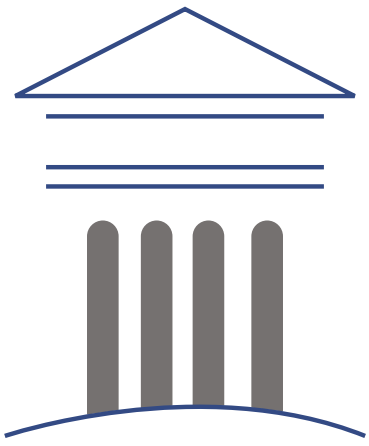
Restoring Rifle and Shotgun Barrels Lesson: 2183

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Objectives

After completing this lesson, you should

1. Understand what condition the bore of a firearm must be in to obtain the best shooting results.
2. Be familiar with the procedure used to lap rifle and shotgun bores.
3. Know which tools are used to lap rifle and shotgun bores.
4. Know how to store reamers.

Introduction

Any experienced gunsmith knows that the bore dimensions and smoothness of the rifling in a rifle barrel are extremely important for accuracy in shooting. Most barrel blanks are now rifled using the broaching method, in which a long tool with serrated edges, or broach, is pushed through the barrel to form the required shape. Although this method produces very smooth barrels, lapping always improves them. Lapping is also an excellent way to restore older, worn barrels to an acceptable condition.

A rough, pitted bore tends to pick up leading or metal fouling as projectiles are fired through it. Shotgun barrels can develop corrosion and pits, which cause erratic shot patterns and make it difficult to clean the bore. Cleaning a rough bore is tedious work, but a barrel with a smooth, well-polished bore is more accurate, so your hard work will be worthwhile.

Shotgun barrels can develop corrosion and pits which cause erratic shot patterns and make it difficult to clean the bore to avoid further pitting.

There are several ways to restore a rifle's accuracy if there are problems with the barrel. The most obvious way is to install a new barrel, especially if the rifle is still being manufactured. If a replacement barrel is not available from the manufacturer, a barrel will have to be custom-made by a qualified gunsmith, which can be an expensive undertaking. Gunsmiths are frequently called upon to restore barrels on antique firearms because a new barrel would lower the collector value.

Before discussing the restoration of rifle and shotgun barrels, let us take a look at laps and lapping, and their purpose in the firearm industry.

Laps and Lapping

In general, lapping is a rubbing process for removing minute amounts of metal from surfaces that must be precision-finished in order to

- Produce true surfaces
- Improve dimensional accuracy
- Correct minor surface imperfections
- Provide a close fit between two surfaces

Filing, milling, or grinding metal produces relatively rough work at best. However, you can remove imperfections by lapping, which requires a good lapping tool (lap), a compound suitable for the job, and some patience. The compound should be approximately the same hardness as the material to be lapped, while the lap itself should be considerably softer than the material. A single lapping compound will not serve all purposes. Therefore, manufacturers of lapping compounds provide guides for selecting the proper compound for a particular lapping job.

LAPPING COMPOUNDS

Both external and internal universal laps are available, but most gunsmiths make their own. To use an external lap, apply the appropriate lapping compound generously to the object you want to lap and also to the lap, and process either by hand-polishing or by rotating the object in a lathe while applying the lap by hand. The revolving speed should be approximately 300 rpm, and the lap should move across the work slowly and with light pressure. Check the size and finish of the work frequently, and use a hot, strong cleaning solution to clean all surfaces before finally drying them with a clean, soft rag.



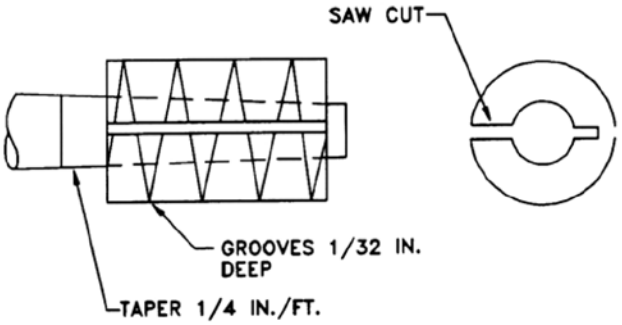


Figure 1: *A cast-iron lap used for lapping the inside of a hardened steel receiver.*

The lap may be very simple, consisting of a strip of some type of abrasive cloth attached to a shaft, or it may be elaborately constructed of lead, copper, cast iron, etc. Figure 1 shows a cast-iron lap used for lapping the inside of a hardened steel receiver. The workpiece is secured in the lathe chuck, while the lap, on a tapered mandrel, is secured in a drill chuck in the tail stock of the lathe. While the work rotates, the lap is slowly fed into the receiver. Conventional automotive valve lapping compound will suffice for most applications, but Clover abrasive compound kits seem to suit most needs of the average gunsmithing shop. Two kits, No. 4 and No. 6, seem to be the most popular.

Clover Kit No .6. Six different grit sizes are available in this kit. The grit consists of silicon carbide formulated with a special grease base that lasts a long time and does not break down under heavy use. The sizes (120 – 800-grit) are ideal for nearly all fitting, lapping, and running-in operations. They are also good for the initial work or reworking of metal-to-metal fits where both metals are steels.

The abrasives in kit No. 6 are not designed for use between steel and aluminum alloys, because silicon carbide crystals will embed in the softer metal. The kit contains 2-oz. metal cans in the following grits:

- E, 120 (coarse)
- D, 180 (medium coarse)
- B, 240 (medium fine)
- 1A, 320 (very fine)
- 4A, 600 (extremely fine)
- 5A, 800 (micro-fine)

Clover Kit No. 4. This kit contains four different grit sizes of ultra-fine water-soluble aluminum oxides, and is formulated with a petroleum-based emulsion-type carrier, which is water soluble and easily removed from the work surface once you are finished. It is particularly useful for lapping inside surfaces where solvents are difficult to apply. The crystal used is aluminum oxide, which is rounded and breaks down into

smaller rounded pebbles as it is used. These crystals are extremely tough and have great durability and wear resistance, but they do not embed because they are not sharp. While these compounds cut slower than others, they are recommended for metal-to-metal fitting situations where steel is fitted to aluminum alloy, because the crystal will not embed in the softer metal. The grit sizes in this kit are as follows:

• 4A, 600 (14 microns)

• 5A, 800 (9 microns)

• 6A, 1000 (5 microns)

• 7A, 1200 (3 microns)

Three types of lapping medium normally used for lapping in the firearm industry are

• Metal laps and loose abrasive mixed with a lubricant

• Bonded abrasives for commercial production work

• Abrasive paper or cloth

One common lap consists of a split sleeve and a tapering holder or arbor which is used to expand the sleeve to fit the hole being lapped. Lapping compound is applied to the lap and then moved gradually through the hole until the desired finish is obtained. The split in the lap allows it to be expanded as it becomes worn.

The busing forming the lap frequently is made of cast iron or copper. The actual lapping operation involves moving the lap in and out to cover the entire surface of the hole in the case of internal lapping. The lap length should be about three times greater than the diameter of the hole being lapped.

