# The Study of Gunsmithing



Sonoran Desert Institute

MODULE NUMBER 4

## Rechambering, Rebarreling & Trigger Work




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## MODULE NUMBER 4

# Rechambering, Rebarreling & Trigger Work

2179 Rebarreling and Headspacing

2180 Chambering, Free Boring, and Trigger Work

2181 Shotgun Chambers, Chokes, and Ribs

2182 Custom Fitting the Shotgun

2183 Restoring Rifle and Shotgun Barrels

2184 Making and Replacing Obsolete Gun Parts

2160 Stock Fitting and Metal Work Lab (#)

(#) Indicates point in your program at which additional lesson materials will be sent as you complete and return the lesson exams for grading.

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# Rebarreling and Headspacing Lesson: 2179


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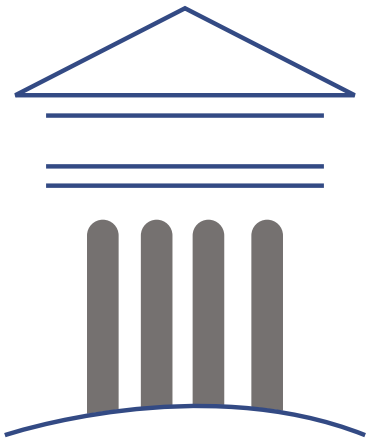
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## Objectives

After completing this lesson, you should

1. Be familiar with the procedures for testing the accuracy of the lathe centers.
2. Know how the lathe is used to turn a tapered shaft.
3. Understand how and why the barrel is supported during the contouring process.
4. Know which rifles use square threads on the barrel and receiver.

## Introduction

The installation or alteration of a barrel is a common job in the gunsmithing profession. Such a job requires the ability to work with a lathe and the technical knowledge of various procedures and operations.

There are many reasons for rebarreling a rifle. For instance, the original barrel might have been shot out or become pitted due to misuse or neglect. The shooter might have a new barrel that needs to be chambered for a special "wildcat" cartridge. An existing barrel might need to be rechambered for an improved cartridge. The shooter might have acquired a rifle action — such as a Springfield or Mauser—and would like to build a custom rifle from scratch. Whatever the reason, rebarreling a rifle is a common request for many gunsmiths. Because of this, it is important for you to become associated with barrel work. Even if you do not intend to do the work yourself, knowledge of the procedures can help you discuss the matter more intelligently with your customers or the person doing the work for you.

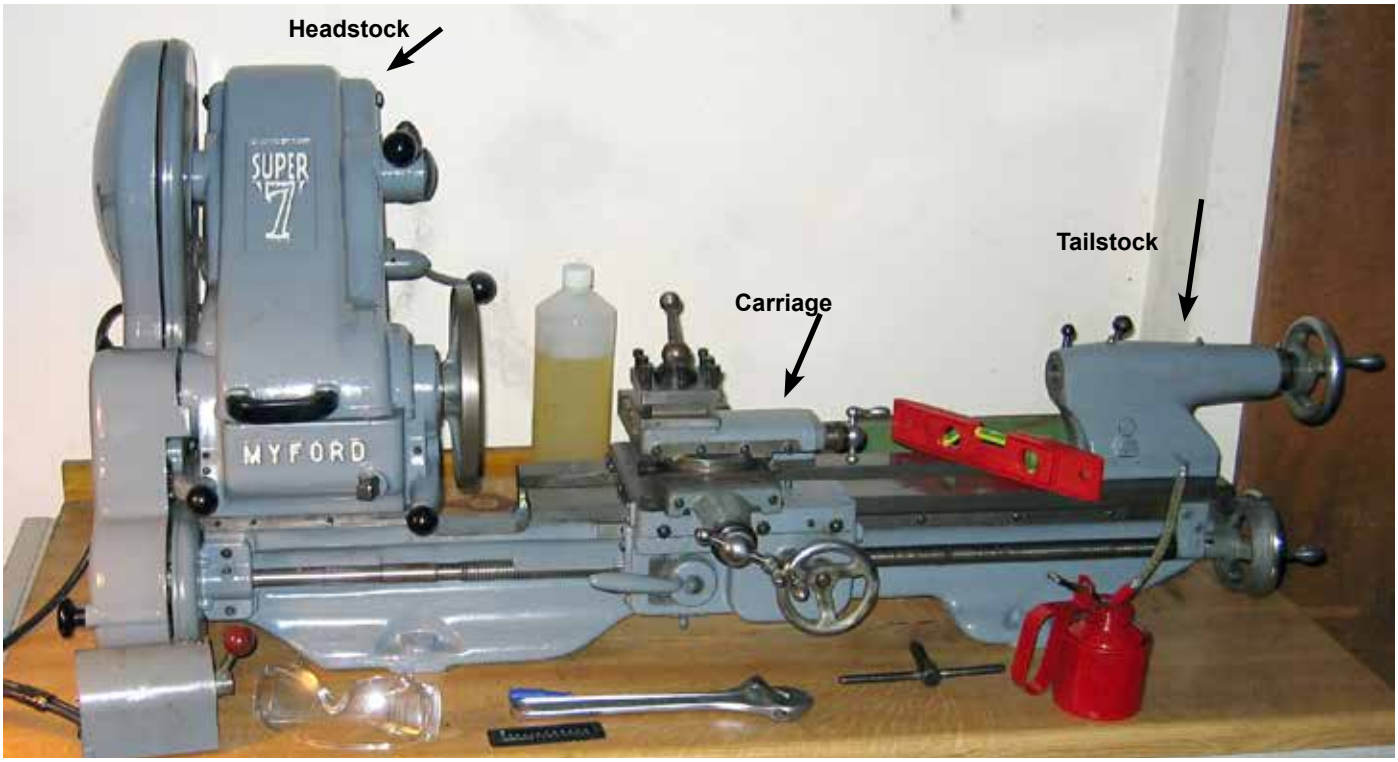



***Figure 1:*** *The Myford Super 7 is a high-quality lathe, ideal for a gunsmith's first lathe.*

This lesson gives you an overview of turning and con- touring barrel blanks to the desired dimensions, how to thread the barrel for attachment to the rifle receiver, and how to chamber the barrel for a specific cartridge.

# Lathe Lore

The screw-cutting, metal turning lathe is the oldest and most important machine tool. From it, practically all other machine tools have been developed. Lathes vary in size from the jeweler's or clockmaker's lathes used for making tiny parts, to the large gap bed lathes and special-purpose lathes used in mass production work.

The lathe size is determined by the diameter and length of the work the lathe can handle. For example, a 9" x 36" lathe has a swing over the bed that is large enough to handle work up to 9" in diameter and a distance between lathe centers of 36 inches.

When selecting a lathe for gunsmithing work, consider the needed size and amount of work required by the lathe. Ideally, the lathe selected should have a swing capacity and distance between centers at least 10% greater than the largest anticipated job.

## PARTS OF A LATHE

A lathe, shown in Figure 1, on the next page, is made up of many parts. The principal parts include the bed, headstock, tailstock, carriage, feed mechanism, and thread-cutting mechanism.

**Bed**. The bed is the foundation on which the lathe is built. It must be well constructed and designed. The most common types of beds are flat-ways and prismatic V-ways. Flat-ways are shown in Figure 1.

**Headstock**. The headstock is on the left-hand end of the bed and is one of the most important parts of the lathe. It should be geared toward the back to allow more versatility. The back gear provides a means of controlling the spindle speed. A lever engages the back gear for slow spindle speeds (75-280 revolutions per minute (rpm)) or disengages it for high spindle speeds (300-1,100 rpm).

**Tailstock**. The tailstock assembly moves on the bed ways and carries the tailstock spindle. The tailstock spindle has a standard Morse taper to receive various types of lathe centers. The tailstock handwheel is at the other end to give longitudinal movement when the workpiece is mounted between centers. The tailstock can also be used for drilling operations when the work is held in a gripping device, known as a chuck, or bolted on the faceplate so the work revolves and the drill remains stationary.

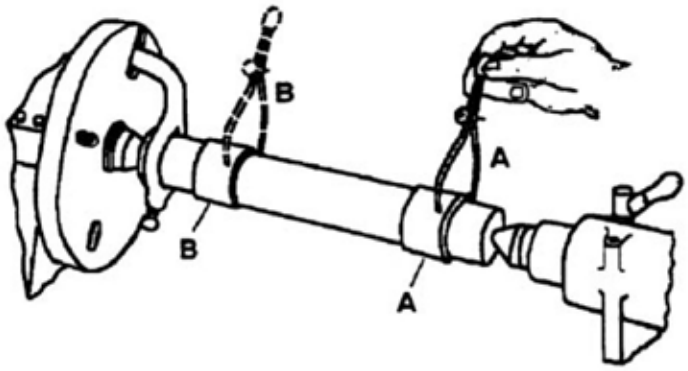



***Figure 2:*** *A test bar being used to check lathe centers. A test bar must be concentric and straight to within 0.001 inches.*

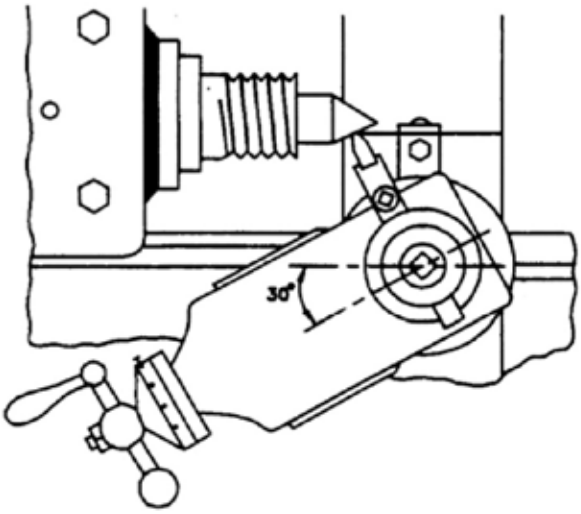



***Figure 3:*** *The degree setting on a compound rest for turning 60° lathe centers.*

**Carriage**. The lathe carriage includes the apron, saddle, compound rest, and tool post. Since the carriage supports the cutting tool and controls its action, it is one of the most important units of the lathe.

