type. On each side of the slider rod a length of resistance wire is arranged so that it will be in contact with the slider at all times. The switch is connected to the two machines which will be required, as shown in the drawing. As the location of the slider is changed the light in one projector gradually fades, and is finally extinguished, while the light in the other becomes brighter.—Philip A. Wall, Bedford, Mass.



A Simple Sliding Switch Which Produces a Dissolving Effect for Use with Postcard Projectors



A CONCEALED LOOP AERIAL

By F. L. Brittin

THE BOY MECHANIC – 1925

NEARLY all designs of loop aerials now in use demand a considerable amount of space, and this is usually at a premium in the average amateur's radio laboratory.

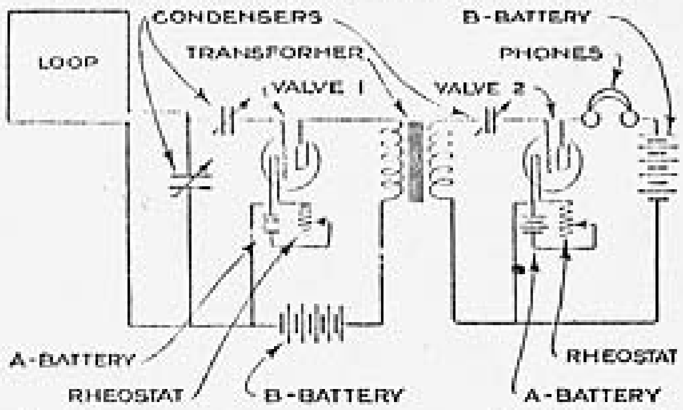
The loop illustrated in the drawing, although slightly directional in its performance, will be appreciated by those who need the extra room and are not "finicky" about directional values. It is of particular value to the jeweler who receives his time by wireless and does not wish to mar the interior of his store with unsightly equipment, or to the amateur living in a small apartment.

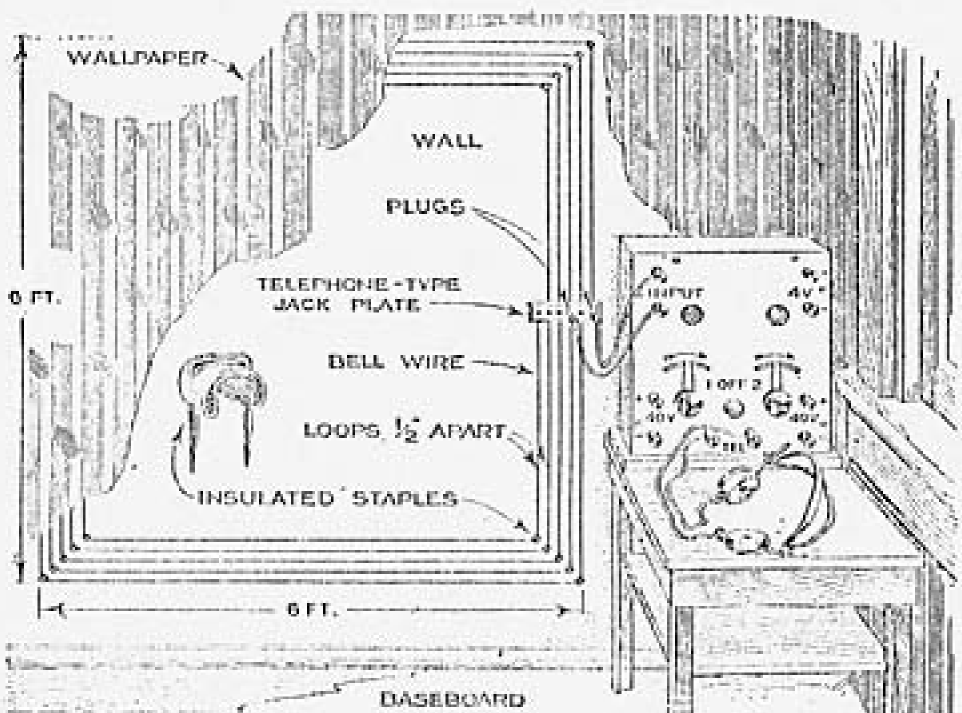
Select a 6-ft. wall space, and wind the loop as in the drawing, using five or more turns of wire, which may be common bell wire, fastening it at the corners with insulated staples, and spacing the loops ½ in. apart.

The brass plate is of the switchboard plug-and-socket type, obtainable from electrical-supply houses, a socket being provided for each loop of the aerial. Push-button of the flush-plate, wall-type or snap switches may be placed above or below the plate for the purpose of cutting out dead ends. The wires may be concealed by mounting a wallboard panel over them, about ½ in. from the wall, and covering the panel with wallpaper of the same design as on the wall. At a distance of a few feet, the panel will be practically unnoticeable. If this is done, the plug plate must be mounted on the front of the panel; the wires may, if desired, be mounted on the back, thus making the loop readily portable; this method is, indeed, preferable.

The following table is given as a guide to those who wish to know the number of turns necessary to receive a definite wave length, using a 6-ft. loop:

Wave Length, Meters	Turns
200 to 250	2
400 to 600	4
600 to 800	7
800 to 1,000	10
1,600 to 2,000	20
2,000 to 3,000	30





A Method of Mounting Loop Aerials That Does Away with Unsightly and Bulky Frames: The Wires may be Concealed by a Wallboard Panel

Signals may be heard at wave lengths greater than those for which a loop is intended, but never less; this is important to remember when tuning in on short wave lengths, and care should be taken to cut out dead-end effect. Loop aerials work on a great variety of circuits, but the best results are obtained with the high-amplification circuit given in the smaller drawing.

A Desk Cabinet for Radio Apparatus

By F. L. Brittin

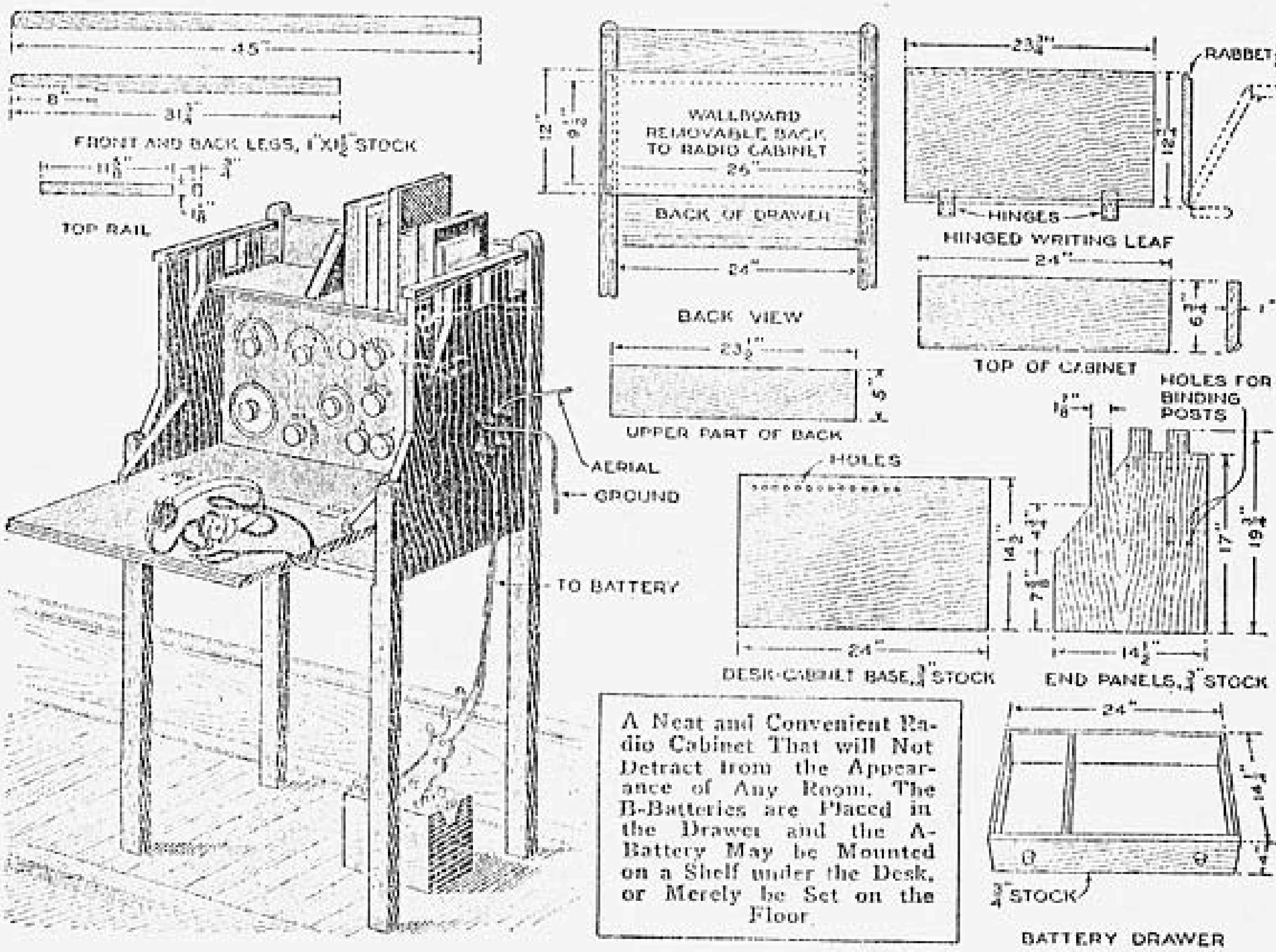
THE BOY MECHANIC – 1925

No longer does the radio enthusiast, from the beginner to the most advanced operator, consider it necessary to make of his laboratory a bewildering maze of wires, casually arranged switches, and ponderous and conspicuously disposed apparatus. The modern tendency is to inclose the entire set and make it as compact as possible, so that little or nothing is visible but the necessary adjusting knobs and binding posts.

The drawing shows a radio-instrument cabinet that is very neat and convenient, as all the instruments are completely protected from injury and dust; there is a commodious drawer and writing leaf, and all binding posts, with the exception of those for the phones, are on the outside, so that the apparatus need not be disconnected when the cabinet is closed. The construction cost is slight, and the materials are readily obtainable and easily worked, to the dimensions given, in the amateur's workshop. The dimensions are taken from a cabinet that has actually been constructed, although it may be necessary to alter them more or less, to suit the builder's radio set.

The kind of wood is, of course, entirely optional; almost any hardwood can be used, and finished as desired, although for this particular style, which is designed somewhat along mission lines, the use of oak, stained green or fumed, is suggested. However, if the other furniture in the room is mahogany, birch may be used, finished to correspond.

Care should be taken to fit all parts accurately; the end panels should be grooved to take the horizontal pieces, and the joints should be coated with good glue, to supplement screws, wherever necessary.



A Neat and Convenient Radio Cabinet That will Not Detract from the Appearance of Any Room. The B-Batteries are Placed in the Drawer and the A-Battery May be Mounted on a Shelf under the Desk, or Merely be Set on the Floor

The following materials will be necessary:

2 legs, 1 by 1½ by 31¾ in.
2 legs, 1 by 1½ by 45 in.
2 top rails, ¾ by 1⅝ by 11⅝ in.

2 end panels, ¾ by 14½ by 19¾ in.
1 writing leaf, 1 by 12¾ by 23¾ in.
1 cabinet top, 1 by 6¼ by 24 in.
1 cabinet base, ¾ by 14½ by 24 in.
1 upper part of back, ¼ by 5 by 23½ in.
1 piece wallboard, 12 by 26 in.
2 pieces for back and front of drawer, ¾ by 4 by 24 in.
2 drawer ends, ½ by 4 by 13 in.
1 drawer bottom, ½ by 14¼ by 24 in.
1 hard-rubber panel, ¼ by 9½ by 24 in.
2 brass hinges.
2 leaf brackets.

The instrument panel is made of hard rubber, with the various instruments grouped to meet the individual taste of the builder. This particular set is mounted for the short-wave regenerative hook-up, with audion bulb and controls. If desired, the upper shelf may be divided into pigeonholes, but using it as a bookshelf adds considerably to the cabinet's appearance. The back panel is made of wallboard, and is removable for easy access to the instruments and circuits, to make changes and adjustments. The drawer should slide easily without binding, and may be partitioned off as desired, although, as shown, it is used for holding a bank of B-batteries, with flexible leads of sufficient length to permit the drawer to be pulled out.

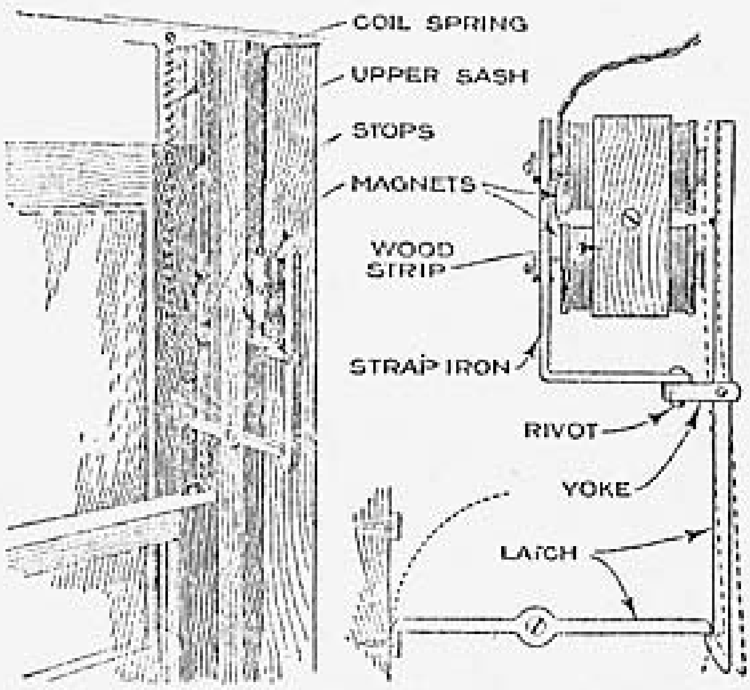
The hinged writing leaf is covered on the writing surface with green felt, extending back to the panel; this is applied in two pieces and is glued to the wood, providing a measure of protection if the phones should be dropped on the hard surface. The hinges are countersunk, and they, as well as the brass brackets which hold the writing leaf, are obtainable from any hardware store.

THE BOY MECHANIC – 1925

An Automatic Window Closer

In the early hours of the morning when the temperature is around zero, it requires courage to climb out of a warm bed and close the bedroom window. However, by installing the electrically operated device shown in the drawing, the window will close itself.

The window is closed by a spring of the screen door type, and is held open by a simple latch which engages with stops fastened to the upper sash. A groove must be cut in the lower sash to permit the stops to clear it. The latch is released by an electromagnet, connected as shown and operated by one or two dry cells. The device is wired to an ordinary alarm clock, or to the automatic regulator with which many furnaces are equipped, so that at the hour set, the circuit will be closed, releasing the latch, and permitting the window to be drawn up. Three or more



An Electromagnetic Arrangement for Closing the Bedroom Window can be Connected to an Ordinary Alarm Clock or Used in Conjunction with an Automatic Furnace Regulator

stops may be used so that the window may be only partly or fully opened. If the presence of the spring should be undesirable, extra-heavy sash weights can be used.

THE BOY MECHANIC – 1925

Number of Feet in Pound of Insulated Wire

Amateur electricians will welcome the handy table shown below.

B & S GAUGE	SINGLE COTTON-COVERED	DOUBLE COTTON-COVERED	SINGLE SILK-COVERED	DOUBLE SILK-COVERED
20	311	298	319	312
21	399	370	403	389
22	488	461	503	493
23	612	584	636	631
24	762	745	800	779
25	957	903	1005	960
26	1192	1118	1265	1202
27	1488	1422	1590	1613
28	1852	1759	1972	1917
29	2375	2207	2570	2485
30	2860	2534	3145	2909
31	3800	2768	3943	3683
32	4375	3727	4950	4654
33	5390	4697	6100	5689
34	6500	6168	7740	7111
35	8050	6737	9600	8034
36	9850	7877	12000	10039
37	11060	9309	15000	10666
38	14300	10636	19660	14222
39	17130	11907	23150	16516
40	21590	14222	28700	21333

This Table Gives the Number of Feet per Pound of Insulated Magnet Wire Used in the Construction of Radio and Other Electrical Apparatus

THE BOY MECHANIC – 1925

Making Molded High-Tension Condensers

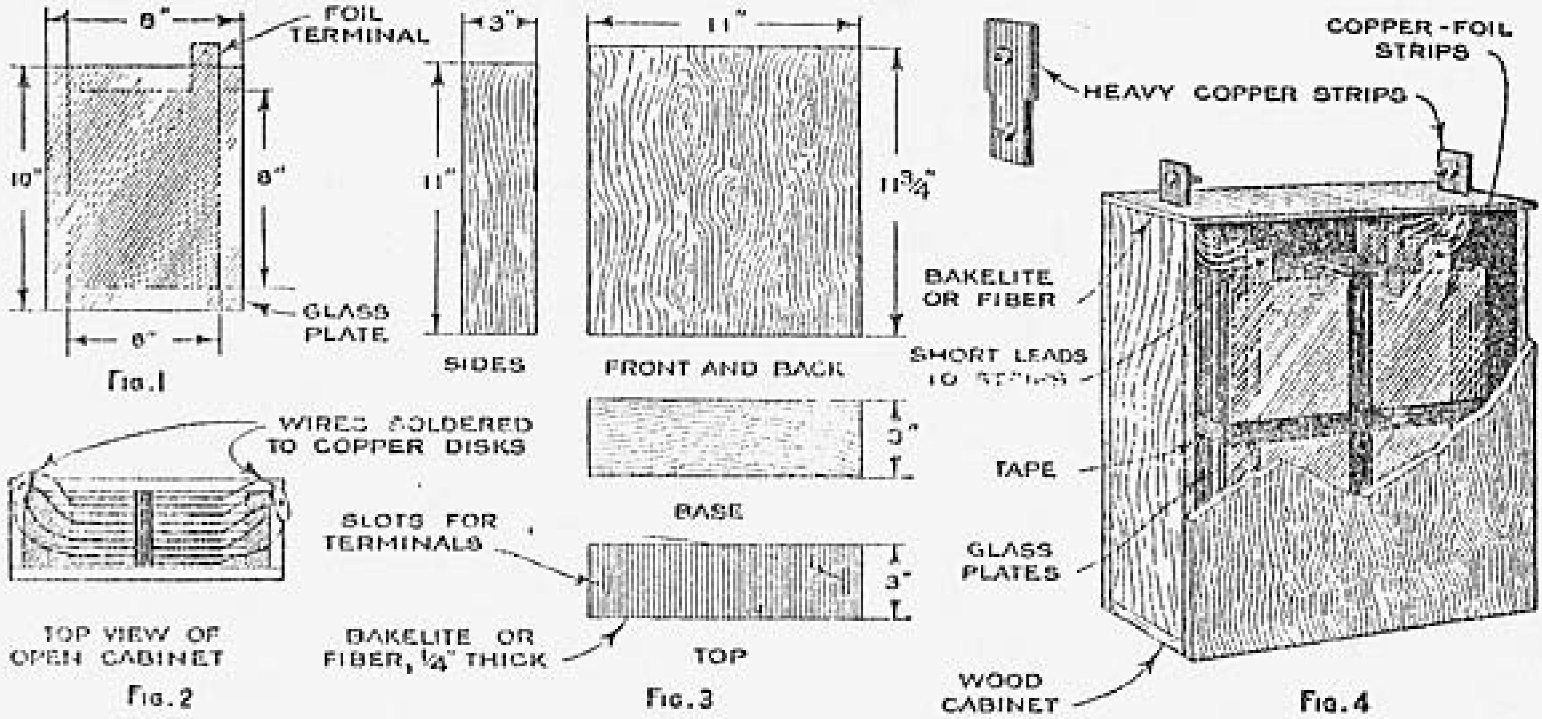
By F. L. BRITTIN

MOLDED condensers have always been held in high favor by radio amateurs. Owing to its portability and absence of brush discharge, a well-made molded condenser will stand a considerable overload without break-down, and is not messy or greasy like the oil-immersed variety, which is often used, owing to the high price of the molded article. By carefully following the directions given in this article, the amateur can make for himself, at a fraction of the cost of the manufactured one, a molded condenser that will equal the results of the factory product.

Molded Condensers are So Easily Made That Their Use should Be Universal among Amateurs

Ten 8 by 10-in. photograph plates can be obtained from any photographer, at little or no expense, from his pile of discarded negatives; these plates are glass of good quality and make a good dielectric. The gelatin emulsion on the negatives can be soaked off with hot water, and the glass thoroughly cleaned and dried.

Cut nine sheets of thin sheet copper, or if this is unobtainable, florists' foil, into pieces 6 by 10 in., allowing 2 in. at the upper end for the formation of the terminals, as shown in Fig. 1; or these terminals may be small strips of sheet copper, or brass, drilled with a small hole for connecting to the heavy copper strips. The cabinet can be made of any wood at hand, and is 3 by 10 by 11 in., inside measurement, coated inside and out with black asphaltum insulating paint; the top end should be made from fiber or bakelite, with small slots in each end, as in Fig. 3, to accommodate the terminals. The cabinet is joined together and laid flat, leaving the top cover off and with an extra piece of glass in the bottom, cut to fit exactly inside the cabinet. Then, make up the condenser unit, as shown in Fig. 4. The nine sheets of foil or copper, cut as in Fig. 1, are placed alternating with the glass plates, every other sheet of foil being reversed so that the leads, or tabs, are on opposite sides. The metallic sheets should be placed exactly in the center of the glass plates, so that there will be a 1-in. margin of glass on all sides, as in Fig. 1. If using thin foil, put small cardboard strips between the plates, at top and bottom, to allow for a free circulation of the insulating wax. Tape the unit together, as shown in Fig. 4, and place it inside the cabinet. Connect the leads to the terminals, using either the heavy copper strips shown in Fig. 4, or large binding posts. After all connections have been well soldered, the instrument is ready for the insulating compound, which is a wax obtainable from any electrical-supply house; its melting point is around 212° F., and it is the kind generally used in transformers. The wax is melted and made ready to pour on. See that the cabinet is free from all moisture, and that the unit is in its proper position in the cabinet, with a 1-in. space around the edges on the sides, and a ½-in. space at the bottom. Pour in the insulating wax and completely cover the condenser unit to within ⅛ in. of the top; when cold and hard, place an extra piece of glass over the wax to completely



Discarded Photographic Negatives, Thin Sheet Copper, or Tin Foil, Together with Other Easily Obtained Materials, are Transformed into the Condensers Necessary for the Radio Experimenter

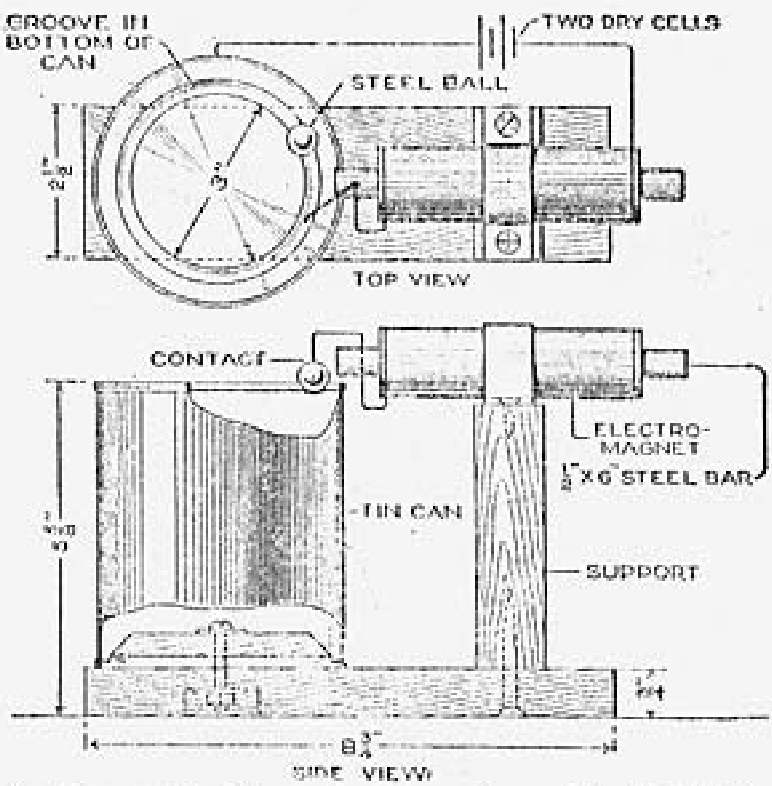
cover it, and screw on the front of the cabinet.

Such a condenser is a very good size for use with a ½-kw. transformer and, if more condenser capacity is needed for higher potentials, two or more such condenser units can be made and connected in parallel-series.

THE BOY MECHANIC – 1925

Steel-Ball Motor Operated with Dry Cells

An interesting electromechanical toy may be made from a ½-in. steel ball, the grooved bottom of a tin can, and a battery-operated magnet. The magnet consists of two layers of bell wire wound around a ½ by 6-in. iron core. It is mounted as shown in the illustration. A tin can having a circular groove, 3 in. in diameter, is inverted and fastened to the base. The battery is connected to the can, and to the far end of the magnet. The other wire of the magnet, next the can, is left bare and tied securely to the magnet bar with a string. The wire is bent to form a brush over the center of the groove, varying from ¼ to ½ in. from the iron core, which is placed as near to the steel ball as possible while still permitting it to roll by. To operate the motor, the ball is placed in the groove and given a push. As it touches the wire the current flows through the can, the steel ball, and the contact wire to the magnet. The magnetism vigorously attracts it but then the circuit is broken and the ball rolls around the can by the momentum it has gained. A continuation of the same operation keeps the ball spinning.



By Harnessing Magnetic Attraction, a Steel Ball is Made to Revolve at High Speed in a Groove in the Top of a Tin Can

The Construction of a Polarized Relay

By THOMAS W. BENSON THE BOY MECHANIC – 1925

THE trend of amateur construction is to utilize standard parts of easily obtained apparatus in making other devices with a minimum of work. A good example of this is the very sensitive polarized relay described in this article.

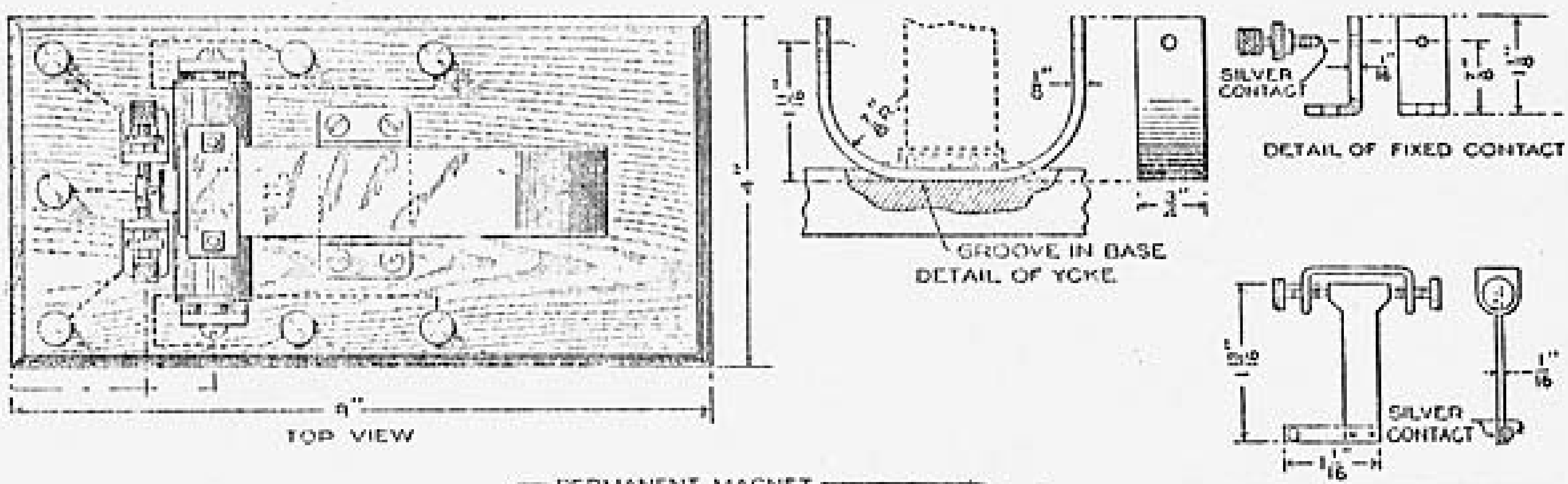
The permanent magnet, used in this relay, is from an old telephone magneto. The pivot for the armature is from a polarized ringer. The long ends of the ringer-pivot bar are cut off, and holes are drilled in it at such a distance from the center that two bolts inserted in them will straddle one leg of the magnet. A short piece of brass, or iron, is similarly drilled, for mounting the armature pivot to the magnet, as shown.

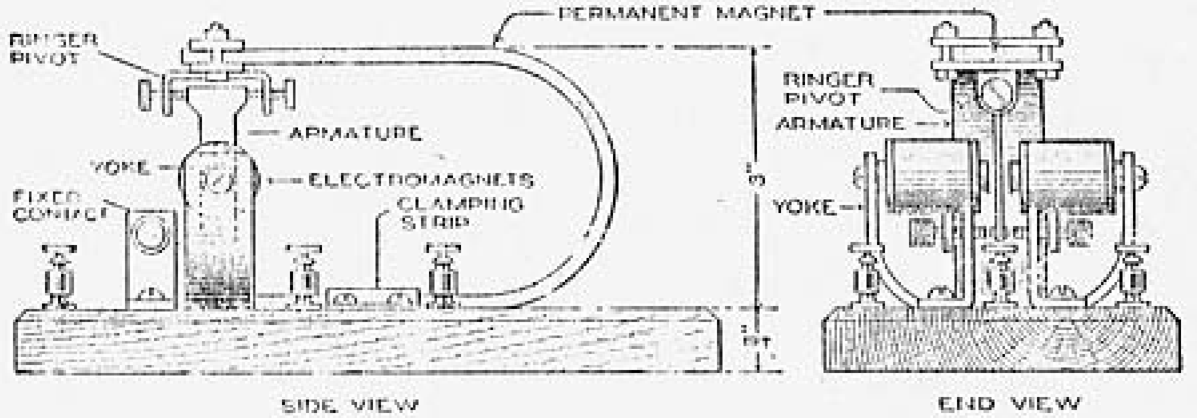
The armature is made of soft iron, just wide enough to fit between the pivot screws, and its length should be about two-thirds of the distance between the ends of the magnet. A center punch is used to make recesses on the edges of the armature, for the pointed pivot screws. The rest of the armature may be cut down to the same width as the cores of the electromagnets. At the lower end of the armature a short piece of brass is riveted with small rivets made from copper wire. The free end of this brass strip is provided with a silver contact point, made by drilling a small hole in the brass, into which a piece of silver wire is riveted.

The electromagnets, wound for a resistance of about 75 ohms each, are from single-pole telephone receivers. These coils are mounted at the ends of a U-shaped iron yoke, so as to leave a space of about ¼ in. between the cores. The legs of the yoke should be long enough to bring the coils midway between the legs of the magnet. The coils are mounted with machine screws, through holes in the ends of the yoke, and should be lined up accurately.

The stationary contacts are made from brass strips, bent as shown. Holes for attaching to the base and to the adjusting screws are drilled. The holes for the adjusting screws should be tapped to accommodate the screws, which should be provided with locknuts. Silver contacts are soldered to the ends of these screws.

A groove is made in the wooden base to fit the yoke supporting the coils, as shown in the drawing. The yoke is held in place by the magnet, which is attached to the base by the brass clamping strip,





Parts Taken from an Old Telephone Magneto are Used to Make This Very Sensitive Polarized Relay, the Resistance of Which can be Varied to Suit Operating Conditions. By Using the Proper Posts the Cords can be Used Alone, in Series, or in Parallel

as shown. A short length of fine copper wire is soldered to the brass strip on the armature, to carry the current. Each coil should be connected to a separate set of binding posts; the two stationary contacts and the armature contact being connected to the other three posts.

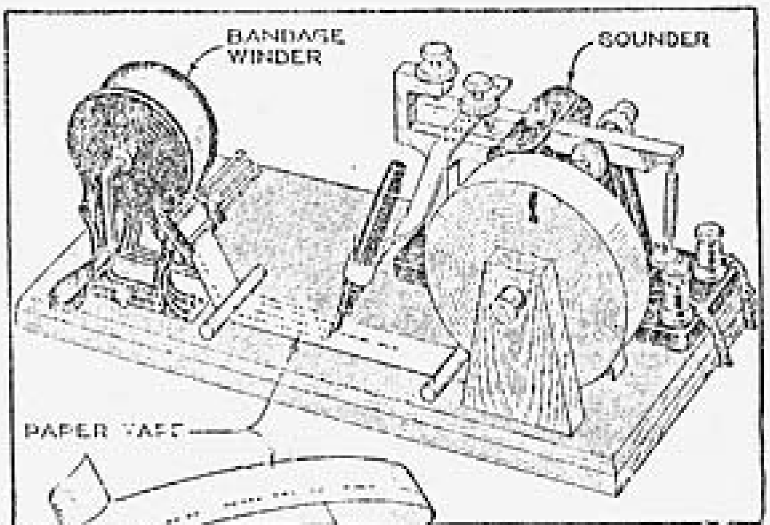
By using the proper posts, the resistance of the relay may be altered as found necessary. With both coils in series, the resistance is about 150 ohms; using one coil alone, 75 ohms, and with both coils in parallel, about 32 or 33 ohms. In making connections, care should be taken to have the magnets form opposite poles on the different sides of the armature.

THE BOY MECHANIC – 1925

A Printing Telegraph Instrument

As every amateur telegrapher knows, it is much easier to send messages than it is to receive them from another station. To provide a means for printing the messages on paper tape, almost any type of sounder can be converted into an improvised printing telegraph instrument without alteration.

The armature setscrew is removed and, in the original instrument, a strip from a "model builder" set is inserted underneath it. The metal strip is bent into the shape shown, with a clip at the outer end, through which a fountain pen is inserted and tightly fastened with a small wooden wedge. The paper tape, which is the kind



An Ordinary Telegraph Sounder can be Easily Converted into a Simple Printing Telegraph Instrument without Altering the Sounder

used on most types of adding machines, passes under the strips to the winding apparatus, made of a bandage roller.

The pen is adjusted so that, when the armature is drawn down by the magnets, the pen will come into contact with the moving paper, making a short line for a dot and a proportionately longer one for a dash, the winder being turned so that the tape passes under the pen at a constant speed.—W. G. Dewar, Ottawa, Ont.

THE BOY MECHANIC – 1925

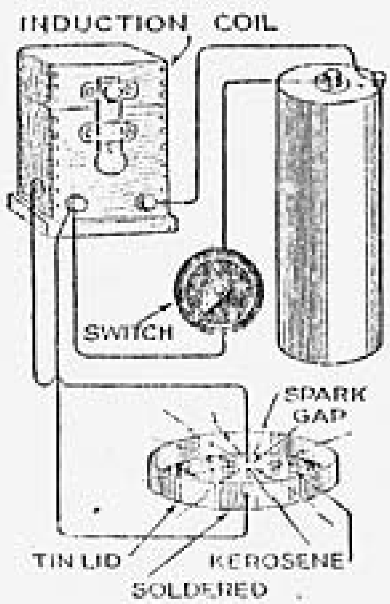
Water Rheostats in Series

A simple water rheostat can be made from two dry-cell carbons, held about 3 in. apart by a clamp made from two strips of wood, stove bolts being used at ends and center. The carbons are immersed in a glass jar filled with salt water. The binding posts on the carbons provide a quick and convenient means of connecting the resistance to the circuit. A battery of such rheostats can be made, and the required amount of resistance obtained by connecting them in series to a switch having a point for each rheostat. —Chas. Waller, Montreal, Que.

THE BOY MECHANIC – 1925

Producing Intermittent Lightning

With the assistance of a small jump-spark, or induction coil, the effect of lightning flashes can be obtained in the following manner: A shallow tin lid,



containing about half a teaspoonful of kerosene, is connected to one wire from the coil, in the manner shown; the other wire from the coil is arranged over the oil, with a small gap for the spark to jump across to the oil. When the switch is closed, the spark passes between the oil and the wire above it, volatilizing the oil which ignites with a flash, and as suddenly dies away; as long as the switch is closed this intermittent flashing continues. A good, hot spark is required, and the spark gap should be very short.—K. McLean, Caledon, S. Africa.

Revolution Counter Useful in Coil Winding

A small revolution counter, or speed indicator, attached to the winding jig, as suggested in the drawings, makes accuracy certain in counting the number of turns when winding electric coils.

As the lathe is usually used for medium and heavy coil winding, Fig. 1 shows how the counter may be attached to a wooden bushing driven into the hollow lathe spindle. If the spindle hole is not large enough, or not hollow, a wooden coupling can be fitted over the spindle instead of into it, as in the detail. If the counter is in good working order, there should be no tendency for it to rotate with the lathe spindle; if it does, a small clamp will act as ballast, as indicated. When a lathe is not available, hand turning must be resorted to. Figure 2 shows an extremely simple rig for fine-wire coils; the spool is driven directly on the counter spindle. The counter may be clamped in a vise or to a bench, and a handle is fastened to the spool, for turning by hand. To speed up the winding, a hand drill with the spool held in the chuck is frequently used, the drill being clamped down or held in a vise. Such an arrangement is shown in Fig. 3. While the counter is usually clamped to the bench, the same as the drill, it may be allowed to swing free, as suggested in Fig. 1. In Fig. 4 is shown a simple type of winding jig, rotated by a crank handle, while the counter is attached through a hardwood coupling to the other end of the winding shaft; a wood post keeps it from turning.

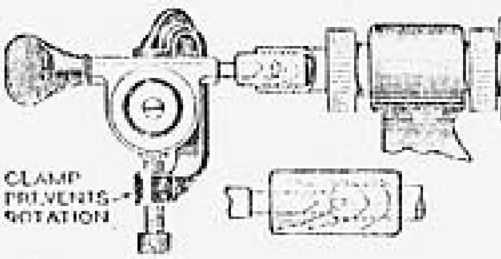


FIG. 1: REVOLUTION COUNTER PLUGGED IN REAR END OF LATHE SPINDLE

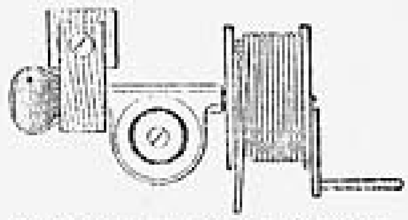


FIG. 2: SMALL BOBBIN DRIVEN DIRECTLY ON COUNTER SPINDLE, TURNED BY HAND

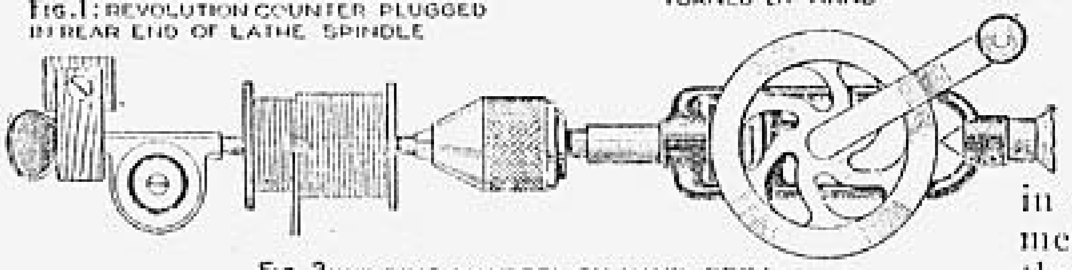


FIG. 3: WINDING MANDREL ON HAND DRILL, BOTH DRILL AND COUNTER CLAMPED TO BENCH

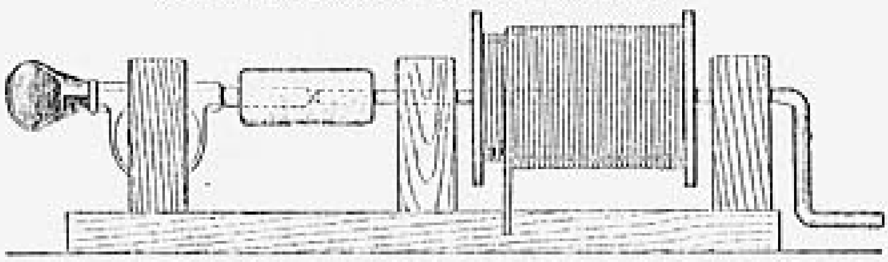


FIG. 4: ATTACHED TO WOODEN WINDING JIG

Various Arrangements are Illustrated by Which an Ordinary Speed Indicator, or "Revolution Counter," may be Used to Keep Accurate Count of the Turns of Wire When Winding Coils

THE BOY MECHANIC – 1925

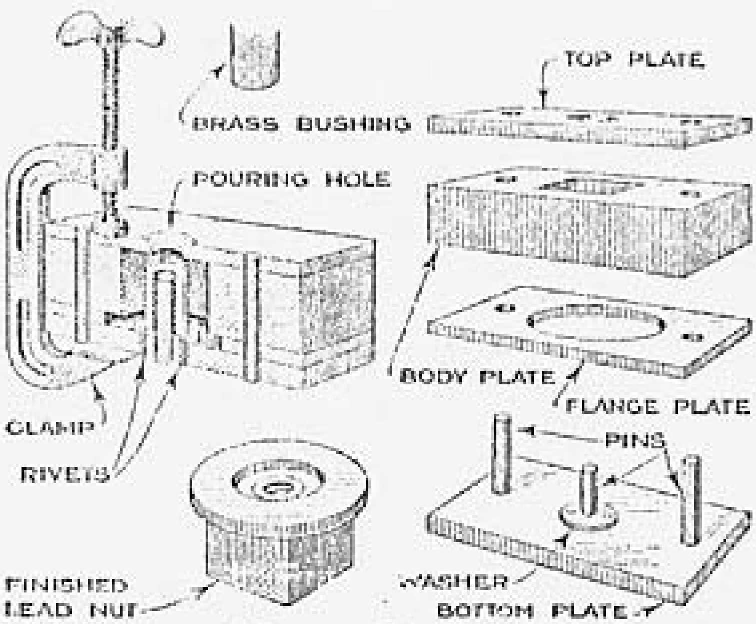
Casting Terminal Nuts for Storage Batteries

A mold for casting storage-battery terminal nuts is a convenient accessory about the garage or private lighting plant.

Such a mold can be made of hardwood, or hard fiber, if but a few nuts are to be cast, but a more substantial article is made of iron or steel plates; if brass is used, the surface must be oxidized to prevent the lead from sticking.

A top plate is first made; this to have a countersunk pouring hole, about 3/16 in. in diameter. Next comes the thicker plate with a square hole, the size of the nut body; this is easily chiseled out of wood or fiber, but if metal is used, a square or triangular file must be used to form the corners after the hole has been drilled to the diameter of the flats. The square hole must be tapered slightly toward the bottom so the casting can be easily removed. Then comes the bottom plate, in the center of which is driven a pin the length of the brass bushing to be used and small enough to enter the bushing after it has been tapped. An iron washer, rusted or coated with graphite to prevent the lead from sticking to it, is placed over the pin and riveted to the bottom plate. The purpose of this washer is to form a shallow cavity in the bottom of the nut. This cavity is filled with vaseline or grease before the nut is screwed into place on the battery, to protect the brass stud and exposed end of the bushing from corrosion. After all the parts have been completed, they are assembled in their proper relationship, clamped together, and a hole is drilled in each end to take the dowel pins which are fitted into the bottom plate.

A bushing is made of round, or square, brass bar, drilled and tapped for the stud it is to fit. The outside is tinned with solder to make the lead stick to it, and to prevent it from working loose and turning inside the lead casting. When ready to use, the bushing is placed over the central pin of the bottom plate, and the mold is assembled, sheets of paper being placed between adjacent plates, and care being taken to see that the paper does not extend into the mold cavity. One or two small clamps are used to hold the parts of the mold together, and everything is ready for pouring the melted lead. If the mold is made of metal, it should be heated before



Lost or Battered Battery Nuts may be Replaced by Using Scrap Lead in Connection with This Simple Mold

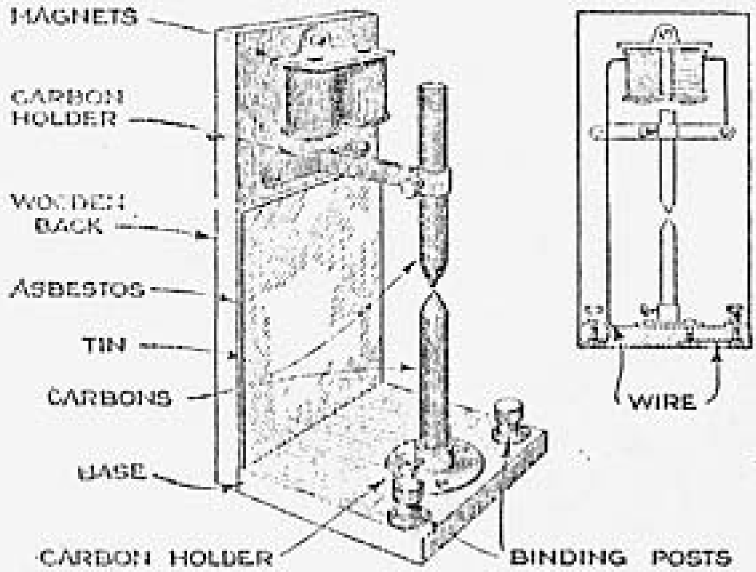
the metal is poured. The casting is easily removed from the metal mold by removing the two dowel pins and driving off the top plate edgewise, thus shearing off the "gate," but if wood or fiber is used, the top plate should be made in two parts, the dividing line being through the countersunk pouring hole.