Be careful when applying the abrasive compound, especially toward the final stages of the operation. If you apply too much, the ends of the hole will enlarge because of the abrasive particles crowding under the edges of the lap.



Figure 2: *A lapping tool.*

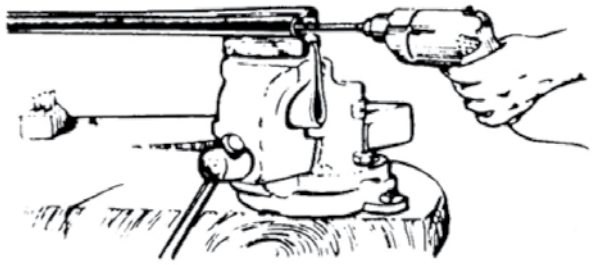


Figure 3: *Method of using the polishing head to polish shotgun barrels.*

LAPPING OPERATIONS

When lapping is done precisely, metal can be brought to a given dimension with greater accuracy and a finer finish than by any other means.

Lapping operations fall into two categories: hand lapping and machine lapping. Hand lapping is frequently done in most gun shops, while machine lapping is usually done in industrial applications where speed is of the utmost importance. Hand lapping, although slow and tedious, avoids the high cost of lapping machines, and every gunsmith should know the basic principles of hand lapping for truing external, internal, and flat surfaces. Obviously, hand lapping is employed for lapping small quantities of work.

PRACTICAL APPLICATIONS

Shotgun Barrels. For best results, shotgun barrels should be lapped with power tools—either a drill press or a speed lathe. Laps can be made from steel, lead, or wood. However, the rod should be constructed of steel, since wood will vibrate too much when turned at high speed.

Since lapping is really polishing, one of the easiest and least expensive ways to lap is to use a shotgun polishing head like the one shown in Figure 2.

In general, it consists of a steel head designed to rotate. With the shotgun polishing head, polishing the choke to a mirror-like finish without changing its dimensions is as easy as polishing the straight part of the bore.

When using a electric hand drill, clamp the barrels in a bench vise as shown in Figure 3. Then chuck the rod in the drill motor before inserting the polishing head in the breech end of the barrel. Start the motor and push the revolving rod slowly forward and back.

You can use coarse strips of abrasive cloth to remove lead and scratch marks; use the finer grit sizes for polishing.

LAPPING RIFLE BARRELS

Since rifle barrels have a rifled interior, general polishing will not work because the rifling will be removed in the process. The lap must spin with the rifling in the bore as it is being pushed up and down the interior of the barrel. The first step, therefore, is to remove the barrel from the receiver and take accurate interior measurements of the lands and grooves. You can use calipers to measure at each end of the barrel, but for best results, use a soft lead slug slightly larger than the bore itself. This lead slug can be started into the muzzle end of the barrel and pushed or gently tapped through the entire length of the barrel to fall out the breech end. The lead slug will give a perfect imprint of the rifling (land and grooves) on the inside of the barrel, and you can measure these imprints with a micrometer to get the dimensions you need. Figure 4 illustrates correct and incorrect barrel crowns.

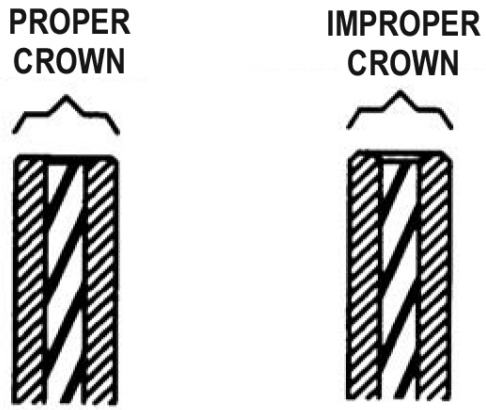


Figure 4: *Cross-section of a typical rifle barrel showing correct and incorrect barrel crowns.*

Continue by making a lapping rod out of steel with a diameter large enough to slide easily through the bore. The head of this rod should be turned or filed as shown in Figure 5. The opposite end of the head should then be brazed, silver soldered, or welded to a handle assembly so the rod will turn freely on a smooth-working ball bearing.

Once the rod has been made, secure the barrel in a vertical position in a bench vise. Wrap a piece of cotton twine around the lapping rod just below the rod tip, enough to provide a snug fit inside the barrel. Now insert the rod from the breech end of the barrel, pushing it in and stopping it about ½" from the muzzle of the barrel. Heat the barrel with a propane or other low-heat torch until the barrel is just hot enough to melt solder, yet not hot enough to affect the metal finish. When the barrel reaches this temperature, use a ladle to pour melted lead carefully into the bore to form a solid slug around the tip of the rod, as shown in Figure 6. Let this slug cool slightly,

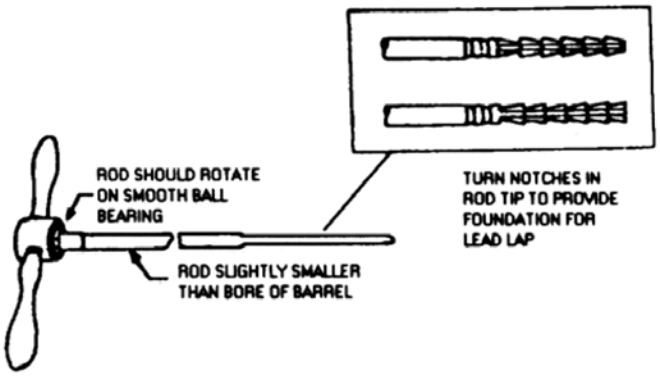


Figure 5: *Details of barrel-lapping rod.*

then push it about an inch out of the muzzle of the barrel. Be careful not to push it out all the way or you will have to start over. Note that the slug now has the full imprint of the barrel's rifling and is molded to the exact dimensions of the bore. With the lap partially protruding from the muzzle, file off any burrs or fins that may prevent the lap from being pushed and drawn through the barrel.

Now, change the position of the barrel. Place it horizontally in the vise, with the handle of the rod projecting from the breech end. With the lap still projecting from the muzzle end only about three-fourths of its length, completely coat the lap with a suitable lapping compound—fine valve lapping compound or Clover lapping compound, for example. Squirt some oil into

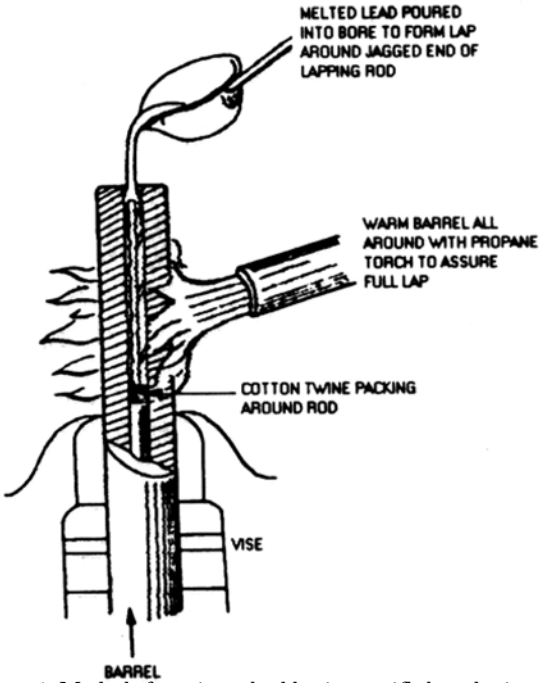


Figure 6: *Method of pouring a lead lap into a rifle barrel prior to the lapping operation.*

