

GUNSMITHING AND TOOL MAKING BIBLE



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We have put together a complete library of books on gun work and tool making into one file on a CD. This is the most complete volume covering information that is no longer available. H. Hoffman

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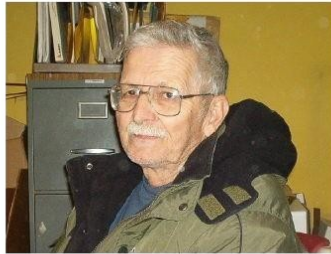
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Zaibatsu Release

I am the alpha, the omega,
the beginning and the end

GUNSMITHING AND TOOL MAKING BIBLE



ABOUT THE AUTHOR

Harold Hoffman has through his 30 plus years of experience as a Gunsmith, Toolmaker and Custom Knife maker has passed on to you through his books information that soon may be lost or forgotten. His books are not intended for the person wanting to make a complete firearm, but for learning basic shop tool making. The information found within his books is for instructional purpose only. -- The titles DO NOT actual cover gun repair on firearms, but how to make needed parts for firearms which is about 40% of all gun repair. Without this information you will be severely limited in gun repair.

He first started gun repair when he was 18 years old doing minor repair for the farmers and local hunters in the Bucklin, Kansas area. His main interest was how to make rifle barrels, as he was an avid hunter. Moving into a bigger shop he bought a lathe and proceeded to learn how to use it.

He wanted to find out how to make rifling buttons to rifle barrels, tool making, and learn everything about making barrels. Over the years he became an expert toolmaker and how to build most everything that was needed in the shop. The information found in his books will show you how to make most of the equipment and tools needed in most shops.

After an eye accident he quit Gunsmithing and started writing books on everything that he knew. He had so much difficulty finding any information that he wanted all this information that he had learned in over 30 years to be available to everyone otherwise it would be lost.

His books are now about the only books available on Gunsmithing/Tool making, as most publishers do not publish Gun or Gunsmithing books anymore.

GUNSMITHING AND TOOL MAKING BIBLE

INTRODUCTION

When I first interested in how barrels were made, I was a full time gunsmith in Bucklin, Kansas. I was doing a lot of barrel work, such as chambering and fitting actions.

I started to research the subject in all the different books that I could find. One thing that I found out very fast was that there was not any information on the process of button rifling.

This was in 1956, and all the available information was on cut, or broach rifling. I started to experiment and about 1-1/2 years later, I was able to come up with a fairly decent barrel.

I had been manufacturing all types of barrels for a few years, and had been keeping notes on all the different processes and information that I used. I kept thinking that if this information is not passed along to others, it might soon be lost.

In 1962 I gathered all my notes and started putting together a manual on barrel making. I included every process that I used in the shop. At the time, I had a very good business making barrels in Bucklin, Kansas.

My main idea in writing this book is to give the readers an idea how gun barrels are made. This book may seem to be a little vague at time, but once the reader starts making the barrel, etc. it all falls in place.

If the reader follows the instructions, a first class barrel can be made that will compete with the best. I have many readers tell me it sounded to simple. Well making barrels is a simple process, much simpler than other barrel makers would like it to be Known.

GUNSMITHING AND TOOL MAKING BIBLE

MILLING MACHINES

GENERAL TYPES

Hand milling machines may be of the column and knee type or constructed with a table mounted on a fixed bed. This type of machine is intended for small work only. The hand feed operates by means of levers or a hand screw for work such as slotting and cutting grooves and key ways.

The machine is provided with a horizontal spindle with speeds of 75 to 4,000 rpm (4- ranges). The worktable has longitudinal and vertical feeds also a cross feed. A machine of this type can be used for production work if provided with stops and specially designed fixtures where parts can be rapidly loaded and unloaded.

Milling machines are designed to hold and rotate a milling cutter, hold a work piece, and feed the work piece to the milling cutter in one of several directions. The work piece may be held directly, or indirectly, on the table of the milling machine.

The table and the work piece may be moved or adjusted about the rotating milling cutter, in three directions, that is vertical, horizontal, parallel to the rotational axis of the spindle, and horizontal, perpendicular to the rotational axis of the spindle. Along any one of these three directions, feeding may be accomplished.

Movements along the other two directions then are used for locating the cut that includes obtaining the depth of cut. Adjusting the movements along these three directions can be controlled to within 0.001 inch.

Milling machines are available in several different types, and can be used for making a large variety of machining cuts. Milling machines with a horizontal spindle for rotating the milling cutter are called horizontal milling machines. Milling machines with a vertical spindle are called vertical milling machines that we will be using here.

VERTICAL MILLING MACHINES

A vertical milling machine has the same table movements as a horizontal machine. It is called a vertical milling machine because the spindle is located vertically and at right angles to the top of the table. The head may be swiveled for angular or bevel milling operations.

Vertical milling machines use end-milling cutters of various types and sizes depending upon the kinds of operations to be performed. These operations consist of milling horizontal surfaces, angular surfaces, milling grooves, key ways, T-slots, and dovetails.

Vertical milling machines can also be used for drilling and boring operations where it is necessary to space a number of holes accurately. In this type of operation, dial gages, veneer scales, precision

GUNSMITHING AND TOOL MAKING BIBLE

measuring pins, and rods can be used advantageously for producing precision holes.

The table, saddle, and knee portion of a vertical milling machine is the same as that of a horizontal milling machine. A vertical milling machine is not suitable for using arbor-mounting milling cutters that must be mounted on an arbor. There is no provision for supporting the outer end of an arbor. Compared with a horizontal milling machine, a vertical milling machine can use shank mounted milling cutters easier.

Using a shank-mounted milling cutter on a vertical milling machine, the operator can more easily setup the work piece and observe the machining. On some vertical milling machines the head, that contains the spindle, may be swiveled about a horizontal axis. The milling cutter may then be set at any angle in a vertical plane parallel to the direction of table movement.

UP AND DOWN MILLING

All milling machines have an electric motor, housed in the column, to provide power, through suitable gearing and a clutch, for rotating the spindle. The gearing provides means for obtaining different speeds (rpm's) for the spindle for different cutter diameters and machining conditions. Power from the electric motor, through the gear train, can be used for moving the table, saddle, or knee. This gearing may be quickly changed to get a variety of desired movement velocities. When used during machining, this is called power feeds. A more rapid movement of the table, saddle, or knee, a rapid traverse is available. This is used when setting up a milling machine. Accurate positioning of the table, saddle, and knee during setup is set by hand, using the hand cranks and micrometer dials.

CUTTER TEETH

Cutters with comparatively few widely spaced teeth have distinct advantages over fine-toothed cutters.

A coarse-toothed cutter with few widely spaced teeth can remove a maximum amount of metal, without distressing the cutter or overloading the machine. These cutters have a free cutting action, largely because a smaller amount of cutting is required to remove a given amount of metal.

Other advantages are:

The rake and increased spiral of the teeth gives a shearing action. Wide spacing decreases the tendency of the cutter to slide over the surface.

Less friction is created, resulting in cooler teeth and consequently decreasing the necessity of regrinding operations. There is decreased power consumption. Increased production is possible.