THE BOY MECHANIC – 1925

A Low-Voltage Arc Lamp

An arc lamp that can be used for experimental and practical purposes can be made by the amateur electrician at slight cost in money and time.

Build a stand of wood after the style illustrated, so that the back will be about 15 in. high and the base 6 in. long, the width of both to be about 6 in. Obtain a pair of good-sized magnets from an old bell, and remove the small-gauge wire with which they are wound, substituting



A Simple Arc Lamp That can be Built in the Experimenter's Workshop to Operate on a 30-Volt Current Furnished by Dry Cells

for it the regular No. 18 gauge bell wire, and making sure that this is wound onto the cores in the same direction as the original winding. After rewinding the magnets, they are attached to the top of the rack by the iron yoke that holds the cores together. Just below the magnets, fasten one of the carbon holders to the back, carefully insulating it from the wood. This holder is made from a strip of brass, bent to hold the carbon and provided with a thumbscrew. Directly below this holder a socket is provided for the lower carbon. Make this part from a section of brass tubing set into a fiber washer. A setscrew should also be provided in this for holding the carbon rigid.

The wooden back is insulated with a piece of sheet asbestos, and this is in turn covered with a sheet of tin, which serves as an additional protection for the back and also as a reflector.

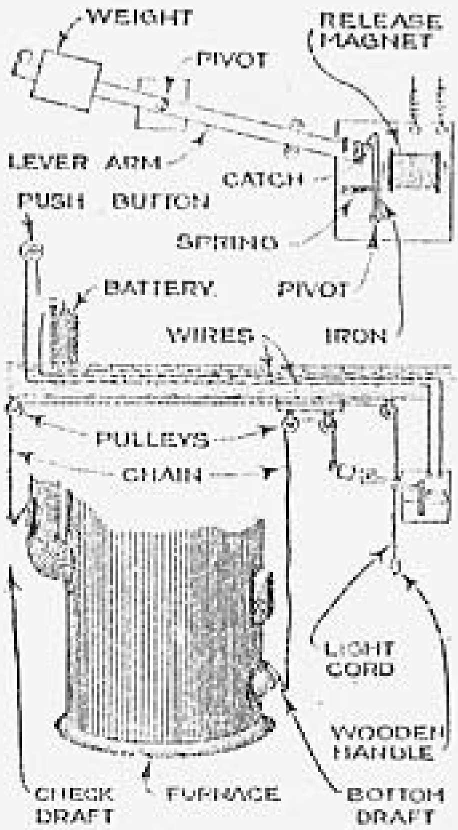
Wire one pole of the magnets to the upper carbon holder and the second to a binding post on the base. The bottom carbon holder is connected to a second binding post. Connect this arc lamp to a battery of about 15 dry cells, or other source from which approximately 30 volts can be obtained. Adjust the distance between the carbons until a position is obtained at which the arc will be strongest. As the carbons burn away they must be readjusted manually.—L. B. Robbins, Claremont, Calif.

 GRANDDAD'S ELCTRICITY BOOK

THE BOY MECHANIC – 1925

Push Button Opens Furnace Draft

By merely pushing a button, the drafts of a furnace can be operated, without descending to the basement.



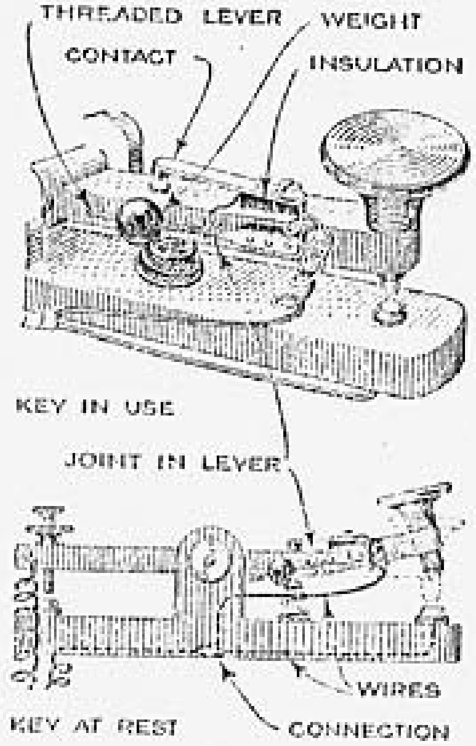
A lever, 14 in. long, is pivoted at its center, in a position near the furnace, where it will not interfere with the head-room. A light chain is run from the check-draft door to one end of the lever, while another chain connects the opposite end of the lever to the bottom draft. A weight is placed on the lever arm, at the end that is connected to the bottom-draft door, to act as a counterweight.

The device is operated by a simple spring-actuated catch, which engages with the end of the lever when it is pulled down to check the draft. A light cord, with a handle attached, can be provided to set the device, if it is located above reach. When it is desired to open the draft and start the fire, pressure on the push button causes the electromagnet to pull back the latch, thereby releasing the lever, which closes the check draft and opens the bottom draft. The same apparatus may easily be adapted to be operated automatically by means of an alarm clock.

THE BOY MECHANIC – 1925

A Self-Closing Telegraph Key

Every telegraph key in an American circuit must be kept closed when not in actual use. The switch commonly provided in series with the key must be opened or closed by hand, and it is decidedly human to forget to do



this.

The drawing shows a telegraph key that automatically closes the circuit as soon as the operator's hand is removed from the knob. The key lever is jointed, or hinged, about the center of the front half. Firmly attached to the part in front of the joint, is a light wire lever, which is threaded so that a weight may be screwed up or down upon it, to adjust the pressure on the contacts. A light spring may be used instead of the weight and lever, if desired. Attached to, but insulated from, this forward portion of the key lever, is a short metal finger, the free end of which is fitted with a contact point; this finger is connected to the circuit by a wire, which is also connected to the lower main contact of the key.

When at rest, there is no hand pressure upon the key knob, and the weight causes the front portion of the key lever to rise a short distance, until the metal finger makes contact with the main part of the key lever. Thus, there is an unbroken pathway for the current from one side of the line to the other, through the contact points on the metal piece and key lever, yet, at the slightest touch of the finger, the key comes to the normal sending position, automatically opening the line.—Samuel W. Beach, Washington, D. C.

THE BOY MECHANIC – 1925

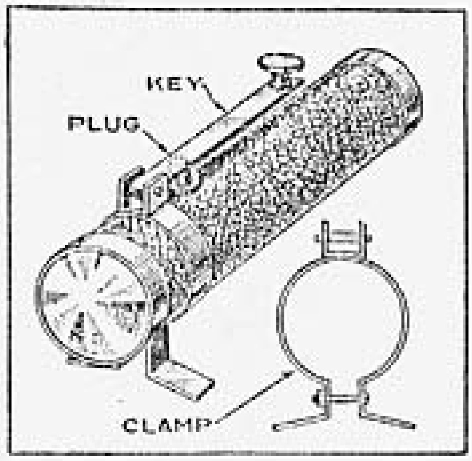
Signal Key for Flashlights

A flashlight offers a convenient means of night communication, by flashing the dots and dashes of the International or Morse codes. Certain types of flashlight, particularly those operated by a push button, can be fitted with a key which converts them into portable blinker sets.

The key may be made of any flat metal, and is secured to the flashlight by means of a clamp, as shown in the drawing, the

 GRANDDAD'S ELCTRICITY BOOK

ends of the clamp being formed into feet to keep the light in place, and prevent it from rolling. The key bar is fitted at one end with a suitable knob, and the opposite end has a small

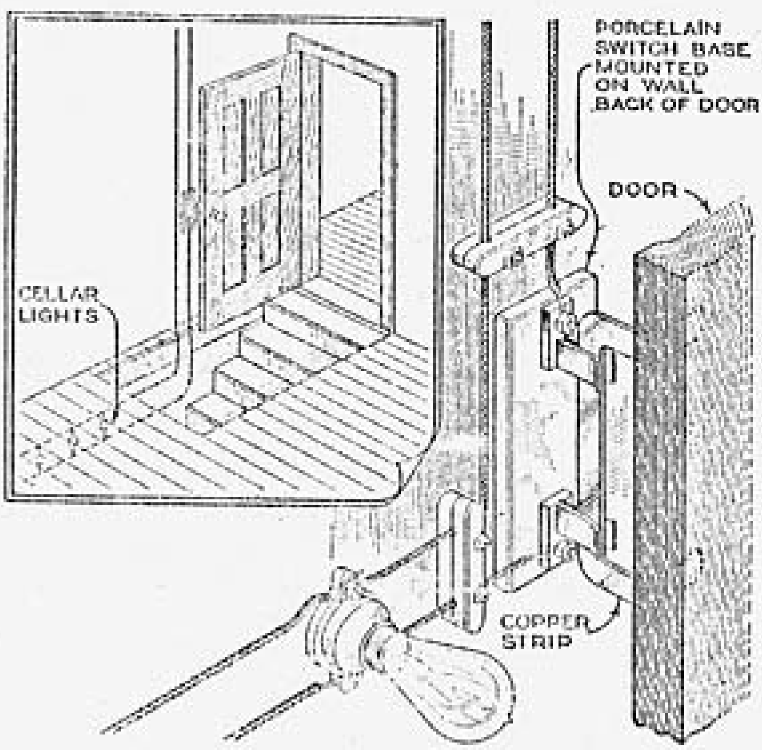


pin soldered to it, the ends of which fit into holes in the U-shaped part of the clamp. A short distance from the clamp, a small metal plug is soldered to the under side of the key bar, for depressing the flashlight button. No auxiliary spring is needed, as the spring of the button is sufficiently strong to raise the key.—George E. Perkins, South Bound Brook, New Jersey.

THE BOY MECHANIC – 1925

Cellar Door Operates Light Switch

To prevent the cellar lights from burning all night through the oversight of



A Simple Switch for Cellar Lights, Which Prevents Any Possibility of Lights Burning When the Cellar Is Not in Use

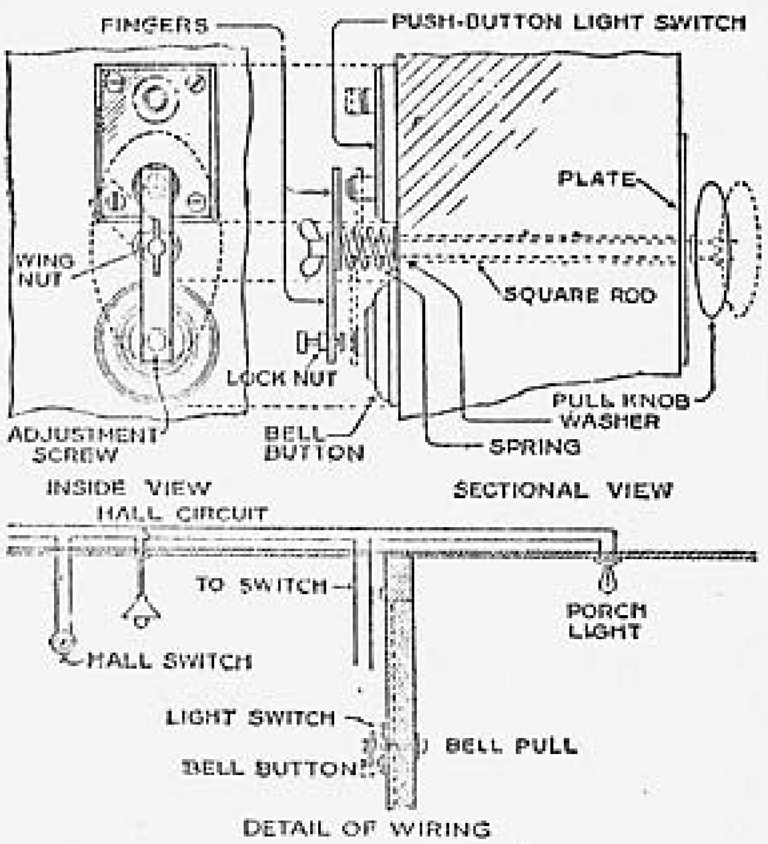
some one who forgets to turn off the switch, the cellar door can be made to switch the lights on and off, since one rarely, if ever, forgets to shut it. A single-pole, porcelain-base switch is used for the purpose by removing the switch lever, and attaching an extra clip, as shown. This altered switch is mounted on the wall of the stairway, at the rear of the door, where it will be out of the way, and is connected to the circuit as indicated. A stationary switch bar is formed from a strip of stiff sheet copper or brass, and mounted to the back of the door directly in line with the switch clips, with which it engages and completes the circuit when the door is opened.

THE BOY MECHANIC – 1925

Ringing the Doorbell Switches On the Porch Light

A doorbell button that switches on the porch light and rings the bell simultaneously, makes it possible to identify nighttime callers before the door is opened.

A hole is drilled through the wall, and if an old fashioned bell-pull is unobtainable, a door knob may be attached to the end of a piece of square rod, which should extend through the wall and about an inch on the inside when the knob is against the outside of the wall. A small hole is drilled and tapped in the inside end of the rod. A flush push-



Pulling the Knob Rings the Doorbell and Turns On the Porch Light, Making It Possible to Identify Night Callers before Opening the Door

button switch is set into the wall about

 GRANDDAD'S ELCTRICITY BOOK

1 in. above and in line with the hole; the bell button about the same distance below. The switch should be arranged so the lower button turns on the light.

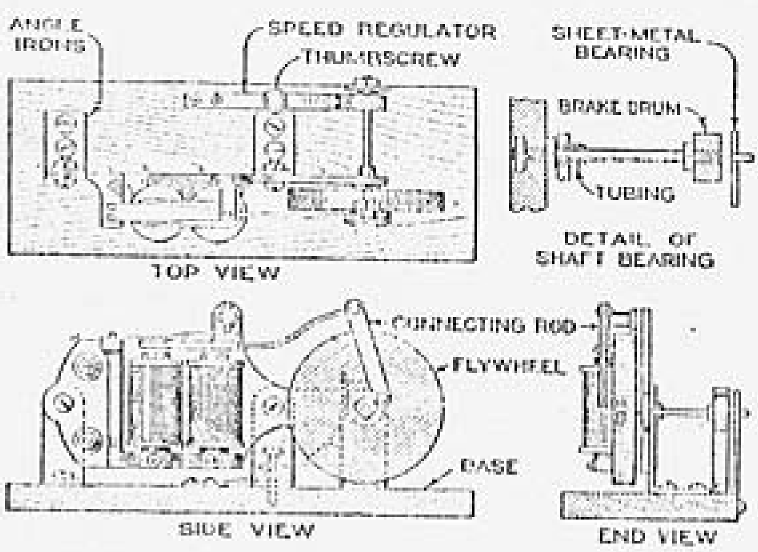
Measure from the threaded hole in the end of the square rod to the switch and bell buttons. Make two iron fingers to conform to these measurements and drill a hole at one end of each for attachment to the rod with a wing-headed screw. A smaller hole is drilled in the lower end of the bell-button finger, to take an adjusting screw and locknut. A washer, or plate, having a square hole in the center, should be attached inside the wall to prevent the shaft from being turned and making the device inoperative. Before attaching the fingers, a light spiral spring is slipped over the rod between them and the wall for returning the knob to its original position for the next caller.

When the knob is pulled outward, the push button is depressed, ringing the bell; the switch button is pressed in, and the porch light is turned on, both at the same time. When the knob is released, the bell ceases to ring, but the light continues to burn. When the call is answered, the top button of the switch is pushed and the light turned off. During the day, the switch finger is turned to one side, permitting the bell to be rung without operating the switch.

THE BOY MECHANIC – 1925

Motor Made from Electric Bell

An entertaining and instructive electric motor can be made from an ordinary electric doorbell, and while it is not at all



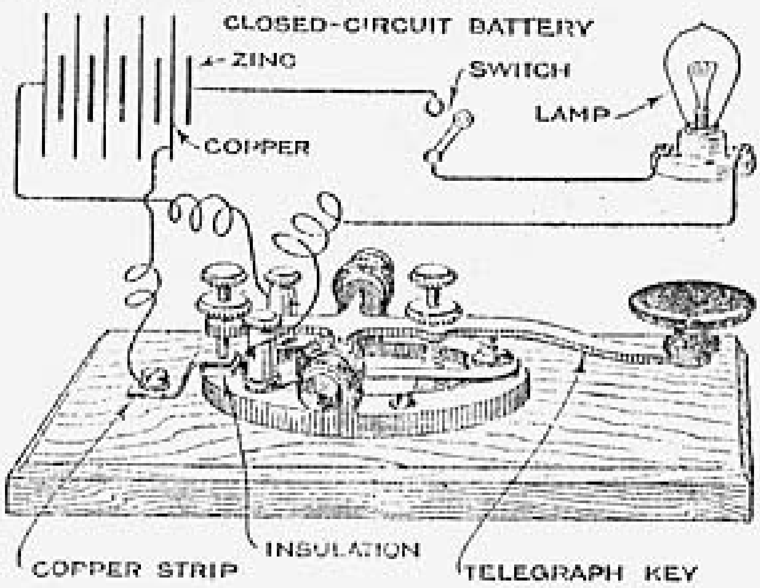
An Ordinary Electric Doorbell is Converted into an Entertaining and Instructive Electric Motor by Means of a Few Simple Alterations

powerful, it will run at high speed when properly adjusted. If possible, procure a bell with a wooden back, as such a back is easier to attach to the base. Set the bell on the base, edgewise, with the hammer, or tapper, up, and secure with screws through the base. If a wooden-backed bell is unobtainable, a bell with an iron frame may be attached to the base by using angle irons, as shown in the drawing. Remove the bell and bell post, and substitute a small piece of metal tubing where the post pierces the board; in the case of an iron-frame bell, a hole will first have to be drilled through the casting. Then cut out a wooden flywheel of about the same diameter as the bell, and run a piece of stiff steel wire through the center for a shaft; this wire should be of a size to fit easily in the tube. The other end of the shaft is supported by a sheet-metal bearing, fastened at the rear of the base and drilled with a hole, near the top, to accommodate the shaft. Rivet the end of the shaft slightly to prevent it from pulling out, or drill a hole through it and insert a pin, or piece of wire. Before setting the shaft in place, a brake drum made from a small spool, or disk of wood, is forced on in the position shown. Then arrange a strip of spring brass to the base, so that it will not quite press against the brake drum; a thumbscrew may be added for holding the spring against the drum, if desired. The hammer is next flattened on both sides, and a small hole is drilled through its center; this is then connected to a screw which is placed near the center of the flywheel by means of a sheet-metal connecting rod, as shown. Determine how far the hammer will move when attracted by the magnets, and then place the screw just half this distance from the center of the wheel; it may be possible, by adjusting the tension of the spring, to obtain greater freedom of armature movement. Such a motor will operate on one or two dry cells, and will provide sufficient power to operate small mechanical toys.—L. B. Robbins, Harwich, Mass.

THE BOY MECHANIC – 1925

Improved Telegraph Blinker

The least expensive method of communicating at night, between points within sight of each other, is by blinker telegraph; a system whereby a miniature electric lamp, mounted on a housetop, tree,



By Means of the Apparatus Illustrated, an Almost Instantaneous Lighting Effect is Obtained, Enabling Signals to be Rapidly Sent

or other elevated location, is "blinked," in dots and dashes, by an ordinary telegraph key in the house, or from any position where the operator may keep the light of the distant station in view. Lamps may be bought for a few cents that will not require more than four or five cells to light them. Light in an electric lamp is caused by the current passing through the lamp filament with a little more force behind it than the filament is capable of handling with ease. Naturally, it takes a little time for the current to heat up the filament, as well as for the light to completely disappear after the current ceases to flow. Should the lamp be connected directly in series with the key and battery the signals must be slow, to allow time for the filament to heat sufficiently to make a light. If, however, a single cell is always kept in series when the key is open, the lamp filament will be kept partly heated, although not enough to make a light. This arrangement allows almost instantaneous lighting when the full power of the battery is turned on by depressing the key, and greatly increases the speed of signaling.

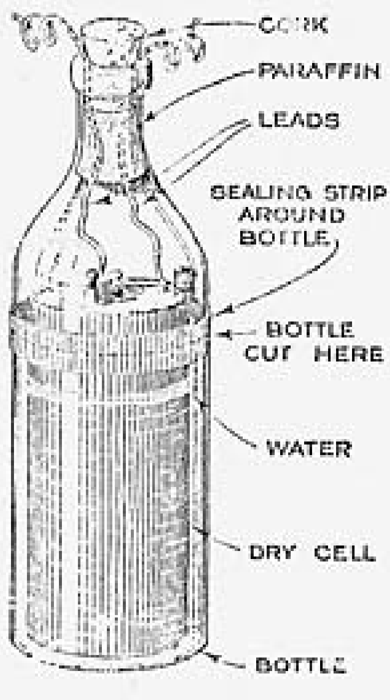
As shown in the drawing, an ordinary telegraph key is used, but a back contact, which consists of a strip of copper, bent to the shape shown, is necessary; this contact is insulated from the key and screwed to the instrument base, as indicated. A wire from the back contact is connected to the copper electrode of a single cell, as shown. When at rest, the key is resting upon the back contact, which allows a relatively weak current from the one cell to flow through the key lever to the lamp and thence back to the cell. When the key is depressed, to make a signal, the back contact is broken and the united strength of the whole battery flows through the lamp, causing it to light.

Closed-circuit, or gravity, cells should be used in this hook-up, and the end cell interchanged with one of the others, at intervals, so that it will not be overworked. Perhaps the best battery for the purpose, and the easiest obtainable, is the familiar "crowfoot," with zinc and copper electrodes immersed in a solution of blue vitriol and water. A switch may be inserted in the circuit, between the lamp and the first cell, so that the latter may rest when the apparatus is not in use.—Samuel W. Beach, Washington, D. C.

THE BOY MECHANIC – 1925

Prolonging Life of Dry Cells

When dry cells are used for doorbells and other intermittent service, they usually dry out before their full energy has been utilized; this is prevented by furnishing moisture, as shown in the drawing. Large glass bottles are cut at the point indicated, either by pouring oil into the bottle to the correct height and plunging a hot poker into it, or by wrapping a string, soaked with alcohol, around the bottle, and igniting it; when the alcohol has burned out, the bottle is plunged into cold water. The lead wires are inserted through the neck of the bottle and separated by a cork, as shown, enough wire being left below for connecting to the cell. The cardboard carton is removed from the cell and several holes are punched through the bottom of the zinc container. The lower half of the bottle is partly filled with water, the battery is connected to the wires and placed inside the bottle which is secured together, at the cut, with a strip of tape or gummed paper.—Thos. W. Benson, Philadelphia, Pa.



How to Build Small Electromagnets

By JOHN A. PRIOR THE BOY MECHANIC – 1925

THE first piece of electrical work to be attempted by most amateurs is the construction of some kind of electromagnet, for such magnets, besides being fundamental to almost every kind of electrical apparatus, are interesting in themselves.

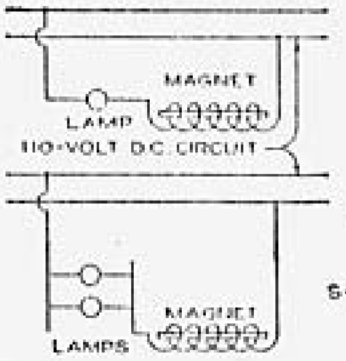


FIG. 1: LOW-VOLTAGE MAGNETS CONNECTED THROUGH LAMP BANK

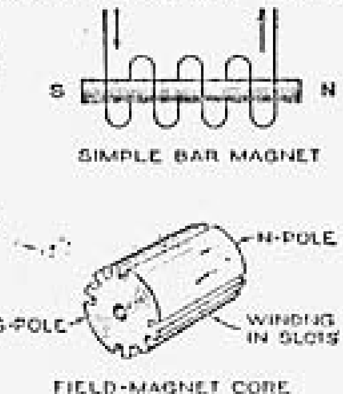


FIG. 2: BAR-TYPE MAGNETS

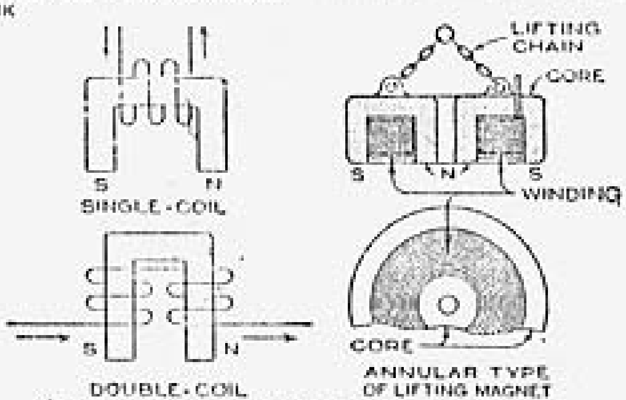


FIG. 3: WINDINGS FOR HORSESHOE-TYPE MAGNETS

Figs. 1, 2, and 3 Illustrate Diagrammatically the Way in Which Magnet Windings are Directed and Shaped

While almost any winding on any iron core constitutes a sort of magnet, far better results are to be had by correct proportioning. It is the purpose of this article to give an idea of what these proportions are, in the smaller sizes of magnets, for low voltages. These magnets can also be used on regular lighting circuits; the making of small magnets wound especially for such high voltages is a tedious proposition.

For use on a direct-current lighting circuit, connect the magnet in series with a lamp of slightly greater normal amperage. For example, the ¼-ampere sizes will operate well in series with a 40-watt lamp, on a 110-volt direct-current circuit, as diagrammed in the upper half of Fig. 1, or on a 220-volt circuit, with a pair of 40-watt lamps connected as shown below. Likewise for the ½-ampere sizes, use two 40-watt or three 25-watt lamps on a 110-volt circuit. All lamps should be of regular circuit voltage.

The general construction of electromagnets is familiar to almost everyone. The essential parts are a soft-iron core, surrounded by a winding of insulated copper wire. The bar magnet is the simplest type and is diagrammed in Fig. 2. Here also is shown a turbogenerator rotor, which is also of the bar-magnet type. For increased power, a magnet core is more often bent into a "U," or horseshoe shape, so that both poles are brought to the load. A few forms are shown, with method of winding indicated, in Fig. 3. The annular form is simply a modification of the horseshoe, often used in lifting magnets. Figs. 4, 5, and 6 show three forms of core suitable for small magnets; the one in Fig. 6, although more difficult to make than the others, gives complete protection to the winding, and is very suitable for a magnet to be used for practical purposes.

A small current in a properly designed magnet will support a heavy weight. It will not, however, exert this force for any considerable distance from the pole faces. A great lifting magnet, capable of handling a 10-ton casting, will not disturb a knife in a pocket 10 ft. away—though it may disturb a watch very seriously. Even the scale on a rough casting may interfere with the ability of a magnet to hold it, and has to be considered in design. Neither can a magnet exert as great a force on comparatively small objects as on larger ones. For instance, a magnet capable of lifting a 20,000-lb. "skull-cracker" ball (such as is dropped some 20 ft. on a scrap pile, to break it up) cannot hold 1,000 lb. of scrap iron.

It will be seen, then, that although a

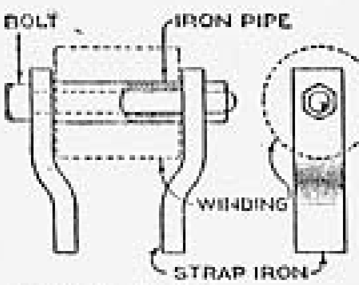


FIG. 4: SINGLE-COIL, HORSESHOE-TYPE

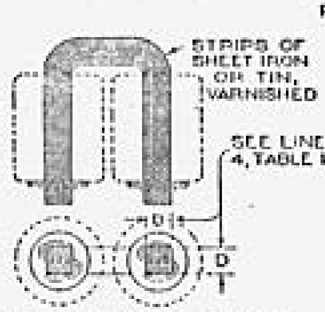


FIG. 5: LAMINATED DOUBLE COIL FOR EITHER A.C. OR D.C.

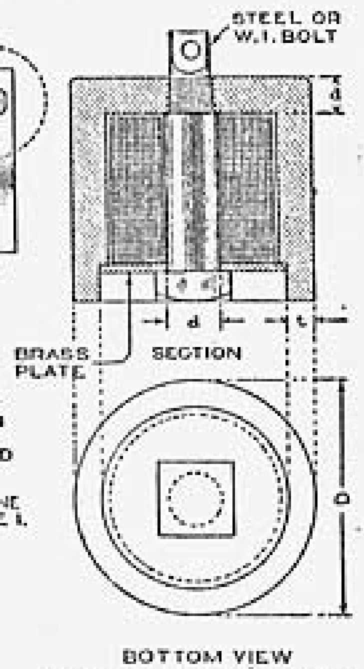


FIG. 6: ANNULAR LIFTING MAGNET DIMENSION t = $\frac{d}{40}$" OR GREATER

Figs. 4, 5, and 6 Show Practical Methods of Construction for Small Electromagnets Operated from Batteries magnet can be designed accurately for a specific purpose, it is impossible to give exact data for one to be used for general duty. Therefore, the data given in Tables I and II must be considered as suggestive, rather than hard and fast. It applies to magnets working under favorable conditions, that is, lifting flat, smooth iron objects, of cross section at least equal to that of the core. Under these conditions, the rated holding power can be obtained. It will be noted that the smaller sizes are less economical of current than the larger, chiefly because of the resistance of the air gap between the poles and the load, which is about the same for all sizes.

Theoretically, a holding magnet does no work, and therefore should consume no power at all. The power used in the actual direct-current electromagnet is all lost in overcoming the resistance of the winding. Therefore, by using sufficient wire of proper size, the current may be made very small indeed. In practice, a balance is struck, determined by practical considerations. In the tables below, to avoid extremely heavy windings, a fairly high value of the current has been taken in the calculations; but it is not higher than can be drawn economically from a battery.

If it is desired to use a different winding and current on any size, it is only necessary that the product of the turns of wire times the current should be the same as that given as ampere turns in

TABLE I.
General Data for Small Electromagnets of Any Voltage

Pull, or Holding Force, in Lb.	2	5	10	20	50	100
Ampere Turns	175	225	300	400	800	1,500
Area of Core (Minimum) in Sq. In.	.04	.1	.2	.4	1.0	2.0
Diameter of Round Core in In.	¼ to ⅜	⅜ to ½	½	¾	1⅛	1½

Note: Pull is calculated for a cast-iron armature of area equal to that of the core; the air gap is assumed, .005 in. for smallest size.

Other core dimensions should be determined to suit the form and size of the windings, making the core as short as convenient.

Table I. For example, the 10-lb. magnet can be wound by either of the two methods in Table II. Both give 300 ampere turns; in one case, ¼ ampere by 1,200 turns; in the other, ⅓ ampere by 900 turns. It would develop the same pull

TABLE II.
For Finding Dimensions of a Winding

Voltage	Holding Power in Pounds	Current in Amperes	Number of Turns in Winding	Gauge of Wire	Diameter of Wire in Decimals of One Inch	Length of Wire Needed
1½	2	¼	700	28	.012	105
	5	¼	900	25	.018	180
	10	¼	1,200	23	.022	300
	10	⅓	900	23	.022	225
3	2	¼	700	31	.008	100
	5	¼	900	28	.012	170
	10	¼	1,200	26	.016	300
	10	⅓	900	26	.016	225
6	2	¼	700	34	.006	100
	5	¼	900	31	.008	170
	10	¼	1,200	29	.011	300
	10	⅓	900	29	.011	225
	20	⅓	1,200	26	.016	425
	20	½	800	26	.016	280
12	10	¼	1,200	32	.008	300
	10	⅓	900	32	.008	225
	20	⅓	1,200	29	.011	425
	20	½	800	29	.011	280
	50	½	1,600	24	.020	850
	100	1	1,500	21	.028	1100

with 1 ampere and 300 turns, or .1 ampere and 3,000 turns. So one can suit himself in the matter of windings, given sufficient wire, and patience in winding it on. The core is the same in any given size, whatever the winding.

The windings are best made up of cotton-covered magnet wire; in fact, this is about the only form in which such small sizes of wire can be had in most places. Rather than wind directly on the core, it is better to make up the winding on a false core of wood or paper, wrapping it with tape before placing it on the iron core. The winding may be made up in two coils, if desired.

The core may be of any shape of section, but where the coils rest upon it, it should be round or nearly so, or a waste of wire will result. In any case, its area should be at all points equal to, or greater than, that of the round core listed in the table. Other dimensions are made to suit the winding.

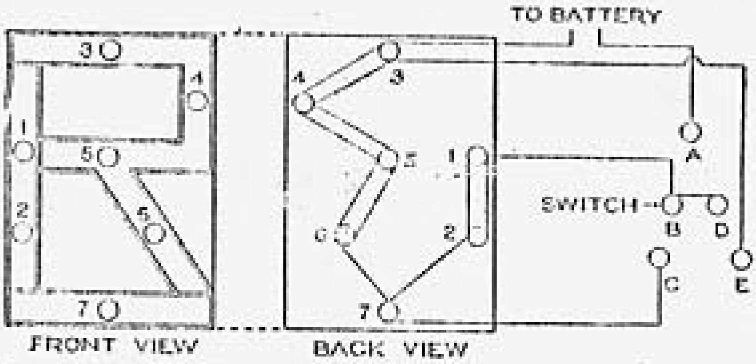
These magnets will operate, after a fashion, on alternating current, if the voltage is high enough, but will heat up from core losses. This heating can be much reduced by making the core of iron wire, or of a bundle of sheet-iron strips, insulated with paper or varnish, as shown in Fig. 5. To get sufficient voltage it will be necessary to connect through lamps to the lighting circuit, exactly as outlined above. It will be impossible to get as much holding power as can be had with direct current, without overheating.

Closely allied with the subject of electromagnets is that of solenoids, for use with a core which is to be pulled into the coil, thus operating some mechanism. Such cores necessarily have a large air gap; that is, there is no nearly complete magnetic circuit of iron, as in a horseshoe magnet. For this reason, it is hardly possible to give very definite data for the pull to be expected from a certain winding. The table will give suggestions for the windings of such solenoids, though the pull will of course be much less than that given for magnets. In general, the pull depends on the cross section of the core and the ampere turns of the coil, so that a greater pull can be obtained by increasing either factor. For best operation, however, a reasonable proportion should be maintained between the two. With a solenoid and plunger, a motion of an inch or more is readily obtained, though this involves, of course, a corresponding reduction of the pulling force.

THE BOY MECHANIC – 1925

Automobile Direction Indicator

A direction indicator for automobiles, for use at night to show a following driver the intentions of the driver of the



An Electrical Direction Indicator Which Shows the Driver of a Car Following the Intention of the Driver to Turn to the Right or Left

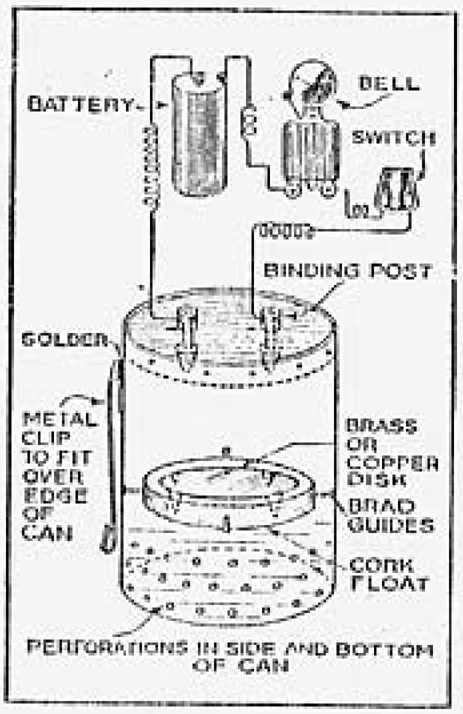
car, is easily made and attached to any car with an electric-lighting system. The indicator shown is an electrically illuminated combination of the letters "R" and "L," with a switch on the dash or on the steering wheel.

The letters are formed by troughs about 1 in. wide and ⅛ in. deep, and painted white, to reflect the light from the small electric lamps which are mounted in them, as shown. The entire monogram should be about 3 by 4½ in. When lamps 1, 2, and 7 are lighted, the "L" will be illuminated, and when lamps 1, 2, 3, 4, 5, and 6 are on, the "R" will appear; these results are obtained by throwing the switch lever to the right or left. The switch lever is fastened at A, and when thrown to the left, makes contact with B and C. By tracing out the circuit, it will be seen that this will light the "L." In the same manner, when the switch lever is thrown into contact with D and E, the "R" will be lighted.—Alton D. Spencer, Columbus, Ohio.

THE BOY MECHANIC – 1925

Alarm Prevents Overflowing of Ice Box

An effective alarm that can be attached to or detached from the drip pan of an ice box without danger of affecting its operation is made as shown in the drawing. An ordinary tin can is obtained and one end is cut away, close to the edge, and the bottom and lower part of the can are perforated to permit water to enter. A large, flat cork, of smaller diameter than the can, is obtained and given a coat



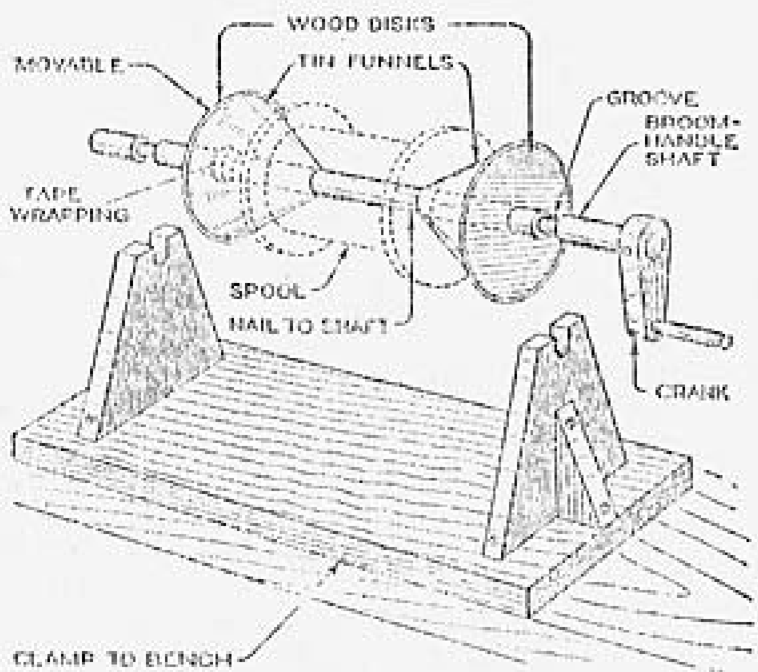
of shellac, or melted paraffin, and four wire brads are inserted at diametrically opposite points, as guides. A brass or copper disk is made as shown, with four or more points around the edge, which are driven into the cork. The top of the can is closed by a disk of wood that has been waterproofed by dipping in melted paraffin; this disk contains the binding posts, the lower ends of which establish a circuit, when the water level in the pan floats the metal-surfaced cork to the proper height. A metal clip, to hold the device to the side of the pan, may be soldered to the side, as indicated, or it may be merely set in the pan. This alarm is intended to be used in connection with the simple bell circuit shown.—Geo. E. Perkins, S. Bound Brook, N. J.

THE BOY MECHANIC – 1925

Winding Hollow Wireless Coils

The radio fan's enthusiasm for making his own apparatus does not begin to suffer until he starts winding coils on hollow cores. With the assistance of the winder shown in the drawing, coils of almost any length and diameter can be quickly and neatly wound.

A piece of old broom handle makes a suitable shaft, and grooves are cut about 3 in. from each end to fit into the endpieces of the support. Two tin funnels are obtained, and the tips are cut off so they will slide onto the shaft; one of these funnels is nailed in place on the end



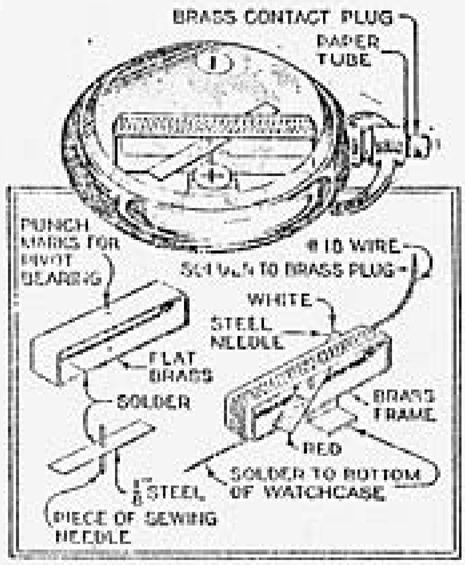
A Coil-Winding Machine That Simplifies the Wireless Fan's Job of Winding Hollow Coils: The Apparatus Is Inexpensive and the Results Satisfying

where the crank, or pulley (if power is to be used), is to be attached. The other funnel moves freely on the shaft, and can be removed entirely. A wooden disk with holes at the center is attached inside the large end of each funnel, for rigidity. A simple support is made, such as the one shown in the drawing, with the endpieces a suitable distance apart. In use, the movable funnel is slipped off and the spool is put on; the funnel is then replaced, and pushed up until the spool is held firmly in place between the two funnels, as shown. The movable funnel is held in place by wedges, or by a wrapping of tape around the shaft, and the winding is proceeded with in the usual manner.—James B. Keller, Alexandria, La.

THE BOY MECHANIC – 1925

To Make a Watchcase Galvanometer

A convenient galvanometer and pole tester may be made from an old watchcase. A strip of brass, about ¼ in. wide, is bent to form a narrow rectangular frame, the ends of which are soldered after two punch marks have been made as bearings for the needle. A short crosspiece is soldered across the bottom, as shown, for soldering to the watchcase. Wind the frame with from four to eight turns of No. 18 gauge bell wire. The needle is made from a strip of ⅛-in. steel, which is drilled at the center and soldered to a short piece of an ordinary sewing needle for a pivot. When finished, the needle is sprung into place with the ends of the pivot resting in the bearings made by the punch marks. One end of the needle is painted red and the other white. The winding stem is removed from the watch, and its place is taken by a tight-fitting brass plug, insulated from the watchcase by a paper tube. The brass frame and one terminal of the coil are soldered to the bottom of the watchcase, the other terminal to the brass plug. Test the instrument with a dry cell and, underneath the glass, paste, at diametrically opposite points, two small pieces of paper marked with the conventional positive and negative signs, as indicated by the side to which the red half of the needle turns.

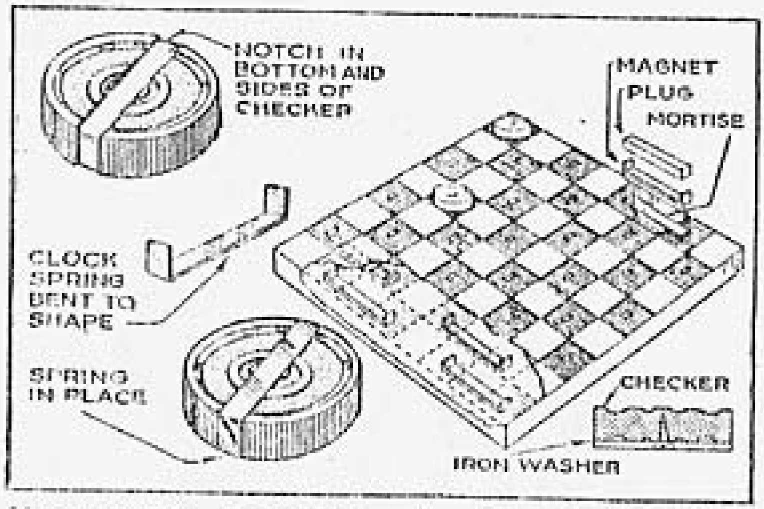


The first passage of current through the coil will magnetize the needle. Sudden application of current, or heavy currents, without suitable resistance between the source and the instrument, are likely to reverse the polarity of the needle and make readjustment necessary.