**Feed Mechanism.** Quick-change gear lathes are preferred in gunsmithing shops where frequent changes of threads and feeds are required. On most lathes, the quick-change gearbox is located directly below the headstock on the front of the lathe bed. A wide range of feeds and threads per inch can be selected by positioning the gears. The index plate is an index to the settings of the lever, which positions the gears for the different feeds and measurements so the carriage moves per revolution of the spindle.

The reversing lever reverses the direction of rotation of the screw for chasing right- or left-hand threads and reverses the direction of the carriage assembly feed. Levers on the quick-change gearbox should never be forced into position.

## CENTERING WORK

Both centers of a lathe must be in perfect alignment. One way to check center alignment is to use a test bar, such as the one shown in Figure 2. This can be a 12" length of round stock, 1" in diameter, concentric and straight to within 0.001 inch. By using this type of bar, the centers can be aligned easily.

Another method used to align lathe centers is the trial cut method. The trial cut method requires that you make a tight cut on the workpiece. Measure at the tailstock end of the workpiece and at a point midway between centers. If there is a difference in the two readings, then the tailstock is moved to the measurement that equals the difference. If the tailstock end is the larger of the measurements, the tailstock is moved toward the operator; if the tailstock end is smaller, it is moved away from the operator.

## TAPER-TURNING

One of the operations that often confronts the professional gunsmith is tapering a rifle barrel from a barrel blank. In general, there are at least three methods for taper-turning on a metal-cutting lathe. The simplest method is performed by swiveling the compound rest to the required angle and traversing the top slide by hand. Naturally, this method is limited to short taper parts, such as lathe centers, to hold the barrel blank because the top slide is limited to only a few inches of travel (See Figure 3).

## TOOL SETTING

When conventional cylindrical work is being turned, the height of the cutting tool has little effect on the accuracy of the work, although it might affect the quality of the finish. However, when tapering centers on a lathe, the cutting tool must be exactly on the centerline of the work, as illustrated in Figure 4. Otherwise, a true cone cannot be obtained.

In Figure 4, the full lines represent the small and large ends of a taper surface. The cutting tool moves outward the distance A as it travels along the workpiece. However, if the tool is set at the height B, where the tool would touch the small end of

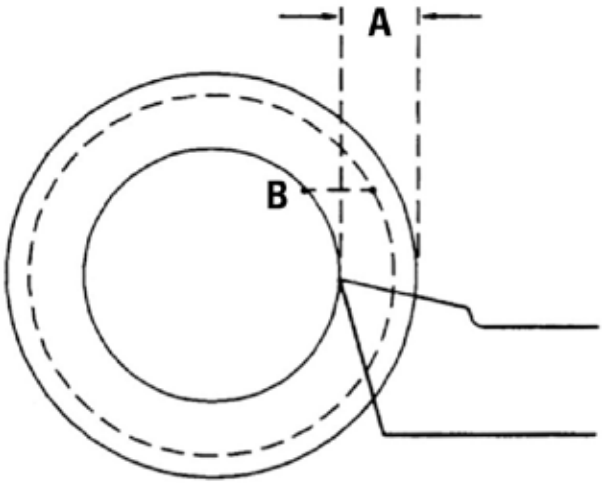



***Figure 4:*** *The cutting tool point for taper-turning must be exactly on the centerline.*

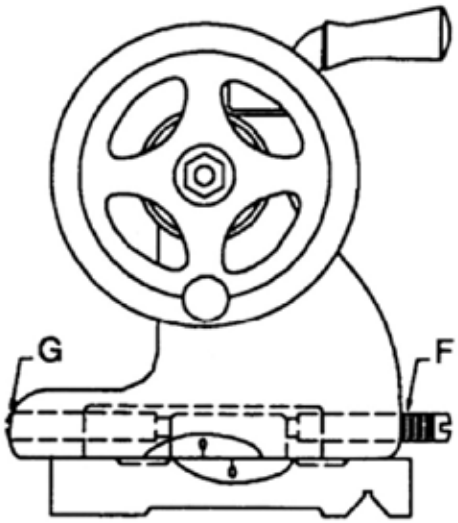



***Figure 5:*** *A tailstock showing adjusting screws (F and G).*

the taper, and then traversed along, the tool would still move distance A. In this case, the tool would terminate at the dotted line position, making the large end of the taper much too small. When turning the work to a fine point, such as the lathe center, if the tool is set either above or below the work center, the tool leaves the work before a point can be produced. It is impossible to produce a pointed workpiece unless the tool is set correctly.

A simple way to set the tool correctly is to compare the height of the cutting edge with one of the lathe centers before placing the work in the lathe.

## OFFSETTING TAILSTOCK

One of the most popular methods of tapering long workpieces is offsetting the tailstock, as shown in Figure 5. When the tailstock is offset, the angle of the taper varies according to the length of the work. The amount of offset depends on the amount of taper per foot and the overall length of the work. With the same amount of offset, pieces of different lengths can be machined with different tapers.

Setting the tail stock toward the operator (or tool post) results in a taper with a smaller diameter at the tailstock; setting the tailstock in the opposite direction results in a smaller diameter at the headstock.

To determine the proper amount of tailstock offset, remember that the tailstock center is offset one-half the total amount of the taper for the entire length of the work. Following are equations to be used to calculate the amount of offset.

When the taper per foot is given, such as inches per foot, the equation used is

$$\text{Offset} = \frac{\text{taper per foot x length of taper in inches}}{24}$$

To demonstrate the use of this equation, assume that a piece of stock is exactly 1' long and is to be tapered ½" per foot. Substituting these values in the equation, we have

$$\text{Offset} = \frac{.5 \times 12}{24} = 0.250 \text{ or } ¼"$$

To obtain the required taper, the tailstock should therefore be set ¼" off center. If the piece were only 10" long, then the offset would be

$$\text{Offset} = \frac{.5 \times 10}{24} = 0.208"$$

When the entire length of the piece is to be tapered and the diameters at both ends of the tapers are known, divide the large diameter minus the small diameter by 2 to obtain the amount of offset. For example, a piece of stock 1' long with a 1" diameter at one end and ½" diameter at the other, should have the tail stock set over the following amount:

$$\text{Offset} = \frac{1 - .5}{2} = 0.250 \text{ or } ¼"$$

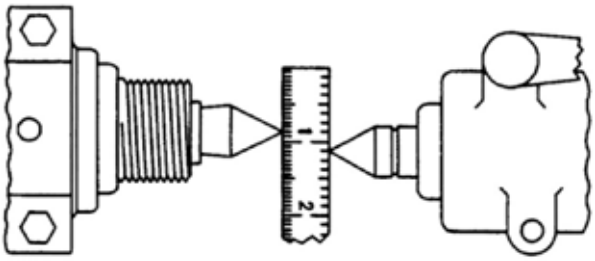


***Figure 6:*** *Approximating the amount of tailstock offset using a metal scale.*

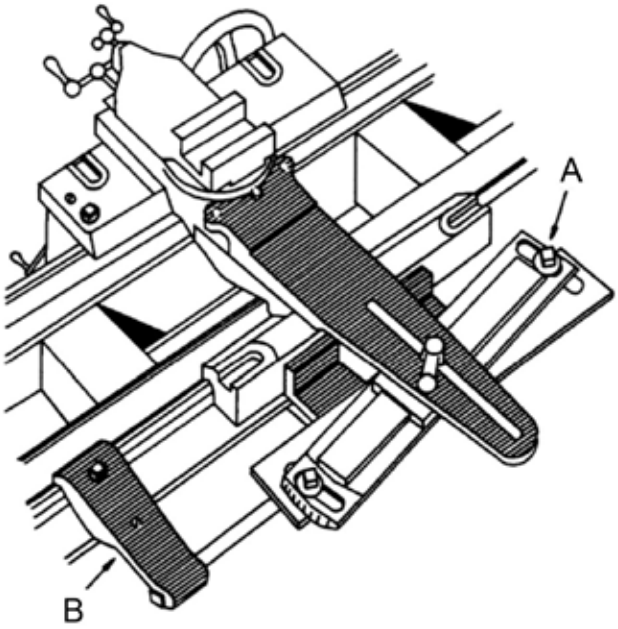



***Figure 7:*** *With a taper-turning attachment, the lathe centers remain aligned, but the tool traverses in a tapering direction according to the setting of the centers.*

When a portion of the stock is to be tapered and the diameter at the ends of the tapered portion are known, divide the total length of the stock by the length of the portion to be tapered and multiply this quotient by one-half the difference in diameters. The result is the amount of offset.

$$\text{Offset} = \frac{\text{total length of work}}{\text{length to be tapered}} \times \frac{\text{lg diameter} - \text{sm. diameter}}{2}$$

The method of adjusting the offset will vary slightly with the make of lathe. In most cases, all that is required is to loosen the clamping nut or lever and back off one of the offset screws, located on each side of the tailstock body. Then screw in the opposite screw until it is tight and reclamp the tailstock to the lathe bed. A zero mark is usually engraved at the end to mark the normal tailstock location for parallel turning.

To measure the offset of the tailstock center, place a metal scale that is graduated on both edges between the two centers, as shown in Figure 6. This will give an approximate measurement of the tailstock offset.

The best way to machine an accurate taper is to fit the taper to a standard gauge. To test the taper, make a chalk mark along the entire length of the taper gauge. Then place the roughly tapered work into or onto the gauge. Revolve the work carefully by hand. Remove the work from the gauge. The chalk mark will show you where the taper is not accurate so that you can make adjustments. Be sure the taper is correct before turning to the finished diameter.

The alignment of lathe centers should be checked at regular intervals to maintain accuracy of long cuts, even though the tailstock might not have been moved purposely.

## TAPER ATTACHMENTS

Many lathes are fitted with a taper attachment that permits the lathe centers to remain in alignment, as in conventional, cylindrical turning. At the same time, a taper attachment lets the tool traverse in a tapering direction as compared to the setting of the lathe centers. This arrangement is considered to be the best method of taper-turning by many machinists. A typical taper-turning attachment is shown in Figure 7. It is fitted to the back of the lathe saddle and to the rear slide of the bed. A slotted bar is fixed to the tool post, and can be clamped to a short slide on swivel bar A. For plain turning, the swivel bar is aligned with the slides of the bed, so that the tool follows a longitudinal path only when the sliding feed is engaged. If the bar is swiveled, then the tool follows a path that is set by the angle of the attachment. Taper-turning attachments can be placed on any part of the bed by its clamps or screws.