GUNSMITHING AND TOOL MAKING BIBLE

| MILLING MACHINE R.P.M. NECESSARY TO GIVE A DESIRED CUTTING SPEED | | | | | | |
|--|-----------------------------------|-----|-----|-------|-------|-------|
| DIAMETER (INCHES) | CUTTING SPEEDS IN FEET PER MINUTE | | | | | |
| | 40 | 50 | 60 | 70 | 80 | 90 |
| | Revolutions per Minute | | | | | |
| $\frac{1}{4}$ | 611 | 764 | 917 | 1,070 | 1,222 | 1,375 |
| $\frac{5}{16}$ | 489 | 611 | 733 | 856 | 978 | 1,100 |
| $\frac{3}{8}$ | 407 | 509 | 611 | 713 | 815 | 917 |
| $\frac{7}{16}$ | 349 | 437 | 524 | 611 | 698 | 786 |
| $\frac{1}{2}$ | 306 | 382 | 458 | 535 | 611 | 688 |
| $\frac{5}{8}$ | 244 | 306 | 367 | 428 | 489 | 550 |
| $\frac{3}{4}$ | 204 | 255 | 306 | 357 | 407 | 458 |
| $\frac{7}{8}$ | 175 | 218 | 262 | 306 | 349 | 393 |
| 1..... | 153 | 191 | 229 | 267 | 306 | 344 |
| $1\frac{1}{8}$ | 136 | 170 | 204 | 238 | 272 | 306 |
| $1\frac{1}{4}$ | 122 | 153 | 183 | 214 | 244 | 275 |
| $1\frac{3}{8}$ | 111 | 139 | 167 | 194 | 222 | 250 |
| $1\frac{1}{2}$ | 102 | 127 | 153 | 178 | 204 | 229 |
| $1\frac{5}{8}$ | 94 | 117 | 141 | 165 | 188 | 212 |
| $1\frac{3}{4}$ | 87 | 109 | 131 | 153 | 175 | 196 |
| $1\frac{7}{8}$ | 81 | 102 | 122 | 143 | 163 | 183 |
| 2..... | 76 | 95 | 115 | 134 | 153 | 172 |
| $2\frac{1}{4}$ | 68 | 85 | 102 | 119 | 136 | 153 |
| $2\frac{1}{2}$ | 61 | 76 | 92 | 107 | 122 | 137 |
| $2\frac{3}{4}$ | 56 | 69 | 83 | 97 | 111 | 125 |
| 3..... | 51 | 64 | 76 | 89 | 102 | 115 |
| $3\frac{1}{2}$ | 44 | 55 | 65 | 76 | 87 | 98 |
| 4..... | 38 | 48 | 57 | 67 | 76 | 86 |
| $4\frac{1}{2}$ | 34 | 42 | 51 | 59 | 68 | 77 |
| 5..... | 31 | 38 | 46 | 54 | 61 | 69 |
| $5\frac{1}{2}$ | 28 | 35 | 42 | 49 | 56 | 63 |
| 6..... | 25 | 32 | 28 | 45 | 51 | 57 |
| 7..... | 22 | 27 | 33 | 38 | 44 | 49 |
| 8..... | 19 | 24 | 29 | 33 | 38 | 43 |
| 9..... | 17 | 21 | 25 | 30 | 34 | 38 |
| 10..... | 15 | 19 | 23 | 27 | 31 | 34 |
| 11..... | 14 | 17 | 21 | 24 | 28 | 31 |
| 12..... | 13 | 16 | 19 | 22 | 25 | 29 |
| 13..... | 12 | 15 | 18 | 21 | 24 | 27 |
| 16..... | 10 | 12 | 14 | 17 | 19 | 22 |
| 18..... | 8 | 11 | 13 | 15 | 17 | 19 |

CUTTING SPEEDS FOR MILLS

Positive radial rake angles of 100 to 15° are used on high-speed steel cutters. These angles serve in

GUNSMITHING AND TOOL MAKING BIBLE

machining most materials and give good cutting ability to the cutter without sacrificing strength of the cutter. In milling softer materials, a greater rake angle can be provided to improve cutting ability.

Negative rake angles are provided on carbide-tipped cutters for high-speed milling operations. Since the angles are both radial and axial, tool life can be increased by increasing the lip angle. For softer steels, a negative rake angle of 5° to 10° is provided on plain milling cutters with teeth on the periphery. This angle is increased when medium-carbon and alloy steels are being machined.

| SPEEDS | | | | |
|--------------------|------------|---------------|------------------------|------------------------|
| Material | Brn. Range | H.S.S. Cutter | Cast Alloy | Carbide |
| | | S.F.M. Range | Cutter S.F.M. Range | Cutter S.F.M. Range |
| Aluminum | 100—150 | 1000—550 | 2000—1100 | 4000—2200 |
| Brass | 100—175 | 650—250 | 1300—500 | 2600—1000 |
| Low-Carbon Steel | 100—200 | 325—100 | 650—200 | 1300—400 |
| Free-Cutting Steel | 150—200 | 250—150 | 500—300 | 1000—600 |
| Alloy Steel | 150—250 | 175—70 | 350—140 | 700—280 |
| Alloy Steel | 250—350 | 70—40 | 140—80 | 280—160 |
| Cast Iron | 125—175 | 100—60 | 200—120 | 400—240 |
| Cast Iron | 175—200 | 60—45 | 120—90 | 240—180 |
| Cast Iron | 200—225 | 45—40 | 90—80 | 180—160 |
| Cast Iron | 225—250 | 40—35 | 80—70 | 160—140 |

Cutting Speeds For Mills

Clearance angles are kept on the small side to avoid weakening the cutting edge of the tooth. With a minimum amount of material behind the tooth, the strength of the tooth is diminished. Clearance angles of 3° to 5° are used on cutters over $\frac{1}{2}$ " in diameter. This is increased on smaller diameter cutters to prevent the teeth from a rubbing instead of a cutting action.

The type of material being machined affects clearance angles. If cast iron is being machined, 4° to 7° might be used; nonferrous materials require clearance angles of 10° to 12° . The land on a cutter can be from $\frac{1}{32}$ " to $\frac{1}{16}$ " in width, with a secondary clearance back of the land.

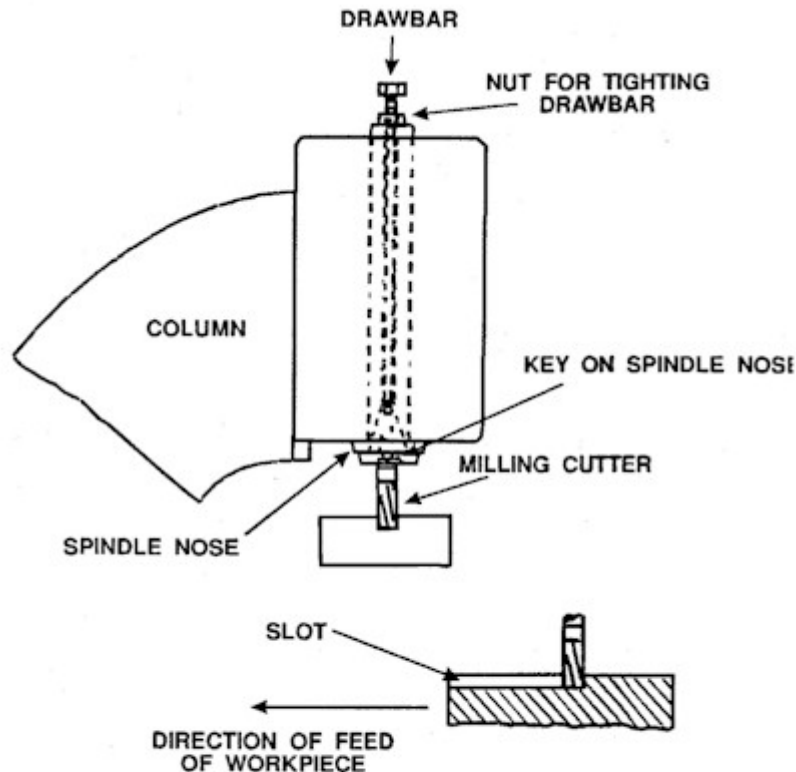
ARBOR-MOUNTING MILLING CUTTERS

A milling machine arbor has a shank with a locating taper for locating it so that it will rotate concentrically with the spindle. The arbor shank is driven by a key on the spindle nose. It is held to the spindle nose by a draw bar that extends through the hollow spindle. After screwing the draw bar into the end of the arbor shank for at least, four full threads. The nut is then tightened to hold the arbor firmly in the taper of the spindle nose.

An arbor-mounting milling cutter has a central hole that closely fits an arbor diameter. A nut at the outer end of the arbor is turned for tightening all collars and cutters on the arbor. Running the length of the accurate cylindrical portion upon that the milling cutters are located, milling machine arbors have a keyway, and thus a key may be used to drive a milling cutter.

GUNSMITHING AND TOOL MAKING BIBLE

Often with lighter cuts and especially with hand feeding, a key is not used. If a milling cutter driven without a key slips when power feed is being used, the amount of material to be removed by the next cutter tooth may be increased. This may cause either more slippage or possible breakage.



VERTICAL MILL AND END MILL

PLAIN MILLING CUTTERS

Plain milling cutters are cylindrical with teeth on the periphery only. The periphery of a milling cutter is the imaginary cylindrical surface enveloping the outer ends of the peripheral teeth and determining the diameter of the cutter. These cutters are used primarily for milling flat surfaces. They can be combined with cutters of other types to produce surfaces with various forms. The teeth may be either straight or helical, depending upon the width of the cutter. Plain milling cutters with helix angles of 45° to 60° and higher are called helical cutters.

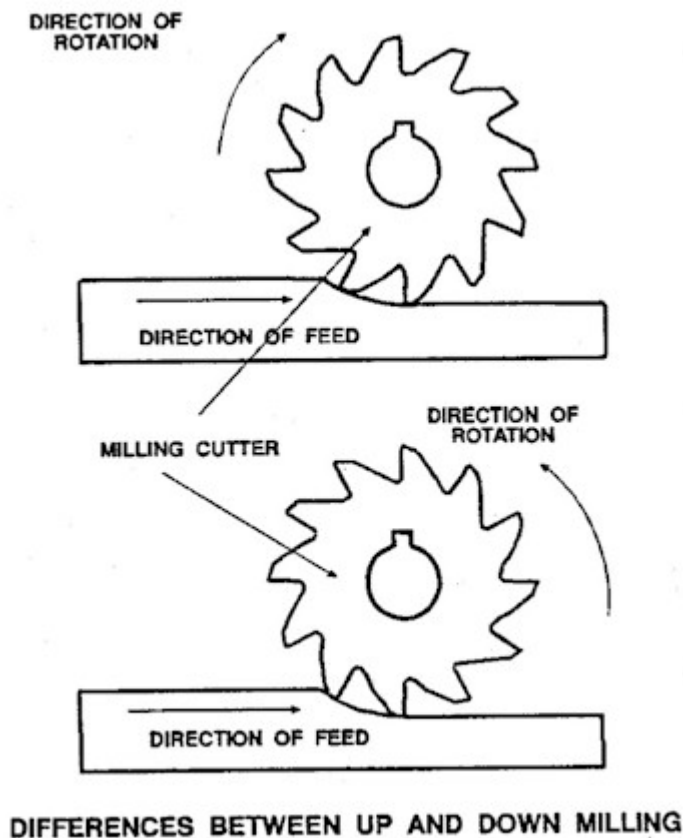
ANGULAR MILLING CUTTERS

Angular milling cutters are used for operations such as: cutting V-grooves, notches, dovetails, flutes on milling cutters, and reamer teeth. Single-angle cutters have one angular surface while double-angle cutters are made with V-shaped teeth. These cutters, with equal conical angles on both faces, are made with an included angle of 45° , 60° , or 90° .