THE BOY MECHANIC – 1925

Magnetized Checker Men

Anyone who has played checkers knows how easy it is to have the pieces become disarranged, usually at the most interesting point of the game. Two methods of preventing this are illustrated in the accompanying drawing. One of these ideas



Magnetism is Called Upon to Prevent Chess and Checker Men from becoming Disarranged on the Board

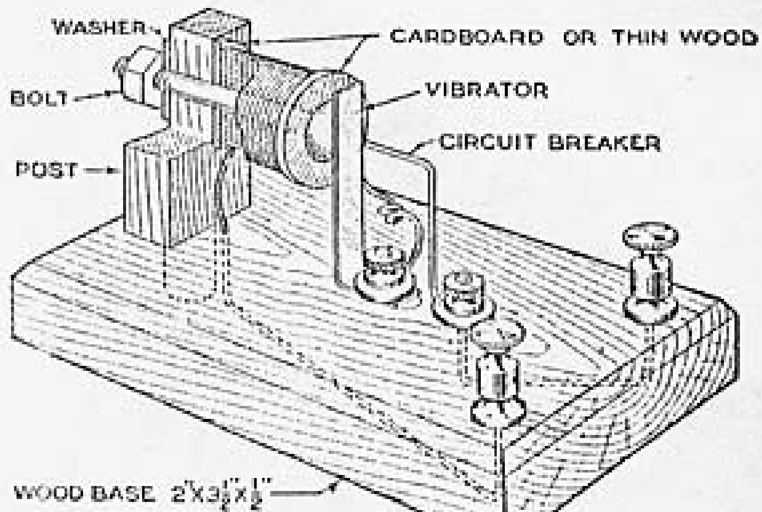
requires small magnets made from clock spring, which are attached to the bottom of the checker men. A metal board is required. Three or four of the checkers are clamped in a vise, and grooves are filed on opposite edges and one side, as shown. Some pieces of clock spring of good thickness, but not more than ¼ in. wide, are cut into pieces of the proper length and bent to fit neatly and snugly into the filed grooves, and flush with the face of the checker. These pieces are magnetized by bringing them into contact with an ordinary horseshoe magnet. The checkerboard used with these checkers may be an ordinary board with a covering of galvanized iron, or tin plate, on which the squares are painted. Chessmen are fitted with magnets in the same manner as checkers.

The second idea is to imbed the magnets in the checkerboard, and is to be preferred, for the reason that heavier magnets may be used, which makes them stronger and longer-lived. As shown in the drawing, mortises are cut into the board so that the ends come at the centers of two black squares. The magnets are formed and magnetized in the manner described, and put in place, after which the opening is plugged up with wood to match the rest of the board. After all the magnets have been put in place, the surface of the board is finished smooth, so that the ends of the magnets will just come flush with the top. The checkers are held to the magnets by means of soft-iron washers which are attached to one side with small screws, as indicated.

THE BOY MECHANIC – 1925

Simple Homemade Buzzer

A small, though satisfactory buzzer can be easily made by the young electrician from a few odds and ends of metal and several yards of wire. A hardwood block is provided for the base, and a hole is drilled at one end for the post which supports the coil. The wire is wound around an ordinary bolt, as shown, the flanges at the ends being made from heavy cardboard or thin wood. A hole is drilled through the wooden post, and the coil is attached to it by screwing a nut on the threaded end of the bolt core. The vibrator is a strip of tin, fastened to the base with a binding screw from an old dry cell. The circuit breaker, or interrupter, is bent from a piece of heavy copper wire, attached to the base by one of the binding posts, which have been



Simple Electric Buzzer for the Young Electrician, Made from Easily Obtainable Parts

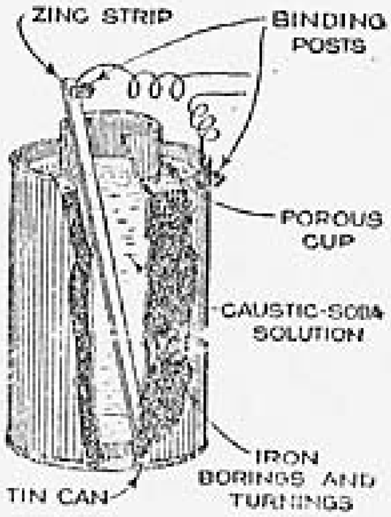
taken from dry cells. The manner of connecting the wires is clearly shown in the drawing. The tone of the buzzer is regulated by moving the circuit breaker closer to or farther from the vibrator, and with a little experimenting a satisfying buzz will be obtained.—Chas. Martin, Warner, Alta.

 GRANDDAD'S ELCTRICITY BOOK

THE BOY MECHANIC – 1925

A Cheap Wet-Battery Cell

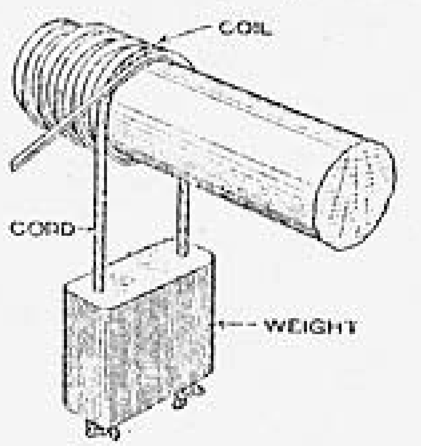
The high cost of dry cells has encouraged many to make and use homemade cells of various kinds, and the one described has the merit of cheapness and efficiency, as well as long life. For the battery jar, an old can, about 6 in. high and 4 in. in diameter, is used. A porous cup is required, and this is made by rolling a strip of blotting paper around a stick, 1½ in. in diameter, and securing the ends with melted paraffin. The bottom of the cup is made by standing it on a smooth surface which has been greased with vaseline, and pouring in plaster of Paris, or melted paraffin, to a depth of about ½ in. When completed, the porous cup is stood in the center of the can, the outside space is filled with chips, borings, and turnings of iron, and a strip of zinc is placed inside the cup, as shown in the drawing. The battery solution is made by dissolving caustic soda in water until it will take up no more; a saturated solution, in other words. The cell is filled with this solution to within an inch of the top, and connection is made with the zinc strip and the can by means of binding posts, as shown. Owing to the caustic character of the battery solution it should not be allowed to come into contact with the skin or clothing. Such a cell has a voltage of about 1.2, and will deliver approximately two amperes on short circuit, depending on the purity of the chemicals and the fineness of the borings and turnings. The internal resistance of these cells is high, and best results are obtained by connecting a battery of them in parallel, if a large amount of current is required. However, one or two such cells will give good results for light service, such as a doorbell circuit.



THE BOY MECHANIC – 1925

Spacer for Coil Winding

When winding coils for electric heaters, where the turns of wire are required to be evenly separated from each other, considerable care is necessary to make the separation uniform. A piece of cord, the same thickness as the space required between the turns, and a small weight are used to make the simple device shown in the drawing. Both ends of the cord are attached to the weight and the device is placed on the coil-winding mandrel, as shown, automatically spacing the turns.



THE BOY MECHANIC – 1925

Carbon-Lamp "Kick-Back" Preventer

To protect fixtures and house wiring from high-voltage "kick-backs," and to prevent the lights from blinking when using a wireless-transmitting set connected to the house current, a kick-back preventer is a necessity. Such a device may be made up of a number of carbon

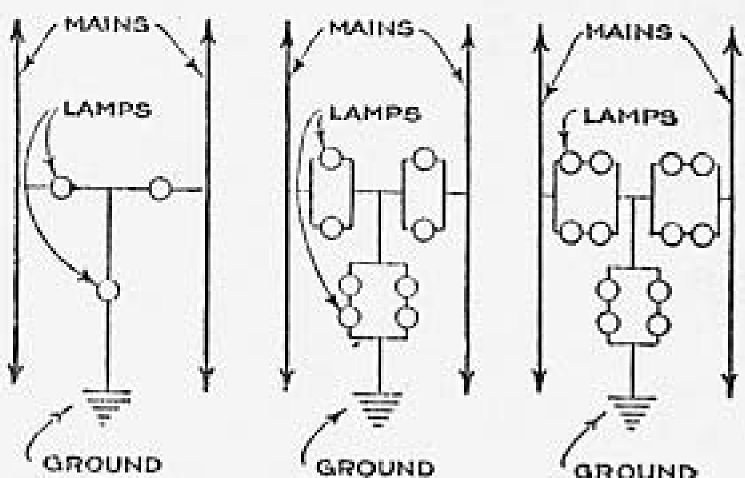


Fig. 1 Fig. 2 Fig. 3

Carbon-Filament Incandescent Lamps, Connected across the Supply Line and Grounded at the Center, Protect against High-Voltage Surges from Wireless Transmitters

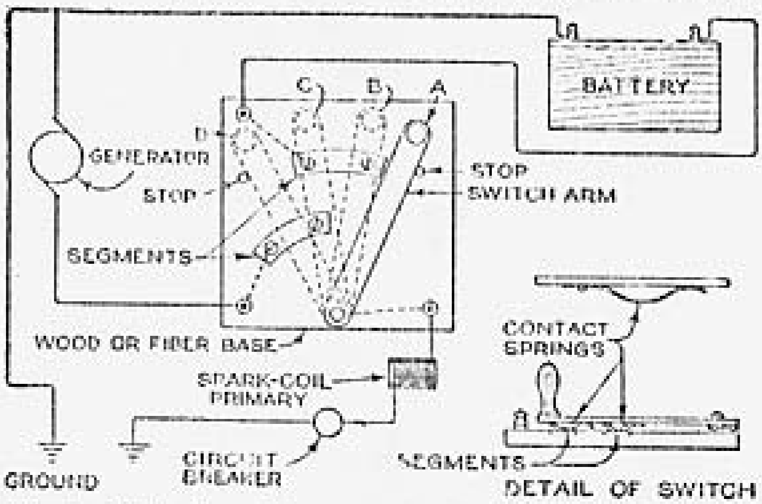
lamps connected across the power line and grounded at the center, as shown in the drawing.

Two carbon lamps are connected across the line, the connecting wire between the lamps being grounded through the third lamp, as shown in Fig. 1. This arrangement will give sufficient protection for low powers. In Figs. 2 and 3 are shown diagrams of preventers that have ample capacity for taking care of surge-backs up to the maximum voltage used by amateurs. Carbon lamps are used because they will carry heavy overloads.

THE BOY MECHANIC – 1925

Switch for Battery Charging on Motorboat

To prevent the storage battery from exhausting itself through the generator



Simple Switch to Prevent the Storage Battery from Exhausting Itself, for Motorboat Circuits Where Both Generator and Storage Battery are Used

windings when the engine is stopped, the simple switch shown in the drawing will be found to work successfully on motorboat circuits where the combination of generator and storage battery is used.

The switch base is made of wood, fiber, or other nonconducting material. A switch lever is pivoted to the bottom with a small bolt, and wired to a binding post at some convenient point. Two segments of copper, or brass, shaped to follow the sweep of the lever, are fastened to the base with countersunk screws. Each segment is connected to a binding post. The storage battery is connected to the upper segment; the generator, or dynamo, to the lower one, and the switch lever to one side of the ignition circuit. The wiring is completed as shown. Light spring-brass fingers are riveted to the underside of the switch lever, to bear against the segments and insure good contact.

When the switch is placed at A, all circuits are open. At B, the battery is thrown into the ignition circuit so the engine may be started; at C, after the engine is running, both battery and generator are in the circuit, and the generator will charge the battery. When the battery is sufficiently charged, place the lever at D, which cuts out the battery and runs the engine from the generator alone. To stop the engine, push the lever back to A; this not only cuts out the ignition circuit but disconnects the generator from the battery as well, and prevents the passage of current.

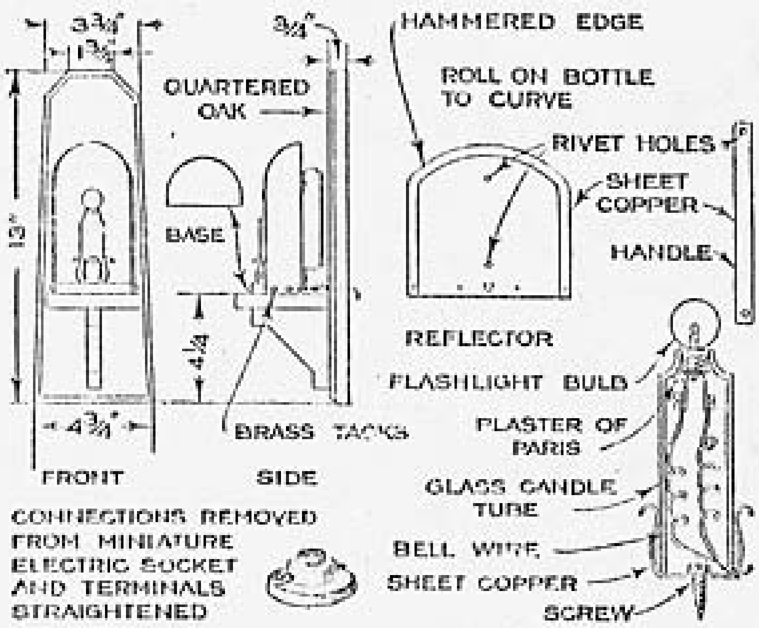
A pin stop at each side of the switch base prevents the lever from dropping over too far.

THE BOY MECHANIC – 1925

Electric Candle Sconce

The electric candle sconce shown in the drawing enabled a storekeeper who had become partly deaf to enjoy the comforts of his private rooms while at the same time attending to the store, which was connected with his home.

The sconce will require a glass candle tube, which can be obtained from electric shops, and a miniature bulb, the two being combined as shown in the drawing. The metal parts are removed from the porcelain base, and the terminals are straightened parallel with the socket. The wires are attached and the socket is fastened inside the candle tube with plaster of Paris or melted sealing wax. The candle tube is held to its semicircular



A Deaf Storekeeper Made This Electric Sconce Which Lights When the Door of His Store is Opened

Model Engineer

AND

Amateur Electrician.

A JOURNAL OF MECHANICS AND ELECTRICITY FOR AMATEURS AND STUDENTS.

EDITED BY PERCIVAL MARSHALL, A.I.MECH.E.

VOL. I. NO. 3. Vol. I.—1898. PRICE TWOPENCE.

London:

PUBLISHED FOR THE PROPRIETOR BY

DAWBARN & WARD, LIMITED,

January, 1898. 6, FARRINGDON AVENUE, E.C.

The New Wireless Telegraphy.

Some Interesting Experiments for Amateurs.

By LESLIE MILLER, A.I.E.E.

WHEN amateur electricians read in the daily papers that a special grant of money was asked for in Parliament for carrying out the experiments with Marconi's apparatus for signalling without line wires, and that a skilled staff had all the resources of the British Post Office at command, they probably thought trials on their own account were out of reach. The object of this paper is to prove this is not the fact; that the apparatus employed is of a character easy to construct, and experiment with, though it may be difficult to understand exactly the causes that produce visible results. To any one with a properly constituted scientific mind, the mode of action of a pistol that carries ten yards is just as interesting as that of a field gun with a range of ten miles. The two are essentially the same, though the latter is best for booming purposes. The reader of this can signal without line wires all over the house, or down to the bottom of his suburban garden, without a grant from his own pocket of more than a few pounds, even if he does not already possess suitable electrical appliances.

If a man is in a free balloon the only medium of communication between him and the ground must be either the air or the ether. We will suppose him out of earshot, and trust to waves in the ether. There are some ready made to hand, light waves, also a suitable receiver, our eye; but we exclude the use of the heliograph from this paper, also X rays, which could be used over thirty yards for signalling purposes. We will make our own waves by electrical means. As the waves set up by making and breaking a current flowing in a wire, and so creating a current in a neighbouring wire, are long waves which have not been found suitable for practical telegraphy in many circumstances that actually arise, we will proceed to describe how to generate Hertzian vibrations of short wave length, and their action on the best detector of them —a simple thing called a coherer.

In the limits of this paper it is impossible to explain

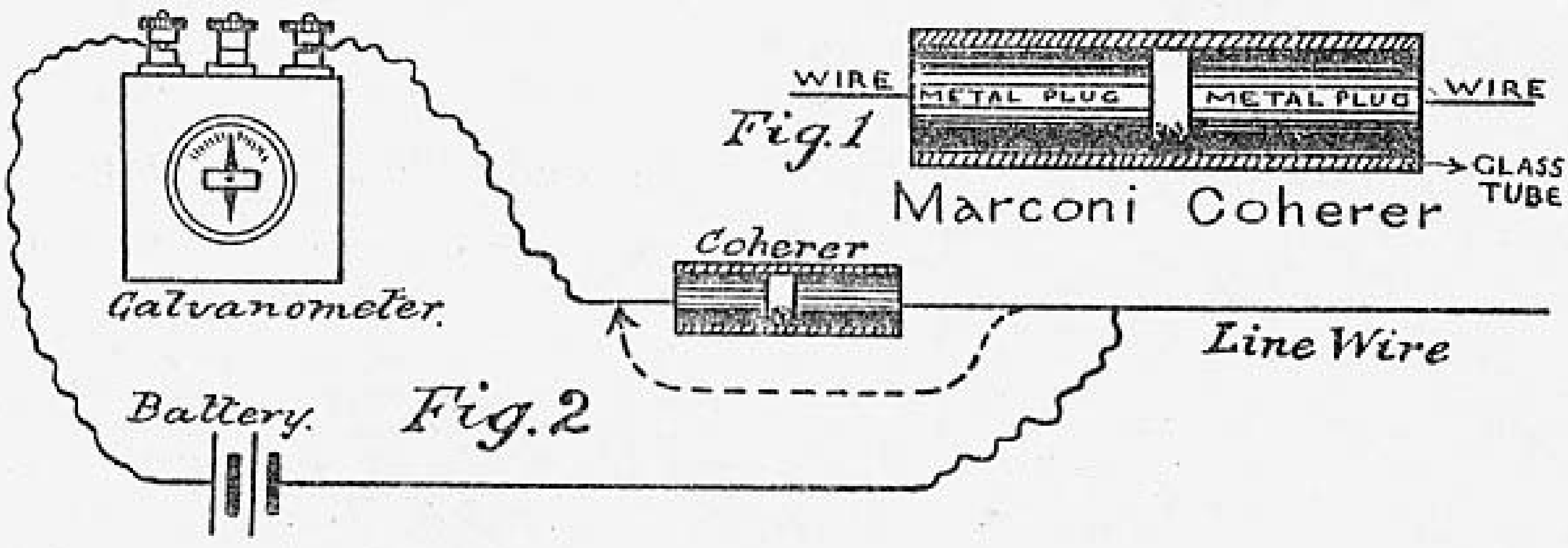


Fig. 1 Marconi Coherer

Fig. 2

with any completeness what Hertz waves are, and it must suffice to say that Clerk Maxwell foretold and Hertz demonstrated that whenever there is an oscillatory discharge of electricity between two conductors, waves are set up in the ether at right angles to the line of the discharge. These waves all travel at the same rate, which is that of light waves, 186,400 miles per second. But the shortest of them are to be counted in millions per second, instead of in hundreds of billions, as in the case of light waves. Professor Lodge is just publishing a new edition of his book, "The Work of Hertz and Some of His Successors," price 3s. 9d., and readers interested in the subject are recommended to buy it and study it.

The essential point about a generator of Hertzian waves is that it must set up an oscillating discharge. No steady leak like that of a charged Leyden jar through a piece of wet string will create Hertz waves. An abrupt discharge must take place, so that the charge will oscillate from one to the other of the discharging bodies. There must be no preliminary brush, therefore all points must be avoided, and the discharge take place between polished balls, or in order to do away with the necessity of frequent polishing between balls immersed in oil or vaseline.

As a sending instrument, therefore, anything which sets up an oscillating discharge can be utilised, such, for instance, as a highly charged cloud giving rise to lightning flashes or a cheap electric bell. The oscillations from the former can be detected when taking place ten miles off, and the latter about two feet. Any electro-magnet, Wimshurst machine, electric gas lighter, induction coil, or Tesla coil, will generate the waves. To detect them is a question of distance and sensitiveness of the receiver, and in the case of long waves of tuning. It is obvious that if the generator keeps the oscillations going steadily for some time, the receiver should be arranged so that it is capable of oscillating in tune. It is difficult to do this, and, therefore, the transmitter should be capable of giving a few violent oscillations which die away at once. Then there will be no need for accurate, or even any, tuning at the receiving end. An induction coil sparking between balls is the best known way of producing the most suitable waves. The diagram shows the arrangement devised by Professors Lodge and Righi respectively. In both cases the wires from the secondary of an induction coil are brought to the two small balls outside. In the Lodge transmitter there is one central ball, and in that of Righi (used by Marconi) two balls. The two latter have the space between them filled with oil or vaseline.

LODGE TRANSMITTER.

MARCONI TRANSMITTER.

Those readers who have induction coils with spark pillars and rods can screw round balls on to the ends of the rods and spark to a large central ball, or to the two balls, in case they are not frightened by Mr. Marconi's patent claims, valid or otherwise. A tubular hole, 2½ ins. diameter, may be left in a square block of paraffin wax cast in a cardboard mould, and one ball forced three parts in from one end and paraffin poured round it from the outside. Then from the other end, a paper tube of the right length to keep the balls ¼ in. apart should be inserted, then a quantity of vaseline, and finally the other ball. When some paraffin is poured round the latter everything is secure and clean.

Any amateur can make this, and it is just as effective as if it were made of ebonite. The distance between the two large balls (4 ins. diameter) mentioned by Marconi as suitable for an 8-in. coil, is 1 25th in. to 1-30th of an inch, and that between the large and small balls 1 inch. The writer is easily able to signal all over the three floors of the building at his disposal, but he has made no tests to find if this could be improved.

To be able to translate the signals sent into space into words at the other end, they must have a definite time interval, representing dot or dash, between them. This is done with a key in the primary circuit of the coil.

Now for the receiving instrument, named by Professor Lodge, a coherer, but often called a Branly tube, after the discoverer of the property possessed by metallic filings or powder of changing from a non-conductor to a conductor when hit by an ether wave, and returning to the non-conducting state when agitated mechanically. These coherers may be made in endless forms, like their near relation, the microphone, and afford a fine field for amateur experiment. The one shown in the diagram (Fig. 1) is the same shape as that patented by Marconi, but instead of the metal plugs in the glass tube being silver, and the powder nickel with 4 per cent. silver and a trace of mercury, I would recommend the plugs and powder to be wholly nickel, or in default of this, of iron. The tube may be exhausted, but the only gain appears to be non-liability to oxidise and freedom from damp. One of the writer's exhausted tubes cracked in use, but no deterioration could be detected, though the fine powder clung to the glass more than before. A 2 to 1 mixture of spelter and iron filings makes a good mixture, but Marconi claims mixtures in his patent!

Another coherer, used on the Continent to detect lightning ten miles off, consists of a brass tube about 1¼ in. long by ⅜ in. diameter, filled loosely with aluminium filings, through the centre of which a platinum wire passes. A single contact coherer, such as the point of a sewing needle resting on a piece of aluminium foil, was found by Professor Lodge to be more sensitive than filings, but not so readily de-cohered, and therefore not so practical. The writer is patenting another form that he has found to work well, together with a new automatic de-coherer.

Returning for a time to our friend in the balloon, we will give him the privilege of using a single line wire between himself and earth. Ask an ordinary telegraphist what good this will be, and he will probably reply that it will be useful as a bell-pull, but will be of no use in telegraphy without a return wire. But he would be mistaken. By means of the simple apparatus shown in the diagram (Fig. 2), the sensitiveness of any coherer may be roughly tested, and by attaching a similar set at the other end of a single line, one-wire telegraphy can be accomplished. Proceed as follows:—

First see that the coherer is in good working order. Shake it up and see that only a trace current flows through the galvanometer. If current flows, in spite of shaking, try the effect of taking one cell away; if it still conducts, remove one electrode a little further away from the other, so that there is less pressure on the filings. Then short circuit the galvo by touching the two sides with a piece of wire. The needle will, of course, be violently deflected, and, strange to say, *remain deflected* when the short circuit is removed. At the moment when the short circuit is removed, the large current in the galvo coil rapidly dies away and an extra current is produced which has the power of breaking down the resistance of the coherer. It may be restored to its non-conducting condition by a tap so as to agitate the powder and the needle goes back to zero. This is a simple but most important experiment, and one that requires more time for investigation than the writer has been able to give it. When I found that the resistance of the coherer was broken down just the same when connected not directly to the galvo but through ten miles of wire (the secondary of an induction coil), I began to be astonished, and the feeling increased when I found it still acted when I substituted a P.O. resistance box for the coil with *the infinity plug out.*

It should be noted that there was little capacity in the circuit, but, bearing in mind the feebleness of the generator, it proves the marvellous sensibility of the coherer. A telephone would have been quite silent.

It is a return to the static telegraph of Ronalds, and any reader who has an acquaintance who can put up an electric bell, and thinks he knows all about electricity, will be able to confound him with this experiment.

Lately, Mr. A. C. Brown has stated that signals can be sent many hundreds of miles along a naked cable lying at the bottom of the sea and received on a coherer. If the end of the line wire shown in the diagram be attached to any part of the gas or water pipes of a house, and some other part of the pipes be sparked at with a coil, the coherer will be broken down.

Someone having the opportunity can try a railway line instead of a gas pipe and signal to a moving train. Mr. Brown has suggested, and I believe patented, a number of applications of the coherer and many other investigators are at work. It will soon be time for the company promoter to commence operations, and it will not be Professor Branly who will benefit financially by his discovery of the coherer.

Returning more directly to wireless telegraphy, readers should try the effect of any apparatus they may happen to have in their possession as generators of the waves. An induction coil or a Tesla transformer is best, but a Wimshurst machine, an electric gas lighter, a magneto generator for ringing bells, any electro-magnet or coil of wire with many turns, will act on a properly made coherer across an air space. It is only a question of distance. With my own 6-in. induction coil as transmitter, it is possible to ring an ordinary cheap electric bell when it is placed directly in the circuit shown in the diagram up to about three yards off, but with the help of a relay anywhere about the building, and doubtless much further. A coherer should respond to the spark of an ordinary electric bell up to 2 ft. or more away. For working over long distances a very high vertical wire is fixed to one pole of the induction coil, and the other pole earthed. A vertical wire of the same height is also fixed to the coherer at one end, and the other earthed. Marconi was the first to clearly demonstrate the great gain of this. Professor Slaby, in Germany, has found that Hertz waves get a lift on the road by any telegraph wire that may be in the direction of the line of progress of the wave, and also that a Hertz wave telegram may travel along the outside of wire at the same time that an ordinary telegraphic current is flowing in the inside.

In order to decohere a tube automatically the current through it must work a relay that controls an electric bell, the hammer of which hits the tube.

All an amateur electrician need trouble about is to obtain a good swing of the needle on an ordinary detector galvanometer, and a sure return to zero. He then knows that by substituting only a moderately sensitive relay for the galvo, he will be able to ring a bell, fire a fuse, or work the usual telegraphic apparatus in the local circuit if he cares to do so.

Finally, a few words as to patents covering the ground. The Lodge transmitter is quite clear, and various arrangements of balls have been used before Marconi; also oil between them. Coherers of numerous shapes are also quite clear; of course not the actual one patented by Marconi. The automatic tapper is claimed by Marconi, but was used by Professor Lodge some time previously to his patent, and also by R. Popoff in St. Petersburg. Since the nineteen claims of Mr. Marconi's patent were worded, evidence has come to light which proves that every one of his ideas have been more or less anticipated in various parts of the world without his knowledge, but he has, in sporting language, forced the pace, and done good work for which he deserves to benefit. There are also other recent patents covering applications of the coherer, &c., most of which are not yet published.

How to Make a Useful Bichromate Battery.

By CECIL M. HEPWORTH.

ONE of the simplest, and at the same time one of the best electric batteries for experimental work, is that known as the single-fluid bichromate of potash cell. It is very energetic, for it yields a higher voltage than any other practicable form of primary battery, and

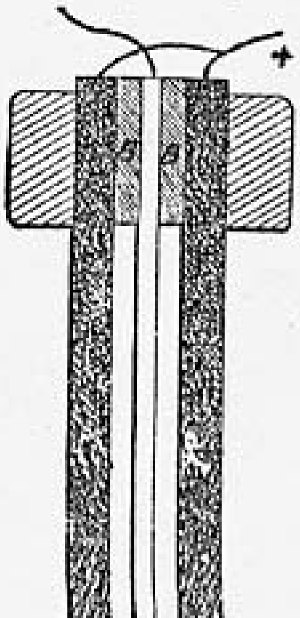


FIG. 1.

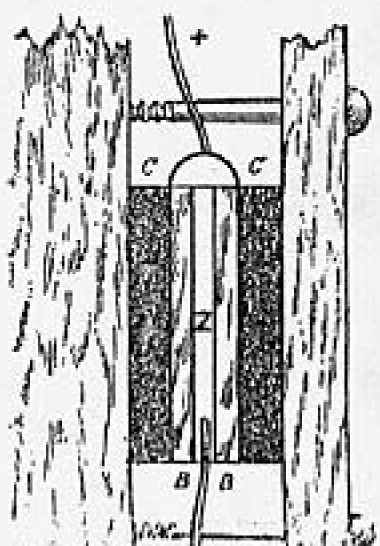


FIG. 2.

made on the plan which I am about to recommend, is quite inexpensive, and will, with ordinary care, last for years.

It consists essentially of a zinc plate A (see Fig. 1), on either side of which, but insulated from it by pieces of non conducting material B B, are two plates of carbon, C C. A wire in connection with the zinc forms the negative terminal, while two others from the two carbons unite to form the positive. If we immerse the lower half of an "element" thus constructed in an exciting fluid—or

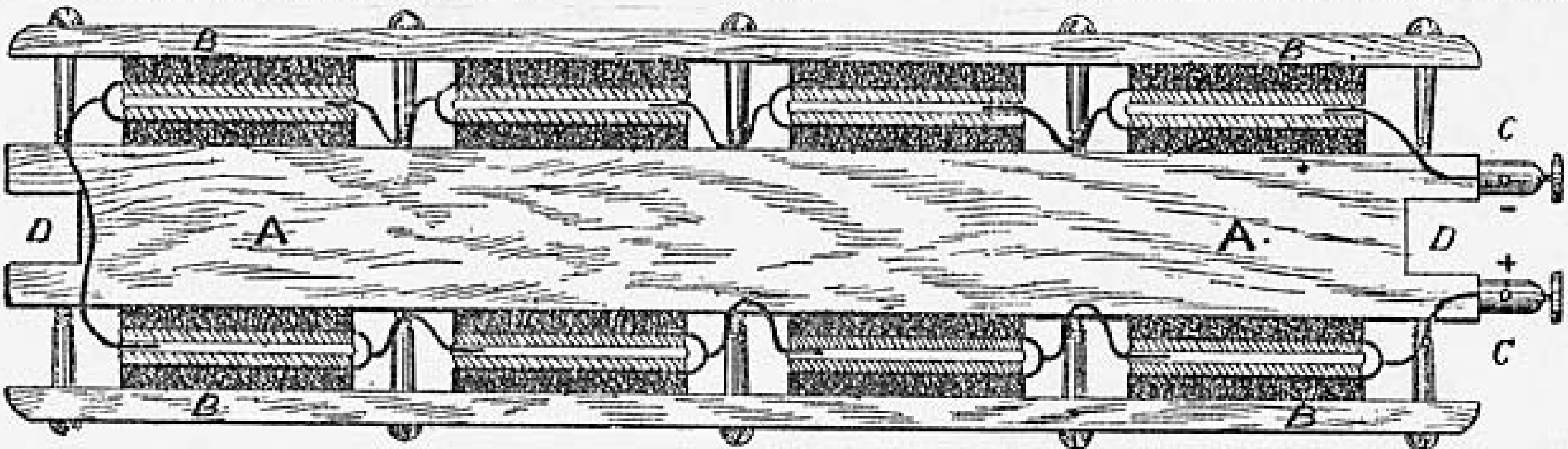


FIG. 3.

"electrolyte" as it is more properly called—consisting of eight parts of a saturated solution of bichromate of potash to one part of sulphuric acid (oil of vitriol), we shall find that nothing will happen while the conducting wires remain separate, but that when these are connected together a current of electricity will be generated. When I say nothing will happen while the wires do not touch, that is theoretically correct, and would be so practically also, if the zinc were chemically pure, but as it never is, minute particles of carbon and iron, present on its surface, set up an incessant local action, which will gradually destroy it, while quantities of hydrogen gas will be given off.

To obviate this waste of zinc and exciting fluid—which are always spoiled together—the zinc plate must be amalgamated with quicksilver or mercury, the purpose of which is to smother these energetic particles as it were and prevent them setting up such independent electrical action, while at the same time it allows the legitimate action of the cell to go on undisturbed. Apply the mercury to the zinc—which must be previously cleaned with dilute acid—by means of a piece of rag, rubbing it in well until its surface presents a bright silvery appearance. This will, to a great extent, prevent this tiresome local action by covering up the electro positive particles, and thus rendering them powerless. Of course, all the time the battery is in use, the zinc plate will be steadily eaten away in direct proportion to the strength and duration of the current.

But the protection of the mercury would be soon undermined if the plates were exposed to the action of the acids

FIG. 4.

for any length of time, therefore it is necessary to lift them out of the fluid when the electric current is not required, and herein lies a drawback to this form of battery, because as is easy to see, the mechanism necessary to lift each zinc out of a large battery of several cells would be elaborate and costly, while to take them out separately would involve considerable trouble. For this reason it is usual to fasten the tops of all the elements together, and lift both zincs and carbons out of the cells leaving nothing but the liquid. It is not easy, however, to bind the elements firmly together in such a manner that the carbons are thoroughly insulated from the zincs and from one another—which is a *sine qua-non*—and it generally necessitates costly brass fittings.

It was to overcome this difficulty that I designed the battery which is illustrated in the diagrams shown on this page, and the construction of which I will now describe.

From a cigar box cut out sixteen pieces of wood, each 2 ins. long, by ¾-in. broad, and soak them for a while in hot paraffin wax. These are to form the insulators to keep the zinc plate separate from the carbons, as shown in Fig. 1, in which B B are the insulators, C C the carbon plates, and Z the zincs, while the conducting wires are distinguished by the negative and positive signs. Procure eight plates of zinc (about ⅛-in. thick), and sixteen pieces of carbon of the usual thickness supplied for battery work, all measuring 3½ ins. long, by 2 ins. broad.

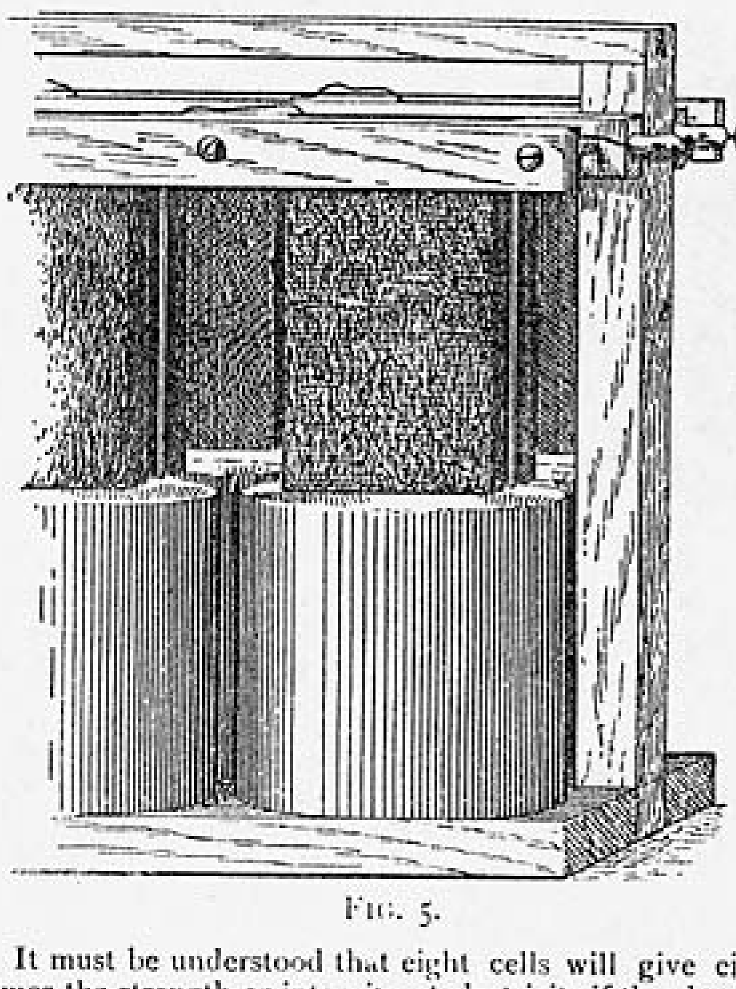


FIG. 5.

It must be understood that eight cells will give eight times the strength or intensity of electricity if they be connected in series, that is to say, the zinc of one cell joined electrically to the carbon of the next, and so on right through, as shown in Fig. 3, where a wire from the carbon of the first element forms the positive terminal, while another from the zinc of the last constitutes the negative.

If all carbons were connected together at one terminal, and all the zincs joined in the same manner to form the other, the battery would yield eight times the quantity of electricity, but its intensity of strength would be only that of one cell. For this reason the latter method of grouping the elements—known as "connecting in parallel"—is only used in those rare cases in which a large flow of electricity at very low potential is required.

In order to make satisfactory connection—which is extremely important—cut out of thin sheet copper eight strips each ¾ in. wide by 7 ins. long. Bend each in the shape of a narrow U, as shown in Fig. 4, and solder at the bend a short piece of copper bell wire, the other end of which is to be affixed in the same way to the zinc plate of the next combination. This arrangement is shown in Fig. 2. Now cut out of ⅞ in. wood—pine by preference—a piece measuring 15 ins. by 3 ins. (AA, Fig. 3), and from ⅜ in. wood cut two slips, BB BB, also 15 ins. long and ⅞ in. broad. Ten iron screws 2½ ins. long will also be required for the purpose of binding the whole together as shown. Each element may now be bound up temporarily with string, taking great care that the various parts occupy their proper position—first the zinc plate in the middle with its insulators on either side, then the copper connecting strip, and lastly the carbons.

Having drilled holes for the screws, lay the wooden piece, AA, face downwards on the table, put the strip BB BB in position, and insert the screws, giving each a few turns, so that the whole hangs lightly together. The eight elements with their string bindings can then be easily inserted, and the screws driven home so that the various elements are held as in a vice. Next remove the string bandages, and connect the two disengaged wires—one from a zinc plate, and the other from a pair of carbons—to the two brass terminals CC, as shown in the diagram, Fig 3, and this portion of the apparatus is then complete. It will be noticed on reference to the diagram that there is a space (DD) ⅞ in. square at either end of the centre board, AA. These gaps are designed to receive the uprights glued to the base board, as shown in Fig. 5, an arrangement which insures that the zinc and carbon elements may be easily lifted out of or replaced in their cells without inconvenience, and the uprights also form a support to the system, which is held in place when not in use by means of a wire spring similar to that employed to keep an umbrella open or closed. When the battery is required for use these springs are simply depressed by the thumbs, and the elements lowered into their respective cells without any trouble. The cells proper, consisting of ordinary one pound jam jars, or gallipots, are, of course, arranged in two rows of four each on the base-board, and they should be about half filled with the bichromate solution, mixed as already described.

My own battery constructed exactly on these lines is, when first charged, quite powerful enough to light a little incandescent lamp of three or four candle power, or it will work a small motor, excite a powerful electro-magnet, or do any other experimental electrical work on a small scale very satisfactorily. It polarises after a time, if used continuously, but with short periods of rest, such, for instance, as it would get between several experiments, it works admirably. It has advantages of extreme portability, coupled with high efficiency, while it is cleanly to use, free from disagreeable smells or noxious fumes, and, most important of all, is very inexpensive, both to make and to use.

Microphones and How to Make Them.

February, 1898.

By F. E. P.

JUST as a microscope is an instrument used to observe very tiny visible objects so a microphone is an instrument used in the observation of minute sounds. But there the resemblance ceases. The microphone, although an exceedingly delicate arrangement, is amongst the simplest pieces of electrical apparatus the amateur can have to make. It is at the same time interesting from a purely scientific point of view, and of very great use in the commercial world.

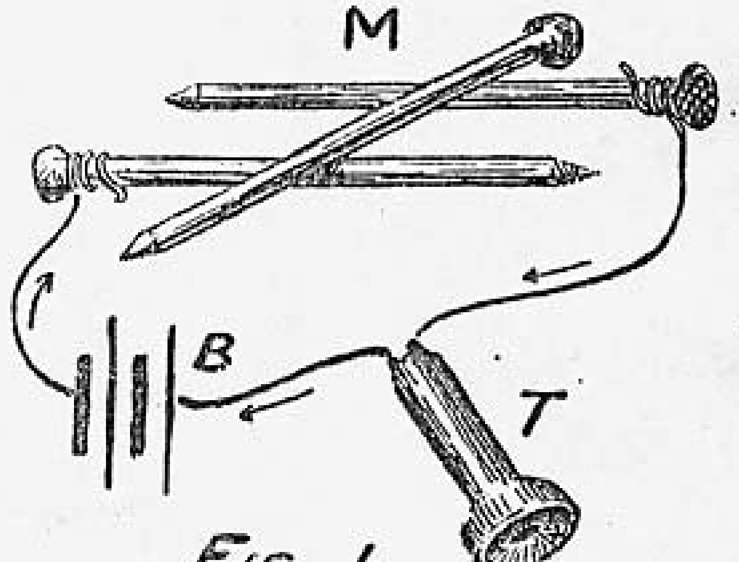


FIG. 1

All microphones are constructed on one principle; the difference between the simplest and the most complex being a matter of structural detail for purposes of strength, convenience, or appearance. The principle is always that a current of electricity is allowed to flow through two conductors which merely touch one another (and therefore offer great resistance to the flow), one or both the conductors being so arranged that the slightest vibration will cause it to press more or less heavily upon the other con-

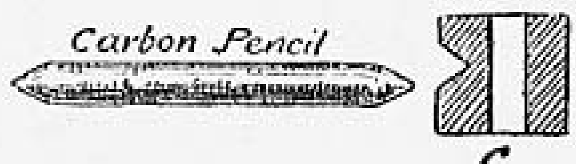
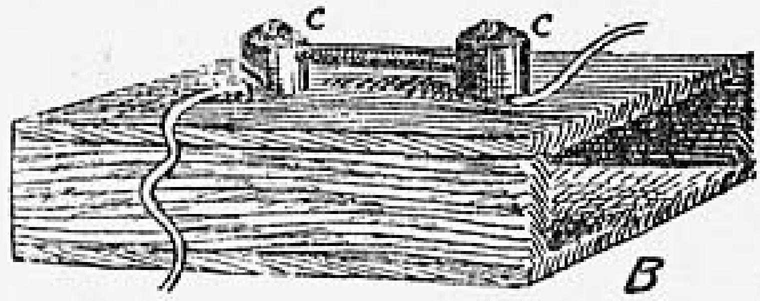


FIG 2



ductor. This variation in the pressure produces a corresponding variation in the strength of the electric flow, which being conveyed through a telephone receiver is made manifest to anyone listening. A sketch of the simplest possible arrangement is given in Fig. 1. The telephone receiver is shown at T, the battery at B, and the microphone at M. This latter consists merely of three wire nails (often known as "French" nails) placed as shown, and was one of the forms of microphone experimented upon by Professor Hughes, in 1878. It will be seen that the electrical current from the battery flows through the microphone by means of the top nail, which bridges the two others. Anything which upsets the very delicate balancing of this nail, and causes a variation in pressure on the bottom nails, produces a sound in the telephone (T) in the manner already indicated. A slight scratching on the table, for example, is reproduced and exaggerated, and the listener can of course be far away from the source of the sounds.

Certain disadvantages are quite obvious in the arrangement already quoted. There is a want of permanency about three French nails, which are liable to be snapped up at any moment for common domestic use. Then, also, it is a well-known fact that all sounds are magnified if a large hollow vessel can be made to vibrate by their aid. This suggests the use of a sounding-box, and Fig. 2 shows a microphone constructed to include these improvements. In this B is a hollow deal box, open at both ends. Upon this are fixed by screws two pieces of arc-lamp carbon (C C), about ½ in. diameter and ½ in. long, a short copper wire being twisted round underneath as a means of connection to telephone and battery (not shown in this sketch). A conical hole is made in each block of carbon, and a short length (1½ in. will do) of smaller carbon, about 3-16ths in. diameter, pointed at each end, rests lightly between the two. The similarity between this and the previous arrangement is apparent to anyone, and every amateur electrician will appreciate the advantages of the carbon contacts over the metal.