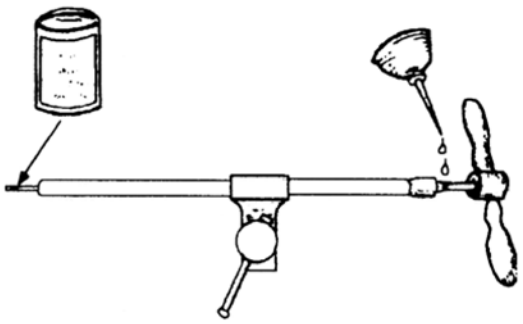


Figure 7: *The barrel must be secured horizontally during the lapping operation.*

the bore from the breech end as shown in Figure 7. Grasp the rod handle in both hands and draw the lapping rod backward, slowly and evenly through the barrel, until about half the lap projects into the chamber or, if there is no chamber, out the breech end of the barrel. Again, be careful not to let the lap pull out all the way; if it does, you will have to start over. Now push the rod so the lap travels back toward the muzzle. Continue this backward and forward motion. Recoat the lap with compound as often as necessary to maintain a smooth cutting action.

The amount of time required to obtain a good job depends on the condition of the bore when you started. Some jobs will be complete after 20-30 strokes, while others may take hours to complete. During the lapping operation, if the lap becomes worn or loose, you will have to melt it down and cast another lap.

Often, lapping a rifle barrel will remove every pit and tool mark in a short period of time, resulting in a fine, smooth, accurate barrel. However, even if lapping does not remove every mark, you will always see some improvement.

When you are finished, withdraw the lapping rod completely. Clean the bore of the barrel with a solvent, using a tight-fitting cleaning patch on a rifle-cleaning rod. You will get better results if you soak the entire barrel in a solution of Brownells D'Solve, then blow it dry with compressed air. Immediately oil the bore, along with the rest of the barrel. Remember, a proper lapping job will almost always improve the accuracy of any rifle barrel—even a brand-new one.

There are several methods of obtaining a free-turning rod. Figure 8 shows one method. This drawing gives complete details for the construction of one type of barrel lapping tool.

SELF-TEST QUESTIONS

Please check your answers on page 18.

1. ***True or False*. In most cases, a barrel lapping operation will improve the accuracy of any rifle barrel.**
2. **What should be done to the rifle barrel when pouring melted lead into the bore to form a lap?**
3. **How should the end of the lapping rod be treated?**
4. **When lapping a rifle barrel, should the lapping rod rotate or remain stationary as it is pushed and pulled through the bore?**

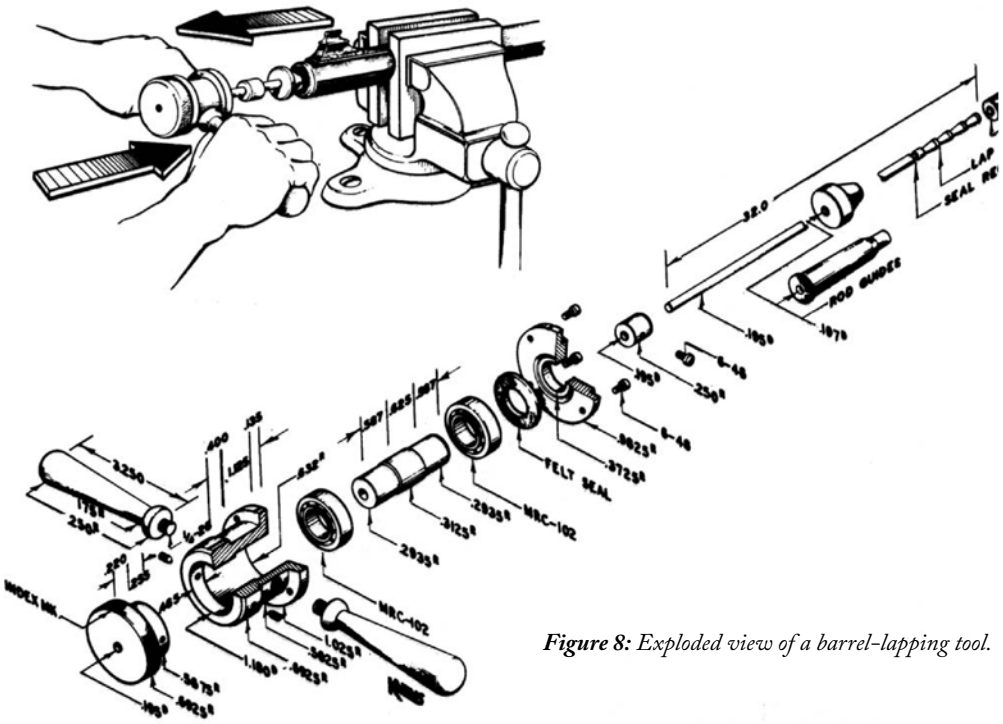


Figure 8: *Exploded view of a barrel-lapping tool.*

Shotgun Barrel Alterations

There are many shotgun barrel alterations that can help restore the gun and also improve its performance. For example, shotgun bore reamers like the one shown in Figure 9 are used for back-boring (enlarging the bore) and choke modification in shotguns. They are also ideal for rejuvenating a badly pitted shotgun barrel. After one pass with the proper bore reamer, the shotgun bore will look new.

The lead angle on a Clymer shotgun bore reamer matches the angle of most chokes and will therefore blend into an existing choke when back-boring. The 8" left-hand spiral flutes provide smooth cutting, which results in a good surface finish.

Clymer bore reamers are stocked in the cutting diameters listed below. Variations are available on special order.

Gauge	Diameters
10 gauge	.765, .770, .775, .780, .785
12 gauge	.720, .725, .730, .735, .740
16 gauge	.652, .657, .662, .667, .672
20 gauge	.605, .610, .615, .620, .625
28 gauge	.540, .545, .550, .555, .560
.410 gauge	.400, .405, .410, .415, .420

If the bore of a shotgun is too badly pitted to be corrected by polishing, back-boring is the only solution other than installing a new barrel. However, before purchasing a shotgun bore reamer, you must determine the inside diameter of the shotgun bore in question.

Let us say you have an old Browning 12-gauge semi-automatic shotgun. The barrel is terribly pitted and you have to put it back in good condition. First, carefully measure the inside bore diameter of the barrel using a micrometer and Brownells inside calipers. Assume that this measurement is 0.725 inch. Looking at the above list, we find that 0.730" is the next largest size of standard shotgun bore reamer available. This size is probably the best choice. If the bore diameter measures 0.730", then you would go to the 0.735" reamer, and so on.