GUNSMITHING AND TOOL MAKING BIBLE

PLAIN MILLING CUTTERS

Arbor-mounting cutters are cylindrical in form and provided with cutting edges of their outer cylindrical surfaces. There are no cutting edges on either side of a plain milling cutter. Plain milling cutters are used normally for machining flat surfaces.



Arbor-mounting cutters with small widths, ranging from a few thousandths up to 3/16 inch, are called slitting saws. They are used for cutting off and narrow slotting operations. Most slitting saws are similar to plain milling cutters as they have cutting edges only on their outer cylindrical surfaces. These slitting saws are ground slightly concave on their sides to provide side clearance so that their sides will not rub. Some slitting saws, especially those with greater widths, nearer 3/16 inch, are used as side milling cutters.

FLY CUTTERS

A fly cutter consists of one or more single-point tool bits mounted in a bar of some type that can be attached to the spindle of the milling machine. Its principle in operation is quite like that of a boring tool. Setscrews are used to hold the tool bit in place; this type of tool is used for special applications.

T-SLOT CUTTERS

GUNSMITHING AND TOOL MAKING BIBLE

T-slot cutters are a special type of end mill having either straight or tapered shanks and designed for cutting T-slots in machine tables and similar applications.

NOTE: In producing a T-slot, a groove for the narrow portion of the slot is first machined with an end mill or side mill and then finished with the T-slot cutter.

WOODRUFF KEY SEAT CUTTERS

These cutters are of special design for cutting key seats for Woodruff keys (that have the shape of a half circle). These are available in all sizes and are of two types, end mill and arbor cutters. The end mill is available in diameters from 1/4" to 1 1/2"; the arbor type, in diameters from 2 1/8" to 3 1/2".

SIDE MILLING CUTTERS

Cylindrical in form, side-milling cutters have cutting edges on one or both sides also on their outer-cylindrical surface. Side milling cutters are quite similar to plain cutters. They also have teeth on one or both sides. In milling operations where two cutters are placed side by side, they have teeth on only one side. The teeth can be straight, helical, or staggered.

Slots machined with side milling cutters have smoother and more accurate sides than those machined with plain milling cutters. Rake angle for the cutting edges at the sides of a side-milling cutter is called the axial rake angle. It is the angle at the cutting edge between the tooth face and the machined surface.

METAL-SLITTING SAWS

Metal-slitting saws are designed for cutoff operations and for cutting narrow slots. The sides are slightly tapered toward the hole to prevent binding. Like other milling cutters, they can be plain or made with side teeth or with staggered teeth.

HOLDING THE WORK PIECE ON THE TABLE

Since more than one cutting edge of a milling cutter is cutting, the total cutting force of the work piece can be large. A machinist needs considerable skill and experience to enable him to securely clamp some types of work pieces. A work piece must be held securely so that it cannot shift during a cut. A work piece should also be supported to prevent any springing due to the cutting force, the clamping, or its own weight. A work piece is usually clamped to the table using the T slots. Smaller work pieces can be held in a vise bolted to the table. There are several types of vises that can be used including the plain vise, swivel vise, and the toolmaker's universal vise.

Most milling vises have two keys on their bases for fitting into a T slot for locating the vise on the milling machine table. Standard vise jaws are flat. They can be removed and replaced with special vise jaws,

GUNSMITHING AND TOOL MAKING BIBLE

designed for locating and holding the work piece. These special vise jaws have locating stops that make possible easy location of the work pieces. The special jaws convert a vise into a milling fixture.

DOWN MILLING

If down milling is used, all looseness must be eliminated in the table feed screw, as the motion of the cutter tends to pull the work piece into the cutter. The machine must be designed with special features, adapting it to down milling if this type of milling is to be used.

In down milling, the maximum chip thickness is obtained close to where the tooth contacts the work piece. No built-up pressure is developed in down milling, and, therefore, no heavy burr (a protruding, ragged metal edge) forms on the surface of the metal.

Down milling that is being done depends upon the side from that the work piece is fed to the rotating milling cutter. In down milling, the portion of the tooth contact with the work piece shows a very good finish. An element of the final milled surface is produced at the end of the tooth travel when the built-up edge is completely developed. This could mean that the finish of the final surface might be of poorer quality than produced by up milling.

UP MILLING

In up milling, the cutter rotates against the direction of feed as the work piece advances toward it from the side where the teeth are moving upward. The separating forces produced between cutter and work piece oppose the motion of work.

In up milling, since the cutter teeth come up from the bottom of the cut, the chip is very thin. It the beginning where the tooth first contacts the work piece. Gradually, the chip increases in thickness, reaching its maximum thickness where the tooth leaves the work piece.

In up milling, the material removed by each tooth starts with a minimum thickness and ends with a maximum thickness.

The chip should form at the center, but due to the resistance of the material to penetration, the cutting action is delayed somewhat and cutting starts slightly ahead of the center. The cutter slides over the work piece to be machined until sufficient pressure has been built up to force it to bite into the surface of the workspace to produce a chip.

The starting of the cutting in up milling is not recommended as the cutting edge of a tooth rubs along the work piece surface at the start, and the beginning of the cutting is difficult. The opposite cutting condition, or down milling, is better, since cutting edges remain sharp longer, and smoother surfaces can usually be obtained.

RPM of the milling cutter=

GUNSMITHING AND TOOL MAKING BIBLE

Pie X diameter of the cutter, in.

Up milling is more commonly used because it is safer. With down milling damage may be caused to the milling cutter, work piece, and milling machine. Down milling the resultant force of the cutter upon the work piece is directed toward and under the cutter.

This pulls the work piece under the cutter. It is better to have this resultant force directed in the opposite direction as with up milling. If the work piece is not securely held, it will be drawn into the cutter so fast that the cutter teeth are unable to make the cut and something will be damaged. If the work piece is held properly, damage can still occur.

The entire milling machine table will be pulled ahead if any there is any play that is known as backlash, exists. The next cutter tooth will probably have too much material to remove and the cutter will be chipped or broken. Since down milling is better since it can be done safely, some milling machines are designed for it. All backlashes must be eliminated.

SPEED, FEED, AND DEPTH OF CUT

Cutting speed as applied to milling can be defined as circumferential speed of the milling cutter expressed in surface feet per minute (sfpm). It is the distance that the periphery of a milling cutter tooth travels in one minute.

The revolutions (rpm) refer to the number of revolutions that the cutter makes in one minute. A small milling cutter must rotate at a higher rpm to cut at the given cutting speed of a larger cutter. A small cutter is more efficient because it travels a shorter distance.

Feed is the rate at that a work piece is moved toward a rotating milling cutter, that removes material from its surface. Feed is limited by the depth of the material that can be removed by each tooth of the milling cutter per revolution. This depth is called the feed per tooth, and its units are inches per tooth.

Feed for milling machines is given in inches per minute, because various milling cutters with different number of teeth may be employed on a milling machine. The desired feed in inches per minute is set by quick-change gears, and the power feeds are engaged by control levers at the front of the machine. Power feeds are usually available for moving the table, saddle, and knee.

Trip dogs are set to disengage power feeds at the correct positions. They are especially useful when more than one similar work piece is to be machined. Ordinarily it is best to use the largest feed per tooth that can be employed safely. By doing this it will reduce, the time required for a milling operation and increases the life of a milling cutter between resharpenings.

Milling cutter life is increased, because the number of cutter-tooth contacts with the work piece surfaces is reduced. A light feed may have to be used for a fragile work piece or when it is difficult to hold a work piece securely. Depth of cut is the normal distance between the work piece surfaces before and after

GUNSMITHING AND TOOL MAKING BIBLE

milling.

ADJUSTING THE LOCATION OF THE WORK PIECE TO THE CUTTER

A surface of the work piece should be located by adjustment so that it just contacts the milling cutter when the latter is rotating. I use a thin piece of paper, of a known thickness. It is held on the work piece surface, while the work piece is carefully moved toward the rotating cutter. Once this contact is made, the work piece is moved accurately a desired distance from this reference to remove the desired depth of material. An edge finder can be used to locate the surface with better accuracy.