Yet another microphone is shown in Fig. 3, known as Locht-Labye's Pantelephone. I made one of these some time ago with a hollow back to act as a sounding-board, and the instrument was marvellously delicate. The construction is simplicity itself. At the top of the backboard is a bar of wood ¼ in. square, and about 5 in. long. At each end is hung a piece of very thin springy brass (such

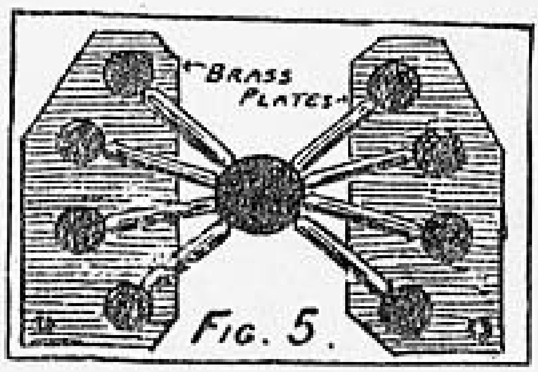


FIG. 5.

as an old stencil plate), 2 in. long by ½ in. wide. These two pieces carry a piece of dry pine 4½ in. wide by 5½ long and ⅛ in. thick, which has glued to it at the middle of the lower end a piece of arc-lamp carbon ½ in. diameter and ⅛ in thick. A small groove is cut in the back of the carbon before glueing it to the board, and when dry, two wires, one going to each brass carrier at the top, are pushed into the groove to make contact. The remaining portion of the apparatus is shown in Fig. 4. It is a bent piece of brass (1-16th in. thick), having a small brass spring soldered to it at A. This spring carries a small platinum contact-piece (similar to that in an electric bell) at P, which is kept in contact with the carbon of the microphone by means of a screw (S). A wire is carried to the battery from the bent brass plate. This forms a most delicate piece of apparatus. The instrument is hung in an upright position against a wall, and conversations can be heard when the talkers are many yards away from it. It is, indeed, too delicate to be spoken to at close quarters; the vibrations are too severe, and the sounds become broken and disjointed, although loud.

The "transmitters" of ordinary telephonic apparatus are, of course, microphones strongly constructed. Their name is legion, but, for the sake of illustration, a simple form is given in Fig. 5. It will be seen that the only important difference is in the number of contacts, which are multiplied both for the sake of ensuring action and in order that all classes of sounds may be equally conveyed. Carbon is used in exactly the same manner as before described, and the contacts are mounted on a thin pine board having a mouthpiece above to direct the sound-vibrations on to the said board.

Every form of microphone described should be made by the amateur worker. They are so simple as to take little time, and the comparison of results is always useful.

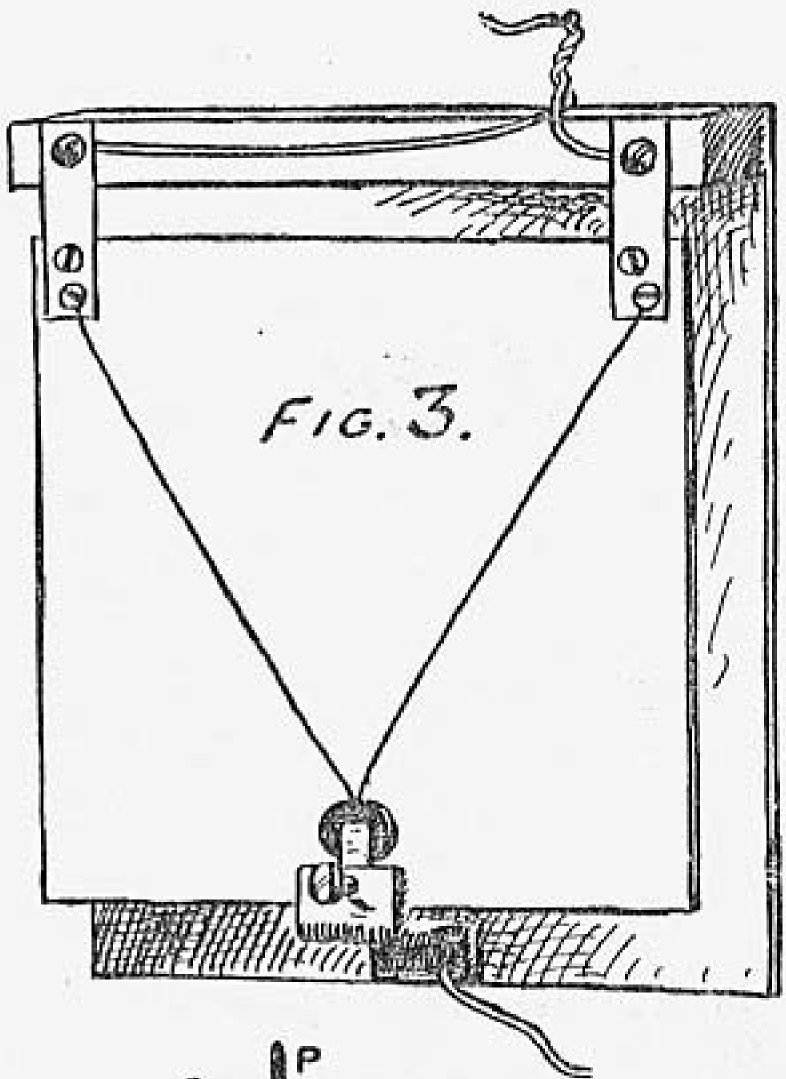


FIG. 3.

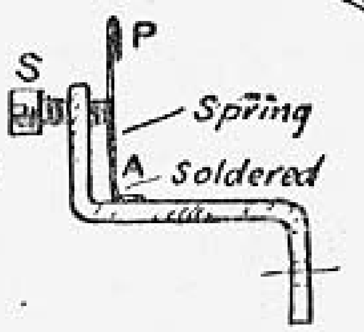


FIG. 4

Your friends cannot help being interested when they hear your watch ticking away loudly, although two or three rooms away. The slightest touch on the microphone itself is magnified, and I once listened for a long time to an imprisoned bee buzzing about the room, its sound varying as it approached to or receded from the instrument. The test is supposed to be the noise of a fly walking upon the sounding-board of the apparatus; but I have, personally, never been able to induce that industrious little creature to exercise himself for my benefit.

How to Make an Electric Cycle Lamp.

March, 1898.

By "ZODIAC."

BY following the instructions given in this article any amateur may construct a first-class electric cycle lamp at a cost of only a few shillings. Should the amateur wish to make an accumulator for any other purpose, such as lighting, coil working, &c., he will find the instructions given to be very useful.

The accumulator will be first dealt with. A two-celled ebonite case will be required, and two pairs of grids (plates) to fit into the cells. The following table will give some idea as to the size required:

FOUR VOLT.

No.	Capacity.	Weight.	Size.
1 A	... 4 hours	... 1 lb. 8 oz.	... 4 × 1 × 3½
2 A	.. 5 ,,	... 1 ,, 9 ,,	... 4 × 1⅛ × 3½
3 A	... 6 ,,	... 2 ,, 8 ,,	... 4 × 1⅛ × 5

Weight is of accumulator only. No. 1 A is rather small for night riding. Each cell will have one positive (+) and one negative (−) plate.

The two positive grids will require pasting with a stiff paste made of red lead and dilute sulphuric acid (one part acid to two parts water). The best way of doing this is to lay the grid flat on a sheet of glass, and press the paste into the perforations (these are wedge-shaped, as in Fig. 1, in order to hold the oxide securely in place) with a horn or wooden spatula. The grid should now be turned over and the other side treated in the same way, after which it must be stood up in a warm room to allow it to dry, for about fifteen hours. Having pasted and dried both plates, the next thing is to place them in a very strong solution of chloride of lime. This will form lead peroxide, and save the trouble of "forming."

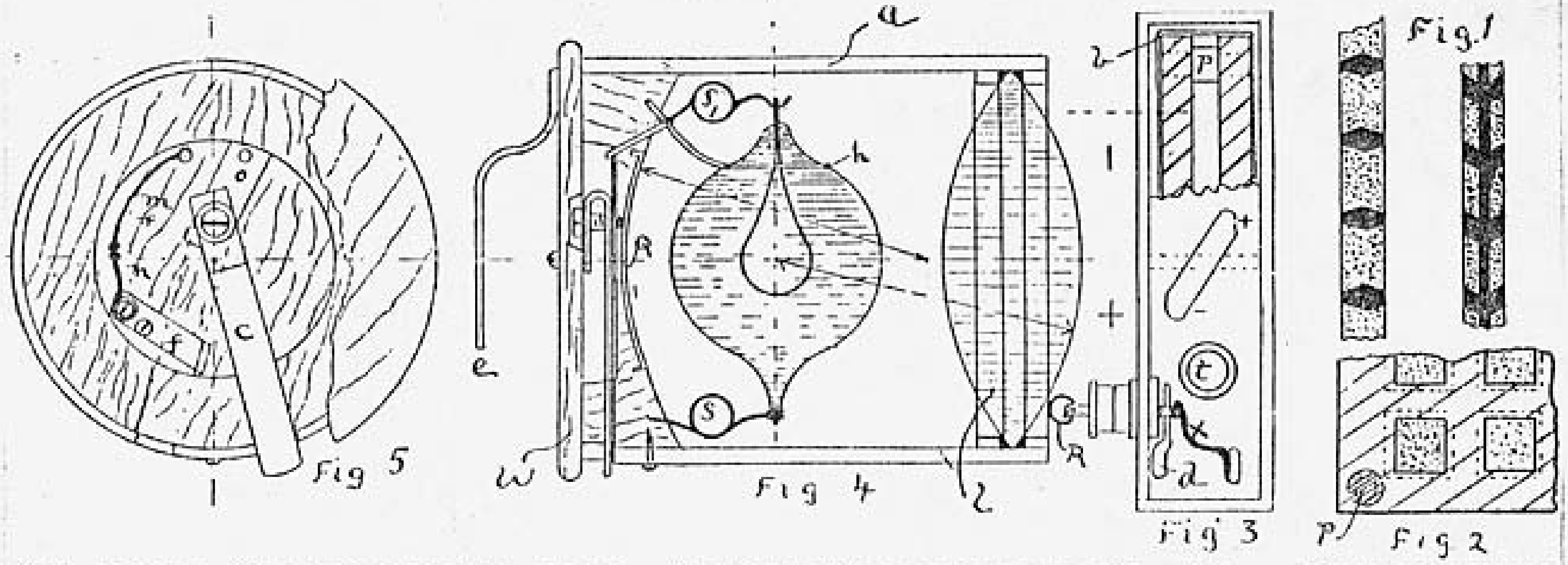
When the action is complete the plates must be washed in clean water; they are then ready to be placed in the cell. The negative grids must be filled in with precipitated lead. To make this, place a few strips of zinc in a saturated solution of lead-acetate, and collect the crystals that are formed. These will adhere together when pressed into the grid.

Before putting the plates together, each negative should have a pair of ebonite separating pins (*p*) fixed along the bottom so as to keep it about ¼ in. apart from the positive plate (see Fig. 3). These pins will then fit into the positive plate, when a rubber band (*b*) will make the whole fast.

If a loose ebonite top is not supplied with the cell, one must be cut out (with a fretsaw) to fit it. Holes must be cut in to allow the four lugs to go through, and two ¼-in. ebonite tubes (*t*) must be cemented in with two parts gutta-percha and one part melted pitch, applied hot, or marine glue.

The pairs of plates are now ready to be placed in the cells, the lid being carefully fitted in. The positive of one cell must be connected to the negative of the other, the two remaining plates being connected to the respective terminals. The terminals are fastened with a nut at the back, a pin (*d*) being put through the shank to prevent it turning. The split-ring (*r*) will prevent the top of the terminal being lost.

The cell is now ready for sealing with marine glue, and Fig. 3 shows it at this stage. Two india-rubber plugs or ebonite stoppers for the tubes (*t*) will complete the cell. Before going on to the lamp, however, it will be well to give a few notes useful to those who wish to make accumulators for lighting, &c. If the amateur wishes to make his own grids he can cast them in plaster-of-Paris moulds, using pure lead. Fig. 1 shows two types of grids, and Fig. 2 shows a side section. The grids are ¼ in. to ½ in. square. For such cells it is usual to have one more negative plate than the number of positive in each cell. Thus, a cell having two positives would have three negatives. This prevents buckling of the positive plates. The whole of the positives in each cell are coupled together, as



FIGS. 1 AND 2.—SECTIONS OF GRIDS. FIG. 3.—SECTIONAL PLAN OF ACCUMULATOR. FIG. 4.—SECTION SHOWING INTERIOR OF LAMP. FIG. 5.—ARRANGEMENT OF SWITCH.

are also the negatives. The electrolyte consists of pure sulphuric acid, diluted with about four times its bulk of water, its specific gravity being about 1·165. Be careful to mix by adding the acid to the water, and never *vice versa*.

The acid having been put into the cells, so as to cover the plates, the accumulators are ready for charging. For this purpose a steady source of supply will be required, from a battery or shunt-wound dynamo, allowing 2·5 volts for each cell to be charged; the maximum charging current being about four ampères per square foot of positive surface, and the discharge rate should not exceed this rate. The positive pole of the accumulator must be connected to the positive source of supply. When the source of supply is from the lighting mains, be sure to test the poles with pole-finding paper, and mark them. Pole-finding paper is a paper coated with—

Potassium iodide	...	2 parts
Starch (stiff paste)	...	40 ,,
Water ...	...	80 ,,

and must be kept dry. Take a piece and damp it; place the wires in contact with it, about ½ in. apart, and a blue spot will appear at the positive wire.

To charge the cycle cell, however, three bichromate cells will be found useful.

When fully charged the cells will gas freely, and the acid turn very milky, the E.M.F. of each cell being 2·5 volts. Never discharge a cell below 1·9 volts, and never leave them discharged or empty. Don't short circuit or "spark" cells.

The lamp and its case next claim attention. By putting a lamp inside an ordinary cycle lamp, it is possible to use it as a combined electric or oil lamp. However, the lamp shown in Fig. 4 will be found far neater. The lamp should be a high efficiency, 4 volts 0·3 ampères, and will cost 1s. 6d. The size of the case will depend on the size of lamp used, the tube (*a*) being of brass or aluminium 1¾ ins. to 2 ins. in diameter. Figs. 4 and 5 will clearly show the construction of the case and switch. The springy brass loops (*s*), make contact with the lamp, and hold it up against the ring (*h*), the spring (*s*) at the bottom holding it steady. The reflector (*q*) and the lens (*l*) serve to throw the light forward as a strong beam on to the road. The dotted arrows show how the position of lens and reflector is found. The hard wood back (*w*) is fastened to the tube (*a*) by means of screws, the switch being inside as shown in Fig. 5. The switch consists of three pieces of springy brass (*o*), (*c*), and (*f*); it is shown in the "off" position, the dotted line in Fig. 5 showing clearly the "on" position. The spring (*e*) serves to attach the lamp to the cycle. The inside of the tube (*a*) should be bright, and the concave surface of the back (*w*) around the reflector (*q*) should be painted with white enamel, the wooden back (*w*) being well polished or varnished.

The whole is now finished and ready to be connected up; one wire (*m*) from the accumulator goes to one spring (*s*) direct, the other (*n*) going to the brass switch contact (*f*). The accumulator should be strapped under the saddle, being put into a leather case.

The connection to the lamp being made with twisted flexible wire, the same as used for pendant lamps, the wire can be kept close to the frame of cycle by means of little rubber bands or clips, and will then look neat.

How to Fit up a Small Intermittent Electric Light.

April, 1898.

By "STATOR."

THE fitting up and running of an electric light plant on ever so small a scale is always a great pleasure to the amateur electrician, though the general idea among the public is that a small electric light produced by primary batteries is only a toy, and of no practical use whatever. I hope the following article will prove that a small electric light, when properly installed, can be made an exceedingly useful adjunct to a bedroom, especially in a country house, where the electric light is not laid on.

The chief point to remember, when reckoning up the cost of running a small electric light from batteries, is not so much the first outlay, but rather, what will be the total expense necessary to keep all in working order. The working expenditure can be reduced to a minimum, provided the right class of batteries and lamps are employed. Of course, the reader must bear in mind that the plant respecting which I am writing is for intermittent lighting only, as it is a well-known fact that continuous lighting from primary batteries is a far too costly, expensive, and messy an undertaking. Nevertheless, intermittent lighting can be made a great success, as the writer has ascertained from the experience of his own plant which has been running fifteen months, the cost for maintenance being only 10d. for fresh sal-ammoniac.

The various parts required for this plant may be classed under five heads—viz., batteries, lamps, lamp-holders and brackets, switches, wire and casing. The type of battery used is the Leclanché, which is made in the following forms: Agglomerate block, Victoria Leclanché, Carporous Leclanché, and most forms of dry batteries. The agglomerate block Leclanché, size No. 1, may be chosen, provided the mouth of the glass jar is sealed up (to lessen evaporation) with a cardboard lid secured with pitch, a small hole being left for the insertion of the zinc rod. The Victoria Leclanché is renowned for its strength of current, but as it does not lend itself to any method of sealing up, and is also rather expensive, I cannot recommend it for this purpose. The carporous Leclanché, size No. 1 is undoubtedly the best form of cell to use, for the following reasons: the internal resistance is fairly low, being ·5 ohm, whilst the evaporation is practically *nil*. There is absolutely no creeping whatsoever, and it has very good recuperative powers.

Perhaps the reader may prefer to use dry batteries for this sort of work. They are very efficient, with the advantage that they require no attention. There is this drawback, however, that eventually, when run down, as of course they will do in time (say in from eighteen months to two or three years, according to the amount of work they do) they have to be replaced by new cells, which will cost half the price of new ones, providing the old ones are returned to the manufacturers carriage paid. The Carporous type, however, can be replenished in five minutes with sal-amnoniac or a new zinc rod, costing 3½d. at any moment. I am not aware, however, how many years the peroxide of manganese will last, but the writer has heard of instances of ordinary Leclanchés working on a house bell circuit for thirteen years and still running satisfactorily.

An illustration of the Carporous Leclanché is given in section in Fig. 1. This cell consists of a carbon cylinder 3 in. diameter inside, ¼ in. thick, and 6 in. high, pierced with small holes with a wooden top (M)

 GRANDDAD'S ELCTRICITY BOOK

and a china bottom (C) secured in their places with pitch. A portion of the top of the carbon cylinder is carried through the wooden top and surmounted by a small circular lead cap, into which is fastened a brass terminal. Through the centre of this top and bottom is fixed a porous tube ⅞ in. diameter inside, 8 in. long, the intervening space between the carbon cylinder and the porous tube, being filled with five parts crushed carbon and four parts peroxide of manganese, this having been filled in before the bottom is secured in its place. The carbon cylinder is placed in a square glass jar with a contracted circular neck, the projecting edges of the wooden top resting upon the rim of the glass jar, thereby preventing creeping and evaporation.

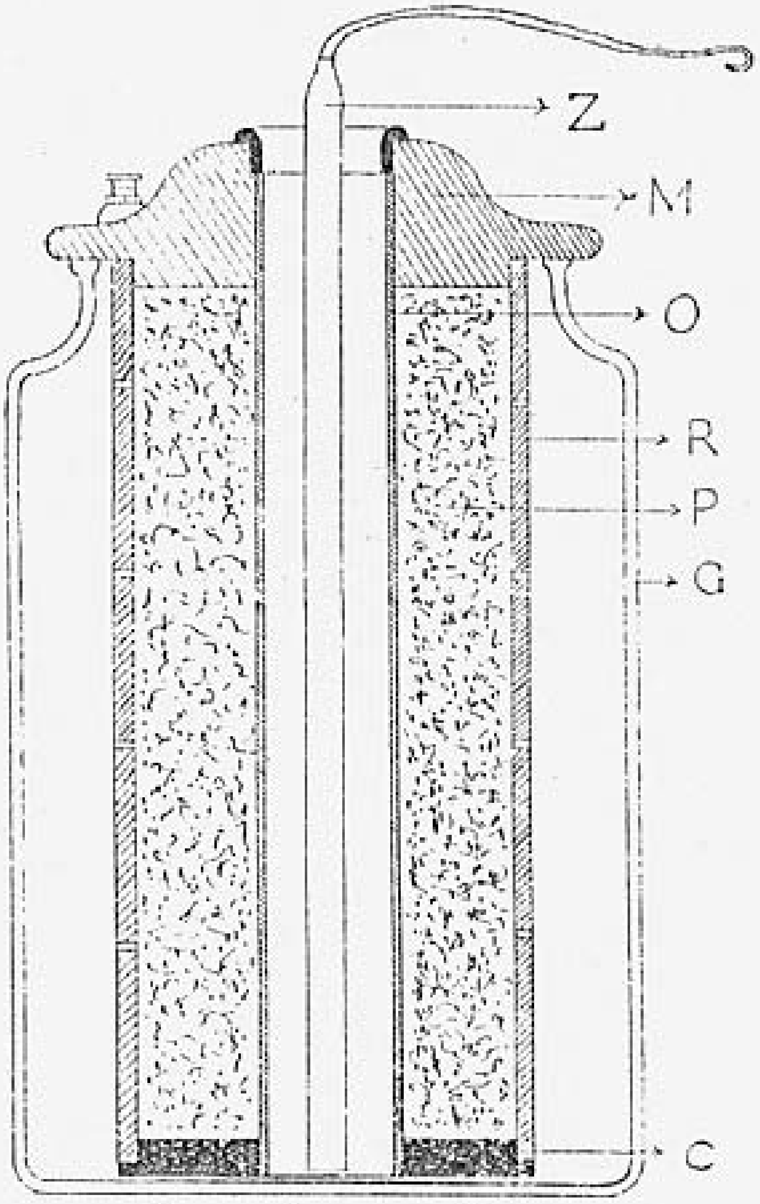


Fig. 1.—Section of Battery.

C. – China Bottom.
M. – Wooden Top.
Z. – Zinc Rod.
O. – Porous Tube.
R. – Carbon Cylinder.
G. – Glass Jar.
P. – Crushed Carbon and Peroxide of Manganese.

It is a good plan to place an indiarubber ring between the wooden cap and the rim of the glass jar, not only as a better means of preventing creeping, but also to raise the carbon cylinder off the bottom of the jar, thus allowing the liquid to circulate more freely. The zinc rod is passed down the centre porous tube, and the batteries placed in a suitable place—connected in series; they are then filled with sal-ammoniac solution up to the neck of the jar by means of a special filling bottle—described further on. The price of a single Carporous battery is 3s. 9d., complete with sal-ammoniac, four being required to run a 4-volt lamp, providing it is not too far away from the batteries. Many persons put their batteries in a box in some out-of-the-way dark corner, almost impossible to be got at, instead of on a shelf in a *cool*, well-lighted place. The writer's batteries rest upon a corner wardrobe in a bed-room.

The next important item to obtain is the lamps. The kind listed as 4, 6, 8, or 10-volt B.C. (bayonet cap), H.E. (high efficiency) lamps are the kind to adopt. Do not, on any account, buy other than the high efficiency lamps, as it is on this point that the economical working of the plant depends. A 4-volt H.E. lamp takes 3 ampère, and gives a very good light for a night-light, passage, cupboard, or w.c., for a period of ten to fifteen minutes. The writer has one lamp in the w.c. and two others, one in each bedroom, with the switch at the head of the bed. The four batteries will only run one lamp at a time, but it is seldom or never that more than one lamp is switched on at the same time. The lamps cost 1s. 6d. each, and supposing their life is from 500 to 600 hours duration (a very low figure), they would last from four to five years if used a quarter of an-hour every night.

Fig. 2 shews how the writer has fitted up a lamp in one of the bedrooms, the holder being of the bayonet type, sold for the lamps at 2s. each, *with* shade carrier, or 1s. 6d. without. The lamp and shade may be suspended by means of flexible wire from a ceiling rose, or the holder, in which is screwed a ⅛-in. gas thread, may be fixed on to the wall, as shewn, by means of a bracket made from a length brass piping, screwed ⅛-in.

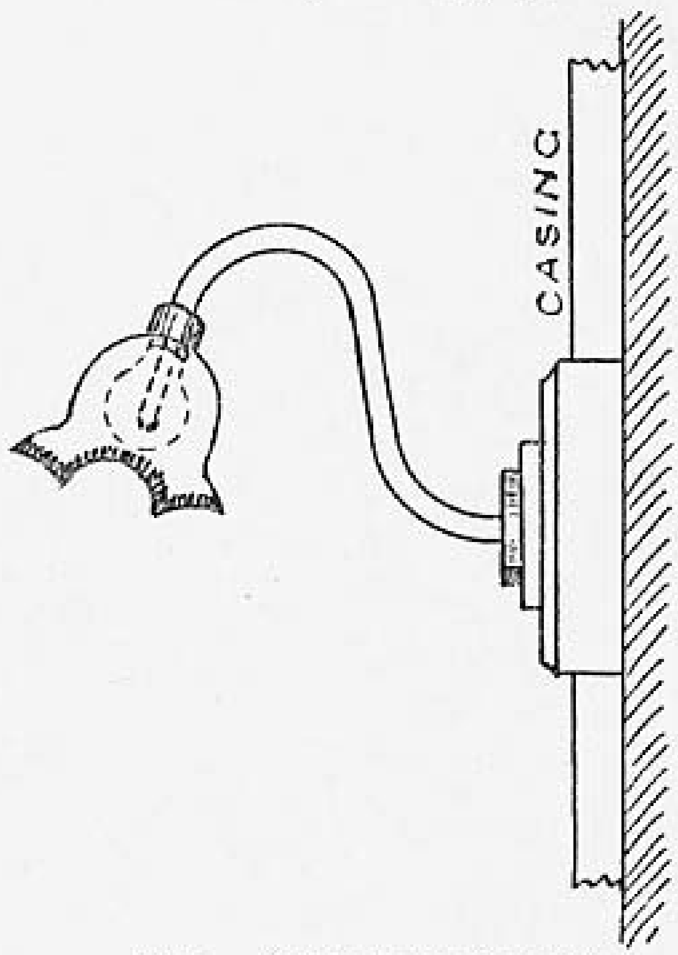


Fig. 2.—Small Lamp Bracket.

gas thread each end and bent into a desirable shape. Before bending the pipe, fill it with melted rosin quite full from end to end; then bend it into shape, holding it in a vice, using lead clamps. When the desired curves are attained, heat the tube slowly, beginning at one end, in a Bunsen flame, so as to melt out the rosin. The bracket, after filing off all the burrs, must be screwed and soldered nto a circular stout brass plate ornamented to taste, and then screwed by means of three brass screws on to a square block of wood, which, in turn, is fastened on to the casing after the wire has been threaded through the bracket.

Most of the types of switches sold for electric bell work will answer for this plant, but for neatness, cheapness, and good finish there is nothing to surpass the tumbler switch (price 2s.). When fixing this switch in position it is desirable to nail a small, neat notice under the switch, thus, "INTERMITTENT LIGHTING ONLY," to remind the person using the light to put the switch over as soon as possible.

Ordinary electric bell wire may be used to convey the current, but be sure and have it of no smaller gauge than No. 20 S.W.G., even if the lamp is close to the batteries;

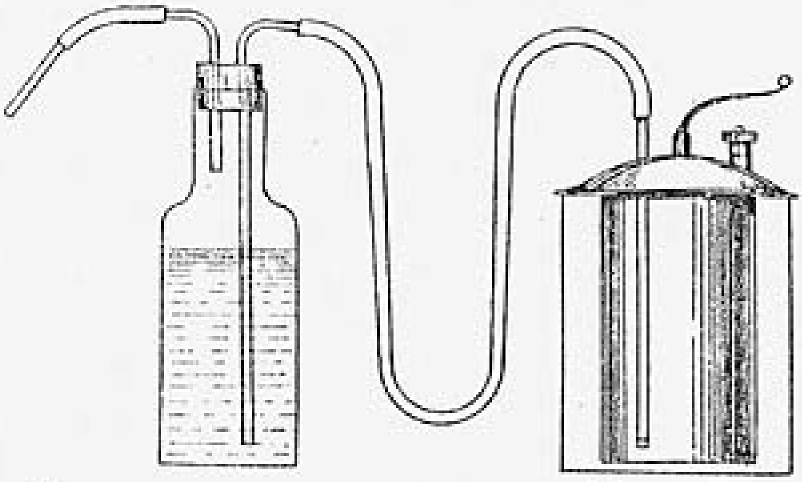


FIG. 3.—APPARATUS FOR RE-FILLING BATTERIES.

if at a greater distance than 15 ft. (single run) use No. 18 S.W.G., and wire the holder and bracket with No. 20 S.W.G. The "finish" of the installation is greatly increased by using wooden casing and capping, which can be bought at the rate of 12 ft. for 8d. from any electrical dealer.

Supposing the amateur decides to purchase the necessary requirements for a 4-volt lamp installation, the cost will approximate as follows:—

	s.	d.
4 No. 1 Carporous cells, at 3s. 9d. each...	15	0
14-volt B.C.-H.E. lamp	1	6
1 holder with shade-carrier	2	0
Glass shade	1	0
Tumbler switch	2	0
Wire and casing, say	1	6
Total	23	0

Of course, this cost may be lessened by omitting the shade and shade-carrier, or by using a cheaper switch and no casing; but on no account use a cheaper lamp, or smaller battery or wire.

The apparatus for filling and replenishing the batteries is shown in Fig. 3, which practically explains its construction and use.

The materials required are: A bottle or flask, to take a rubber cork of about 2-in. diameter, 3 ft. of glass tubing, ¼-in. diameter, and 2 ft. 6 ins. of rubber tubing to fit on to the glass tubing. After bending and cutting the glass tubing into the requisite lengths, as shown in the figure, they must be passed through two holes in the cork and be a tight fit. The long piece of glass tubing must reach nearly to the bottom of the flask, and the short piece project into the neck an inch or so. Cut 6 ins. off the rubber tubing, and fix one end on to the short length of bent glass tubing, and the other end to a short piece of glass tube, to use as a mouthpiece. One end of the remaining length of rubber tubing is connected on to the long bent glass tube, and the other end on to a straight piece, about 6 in. long for insertion into the porous pot.

If the batteries require replenishing with fresh sal-ammoniac, the bottle must be emptied of any liquid it may contain, and 3 ozs. of sal-ammoniac crystals, crushed fine, put into the bottle; then the long glass tube inserted into the porous tube, and the short tube into the operator's mouth. Hold the bottle at a lower level than the battery, and exhaust some of the air out of it. This will cause the liquid to flow out of the battery into the bottle; directly it starts flowing withdraw the short tube from the mouth, so as to allow the liquid to be syphoned out of the battery until it is empty. As soon as the battery is empty hold the bottle at a higher level than the battery, insert the short piece of tubing into the mouth, and by blowing cause the liquid to be discharged back into the cell. Upon repeating these two operations about twice, the sal-ammoniac will all, or practically all, be dissolved and transferred into the battery jar. A fresh quantity of sal-ammoniac crystals must be placed in the bottle, and the operations repeated for each of the other cells.

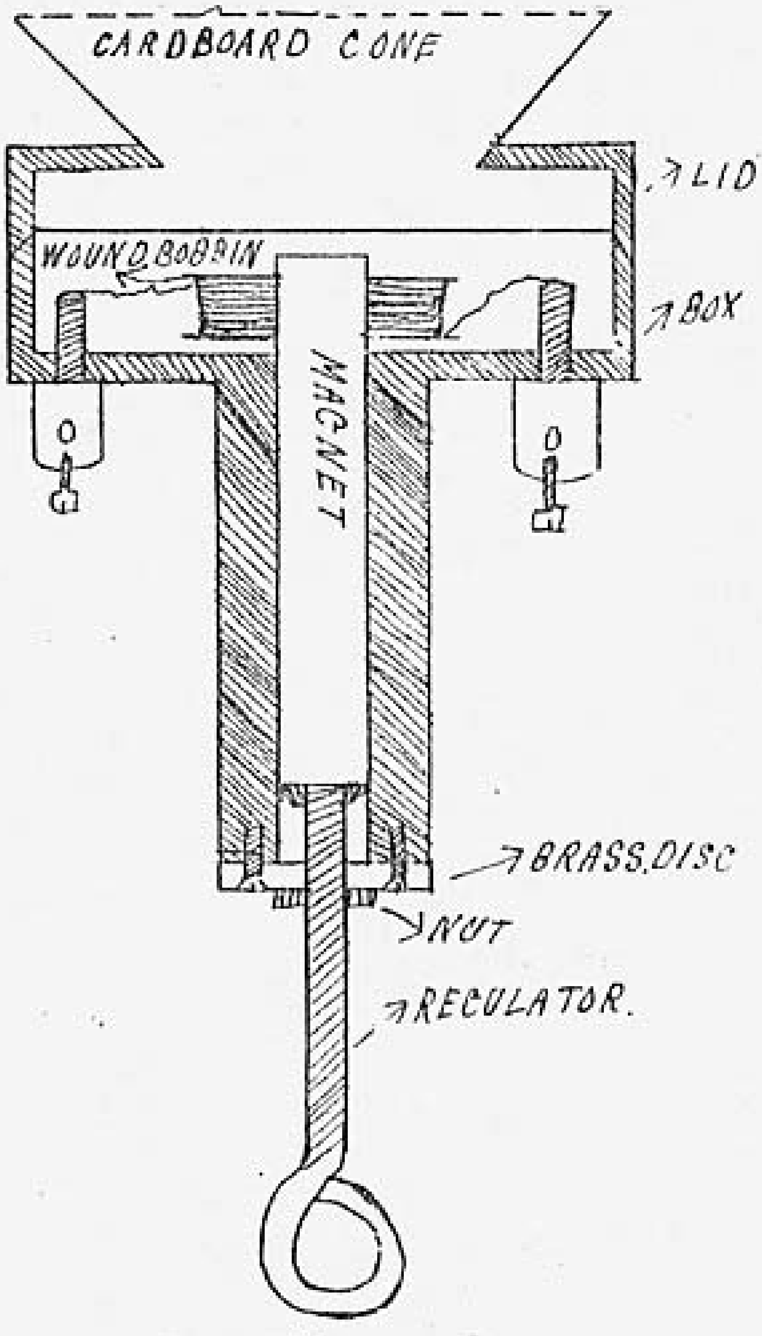
This piece of apparatus can be made for about 2s. It is also advisable to take all the zinc rods out of the batteries about once every six months, and scrape them with an old file.

How to Make a Simple Telephone.

By H. A.

DOUBTLESS many readers have hesitated in making a microphone in any of the ways described in this paper, simply because they do not possess a telephone receiver, and it is needless to state that a microphone would be of very little use without one. For the benefit of those readers, I give the following simple instructions on the making of an instrument that will work well with any microphone shown in No. 2 of THE MODEL ENGINEER.

It will be well to make a list of the undermentioned articles, which will be needed:—A piece of ferrotype plate, 3 in. by 3 in.; about 1 drachm of No. 36 silk-covered copper; 2 small brass terminals; a 3 in. by ¼ in. round bar magnet; a piece of broom-handle, 4½ in. long, and a tooth-powder box, 1¼ in. deep by 2½ in. diameter. We will begin by drilling a full ¼ in. hole through the entire length of the piece of broom-handle. This done, cut a hole in the bottom of box big enough to allow a tight fit on the wooden cylinder. Serve one end of the round wood with hot glue, and push flush with the inside of the box. Procure a piece of brass rod about an ⅛ in. thick, and make a ring at one end, 1 in. in diameter. This will be found handy for hanging purposes. Then cut a thread with screw-plate down to the ring. Take a



A SIMPLE TELEPHONE RECEIVER.

piece of sheet brass, an ⅛ in. thick; file a disc of the same diameter as one end of the cylinder. In the centre of this drill and tap an ⅛ in. hole, so as to fit the brass rod. Two other holes are made in this disc and countersunk at opposite places on each side of the centre hole, at equal distances apart. A small ⅛ in. sheet brass nut is put on the rod.

The brass plate can now be screwed on the end of the cylinder. If the magnet has been bought with an ⅛ in. tapped hole at one end, the brass rod may be screwed in; if not, it may be soldered thereto. After this make a cardboard bobbin, 1 in. long, with ends of the same diameter. Soak the bobbin for a minute or two in melted paraffin wax, and then wind carefully with about one drachm 36 silk-covered wire. Leave 3 in. of wire out at each end for connections with the terminals. Measure the exact inside diameter of the toothpowder-box, and cut a circle in stiff cardboard of the same size. Lay this on the ferrotype plate, and scratch lightly round with a sharp point. Mind not to make any dents on the plate, as this would be fatal to the working of the apparatus. Cut the disc out with a pair of scissors. A 1¾ in. hole must be cut in the centre of the box lid, and a cone of cardboard glued in. All parts now being made, they can be put together. The magnet is slipped in the hole in the cylinder of wood, and the brass disc screwed to the top with a pair of small wood screws—if this has not already been done. The wound bobbin is put on the magnet end, and the free ends of wire are soldered to two terminals—as shown in the sketch. Place the ferrotype plate in the mouth of the box lid, and put it on the box; then screw down the rod until on tapping the ferrotype plate the dull heavy sound indicates that the magnet is touching. Gently turn the rod in the opposite way, when the plate will give a clear sound. The telephone will now be ready for use.

In conclusion, I may say that this instrument has the advantage of being worked, for short distances, without battery or microphone, if a pair are connected with line wires. I used a couple of these telephones between my own house and another, and they gave very satisfactory results. The sketch should give a general idea of the parts when put together, and with a little care and judgment no amateur need fail in making the apparatus.

An Apparatus for Transmitting Pictures by Electricity.

May, 1898.

IN the accompanying illustration we show an apparatus devised for the electrical transmission of pictures by Mr. C. A. Lee. In writing us on the subject, Mr. Lee says :—

"I have not yet constructed my apparatus, but my efforts have hitherto been directed to find a substance sensitive to light which has not got the drawbacks of selenium, but without much success. The possibilities of this system of telegraphy are tremendous, not only for transmitting pictures, but also for news, and from calculations based on my experiments I find that it will be possible to transmit messages with much greater despatch than under the established system. But whether it will ever be possible to solve the greater problem which Herr Szczepanik sets himself to do, namely transmitting scenes with all their movements is very doubtful. The self-induction in the wire alone renders it well nigh impossible."

Description: In the figure, (P) is the picture at the transmitting end of the circuit which it is required to reproduce at the receiving end. Every point on the the picture (P) is successively traversed by the two vibrating mirrors (AA_1) in a continuous path. These two

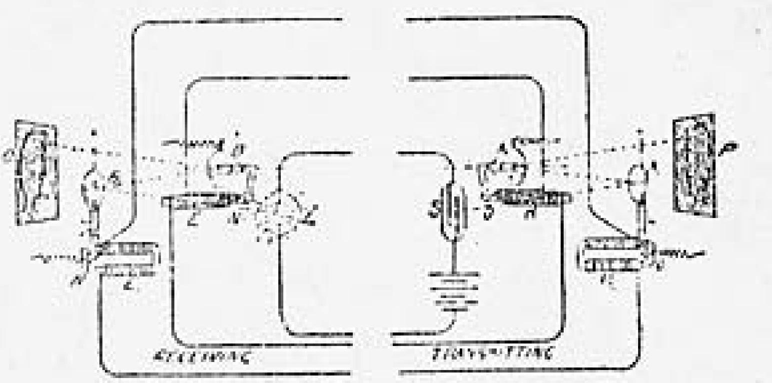


DIAGRAM SHOWING ARRANGEMENT OF APPARATUS.

mirrors vibrate on axes at right angles to one another (A, in the figure, being represented with a horizontal axis, and A_1 with a vertical axis). S represents a cell sensitive to light; a selenium cell is probably the most suitable. This latter, as is well known, has the properties of diminishing or increasing its electrical resistance in proportion as the light falling upon it is of greater or less intensity. Each such successive point in the picture is caused by the vibrating mirrors (AA_1) to fall upon the selenium (one or both of the mirrors may be concave so as to focus each point on the selenium cell). This cell is in circuit with a battery or other source of electric current, and, at the receiving end, with a lamp (L) preferably a vacuum lamp. This lamp is more or less illuminated in proportion as the electrical resistance of the circuit is diminished or increased by the action of the selenium cell (at the transmitting end), or in proportion as the light falling upon the latter is of more or less intensity. A pencil of rays from the lamp (L) (passed through a slit or otherwise), falls on two vibrating mirrors (BB_1) similar to those at the transmitting end (B_1 having a vertical axis and B a horizontal axis), and thence on to a ground-glass screen or sensitive photographic plate (Q). Consequently the pencil of rays from the lamp (L) is caused to traverse in rapid succession every point on the screen. Now, the mirrors (BB_1) at the receiving end are each caused to vibrate exactly in unison with each of the mirrors (AA) respectively. This is accomplished by the aid of two small electro-magnets (EE_1), each in circuit with two similar ones (MM), respectively, at the transmitting end. These may be on separate circuits, as shown, or may, under certain conditions, be coupled to the circuit containing the lamp and selenium cell. An intermittent current is made to flow through these, causing them to attract (each pair in synchronism) armatures (NN_1, MM_1) attached to each of the vibrating mirrors (BB_1, AA_1), respectively, which are returned to their original positions by springs, as shown. The current is also caused to diminish to *nil* and increase alternately, so as to diminish and increase the amplitude of the vibrations of the mirrors, and the paths described by them on the screens may be circles of varying diameter. (To achieve this it is necessary that not only the mirrors vibrate on axes at right angles to one another, but also that their motions are complementary, so to speak; that is, when one is at one of its extreme positions, the other is at its central position). Moreover, every successive grade of illumination on the picture (P) at the transmitting end is faithfully reproduced on the screen (Q) in its correct position, since exactly similar paths are traversed at each end, and for each point on the path the illumination is proportionate at either end. It is evident that this system may be extended for reproductions, not only of stationary pictures, but that, if in place of the picture (P) we project a real image of an object by means of a lens, this will also be reproduced at the receiving end; also, that if we could make the mirror vibrations of sufficient frequency, it might be possible to produce an image on a distant screen in all its correct motions by reason of persistence of vision.

A Wimshurst Machine—How to Make and Use It.

July, 1898. By Edgell Brown.

[The following is the article which gained the prize of £2 2s. in our recent competition.]

The dimensions of the machine I am about to describe are for a rather large one, but as the cost of making a large one will be little more than a small one, and the effect is so much better, I think no one will regret making the large machine.

The stand may be of good deal, but mahogany is better if one does not mind the extra expense. It should be dovetailed together, and the uprights halved in and fixed with six screws, as shown in drawing. The uprights (Figs. 7 and 8) have a piece of brass tube driven tightly in the lower hole for bearings for the large pulleys, and a wood screw let in edgeways to secure the spindle for the plates.

The large pulleys (Figs. 17 and 18) must be of mahogany. Deal will warp and become oval in a very short time. A piece of mahogany 8½ ins. long—an old curtain pole will do—should have a hole bored right through, and a piece of ¾-in. round iron, 11½ ins. long, driven through, and projecting about ⅝ in. on side. This hole is best bored in the lathe with a twist bit, as it must be fairly true. There will be no difficulty in doing this if the bit is chucked and the back centre kept up to the wood whilst boring. The large pulleys should have a 1¼-in. hole bored in each, and this is best done on the face plate of a lathe; then the wood on spindle may be turned to fit, and a little glue will securely fasten them. Turn them to the dimensions shown, also the ends of iron spindle and cut a fine thread on long end for crank handle. Figs. 5 and 6 show the sides of stand with all dimensions, and Figs. 9 and 10 the ends.

The conductors (Figs. 15 and 16) may be made of brass tube, and supported on a glass rod; rod is better than tube, or the Leyden jars usually used with this machine, may be used to support them. I prefer supporting them on glass rod, and the Leyden jars may be made with a hook and suspended from them. The insulation of the jars is better when supported in this way. The balls at ends of conductors and discharging rods are known as caddy balls, and can be got from any ironmonger.

Turn a piece of hard wood to fit tightly the tube the conductor is made of, and bore a hole 3 ins. deep in end of this; then drive a piece of brass pipe, ¼ in. bore, in this to take the discharging rods. Solder a 1-in. caddy ball on each end, and drill a small hole in one ball to meet the small pipe we have driven in. Ease it out with a round file to get it central, &c. Now fit a piece of the pipe to stand at right angles, and solder to centre of conductor, and a brass ring at end where glass rod enters. This will do away with the sharp edges, as all sharp edges must be avoided in the conductors. Cement the glass rod in with plaster-of-Paris, having previously ground end of glass to give a hold to cement. Drill two holes to receive collecting points or combs, and drive two pieces ¼ brass wire into these and file to sharp point. Bend the points round towards the plates. Let the wires go well into the wood, or they will not remain firm. The wires may be screwed in, which is, perhaps, a better plan than driving them in. Note the conductors must be made right and left handed. A row of points are usually put to draw the electricity off the plates, but I find one point each side is sufficient. To prove this close the discharging rods and no spark can be obtained from plates.