To find a setting for either turning or boring, measure the end graduation, which gives the inches per foot of taper. Sometimes shop drawings and specifications are given in the terms of angles or in terms of taper per foot. The table in Figure 8, on the next page, can be used to convert from one to the other.

| TAPER PER FT. IN INCHES | INCLUDED ANGLE | ANGLE WITH CENTERLINE |
|---|---|---|
| 1/8 | 0°36' | 0°18' |
| 1/4 | 1°12' | 0°36' |
| 3/8 | 1°47' | 0°54' |
| 1/2 | 2°23' | 1°12' |
| 3/4 | 3°35' | 1°12' |
| 1 | 4°46' | 2°23' |
| 1 1/2 | 7°09' | 3°35' |
| 1 3/4 | 8°20' | 4°10' |
| 2 | 9°31' | 4°46' |
| 2 1/2 | 11°54' | 5°57' |
| 3 | 14°15' | 7°08' |
| 3 1/2 | 16°36' | 8°18' |
| 4 | 18°55' | 9°28' |

***Figure 8**: Conversion chart that may be used in calculating measurements for taper-turning.*

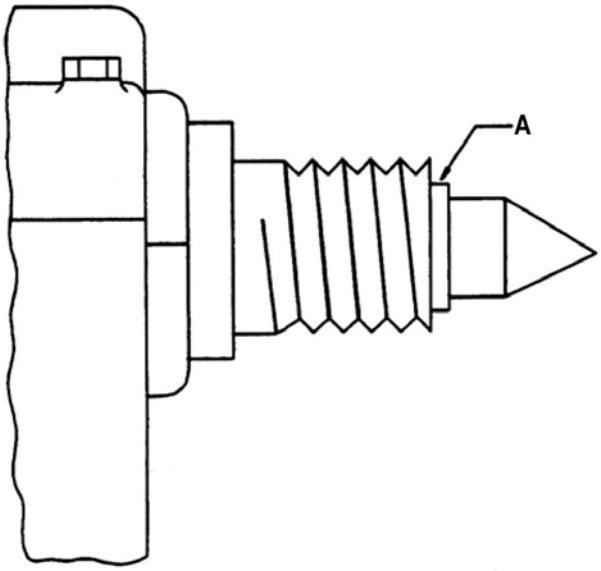



***Figure 9:** A bar of heat-treated steel is turned to use as a lathe center. This turned bar should not be removed from the three-jaw chuck until the turning operation is complete.*

## TURNING BARREL BLANKS

Barrel blanks are normally turned to contour between centers in a lathe. Due to the custom nature of work done by many professionals, most contours turned are one-of-a-kind, and require conventional lathe-turning procedures.

**This section discusses the conventional metal-turning lathe.**

Begin by cutting the raw length blank approximately ¼"-3/8" longer than the finished length, allowing for any metal that will have to be faced off the breech end to obtain the correct length of thread shank. At least 1" should always be removed from the muzzle end of a raw blank to remove any flare in the bore or grooves that might have been caused by the reamers entering or exiting during the bore-reaming process. There is always some run-out in the bore. Cutting the blank close to the finished length ensures that the bore will be concentric with the outside diameter when the blank is turned to its final length and crowned. It is best to get the length close to the finished dimension before turning, leaving just enough excess to remove any lathe center damage that might have occurred during the turning and polishing process.

A bar of heat-treated steel is used for a lathe center. This bar is first chucked in the lathe jaws and turned true. While turning, the compound rest is set at 60° with the lathe spindle revolving in reverse. Refer to Figure 9.

Once the center has been turned and is in position, check the height of the cutting edge of the lathe tool. It must be on center to obtain a true cut. Later, during the turning operation, you should check this setting again; you might have to raise the lathe tool about 0.010" or more above center to obtain the best cut without chatter. The height of the tool will depend upon its shape and clearance angle. Each time the center is removed from the chuck, it must be turned true again. At this point, face off the end of the barrel blank and cut it with a saw.

During the initial turning, chatter will develop near the end of the cut. Chatter indicates that the cutting tool is digging in, causing the blank to climb up over the tool and flex away. Stop the cut and correct the situation by raising the cutting tool slightly above center.

You will find that a slightly dull tool will cut far better than a very sharp one. The type of tool used varies from shop to shop. The most popular type is the brazed carbide cutters used at speeds of 400-1,000 rpm, with a feed of 0.009-0.014 inches. However, the speed and feed depends on how the part is supported—whether it is close to the chuck or the steady rest.

One method of turning is to remove the center in the chuck, and chuck up the barrel directly in the three-jaw chuck (Figure 10). The object of the next turning operation is to remove heavy cuts at a high rpm, and with a fast feed. In doing so, the cut must be made close to the chuck, which will require moving the barrel in and out of the chuck jaws often. The blank is turned in steps during this operation, leaving enough material for final tapering later on. As the blank is reduced in diameter, shorter and shorter sections of the blank are left outside the chuck jaws. This leaves only short lengths of the blank unsupported, which reduces the likelihood of warping the blank. High speed and fast feed reduces the build-up of heat in the blank; and heat is a strong factor in causing barrel warpage.

This heavy removal of metal (hogging off) is best done in two or three stages. Chuck up the blank at one end, then turn it down, approximately 8"-10" from the chuck. When finished, slide that portion of the blank into the chuck, and turn another section to a small diameter. Then repeat the same process. This method allows for the portion of the blank in the chuck to cool as the outside portion is being turned.

The hole through the spindle on some of the smaller lathes will not accommodate the average blank. Therefore, all turning must be done when the blank is mounted on the true center, secured in the three-jaw chuck, and on the live center in the tailstock. During this turning operation, use bore plugs in each end of the blank. Clymer Manufacturing Company offers them for sale at a reason- able price. When using this method, the speed and feed has to be reduced to ensure that the blank does not heat up and warp.

Once the barrel has been roughly turned on centers and stepped down, the hogged-off blank is faced-off square again. Then another true center is turned in the chuck. For the final turning, be very careful not to damage the barrel; use a fine feed and a light cut.

There are two commonly used methods for tapering rifle barrels: using a lathe taper attachment or offsetting the tailstock. The former method provides a neat, accurate cut. However, on the smaller lathes, either the barrel or attachment has to be repositioned every 8-10 inches. Most gunsmiths prefer setting the tailstock to the required measurements in order to acquire the necessary taper.

In determining the proper amount of tailstock offset, remember that the amount of offset varies with the length of the barrel being turned, and that the tailstock must be reset to cut the same taper on barrels of different lengths. Be aware that setting the tailstock forward (toward the tool post) results in a taper with the smaller diameter at the tailstock end of the barrel. Setting the tailstock in the opposite direction results in a smaller diameter at the headstock end of the work.

When the tailstock has been offset by the required measurement, the barrel blank is placed in the lathe between centers. A ball bearing is then selected with an inside diameter that will fit snugly on the barrel blank at a point on either side of the blank's midway point. Rather than purchasing different size bearings for different blanks, some gunsmiths utilize one large ball bearing and then make an assortment of adaptor bushings for use on smaller diameter work.

With the bearing located and fitted to the blank, it is then clamped into the posts of the steady rest. An indicator is used to be sure the steady rest does not push the blank off-center of the lathe's axis. This type of arrangement supports the blank and runs extremely cool. It does not burnish a groove in the blank, as steel or bronze posts do. Bronze posts wear down rapidly and become loose, giving little support to the blank and allowing chatter to occur. Some gunsmiths use small ball bearings installed on each post of the steady rest, which results in burnishing the blank and more time spent on the process than with a single bearing.

When everything is secured in place, one end of the barrel blank is turned to final size and taper. Then the steady rest is moved, and the other section of the barrel is turned in the same manner (supported by the steady rest and bearing). Where the two sections meet, a slight blending is usually required by using a lathe file.

While there are many shortcut methods for taper- turning, the one described here assures neat and accurate results for any type of blank. For blanks that have not been stress-relieved, this method is important and necessary since the blank can warp during turning.

Though soft steel blanks can be turned between centers without any support, barrels of harder steel must have support, like the steady rest in Figure 11.

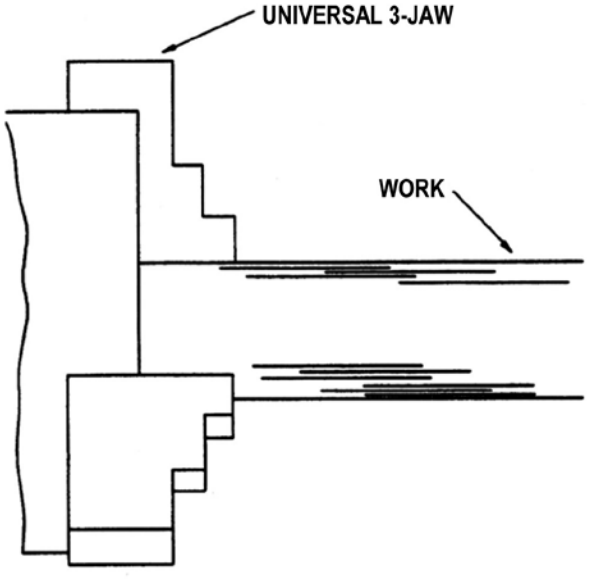



***Figure 10:*** *Barrel blank secured in three-jaw chuck, ready for turning.*

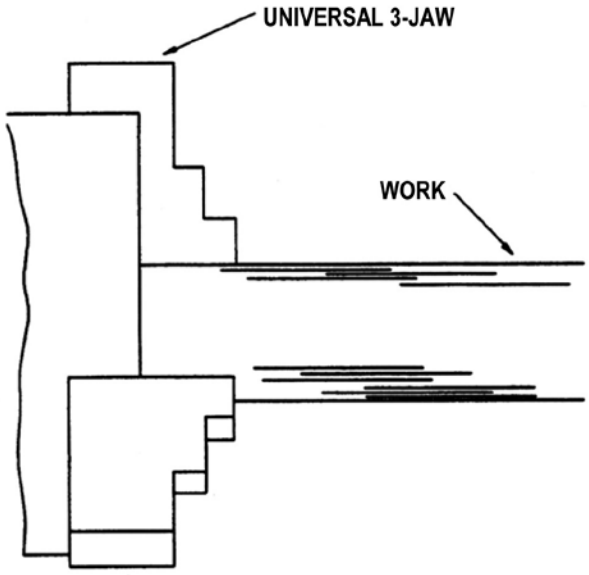



***Figure 11:*** *A steady rest is an important piece of equipment when turning barrel blanks to prevent warping.*

## SELF-TEST QUESTIONS

Please check your answers on page 23.