The depth of material removed can be held to within 0.001 inch. Tolerance of from 0.002 to 0.005 inch is more practicable for milling. To align a machined surface of a work piece, vise, or milling fixture with the movement of the table, saddle, or knee, a dial indicator is attached to the spindle or arbor. This test indicator is positioned to contact the machined surface.

The table, saddle, or knee then is moved, and slight changes of the machined surface location are made, usually with light hammer blows. This is done until the reading of the test indicator either does not change or remains within the desired tolerance.

The principle function of attachments is to increase the variety of work that can be accomplished on milling machines. These attachments position and hold the work piece to the table. Two other important milling-machine attachments are the rotary table and the dividing head. These will be discussed in following paragraphs.

ANGLE PLATE

If your milling machine head does not rotate, the adjustable angle plate can be used. It is bolted to the table of the milling machine, and any angle can be set on it. A vise can then be bolted to it to hold small work.

ROTARY TABLE

A rotary table is mounted on the table of a milling machine as an auxiliary table to superimpose a rotary motion upon the other movements for the work piece. This rotary movement may be used for feeding or for adjustment in locating a cut. This rotary movement is about a vertical axis, and since the rotary table is mounted on the regular milling machine table.

A worm gear directly fastened to the rotary-table vertical shaft is rotated by a worm on a horizontal shaft. The horizontal worm shaft may be turned by hand. If power is used, suitable shafting may bring the power, when desired, from the milling machine feed-power mechanism.

The work piece may be accurately rotated by turning the worm shaft by hand with the aid of a micrometer dial, or an index plate.

GUNSMITHING AND TOOL MAKING BIBLE

Fractions of a complete worm-shaft turn are obtained with a micrometer dial or with an index plate on the worm shaft. An index plate is a disk and has in its surface several holes, arranged in circles. The holes within each circle are equally spaced with accuracy. The circles of holes are concentric with the worm shaft. A spring-loaded pin in the crank handle is adjustable to fit into holes of a particular circle to be used.

The index plate with the crank and spring loaded pin provide an accurate means for obtaining desired fractions of a complete worm-shaft turn. One space between two adjacent holes in a particular circle may represent several degrees or minutes of angular movement of the rotary table. A vertical milling machine provided with a rotary table may machine a complete or partial cylindrical surface having any desired radius. Internal cylindrical surfaces with radius that is too small for available end mills may not be cut. Partial cylindrical surfaces may be joined to flat surfaces by using rotary-table feeds with the regular milling machine feeds.

UNIVERSAL DIVIDING HEAD

Like a rotary table, a universal dividing head may be used for rotating a work piece through precise angles. A dividing head has a spindle that supports and rotates the work piece.

A center may be mounted in the tapered hole at the front end of the dividing-head spindle for holding a work piece between centers.

Other work piece holding devices, such as a chuck, also may be mounted on the front end of the dividing-head spindle. The work piece is mounted so that it will rotate accurately concentric with the axis of rotation of the dividing head spindle. The work piece is rotated by turning the index crank. Since the gear ratio is 40 to 1, it takes, 40 turns of the crank to rotate the spindle and work piece through one complete revolution. In comparison with a rotary table, that rotates only about a vertical axis. A dividing head may rotate a work piece about an axis at any angle, and its indexing ability is much greater. The dividing head spindle axis can be positioned at various angles from below the horizontal to slightly beyond the vertical position.

GUNSMITHING AND TOOL MAKING BIBLE

EQUIPMENT AND TOOLS

In the introduction, I listed a few machines that are needed, to make what you need. What is needed will allow you to make gun barrels, but I am not considering speed, number of operations, or number of barrels produced.

LATHE

Your lathe should have at least a 3-foot bed. If you are planning to make muzzle loading barrels, a 4 ft. bed is preferable. The hole through the head stock should be at least 1 1/2 inch, as you will need to center the barrel blank in the head stock.

There will need to be a collar on each end of the head stock so the blank can be centered. The collars will need to be tapped for 4 -1/4 inch set screws, which will be used to center the blank.

The lathe should be able to turn at least 2000 rpm or higher. It should have tapered bearings in the head stock spindle.

You will have to get extra gears for your lathe so you can slow the feed to give you the minimum of .0004 inch of feed per revolution. This will be needed when you drill barrels for 17-22 caliber. Any higher feed will cause the deep-hole drill to plug up and possible twist off.

OIL PAN

There should be some type of oil pan under the ways to catch the returning cutting oil, so it can be strained before it is returned to the oil reservoir. This tray should extend full length of the lathe.

For drilling barrels, you will need a pump that will turn out at least 400 lbs. of oil pressure. This pressure is needed to clear the chips. More on this later.

TOOL POST GRINDER

If you are going to make your tools, such as reamers, rifling buttons, and other special tools or cutters, a tool post grinder is necessary. With a tool post grinder you can cut your expenses down to a very small percent of what it would be if you had to buy them or have them special made.

You will be able to grind your own reamers, deep hole drills, make your rifling buttons, make your own chambering reamers. In general, be able to make any caliber of barrel with any desired chambering.

MILLING MACHINE

You will need a milling machine with an indexing attachment for making rifling buttons, and reamers. A

GUNSMITHING AND TOOL MAKING BIBLE

vertical mill would be the best choice, as you can do all kinds of gun work with it. You will also need a coolant pump. This can be from a air conditioner pump, the evaporative type.

This will be needed when you grind carbide tools such as rifling buttons, and deep hole drills. The coolant that you should is a water-soluble type that can be found at any machine supply house or oil bulk plants.

A good small mill can be bought from Wholesale Tools. See listing at back of manual under suppliers.

DRILL PRESS

Most shops have these. You will need a drill press for most of your fixture making. There will be quite a few fixtures to be made to drill barrels, and ream barrels.

SHAPER

A shaper is not a necessary item to have but it will save quite a bit of time in making the necessary fixtures that will be needed.

Most of the work can be done on a shaper can be done on a milling machine. However, some special shapes can best done with a shaper. It is easy to shape a lathe bit to what you want rather than to try to reshape a milling cutter.

SAWS

A good band or cut off saw is necessary when you are working with barrel steel. It gets old real quick cutting off a 1 1/4 bar steel with a hacksaw. It will come in handy also in the fixtures that you will be making.

Wholesale Tool has a good one that works as a cut off saw or a vertical band saw.

HEAT TREAT FURNACE

This is necessary to have. There are many small furnaces available on the market that would work for what we want. It should go up to at least 2000 degrees, if you are planning working with high-speed steel. I have found that an oil hardening tool steel (O1) works just about as good. You will need to have good control to hold precise temperatures of the oven.

This can be used to draw the temper of the reamers and cutters also. The furnace can be made fairly easy, and a blower from a vacuum cleaner can provide the air. More on this later.

MEASURING AND LAYOUT TOOLS

GUNSMITHING AND TOOL MAKING BIBLE

The following listing includes all the tools and instruments of this category that are essential to good gunsmithing and tool making. Some of these precision items are a bit on the expensive side when one has to go out and buy them all at once.

Considering the years of good service they will render, if properly taken care of, one can scarcely consider them as being costly.

MICROMETER

You will need a micrometer from zero to one inch, and one to two inches. They should be of a type so you can read down to ten thousandth of an inch.

MICROMETER (DEPTH)

Most of these come equipped with three interchangeable rods giving a range of measurement from 0-3 inch by thousandths of an inch.

MICROMETER (INSIDE AND OUTSIDE)

These should have a capacity of at least 6" and equipped to give a reading in thousandths.

GAUGES

Some of the gauges that will be needed are bore gauges for measuring the finished reamed bore of the rifle barrel. There should be a gauge for each caliber that you make.

Each gauge should have a go and no go gauge on it. They can be turned out on a lathe. The no go gauge should be .015 larger than the go gauge.

HEAD SPACE GAUGES

You will also need also head space gauges for each of the caliber's you chamber for.

ANGLE AND RADIUS GAUGE

Another of the gauges that you will need will be angle and radius gauges. These are not used to often, but they do come in handy when you need them.

You will need a thread gauge, as in every barrel you pull you will have to know how many threads per inch there is.

GUNSMITHING AND TOOL MAKING BIBLE

LEVELS

You will need a very accurate machinist level, one that will have the adjustable degree base, so correct angles can be achieved.

TOOL STEEL

You will need a good supply of tool steel, (oil Hardening) for your reamers. You can experiment with different makes until you find what will fit your needs.

In 30 years, I have found O1 hard to beat. More on this later.

SILVER SOLDER

You will need a good high strength, low melting point silver solder. This will be used to attach the rifling buttons to the pull rod, and for attaching the round carbide to short steel rods for centering.

As you can see from the above that most shops have about all the machines needed to make rifle barrels, except for a few specialize tools and machines.