The discharging rods (Fig. 23) are made of ¼ brass wire, with a piece brazed at right angles to fit in hole at end of conductors, and a saw-slit to make them fit tight enough to retain their position. If made thus, they can be removed and other connections substituted for charging Leyden jars, &c. The handles are best made of ebonite, but any wood soaked in melted paraffin-wax will do. One rod is fitted with a 1½-in. disc ball; the other has a ⅝ in. one. The conductors may be secured to stand with wood screws, or thumb-nut from underneath is better. They

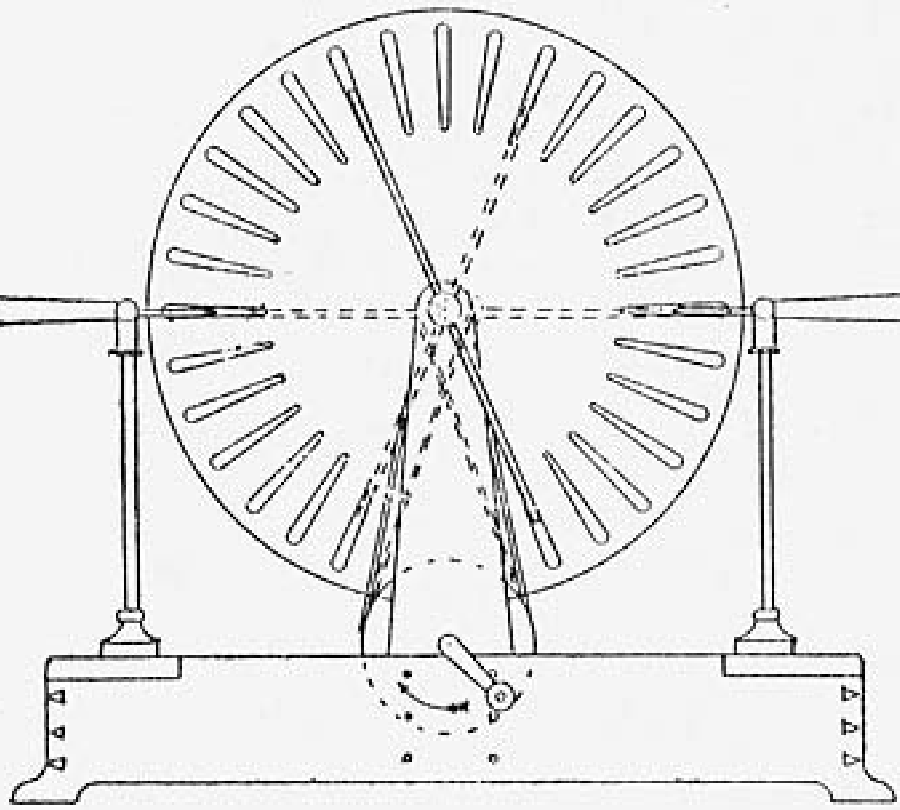


FIG 1

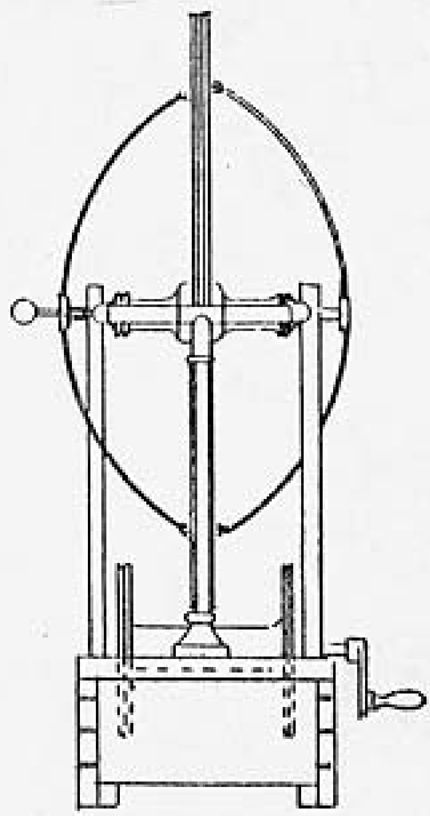


FIG 2

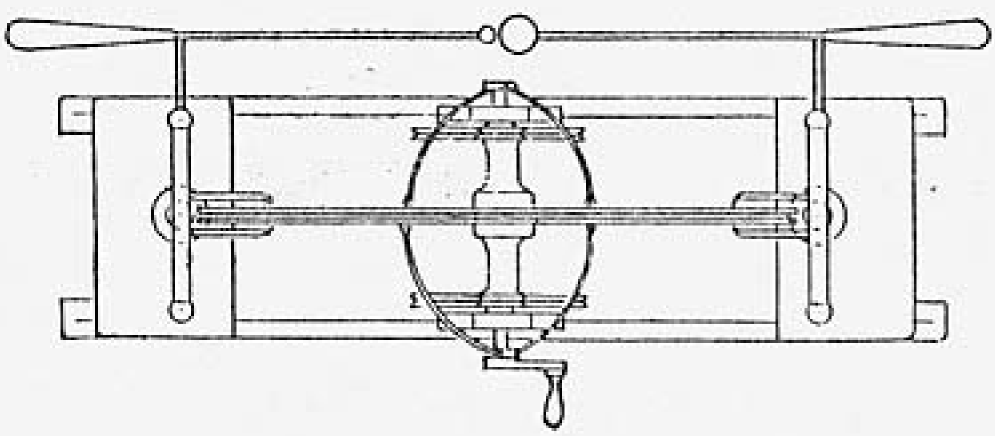


FIG 3

FIG. 1.—SIDE ELEVATION OF WIMSHURST MACHINE.

FIG. 2.—END ELEVATION OF DITTO.

FIG. 3.—PLAN OF DITTO.

Scale—1 inch = 1 foot,

can then be easily removed for cleaning.

The plates may be made of ebonite or glass. Ebonite plates are more expensive, and also be   when the machine is working and rub one another. I think glass is better, especially for a large machine, and it is also very much cheaper. Ebonite answers very well for smaller machines up to 20 ins. diameter, but beyond that size glass should be used. Most of the large glaziers will cut the plates round same price as a square of glass. Select a piece of glass of even thickness, and as flat as possible. Ordinary thin window-glass will do, and is electrically better than a thick glass, though, perhaps, not so strong. If cut round, cement a washer with hole same size as pipe used to bush the small pulleys with, to the centre of plate. This may be done with Prout's elastic glue. Warm the washer and touch it with the glue, and apply to centre of plate, using a wire trammel to insure its being in the centre. If the pipes are not round, fix a piece of brass pipe in a strip of wood, and a diamond or glass-cutter, fastened correct distance from pipe in wood. Now use this as a trammel, using the washer as centre. Roughly cut the corners off, and make a cut from circle to edge, and I think you will then

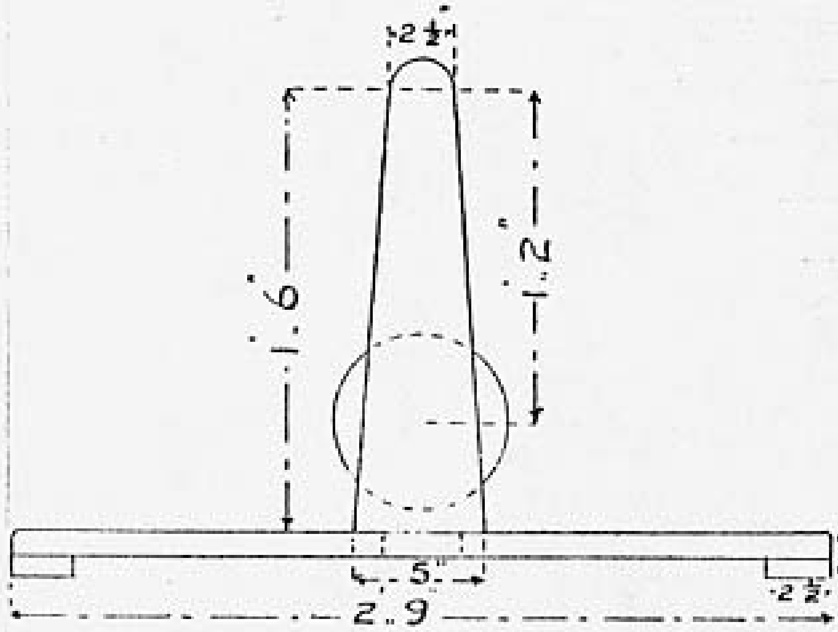
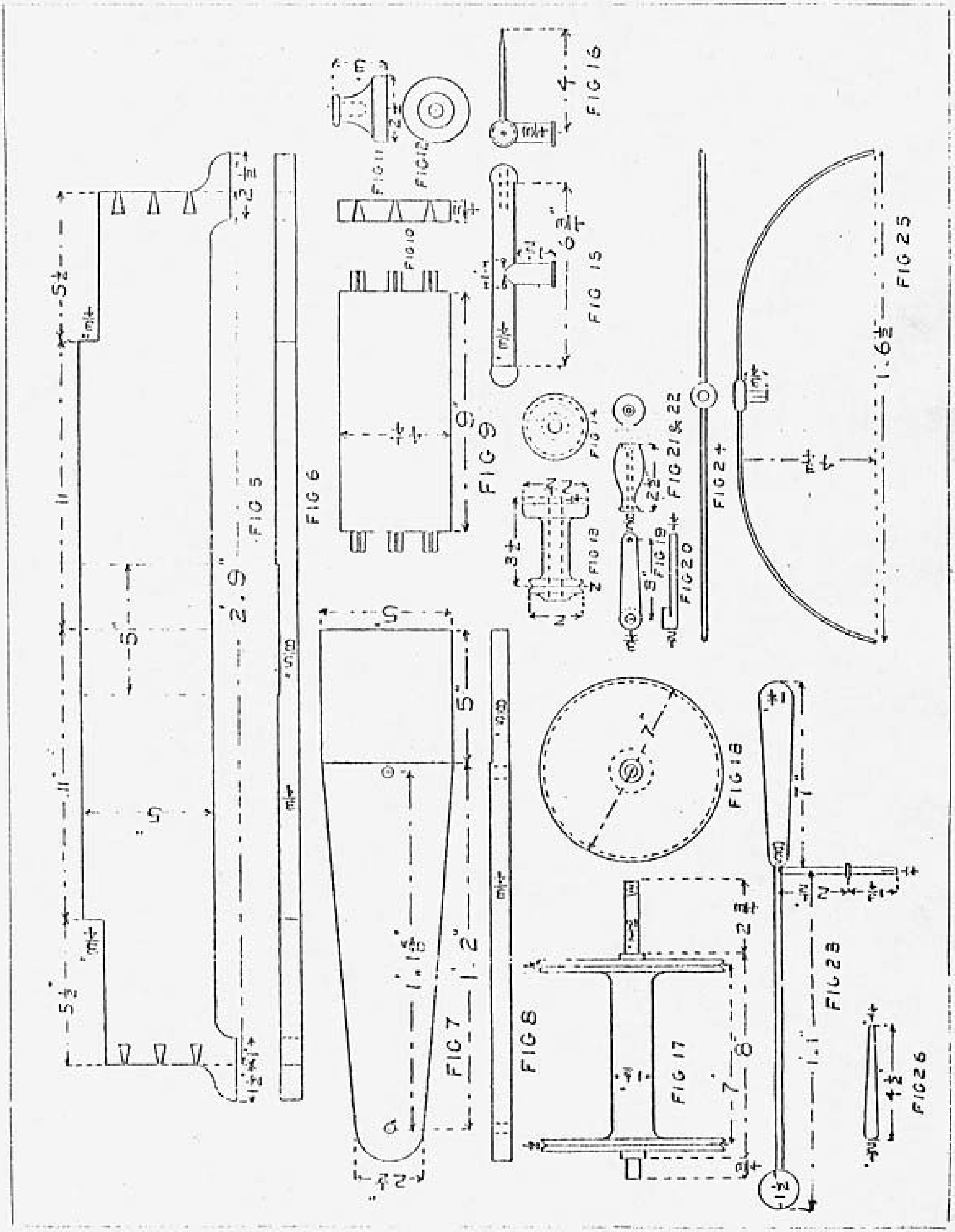


FIG 4

FIG. 4.—SIMPLE FORM OF STAND.



A Wimshurst Machine—How to Make and Use It.

[Detail Drawings of Parts.]

be able to get the circle out by these means. Reject any glass that is not of even thickness throughout, as the plates will not balance when running. Fix a piece of brass pipe same size as used to bush pulleys in lathe, and reverse the headstock; sprinkle a little fairly coarse emery in hole in washer and a drop of turpentine and oil, and let the pipe run in hole in washer. This acts as a guide for hole. If rather thin glass, a small disc will soon be ground out by frequent applications of turpentine, oil, and emery. Do not employ a lot of pressure, but just keep the glass touching the brass tube. I have drilled a plate in nine minutes by this method, and it makes a beautiful hole.

After drilling the plates they must be thoroughly cleaned out and the small pulleys cemented to them. I find Prout's elastic glue to be the best medium for this. Spread a little of the glue on the wood pulley with a hot iron, then cut out a cloth washer size of pulley boss, glue this, and warm plate and pulley before the fire and stick the pulley on, slightly twisting the pulley to cause the glue to spread evenly between pulley, cloth, and plate.

If the pulleys are stuck to the plates with Coaguline or similar cement without a cloth washer they will certainly crack as the cement dries. I broke six glasses in this way when making my first machine, so do not omit the cloth, and use the Prout's elastic glue for glass plates and there will be no fear of their breaking. Glass plates must be varnished with shellac varnish, also the glass rods which support the conductors, and the outside glass parts of Leyden jars to prevent moisture condensing on them.

To make the varnish dissolve ¼ lb. of good shellac in 8 ozs. methylated spirit. This will take two or three days to dissolve. Keep the bottle in a warm place, but do not put it in hot water to hasten it. After it has all dissolved, put a little fine ashes from the fire in it, and shake well and allow it to stand until top becomes clear. The clear portion is what is used to varnish the plates, and must be decanted or filtered, and the thick portion thrown away.

Warm the plates evenly before the fire or over a gas-stove, keep turning them round all the time, and when they feel comfortably hot to back of hand, apply the varnish to the side with wood pulley, first with a broad camel hair brush about 4 ins. wide, and do not go over the same part more than once. When the varnish is evenly spread, warm them well before the fire until the spirit has evaporated. They may then have a second coat if necessary. Varnish both sides in this way. All glass must be well warmed when applying varnish, or it will become cloudy and spoil the appearance. The plates should be of a nice golden colour when furnished.

The sectors (Fig. 26) are thirty-two in number for each plate, and may be of tinfoil. The large end should be ½ in. from circumference of plate. The plates revolve in opposite directions. This is accomplished by twisting one belt. The belt nearest dischargers is usually twisted. For those making other size machines the sectors should be 1-5th to 1-6th diameter of plates in length, the small end ¼ in. wide, and the sides should form radii of circle. To stick the sectors on draw a circle the diameter of the plates, and from same centre draw another circle 1 in. less in diameter. Divide this in thirty-two parts; draw lines from the centre and lay plates on the paper. This will form a guide to stick the sectors on, which may be done with good gum, or the shellac varnish. Then put a narrow line of varnish all round the edges of sectors. This will prevent their rubbing off with the brushes, and partially prevents the charge escaping off the sectors. Now try the plates on the spindle, and if they do not run true, warm them to loosen the pulleys, and lightly press which ever way may be required. The closer the plates will work without touching the better. They should not be more than ⅛ in. apart.

The plate pulleys (Figs. 13 and 14) are made of hard wood and a piece of ½-in. brass gas-pipe driven in and turned up to dimensions on a true mandrel. Drill an oil-hole in each of these.

The neutralising rods (Figs. 24 and 25) are made of ¼-in. brass wire, with holes drilled in end to take the small metallic brushes, which may be secured with a small wood peg pushed in with them. The brushes should lightly sweep the plates, and are made of the gold braid or cord obtained from any military tailor. Dutch metal cut in fine shreds is also very good for the purpose. Anything stiffer will rub the sectors off the plates. In the centre of rods turn up a thick disc of brass and solder ⅞ in. of ½-in. brass pipe to this. Drill two holes in disc and tap to receive the wire that carry the brushes. Make a saw slit in the tube, and fit tight enough to retain its position when the plates are revolving. The plate spindle projects ⅞ in. beyond each upright to receive these. Figs. 11 and 12 are of wood fastened to stand to receive the glass conductor supports. For the position of neutralising rods imagine the plate to be a clock dial. The rod nearest handle should point at 11 and 5, and the one nearest discharging rods at 1 and 7.

Leather sewing machine belts answer well for driving belts, and can be got with the steel hoops for joining them from any sewing machine shops.

Two Leyden jars will be required which may be made of salad oil bottles. Fill them with shot to a height of 2 ins., and coat with tinfoil to the same height outside, covering the bottom also. Cement a small piece of brass or tin with a wire eye to the outer coating of each and well shellac the jar. Fit a good cork to and a piece of brass wire with hook formed at end, and small washer soldered to wire to prevent its pulling through the cork, cover cork with sealing-wax or Prout's glue and put a small ball on end of hook. These bottles answer the purpose as well as the jars to be bought at the instrument shops and are cheaply replaced as they are sometimes broken by the enormous tension they are subjected to by this machine.

The caddy balls for discharging rods should have a piece of sheet brass hollowed up and soldered to open end. Drill and tap a hole in the piece of brass and crews a piece of wire to fit; turn up in lathe to fit the opening in ball; solder ball on and finish off in lathe. The discharge balls must be highly polished.

Fig. 4 shows elevation of a simple stand for those less skilled in carpentry.

Any experiment which can be performed with an induction coil or static machine, can be done with this machine. To excite the machine separate the discharging balls and turn the handle in direction of arrow. If the plates and brushes are clean and free from dust, the machine will at once excite itself; but if from either cause it does not excite, rub a piece of sealing-wax or glass tube and hold near the sectors: this will at once excite it.

To obtain long sparks hang the Leyden jars one on each conductor and connect the outer coatings with a piece of insulated wire; notice the collecting points and if the brushes of light are on the side having the large ball and the small ball side shows tiny points of light at the conductor points, the machine is working right, and we should obtain easily 10-in. sparks from a machine of this size in a dry atmosphere. To light vacuum tubes remove the wire connecting the two Leyden jars, and hang the tubes in its place, and separate the discharging balls about a ¼ in. All sorts of Crookes' and X-ray tubes may be lit in this way. The conductor with the large ball and brushes of light is negative; that with small ball and points of light is positive, and as a Leyden jar is charged with +, or positive, inside, the outer coating becomes −, or negative, so that in connecting an X-ray tube the platinum flat must be connected with the outer coating of jar on negative side, and the aluminium concave disc with the outer coating of jar on positive side. The exposure will be about three minutes for a hand if all is working well. Sometimes the machine excites the reverse way, which I notice usually occurs in damp weather. To reverse it, charge a Leyden jar from right hand conductor, close the balls, and turn the plates in opposite direction. Now open the balls, apply the knob of jar to left hand conductor, and turn the machine the right way. This will at once reverse it. The tube should glow with a yellow light—between yellow and green; but the more yellow there is the more penetration the X-rays will have, and the exposure will be shorter. Separate the balls until the tube appears almost continuously lit.

The following is a pretty experiment. Put a large piece of alum or rock salt on a glass jar or tumbler, and a wire from outer coating of each jar to the alum, so that the spark goes right through the alum or crystal used. Separate the balls until the spark passes through the alum. The crystal will then be beautifully lit up, and produces a fine effect when the room is darkened.

How to Make a Dry Battery for a Portable Electric Lamp.

July, 1898. By H. J. Hunt.

FIRST procure a sheet of No. 11 zinc, 6 in. by 9 in., and bend this into a cylinder by bending it round a short length of 2 in. cornice pole (in the absence of a proper tinman's bar). Solder the seam down and fit a bottom; also solder a short length of No. 16 copper wire inside the cylinder, over the seam, to form the zinc terminal. Then give the whole a coat of Brunswick black, and allow to dry.

Next make a paste of crushed or powdered sal-ammoniac (chloride of ammonium), 25 parts; plaster-of-Paris, 50 parts; water, 25 parts; and glycerine, 2 parts. Mix these well together, and when the mixture is setting coat the inside of the zinc pot to a depth of ⅜ in. and 1 in. at the bottom, leaving 1 in. from the top uncoated. Next place a pad of rubber, paraffined wood, or some good insulating substance, on the bottom, and stand a carbon plate, 7 in. by 1 in., thereon; then closely pack the intervening space with a mixture made up as follows:

Powdered carbon, 50 parts; crushed sal-ammoniac, 25 parts; peroxide of manganese, 25 parts; glycerine, 2 parts; and chloride of zinc, 5 parts. This mixture must be well rammed down to the lever of the plaster casing. On this ramming-down process the efficiency of the cell depends. Fill up the inch space with melted sulphur, (pitch, as advised by some writers, is of no use as the salts creep up the case and destroy the connections); drill a hole in the carbon, place a terminal therein, and the cell is completed.

Having made four of these cells, we next require a mahogany or walnut case, 6½ in. by 8in inside. This should be polished outside and coated with paraffin wax inside for insulating purposes. Place two brass terminals at one side 1½ in. from the top and 2 in. apart. The four cells should be coated with thick paper. waxed, and placed in the case. Care is required in connecting up the battery, which should be done in the following manner. The zinc terminal of the cell nearest one terminal should be connected therewith. The zinc of the next cell is to be joined to the carbon plate of the one attached to the terminal and this rule should be followed throughout the cells—viz.: carbon to zinc. When all the cells are connected a carbon will be left. This should be attached by a short length of india-rubber covered wire to the remaining terminal and forms the pole of the circuit. Melt ½ lb. of paraffin wax in an old tin and coat the whole of the wires, &c., inside the case, and pour the remainder round the cells. This will not only form a splendid insulator, but keep the cells rigid as well.

September, 1898. Inexpensive Motor.

To the Editor of *The Model Engineer.*

Sir,—Those of your readers who have few tools may be interested in the following inexpensive motor, of which I enclose sketches. I have found this machine very useful for driving fans, vacuum tube rotators, etc.

The field magnet is made of ½-in. wrought-iron rod bent to a horseshoe. The tunnel was easily cut out with

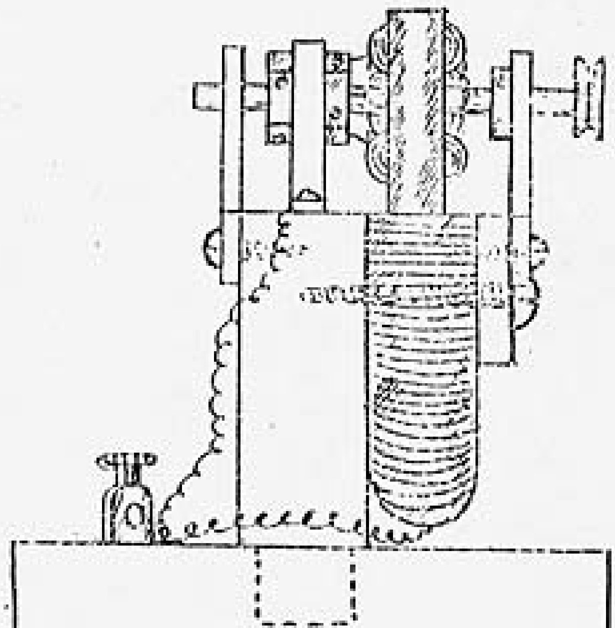


Fig. 1.—Side Elevation.

a half-round file, and was made just big enough to take a 1½-in. armature. This which is of tripolar type, is built up of lamminations cut out of cocoa and meat tins with a pair of stout scissors. As the armature is only ½-in. deep, this is not such a big job as might be expected. Bearings were made of stout sheet brass and could have brass bosses soldered on to make a longer bearing surface.

The magnet is clamped to a wood base by means of a transverse piece of wood, to which is screwed the bearing for pulley end. I find this bearing quite firm enough and it has an advantage in that the armature can be adjusted to a nicety. The shaft is a piece of mild steel rod with collar shrunk on. The commutator, which was the most troublesome item, was made by turning down a piece of hard wood on the shaft while in the bearings; a brass tube being slipped over when

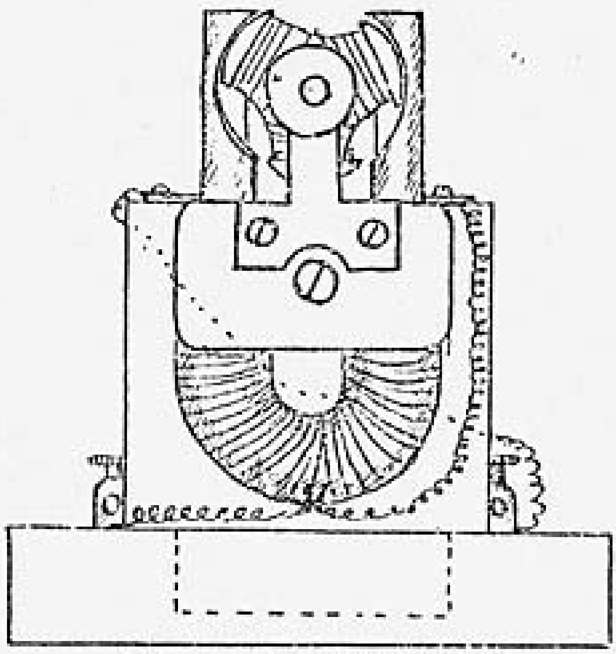


Fig. 2.—End Elevation.

wooden boss was of required size. This tube was then screwed on, and the segments cut. The brushes consist of brass springs screwed to base, but a rocker could be used if bosses are added to bearings.

I wound the field magnet with four layers of No. 20 D.C.C. wire, and the armature with No. 24 D.C.C., the connection being series. The only expense in this machine was for wire and terminals, the rest being obtained from scrap heap. A quart bichromate will drive this little motor at a great speed.—Yours truly,

Clifton. F. M.

A Small Voltmeter and How to Make It.

October, 1898. By "Zodiac."

THIS voltmeter has been specially designed for those readers of The Model Engineer who require a good reliable instrument.

Its readings are constant and little affected by external magnets.

The same movement may be so wound, that it can be used as:

(1.) Voltmeter with two scales.
(2.) Ammeter ,, ,,
(3.) Combined voltmeter and ammeter.

The complete instrument is shown at Fig. 1 and consists of:

Pointer (*p*). with the iron bundle (*i*) pivoted on the axle (*m*); coil frame (*cfc*[1]); scale (*s*); and outer case.

If we pass a current round a solenoid, a magnetic field is set up which is stronger at the edges than near the centre or axis. A piece of soft iron placed in a non-uniform magnetic field will always tend to move into the strongest part of the field.

This is the principle on which this voltmeter works. The coil and frame (*cc*[1]) form a solenoid. Neither the axle (*m*) nor the iron bundle (*i*) are in the centre of the solenoid core. Hence, when the magnetic field is set up, the iron (*i*, Fig. 2) tends to move to the stronger part of the field, thus moving the pointer (*p*) to the right.

The coil frame will be first dealt with. It consists of two discs (*cc*[1], Fig. 2) joined by means of the tube *f*. This may be made of brass throughout, though an aluminium front (*c*) would look well; it would, however, have to be screwed to the tube *f*, as it cannot be easily soldered. The setting out of these two discs will require great care, as the accurate position of the needle centre is of great importance. The holes for the crosspieces (*a*, Fig. 4) should be carefully marked out. The two crosspieces *a* and *a*[1] are alike (Fig. 4) except that the one for the back (*a*[1]) will not require the pieces *d d* (Fig. 4) on, as it fits flush on to the back disc (*c*[1], Fig. 2). The back pivot hole is mounted on the screw *h* (Fig. 2) so as to allow of adjustment.

The movement and pointer will require very careful work. The aluminium pointer (*p*) should be cut out of sheet aluminium with a sharp knife. It is rivetted on to the brass piece *k*. Through the hole in the top of *k* are pushed several fine iron wires to form the bundle *i*; the softest charcoal iron being used. The outer end of the bundle should be bound, the whole being cemented fast with shellac. Two little brass checks fasten the whole on to the spindle *m*. The pivot centres in *a* and *a*[1] may be plain, but would be better if jewelled. I should advise the reader to put the pivotting and jewelling into the hands of a good working watch-maker, who would, for a few shillings, produce a first-class movement.

The controlling force may be gravity, or spring control. At Fig. 1 the *gravity control* is shown, the little weight *w*, is acting on the needle. In this case, the instrument must be kept level, or the pointer will not come to zero when the current is taken off.

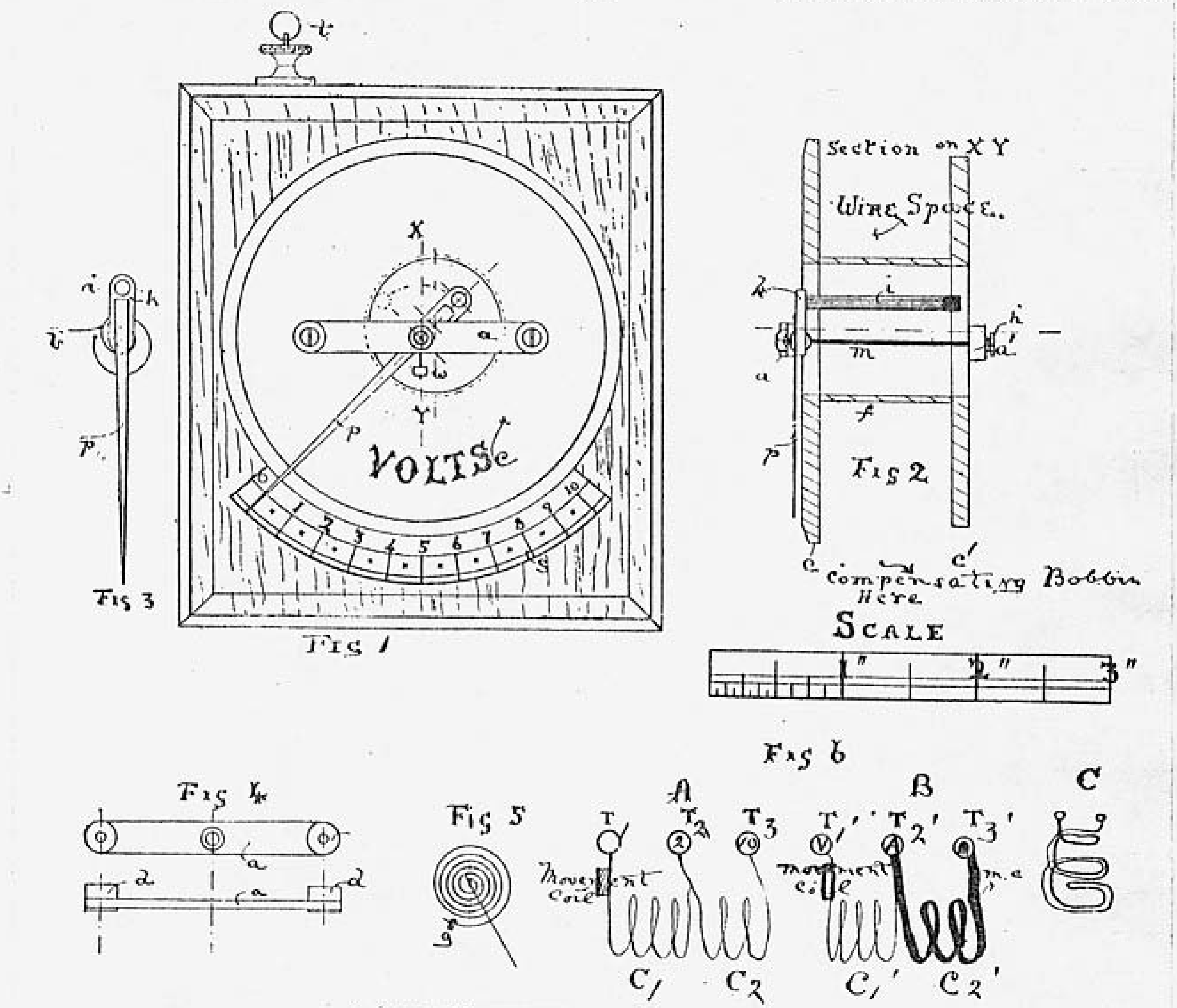
Spring control is far better, as the instruments can then be used in any position. In that case the moving part should be nicely balanced by filing *k* to suit. The method of attaching the spring is shown at Fig. 3 and Fig. 5. If put at the back near *a*[1], it will be out of the way, and have plenty of room to work freely. The hair-spring of an old watch will be found to be first-class for this work.

From Fig. 5 it will be seen that the inner end of the spring is fastened to the brass piece (*k*), the outer end being fastened between two (*g*) pins on *a*[1]. By pulling the end of the spring through *g* the pointer can be adjusted to its zero position.

Should the reader have any difficulty with this part of the work, he should let the watch-maker do it. Old hair-springs can be had by the dozen gratis from any watch shop.

We are now ready to *wind the instrument.* But the movement should be carefully removed before winding, or it may be damaged during that operation. The wire is wound on between the checks (*c c*[1]), being careful to get it even and level, and putting a layer of paper between each layer of wire. Before winding, however, the bobbin should be carefully insulated with silk tape.

For a voltmeter, wind with about 900 turns of No. 36 silk-covered wire, in series with which put a compensating bobbin wound with No. 38 platinoid wire. The required length of this must be found by trial, and will depend on the scale chosen (about ½ oz.). Put on the maximum voltage (say 10 in this case), and then reduce the length of platinoid wire in circuit till the pointer reaches the end of the scale. The correct length being found, it should be cut off and carefully coiled on the compensating bobbin, which can be stored away under the instrument, behind the scale. By putting more or less wire on the compensating bobbin, the instrument may have its scale altered from 4 up to 20 or 30 volts.



A Small Voltmeter and How to Make it.

The platinoid wire should be doubled at the middle, and wound on together so as to have no inductive action on the iron bundle (*i*). This winding is shown at *c*, Fig. 6.

If a voltmeter with two scales is required, then the compensating wire must be wound on two coils and arranged, as shown at A, Fig. 6. Thus by using terminals T_1 and T_2, we only have the resistance of C_1 in series with the movement coil, and your scale may be, say, 0 to 4 volts. By using T_1 and T_3 we introduce the resistance of C_2 into circuit, and thus our scale may be say 0 to 10 volts. These scales can be arranged one over the other. If the terminals were marked 2 and 10, say, then it would avoid any mistake being made in connecting up.

A combined voltmeter and ammeter will be produced, if we wind, over the coil of No. 36, say 9 or 10 turns of No. 16 or No. 18 copper wire, as in Fig. 6 B, where terminals T_1^1 T_2^1 are the voltmeter connections, T_2^1 T_3^1 being the ammeter terminals; the low resistance ammeter coil being kept in series with the voltmeter coil when

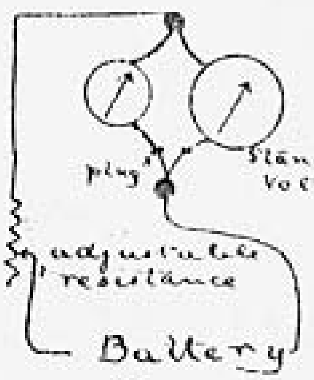


Fig. 7.

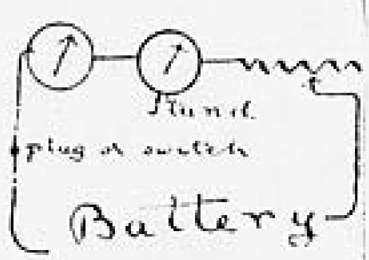


Fig. 8.

it is used for voltages. As an ammeter the No. 36 coil is, of course, not in circuit.

For the ammeter the bobbin should be wound with No. 14 or 16 copper wire. No compensating coil is used, the resistance of an ammeter being kept as low as possible.

A two scale ammeter will result if we divide the winding into two sections.

The scale might be made of paper, but will be far better if brass or aluminium. I prefer the latter. If the scale is of metal it will require engraving.

The outer case may be altered to suit the taste of the reader. In Fig. 1 the instrument is shown mounted in a neat square hard wood case, with bevelled glass front. If thought better a round brass case might be used.

The grading of the instrument will require the use of a powerful battery or sets of accumulators giving 10 volts or 10 ampères, as required; also a standard voltmeter or ammeter. (The method of grading a voltmeter by the use of Daniell cells is not very reliable.)

These latter standard instruments will have to be hired from some electrician.

To grade the voltmeter arrange the circuit as shown in Fig. 7. Plug in the standard instrument, and adjust the number of batteries and the resistance till it reads 1 volt. Now take off the standard instrument and plug in your instrument, note the position of pointer, and mark the scale. Repeat the readings to be sure of them. Do this for every voltage up to 10, say.

To grade the ammeter it must be put in series with the standard instrument, as shown in Fig. 8. In this case the standard instrument is always kept in the circuit. The current is altered by means of the resistance, the grading being repeated as in the case of the voltmeter.

Two scale instruments and *combined instruments* will, of course, have each scale marked separately.

The instrument being now graded and the scale properly marked, the glass front may be replaced, when the whole will be finished. If these directions have been carried out, the result will be a first class instrument.

The Daniell Cell, and How to Make It.

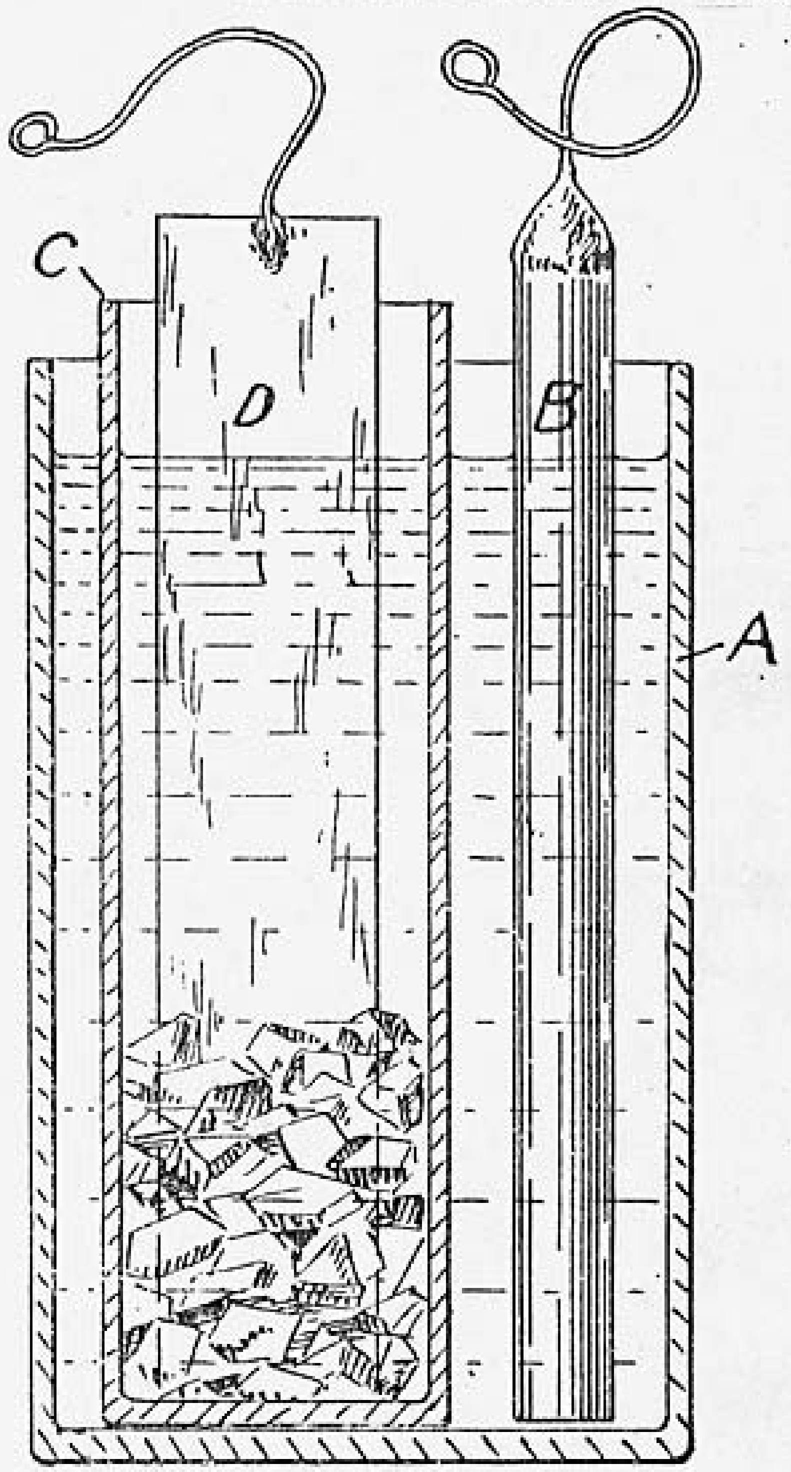
November, 1898.

By F. C. E.

THE Daniell cell, being the only primary cell in which there is complete depolarisation combined with practically no local action, it is rather surprising that it is not more widely used, especially as it is constant, reliable, has a large capacity, and is cheap to maintain. The writer had in use during last winter a small installation of these cells, and found them perfectly satisfactory and reliable for all kinds of electrical work. The following is a description of a simple cell.

The outer vessel (A) consists of a glass jar (an ordinary glass jam jar will do) containing a solution of sulphuric acid—1 part of acid in 12 to 20 parts of water—and a zinc rod (B). Inside this vessel goes a porous pot (C) containing a strip of thin sheet copper (D) and a saturated solution of sulphate of copper (bluestone). The zinc is preferably of the Leclanché form, and it will be found to be cleaner, to last longer, and cheaper than a zinc sheet, besides which it is thoroughly amalgamated. The porous pots should be dipped in melted paraffin wax, both top and bottom, to prevent the solutions mingling too freely and "creeping." It is as well to leave a few crystals of copper sulphate in the porous pot, taking up about quarter of the pot.

The purest chemicals only must be used; the acid preferably that known as "Brimstone" sulphuric acid. In mixing, the acid must be added to the water. Zinc sulphate is frequently used instead, as it reduces the wasteful consumption of the zinc, but it must be as pure as possible.



With care the battery will last for weeks. When, however, it "runs down," an addition of sulphuric acid to the outer jar and a few more crystals put in the porous pot will set it up again. It is advisable to empty and thoroughly clean the cells and refill with fresh solutions every few months.

The writer has found the Daniell battery very useful for charging accumulators. The E.M.F. per cell is 1·079 volts, and it must be remembered that the total E.M.F. of the battery should be 25 per cent. higher than that of the accumulator to be charged.

Electrotyping for Amateurs.

December, 1898. By A. P. Drake.

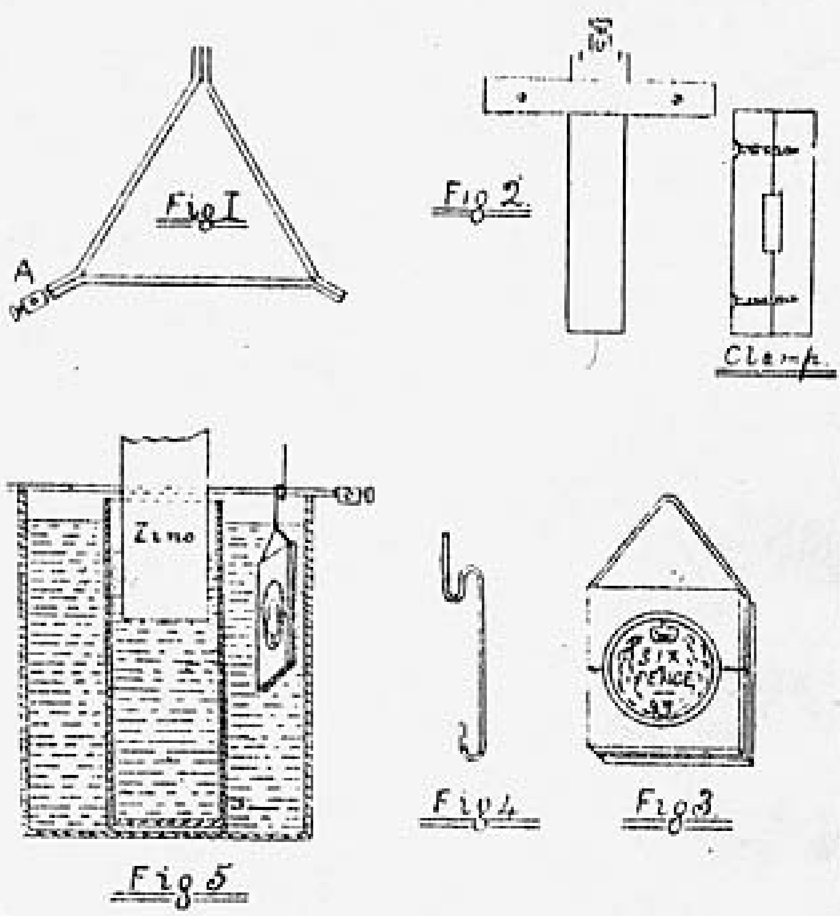
A particular and specialized branch of electroplating is the preparation of plates from printers' type, artists' engravings, etc. This art is known as electrotyping, and is an important phase of electroplating. To make a book plate, for example, melted wax is run over the printers' type as it is locked up in its frame, so that an impression of the type is made in wax. The surface of this wax impression is then made conducting by coating it with **graphite**. This is then put in an electroplating bath of copper sulfate, and a thin shell of copper built up over the wax mold. The shell can then be separated from the mold and backed up with type metal to give it body. Finally it is mounted on a wooden block for rigidity.

AT this season of the year, just as the autumn days are over, it is easy to call to mind forms of life in plants, flowers, seed capsules and insects that we should like to preserve in some permanent shape. In the rivers and on the seashore there are many things of beauty which would look well, and would make nice ornaments if copied in metal, but it would not do to send these things to the foundry in the ordinary way. The pattern would be pounded all in bits, and even if they could be moulded, the castings would be lacking in the fine lines of the original, and so be of little use. It is the intention of the writer to show how to obtain perfect copies of even the most delicate subjects, in metal, and how to mount the same in the form of tie-pins, brooches, hat-pins, etc. For example, a beetle may be reproduced in copper, and either enamelled in natural colours, or silvered to form a scarf-pin. The materials are few, and their cost is very small. The skill can be acquired by practice, aided by the simple directions given in these papers. Neither is a great amount of space required, as any cupboard, or even drawer, can be brought in to hold all the necessary appliances, and it will be found a very pleasurable, and, if the worker so wishes, profitable pastime during the winter months, especially if he has already acquired the knack of soldering.