When you order the reamer, you will also need a 34" extension handle to fit the reamer properly. If the back-boring is to be done by hand, you will need a T-handle extension. Since shotgun bore reamers must be driven as accurately as possible, Clymer offers three sizes of 34" extensions. Large fits the shanks of 10, 12, and 16-gauge bore reamers; medium fits 20 and 28-gauge tools, and small fits a 0.410 bore only.

Any way you look at it, back-boring a shotgun barrel is not something that can be done quickly. Even if you use power tools, the job is going to take a long time. You cannot expect to slap some cutting oil on the reamer and run it through the bore as you would when drilling a ¼" hole through a thin piece of steel. You must go slowly, and frequently remove the reamer for cleaning and re-oiling. It will probably take about two hours to back-bore a shotgun barrel if you use power tools; it will take a little longer if you do it by hand.

Bore reamers are relatively self-guiding, but you must go slowly. At the slightest sign of any stress or resistance in the cutting action, you must remove the reamer, thoroughly clean off any cuttings, completely wipe out the bore, re-oil the reamer, and cut a little more. Continue this operation until the end of the reamer barely sticks out of the muzzle of the barrel by just a few thousandths of an inch.

Once again, clean the reamer and also the bore of the shotgun, making sure you remove all oil and cuttings. Even a tiny piece of metal left in the bore can cause damage to the bore.

Once the reaming operation is complete, there will probably be some tool marks remaining. Consequently, the shotgun bore should be lapped or polished as described earlier in this lesson.

The degree of polish on the inside of a shotgun barrel is very important. Lead shot tends to stick to steel or lead, and if it goes through a rough bore it develops flats, causing poor shot patterns. The smoother the shotgun bore, the better the shot patterns. A smooth barrel with the correct load will outperform a rough barrel consistently.



Figure 9: *Shotgun bore reamers for back-boring and choke modification.*



Figure 10: *Choke-removing reamers are used to remove a choke or to open a parallel section of a choke to give less constriction.*

CHOKE-REMOVING REAMERS

For the back-boring operation, you can obtain reamers to open up the present choke or leave the same degree of choke in the barrel. However, in some cases, you may want to open the choke on a shotgun barrel that does not require back-boring. Again, a reamer is used. The choke-removing reamers, like the one shown in Figure 10, are used to remove a choke or to open the parallel section of a choke to give less constriction (for example, when changing a "full" choke to a "modified" choke). These reamers have eight high-spiral flutes that give excellent cutting action. In use, the tool is inserted from the breech (chamber) end and pulled out of the muzzle while either the barrel or tool is rotated. A gentle lead angle combined with a 2¼" long straight section ensures that the reamers will run true to the existing bore axis. A ½" long circular ground section at the heel of the tool prevents spiral rings from being left in the bore. The cutting diameters listed in Figure 10 are available from stock, while other diameters can be special ordered. Back-boring can make neglected bores look new, as shown in Figure 11.

CARE AND USE OF REAMERS

Proper care and handling of reamers is extremely important. When not in use, always store reamers in their shipping containers or plastic tubes to prevent nicks in the cutting edges, which can cause rings in the surface of the barrel or chamber.

Most experts agree that a reamer should be honed only to remove a nick or burr. A reamer that has been properly ground and cared for should turn out quite a few jobs before it becomes dull. When it does become dull, you can return the reamer to the manufacturer for resharpening. This service is usually offered to customers at a reasonable cost.

Before using any reamer, you should double-check the dimensions to be sure it is the tool you intend to use. When using reamers—either in the lathe or by hand—use the best grade of sulfur-base cutting oil available. The more sulfur in the oil, the better; this facilitates cutting and gives a better finish. Thread-cutting oil, such as that offered by Ridgid Tools, is excellent for use in reamers.

When cutting with reamers, be especially careful. To prevent the flutes from loading with metal chips, which can cause the tool to cut oversize, the reamer should be cleared every $^{1}/_{32}$" of depth. Brush the reamer with a small brush to remove any chips.

A floating reamer holder used in the tail stock of the lathe allows the reamer to seek a true center of the bore and helps avoid cutting the base diameter too large. Run the lathe at its lowest rpm and feed the reamer in slowly so it will not grab and chatter as it starts to cut. If it does chatter, remove the reamer and take a drill slightly larger than the neck of the reamer and drill out the chatter marks. Replace the reamer and resume cutting.



Figure 11*: Many fine shotguns, like this Winchester Model 21 double-barrel, have neglected bores than can be made to look like new by back-boring.*

When hand-chambering, be sure to hold the reamer true to the bore. Use caution, since the reamer may snap off if it is cocked to the side. Press down firmly on the reamer when beginning the cut and then turn it slowly so the tool will not jump and chatter.

SELF-TEST QUESTIONS

Please check your answers on page 18.

5. **In general, what takes place in a shotgun barrel when it is back-bored?**
6. ***True or False*. When using any reamer, the maximum depth it should cut before the reamer is removed and cleaned is $^{1}/_{32}$ inch.**
7. **What type of cutting oil should be used with shotgun-bore reamers?**
8. **If you are back-boring a 12-gauge shotgun barrel with an inside bore diameter of 0.735", what standard size shotgun bore reamer should you use?**



Soldering, Brazing, and Welding

Now that you are learning about restoring firearms, you should obtain a good knowledge of soldering, brazing, and welding. All three of these techniques will prove invaluable in your career as a professional gunsmith.

With this knowledge and the proper equipment, the gunsmith can repair many broken gun parts so that they will last as long or longer than the original part.

Soldering is useful for mounting sight ramps and for resoldering old double-barrel shotguns when the soldering deteriorates to the point where the parts might come apart upon firing. This latter technique is not for the amateur: the job takes a set of special barrel wedges, clamps, and the professional skill that few gunsmiths possess. But if you put forth much effort, you can do it (Figure 12).

It is best not to apply heat to any part of a gun until you are absolutely certain that you know what to do. However, a beginner can make repairs on certain noncritical parts by silver soldering, if care is exercised. For example, the thin, semi-fancy trigger guards of certain double-barrel shotguns are subject to breakage; these may easily be repaired by silver soldering, and then reblued. Tangs on some of the older Winchester Model 92 lever-action rifles are often found broken, and can be helped by silver soldering. Many other noncritical parts found on firearms—hammer spurs, triggers, and swivels—can also be helped by silver soldering.