There are a few other machines that you will need. One is a rifling machine, which I will show you how to make in a later chapter. There is also the deep hole drilling attachment, which we will cover later.

If you do not want to go to the trouble of making the deep hole drills, or rifling buttons, they can be purchase from various suppliers (listed in the back of this manual).

Deep-hole drills are fairly expensive, and making them can cut the cost by about 1/2 of the new cost.

Reamers can if you want to made from worn out hand reamers. All that is necessary is to regrind them to the size needed. All sizes and dimensions will be given in later chapters, along with all other information and sketches.

- I might point out that the drilling of the rifle barrel is one of the simplest operations of all the processes that goes into making a gun barrel. It will take about 20 minutes to drill through a 26" steel bar.

If you follow the directions carefully, you will be able to turn out high precision rifle barrels. They will be as accurate and as good as any rifle barrel on the market and much better than the ones that are turned out on the new computer machines.

In the big barrel making shops most barrels are mass-produced and inspection is not as good as it could be. You will also understand firearms better when you finish this manual, why some barrels shoot

GUNSMITHING AND TOOL MAKING BIBLE

better than others do.

You will learn of some of the sales gimmicks that is used to sell a supposedly to be better and more accurate barrel. They in turn may not be as good as other leading brands of barrels.

You will also, if you make your own barrels, be able to select a possibly better steel to make your barrels out of as no matter what is said to the contrary.

Factories use the type of steel that can be mass-produced with the least amount of inspection and rejects, not the steel that will necessarily give the longest life and greatest accuracy.

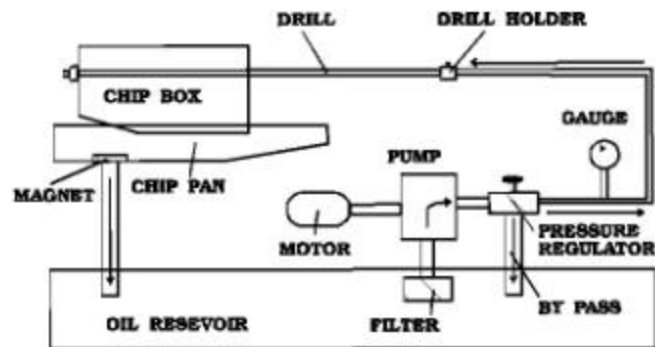
In the following chapters, we will break down each step of the operation that goes into making a rifle barrel.

GUNSMITHING AND TOOL MAKING BIBLE

CONVERTING THE LATHE

You will need a lathe with a hole through the head stock of at least 1 1/4 inch. This is so you can take the 26-inch or longer barrel blank through the spindle. You will also need to get a gear train so you can reduce the feed of the lathe down to at least .0005 feed per revolution.

This slow feed is necessary to be able to drill the 17 cal. barrels. From the 17 cal barrels, the feed will be speeded up as the cal. gets bigger.



COOLANT SETUP FOR DRILLING

In addition, if you have plans to make quite a few barrels it would be wise to get the right size pulleys to be able to increase the speed of the spindle up to 3000 RPM. Now you might say, and some of the people who manufacture the bearings for the lathe, that the bearings will not take this kind of speed.

My drilling lathe was a 10-inch Clausing, 36-inch bed, which I used 8-9 hours a day. Sometimes 7 days a week for almost 5 years before I had to change the bearings. The Key to this is **GOOD OIL AND PLENTY OF IT**. There is little pressure on the bearings when drilling or reaming, just a light push or pull on the spindle.

Also if you have plans to make quite a few barrels using cut rifling, it would be wise to get the right size pulleys to be able to increase the speed of the spindle up to 2000 RPM to handle the smaller caliber's such as 30 caliber. My drilling lathe for reboring was an older South Bend with a 60-inch bed, which I used 8-9 hours a day. This lathe was excellent for reboring and liner making, and proved excellent for cut rifling. Sometimes 7 days a week for almost 5 years before I had to change the bearings.

You want everything to be easy to change so when you go back to reaming or regular lathe work there won't be any problems.

OIL TRAY

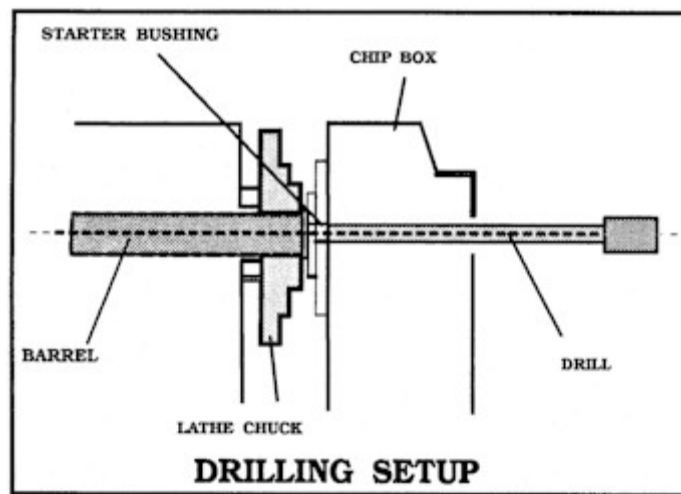
If your lathe doesn't have an oil tray or chip pan underneath, you will have to construct one. The tray needs to extend a few inches past the head stock spindle.

GUNSMITHING AND TOOL MAKING BIBLE

If it does not it won't be too much of a problem to build a cover that will fasten to the lathe or tray to catch the oil from the barrel and return it to the tray. This cover needs to be high enough to cover the spindle hole with a piece of canvas with a hole in it to keep the oil from splattering all over everything.

CHUCK COVER

You will need a cover that will go over the 3 jaw chuck, or collet, as there will be quite a bit of oil thrown out there. This cover can be made to rise straight up and on the front there should be a long slot to clear the drill or reamer tube. You will also need an oil container, of at least 55 gallons. This can be the oil drum that the oil comes in.



There will also need to be a container of at least 20 gallons to catch the oil and chips before it returns to the main oil container. You will need some kind of baffles which can be 1 inch angle iron laid flat in the tray in the lathe. This is to help separate the chips from the oil, and help to settle the fine chips. From there, it goes to a 1-1/2 inch return pipe on the tray, down to about a foot off the bottom of the 20-gallon container. This is done to help separate the chips from the oil. From this container the oil over flows through a 1 1/4 inch pipe to the 55 gallon drum, which is laying on its side.

In front of the overflow pipe is a large magnet, which will trap the very fine metal that didn't have time to settle. This will prolong the life of your pump.

HYDRAULIC PUMP

You will need a hydraulic pump that will turn out at least 500 lbs. of pressure, and a good flow rate. You will need the high pressure for drilling to get the required flow to remove the chips. In the reaming operation, you will also need a large volume of oil to keep the flutes clear. Not enough oil flow and the flutes of the reamer and ruin the reamer and barrel.

GUNSMITHING AND TOOL MAKING BIBLE

COOLANT VISCOSITY

Coolant viscosity for drill sizes 1/4 to 3/8 inch should be 80/125 Saybolt Seconds at 100 degrees.

COOLANT VOLUME REQUIREMENTS.

If you have an Army and Navy Store, there you might be able to pick up a pump there, along with other valves, etc. Farm stores carry stock pumps that will work for some operations.

| COOLANT VOLUME REQUIREMENTS | | | | | |
|-----------------------------|----|-----|-----|-----|-----|
| VOLUME | | | | | |
| DEPTH OF HOLE | | | | | |
| | 6" | 12" | 18" | 29" | 36" |
| HOLE DIA. INCHES | | | | | |
| 3/16 - 1/4" | 2 | 3 | 3 | 3 | 3 |
| 5/16 - 1/8" | 4 | 4 | 5 | 66 | 6 |
| 15/32 - 1/2" | 5 | 6 | 8 | 10 | 11 |
| 17/32 - 3/4" | 7 | 8 | 10 | 13 | 17 |

If you have 3-phase electric power, it would be wise to use a 3-phase motor of at least five horses for the coolant pump. The pump doesn't have to be a big one as the 500 lbs. of pressure is held through a .062 hole, and as the drill size increases, the pressure goes down.

After you have completed the plumbing, connected the electrical switch, which should be very close and handy to where you will be standing, and all electrical connections done. You will then be ready to make the chip box starter bushing.