1. **If chatter develops when turning barrel blanks, should the cutting tool be raised or lowered?**
2. **How often should the lathe center be trued when turning barrel blanks?**
3. **What is the term used to describe large cuts taken at the first stages of turning a barrel blank?**
4. **What is the name of the lathe attachment used to steady the barrel blank on the lathe ways while it is being turned?**

# Cutting Barrel Threads

Threads in metal work can be produced by several different methods. The metal-turning lathe is the preferred method to use when the threads must be concentric with other turned surfaces, such as matching barrel threads to the receiver threads. Threads of various pitches can be cut on the lathe by connecting the headstock spindle of the lathe with the lead screw via a series of gears so that a positive carriage feed results and the lead screw is driven at the required speed in relation to the headstock spindle.

The lead screw on one popular lathe, for example, has eight threads per inch. The gearing between the headstock spindle and the lead screw can be arranged so that practically any desired pitch of threads can be cut. To illustrate, if the gears are arranged so that the headstock spindle revolves four times while the lead screw revolves once, the thread cut will be four times as fine as the thread on the lead screw or 4 x 8 = 32 threads per inch.

Either right-hand or left-hand threads can be cut by reversing the direction of rotation of the lead screw.

Threads can also be external or internal. An external thread is a thread on the outside of a member, as on a threaded gun barrel. An internal thread is a thread on the inside of a member, such as the threads on the inside of a receiver.

To cut an external thread, the thread-cutting tool is fed into the work by means of a compound rest feed. This rest is sometimes set to advance the tool squarely into the work, but many shops prefer to set the feed on a 29º or 30º angle. The cutting tool then removes metal only with its left-hand edge and tends to produce a smoother thread than if it were fed straight in. When the tool moves into the work at a 30º angle it is advanced 1.154 times the actual depth of the thread.

To prevent the tool from tearing the threads and to allow ample time to engage the dial at the proper mark, the lathe spindle speed should be slow — about 28 rpm. Once you are familiar with the size and the type of metal being threaded, the spindle can be increased. The gears which drive the lead screw must be arranged to produce the specified number of threads per inch.

Use a cutting oil on the work and feed the cutting tool into the work with the compound rest. When feeding in the tool, the gauge mark on the compound rest must be set for the proper depth of cut. For roughing the thread in steel, the maximum depth of cut should be not over 0.005", and for the last two or three cuts, no more than 0.001 inches. Heavier cuts can be made on brass, bronze, and aluminum.

Once the first shallow trail cut is made, every successive cut must track in the same spiral, which requires engaging the lathe carriage to the lead screw at exactly the right moment. This is easily done with a threading dial, as shown in Figure 12. The purpose of a threading dial is to position the tool accurately in relation to the work so that after withdrawing the tool from a completed cut, the tool returns to the same starting place for the next cut. By using a threading dial, you do not need to reverse the direction of the carriage to return the tool after each cut. Standard threading dials are divided by four marks, as shown in Figure 13. If an even number of threads per inch is being cut, the lead screw can be engaged when anyone of the four marks on the dial is opposite any index mark. In cutting an odd number of threads per inch, the lead screw is engaged at the same number for each succeeding cut. As the thread nears completion, it can be checked with a screw pitch gauge.

Left-hand threads are cut in the same way as right-hand threads, except that the carriage travels toward the tailstock and the compound rest is set at 29° or 30° in the opposite direction.

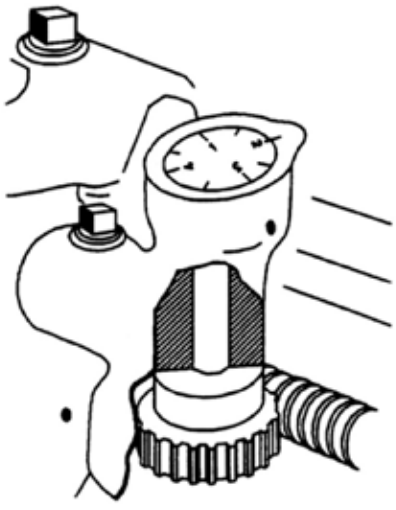


***Figure 12:*** *A lead screw dial indicator is essential for cutting threads on the metal-turning lathe.*

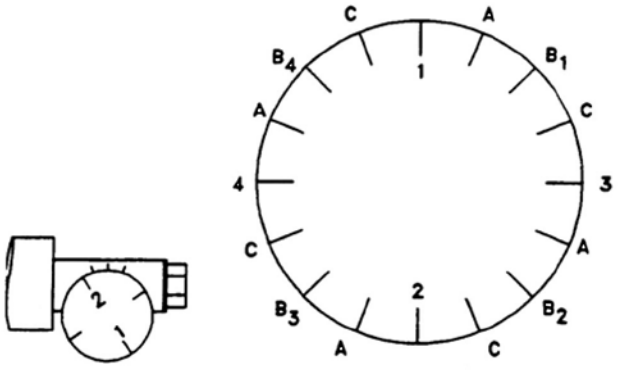



***Figure 13:*** *A threading dial with four basic markings and additional markings for cutting multiple threads.*

## THREAD FORMS

In modern industry there are many different types of thread forms. Those in normal use are described below:

The *V thread* from the American Society of Mechanical Engineers (ASME) — both fine and coarse — are practically standard for machine shop work in the United States. These threads are 60° V threads. Other types of V threads include the British Standard Whitworth, British Standard Fine, and British Association (B.A.). Actually, few of these are true V threads; most of them have their points cut off so that the depth of them is 75% of the depth of a true V thread of the same pitch.

The tool used for cutting threads is usually ground for cutting sharp-pointed V threads. The thread is cut with the regulation V bottom, but the top is left with the proper amount of flat. Only when the utmost strength is needed should the tool be ground to the exact National Form. However, the tool can be ground to cut an exact National Form V thread by flattening the sharp point so that it will fit in the selected slot of the ASME gauge. The general sharp, pointed, 60° V thread screw does work well with the corresponding nut or other internal threads (Figure 14).

## ACME SCREW THREADS

The Acme Screw thread is often found in power transmissions, where heavy loads require close-fitting threads. Another application is in the lead screws and the feed screws of precision machine tools. For example, the lead screw, the cross feed screw, and the compound rest feed screw of most lathes have Acme threads. Lead screws for certain types of presses and vises also use this type of thread.

Lathe threading tools are ground to the form of the thread desired. Figure 15 shows the proper tool forms for cutting external and internal Acme threads. The forms must be checked with an Acme thread gauge during the grinding process of the bit, and also during the threading operation ( Figure 16).

The various steps in cutting an Acme thread are similar to other types of threads; that is, set the compound rest at 14½° and advance the compound feed after each cut, returning the cross feed each time to the same setting. Threading for Acme screw threads requires a lighter cut than for conventional 60° threads because the total cutting of the tool is longer.