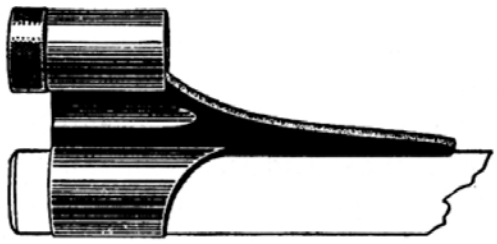


Figure 12: *Some rifle front-sight ramps are designed to be soldered onto the barrel. Your knowledge of soft soldering and the proper tools will do the trick.*

Regardless of the type of metal joining—soldering, brazing, or welding—there are certain requirements common to all three:

- Cleanliness
- Flux
- Proper amount of heat

The first requirement—cleanliness—means that the metal to be joined must be clean, bright, and absolutely free of scale, grease, oil, and dirt. This could mean, in some cases, that the bluing should be removed, such as at the muzzle of a rifle barrel prior to sweating on a sight ramp. The main purpose of flux, the second requirement, is to prevent oxidation. When metal is heated, it will oxidize, preventing the formation of a good joint. Flux, when properly applied, will help prevent this. The third requirement—heat—must be sufficiently high to flow the joining metal, and also to raise the temperature of the parts to be joined. If you can meet these three requirements, you are well on your way to becoming an expert at soldering, brazing, and welding.

Soft Soldering. Sight ramps, shotgun barrels, rimfire barrel liners, scope sight bases, and some other firearm accessories can be attached by soft soldering. However, most solder found in your local hardware store is designed for electrical and plumbing applications, and is not the best for use on firearms. Hot caustic bluing solutions attack the soft-soldered joints, and in some cases will render the joints useless, requiring that they be resoldered.

Brownells solved this problem with their Hi-Force 44 solder, which contains 4% silver and 96% tin, and can be used on all types of gun metals except aluminum. Best of all, users have reported that parts joined with this product showed no effects when immersed in the hot caustic bluing solution.

After you clean the areas on both pieces to be joined, coat them with solder. This process is called tinning. Heat the areas with a torch — propane will do — and apply soldering flux, such as No. 4 Comet. Reheat the areas to a temperature high enough to melt the solder and spread a thin coat of melted solder completely over the areas to be jointed. This is accomplished by heating the metal — not the solder — with the torch. By

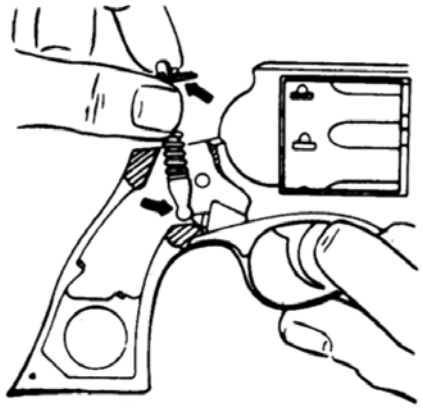


Figure 13: *Gun parts under any type of stress should not be soft soldered. Silver soldering is the way to go. Silver solder is surprisingly strong and will take care of 90% of gun-part repairs.*

doing so, the metal will melt the solder when it reaches the proper temperature. If the solder is heated and melted onto the surfaces, it will not make a good bond or, possibly, none at all. While the surfaces are still hot, take a thick rag and, with a quick swipe, wipe off all excess solder. You will not get a good joint if there is too much solder between the two pieces to be joined. Then let the parts cool at room temperature until they can be easily handled.

Once cool, the parts can be placed exactly in position and then clamped securely. Heat the parts again with a propane torch to a point where the solder flows freely. You can feed additional solder to the two joining areas, either around the edges of the objects or possibly through screw holes in the pieces. Be careful not to clog the holes if this latter route is taken. Immediately wipe off any excess solder with a dry cloth.

If you are soldering a part on a blued surface, remove the bluing only where the parts will join, so that all surfaces that can be seen will retain the blue. Be careful not to apply too much heat or you will discolor the surrounding blued surfaces. Parts that have been properly cleaned and tinned with the Hi-Force 44 solder and then joined together will be permanently attached and will withstand any rough treatment. It is not recommended for repairing broken parts that will be exposed to strain— even the slightest bit (Figure 13).

Silver Soldering. This technique will find the most uses around the gun shop. Silver solder becomes fluid enough with heat to flow through small cracks and, although it requires more heat than soft solder, it normally requires less heat than conventional brazing. For gun work, a solder that flows between 1,000°F and 1,200°F is best; anything higher will render some metals useless for gun work. Clean the parts to be joined as described previously, then hold them in position. Apply flux to the joining surfaces. Then, heat both parts from a dull to bright red — depending upon the metal to be joined — and when hot enough, touch the silver solder to the joint, which will "suck in" the solder between the pieces being bonded.

Since you will encounter many types of metals and alloys during the course of your work, selecting the proper solder for a particular job can be difficult. Knowing the exact proportions of solder and flux — and the right solder and flux — requires considerable experience. Fusion solders come already ground in their own special flux in the correct proportions. Because of this, practically anyone with a minimum amount of experience can do top-quality soldering using the following types of solders.

S-4 1000 Silver Braze. This is a low-temperature, high-strength brazing alloy for use when tight-fitting joints with a minimum amount of fill are desired. It melts at 1,000˚F. When using this solder, make sure that you mix it well and keep the container tightly closed.

S-4 Silver Braze. This solder closely resembles S-4 1000, but has a wider melting range and higher flow point for better filling characteristics. This is the solder to use when putting on front ramps that do not match the barrel exactly. It can also be used for joining small parts where chips of steel have been broken, or when it is impossible to hold parts together for brazing.

DMS-1200-750 Non-Flowing Silver Braze. This solder does not flow when it melts. It can prevent runny solder, and helps you keep from losing the alignment in jig setups, which can happen when solder begins to run. It is excellent when used for ramps, ribs, sights, and repairs where the fit does not have to be perfect.

For most silver soldering work, Brownells Silvaloy 355 is good. It melts at about 1,100˚F and flows at around 1,150˚F. It has the lowest melting point of any commercial silver solder, and is excellent for use on gun parts. It comes in both wire and ribbon forms, for use in most gunsmithing applications.

ACETYLENE WELDING

An oxyacetylene welding outfit is one of the most useful pieces of equipment for the gun shop. The acetylene torch alone may be used for bending, forging, hardening, tempering, and soft soldering. With the oxygen added, it can be used for silver soldering, brazing, and welding. Almost any good set will suffice for gun work, but one favorite has been the smaller unit (with tanks) that can be easily rolled or carried to various locations. It is manufactured by Uniweld (2850 Ravenswood Road, Fort Lauderdale, FL 33312, www.uniweld.com. It is known as an aircraft welder, and comes in kit form with regulators, hoses, tips, and tanks. The tanks are placed in a rolling carriage and can easily be rolled from one area in the shop to another.

Tip sizes are important and should be selected depending on the type of work that you will be doing. For example, size 0 is small and good for spot annealing on some case-hardened receivers prior to drilling and tapping for scope mounts. Size 4 is good for bending bolt handles to accept telescopic sights, while those sizes in between are used for various welding and brazing applications.

You must follow certain safety precautions when using welding equipment. Eye protection, such as a pair of welding goggles, is absolutely necessary. Also important is your method of lighting the torches. Never use a cigarette lighter. Use a flint-type torch lighter designed especially for lighting acetylene welders. You also should have some type of body protection, such as welder's gloves and a leather welder's jacket. The latter is rather expensive, so many gunsmiths wear cotton coveralls or a denim jacket instead. Be extremely cautious about the surrounding atmosphere. Obviously, you would not want to use the torch around any combustible materials or fumes; that could be disastrous. Many auto mechanics have lost their lives when repairing gas tanks. They drain all the liquid gas out, but forget about the fumes—when the torch is applied, an explosion results.