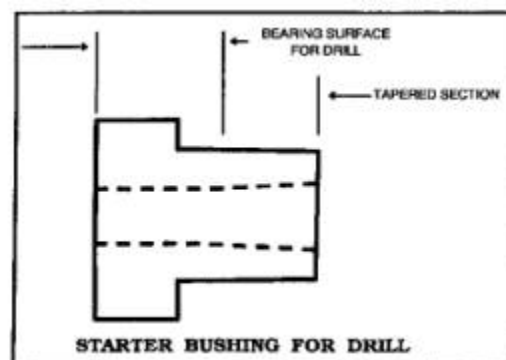
GUNSMITHING AND TOOL MAKING BIBLE

| PRESSURE AND VISCOSITY | | | | |
|------------------------|---------------|-----------|-----------|-----------|
| MATERIAL | | .156 | .250 | .500 |
| LOW ALLOY | VIS. - P.S.I. | 100 - 800 | 100 - 800 | 125 - 700 |
| HIGH ALLOY | VIS. - P.S.I. | 100 - 800 | 100 - 800 | 125 - 800 |
| HIGH SPEED | VIS. - P.S.I. | 100 - 800 | 100 - 800 | 125 - 800 |
| 300 STAINLESS | VIS - P.S.I. | 100 - 800 | | |

These will give you the pressure and Viscosity for your Oil Coolant for different types of materials. Do not forget to put the shield over the end of the barrel, so when you drill through the barrel the oil will not be sprayed over the entire shop.

STARTER BUSHING

This is the most important part of your conversion, as without this you would not be able to get the drill started, and if you were able to start the drill, it would either drill a crooked hole, or come out the side.



On the chip box in front, you will have to bore a hole at least 1 1/2 inch. To this, you will need to bolt a self-aligning bearing and flange. To make sure it is on straight when you bolt it on, you will have to chuck a 1-inch bar in the lathe. Turn down the end of the bar to just slip fit inside the bearing on the self-aligning flange. Slide the housing up against the bearing housing and mark the holes. Once marked and the holes are drilled and tapped, slide the housing back up against the bearing flange and bolt it in place.

The chip box should be made so it can be removed, returned, and still line up exactly in the same place. On mine, I took the tail stock apart and mounted the chip box on it. That way I was able to keep perfect alignment. Let me explain the reason why it is so important to have the starter bushing and bearing in

GUNSMITHING AND TOOL MAKING BIBLE

exact alignment with the head stock spindle.

In later chapters, you will see the design of the deep hole drill. It is a single lip drill on the end of a long hollow V drill tubing.

There is no support for the drill except the starter bushing. The starter bushing is made from tool steel. It fits into the flange bearing, and the starter bushing will then fit up snugly up against the trued and square end of the barrel blank.

The clearance between the hole of the bushing and the deep hole tip is only about .0003 of an inch. This is the only way that you can start the drill with any degree of accuracy, and expect the drill to come out within a 32 nd of an inch or less on the other end of the barrel.

The starter bushing is made from oil hardening tool steel. Make it out of 1 /18 inch stock, the shank should be turned to fit the I.D. of the flange bearing. The fit needs to be a snug hand press fit, or it will rotate while being used, and thus wear on the outside. The hole for the starter can be drilled to the next size smaller than what the deep hole drill is, finished except heat-treating.

Put a barrel blank in the lathe that has the end squared and trued, press the unhardened starter bushing into the bearing. Then very carefully move the chip box with the starter bushing and bearing up flush with the end of the barrel. Make sure that the bushing is flush with the barrel, and not canted. Tighten down the chip box; turn on the machine to make sure all is running true. If everything is running true set in the deep hole drill the size you are making the bushing for, turn on the oil set for low pressure. The drill point will just be started in the bushing.

Turn on the lathe, and slowly feed the drill tip into the bushing, and into the barrel for a depth of about a 1/4 inch. Back out when this depth is reached, shut off the oil, and turn off the machine. This method can be used if a correct size reamer cannot be obtained. This method will not give you the closest fit, but if starting the drill very carefully will usually give you a straight hole.

BUSHING (HEAT TREATING)

After the barrel is drilled to size it can be stamped for size, and heat-treated. Bring up the temperature in the furnace to proper temperature. Coat the bushing with a compound that will stop scaling, and put in the furnace. I have used a surface-hardening compound for this purpose with excellent results. Hard and Tuff is very good. As soon as the bushing has reached the proper temperature, remove and quench in a good quenching oil. You will not need to draw the temper on the bushing, as we need all the hardness we can get.

This bushing will last for a many barrels, and when it starts to wear, you will know, as you will start to get crooked off center holes.

GUNSMITHING AND TOOL MAKING BIBLE

DIMENSIONS FOR THE STARTER BUSHING HOLE

| Caliber | Drill Diameter |
|---------|----------------|
| 172 | .164 |
| 224 | .212 |
| 244 | .228 |
| 257 | .244 |
| 264 | .250 |
| 270 | .264 |
| 284 | .270 |
| 308 | .293 |
| 303 | .297 |
| 323 | .304 |
| 338 | .322 |
| 350 | .343 |
| 375 | .360 |
| 44 | .415 |
| 457 | .443 |

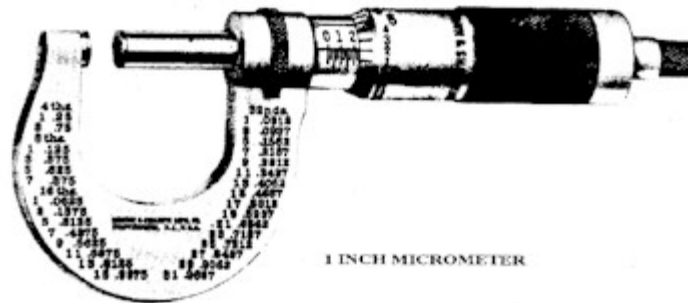
GUNSMITHING AND TOOL MAKING BIBLE

MICROMETERS AND THEIR USE

MICROMETER CALIPER

The first thing that you should know is how to read measuring tools such as micrometers and calipers. These are the handiest to use and will give you accurate measurements of your work

There are many types, and I prefer the one with the dial indicators on it. You will need two sizes of calipers should be provided. One set should be about 4" inch, and the other set 8 inch. They should be of the spring-opening type with screw adjustment. The quick-opening spring nut is a good time saver, as it is possible to open the nut and make a rough adjustment of the calipers without having to run the nut slowly along the thread.

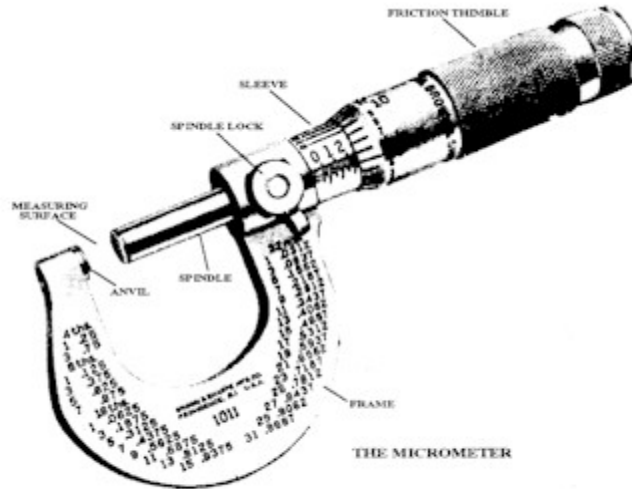


STANDARD 1 INCH MICROMETERS

MICROMETER DEPTH GAGE

A micrometer depth gage is used to measure the depth of such work as holes, slots, recesses, and key ways. The tool consists of a hardened, ground and lapped base combined with a micrometer head. Measuring rods with individual length adjustment are inserted through a hole in the micrometer screw and brought to a positive seat by a knurled nut. The screw has a 1" movement.

GUNSMITHING AND TOOL MAKING BIBLE

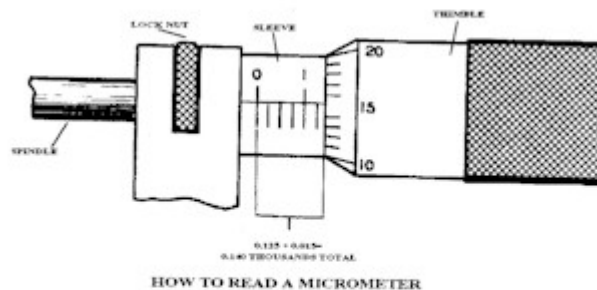


PARTS OF THE MICROMETER

For accurate work you will need a good micrometer. These are rather expensive, but a 1 inch size and a 2 inch size will be used often and are well worth the price. To go with these you should have a set of inside micrometers. These come with adjusting rods to measure from 2 inches up.

For accurately measuring holes smaller than 2 inches across, a telescoping gauge should be used. This has a handle with a telescoping head operated by a spring. Several lengths of pins fit the sliding part of the head, and there is a locking nut at the end of the handle.

For measuring the depth of holes, a depth gauge is necessary. For very accurate work, a micrometer depth gauge should be used. The usual run of work in a home workshop will not require the use of a micrometer depth gauge, so one with a sliding head is good enough.



HOW TO READ A MICROMETER

The smallest measurement in common fractions that can be made with the fixed caliper and steel rule is 1/64." To measure in thousandths and ten-thousandths, you will need a micrometer.