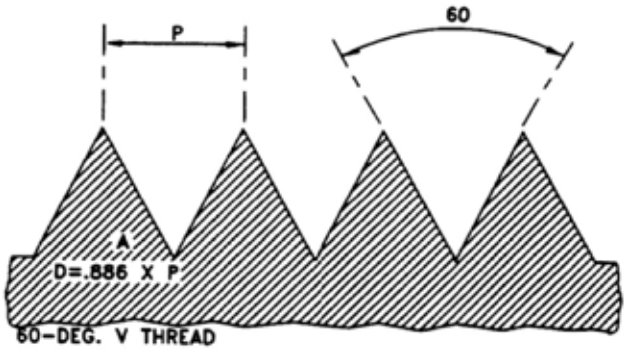



***Figure 14:*** *A standard 60° V-thread.*

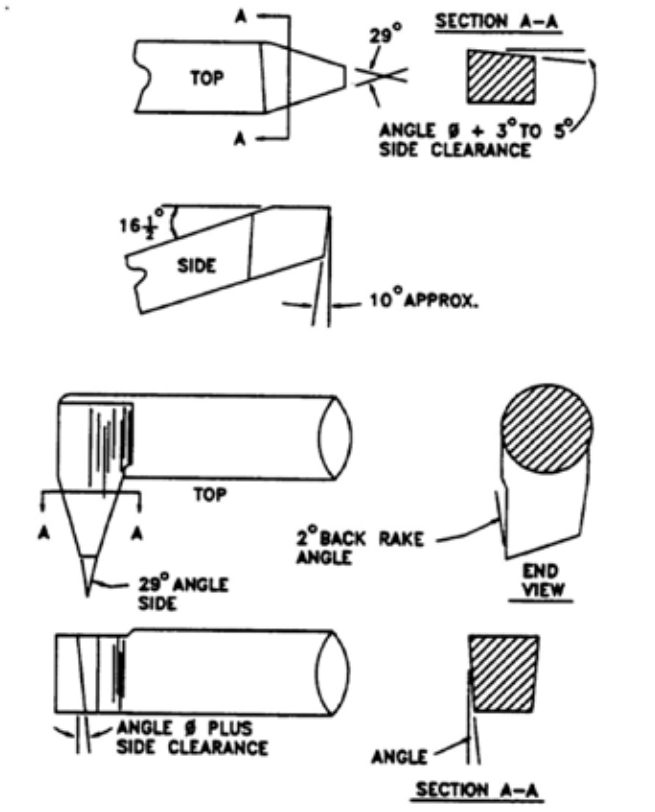



***Figure 15:*** *The proper tool forms for cutting external and internal Acme screw threads.*

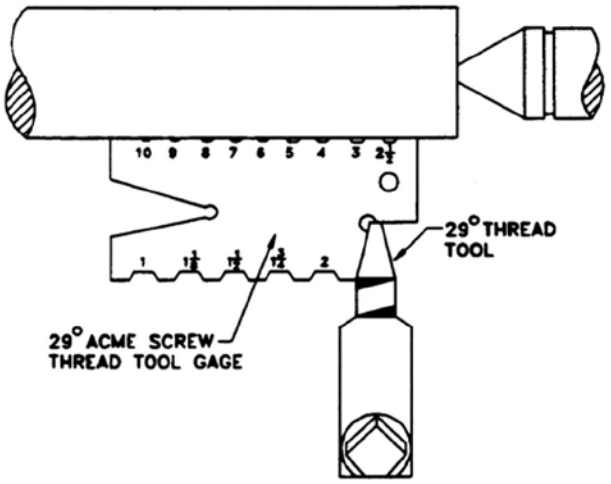



***Figure 16:*** *Checking the tool form with an Acme thread gauge.*

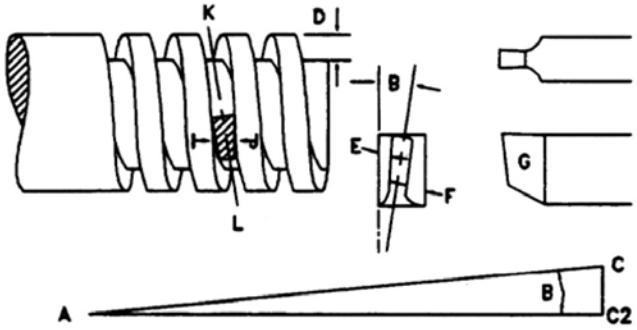



***Figure 18:*** *Details of tools and clearances for cutting square threads.*

## SQUARE THREADS

The square thread (Figure 17) is seldom used anymore because it is difficult to cut. Furthermore, the resulting thread is not as strong as the Acme. Some rifle barrels, such as the 1917 Enfield and 1903 Springfield, utilized square threads for screwing the barrel into the receiver. Currently, square threads are sometimes used to rebarrel these rifles and to thread many vise and clamp screws. When the gunsmith has a choice, the Acme thread is the type recommended for all applications; it is stronger, easier to cut, and capable of closer fitting compared to the square thread.

In cutting a square thread with a large lead, the tool angles must be absolutely correct. Clearance should be allowed on two sides, tapering from both the top and front of the tool as shown in Figure 18.

External square threads should be cut to the minor diameter plus about 0.005 inches. The additional 0.005" allows a small clearance at the bottom of the thread, which helps to compensate for any small inaccuracies in the tool or the cutting operation.

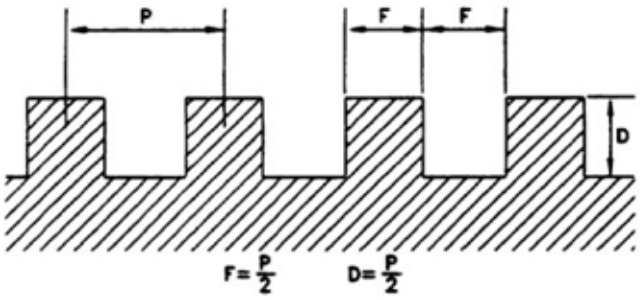



***Figure 17:*** *Square threads with characteristic reference marks.*

## WHITWORTH THREADS

A cross section of a typical Whitworth thread is shown in Figure 19 on next page. This is a standard form in Britain and Europe for many types of threads. The smaller sizes of the Whitworth form are called British Standard Fine.

A Whitworth thread is cut in much the same manner as an Acme thread except for two major differences: the thread angle is smaller, and the radius at the top and bottom of the thread must be shaped properly with a forming tool.

## METRIC THREADS

The Metric Standard screw thread is now the universally accepted thread form. The metric thread angle and form are identical to that of the National Form thread, and the cutting operation is exactly the same, with one exception: the lathe motor must be reversed after each cut. This procedure is necessary because metric threads have no definite relation to the threading dial.

Metric threads, special fractional threads, and others all use the same threading method. As the tool reaches the end of each cut, back out the feed, stop the lathe, and reverse the motor until the tool has been returned to the starting position. Then advance the feed to its original 0 position, turn in the compound rest feed for the next cut, reverse the motor to the original direction, start the motor, and repeat the cutting operation.

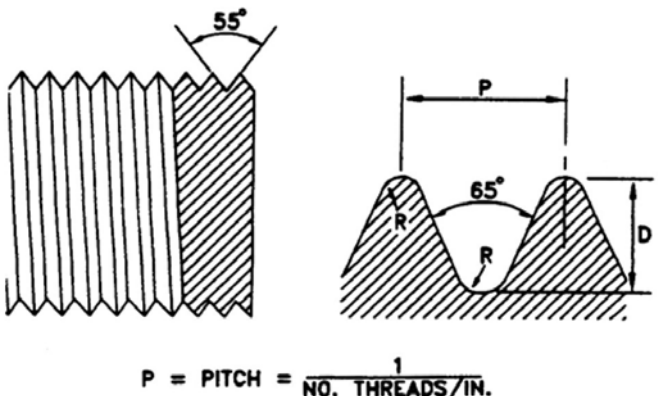



***Figure 19:*** *Specifications of a Whitworth thread.*

## DETERMINING BARREL THREADS

When cutting threads for rifle or handgun barrel blanks, the external threads on the barrel blank must match the internal threads of the receiver or action. The table in Figure 21, on next page gives the average dimensions of popular rifle and handgun barrels. However, since considerable tolerance is found among rifle actions, each rifle should be treated individually. The internal threads must first be measured precisely, and then these measurements must be transferred to the barrel blank. The data in Figure 21 is accurate enough to use in determining whether or not there is sufficient stock in a barrel or barrel blank to permit fitting it to certain action. It will also tell you whether or not your lathe is equipped to cut the required thread.

Let us assume that you want to thread a barrel for a .45 Colt Peacemaker revolver. We will further assume that the barrel contour has already been turned and the chamber end of the barrel has been turned to 0.760 inches. Measure off the thread length (0.700") from the chamber end of the barrel toward the muzzle. The barrel blank is then inserted between centers in the lathe, and the thread-length portion of the barrel is turned to 0.695" — the maximum thread diameter. A fraction of an inch is also undercut at the back of the barrel shoulder. This will facilitate cutting the threads without binding.

The cutting tool in the tool post is exchanged for a V- thread cutter, the gears are adjusted for cutting 20 threads per inch, and the lathe is put on its lowest speed. Advance the cross slide until it barely touches the area on the barrel where the threads are to be cut. Start the lathe and when the indicator on the lead screw dial indicator hits any of the four basic marks, engage the feed gear to cut a trial thread not over 0.005 inches. When the cutting tool reaches the undercut, disengage the feed, back the cutting tool to its original position, watch the marks on the lead screw dial indicator, and start the feed when it reaches the same mark as it was started on before. Continue these operations until the desired thread depth is acquired. The last couple of cuts should be very shallow to obtain a clean thread. Use cutting oil generously throughout the cutting operations.

| Make/Model | Tenon Length | Shoulder Diameter | Tenon Diameter | Type of Thread |
|---|---|---|---|---|
| Marlin Model 56 rifle | 0.875 | 0.742 | 0.630 | Not threaded |
| Marlin Model 57 rifle | 0.875 | 0.742 | 0.630 | Not threaded |
| Marlin Model 80 rifle | 0.875 | 0.742 | 0.630 | Not threaded |
| Marlin Model 100 rifle | 0.875 | 0.750 | 0.630 | Not threaded |
| Mossberg Model 46-M | 1.600 | 0.745 | 0.639 | Not threaded |
| Remington Model 500 series | 1.010 | 0.765 | 0.604 | Not threaded |
| Remington Model 513 rifle | 1.000 | 0.867 | 0.600 | Not threaded |
| Stevens Favorite rifle | 1.536 | 0.740 | 0.665 | Not threaded |
| Winchester Model 77 | 1.125 | 1.080 | 0.875 | Not threaded |

***Figure 20:*** *Barrel tenon data for rifles with threadless barrels.*

| Make/Model | Thread Length | Shoulder Diameter | Thread Diameter | Type of Thread |
|---|---|---|---|---|
| Colt Police Positive revolver | 0.725 | 0.570 | 0.445 | 32 tpi V |
| Colt Official Police revolver | 0.875 | 0.678 | 0.550 | 32 tpi V |
| Colt Peacemaker single-action revolver | 0.700 | 0.760 | 0.695 | 20 tpi V |
| Enfield Model 1917 rifle | 0.800 | 1.325 | 1.125 | 10 tpi square |
| M1 Garand rifle | 0.710 | 1.093 | 0.968 | 10 tpi square |
| Krag rifle | 0.734 | none | 1.040 | 10 tpi square |
| Marlin Model 336 rifle | 0.770 | 0.880 | 0.780 | 12 tpi square |
| Mossberg Model 80 rifle | 0.900 | 0.810 | 0.725 | 24 tpi V |
| Luger pistol | 0.7475 | 0.825 | 0.703 | 20 tpi V |
| Mauser '98 large ring rifle | 0.625 | none | 1.100 | 12 tpi V |
| Ruger Blackhawk .44 Magnum revolver | 0.710 | 0.775 | 0.680 | 24 tpi V |
| Springfield 1903 rifle | 0.734 | 1.145 | 1.040 | 10 tpi square |
| Weatherby Mark V rifle | 0.701 | 1.150 | 1.061 | 16 tpi V |
| Model 52-C rifle | 1.430 | 0.900 | 0.750 | 20 tpi V |
| Winchester Model 70 rifle | 0.728 | 1.145 | 1.000 | 16 tpi V |
| Winchester Model 94 rifle | 1.020 | 0.840 | 0.807 | 20 tpi V |

***Figure 21:*** *Barrel thread data.*

## THREADLESS BARRELS

Barrels on many models of rifles use no threads at all— especially on .22 caliber rimfire rifles. Rather, a tenon is cut slightly smaller in diameter than the shoulder of the barrel. This tenon is inserted into the rifle receiver and is held in place by one or two drift pins. To fit a threadless barrel, merely turn the tenon area (from the chamber end to the shoulder) the proper diameter, file or mill the pin locking grooves into this area, and insert the barrel into the receiver. Finally, drive in the drift pins. Of course, the barrel must be aligned when metallic sights are used, and the headspace must be precise.