The materials needed to commence with are of a rather varied character, and comprise the following:—For a vat we shall have to make a raid on the kitchen, and capture a glass jar, such as is used by confectioners to hold sweets, or a wide-mouthed jam or pickle bottle, about 6 ins. high and 4 ins. diameter. Also annex some fine blacklead, such as is used for polishing the stove. We shall further require a porous pot 6 ins. by 2 ins., piece of sheet zinc 3-16ths in. thick, 1¼ ins. wide, and 6 or 7 ins. long, one pint of sulphuric acid, half-a pint of boiled linseed oil, one pound of copper sulphate (blue stone), one oz. of mercury, and about 2 ft. each of 16 S. and 26 gauge copper wire.

In addition to the above we shall require some good plaster of Paris. This must be fresh, and the finest procurable. It will be best to sift it through a fine hair or muslin sieve, and keep the sifted plaster in a well-stoppered jar, as contact with the outside air deteriorates its quality, and soon makes it worthless for our purpose. The plaster is used to make moulds of the various objects we wish to copy. We shall also want some moulding boxes. These are empty boxes such as jewellery is sold in, or the inner tray of a match box. These should be ¼ in. larger all round than the objects to be copied.

As the moulds have to be blackleaded we shall need blacklead brushes. Unfortunately, the kitchen brushes are too large, so we shall have to visit sister's paint-box, and "borrow" a large sable (about ½ in.) and a few smaller camel-hair pencils. Some fine sand will also be required to form a bed for the subject whilst the plaster is poured on. The silver sand used by florists is the best, and should be sifted free from lumps and grit. Of this we shall need a pint or two.



Having now all the necessary materials for our purpose, we can proceed to set up the apparatus. Take the 16 S. gauge wire and make a triangle, as shown in Fig. 1, of such a size as to clear the porous pot, about 3-16ths in. all round. The ends of the triangle may be bound with some of the smaller wire, but are better if soldered, in addition to the binding. At one corner (A) solder a suitable binding screw or terminal. This is not absolutely necessary, but it is much more convenient than twisting a wire round the corner.

The zinc plate, if not already amalgamated, must now be taken in hand. To amalgamate it take three parts of water and add very slowly one part (by measure) of sulphuric acid. This acid must be handled carefully, as, if spilt on the clothing it will destroy the part by eating the fabric into holes. When making a dilute solution of this acid, always add the acid slowly to the water, and never add water to the acid. If the water be added to the acid the mixture will boil up and fly in all directions. Should the reader be so unfortunate as to do this, well wet the places the acid has splashed with a strong solution of ammonia or washing soda. This, if done at once, will prevent any harmful results. Soak the zinc in the mixture a few minutes, and, with a small pad of flannel tied to a stick, rub the mercury all over the zinc until no black patches show. When in use in the cell the zinc must be re-amalgamated as soon as it becomes black and fizzes greatly.

Now make a clamp of two pieces of wood to fit the zinc so that the clamp will rest on the porous pot and allow the length of zinc in the pot to be altered by pushing the plate through into the acid (Fig. 2). A binding screw or clamp should be fitted to the top of the zinc. The solution for the porous pot is 12 or 15 parts of water to one of acid. The acid used for the amalgamating added to the proper amount of water may be used for this.

For the outer jar a saturated solution of copper sulphate (bluestone is the trade name) must be prepared. The water used should be boiled and strained through calico to get rid of all bits and suspended earthy matter. Then dissolve as much sulphate as the water will take up. Also keep a few crystals of the sulphate in the cell to replace the copper taken out during the time the cell is at work. It is advisable to keep a small piece of strip copper hung over the side of the cell, but not touching the triangle or moulds, and in the solution say 3 or 4 ins., so that if the crystals should get used up the free acid formed may attack the copper strip and not that deposited in the mould.

Having now prepared all the solutions, we are ready to make a mould. Suppose, for a start, we take something of which we only want to copy one side, for a brooch or a tie-pin, *e.g.*, the head of a fancy button, or one side of a coin. Take one of the small boxes and knock out the bottom, so as to leave the four sides intact. The box should be large enough to leave about ¼ in. of space round the object to be copied. Now cut out of some thin paper a piece to fit inside the box, and in the centre of this mark and cut out a piece the exact size of the coin or button. Well oil the inside of the tray, the paper and the side of the subject to be copied. Suppose we take the coin. Place the coin on a level surface, say a piece of window glass, oiled-side up, with the oiled piece of paper round it, and set the tray in position on the paper. We are now ready for the actual moulding. Take half a teacupful of lukewarm water and sprinkle the finely sifted plaster in this, stirring all the time with a stick, until the mixture is as thick as cream; then pour into the mould.

When the mould is set hard enough to move place the lot—glass, coin and mould—without disturbing their relative positions, in a slow oven until the mould is baked "hard as a brick." Then we can remove the tray, paper and coin. The coin must be removed very carefully so as not to damage the mould. Now warm the mould and give it a coat of linseed oil. When this is dry, warm again and give it another coat of oil. This process must be repeated until the mould becomes yellow and smooth like a piece of marble, when it will be non-absorbent, and will not crumble away in the solution. Some workers prefer to soak the mould in melted paraffin wax until it will absorb no more. This is a quicker method than the former, but if care is not taken the wax sets in the fine lines of the mould, and an imperfect electrotype is the result. The mould not being in itself a conductor of electricity, it must be made into a conductor or the copper will not deposit on it. This is done in the following manner:—With a knife, or old file, make a shallow groove round the edge of the mould to take the slinging wire as in Fig. 3. From this slinging wire take two pieces of 26 S. wire and stick them into the edges of the mould, one at each side. If the coin is a large one, say a penny, four wires would be better at equal distances apart. If the subject were, say, a leaf with a long stem and a broken up edge like a fern, several wires would be necessary, one to each remote or outside corner. When the mould has been wired and all the rough edges trimmed off, the design must be blackleaded. Use finely powdered dry blacklead, and work it well into every crevice with the camel-hair brush, and also well round the ends of the conducting wires as the deposit will start from these and spread over the design. Care must be taken not to blacklead any plaster except the design, as the copper will form on the blackleaded portions, and so save energy used in depositing copper where it is not wanted, and the time spent in after trimming. When the whole of the design appears to be smoothly and well blackleaded, the mould is ready for the typing process, except that the slinging wire and conducting wires must be varnished or covered with wax to prevent the copper being deposited on them.

The mould and solutions being now ready we can make the real start and commence to deposit the copper. Put the porous pot in the outer jar, and fill them with their respective solutions to 1½ ins. from the top in the outer jar, and about 3 inches from the top of the porous pot, so as to allow for the zinc. Now clean the triangle with emery cloth and put it in position, and make a double hook of wire (Fig. 4) to hold the mould about an inch below the surface of the solution in the outer jar. Clean the slinging wire and the hook where they touch, and the hook where it hangs on the triangle. Do not let the hook or mould touch the porous pot, and suspend so that the design faces the pot (Fig. 5). Now adjust the zinc so that about ⅜ in. is in the acid, and see that it does not touch the sides of the pot. Connect the zinc to the triangle with a piece of the thick wire. In a few minutes a pink spot will be observed round the end of each conducting wire, where it joins the design. These spots will grow larger, and in time cover the whole of the design. Then the zinc can be lowered a little for say half-an-hour, and then lowered to the proper level. The rule is that the surface of zinc exposed to the acid be equal to the coated surface of the mould. Let the action go on for from twenty-four to twenty-eight hours, when the copper should be thick enough to bear removal from the mould. If the zinc be dipped too deep in the acid at first the copper will go on in the form of brown powder which will all wash off. Should any bubbles be observed on the surface of the mould they must be removed with a feather or camel-hair pencil. If they are not removed the copper will not deposit under them, and thus cause holes in the finished electrotype. When removed from the mould the electrotype must be well washed to get rid of the copper salts, and then the rough outside edges removed with a small file or a pair of stout scissors.

The next article will describe how to prepare a mould for a subject of which it is desired to copy both sides, and also how to mount and finish off the electrotypes to form the various ornaments mentioned above. It will also deal with moulds of paraffin and beeswax, and gutta-percha, with their different methods of preparation and use.

HAVING now mastered an easy subject, the worker may try his skill on something more advanced—say a fern or other leaf in its natural form and convolutions. Lay the leaf on the hand and brush melted beeswax over the side it is intended to copy. When the first layer is cold, add another, and repeat the process until a block of sufficient thickness is obtained. When the block is quite cold carefully peel off the leaf, and a fine impression will be found on the wax. The block may now be blackleaded and wired as before, and an electrotype made from it.

If it is desired to copy both sides of the leaf, proceed as above, only use some freshly mixed plaster instead of beeswax until a sufficient thickness of plaster is formed on one side of the leaf. When the plaster is hard, paint the other side of the leaf with several coats of bisulphide of carbon solution of indiarubber. This is a liquid having a smell like a case of bad eggs all broken at once, so that the best place to perform the above operation is out of doors with the back to the wind. The substance is also very inflammable, so that care must be observed in not approaching too near a fire or light. Next soak a piece of gutta-percha as large as the leaf in scalding hot water until it is soft, and press it on to the newly-painted side of the leaf. When this has set hard, gently pull it off, and we shall have one mould in plaster and one in gutta-percha. If these are blackleaded and wired in the usual way, we shall get two electrotypes, one of each side. These are trimmed at the edges, and washed, as in the case of the coin. The above is a method recommended by Mr. M. Roseleur. Another method is to procure a cardboard tray rather larger than the leaf, and half fill it with fine damp sand. In order not to destroy the natural pose of the leaf, we must lay it on the sand, and pack up the hollows under it with sand. When this has been done satisfactorily, fill up the tray with the plaster paste, and allow to set; then shake off all the sand, but leave the leaf in the mould; well oil the top side of the leaf and the face of the plaster, and again fill up the tray with the plaster. When this is set we shall have two sides of the leaf again in the mould, which may be treated and typed as before.

The above method is used in preparing moulds of seed capsules and small fish such as minnows, only where possible it is best to cut a piece of oiled paper to fit the inside of the tray and round the subject, and place this in position round the acorn, or whatever it may be, before pouring on the plaster. This prevents the sand sticking to the plaster, and also, when operating on the other side, keeps the two blocks of plaster from adhering to each other.

If the subject is not wanted again, the best way to remove it from the moulds is to strongly heat them with the subject inside, and so cause it to shrivel up. If any little bits are left sticking in the mould, they may be removed with a pair of forceps. Should the subject be required again, the two halves of the mould must be carefully separated when dry and the subject taken out. This must be done with great care, or both subject and mould will be spoilt if any little projecting pieces are broken off.

Having now our electrotypes ready for mounting, we must decide on the use we are going to put them to. If the shell is thin, it is best to fill it with solder so as to prevent it being buckled whilst soldering on the back plate. The best way to do this is to use resin as a flux and fill the electrotype with the solder level with the edges. On no account use killed spirits as a flux, as it will in all probability eat through the thin copper in time and destroy it. It is advisable in making copies of seed capsules for hat-pins, or other articles that will be subject to somewhat rough usage, to deposit the copper for two, or even three, days. If this is done, the copies will not require backing up with solder, as the copper will be thick enough to stand fair usage without. When the thin shell has been strengthened with a backing of solder, and the edges trimmed, a back plate—in the case of brooches, tie pins, etc., the same shape and size as the outside edge of shell—is soldered to it. The back plates may be of thin sheet copper, brass or German silver. For small ferns or similar open subjects, an oblong, oval, or other design back plate may be used with the shell soldered in the centre, but for solid leaves a plate to the shape of the leaf should be soldered to the back of the electrotype. Seed capsules for hat-pin heads must be soldered to the pin. To do this, cut off the ordinary glass head and file or emery paper half-an-inch of the end bright and clear; then dip it for a second or two in the outside jar of the cell. When removed, it will be found to be coated with copper. Dry the end and tin it. The pin can now be soldered inside the stem of the electrotype and the surplus solder removed to make a neat job of it. Care must be taken, when soldering up electrotypes, to use no more solder than is required to make a good joint, as the surplus solder has a knack of spreading all over the work and filling up the delicate lines.

The pins and catches for brooches are to be purchased at the local watchmaker's and jeweller's.

As electrotypes in copper look common and soon tarnish, it is usual to either silver or gold plate them. Seed capsules look best gilded, but fish and large leaves are better silvered. If the amateur is near an electroplater's, he can get them done for him as cheaply as if he did them himself; but, as some readers live away from towns, and others prefer to do their own plating, I will in my next article give an outline of the processes used.

THE solutions used are the double cyanides of potassium of either gold or silver. The most simple way of preparing the baths is as follows:—Procure two Daniell cells, and an enamelled iron saucepan which will hold a pint of liquid. In a quart of filtered rain-water dissolve 2 ozs. of best potassium cyanide. We shall also require two silver plates, 2½ in. by 1¼ in., and about ⅛ in. thick, and drill a small hole in the middle of one, short side, large enough to hook in a slinging wire. The silver plates must be perfectly *pure*.

Put a pint of the cyanide solution into the pan, and suspend the plates on opposite sides from two pieces of wood. The plates must not touch each other or the pan. Then connect the wire slinging hooks to the two Daniell cells connected in series, and allow the current to pass from one plate to the other for about two hours. Then take off the plate connected to the zinc end and replace it with a clean brass one. If this plate takes a coat of silver the solution is ready for use. When the silver solution is ready for use it should be poured into a clean glass bottle and labelled "Silver solution—Poison." The gold solution is prepared in a similar way from the remaining pint of solution, only use small strips of pure gold instead of pure silver. Before preparing this solution the pan must be well washed out. The gold solution must be kept at a temperature between 160° F. and 180° F., or scalding hot during this and the plating process.

As the rule for plating is that the "anode" should present a surface slightly over that of the object to be plated, the two gold plates will have to be connected together on the same side of the bath whilst the plating process is proceeding. When the solutions and apparatus are not in use they should be kept in a locked cupboard, owing to the poisonous nature of the materials used. The electrotype must now be polished where it is intended to be plated, and cleaned by brushing with whitening moistened with pearlash water. The parts not to be plated must be varnished with thin shellac or copal varnish.

The electrotype having been well rinsed in warm water to get rid of any whitening, and the varnish dried, suspend it in the solution with a slinging wire. A single Daniell cell will deposit silver or gold from these solutions, and may be made by inserting a copper plate, bent to fit the jar, in the place of the electrotype in the copper sulphate solution. The copper plate may have a binding screw soldered to it, or may be connected with a piece of the thick wire to the triangle. In plating, the zinc must *always* be connected to the article to be plated, and the copper plate to the anode. With a large electrotype, two cells may be required, but always do as in electrotyping, put on the first coating slowly, and afterwards proceed more rapidly by adding the extra cell. If too much current is used the metal is deposited roughly and in small lumps, which have to be smoothed down with a brush made of fine brass wires called a scratch brush.

If the electrotype is only intended for show, a thin deposit only is necessary; but if wearing qualities have to be considered, the action must be continued two or three hours. It will then be covered with a creamy-white deposit, if silver, which is slightly rough. Remove the article from the bath and well wash it in warm water, and brush down all the rough places. This will give it a polished appearance if done whilst wet. After drying in bran or boxwood sawdust, the surface will appear dull, but will feel smooth to the touch. A little further treatment with the brush will add a slight polish, which is all that can be done with ferns and other open leaves.

If gold is deposited on copper, the coating will have a dull 15-carat tint, so that it is usual to first give the object a thin coat of silver, well wash it, and then transfer to the gold solution. A durable coat can be obtained in fifteen or twenty minutes with a hot gold solution. For those readers who intend to take up this subject as a means of increasing their income, and thus needing a larger plant than the one described, I here give the proper plating solutions:

Gold.—Dissolve 1 oz. of potassium cyanide in 1·1 pints of water, and add gold chloride in proportion to the amount to be used. This will, of course, depend on the size of the object or objects to be plated. If the bath is acid, it must be made alkaline with ammonia. It may be used cold, but used hot the colour is improved and the coat is more durable.

Silver.—This bath is prepared from 2 lb. of potassium cyanide, 14·23 pints of water, and 2·4 ozs. of carbon disulphide. The object of adding the carbon disulphide is to make the objects come from the bath with a bright surface, rendering polishing unnecessary, and thus producing cheaper articles.

Since writing the above, I have received, in my capacity of model engineer expert, an inquiry as to the method of making the letters so often seen on brooches in jewellers' shops. The letters are made in dies specially made for each work, and a large number are struck off every time the dies are placed in the "press," as the machine is called. These words, or it may be sentences, or even the whole brooch with a motto or text in raised letters on its face, are made at one blow and sent off to the platers, and are then returned wrapped in tissue paper, in which wrapping they are stored until required. This is the method by which these things are made in a wholesale way, and is not suitable for an amateur worker at all.

He will have to proceed in a rather more round-about way, and also take more time over the job. Procure an alphabet—that is, A to Z—of type from a printer, the letters of the size required for the work in hand. If so disposed, the worker could invest in, say, three complete sets of type, and then could set up a word at once in his trays. Then pack them up with the fine sand, so that the letters are just above the surface. A plaster mould can now be taken in the usual way, and afterwards electrotyped as before described. The type can be bought for about 1s. 6d. or 2s. per lb., and does not weigh very heavy.

Pretty effects can be obtained by neatly soldering a name to a small fern, and then mounting the whole on a back plate to form a brooch.

Should any reader be confronted with any difficulties in connection with this subject, I shall be pleased do my best to set him on the right track.

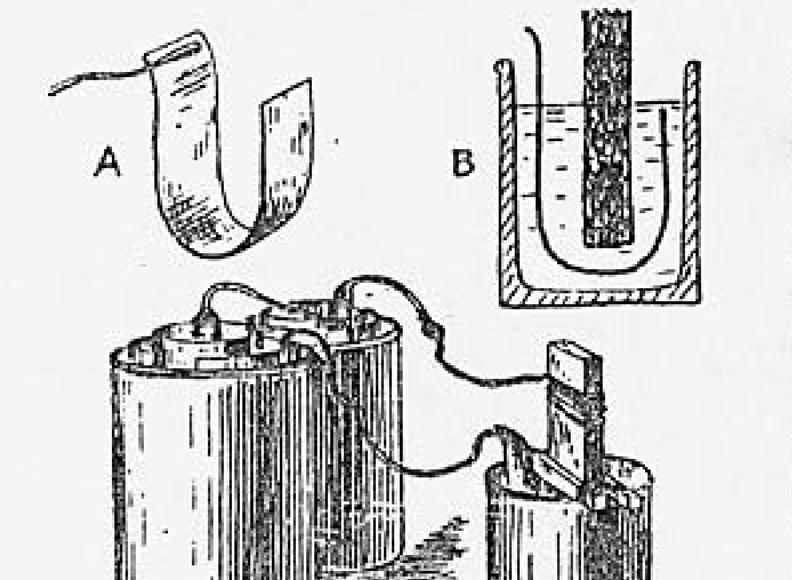
Fitting Up Carbons for Bichromate Batteries.

May, 1899.

By F. E. P.

THOUSANDS of amateurs who use bichromate batteries—and where is the amateur who does not?—would be glad to know of a thoroughly efficient and satisfactory means of connecting up the carbons. The usual method, namely, by clamping the zinc between a pair of carbons which are connected by a copper strip, has the disadvantage that even when there is no creeping, the surface of the copper connecting strip becomes corroded in time and causes a bad contact. If the following suggestions are followed there need be no fear of the connections deteriorating when the battery is out of use, the latter being always ready at a moment's notice.

The writer has always found it best in making up bichromate batteries to clamp the elements together by bolts, one being enough when the plates are about 1½ ins. wide, and two when they are about 3 ins. wide. The holes in zinc should be at least ⅛ in. bigger than diameter of bolt, a little tube of many turns of waxed paper separating the bolt and the zinc plate. Bolts ¼ in. diameter are suitable, and with two carbon plates ⅜ in. thick, zinc ⅛ in. thick, and wooden strips 3-16ths in. thick, the bolts should be 1½ ins. long. Black bolts



and nuts of these dimensions can be bought for about 1s. 3d. per dozen.

Having drilled the necessary holes in the carbon plates about ½ in. from the top, proceed as follows:—Melt paraffin wax in a gallipot by placing the latter in a saucepan of water kept just simmering. Let the wax stand about 1¼ ins. deep in the pot. Now stand two carbons in the wax, tops downwards, keeping them clear of one another and away from the sides, or capillary action will

 GRANDDAD'S ELCTRICITY BOOK

take place, and the wax run too far along the carbons. They should stand for a quarter of an hour or so, being then drained and put aside, and the next pair immersed. Fresh wax will, of course, be required to make up for that absorbed by the plates.

When all are done, make up a simple Daniell battery of two cells, using jam pots, thin copper plates, and Leclanché zincs. A depositing cell will be further needed, and this may consist of a gallipot, which must be nearly full of saturated solution of sulphate of copper. The waxed top ends of carbon plates are to be copper-plated, and this will be effected by placing the carbon top end downwards in the solution of sulphate of copper, allowing about 1¼ ins. to be immersed. A copper plate about 1-16th in. thick must now be bent to the form shown in the sketch at A, the width being about two inches. This copper plate must then be arranged in the depositing cell, as shown diagrammatically at B, care being taken that the copper plate does not touch the immersed carbon at any point. A piece of No. 18 or 20 copper wire may be soldered to the copper plate for connection, and a similar wire connected to carbon by wrapping tightly round it half-a-dozen turns. Connect the carbon with the zinc terminal of the Daniell battery, the cells of which are connected in series. The copper plate must be connected to the copper terminal, and the action will then at once commence. The whole arrangement is clearly shown in the accompanying sketch.

The length of time taken to deposit a fairly thick coating of copper on the carbon may be anything between three and eight hours. When sufficient copper has been deposited to make a firm and substantial joint, a second carbon may be substituted for the first, which may be washed and dried, and it will then be found an easy matter to solder a piece of No. 18 copper wire to the top and so make a connection which will be at once durable and efficient. The trouble of this method will be well repaid in the reliability and permanence of the battery when made up.

How to Make a Cheap Reliable Galvanometer with Bridge and Scale.

By A. S. Weiss.

The galvanometer shown herewith (Fig. 2) is a first-class instrument, for use with a Wheatstone bridge, for measuring resistances of wires for field and armature coils. It is classed as a low-resistance, reflecting, astatic galvanometer, and is easily constructed by amateur electricians, the advantages gained by its use repaying the maker for the trouble taken in its construction. The scale card is cut from paper, being a circle 3 ins. in diameter, divided into spaces of 3° each. The two zero points are opposite, and run up to 90°, each five spaces being marked 15°—30°—45°—60°—75°—90°. The two points marked 90° being opposite.

1. A base is made of wood—cherry will do very well. This is best turned on a lathe, and a slot turned into it for the reception of the glass shade. It can be polished by running the lathe at a high speed, holding a rag saturated with shellac varnish to it. The necessary holes (two for wires, two for binding-posts, and one for standard) should be drilled preparatory to polishing.

2. The coil (Fig. 3) is wound same as shown—best done

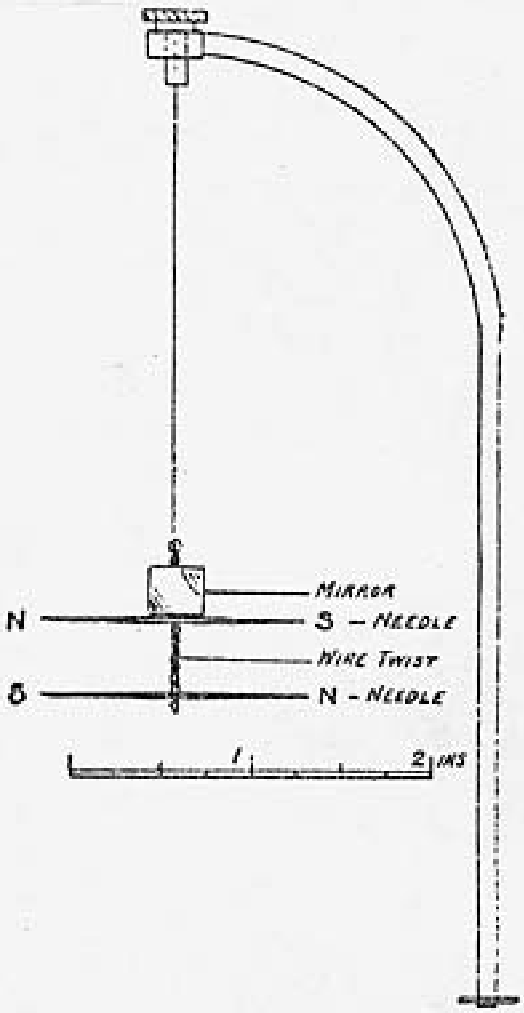


Fig. 1.

on a wooden form one part at a time—both parts together having a resistance of ½ ohm. After winding, a tie wire should be fastened at each end of each part, to hold wires together. The two outside wires are joined, put through hole in cherry base made for their reception, and turned over, partially keeping coil in place; the two inside wires are run through other holes, and one run to each binding post, as shown.

3. The standard (Fig. 1) is made of brass, bent as shown and rivetted to cherry base. A hole is drilled through its head for the reception of a brass swivel to hold system.

4. The system is made by taking two sewing needles and inserting them in the twists of two copper wires, as shown, and fastened by a drop of solder, using sal ammoniac as a flux. The twisted wire ends in a loop through which a single silk fibre passes and runs up to swivel where it is a fastened with a drop of sealing-wax. A small square of mirror glass is fastened to copper twist over top needle by sealing-wax, as shown. Measurements can be taken direct from bluepoint.

5. The coil is mounted and a small brass plate is placed inside of it, so as to engage each part of coil, and screwed to base with a brass screw. The cord is drawn and cut, and fastened to top of coil by sealing-wax. The needles of the system are magnetised to a polarity, as shown, by holding a magnet leg on one end of top needle for twenty minutes; then hold other leg of magnet on same end of lower needle for twenty minutes. The system is now hung and glass shade placed in position, completing galvanometer.

The bridge is used in connection with galvanometer; it is known as the Wheatstone slide metre bridge. As shown in (Fig. 4), it consists of a ½ in. board 4 ins. longer than a metre and 4 ins. wide. A German silver wire is

 GRANDDAD'S ELCTRICITY BOOK

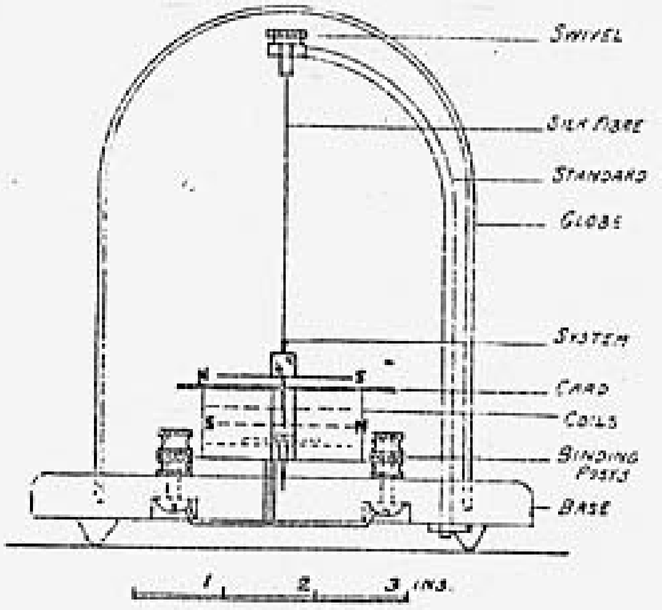


FIG. 2.

placed between two binding posts AB, 1 metre apart and a scale marked under it of 100 centimetres. Then binding posts CDE are inserted and connected on bottom side by a bare copper wire. This completes the bridge. It is used as follows :—

The terminals from a battery are inserted at binding posts, AB. A known resistance, say 50 ohms, is connected to EB, the unknown resistance to AC, one galvanometer terminal to D, the other one slid along German silver wire until needles cease to move and come to zero. Say the scale indicates at F on board 40, then we get the proportion :

50 = known resistance.
x = unknown resistance.
40 = one side of bridge.
100 − 40 = 60 = other side of bridge.

$$x : 50 :: 40 : 60 = \frac{2000}{60} = 33\tfrac{1}{3} \text{ ohms} = \text{unknown resistance.}$$

SCALE.

This is used in delicate tests, and is made of a strip of wood ½ in. thick, 24 ins. long, mounted as shown, and a 1-in. scale marked on each side of a hole made in middle of board ⅜ in. × ½ in. This hole is also cut in a piece of tin, and fastened over aperture in wood to give sharpness to the beam of light transmitted by lamp to galvanometer mirror back to 1-in. scale on faceboard. The lamp is placed in back of scale, so that lamp flame, hole in scale, and mirror in galvanometer are in line. Then when galvanometer is a zero beam of light, invisible as it falls on the aperture in scale. The

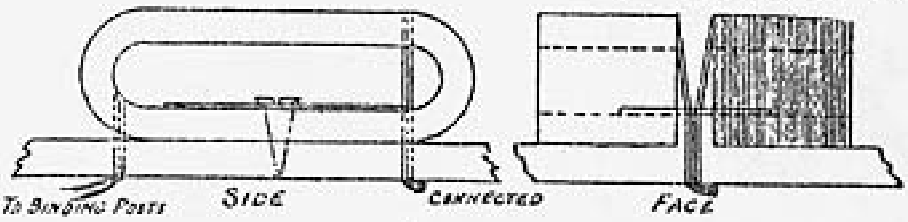


FIG. 3.

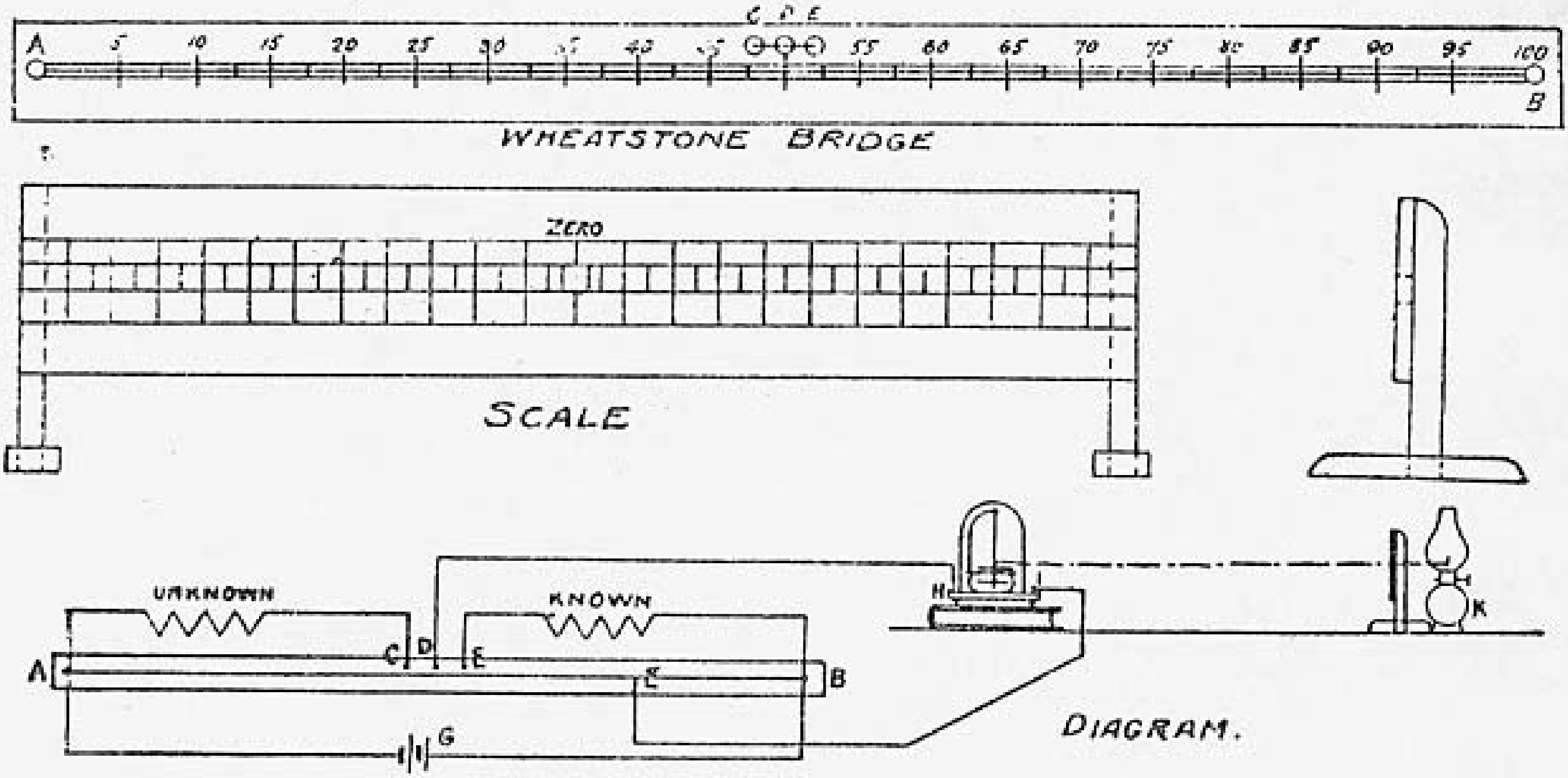


FIG. 4.

least amount of current which unbalances the current causes beam of light to move up or down on the 1-in. scale, although no perceptible move is apparent in system. In a test, connect as shown, and move galvanometer terminal slowly up and down German silver wire on bridge until a perfect balance is brought about, which is made apparent by beam of light falling on hole in scale. Then readings are taken, and the result ascertained by the aforenamed proportion.

This is an invaluable instrument to the amateur, and well worth his best care and intelligence in construction. To these I extend my best wishes.

[Complete sets of parts for making this instrument are supplied by the Stirling Electric Co., Stirling, New Jersey, U.S.A.]

A Medical Coil and How to Make It.

June, 1899.

A MEDICAL or shocking coil is a useful bit of apparatus to possess, easy to make, and you can make a better coil at a cost of ten shillings than can be bought for three times that sum; not so handsome, perhaps, but very effective and powerful. The model which I have, with one or two little modifications, adopted, is that suggested by Mr. Bottone, and is figured below, not quite complete though, for I purpose fitting it with a rack and pinion movement for the better and easier regulation of the secondary coil.

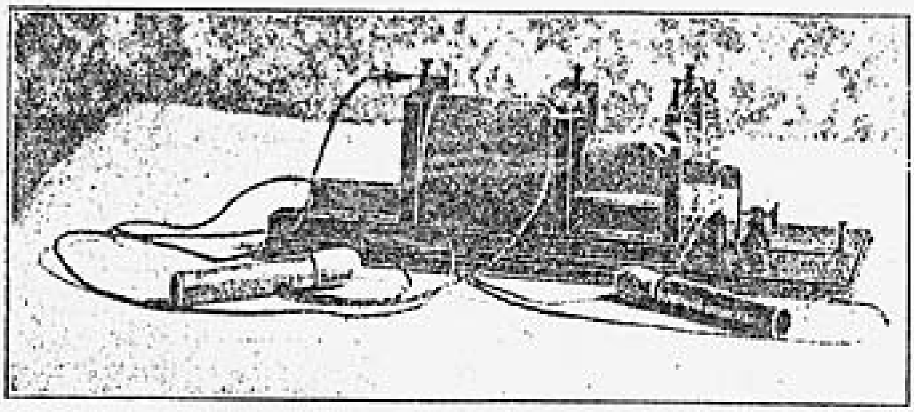


FIG. 1.—THE FINISHED COIL.

Another advantage in this form is that each part is visible; as a matter of fact, the coil takes to pieces, and thus each part may be, if necessary, described in detail for educational purposes.

The first thing to do is to make the core. This is formed of a bundle of straight iron wires, No. 18 gauge. Procure a hank of the softest iron wire; then cut into lengths of about 4½ ins., and make as straight as possible; now get a piece of thin brass tubing about 4½ ins. in length by ½ in. diameter. (This tube, a small break and hammer-head, and the wires, say ½ lb. No. 20 or 22 single cotton-covered wire, and the same weight of No. 36 single silk wire, had better be bought direct of some dealer in electrical stores.) Fill this brass tube with the iron wires, pack tightly, then having drawn an inch or so at a time, bind the wires with wire securely twisted round; file the ends up straight, and having dipped them in "killed" spirits of salts, dip them in molten solder, clean up, wash in hot water, dry, and finally soak to saturation in hot paraffin wax; the result should be a core of wires, over which the brass "regulating" tube will just easily slide.

Make a paper tube, 4 ins. in length, as follows:—Roll a piece of white demy round the brass tube; cut a piece of tough brown paper, 12 ins. by 4 ins.; give this a coat of thin hot glue, and roll it tightly round the papered tube; when quite dry and hard draw out the brass tube, and having squared or trued up the paper tube, give the latter a soak in hot paraffin wax.

Now take the core and form a paper collar half-an-inch from one end and about half-an inch in width, by rolling and glueing a strip of brown paper round at this point. This collar must be just thick enough to take the paper tube just made (it can, of course, if too thick be easily filed down). When dry, give it a coat of glue and slide on or fit it into the paper tube. The brass tube may be left in position during this little operation, and while the joint is drying. See Fig. 2, where *a* is the core, *b* the collar, *c* the paper tube, and *d* the brass tube.

Cut out of mahogany or teak, ¼ inch thick, a 3-inch square; bore a hole in the centre of this to exactly take the paper tube just made and fitted. The end of this tube, with the protruding core, must be then securely glued into the aperture, taking care to fix the tube squarely and at right angles. (See Fig. 3.) When this is dry, put in a couple of terminals as shown, A and B (Fig. 3), and having bared one end of the cotton-

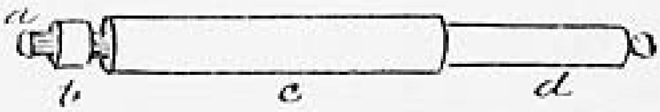


FIG. 2.

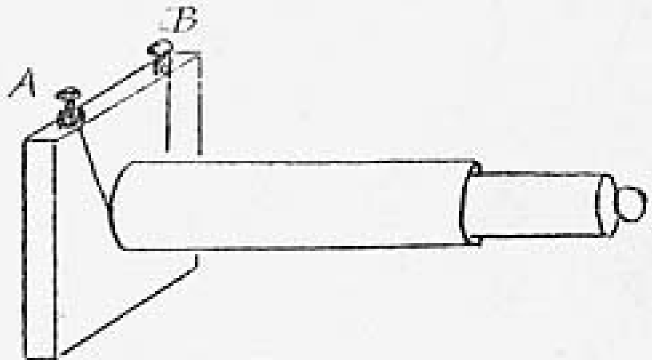


FIG. 3.

covered wire turn it round and under the terminal at A, and proceed to wind on the (primary) wire in tight, even coils nearly to the end of tube; tie down here; baste the layer with hot melted paraffin wax; put on a layer of wax paper; then recommence winding; put on four layers, waxing each in turn as described, finishing up by baring the finishing end and inserting under terminal at B; give the last layer a basting with hot wax, and roll it up smooth and straight as possible in the fingers. Our primary is now complete, and may be mounted on a polished baseboard, 12 ins. by 4 ins. or so, by means of a couple of screws put in from underneath.

We must now make the secondary bobbins. Provide two wood ends, mahogany or teak, ¼-in. thick, but shaped as shown in Fig. 4. Roughly, they may be 3 ins. square, plus the stud at the bottom which is to secure it to the rebated guide strips, afterwards to be fixed to the baseboard.

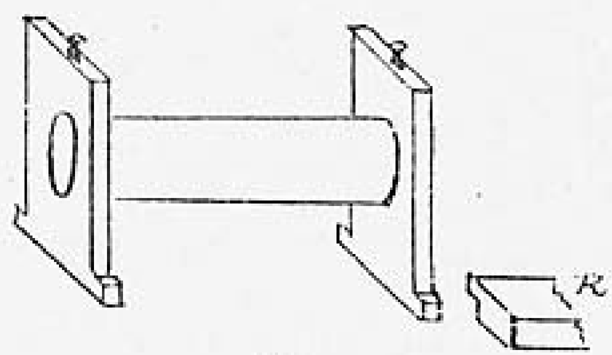


FIG. 4.

Make or procure a thin paper tube, 4 ins. in length, and of diameter large enough to just smoothly slide over the primary, and having given it a soaking in hot wax, mount this centrally between the two wooden ends just referred to. This must be carefully done, and, in fact, all the necessary fitting of the bobbin should be completed

 GRANDDAD'S ELCTRICITY BOOK

before commencing to wind on the wire. Two fillets of wood rebated as shown at R (Fig. 4) are, therefore, glued or screwed to the baseboard, and the finished bobbins adjusted to slide easily between them.

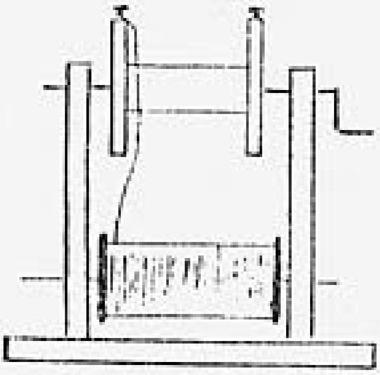


FIG. 5.

Before starting to wind the bobbin, we must make a winder (see Fig. 5); this is formed out of a square of pine or other wood, 8 ins. by 6 ins., with two uprights; the reel of wire and empty bobbin being arranged as shown. The wire should receive a preliminary coating of wax, which is best done by soaking for some minutes in hot paraffin wax, and draining; it should also be tested for continuity by means of a small battery and galvanometer. Having bared one end of the wire (No. 36 silk covered), pass it round the screw of a terminal as shown, and commence to wind, the turns of wire must be drawn tight and close together; in this way the first and succeeding layers must be put on; each layer is also to be basted with hot melted paraffin wax, and receive one layer of thin waxed paper; the wire is thus put on in one continuous length, going from end to end and backwards and forwards in close, even turns, finishing at the opposite terminal to which we started, and here the end is bared and connected.

It is most important to avoid all breaks and flaws, and kinks or knots in the wire; therefore, at the least suspicious part the wire should be cut, the ends bared and twisted together, and a fresh joint made with resin and

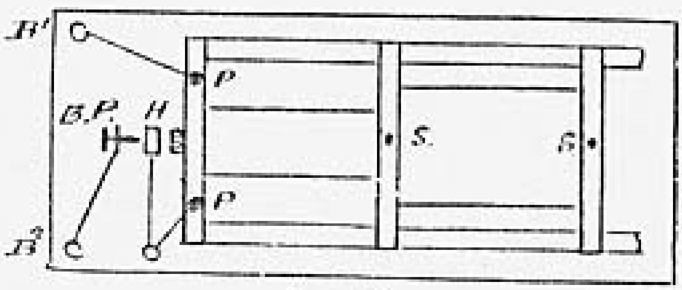


FIG. 6.

solder, the joint then being made good with a little twist silk and wax, and, of course, at such times the wire should be tested for continuity. The bobbins may be "finished" by covering with velvet, or thin sheet ebonite; the wooden parts, ends and base, will also be polished or varnished to suit the worker's fancy or pleasure.

The contact breaker for this little instrument can be bought ready made, with platinum contacts complete; the height required will be $1\frac{1}{2}$ ins.; the requisite holes for these are bored in the base and the parts secured by nuts underneath. If thought proper, the primary wires may also be brought down through the base. Supposing Fig. 6 to be a ground plan of the coil, one of the battery (two bichromate cells) wires is connected to B¹, the other to B², the current will pass through the primary (the other end of which is connected with the break hammer); the core being thus magnetised, draws the hammer head towards it, the effect of which is to break contact with the platinum point at B P. The electric circuit being thus interrupted, the de-magnetised core no longer attracts the hammer, which, being released, makes contact once more with the point at B P, the make and break being repeated as long as a current is available.

We now require two handles, and these, in their simplest form, may consist of two pieces of brass tube, two lengths of flexible wire cord being also provided. One end of each wire is soldered to a tube or attached by means of a screw, the other (terminating in a short piece of stout copper wire) for insertion at S and S respectively. With a coil made as above a battery of two bichromate cells will be found quite sufficient for the purpose.