For welding and brazing, the gunsmith will need an assortment of welding and brazing rods. One type of rod that will fulfill most of your needs is the 3½" nickel steel welding rod.

When welding, securely clamp your work before applying the torch. Many gunsmiths have an assortment of jigs suitable for practically any job. For welding small parts, many gunsmiths use two conventional vises for holding the work, one half of the part in each vise. The vises are then swiveled until the joint is in perfect alignment. If the parts are very small, use alligator clips with Brownells Heat Stop to prevent the springs from losing their temper too quickly. Have plenty of these clips on hand, because eventually the springs will be of little use and will have to be discarded due to the high heat used in welding.

Each welding torch tip normally comes with recommendations for the proper gas pressure (set the regulators accordingly). Follow these recommendations until you have reason to do otherwise. The chart in Figure 14 should be helpful.

To use the torch, first turn on the acetylene and ignite it with the flint-type striker. This will give a dirty, sooty flame. Then turn on a small amount of oxygen and the flame will clear. If the oxygen is below normal requirements, the light-colored inner portion of the flame will be long, or "fishtailed." This is known as a reducing flame, one which has an excess amount of acetylene. As the amount of oxygen is increased, the light-colored inner portion, or oxygen cone, will shorten and become clearly defined. This is known as a neutral flame, one which contains enough oxygen to burn all the acetylene; this is the type of flame you will use most around the shop. If the oxygen is increased even more, the oxygen cone will grow very short, and there will be an excess of oxygen known as an oxidizing flame.

Too much of either gas does steel no good. For example, the reducing flame will carburize the metal and harden it. However, it is recommended for brass, since it will not burn it. The oxidizing flame will burn the carbon out of the steel and ruin it. Remember, when welding or bending bolt handles, never let the oxygen cone in the center of the flame touch the metal or it will quickly burn out the carbon in the steel.

When welding, the general principle is to heat the two parts enough that they begin to flow and fuse together. Then use the welding rod to fill in the gaps. This is easier said than done, and you should practice a lot on scrap metal before working on good parts.

In addition to repairing small parts, the welder is frequently used in gun shops to weld on new bolt handles. You can purchase these handles from various sources for only a few dollars a piece. The bolt ends are normally cut at an angle; when cutting off the original bolt—prior to welding on the new one — this bolt should be cut at an angle, too.

Bolt welding jigs are available, but many gunsmiths prefer to use two vises — one fixed and one portable—to hold the bolt and bolt handle. The steel vises draw sufficient heat from the lugs, provided they are placed correctly. Then, by "playing" the flame of the torch away from the bolt body, the job can be done in a relatively short period of time. The usual procedure is to "tack" the two pieces first, then let them cool slowly at room temperature. However, before doing this, some gunsmiths pack the inside of the bolt body with wet asbestos to help keep the

Tip Size	Drill Size	Min. Oxygen Pressure (psi)	Max. Oxygen Pressure (psi)	Min. Acetylene Pressure (psi)	Max. Acetylene Pressure (psi)	Min. Acetylene Consumption (cfh*)	Max. Acetylene Consumption (cfh*)	Metal Thickness
000	75	½	2	½	2	½	3	Up to 1/32"
00	70	1	2	1	2	1	4	1/64"-3/64"
0	65	1	3	1	3	2	6	1/32"-5/64"
1	60	1	4	1	4	4	8	3/64"-3/32"
2	56	2	5	2	5	7	13	1/16"-1/8"
3	53	3	7	3	7	8	36	1/8"-3/16"
4	49	4	10	4	10	10	41	3/16"-1/4"
5	43	5	12	5	15	15	59	1/4"-1/2"

Figure 14: *Recommended acetylene welding settings.*

temperature down. The entire bolt body and accessories must be completely stripped before any heat is applied. This includes the firing pin (striker), striker spring, extractor, and ejector.

When the part has completely cooled, heat the two parts again and fill in the voids with the 3½" nickel steel welding rod. If you have never done this, or if your welding experience is limited, it is strongly recommended that you do your first couple of jobs under the supervision of a professional. The locking lugs on any bolt are hardened and heat-treated to withstand a given amount of pressure. Any heat that will color the steel will do damage to these lugs, so use extreme caution when applying heat to the bolt handle.

BASIC WELDING PRINCIPLES

The basic principle of welding is realized in a common operation performed by the old-time blacksmith or gunsmith over the anvil, where two pieces of wrought iron or steel were heated to a white heat and then hammered together. The best blacksmiths and gunsmiths could perform the work so skillfully that a joint could not be detected. If this kind of joint is tested in a testing machine to pull it apart, it would probably fail at the weld rather than in the actual metal, but a good hammer weld should have about 75% of the strength of the metal itself.

Chain was once made by hammer welding, and the familiar joints for this type of work were also used in making Damascus shotgun barrels as shown in Figure 15.



Figure 15: *Damascus shotgun barrels have beautiful patterns, but all of them can be deadly to shoot, especially with modern loads.*

Operations of this kind are rather primitive by today's standards, but the basic principles of welding may aid the gunsmith when using more modern methods.

Wrought iron is a better welding material than steel, because when steel is heated, the parts become coated with oxide or iron in the form of a black scale. If this is not removed, the weld will be defective. In the case of wrought iron, the metal may be safely heated to a temperature which will melt the oxide, which is then forced out during the hammering. But since this is too high a temperature at which to work steel, it is necessary to use a flux— usually borax. Borax powder and fine, clean sand in equal parts makes a good flux, especially if mixed with 25% iron (not steel) filings. However, in most cases, it is probably better to use one of the welding compounds which are sold specifically for different kinds of welding.

Extensive use was made of what is basically hammer welding in the fabrication of Damascus gun barrels, which were popular around the latter part of the nineteenth century. In general, Damascus barrels consist of a combination of forged iron and steel. Strips of iron and steel are braided and formed into a band. This is then wound around a mandrel and welded. The manufacturer proceeds little by little; the form is worked with light hammering until all the small rods or wires are joined into a solid piece. The mandrel used as a form is then removed by boring it out. Depending upon how the wires are braided and twisted, a pattern will appear upon the finished barrel after browning or bluing takes place.

The cheapest Damascus barrels were the so-called "brand" Damascus barrels. Better-quality types were the Horseshoe Damascus, Rose Damascus, Bernard Damascus, Crolle Damascus, Moire Damascus, and Laminette Damascus. Other fine types of Damascus included those made in England, known as "Laminated Steel," and the genuine English Damascus produced in Marshall's workshop in Birmingham, England. Confidence in the quality of Damascus barrels was so great that even ordinary steel barrels were either painted or covered with decals showing Damascus patterns. You can still occasionally find these imitation Damascus barrels.

The improvements in barrel steels drove Damascus barrels off the market generations ago. But until about the year 1900, approximately one-third to one-half of all Belgian shotguns were produced with Damascus barrels.