The table in Figure 20, on previous page, gives the average dimensions of some popular rifles utilizing threadless barrels.

## SELF-TEST QUESTIONS

Please check your answers on page 23.

5. **Why is it impractical to use a standard table for all barrels of the same model rifle?**
6. **What is the thread length on a Marlin Model 336 lever-action rifle?**
7. ***True or False*. The threads on a Marlin Model 336 rifles are square.**
8. **How many threads per inch are used on Luger pistol barrels?**

# Bushing and Barrel Preparation

The gunsmith specializing in custom pistol work will often encounter barrel and bushing adjustments on the Colt Model 1911 pistol. There are many types of competition-style barrel bushings available, including matched or prefitted, undersized, and oversized. They are produced in chrome moly and stainless steel and are available in finger or full skirt styles. Be selective when choosing the size and style to ensure that it will closely satisfy your requirements. This will reduce fitting time required to prepare the bushing.

Note: For match-grade performance, avoid reworking standard bushings with expansion or swaging methods to obtain proper fit. This procedure is useful when addressing the requirements of a standard gun but should be considered inadequate to maintain match grade tolerances.

Prior to turning the outside diameter of the oversized bushing, check the bushing seat in the slide to insure that it is true and free of irregularities. After determining the inside dimension of the seat, the outside skirt diameter can be turned to size. Using a two-piece mandrel to secure the bushing will facilitate this operation (Figure 22). The tapered center, in conjunction with the flat seat of the female mandrel, locates the front of the bushing and the hardened cone of the male retainer centers the rear for an accurate setup.

This threaded, two-piece mandrel can be fabricated from ¾" round stock. Two sections are required. The male and female threaded mandrels are defined in Legend I (Figure 23, on page 17).

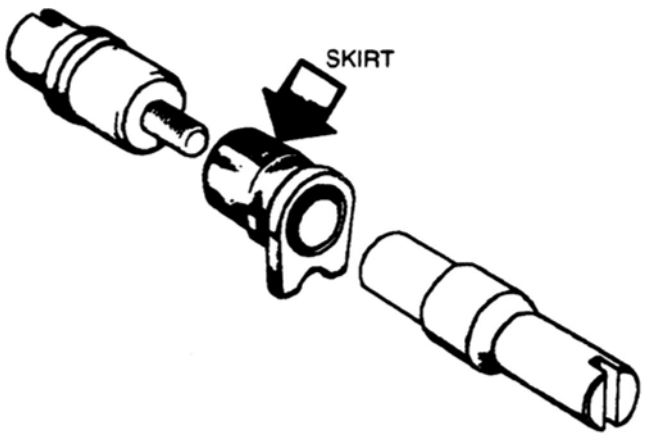



***Figure 22:*** *Mandrel used during the process of bushing/barrel preparation for the Colt Model 1911 pistol.*

**NOTE**: The noncritical dimensions can be varied to meet your requirements. The reduced ½" shanks are optional and are provided if you are restricted to a 0.500" collet or a ½" chuck.

After the machining operation, final fitting is completed by hand. All edges are deburred and surfaces polished as the lug is fitted and honed for a full contact fit. This procedure will be facilitated by applying a layout fluid to indicate the tight areas. A bushing wrench (Figure 24) is used to gain the leverage necessary for hand fitting. This accessory will also be required by the shooter for both installation and removal of the match-fit bushing.

The illustrated version is a Colt Combo Wrench which exhibits additional features to aid in the removal of the ratchets of both large and small frame Colt revolvers.

## BARREL PREFIT PREPARATION

Most custom barrels exhibit acceptable machine finishes in areas that might not require prefitting. However, it is strongly suggested to check all critical areas to ensure that the finish specs meet your fitting requirements. First, inspect the locking lug areas to see that they are smooth and free of imperfections. The leading edge of the lugs should exhibit a light radius. The top surface of the barrel should be polished from the face of the barrel hood, including the top of the locking lugs. Visually inspect the muzzle, bore, and barrel lug areas to see that no defects exist. Next, check the barrel face, chamber area, and barrel hood to see that they are free of blemishes, although these areas will generally require refitting or alteration.

Figure 25, on page 17, shows an oversized barrel chucked in a lathe ready to turn the outside diameter to the required dimensions. This fits the bushing and establishes proper clearance. The setup illustrates a centering mandrel, fitted with an adjustable dog "A" positioned to engage the barrel lug. The muzzle is secured on a live center "B" which both locates and aligns the barrel. When turning the bearing surface of the muzzle




***Figure 24:*** *Brownell's Colt bushing wrench*

**LEGEND 1**

A 0.0570"
B 1/4-20 UNC 1.00" DEEP
C 0.500°*
D 0.750°*
E 1.375°*
F 0.500" SLOTTED SHANK
G 0.725°*
H 60-DEGREE CENTERING CONE
I BUSHING
J 45-DEGREE TAPER*
L 0.500" CENTERED DRILLED AND SLOTTED SHANK
M 0.500"
N 0.250°*
O 1.250"
P 60-DEGREE CENTERING CONE
Q 0.875"
R 0.675"
S 1/4-20 THREADED SHANK
T 0.4375°*
U BUSHING

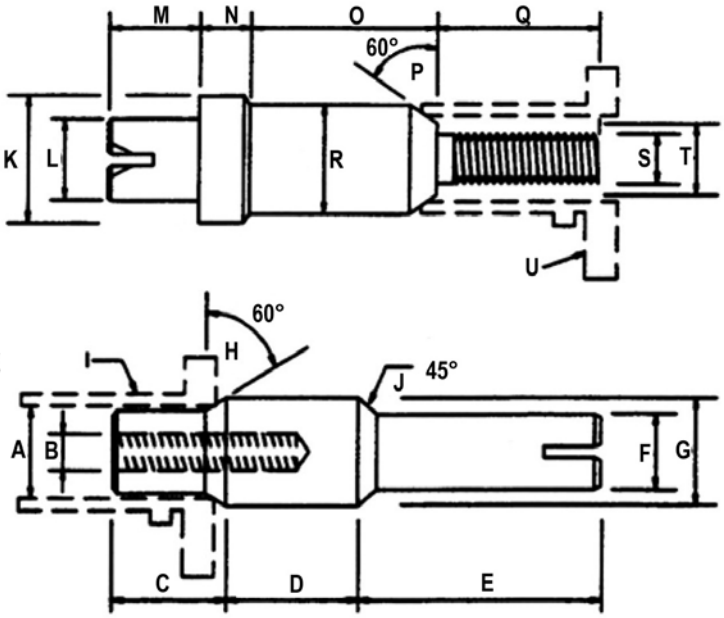



***Figure 23:*** *The threaded two-piece mandrel can be fabricated from the 0.75" stock.*

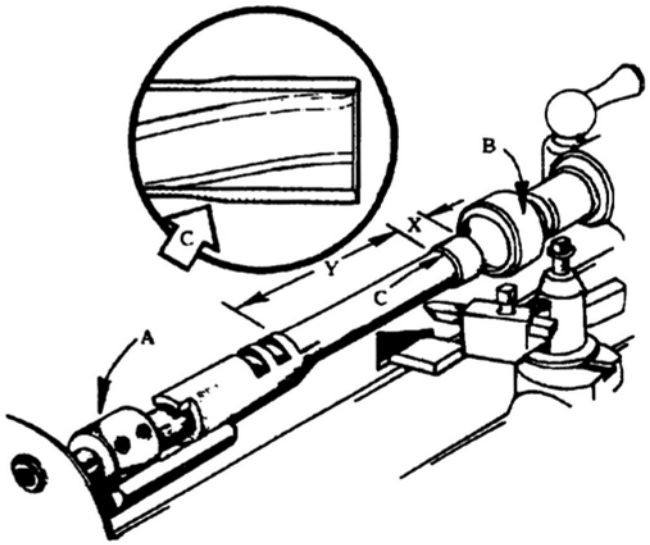



***Figure 25:*** *An oversized barrel chucked in a lathe, ready to turn the outside diameter to the required dimensions.*

end of the barrel, indicated by dimension "X," remove only the metal required to ensure that the outer surface of the barrel is both true and concentric to the bore.

**NOTE**: After comparing the new muzzle dimension to that of the oversized bushing, reduce the muzzle diameter to retain additional bushing wall thickness. The length of this bearing surface should not exceed 0.500" and its profile should be terminated with a gradual taper, indicated by arrow "C." This taper should blend into the relieved area of the barrel, designated by the "Y" dimension. This second cut should reduce the diameter of the barrel by 0.003"- 0.005" to provide additional clearance, which eliminates drag and prevents binding. This relief cut can extend from the recess of the front locking lug to the taper of the bushing-bearing surface.

After this machining operation, the tapered surface area, designated by arrow "C" in the insert, should be honed. This ensures a smooth transition movement from the barrel through the bushing during the lock-up cycle.

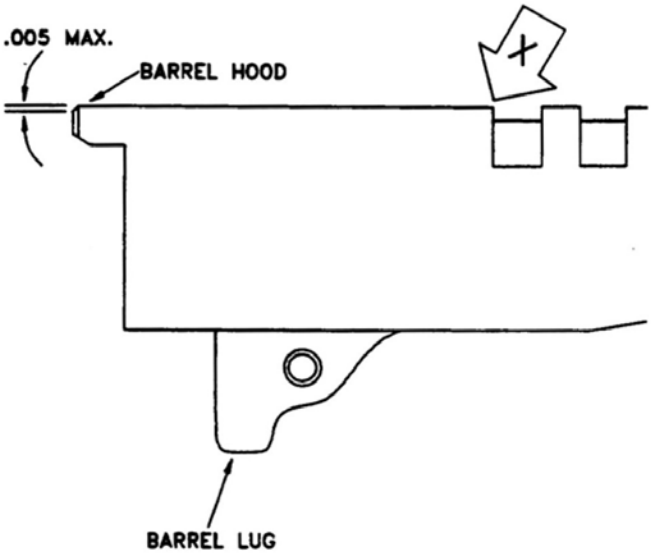



***Figure 26:*** *To complete the pre fit preparation of the barrel, polish and relieve the area immediately above the chamber.*

To complete the prefit preparation of the barrel, polish the barrel above the chamber area, as shown in Figure 26. This operation can be performed using a cloth-backed abrasive. Start with an appropriate grit to remove any minor irregularities that might exist. Dress the barrel from the rear locking lug to the face of the barrel hood as indicated by the "shaded area" of the insert. Begin at arrow "X". Continue with progressively finer grits until completing the operation. The final polish should be made using 500 – 600-grit.