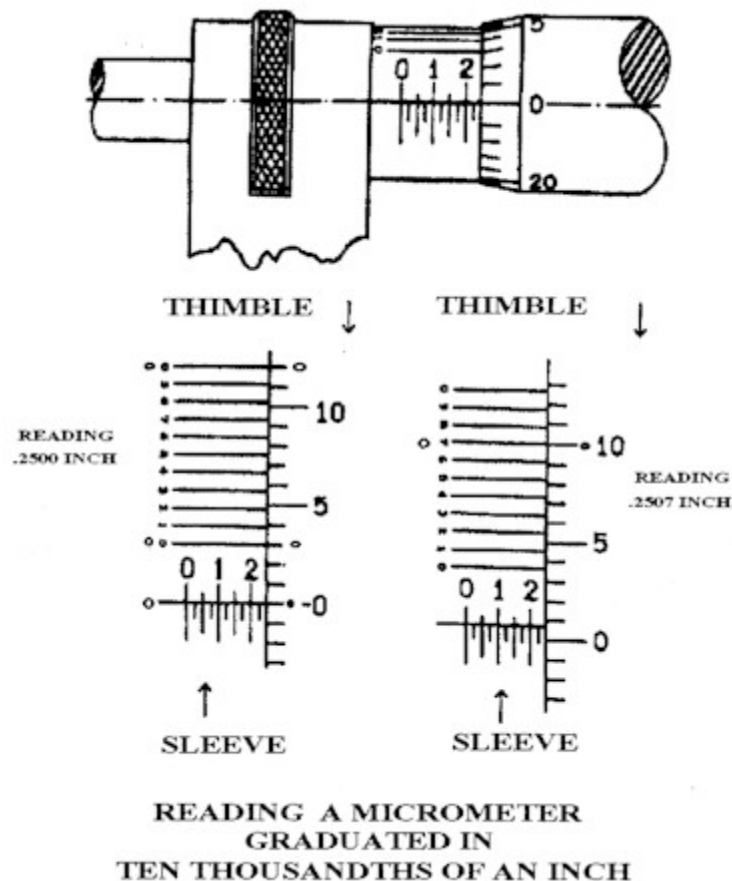
GUNSMITHING AND TOOL MAKING BIBLE

READING THE MICROMETERS

To use these you must understand that the pitch of the screw thread on the spindle of a micrometer is $1/40"$ Or 40 threads per inch. So one complete revolution of the thimble advances the spindle face toward or away from the anvil face $1/40"$ or $.025"$.

On the longitudinal line on the sleeve it is divided into 40 equal parts by vertical lines that correspond to the number of threads cut on the spindle. On the spindle each vertical line designates $1/40"$ or $.025"$ and every fourth line designates $.100"$. You will see that the line marked "1" will represents $.100"$, the line marked "2" will represents $.200"$ and so on.

The beveled edge of the thimble is divided into 25 equal parts with each line representing $.001"$ and every line numbered consecutively. By rotating the thimble to the next higher line moves the spindle $1/25$ of $.025"$ or $.001"$. Twenty-five divisions shows a complete revolution, $.025"$ or $1/40"$.



What would be the answer if the reading if the edge of the thimble is between the $.125"$ and the $.150"$ lines, and the line on the thimble is the coinciding line? The answer is: Micrometer reading = sleeve + thimble or $.125 + .015 = .140$ of an inch.

GUNSMITHING AND TOOL MAKING BIBLE

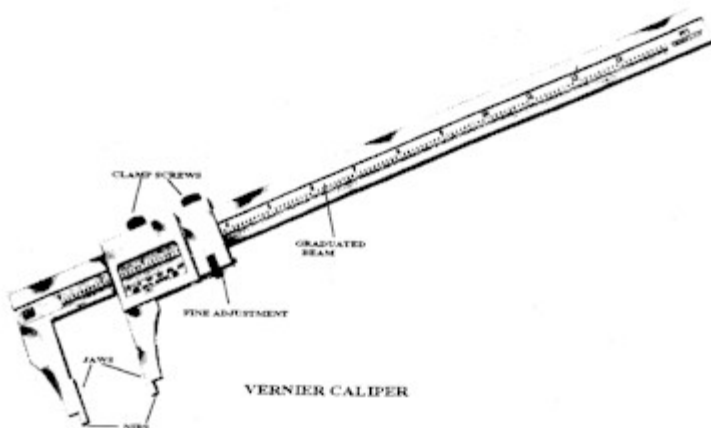
It is very important to keep your micrometers clean as dirt between the anvil and spindle will cause the micrometer to read incorrectly. If you want to test to see if the micrometer is accurate, clean and bring the anvil and spindle together carefully. If the zero line on the thimble and the axial (longitudinal) line on the sleeve fail to coincide, wear has taken place either in the screw or contact surfaces.

Micrometers are made in a wide range of sizes and in matched sets. The ratchet on the micrometer is used to rotate the spindle when taking a measurement and insures consistent, accurate gauging by limiting the spindle pressure on the work piece.

There is a locknut that makes it possible to lock the micrometer spindle at any desired setting. A slight turn of the knurled locknut ring contracts a split bushing around the spindle and makes the micrometer a fixed gage.

If you want very accurate measurements are required, a micrometer that has an extra scale added to the sleeve is used, enabling the micrometer to be read in ten-thousandths of an inch. This scale consists of a series of lines on the sleeve parallel to its axis.

Ten divisions on the sleeve mark the same spaces as nine divisions on the beveled edge of the thimble. The difference between the width of one of the ten spaces on the sleeve and one of the nine spaces on the thimble is one tenth of a division on the thimble. Since the thimble is graduated to read in thousandths, $1/10$ of a division would be .0001 or one ten-thousandth.



CUTTING TOOLS AND TOOL HOLDERS

Because cutting-tool materials are expensive, it is desirable to use as small amounts as possible. It is necessary that the cutting tool should be supported in a strong, rigid manner to minimize deflection and possible vibration. Lathe tools are supported in various types of heavy forged tool holders. The tool bit should be clamped in the tool post with minimum overhang. If there is much overhang, tool chatter and poor surface finish may result. Most lathe work is done with high-speed steel, carbide, or ceramic tools.

Where large tool bits are required, the heavy type of forged tool holder is used. It provides adequate method of clamping and supporting the tool than is provided by an ordinary tool post. The tools used in such cases have a heavy shank of Tool Steel or hot-rolled bar stock in which a carbide tip is brazed.

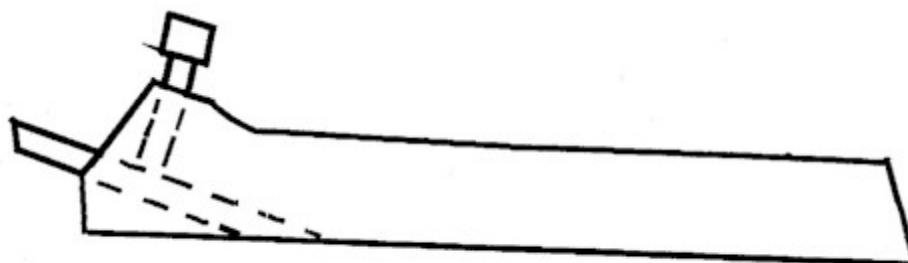
Most all of the lathe operations are done with simple, single point cutting tools. On right-hand and left-hand turning and facing tools, the cutting takes place on the side of the tool so that the side rake angle is important so deep cuts can be made. On the round-nose turning tools, cutoff tools, finishing tools, and some threading tools, cutting takes place on or near the end of the tool, so that the back rake is of importance, and is fed with light depths of cut.

TOOL HOLDERS

In most lathe work, the nose of the tool should be set exactly at the same height as the axis of rotation of the work. Any setting below the axis causes the work to tend to climb up on the tool, and in most operations you will need to set your tool a few thousandths of an inch above the axis, except for cutoff, threading, and some facing operations.

Where there are more than 1 operation on a lathe are performed repeatedly in sequence, the time required for changing and setting tools may make up as much as 50 per cent of the total time. Quick-change tool holders are being used to reduce the time of tool changing.

The individual tools, preset in their holders, can be interchanged in the special tool post in a few seconds. With some systems, a second tool may be set in the tool post while a cut is being made with the first tool, and then be brought into proper position by rotating the post.



CUTTING TOOL HOLDER

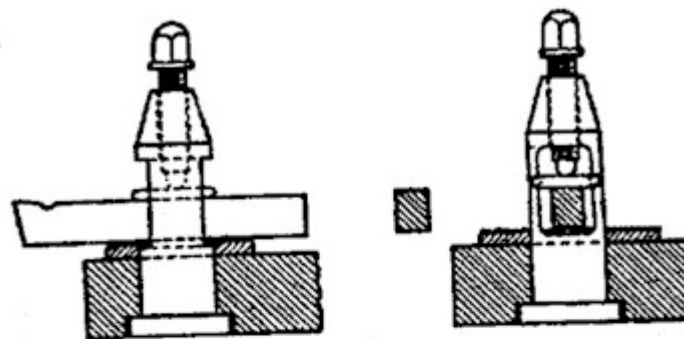
SETTING A SINGLE POINT CUTTING TOOL.