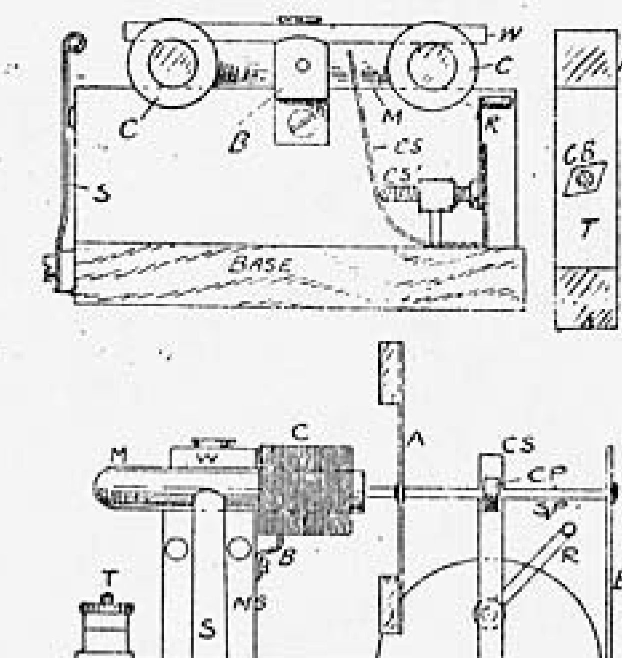
Simple Electric Motor.

TO THE EDITOR OF *The Model Engineer.*

DEAR SIR,—Perhaps the following description of a simple electric motor may interest some of your readers. It can be constructed very cheaply, and, if properly made, will run at a great speed.

The magnet support (MS) and base are made from a a piece of wood of a suitable thickness, and varnished. The magnet (M) is made from a piece of soft iron rod, $\frac{1}{4}$ in. in diameter and about $4\frac{1}{2}$ ins. long. It is wound with No. 26 S.C. wire, about $\frac{1}{2}$ oz., but 1 oz., I think, would be better. The magnet is held down on the support by a piece of wood (W) laid across the magnet, and a screw passing through the wood (W) into the support.

The next thing to make is the two bearings (B and B¹) of stout brass. One is straight, about $2\frac{1}{2}$ ins. long; the other shaped [shape] about 1 in. long. In the end of each, two conical holes are drilled for the spindle (SP) to run in. At the end two holes are drilled right through for the screws which fasten them to the base and magnet support.



The spindle is made from a very fine knitting-needle, the ends filed to run in the conical holes in the bearings (B and B¹). The armature is made of two square pieces of iron (IP), $\frac{3}{8}$ in. square, soldered to a piece of tin (T) about $1\frac{1}{2}$ ins. long. The armature must then be soldered on the spindle, so it runs quite true, as near the magnet as possible without touching. The contact breaker is a piece of copper (CB), shaped / / about 3-16ths in. long, soldered on in a position as shown, but the best position is found by experiment. The spring (CS) is a piece of watch-spring, which is made to approach or recede by the screw (CS[1]) worked by the handle (R) which regulates the speed. A switch is fitted as shown at S. Two terminals are fitted at the back. The current goes from T to magnet, from magnet to bearing, through contact breaker and spring to switch, and from there to terminal (T[1]) not shown.

The motor runs about 2000 revolutions per minute, with a quart bichromate. It is well worth making. I have shown it to several friends who think it very good, and one has made one the same with the same success.—Yours truly, J. W. T.

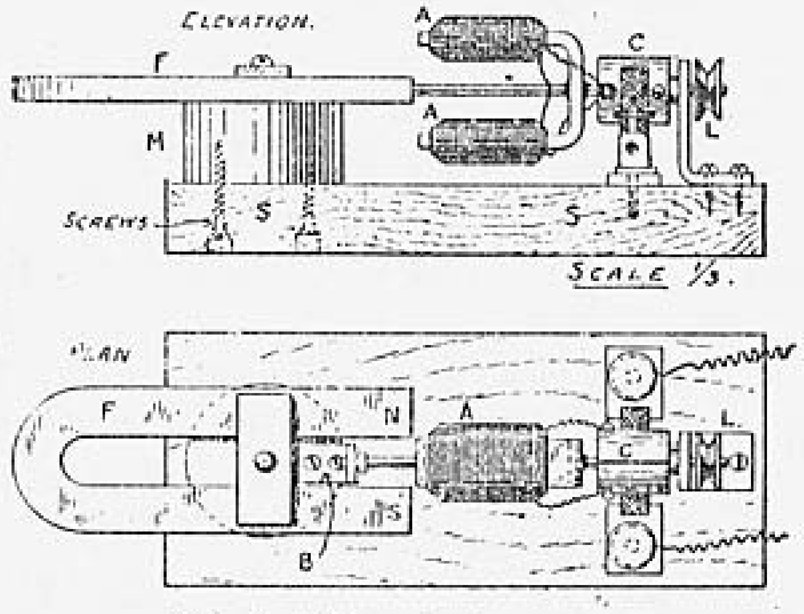
Richmond.

How to Make a Very Simple Electro-Motor.

September, 1899. By R. F. M. W.

THE motor here described is suitable for the younger readers of this paper, as it gives a good insight into motor principles in general, is very easy to construct, and runs well when carefully made. The field magnet F first demands our attention. It consists of a permanent steel magnet with parallel limbs—4 ins. long, ½ in. between limbs, metal ½ in. wide and ¼ in. thick. This can be obtained from any electrician's for about a shilling.

The armature A is made from a piece of soft iron about 4½ ins. by ½ in. by ¼ in. It is bent into horseshoe shape (the metal being heated to redness), with its limbs 1½ in. long and ⅞ in. apart; it should be left to cool by itself. A central hole is drilled in this magnet, and a 3½ in. spindle cut from a true and straight No. 19 steel knitting-needle. This is soldered firmly and truly in the



armature, which should be well balanced. The spindle should protrude about 1¼ ins. on the commutator end C. Now a small collar of brass or copper is soldered on to the front end of the spindle, leaving about 3-32nds in. to enter the bearing. This bearing is the front bearing (B), and is made from a piece of brass ¾ in. by ⅜ in. by 1-16th in., ¼ in. of this being bent sharply at right angles. (To bend brass and copper, the metal should be heated to a red heat and then quickly cooled in water, after which it will bend well and without breaking.) In the longer end two small holes are drilled for the holding down screws. The back bearing L is made from a piece of brass 2 in. by ⅜ in. by 1-16th in. This is softened, and about ¾ in. is bent at right angles to the rest. The longest part may be tapered away towards the top, and neatly rounded. Two holes for holding down screws are drilled in the short end.

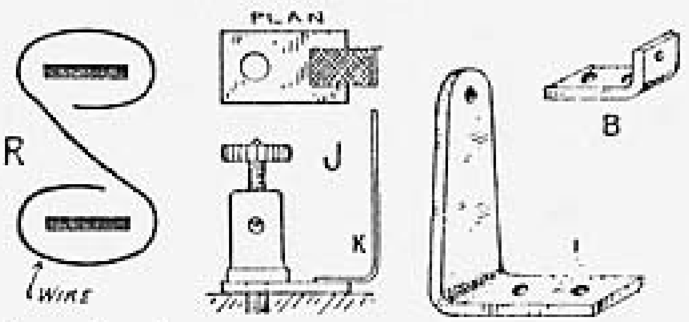
The stand S is made of a piece of well-seasoned wood, about 6 in. by 2½ in. by ¾ in. This is well planed and sandpapered up, and then varnished or polished. The field-magnet saddle is then constructed, and may be either round or square; a good size is 1¼ in. square (or diameter) and ¾ in. high. The centre line of the stand is now carefully obtained, and the saddle is screwed down near one end of the stand. A piece of brass about 1½ in. by ½ in. by ⅛ in. is cut out, and a hole drilled in its centre. The field-magnet should now be screwed down on its saddle by means of this brass plate and a screw, which is driven into the centre of the saddle. A hole has now to be drilled in the front-bearing B, at such a height that when this is screwed on to the saddle the field magnet and spindle will be in the same plane. The front bearing is then screwed down, and the back bearing L put face to face with it, so that its hole may be marked off and drilled in the right place.

Now comes the most difficult part, namely the commutator C. It consists of a brass tube, ⅝ in. diameter and ⅞ in. long, and about 1-16th in. thick. This is forced on to a circular piece of ebonite or boxwood, in which a hole is drilled to fit the spindle. Four short brass screws are screwed into the tube and ebonite, two at each opposite end of a diameter, one of each of these being countersunk level with the surface of the tube, and fixed smooth. Two saw cuts must be made at each end of a diameter, the diameter being at right angles to that of the screws. These saw cuts must be clean through the brass tube and a short way into the ebonite as well. The screws used to hold the two brass cheeks (just cut) on to the ebonite or boxwood must be short enough to quite clear the steel spindle. Such a commutator can be obtained for about 1s. 6d. from electrical dealers. It is troublesome to make, especially for those who do not possess a lathe, and it should run quite true when on the spindle. Now force the commutator on to the spindle so as to clear the armature by about ⅛ in. Twist it so that its cuts are at the top and the bottom when the armature limbs are at the top and bottom (see sketches).

The armature may now be mounted in its bearings. Place a small metal washer on the spindle between the commutator and the back bearing. Slide the back bearing on the base until only a small amount of end play is allowed to the armature, and screw the back bearing down to the stand with two brass screws. Adjust the field-magnet to clear the armature by about 1-32nd in. to 1-16th in. Take the armature and spindle out for winding.

The armature limbs must be covered with silk cloth or thin paper, so that not a bit of bare iron is left exposed. Commence winding by tying about 2 ins. of the wire (No. 26 D.C.C. or S.C.C. copper wire) to the commutator, and start winding along the limb, winding each wire close to its neighbour, and wind tight like a reel of cotton. When the end is getting near (say about half way) put a piece of silk, the same colour as the insulation of the wire, under the wire, and leave about an inch. Now wind on till you reach the end. Pull the silk up tight over the last wire, and wind back. Do this with every layer at each end. It prevents the under layers

 GRANDDAD'S ELCTRICITY BOOK



slipping when the top ones are wound over them. Six layers must be got on each limb, making the total wire about 36 yards or 2 ozs. When crossing over to the second limb, wind the reverse way (see R) like an S. When both limbs are wound with the same number of layers (and turns as near as possible), the end of the winding must be firmly tied to the limb. Now cut off all the stray insulation which sticks to the unwound iron, and clean up. Test for leakage by cleaning one end of the winding and connecting any good cell to one end. Leave the other end of the winding free. Touch a wire from the other pole of the cell on to a piece of the iron which has been scraped clean. If in a dark room no spark is seen when contact is made with the iron, there will be no leak. Connect the cell through the winding and the armature should be a fairly powerful magnet. If it does not magnetise there is a short circuit or a wire broken, and the armature must be re-wound. Clean both ends of winding and twist them under the two commutator screws; then drive the screw home.

All that remains to be done is to put some terminals and brushes on the machine. Cut two copper or brass blocks (see J) about ⅝ in. by ⅞ in. by 1-16th in. or 1-32nd in. Drill a hole in each well towards one end to fit the tang of a binding screw. Cut two brushes of thin copper gauze about 1⅝ in. by 3-16ths in., and solder them to these copper bits and bend them at right angles (K). Now place these blocks so that the brushes spring firmly on to the middle of the commutator; bore a hole for each binding screw, and screw them home. These brushes should only be one thickness of gauze, and should press firmly on to the commutator. The machine looks well with all the iron-work painted up one colour and the coils shellaced, varnished red or black (mix red ead or lampblack with S-varnish), and the saddle and base varnished or polished. The motor will run very fast with one Leclanché or any cell on, and at a furious speed with two cells on in series—even a piece of carbon and zinc in salt and water will make it work well. The best cell for long runs is porous pot with carbon and a solution of water, potassium-bichromate and sulphuric acid; outer cell sheet zinc in salt and water. The writer has run his little machine for fifty four hours without a stop with one charge from the above cell, and at a speed somewhere near 2000 revolutions per minute. A small metal or wooden pulley may be keyed on to the shaft at L. The principle on which this motor acts is—"Similar magnetic poles repel, dissimilar poles attract." The current is changed by the commutator always at such a time that the actions between the electro-magnet (armature) and permanent magnet (field) tend always to keep the former in motion. This little machine is not self-starting, and, of course, very little work can be got out of it.

October, 1899.

I. How to Make an Electric Bell.

IT is intended in this series of papers to deal with the construction and management of electric bells, indicators, &c., with their various accessories and applications. For the benefit of the younger readers of THE MODEL ENGINEER there will, wherever possible, be given a description of the cheapest and most easily made form of the piece of apparatus under consideration, together with the ordinary or commercial form—illustrated, of course, by the necessary diagrams.

It is not necessary to describe in this paper the ordinary Leclanché cell, as it has, in the Carporous type, been already fully explained in the April and September, 1898, issues of this journal. This cell is made in three sizes—the No. 2, or quart size, being the one in general use for bell and telephone work. The No. 2 size costs about 1s., and is, all things considered, cheaper to buy than to make at home.

We will, therefore, take in hand the construction of an electric bell—say, with a 2½-in. gong. We shall require a piece of 5-16ths in. round iron, bent into a horseshoe or, rather letter U shape, and 1-⅜ ins. long in the straight and 9-16ths in. apart inside. This is for the magnet core. Soften the core by placing it in the kitchen fire overnight, and taking it out of the ashes in the morning. By this method the iron is made red hot and very gradually cooled, thus making the metal as soft as possible. Now clean off the scale, and file up the ends true and square with each other.

We now proceed to make the magnet coils. There are two methods of winding these coils. One is to make a bobbin of stout brown paper, 1 in. long, to fit each magnet link. The bobbin ends may be either brown paper, cardboard, thin fretwood, vulcanite, or fibre, but they must be firmly fastened to the brown paper tube. The ends should be 1 in. diameter.

The other way is to make a paper tube, and then wind the first layer of wire the length required—1 in. The next layer is left one turn short, and the layer above another turn short at each end, as in Fig. 2. This method saves the trouble of bobbin ends, but is much more difficult to carry out, as, if due care is not taken, the wire falls away at the ends of the coil. Having decided on our method of winding, we rig up a little windlass with a spindle to fit in our bobbins. We shall require a 4-oz. reel of No. 22 green, either silk or cotton covered wire. If white covered wire is used, the coils will require a coat or two of shellac varnish when wound. This is made by dissolving orange shellac in methylated spirit. Two coats of rather thin varnish will give a much better finish than one coat of thick. The 4-oz. reel will be ample for our purpose. Leave about 6 ins. of wire before commencing to wind, and wind each coil full, that is, to about 1 in. outside diameter, with about 6 ins. to spare at the finishing end. Wind each coil in exactly the same way and direction. Now slip the coils on the magnet limbs so that the iron projects a good 1-16th of an inch beyond the coil ends, and with both starting ends toward the bend. Make a short coil of each starting end by winding the wire round a piece of ⅛-in. wire, clean the ends for about 1 in. up, twist, and solder them together.

The baseboard next claims our attention. It is made from a piece of mahogany, walnut, or even deal will do, if anything else cannot be had. A piece of wood ½ in. thick, and 6½ ins. long by 3¾ ins. wide, will be required.

The lower corners should be cut away as in Fig. 1. The base may be either polished or varnished. We also require a saddle of hard wood about 5-16ths in. thick on which to screw the magnet. A piece of wrought iron 1⅜ ins. long, ½ in. wide, and ⅛ in. thick is now annealed in the same manner as the magnet core, and then filed up true and square for the armature D. A piece of old clock spring, ¼ in. wide is now bent to form shown in Fig. 2. The end P has two ⅛ in. holes punched in, and the end O, a small piece of platinum, soldered on. The hammer H is made from a piece of 1-16th-in. iron wire, on one end of which is driven a piece of brass either in the form of a ball about 7-16th in. in diameter, or shaped

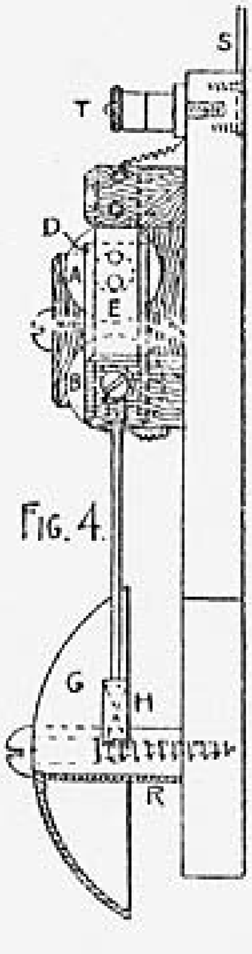


FIG. 4.

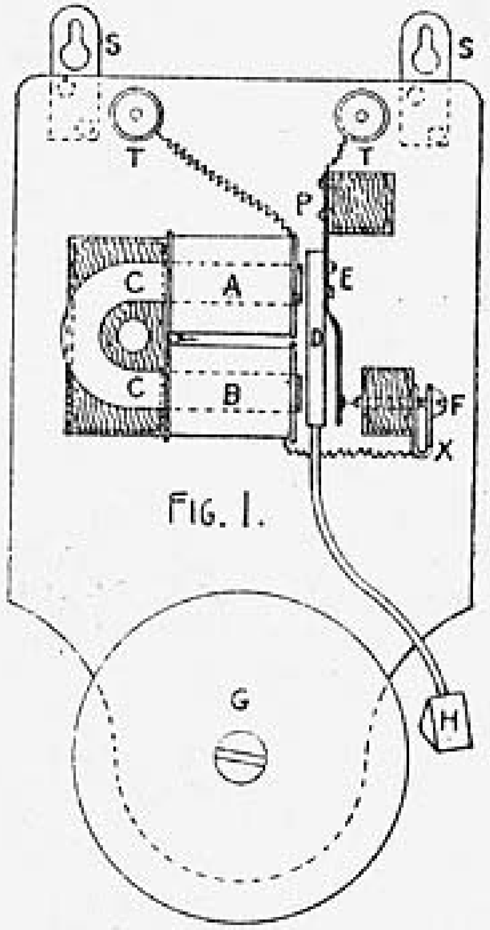
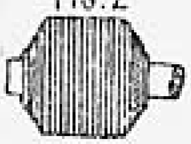


FIG. 1.

FIG. 2



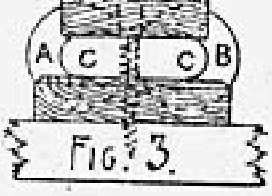


FIG. 3.

like the figure. The other end of the wire is firmly driven into the end of the armature. The clock spring is now soldered on to the armature in the position shown. If the worker has the tools, a better job is to rivet the spring to the armature, as in Fig. 1 at E.

Now take a brass wood screw (F) about 1 in. long, and file off the point. Drill 1-32nd in. hole about ⅛ in. deep in the end, and solder in a small piece of platinum wire. The end of the wire is now gently hammered over the end of the screw until it is about 1 16th in. diameter. A small piece of thin spring brass, 1 in. long and ¼ in. wide, is bent like X in the figures and drilled to just clear the screw just made.

We can now proceed to put the bell together. Commence by setting out the parts as shown in Figs. 1, 3, and 4. The magnet is fixed in position by means of the large wood-screw, as shown in Fig. 3. The lower block of wood, and also the two smaller blocks which carry the armature and contact screw, are fixed in position by screws from the back of the baseboard. The armature is placed so that its centre line is the same height as the centres of the magnet ends and ⅛ in. clear of the ends.

Now place the contact screw block in position, and mark on the armature spring a point just opposite the platinum point of the screw. A small piece of platinum is soldered on the spring at this point. These pieces of platinum can be got at an electrical stores for about 2d. or out of an old incandescent lamp. Get a broken or "burnt out" lamp and dig out the plaster in the cap. You will then find two scraps of a silver-like wire going through the glass. These are the platinum pieces required.

The gong G is better bought, and will cost about 3d. It is mounted on a short piece of brass tube (R) so that the hammer will strike it about ⅛ in. above the rim, as in Fig. 4. Two small hangers are let into the back of the baseboard, as shown in Fig. 1, and a couple of terminals (T) screwed into the baseboard will complete the bell, except that it requires "connecting up."

This is done by taking the finishing end of the upper coil and coiling it round a piece of ⅛ in. wire. Bare and clean about 1 in. of the end, and fasten it under the left-hand terminal. The finishing end of the lower coil is coiled and bared the same way, but the end is wrapped round the bend of the small brass U, and soldered in place. A short piece of wire is now coiled round the ⅛ in. wire, and both ends bared and cleaned. One end is fixed under the right hand terminal, and the other end is placed under the screw head which holds the armature spring to the wood block.

Our bell is now complete, except for a small wood box made from an old cigar box, to cover in the works. The cover must have a slot cut in the under side to allow the hammer shaft to work.

HAVING made the bell, the beginner in electricity will enquire "How is it that the bell will ring?" When a current of electricity flows in a coil of wire placed round a piece of soft iron, the iron is converted into a magnet. When the current is cut off the soft iron immediately loses its magnetism. If, therefore, a current is passed through the bell by connecting a battery to the terminals, we get a circuit through the coils A and B (Fig. 1), through the screw F, the two pieces of platinum, spring E, and to the terminal. The current passing through the coils makes C C into a magnet, and attracts the armature D. When D is attracted toward C C the two platinum pieces no longer touch each other, and so the circuit is broken. The iron C C loses its magnetism, and spring P E brings the armature into its original position. This completes the circuit, and the cycle of operations is repeated. All this takes place very rapidly, and we get the well known sharp ring of the electric bell. The object of the platinum points is to prevent corrosion. When an electric current is switched on and off very rapidly a great deal of sparking and burning takes place at the points of make and break, and platinum is about the only metal which will stand this treatment.

A Novel Use for an Electric Bell.

December 1, 1900

By Jas. Strachan.

It is not generally known that an ordinary electric bell can be very easily transformed into a pretty effective shocking coil. The change is only temporary, not in the least affecting the material construction of the bell, and may be executed in a few minutes only. When a current is passing through the coils of the bell magnet, every time that the circuit is broken by the trembling action of the contact-breaker, an extra current—caused by self-induction—is produced, flowing in an opposite direction to that of the primary current from the battery. This extra, or secondary, current makes itself visible at the platinum contacts of the break as a short electric spark, since the E.M.F. is very high, usually amounting to several hundreds of volts. If two copper wires be attached to the circuit, one on each side of the contact-breaker, this current can be led off, and made more apparent to the nervous system, by grasping a couple of metallic handles connected to the wires. The copper wires may be very thin—say No. 40 silk-covered, and should be made into flexible spirals by winding them round a wooden rod, such as a pencil. One wire is fastened to the brass screws which hold the armature-and-hammer spring in position, and the other to the brass pillar which carries the regulating screw for adjusting the speed of the break.

Before making the above connections, the ends of the wires must be scraped clean. The free ends of the wires may now be connected (preferably by soldering) to the handles, which may consist of two 3-in. lengths of ¼ in. brass tubing or rod, but a couple of zinc or tinplate cylinders will serve the purpose equally well. The battery should be a 1-pt. bichromate cell with lifting zinc, although a couple of quart Leclanchés will do fairly well. The strength of the shock is regulated by raising or lowering the zinc into the battery solution, or a water resistance may be employed.

Of course, you cannot expect too much from such a makeshift, and, consequently, only one person at a time should try it, and, usually, it is almost unbearable. To obtain the maximum effect the hands may be moistened with salt water.

As the ringing of the bell may prove undesirable, the gong may be screwed off for the time being, or, more simply, muffled with a piece of cloth. With a little ingenuity and a couple of metal finger rings, the novelty may be applied to an electric alarm, which is bound to waken the sleeper, who too often turns a deaf ear to the bell alone.

How to Make a Wehnelt Electrolytic Interruptor.

January, 1900

By D. W. Gawn.

There can be little doubt that this device constitutes a most notable advance in that department of electricity which may be said to have been created by the x-rays, and if its promise can be taken as any reasonable indication of its future, it should certainly have considerable sway upon the making of large induction coils—even to the length of obviating the necessity of very large coils altogether for the more ordinary class of work.

What strikes one as something of quite a revolutionary character, is that mechanical breaks and condensers are displaced entirely by the electrolytic device—the coil thus becoming simply a plain bobbin on a plainer stand.

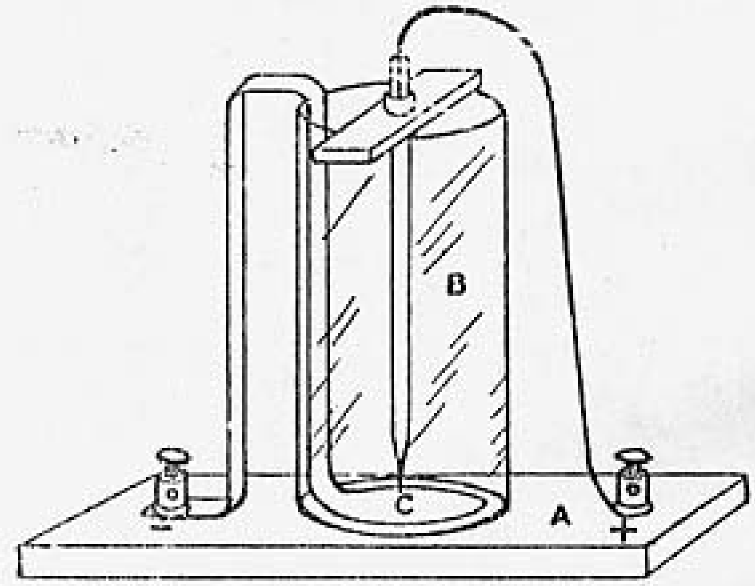


Fig. 1.

One's momentary impressions on using, for the first time, this remarkable piece of apparatus—when the small blue-violet spark is seen to flash its way between the submerged electrodes, and the thick, hot spark traverses the space separating the discharging points of the coil, while the latter, though devoid of the deafening clatter usual with a hammer break, is, nevertheless, full of weird murmurs as of a partly successful suppression of some mysterious power—one's impression, then, is assuredly not far removed from that of utter amazement. It must be seen to be believed. The moment passed, however, curiosity becomes the predominant spirit, and from this to investigation or experiment, a field in which the interruptor doubtless will afford the subject of much valuable and enjoyable study, is, of course, but a natural sequence.

In its original form, so far as the writer can learn, the break was as shown in Fig. 1, consisting of a wooden sole or baseboard (A), carrying a cylindrical glass vessel (B) of about 600 cubic centimetres (approximately = 21 fluid ounces) capacity, containing a circular plate (C) of sheet lead, with a connecting strip leading outward therefrom to a binding-screw on the sole. The mouth of the vessel was bridged across with a piece of wood or ebonite, and in this, at about its centre, a hole had been bored to take a paraffin-saturated cork, or a small caoutchouc bung, perforated in turn to take a glass tube of about 6 millimetres (= ¼ in., say) in diameter, by rather longer than the vessel's height. The lower end of the tube was sealed, and had fused into it, and projecting outward, a short piece of fine platinum wire, the tube then being thrust through the cork until it reached to within about 1½ centimetres of the lead plate—a distance varying, however, according to circumstances. From another binding-screw on the baseboard was led a convenient length of insulated copper wire, its upper end bared, reaching to, and being inserted in, the glass tube, this having been partly filled with clean dry mercury to complete electrical connection with the platinum point. Lastly the vessel was filled with water acidulated with about 20 per cent. its bulk of sulphuric acid, and the whole arrangement connected in series with the primary wire of the coil and the source of energy, the positive lead going to the mercury tube.

The action of the apparatus is peculiar; the interruptions of the current being caused apparently by an incredibly rapid formation and disruption around the anode of a gaseous sheath. The circuit into which it is inserted should possess a certain degree of self-induction, as otherwise it will fail to operate. It is also, upon this induction, the electro-motive force of the current, and the surface area of the anode that the frequency of the interruptions or oscillations depend, it being possible, by the relative alteration of these three factors, to effect wide variations.

Examination with a rotating mirror, such as usually employed for determinations of this kind, has shown that the interruptions may reach, if not actually exceed, the extraordinary number of 1,500 per second. This admirably fits the break for radiographic work, the fluorescent screen particularly, since at such a rapidity there can be no flickering of the light sensible to the eye.

It has been found, in experimenting with the Wehnelt contact-breaker, that the potential difference of the circuit must be greater than that which customarily suffices, though the voltage may need but slight augmentation if the electrode bath be heated to about 150° F.—a quality

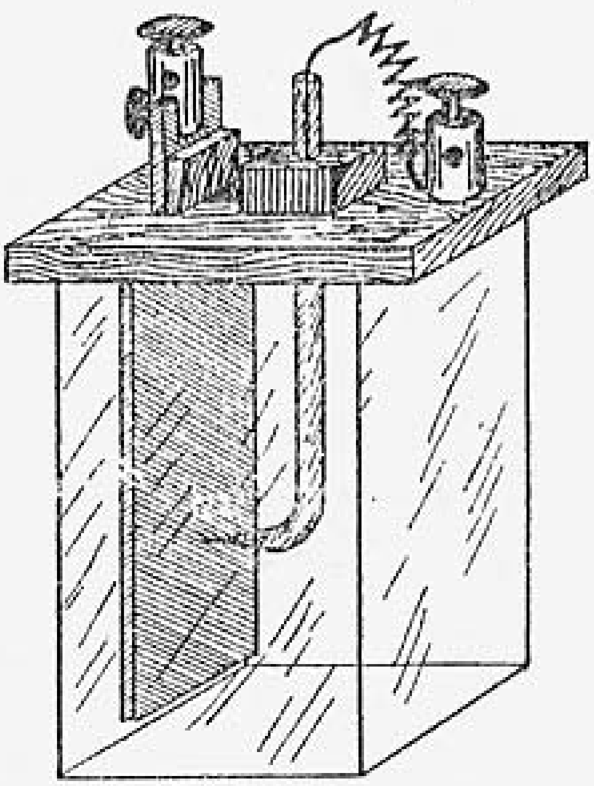


FIG. 2.

self acquired, to some extent, after a short period of use; that the secondary spark or, as it more resembles, flame, discharge of the coil is of extreme heat, whilst, also, its thickness far surpasses that which could be obtained by using a hammer, or indeed, any mechanical break.

Owing to the heat of the discharge the current must be regulated with the greatest nicety, and for this purpose it is advisable to insert in the circuit either a choking coil or a rheostat and suitable measuring instruments.

From two to three or, at most, four amperes of current will, in the majority of cases, be found sufficient for radiography, a heavy current being most destructive to the vacuum tubes.

Those who need the break in its simplest form may proceed to make it according to the brief description in the foregoing, but another improved form has lately been devised, of which Fig. 2 is a fair representation as modified in some few details by the writer.

Therein it is seen that the lead plate assumes a vertical position, and that the glass tube is curved to allow the anode to point squarely towards it. By so arranging the electrodes, the gases and heat generated have a clear passage upward to the surface of the bath, and not, as in the original type, with the glass tube directly above the point whence the bubbles ascend. It was through this latter that fracture of tubes became an occurrence much too frequent to be tolerated, hence the reason and preference for the later form.

To construct the break as shown in Fig. 2, procure a square glass (or earthenware) accumulator cell, measuring about 5 ins. by 3 ins. by 3 ins., and from mahogany, ⅜-in. in thickness, cut a piece to form for it a lid or cover 4 ins. square, to allow ½ in. overhang all round. On a centre line drawn across its grain, cut an aperture 1½ ins. long by ½ in. wide, and at one end, and right angles thereto, cut another 1¼ ins. by ¼ in., thus making the complete aperture T-shaped.

On that side of the cover which ultimately will be innermost, screw on two narrow fillets, one at each side of the larger part of the opening, in such a manner that their ends and one side will just butt against the upper edges of the vessel, so as to serve the twofold service of forming a step for the cover and a prevention of warping. Fig. 3 shows this, the dotted lines indicating the top of the vessel. The under side of the cover should be rendered impervious to steam and water by enamelling it two or three coats, and the edges and upper side finished by polishing or varnishing.

Next cut a piece of a piece of close-grained cork to the shape shown in Fig. 4. Virtually it is a 1-in. cube rabbetted ½ in. deep on either side to fit and slide rather stiffly in the larger slot in the cover.

Take a piece of uranium glass tubing of ¼ in. diameter by 8 ins. or 9 ins. long, and, with the aid of a

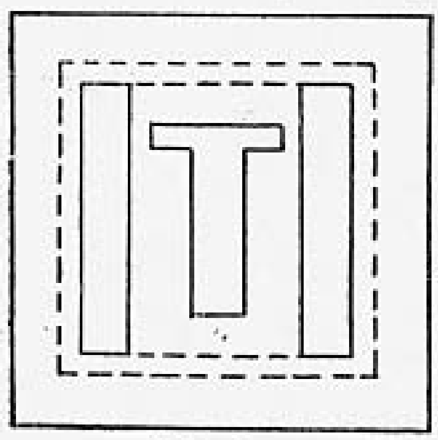


FIG. 3.

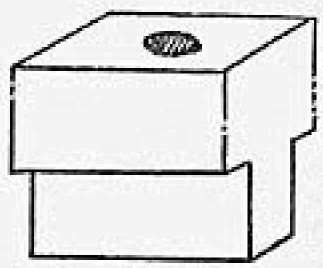


FIG. 4.

spirit-lamp or gas Bunsen flame, heat it near one end until soft. Ere it has time to cool, stop the end with the finger-tip, and, blowing gently with the lips at the other, bend it to as near a right angle as possible. The objet of blowing, it may be mentioned, is to prevent the walls of the tube in their plastic condition from collapsing; on the other hand, if blown too violently, an unsightly bulb probably will appear.

The tube, at this stage, should be as at A, Fig. 5. At a distance of about ¾ in. from the bend, re-heat the tube and carefully draw in it a narrow contraction by pulling, insuring, in so doing, to keep the part perfectly straight (see B, Fig 5.) When cool, take the tube in both hands and with thumb nails together at the point marked by a dotted line in the figure, break it cleanly in two. Insert in the small orifice, which the tube will then have, a piece of No. 20 S.W.G. platinum wire about ⅜ in. long, projecting ¼ in. or ⅜ in., and secure it by playing on the tip of the glass with a very fine blowpipe flame. Let the glass accumulate only sufficiently to hold the wire in place, as should it become much thickened it will be liable to fracture when in use. The instant the final operation is completed, thickly cover the tube from point

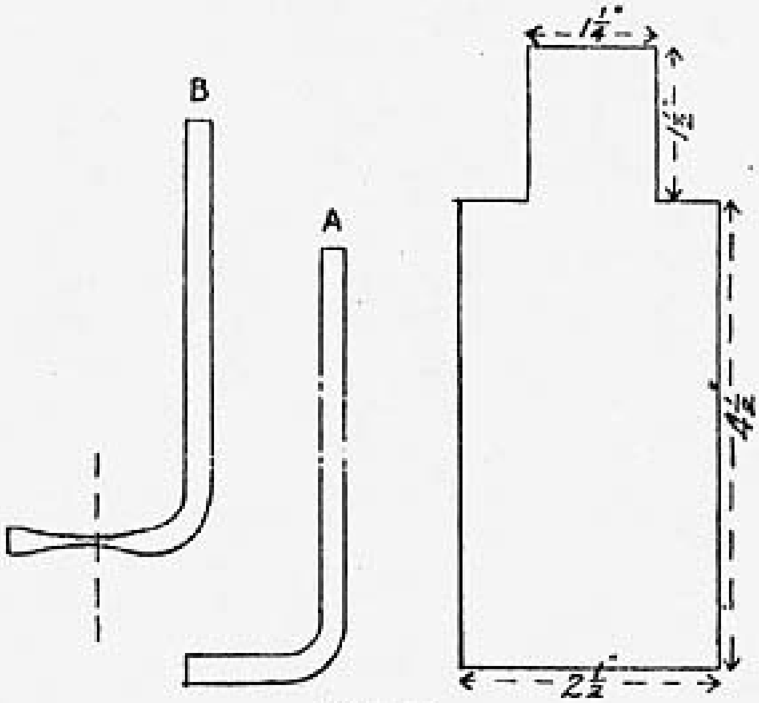


FIG. 5.

to bend with the deposit of a smoky gas flame. Beneath this carbonaceous envelope cooling will progress comparatively slowly, so that, for all practical purposes the glass will be thoroughly annealed—a most desirable quality it is to be noted.

Bore a hole in the piece of cork previously fitted to the vessel's lid and thrust the upper end or straight part through it from its under side, adjusting the tube in the hole, which, by the way, it should fit tightly, so that the platinum point may reach about midway down the depth of the bath. A piece of sheet lead must now be cut to the form and dimensions given in Fig. 6, a suitable gauge for this being No. 16 B.W.G., though it is scarcely necessary to be particular within one or two numbers of that gauge.

Cut a small wedge-shaped piece of any wood 1¼ ins. wide, by 1 in. long, and tapering from ¼ in. to ⅛ in. Place the lug of the lead plate through the smaller slot of the lid from underneath, fasten it firmly into position *from above* with the wedge, and finish that electrode by clamping to its upstanding portion an appropriate brass binding-screw.

A terminal for the anode may be screwed into the cover on the side opposite to the cathode. Twist a piece of fairly heavy-gauge silk-covered copper wire into spiral form, bare both ends, bending one to the shape of a ring that it may be clamped securely under the base of the binding-screw, and straightening the other to dip an inch or so into the top of the glass tube. To complete the break for use, fill the vessel to within ¾ in. of the top with water and sulphuric acid of the proportions previously stated, and pour sufficient pure mercury into the tube to enable connection to be made between the platinum point and the dipping wire.

Generally, it will be found convenient to make several platinum electrodes, each with its distinctive feature, such as length and thickness of the point, its degree of sharpness, and the reverse. If one only is made it is well to decide upon the E.M.F. of the current usually to be applied, and then to shorten or, it may be, lengthen the piece of platinum until the best effect on that particular circuit is attained. Needless to say, the former course is the better of the two.

When first trying the break, the bath being cold, switch on a current of from 2 to 3 ampères at a potential difference of about 45 volts. It may be of interest to those uninitiated in the methods of glass-working to know that they may substitute the glass tube of the simpler kind of break in the following manner :—Obtain a short hollow piece of young bamboo cane or, indeed, any tube of non-conducting waterproof material of about ¼ in. in diameter ; plug one end with wood, cork, or indiarubber, and in the centre thereof bore a fine hole. In this insert a piece of platinum wire and allow it to protrude inside slightly as well as outside to the extent stated before. To render the seams at the end watertight, apply a coat of any paint or varnish at hand.

How to Make Incandescent Electric Lamps for ½d. each.

February, 1900.

By "SPARKS."

INCANDESCENT electric lamps were first constructed by Thomas Alva Edison, in 1878. These lamps were constructed of platinum wire—a fine piece some inches long being used and mounted in a glass bulb or shade for protection. This wire offers great resistance to the passage of an electric current, and becomes very hot when a current is forced through it. If the current is sufficiently strong the wire will be made bright red hot, or even white hot. If, however, too great a current be used the wire will melt and the lamp will be useless. Edison designed an ingenious automatic device by means of which, if the current grew too strong, some of it was shunted past the lamp, which was thus saved from damage.

In 1879 the carbon filament was first made, and until recently has held its own against all comers. Carbon may be heated above the melting point of platinum without being volatilized, and will give a whiter and more efficient light. Carbon filaments have to be isolated from the air, as hot carbon readily burns or oxidizes. The Nernst lamp, recently invented, has a filament constructed of rare oxides, which will carry an electric current if first made hot. These filaments may be raised to a higher temperature even than those made of carbon, so that they give an even brighter light, and they cannot oxidize.

Platinum lamps are very easily made, and the materials required are not expensive. The writer has made lamps from 5-32nds of an inch to more than an inch in diameter over an ordinary bat's-wing gas burner, the only tools used being a pair of scissors, a small file, and a small hammer. Lamps, the size of a marble, and which will give as much light as a Christmas-tree candle, cost for material about one-third of a penny a piece ; and first-class lamps, with sealed platinum terminals, may be made for 3d. each.

I shall first describe how to make the cheaper lamps, and then show how, with a few more tools, the better ones may be made.

The following materials will be required :

(1) Some fine platinum wire, the finer the better; for not only is the finer wire cheaper, but it can be made incandescent with a smaller current. This wire should

have a diameter of from two to four thousandths of an inch. The following sizes may be used:

No. 42 Standard Wire Gauge ...	0·0040 diam.
No. 44 ,, ,, ,, ...	0·0032 ,,
No. 46 ,, ,, ,, ...	0·0024 ,,

(2) Some glass tubing, about ¼ in. outside diameter. The sizes known as Nos. 3 and 4 in the trade are just the thing. Soft glass (usually called soda glass) should be asked for, and see that you get it clear and free from streaks. Those who have a foot blowpipe and know how to use it, will not need to be told that lead glass is better suited to their requirements, or that they may use coloured glasses if they please.

(3) Some copper wire, about 1-64th in. diam. or rather less. Nos. 28, 30, and 32 S.W.G. are suitable.

For the better class of lamps some thicker platinum wire will be required, about No. 32 S.W.G. As this wire is not used for our cheaper lamps, it will be necessary to fuse the copper wire straight on to the fine platinum. For this purpose a blowpipe will be required. This may be obtained for 4d. or 6d., but we may make one which will answer our purpose out of a piece of our glass tubing, and the experience gained in working our glass will be worth having. A glass blowpipe, however,

Fig. 1

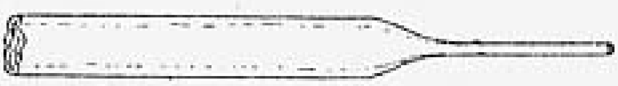


Fig. 2

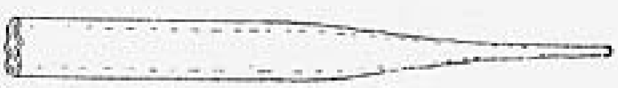


Fig. 3

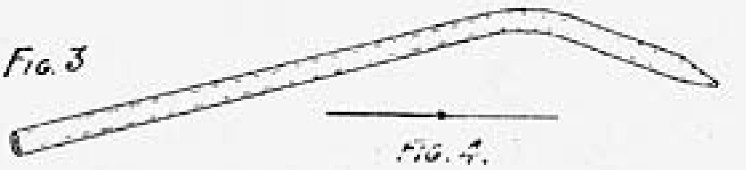


Fig. 4.

has this disadvantage as compared with a metal one, viz.—that sooner or later the nozzle is sure to melt during use. To make the blowpipe, choose a piece of tubing rather thick walled and cut off one end square. This is done by making a sharp nick across the tube with the file, and then pulling the ends apart. The end we have prepared is to be the mouthpiece, and must be rounded in the flame to remove the sharp edges. Heat about half an inch of the end of the tube over the burner, holding it about an inch above the flame. The gas should be turned full on, but not so that it flares and flickers. Turn the tube round and round so as to heat it evenly, and bring it to the flame so that the end to be rounded just enters the top edge which is the hottest part. Almost immediately the orange glow of burning sodium will make its appearance about the hot part of the tube, which will then be found to have been melted more or less and the edges rounded. As the glass is uniformly thick it may be waved about in the air to cool it. If this were done, however, with a piece of glass of irregular thickness it would almost certainly produce a fracture, as the thin parts would harden first, and then when the thick parts cooled and contracted a stress would be put on the thin parts. You will soon meet with this phenomenon. The moral is—"cool irregular pieces as slowly as possible." Hints on this will be found in the proper place.

We now make the nozzle, cutting off the tube to length at the same time. Hold the tube across the flame so as to heat a point about 8 ins. from the rounded end, taking the same precautions as to warming and heating uniformly. Support the part of the tube on both sides of the flame. It will be found most convenient to work with the flame pointing towards the left shoulder, and to hold the left hand beyond the flame. The thumbs of both hands should be towards the body, and the right hand should lie over the tube. When the tube has softened, draw the ends apart, first removing the tube from the flames. Pull quickly and as straight as possible. Each piece will be found to have a symmetrical conical end, as shown in Fig. 1. If, however, the cone is long and tapering, as shown in Fig. 2, you have heated too much of the tube. This may be rectified by heating the conical part again

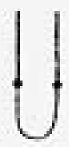


Fig. 5

Fig. 6

Fig. 7

Fig. 8

Fig. 9

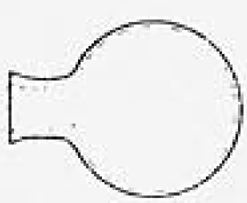
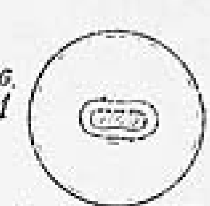


Fig. 10

Fig. 11



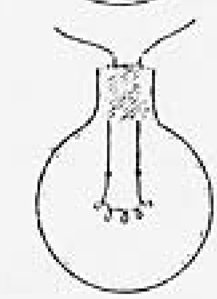
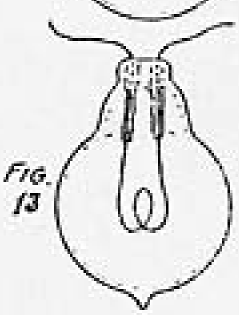


Fig. 12

Fig. 13



and pulling it out sharply. Break off or melt off the thin end, leaving an inch or so to hold on to while the tube is being bent. To get a nice uniform bend, heat about 2 ins. of the tube, by holding it along the top of the flame, and be very careful about heating it uniformly. When the tube is quite soft, bend it as shown in Fig. 3, trying to let it bend by its own weight as it were, *i.e.*, not forcing it. Now break off the point with the file, and round the nozzle in the flame. If you are not careful you will close the nozzle right up, in which case it must be drawn out again. To do this, melt the end, and then touch the point while soft with a thin bit of glass, which will stick, and enable you to draw out the end again. If you did not succeed in breaking the tube off straight, the jagged points should be removed with the file. Hold the file at an angle of 45 degs. with the tube, not at right angles to it, and hold the tube in mid-air, not against a support. Use the file rather roughly, hitting the glass as it were, to make it bite. I believe the use of turpentine, in which camphor has been dissolved, as a lubricant, assists the operation; but I have never had occasion to try it.