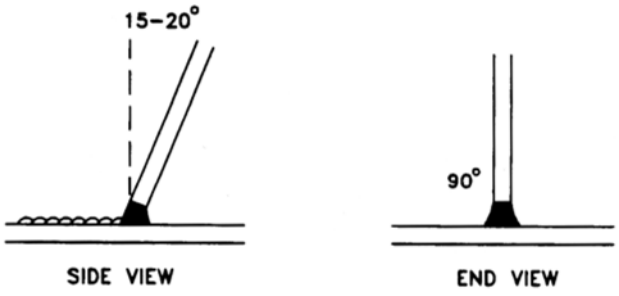


Figure 16: *Relationship of welding electrode to work.*

ELECTRIC WELDING

You cannot learn electric welding by reading alone; skill comes only with practice. However, the following section gives the basic principles.

Four simple factors are of prime importance in welding:

- The correct welding position
- The correct striking of the arc
- The correct arc length
- The correct welding speed

For arc welding, hold the electrode holder in your right hand (for right-handed persons), and then touch your left hand to the underside of your right hand for support. Place your left elbow by your left side. Whenever possible, weld using both hands. This gives you complete control over the electrode's movements. Also, whenever possible, a right-handed person should weld from left to right in order to clearly see the operation. The electrode should be held at a slight angle as shown in Figure 16.

Before striking an arc, make sure that the work clamp makes good electrical contact with the work. Then lower the head shield and scratch the electrode slowly over the metal. You will see sparks flying. While scratching the metal, lift the electrode about $^{1}/_{8}$" and the arc will be established. However, do not stop the electrode during the scratching process or it will stick to the work. This scratching should be done relatively slowly; fast jabbing of the electrode will cause it to stick and break the arc.

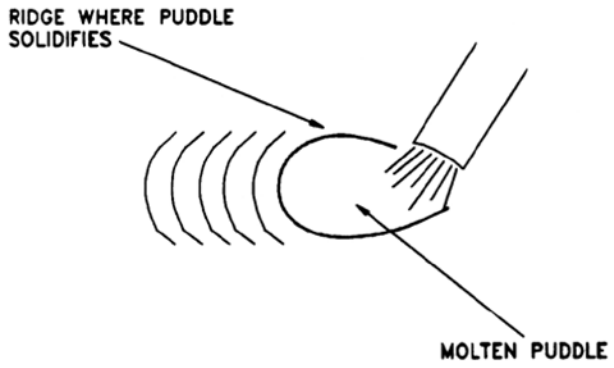


Figure 17: *The ridge where the molten puddle solidifies should be approximately $^{3}/_{8}$" behind the welding electrode.*

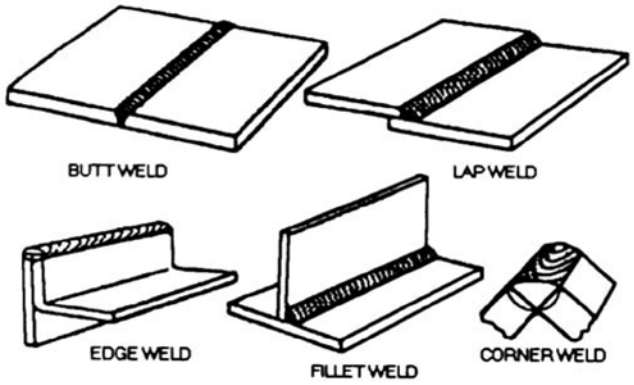


Figure 18: *Various types of welds.*

The arc length is the distance from the tip of the electrode core wire to the base metal. Once the arc has been established, maintaining the correct arc length is extremely important. The arc should be short, approximately $^{1}/_{16}$"-$^{1}/_{8}$" long. As the electrode burns off, it must be fed closer to the work to maintain the correct arc length.

The easiest way to determine if the arc has the correct length is by listening to its sound. A nice, short arc has a distinctive cracking sound, similar to eggs frying in a pan of grease. An incorrect, long arc has a hollow blowing or hissing sound.

When welding, watch the puddle of molten metal directly behind the arc constantly. However, do not watch the arc itself. The appearance of the puddle and the ridge where the molten puddle solidifies indicates correct speed (Figure 17). The ridge should be approximately $^{3}/_{8}$" behind the electrode. If the speed is too fast, the bead will result in a thin, uneven, "wormy" appearance. In general, thin material requires a faster speed, while heavier plates require a slower speed.

TYPES OF WELDS

The five most common welded joints are butt welds, fillet welds, lap welds, edge welds, and corner welds. Of these, the butt and fillet welds are the most common (Figure 18).

Butt Welds. Butt welds are the most widely used welds. To make a butt weld, place two plates side by side, leaving about $^{1}/_{16}$" space between them for thin materials and $^{1}/_{8}$" for heavy metals. This distance allows adequate penetration of the weld. Start by tracking the plates at both ends as shown in Figure 19(A); otherwise the heat will cause the plates to move apart as shown in Figure 19(B).

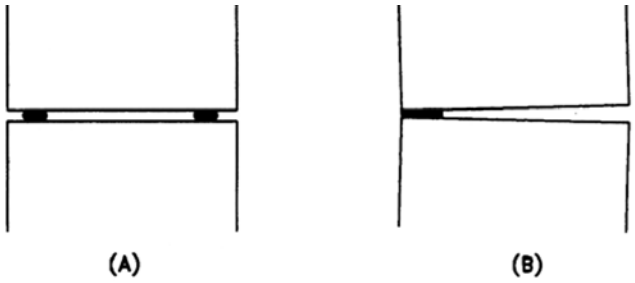


Figure 19: *When performing butt welds, track the pieces at both ends as shown in (A); starting at one end and working toward the other end will cause the pieces to separate as shown (B).*

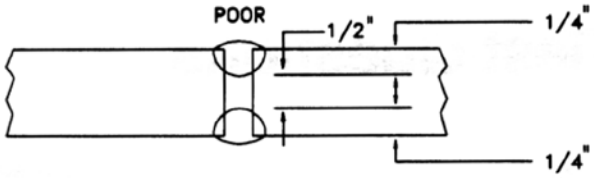


Figure 21: *In this weld, the total weld is only one-half the thickness of the material — making the weld approximately half as strong as the metal.*

The plates can now be welded together. The weld should run from left to right (if you are right-handed). Point the electrode down in the crack between the two plates, keeping the electrode slightly tilted in the direction of travel (Figure 20). Watch the molten metal to be sure it distributes itself evenly on both edges and between the plates.

Unless a weld penetrates close to 100%, a butt weld will be weaker than the material welded together. In Figure 21, for example, the total weld is only half the thickness of the material, making the weld only about half as strong as the metal.

In the example in Figure 22, the joint has been flame-beveled or ground prior to welding so that 100% penetration could be achieved. The weld, if properly made, is as strong or stronger than the original metal. When heavier metals are used, successive passes must be used to build up butt welds as shown in Figure 23 on next page.