Do not alter the barrel profile at arrow "X" or lower the locking lug at this time.

## SELF-TEST QUESTIONS

Please check your answers on page 23.

9. **Name the three basic competition-style barrel bushings available for the Colt Model 1911 pistol.**
10. **What operation must be performed before turning the outside skirt diameter of an oversized bushing for the Colt Model 1911 pistol?**
11. ***True or False.*** **The Brownell Bushing wrench is used to gain the necessary leverage during hand- fitting Colt Model 1911 bushings.**
12. **When polishing and relieving the area on the barrel immediately above the chamber in a Colt Model 1911 pistol, what is the maximum amount of metal that can be relieved?**

# Headspace

Headspace is the measurement from the rear of the cartridge case to the face of the bolt. In general, if too little headspace is provided, the bolt will not close. If the bolt closes on the cartridge and there is too large a gap between the cartridge and bolt face of the rifle, the weapon has too much headspace. In this latter case, when the rifle is fired, the cartridge case stretches and will often separate, as shown in Figure 27 (A), allowing harmful gas to escape to the rear of the case.

There are basically four different methods used to ensure proper headspace, all of which are shown in Figure 27. The cartridge in Figure 27 (B) uses the rim of the case to obtain proper headspace. The front of the rim rests against the face of the barrel, while the rear side of the rim rests against the breechbolt. Thus, headspace on rimmed cartridges is determined by the distance from the face of the breechbolt to the face of the barrel, or barrel recess.

Figure 27(C) shows a rimless cartridge case. The shoulder of the case stops the cartridge from entering the chamber too far. Headspace gauges are designed to measure from the bolt face to the case shoulder.

Belted cases, like the one in Figure 27 (D), utilize a raised belt around the rear of the case to obtain its headspace. When chambered, the case is stopped by the front edge of the belt.

The final type is the straight, rimless case, as shown in Figure 27 (E). These cases are used in semi-automatic pistols. The headspace is measured from the face of the breechbolt to the front edge of the cartridge case.

A good rifle should have no more than a 0.006" variance in headspace to allow for the variance in ammunition cases. Even if the rifle comes from the factory with perfect headspace, it will change after the rifle has been fired several times. The main cause of the change in headspace is the wearing of the locking lug surfaces. As the rifle is fired, the movement of the bolt locking lugs and the pressure put on them when firing changes the fit and position of the locking lugs.

This action changes the position of the bolt face. When excessive headspace is found in a rifle, there are generally two ways to correct it: replace the breechbolt with one a little longer to compensate for the excessive headspace; or set the barrel back one turn and rechamber.

Headspace gauges are steel, plug-like gauges. They test headspace in all types of firearms. They are designated Go, No-Go,

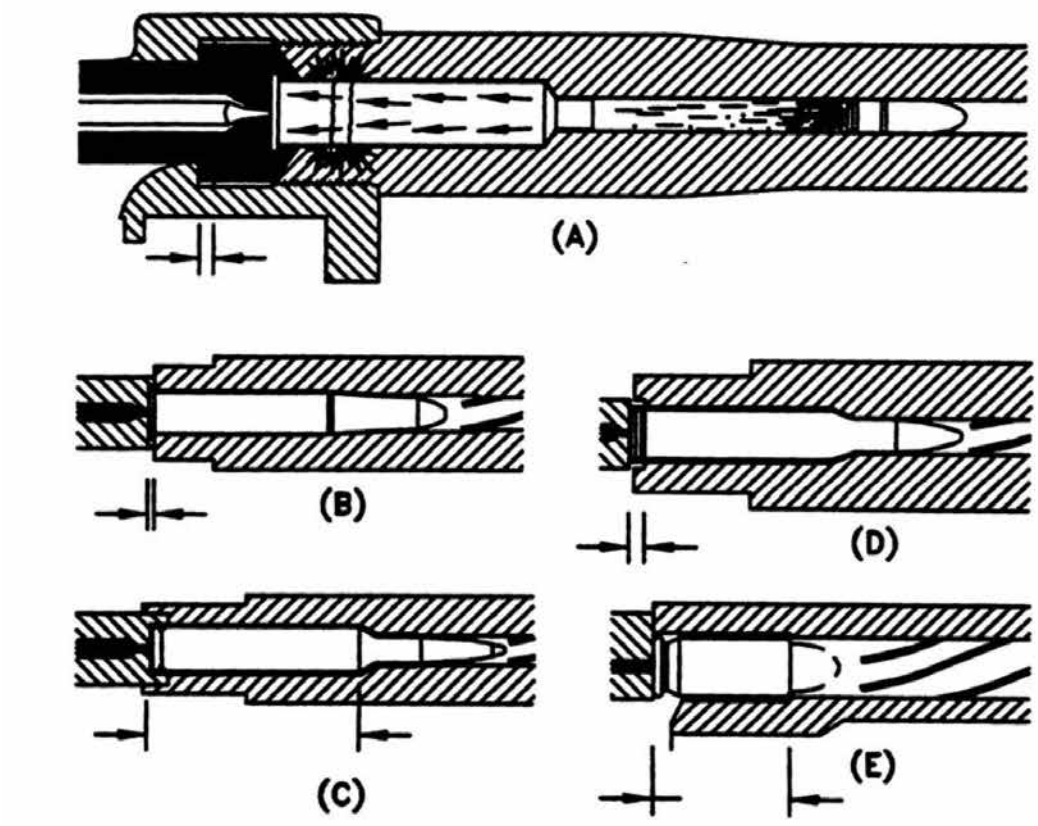



***Figure 27:*** *Characteristics of headspace: Too much headspace (A) can cause separation; rimmed cases (B) use the front of the rim to check headspace; rimless cases (C) use shoulders to check headspace; belt cases (D) use the front edge of the belt to check headspace; straight rimless cases (E) use the front of case (mouth).*

and Field. For most gunsmithing work, you should have both the Go and No-Go gauges. In checking headspace, the action should close on the Go gauge. It should not close, without excessive force, on the No-Go gauge. If the action closes on the Field gauge, the rifle is extremely dangerous to fire.

## RIMFIRE HEADSPACE PROBLEMS

Contrary to popular belief, headspace can be critical in a .22 rimfire rifle. If the headspace is a bit short, a cartridge might fire from pressure since the bolt is closed. If the headspace is too long, ignition is uncertain and not uniform. In match rifles, like the Winchester Model 52, headspace should be limited to 0.044-0.045 inches. The hunting arm can have broader tolerance — 0.043-0.046 inches. Firing pin protrusion should be 0.045 inches. Less protrusion causes non-uniform ignition, while more protrusion cuts a dent in the chamber and the firearm is snapped empty.

When inevitable wear causes a bolt to drop back a few thousandths of an inch, leading to excessive headspace, ignition will no longer be entirely uniform.




***Figure 28**: Three types of headspace gauges, from top to bottom: Go, No-Go, and Field*

The .22 cartridge is so small that any variation in the flash of the primer can change the point of impact. With a small-bore ten-ring, .15" in diameter at 50', a slight variation of headspace can cause a great difference between the aim and the actual target impact.

Each type of rifle presents its own problem when you start correcting headspace. Most of the .22 rimfire bolt- action rifles lock on the root of the bolt handle. In some instances it will be necessary to build up the root of the handle with a welding torch and then file it to fit. Quite commonly, though, one will need to correct the older and better-quality .22 match rifles such as the Winchester Model 52. On this rifle, the bolt body can be separated and a very thin shim placed between the sections, to move the forward portion of the bolt ahead.

## CHAMBER CHECK FOR COLT MODEL 1911

After you have achieved the proper barrel, frame, and slide fit for the Colt Model 1911 semi-automatic pistol, the chamber lengths should be checked for proper headspace. You can confirm the correct headspace tolerance by using both Go and No Go headspace gauges (Figure 29).

Note: The .45 ACP is a rimless straight case which headspaces off the case mouth. The nominal chamber length is 0.898 inches. You can confirm by carefully chambering the Go headspace gauge. This initial test confirms that the chamber is the proper length. To further establish that there is no excessive length, insert the No Go gauge and ease the slide down. If this gauge prevents the barrel from locking up, the correct headspace has been attained.

Usually, this procedure confirms that you have maintained proper chamber tolerances. However, if the fitting operation resulted in a tight chamber, you should use a chambering reamer to return the chamber to its correct dimension. This procedure can be completed by hand using a finishing reamer (Figure 30 on page 22). Work slowly, using multiple, light passes to recut the chamber to the required depth. Check your progress frequently with the headspace gauges. Remove the reamer carefully and clear the chamber area each time before inserting the No Go gauge. As you near the correct chamber depth, the barrel will move into lock-up position. To complete the operation, confirm the chamber dimension with the Go gauge. An excellent source for both chambering reamers and headspace gauges is Clymer Manufacturing.