In all these matters a little practice with one method is worth a lot of book-lore. Have you ever seen a lens grinder cutting a piece of glass into a rough lens shape, with a tool like a worn-out curling-tongs?

Let us now use our blowpipe to make a small lamp. The filament (the part which glows) is to be made of platinum, and we have to join pieces of thick wire on to each end, to lead the current in and out. For our cheap lamp we use copper wire. The end of the copper wire is to be fused and the end of the platinum wire thurst into the molten globule on the copper wire. If the platinum wire is cut with scissors the ends will be burred, and a stronger joint will result. On cooling, the copper contracts more than the platinum, which it grips very tightly.

Just a few hints as to the method to be followed: Turn down your gas flame to the height of a halfpenny (1 in.); put the nozzle of your blowpipe into the flame and hold the end of the copper wire near the tip of the blowpipe flame; hold the platinum wire almost in the flame and in line with the copper wire, and immediately the latter melts, thrust the platinum wire into it, and remove both from the flame (Fig. 4 shows the joint). Do not keep the blowpipe in the flame longer than is necessary. Support your fingers on the ring round the gas burner which usually holds the globe, and support the nozzle of the blowpipe on the rim of the burner.

Seal a piece of copper in the manner described on both ends of the platinum, and cut off to two or three inches at each end. The filament may now be bent to any form you choose, according to the globe you are going to put it in. Short filaments look best in single loops or once doubled (see Figs. 5, 6, and 7), while long ones from an inch upwards may be zig zagged or made into spirals (see Figs. 8 and 9). All the forms may be made with two needles, two hands, and a little skill. To make a spiral, twist the wire round a fine needle, continuing the twist close up to each end and keeping the turns close together. Carefully pull out the needle and spread the spiral by pulling the ends. To loop the spiral, bend it round a large knitting-needle or wire nail.

There are several ways of making globes and of sealing in the filament. I shall describe the simplest first: Take a piece of clear tube, from three to ten inches long, and clean it thoroughly inside and outside with water, and, if necessary, with vinegar, nitric acid, spirit or ammonia. Close up one end of the tube by heating it, as described above for rounding the end, but continuing until the end just closes. Immediately the end is sealed, blow into the open end and expand the sealed end a little. This is to prevent a thick lump from forming on the end. Now heat about ¾ in. of the end, and when the whole is soft, blow your bulb about the size of a marble. Your first attempt will be a failure. The secret of success lies in heating the glass evenly, and not attempting to blow it out all at once. Give the first puff as soon after you take the glass from the flame as possible, letting the tube hang vertically while blowing. The thin parts will cool and set a little between the puffs and the thick parts being softer will expand most during the succeeding puffs. If the bulb is not satisfactory, heat it evenly all over until it melts down again, then blow it afresh. If it is very uneven it should be blown out only a little, and melted down again several times, until it is sufficiently uniform in thickness.

The glass, when molten, tends to assume a spherical form. Advantage may be taken of this tendency, if we want to blow a large or a thick bulb on a small tube. Heat, say, half an inch of the end of the tube, and expand this to, say, twice its size; then heat the next half-inch, and expand this in the same way. Continue until you have enough glass blown out to make your bulb; then melt the whole and blow it out. Owing to the comparatively large diameter of the expanded part, it will not double up so readily as the narrow tube would have done. It is obvious that pear-shaped bulbs may be made by expanding a good deal of the tube a little, and a little of the tube a good deal.

Having made a satisfactory globe, cut it off the tube—not too close—and round the edges. If you do burn your fingers, put on a little ammonia at once; if you don't burn your fingers, you might try expanding the opening a little with the point of a French nail. Heat the nail before you touch the glass with it, and melt the glass all round the mouth; then run the nail round and round just inside the rim. You will thus make the short tube leading into the bulb conical at both ends (Fig. 10), and the wood plug, next to be made, will fit the tighter. Cut a little wood plug, slightly taper, and just large enough to fit tight in the mouth of the bulb. Push it in with a screwing motion, and nick it all round just above the neck of the tube. Take it out and cut the length to size. Now split it down the middle, lengthwise; lay your copper wires attached to the filament along the split surface of one-half, put the other half on top, push the whole into the neck of the bulb, and the lamp is done (see Fig. 12).

The copper wires may be sealed in by melting the glass instead of using a wood plug. This is much more easily done if the bulb is blown with a stem attached to hold on by. Draw out some tube as you did to make the blowpipe nozzle, and use the thin extension as a stem. Cut off and seal up the thin part about 2 ins. from the wide part, and blow the bulb just where the taper begins. Melt off the stem when the lamp is quite finished. To seal up the top, melt the end of the tube all round, and flatten it by pressing it against the side of the burner, so that the mouth of the tube appears as shown in Fig. 11. Insert the filament, spreading out the copper wires, and then melt up the mouth at the top of the flame. As soon as the glass melts and the wires begin to sag, turn the bulb over. It is best not to seal the mouth right up, but just enough to grip the copper wires. It is a good plan to push the filament rather far into the bulb in the first place, and to pull it back last thing, by pulling the copper wires and stretching the soft glass. This reduces the likelihood of the glass cracking.

Copper expands when heated at least twice as much as glass does; it is therefore impossible to make a thoroughly satisfactory joint between these two substances. Platinum, however, expands at about the same rate as glass does, so these two substances may be fused together. For this reason platinum (or a special alloy of nickel having similar properties) is preferred for making the sealed connections in carbon lamps which have to be air tight.

Platinum lamps with sealed platinum connections have a better appearance than those previously described, and are much stronger; indeed, if carefully annealed, they will last until lost. Instead of fusing copper ends on to our filament, we now weld on thick platinum ends. This sounds difficult, but in practice it is delightfully easy, because when you heat the platinum to the welding temperature, all dirt burns off, leaving the surfaces beautifully clean. It is almost impossible to melt the wire in the gas flame, so you may take your own time about the work. We simply twist the end of the fine wire round the thick, heat both to a white heat, and while it is in the flame give the joint a gentle tap.

You will want something to use as an anvil, and the round head of a poker will be found just the thing. The smooth (hammered) end of a nail punch makes an excellent hammer. One tap is sufficient, and do not flatten the filament. Do not cut either of your wires to length until you have made the first joint.

The platinum wires are to be sealed into the bulbs as described for the copper. A neater joint may be made with the platinum by first coating the wire with glass. Fine tubes of glass are made by softening an ordinary small tube in the flame and drawing it out. Slip short pieces over the platinum and melt them on. The glass must be melted very thoroughly all round the platinum wires and allowed to cool slowly by gradually lowering the gas to an inch flame and turning the bulb about in it until thoroughly blackened.

Copper wires may be fused on to the thick platinum and will make a better connection than can be made with lamps as usually constructed. The finished lamp is shown in the last Fig. (No. 13). The illustrations show the actual size in each case.

How to Make An Electric War Map.

Mrch, 1900

By R. W. Hill.

EVERY intelligent person is greatly interested in the war just now raging in South Africa; and many will readily buy a coloured map and stick coloured pins, or glue small coloured flags to these pins and stick them into certain places of the map where our troops and those of the enemy are situated. The result of this old-fashioned plan of sticking of the pins according to strategical movements of the combatants is complete perforating or tearing of the map, and it occurred to me to try the following improved and up-to-date war map. The map is first glued to a sheet of iron of the same size, and small bits or pieces of flat steel or wire, ¼ in. by ⅜ in., are then magnetised and coloured to represent the opposing forces, By merely placing these tiny but powerful magnets on the surface of the map made as mentioned, they will tenaciously stick to any part of same, regardless of vertical or horizontal position of the map. In order to magnetise these bits of steel I had made and fixed to the same board a small coil or solenoid, connected in series with one 50-c.-p. 100-volt lamp, which throws light on the map referred to, and will, if necessary, indirectly convert bits of steel into small but strong magnets. Care should be taken that the paper is evenly glued to the sheet of iron, thus preventing the formation of ærial layers between the map and the iron. I think the description of the arrangement is so simple and lucid that no sketch is required.

An Electric Gun.

June, 1900.

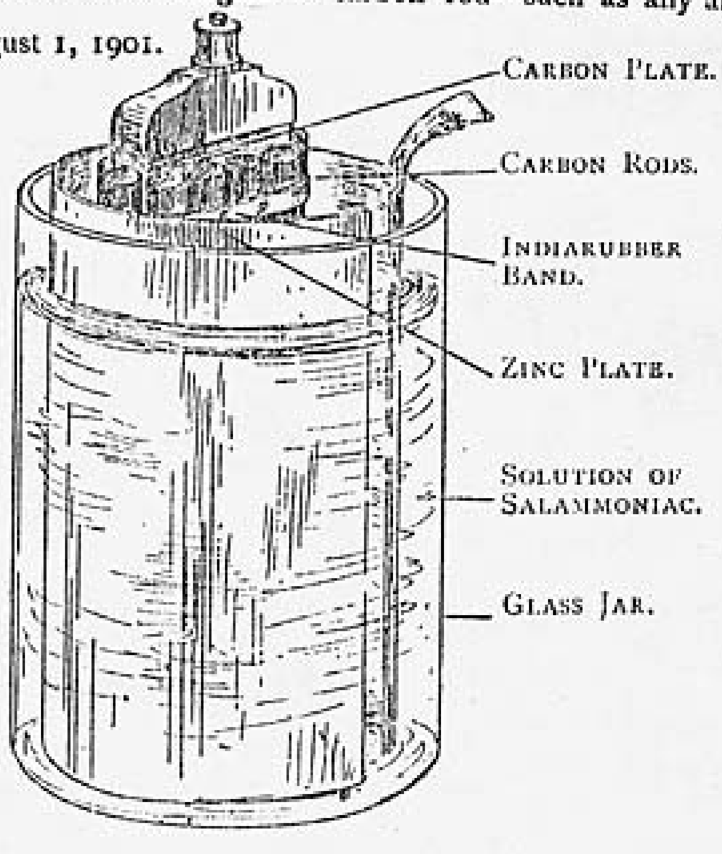
L. S. GARDNER, of New Orleans, according to the *Western Electrician*, has invented an electric gun, which, it is said, will be of much value in works of defence, and in the navy, where electric current is available. The inventor's description of the weapon is as follows:—"The gun is simply a line of short coils or hollow magnets which form a continuous tube. Each magnet is provided with a mechanical device for switching on and off the electric current in it. This device consists of a thin disc with a row of metal buttons running from the centre to the outer edge. The switch is attached to the breech of the gun, and is operated at the will of the gunner, slowly or rapidly. It is by the speed at which this switch is revolved and the number of magnets that the muzzle velocity of the gun can be controlled. As it turns, each in succession of the hollow coils running from breech to muzzle becomes magnetised with indescribable rapidity, and the projectile is dragged to the muzzle and shot out with tremendous force. There is an opening opposite the line of buttons on the switch disc, which allows projectiles to pass from the feed box to the barrel at every revolution."

Mr. Gardner's invention is based on a familiar experiment in physics showing the magnetic effect of an electric current. The model which he has made consists of a small glass tube with a calibre of one-fourth of an inch. This tube is wound with three coils of wire, each constituting an electro-magnet. With this model a wire nail from which the head was cut off was projected a distance of 20 ft., and made to pierce a pine board ½ in. thick!

How to Construct an Agglomerate Leclanche Cell.

SIR,—Any reader who requires a cell of the above description need not go to the expense of, say, 7s. or 8s., if he has any old scrap carbon of any kind. First procure the carbon rod out of an old Leclanché porous pot, and get a few short lengths of carbon rod—such as any arc

August 1, 1901.



lamp trimmer will give you for the asking—about 6 ins. in length. Get eleven of these, and place them round the rod before mentioned; then slip an indiarubber band round them rather tightly at the bottom and top, so as to hold them firmly together. The carbon element of the battery is then composed of one dozen pieces, at a cost of about 4d. or 5d. The zinc element can be made out of a piece of zinc sheet from a tinsmith's scrap heap at the price of about 1d. The sheet is bent round in the shape of a C round the carbon element, but about ½ in. open from top to bottom to allow the solution free movement. The zinc must not touch the carbons on any account, as this will short-circuit the cell. The outer jar can be an old preserve jar, or the outer jar of a disused ordinary Leclanché, which, if the reader has not one about him, can be obtained for about 7d. or 8d. each. The charge

 GRANDDAD'S ELCTRICITY BOOK

for this battery is 4 ozs. sal ammoniac, and two-thirds full of water. Cost of charge about 2d. The E.M.F. is about 1·55 volts, and the resistance 20 ohms. The above bell is very handy for alarms, bells, model telephones and telegraphs, small motors, and general experimenting, and need not cost more than 2s. at the very most.—Yours truly, J. H.

My Wimshurst Machine, and How I Made It.

November 1, 1900.

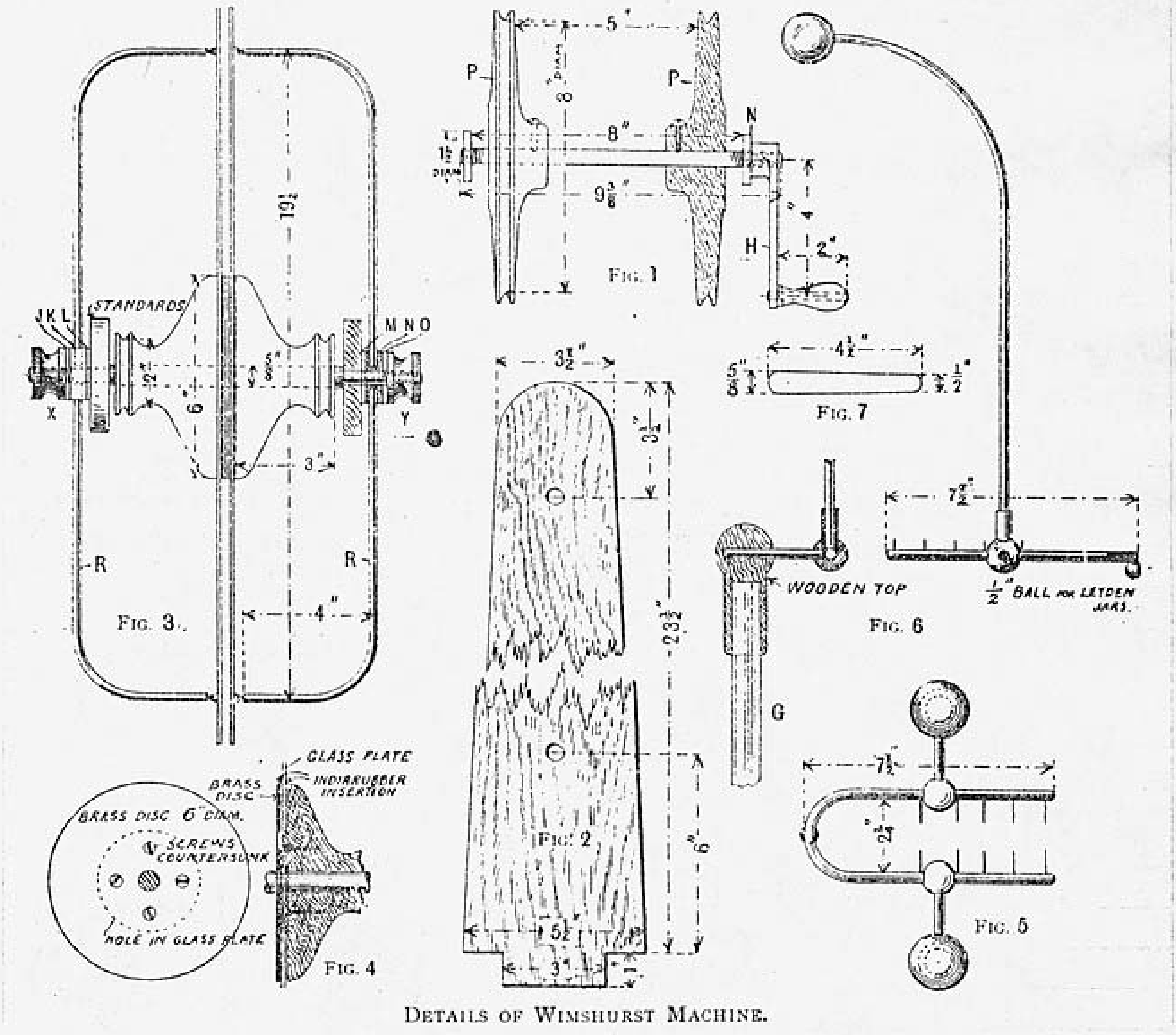
By A. Booker.

THE photo which accompanies this article is one which I have taken of a Wimshurst machine, made entirely by myself. Below I give details and measurements required to construct a similar machine.

Baseboard.—This is of solid mahogany, 30 ins. by 17¾ ins. by 1 in., planed and bevelled. It would be cheaper and just as good if made of deal or pine, but it must be perfectly dry and well finished. It may have stout battens, screwed crosswise underneath, to prevent any possibility of warping. Into this are mortised the standards.

Standards.—These are two in number, made of similar wood as baseboard. They must be perfectly smooth and rounded, and to the dimensions shown on Fig. 2. Two 7-16ths-in. holes must be bored in the places shown for the driving and plate spindles respectively.

Driving Spindle, Pulleys, and Handle.—The driving spindle is 7-16ths-in. brass rod; each end is screwed Whitworth for the distance shown, see Fig. 1. On this the pulleys, which are made of any hard wood, 8 ins. diam., with a V groove, are screwed as shown at P, P, in Fig. 1. The spindle is then put into the bottom holes of the standards, and on each end a round brass nut, 1½ ins. diam., is screwed to keep it firm. The driving handle H, Fig. 1, made of brass to dimensions shown, is then screwed outside one of the nuts, N.

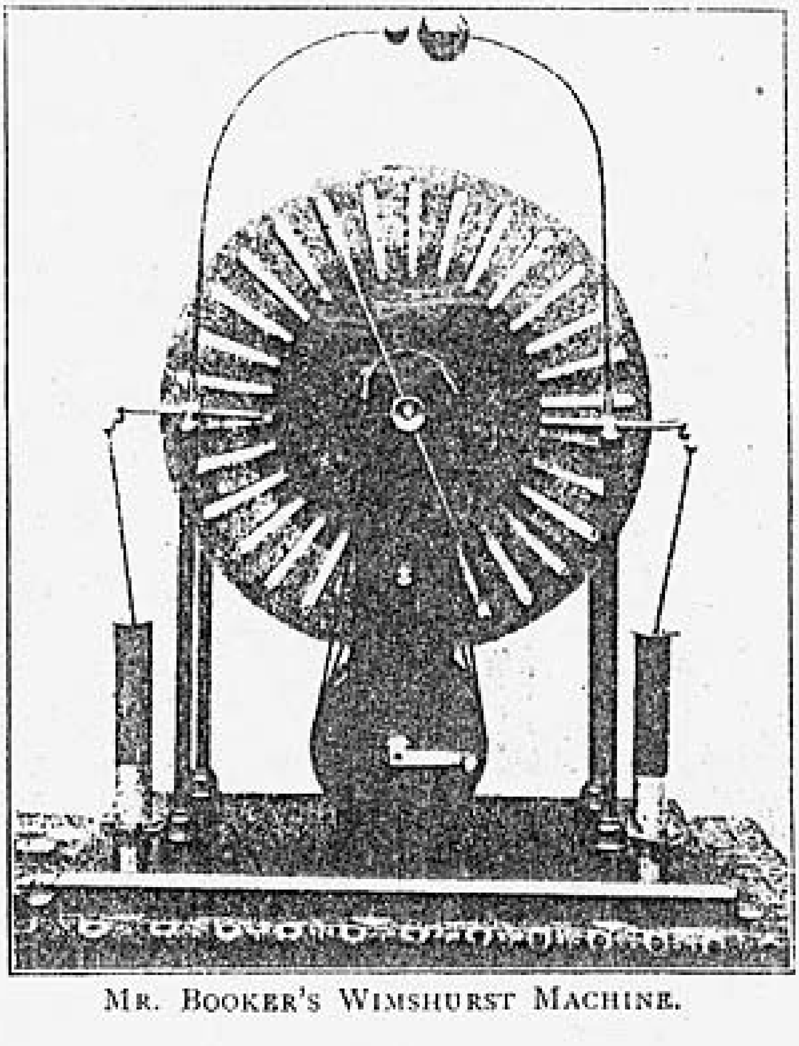


Details of Wimshurst Machine.

Plate Spindle, Neutralising Rods, and Bosses.—These are shown complete with plates and neutralising rods (Fig. 3). The spindle was the cause of a great deal of trouble and experiment. I first tried 7-16ths-in. brass, then 7-16ths-in. steel, both of which bent. The one which I now use, and which gives every satisfaction, is ⅝-in. tool steel, turned down to 7 16ths in. at each end, and screwed Whitworth thread. The washers (J, K, L, M, N, O, Fig. 3), were made from castings, as also were the nuts X and Y. The neutralising rods R, R, are ¼-in. brass tube, pinned into two washers, K and N, slipped on the spindle. The brushes are tinsel wire. The bosses carrying the plates are made of sycamore to dimensions given in Fig. 3.

Plates.—These are 26-oz. glass, with hole 3 ins. diam. in *centre*, and are about 22 ins. diam. They were a source of very great difficulty to me. I tried all the usual ways recommended to fasten them to the bosses, but none of these were satisfactory. First, the great difficulty was to get them true; then some part of them would not adhere to the boss at all, and when at last they were considered to be properly fastened they cracked. This happened to three pairs of plates, and then I fastened them on in my own way. It consists of putting the plate between two thin rubber insertion sheets, and then screwing it on with a brass plate. This method has given every satisfaction under all conditions. Fig. 4, which shows a vertical section through the plate, spindle, and washers, will make it plain.

Sectors.—As this machine was designed more especially for *x*-ray work, it was necessary to put on a greater number of sectors than would otherwise be required if made only for long sparks. The sectors number thirty-six on each plate, and are made of tinfoil to the dimensions shown in Fig. 7.



Mr. Booker's Wimshurst Machine.

Collectors.—These are ⅜-in. brass rod, made as per Fig. 5.

Points.—These are No. 22-in. gauge bare copper wire, with ends filed to a point, and fixed to collectors by drilling holes in the latter and soldering the points in.

Condensers.—These are two in number, and are constructed from 10 in. gas jars as used in chemical experimenting, coated 2 ins. high with tinfoil.

Dischargers.—These are ¼-in. brass tubes, fitted with ball and tube, screwed into combs (Fig. 6). Positive ball, 1⅝ in.; negative, 2½ ins. diam.

Insulators.—Four in number, ¾-in. glass tube. (See G, Fig. 6).

Driving Band.—Ordinary round sewing-machine bands.

Should any readers of The Model Engineer require further particulars, I shall be pleased to forward them. The proportions given are suitable for any smaller machine.

[Mr. Booker also sends us an excellent "radiograph," or photograph taken by means of the *x*-rays, showing very plainly indeed the skeleton and structure of a human hand. This was taken by means of the Wimshurst machine here described, and a 6-in. focus tube, and shows the good results obtainable from a carefully built, home-made machine at a very moderate outlay. This radiograph is not reproduced.]

The Crookes tube works best in the Leyden jar circuit, and gives good results with a home-made fluorescent screen, costing 2s. Following are a few hints to intending makers:—

Use small Leyden jars.
Warm all parts before varnishing.
Use best shellac only.
Leave no points anywhere, except on combs.
In my experience, ebonite is very unsatisfactory.
Do not take a shock, as it may have serious results.

Improved Methods of Making Induction Coils.

October 15, 1900.

By James Asher.

FOR a long time electricians have earnestly striven to invent means whereby sparking might be suppressed at the current interrupter of the induction coil. These efforts have hitherto been attended with but comparatively little success. A condenser, consisting of many sheets of tinfoil, insulated from one another by paper and paraffin, in a big box beneath the larger instruments, is employed in order to diminish sparking at the interrupter, and thereby to increase the length of the spark from the secondary coil of fine wire.

The writer will herein describe several simple, original methods of suppressing sparking. In none of these is a condenser employed.

Several methods of winding straight electro-magnets will first be considered. The first and fourth methods are believed to be original, and the rest are not generally known. The primary wire and the core of an induction coil should be regarded as constituting a straight electro-magnet. It is well-known that when the ordinary winding is used on an electro-magnet, furious sparking occurs at the interrupter or contact-breaker, at each breaking of the circuit. Sparks are generated also at each closing

destroy the cast. The cast-gate is at the lower flange, Sparking at the interrupter is due to the currents of self-induction, or extra currents, in the wire which is wound around the core of the electro-magnet. At closing the circuit these currents oppose the current from the battery, but at breaking the circuit they flow in the same direction as the current from the battery. These extra currents are of considerable tension. The powerful sparking injures the contacts of the current interrupter.

First Method.—Two insulated wires of the same length and kind are wound as one strand on the bobbin throughout their entire length. The two ends of one of these wires are firmly fastened together. The two ends of the other wire are connected with the interrupter and the battery in the ordinary manner. The extra currents in the winding, which is connected with the battery, are completely annihilated by the induced currents, which are generated at their expense in the closed winding, which is similar and similarly situated to the winding, which is connected with the battery. Hence we have no sparking at the current interrupter.

Second Method.—This was invented by Carlier. It consists in simply winding the bobbin with bare copper wire, and separating each layer from the next by paper. When electric currents of low voltage are employed, the lateral contacts of the coils of wire are sufficiently imperfect to prevent much passage of current from the battery by direct flow from coil to coil, while they easily allow the lateral passage of the extra currents which are always of comparatively high tension. These become self-cancelled in passing through the coils of bare copper wire. Du Moncel states that this method is very effective, and he expresses his surprise that it has not been more frequently employed. Perhaps if the wire were dipped into very thin varnish before winding, we might use the magnet in connection with a battery capable of generating a current of high voltage.

Third Method.—The magnet has two separate windings of the same length and of the same kind of wire. These two wires should be wound together as one strand on the bobbin throughout their whole length. The two ends of one wire are fastened to the terminals of the battery, consequently there is a closed circuit in this winding during the whole time of operating the electro-magnet. The two ends of the other wire are connected with a circuit interrupter and the battery. The interrupter in this case must either be operated by hand or by some other suitable external method. The connections of the two wires are made in such a manner that the current in the winding connected with the interrupter flows round the core in the opposite direction to that of the current in the other winding, which is connected with the battery. The two equal currents, passing round the core in opposite directions, fail to develop magnetism in the iron. On opening the circuit of one of the wires the core becomes magnetised. The effect on the core is directly opposite to that in the common method. We get absolutely no spark whatever, either at closing or at breaking, according to Professor Silvanus P. Thompson.

Fourth Method.—Two insulated wires of the same kind and of the same length are wound as one strand on the bobbin. The first two ends of the wires are fastened to a wire which extends to one binding screw of the battery. The last two ends of the wires are fastened to a wire which extends, by way of the interrupter, to the other binding screw of the same battery. The extra currents in the two windings at breaking circuit are neutralised by their mutual reactions.

Fifth Method.—This is a simplification of Billet's winding. Du Moncel described Billet's winding in his book, which is entitled—"Electricity as a Motive Power." Instead of a two-legged electro-magnet like Billet's, we need for our present purpose a straight electro-magnet. We begin at the middle of the bobbin and wind, say, from us enough wire on the left half of the bobbin. We next wind an equal length from us on the right half of the bobbin. The unbroken wire at the middle of the bobbin is fastened to a wire which extends, to one binding screw of the battery. The two ends of wire at the ends of the bobbin are fastened to a wire which extends by way of the interrupter, to the other binding screw of the same battery. The extra currents at breaking circuit are suppressed by mutual inductive reactions in the two windings. The weak extra currents at closing circuit, however, are not destroyed by this method. Consequently, a small spark appears on closing circuit.

Sixth Method.—This was invented in England by Langdon Davies. Each wire is wound as only one layer, and the ends are allowed to slightly project. After all the layers have been wound, the separate ends, at one end of the bobbin, are joined to a wire which forms one terminal of the battery, while the separate ends of wire at the other end of the bobbin are joined to a wire which constitutes the other terminal. On interrupting either terminal the sparking is found to be weaker than is usually the case. The extra currents in the different layers are not quite simultaneous, because the length of wire is not the same in any two layers.

Seventh Method.—This was invented by an American named Paine. After winding each layer of wire around the bobbin, a thin sheet of metal, usually so thin that it may be regarded as foil, is wrapped around the layer. At breaking circuit the extra currents in the wire develop currents in the sheets of foil and in the opposite direction. In consequence, sparking at the interrupter at each closure of the circuit is greatly diminished.

Eighth Method.—A sheet of copper is wrapped around the bobbin before winding wire thereon. At breaking circuit induced currents are generated in the copper sheath. The sparking is considerably weakened. This method was either invented or adopted by Mr. Brush.

The core of an electro-magnet, especially when used as the heart of an induction coil, should consist of a great number of the purest and softest iron wires. I think that these should not be round and in metallic contact with one another, as is usually the case, but that they should be square and laid in neat rows in the hollow bobbin, after having been dipped into thin varnish. If we use square wire we can introduce about one-fifth more iron into the hollow bobbin than we could by using round wire. Having insulated the wires of our core by means of varnish, we shall find almost no loss of energy due to eddy currents in the iron core. A further improvement for use in induction coils consists in making the core about 40 per cent. longer than the secondary coil. Gooding stated that the spark from the secondary coil could be increased in length from 1½ to 3 ins. by this improvement alone.

We may now suppose electro magnets constructed according to the methods herein described to be surrounded with a bobbin of fine, insulated wire, to constitute improved induction coils. The cores should consist of square, varnished, soft iron wires, laid in neat rows, and the core should be 40 per cent. longer than the secondary coil.

The methods herein proposed enable us to entirely dispense with the clumsy condenser.—*Western Electrician.*

How to Make a Simple Sensitive Galvanometer.

December 1, 1900.

By R. F. M. W.

THE instrument about to be described is very easily made, and can be used as a delicate current detector and measurer, or for testing for leaks, broken wires, &c., in dynamos, bells, installations. A galvanometer is based on the discovery made by Oersted in 1819—he discovered that a magnet tends to set itself at right angles to a wire carrying a current.

To construct the instrument (shown complete in Fig. 1) we first require about 1 oz. of No. 24 silk or cotton covered copper wire; this is wound into a ring of about one hundred turns, and either of the ways mentioned below may be adopted. (*a*) Suitable for anyone who can

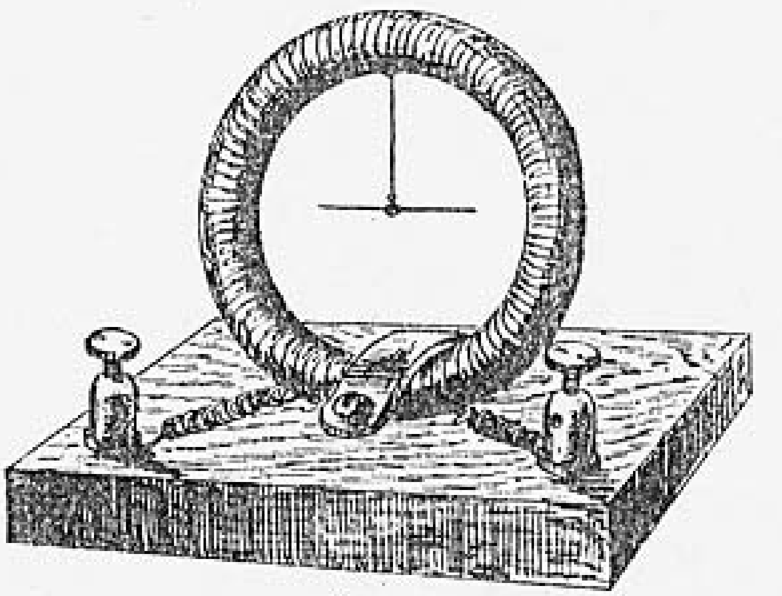


FIG. 1.

get access to a lathe.—A wood ring of 1¼ ins. bore, 2¼ ins. diam., and ⅝ in. thick is turned, and a groove is put in it about ⅜ in. deep and ⅜ in. wide; this ring is now painted or polished, and when dry the wire is carefully and evenly wound into the groove. Two small holes had better be made through one side of the bobbin to lead the two ends of the winding out; these ends had better be left 8 ins. long; the wires may now be covered with a layer of black tape, coloured silk, or simply shellac varnished. The ring or bobbin is shown in Fig. 2. (*b*) The other way is to cut a circle of wood ⅝ in. thick and 1¼ ins. diam., and then to fix on to it two thin sides and to wind the wire carefully into the groove thus formed (it is well before winding to lay four bits of thin twine in the groove crossways to the winding, and at about equal distances apart). These pieces of twine are tied when the winding is completed, and serve to hold the layers together while one side of the wooden core is removed and the coil slipped off. The ends of the coil should be near together, but should not be twisted together. Some twine is now procured (not too thick), and one end is firmly tied round the coil near its ends; a short length of twine is left over. Now the coil is tightly and evenly overwound with one layer of twine (crossways), (Fig. 1), and the end is tied to the other end which we left over for that purpose; this will look well when varnished, and a good varnish is made by mixing lampblack or fine powdered carbon with shellac varnish; this layer of twine holds the wires well together and protects them. It will be found that the section of the coil will now become practically circular.

A wood base is next cut about 3½ ins. square and ½ in. thick, and is finished as desired. If our coil is of type A, a small bit of wood is cut about 1 in. by ⅛ in. by ½ in., and the ring is glued to it and to the base (see Fig. 2), the bottom of the ring being slightly flattened by filing or cutting where it is to be glued to the base. When the glue has set this will be found quite firm. It is well to put the block at the back of the ring, and to let the wires project in front. Each wire is now coiled neatly into a spiral (say, upon a pencil), and is then put under the bottom face of a terminal and the latter screwed down tight. Ends of wire and bottom of terminal must be well cleaned. If it is preferred, the ends of wire can be taken down underneath the base through a small hole led in grooves to where the terminals are, and then again brought to the surface; the grooves may then be filled in with cement, such as Prout's glue. If our coil is of type B, the easiest way of fixing is to cut a piece of brass about 1¼ ins. by ⅜ in. by ⅛ in., and drill two small holes near the ends of it, and then to screw the coil down as shown in Fig. 1. The strip should be bent into the arc of a circle. Either way of connecting to terminals may be adopted. All that now remains to be done is to place a well-magnetised magnetic needle in the centre of the coil, and there are three suitable ways of doing this.

1. For rough work (testing, &c.) mount an ordinary compass-needle, about 1 in. long, on a fine needle point. This may be stuck, head downwards, into a small piece of wood or cork, which is then cemented to the inside bottom of the coil; or, if the instrument is to have more than one kind of magnetic needle, the block should be cut to fit over the bottom of the coil, and so be easily slipped out.

2. Another way is to well magnetise a fine sewing needle (by rubbing it from end to end with one pole of a strong magnet a few times); the pointed end is broken off, so as to leave the needle about 1 in. long; a tiny hook of fine wire is twisted and cemented to the centre of the needle, and a similar one is cemented to the inside top of the coil, or else only a small lump of cement is melted on to

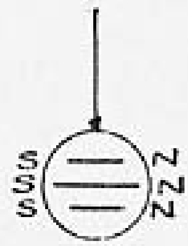


FIG. 3.

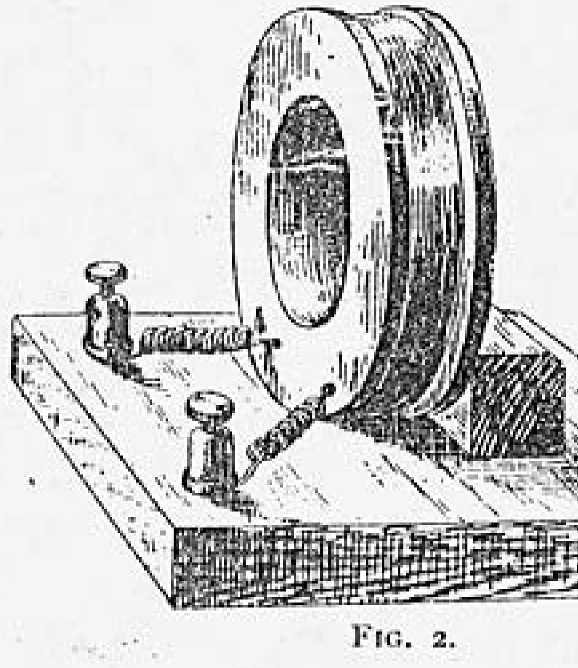


FIG. 2.

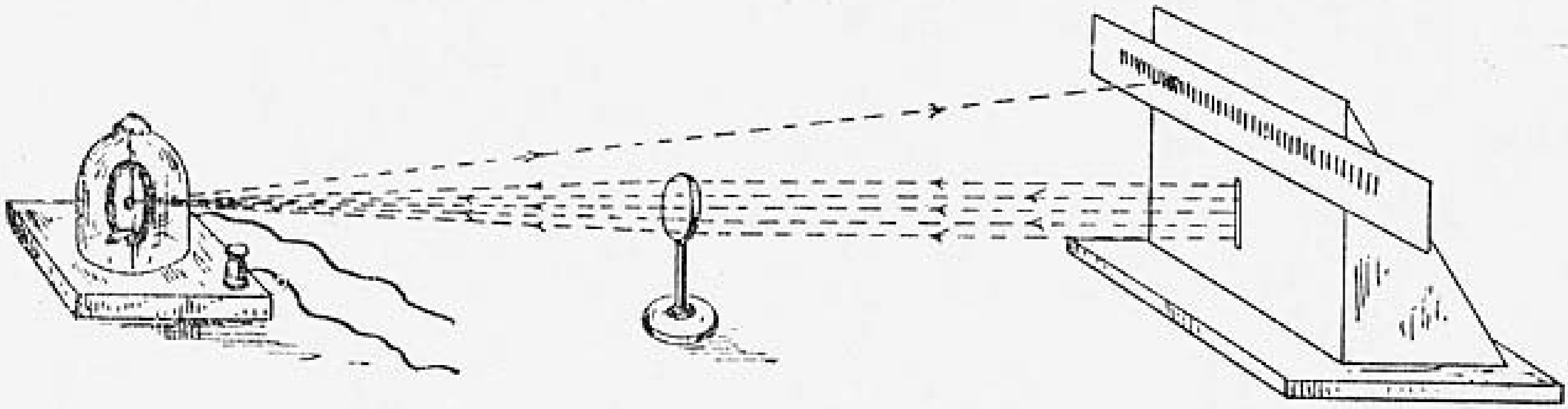


FIG. 4.

the latter place; a very fine thread of cocoon silk (it can be pulled from common silk) is tied or cemented to the needle hook, and then tied or cemented to the top of the coil, or passed over the hook and cemented (it will be found a very wearisome task to handle this very fine silk, and it takes a lot of patience to tie it—in fact, it is often hard to see it at all !)

3. The last method is by far the most sensitive one, and it was devised by Lord Kelvin. A tiny mirror, about ½ in. or less in diameter and very thin, is hung by means of the silk described, and on its back are cemented two or three tiny pieces of magnetised sewing needles. These pieces should all have their N. poles and S. poles pointing the same way. This may be easily arranged by seeing that the pole of a magnet attracts all the ends to be placed pointing the same way, and repels all the other ends. The mirror is illustrated in Figs. 3 and 4.

To use the galvanometer it should be turned until its needle lies parallel to the coil, or else the needle may be brought parallel with the coil by placing a small magnet on the table (not too near), and turning it till it influences the needle into the correct position (parallel to the coil). It is well to put a small glass shade over the instrument, especially if it is arranged with silk suspension. A neat shade may be formed by breaking off the stem of a thin wineglass, and grinding the fracture smooth ; this just covers the coil well. No powerful generator, such as an ordinary battery, should be applied straight across the terminals, as the effect is far too violent. The first method is suitable for testing for leaks in electro-magnets, &c. (a weak cell made by a strip of zinc and one of copper, put into a solution of salt and water, may be used, and should be small—say, the size of a wineglass). It may also be used for experimental work, and to show the laws of electro-magnetism. It will show a deflection if a few inches of copper and iron wire are cleaned and twisted together for ½ in. at one end, and the other ends are put into the terminals ; the junction is now heated with a candle or a match : this is thermo-electricity. The second method is far more sensitive, and cannot well be used for rough purposes ; it will show a large deflection with the above copper-iron pair, and will show a small effect if a battery, made of one drop of sulphuric acid and water, a copper wire and tiny zinc strip is applied : this is voltaic electricity. Electro-magnetic induction may be well illustrated—an electro-magnet (such as a bell-magnet or iron horseshoe, wound with one hundred turns of wire) is applied to the terminals, and a permanent steel magnet is now moved in front of the electro-magnet ; at every movement the needle will give a kick. The magnets here must be some way from the instrument, or a direct effect from them will affect the needle. An assistant can manipulate the magnets at the other end of the room, while the operator himself watches the needle. This electro-magnetic induction is the vital principle of a dynamo's action ; in fact, the magnets here constitute a dynamo and the galvanometer a motor.

The last method requires a lamp (or candle), scale, and lens for its use, and is far too delicate for anything except very feeble currents and careful hands. Fig. 4 shows the way to set the apparatus up. A box of wood or cardboard is set up in a darkened room ; this has a slot cut in it about ¼ in. wide, and a lamp is placed behind, the rays of which pass through the slot, and then through a convex lens on to the mirror. From the latter they are now reflected back on to a white scale put to catch them ; the lens is moved until it brings the rays to a focus on the scale, and, if a very definite line is required, a thin wire put vertically in the slot will come out clear and sharp on the scale. When hunting for the spot, when setting up apparatus, it will be found convenient to explore with a sheet of white paper or card. To stop the needle vibrating quickly after it has once been set in motion, a weak bar-magnet held in the hand and moved so as to act on it (the needle) will bring it to rest very quickly after a little practice ; it can be slowly taken away as needle comes to rest. The lens may be abolished if a very sharp spot is not required.

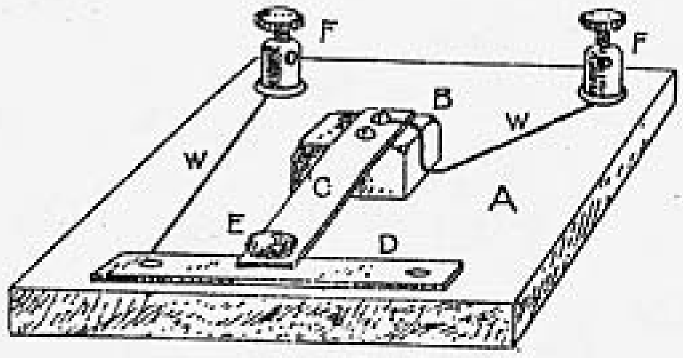
Almost anything which a galvanometer will show can be shown here. The scale readings are directly proportional to the currents producing them, and are proportional to the volts applied if a coil of high resistance is put in series with the instrument. A few turns of wire slid up or down the pole of a magnet will produce a kick at each move (electro-magnetic induction). A copper-iron pair heated with the hot hand or breath, one cell applied through the operator's hands—one pole of cell is applied to galvanometer, the other is applied to his left hand and a wire is put connecting his right hand to the other terminal of instrument. A good contact should be made to each hand by holding two pieces of metal, such as a hand-vice in one hand, and a pair of pliers in the other, the wires being held tight to the metal : this will produce an effect. Even a carbon or copper plate held in one hand and a zinc in the other will produce a displacement of the spot (the hands should be damp). The operator, in this latter case, forms a part of a battery.

A Simple Morse Key.

TO THE EDITOR OF *The Model Engineer.*

SIR,—I have pleasure in sending you particulars of a very simple Morse key, which I made for a small telegraph a little time ago. The baseboard (A) is of mahogany, 4 ins. by 3 ins. by 3/8 in. In the centre of this, screw a block of wood (B) 1 in. square. At one end of the baseboard nail with small brads a strip of brass (D). On the top of the block B, fix another strip (C), just long enough to touch the first one when depressed; a small knob of wood (E) should be affixed to the end of the upper strip; wires (W, W) should connect the strips to two terminals (F, F) at the other end of the base.—Yours truly,

Frome. C. G. R.



INDEX OF SUBJECTS

Granddad's Wonderful Book of Electricity

By Kurt Saxon

ISBN 1-881801-20-9
PHONE (870) 437-2999
FAX (870) 437-2973
KURT'S WEB SITE survivalplus.com

ATLAN FORMULARIES
P.O. BOX 95
ALPENA, AR 72611

SEE ALSO "THE AMATEUR ELECTRICIAN'S HANDBOOK"
1924 366 PAGES THE SURVIVOR VOL. 3, PAGE 1165