Do not start long seams at one end and continue in the same direction, because unequal expansion and contraction will result in distortion and severe stresses. The joint should be tack-welded in a few places and completed in sections starting at the center, then moving to a section on one side some distance away, then a similar section on the other side.

FACTORS CAUSING FAULTY WORK

In soldering, the metal runs into the joint at a low temperature which does not spoil the solder, but a welding operation is virtually a local casting of metal done under exceedingly bad conditions for the metal. There is always the risk of weakness developing from strains and slag inclusions. Good results depend on skillful use of the correct filler rods and other tools, and it is not possible for us to give more than general rules.

In the welding of any particular metal, such as the various alloy steels, aluminum, etc., the supplier's instructions are the best guide. Always study the manufacturer's instructions before undertaking any work.

In metallic-arc welding the essential principle is that an electric arc is maintained between a piece of wire— the electrode — and the work being welded. The heat generated by the arc fuses the electrode and the molten metal.

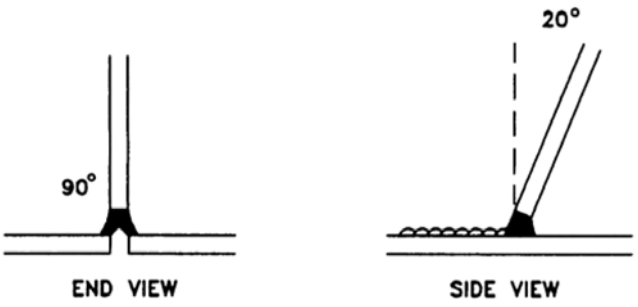


Figure 20: *Correct position of electrode to work for butt welding.*

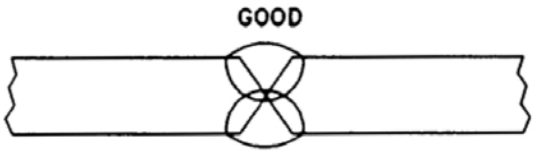


Figure 22: *This is a good welding joint giving 100% penetration.*

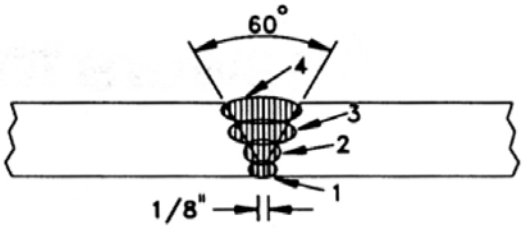


Figure 23: *Successive passes must be used to build up butt welds on heavier material.*

SELF-TEST QUESTIONS

Please check your answers on page 18.

9. **Should soft soldering be used on gun parts that will undergo some degree of stress?**
10. ***True or False.*** **During soldering, the cleanliness of the pieces to be soldered is of little importance.**
11. **When using an acetylene torch to spot anneal a rifle receiver before drilling and tapping for scope mounts, what is a good torch tip size?**
12. ***True or False.*** **Borax powder and fine, clean sand in equal parts make a suitable flux for welding.**

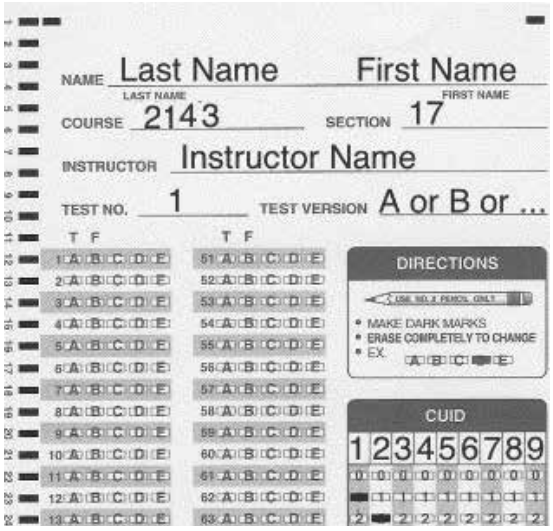
Answers to Self-Test Questions

1. True.
2. It should be warmed with a torch prior to pouring the lap.
3. It should have several grooves cut into the end to better hold the lap in place.
4. Rotate.
5. The bore is slightly enlarged.
6. True.
8. 0.740 inch.
9. No.
10. False.
11. Size 0.
12. True.

Lesson Questions

THIS IS LESSON NUMBER 2183.

Make sure you print your name, student number, and lesson number in the space provided on the Lesson Answer Form. Be sure to fill in the circles beneath your student number and lesson number.



REMINDER: A properly completed Lesson Answer Form allows us to evaluate your answers and send the results and additional study material to you. Do not hold your Lesson Answer Forms to send several at one time. You may run out of study material if you do not send your answers for evaluation promptly.

You may also complete your exam online at www.sdi.edu, click on the *online exams* tab.

1. **What is the process called when the entire shotgun bore (from the front of the chamber to the rear of the choke) is reamed out to a slightly larger size?**
   a. Choking.
   b. Full choking.
   c. Back-boring.
   d. Chambering.

2. **What condition should a rifle or shotgun bore be in to obtain the best shooting results?**
   a. Slightly rough.
   b. Smooth and highly polished.
   c. Polished with a few shallow pits.
   d. Rough, with a smooth chamber.

3. **What is the process called that entails rubbing minute amounts of metal from surfaces that must be precision-finished?**
   a. Lapping.
   b. Reaming.
   c. Hand-polishing.
   d. Choking.

4. **For best results, how should a shotgun bore be lapped?**
   a. With a rotating lap that follows the rifling.
   b. With gun cleaning patches only.
   c. With a rotating polishing wheel.
   d. With a reciprocating polishing wheel.

5. **For best results, how should a rifle barrel be lapped?**
   a. With a rotating polishing wheel.
   b. With a reciprocating polishing wheel.
   c. With a rotating lap that follows the rifling.
   d. With gun cleaning patches only.

6. **When lapping a rifle barrel, and to ensure a full lap, what must be done to the barrel as the lap is being poured?**
   a. An optical boresighter must be used.
   b. The barrel must be made entirely smooth on the inside.
   c. The barrel must be packed with dry ice to keep it cool.
   d. The barrel must be warmed with a torch all around.

7. **During the lapping process, in what position should the rifle barrel be placed?**
   a. Vertically.
   b. Horizontally.
   c. At a 30˚ angle to the floor.
   d. At a 60˚ angle to the floor.

8. **What is the main purpose of lapping a rifle or shotgun barrel?**
   a. To smooth the bore for easier cleaning, better accuracy, or better shot patterns.
   b. To enable easier maintenance of the stock.
   c. To adjust the bullet's point of impact on the target.
   d. To make sighting easier.

9. After a lapping operation is complete, what is the next step to preserve the bore?

a. Shoot out any loose lead from the lap.

b. Thoroughly clean and oil the bore.

c. Line the bore with tight-fitting cleaning patches.

d. Tin the inside of the bore with solder.

10. How should reamers be treated?

a. They must be honed before and after each use.

b. They should be slightly dulled to avoid chatter.

c. They should be carefully cleaned after each use and stored in their shipping containers or plastic tubes.

d. Their flutes should be allowed to overload.