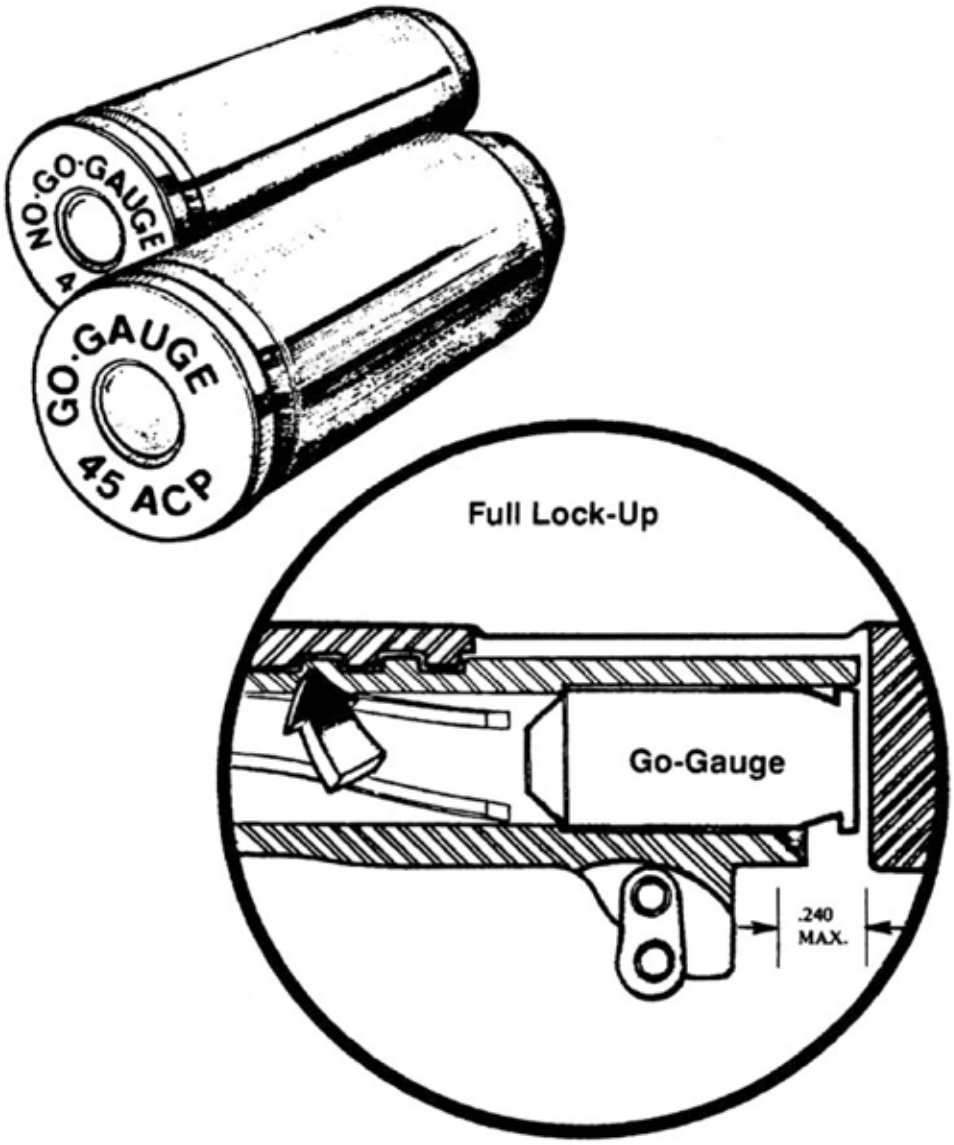



***Figure 29:*** *Once the barrel/frame/slide relationship is determined, check the work with headspace gauges.*

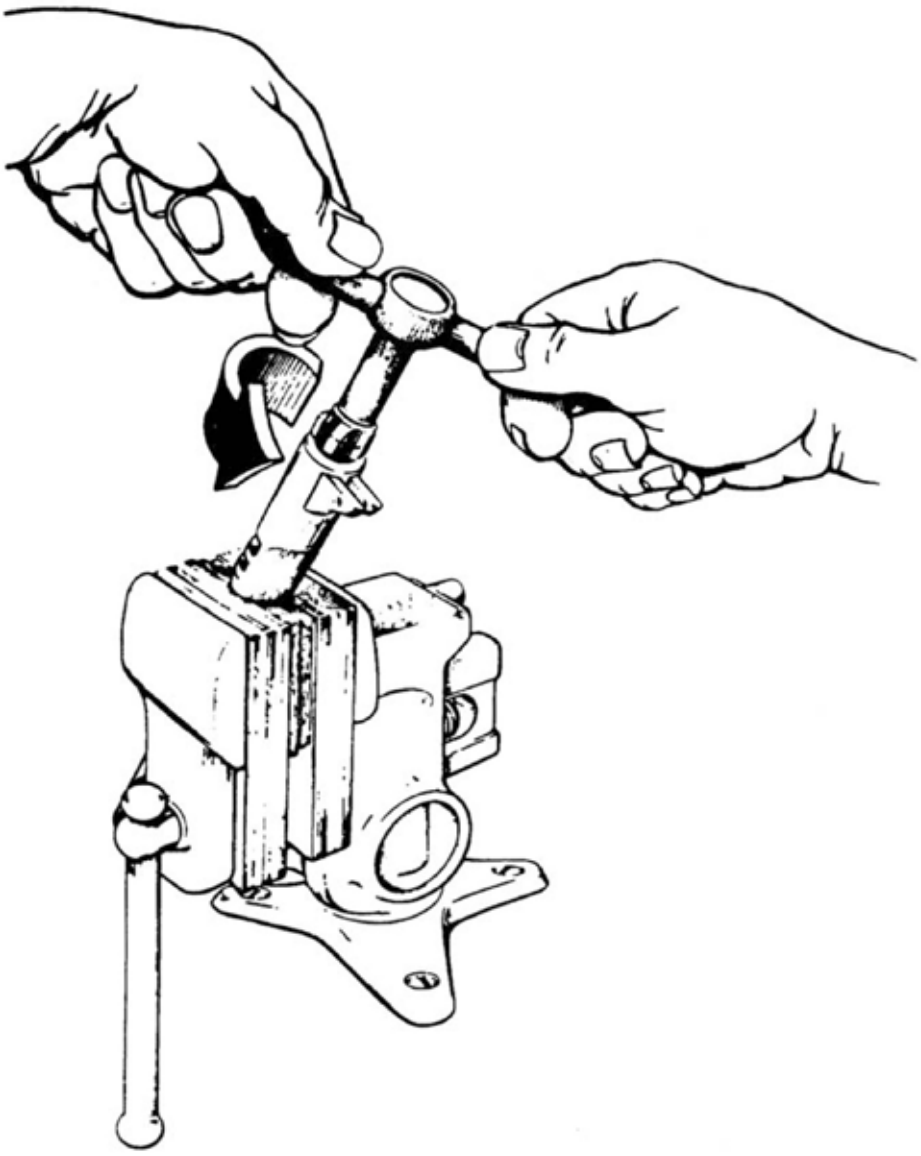


***Figure 30:*** *It might be necessary to use a chambering reamer to correct chamber dimensions.*

## SELF-TEST QUESTIONS

Please check your answers on page 23.

13. **What is the term that defines the distance between the head of the cartridge and the face of the bolt?**
14. **Name the three basic types of gauges used to measure headspace.**
15. ***True or False*. While headspace can be a problem in centerfire rifles, it is never a problem in .22 rimfire rifles.**
16. **What is indicated when a rifle bolt closes on a Go headspace gauge, but will not close on a No-Go gauge?**

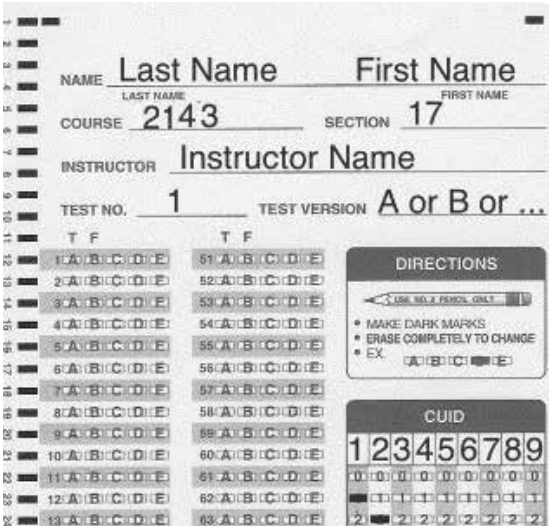
# Answers to Self-Test Questions

1. Raised.
2. Each time the center is removed.
3. Hogging off.
4. Steady rest.
5. Tolerances vary too much.
6. 0.770 inches.
7. True.
8. 20 threads per inch.
9. Matched or prefitted, undersized, and oversized.
10. Check the bushing seat in the slide to ensure that it is true and free of irregularities.
11. True.
12. 0.005 inches.
13. Headspace.
14. Go, No-Go, and Field.
15. False.
16. The headspace is sufficient.

# Lesson Questions

**THIS IS LESSON NUMBER 2179**

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. **Which one of the following tools, in many cases, is required to install new barrels on centerfire rifles?**
   a. Milling machine.
   b. Metal-turning lathe.
   c. Rockwell Hardness Tester.
   d. Power band saw.

2. **What is the name of the foundation upon which a lathe is built?**
   a. Bed.
   b. Crossfeed.
   c. Headstock.
   d. Tailstock.

3. **One way to test the accuracy of lathe centers is with a**
   a. Morse taper.
   b. Square thread cutting tool.
   c. Acme cutting tool.
   d. Test bar.

4. **What is the name of the process that describes turning cylindrical work on a lathe with different diameters throughout its length?**
   a. Headstock turning.
   b. Angle cutting.
   c. Taper-turning.
   d. Tailstock turning.

5. **What is another way to obtain a taper besides using a tapering attachment on a lathe?**
   a. Offsetting the tailstock.
   b. Advancing the cross-feed.
   c. Gear the lathe to its lowest speed.
   d. Watch the work as it progresses.

6. **What is used to support a barrel blank while performing the contouring operation?**
   a. Tapering attachment.
   b. Steady rest.
   c. Cross-feed rest.
   d. Dial indicator.

7. **What is the term used to describe the removal of metal when work is performed in a metal-turning lathe?**
   a. Hogging off.
   b. Big bore.
   c. Heavy metal.
   d. Turning a true center.

8. **What type of fluid must be used when cutting barrel threads in the lathe?**
   a. Hydraulic fluid.
   b. Brake fluid.
   c. Cutting oil.
   d. Transmission fluid.

9. **Which of the following rifles utilizes square barrel threads?**
   a. Winchester Model 94 carbine.
   b. Model 1917 Enfield.
   c. Remington Model 500.
   d. Winchester Model 61.

10. **What is the thread length of a Model '98 large ring Mauser barrel?**
   a. 0.725 inches.
   b. 0.875 inches.
   c. 0.710 inches.
   d. 0.625 inches.