GUNSMITHING AND TOOL MAKING BIBLE

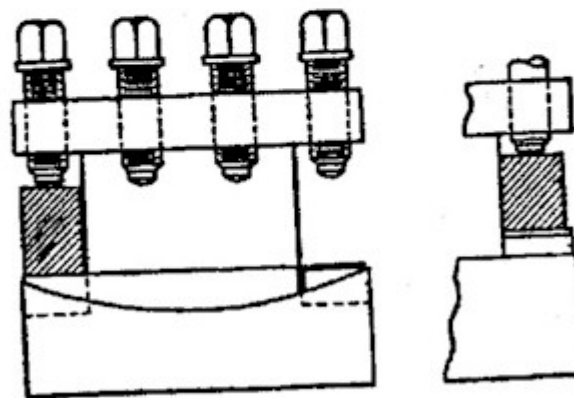
Single point cutting tools for the lathe are ground sharpened for the on center settings. Tilting the cutting tool to some angle other than the angle for which it was ground will affect the cutting action. A Single point cutting tool should be set in the position for which it is ground. For a heavy cut, the cutting edge of a cutting tool should be arranged so that it will deflect under heavy forces away from the work piece surface instead of into the work piece surface. The cutting force may become great enough to deflect the cutting tool about the vertical axis of the tool post. For light cuts, the cutting edge may be set ahead of the tool post in the direction of feeding.

SHARPENING THE BIT

You will need some type of bench grinder to sharpen the tool bits when they get dull. In most cases the bit can be sharpened without a gauge, after you get some experience. When sharpening the bits, be sure that you have enough clearance so the tool does not rub on the work.



SINGLE SCREW TOOL POST



FOUR WAY TOOL POST

TOOL HOLDERS

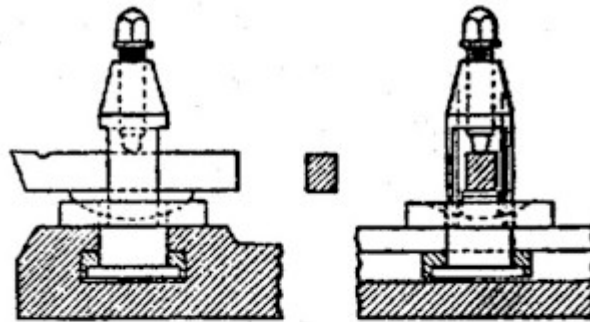
This can be checked with the tool in the holder and the point on the center of the work piece, or it can be set on the center that is in the tail stock.

GUNSMITHING AND TOOL MAKING BIBLE

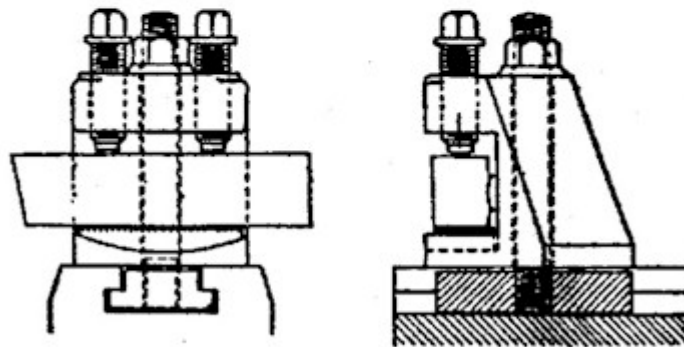
The type of fixture for holding and controlling the movement of the cutting tool include the tail stock, carriage, cross slide, and compound rest. The carriage, like the tail stock, is movable on the ways of the bed. The motion is parallel to the rotational axis of the spindle, and this motion is commonly used for producing cylindrical surfaces.

A compound rest is used for producing some tapered surfaces, for helping in the cutting of threads by thread chasing, and for several other types of applications. Mounted above the compound rest, the tool post serves to clamp the cutting tool, or tool holder, in a desired position.

At the base of the tool, post the rocker plate has a concave spherical surface facing upward.



SINGLE POINT TOOL & TOOLPOST



OPEN SIDE TOOL POST

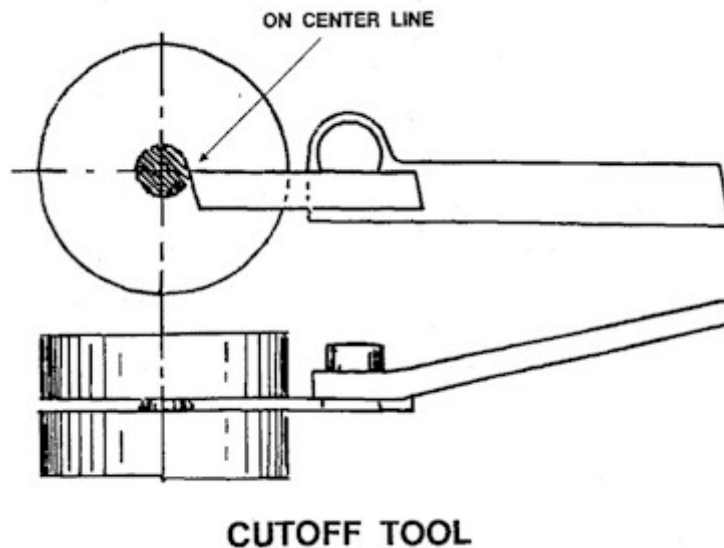
TOOL HOLDER TYPES

Usually the cutting tool consists of a tool holder, which carries a tool bit. Different tool holders are available to hold tool bits at various desired horizontal angles. A rocker for mounting the tool holder that has a mating convex spherical surface fits above the rocker plate, and the cutting tool is clamped above this rocker. The rocker plate and rocker thus permit the cutting edge of the cutting tool to be raised or lowered. When the cutting tool has been properly positioned, a setscrew is tightened to clamp the cutting tool rigidly.

GUNSMITHING AND TOOL MAKING BIBLE

USE OF FORM TOOLS

In lathe work, form tools are used for form turning, producing short tapers, thread chasing, and other applications. If a form tool is to reproduce the special contour of its cutting edge on the work piece surface, it is important that the cutting edge should be adjusted so that it is at the same height as the rotational axis of the work piece. This is known as adjusting the cutting edge on center. If a form tool is set above or below center, a contour differing from that of the cutting edge will be produced on the surface of the work piece. For the feed, a form tool is moved into the work piece with the cross slide.



PARTING OR CUTTING OFF

Parting is the operation of severing a work piece from a bar. It is done with a narrow cutting tool, which cuts only at its end. A parting tool should be adjusted so that its cutting edge is on center if it is to cut to the center of a bar. It should also be set so that no rubbing or cutting will occur along its sides.

GROOVING

A groove can be produced with a parting tool or with a form tool.

KNURLING

Making a raised diamond-shaped pattern on the cylindrical surface of a work piece is known as "knurling." Surfaces are often knurled so that they may be more easily gripped with the fingers or by hand. A knurling tool has two serrated hardened-steel rollers with the serrations slanted at 4-5 degrees from the horizontal.

The serrations of the roller are slanted at 90 degrees from those of the other roller. Both rollers are

GUNSMITHING AND TOOL MAKING BIBLE

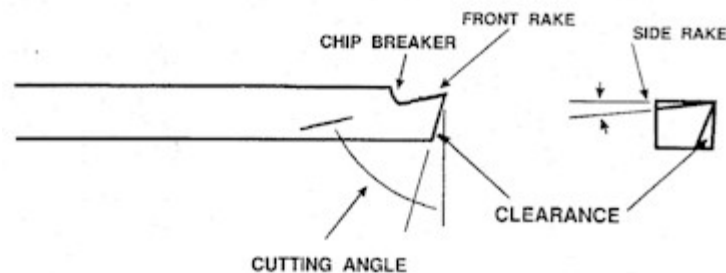
mounted on a floating head, which permit the rollers to exert equal pressure as they are pressed against a rotating work piece. Knurling is a mechanical-working process, in which the metal on the surface of the work piece is deformed rather than removed. Since greater forces are used in knurling, the work piece should be well supported.

The work piece, although held in a chuck, is given extra support by the center of the tail stock. When knurling, the knurling tool is forced to a workable depth into the work piece surface with the cross slide, and then it is fed for the length of the desired knurl with the carriage.

This is repeated until final depth and a finished knurl is obtained. Since work pieces with various diameters may be knurled, the circumference will seldom be equal to a whole number of the diamond shaped patterns. Thus after the first complete revolution, some fraction of a diamond ordinarily remains. With continued knurling, this fraction of a diamond distributes itself evenly over the complete circumference, so that it cannot be detected.

DRILLING WITH A LATHE

A drill is held in the tapered hole of the tail stock quill, which should locate it concentric with the rotational axis of the spindle. The work piece to be drilled must be positioned so the desired hole is concentric with the rotational axis of the spindle. Reamers, counter bores, and other cutting tools may be held by the tail stock quill. They may be used after drilling.



TOOL GRIND ANGLE

PRODUCING TAPERS

The method to be used for producing a taper depends upon the length of the taper, included angle of the taper, number of work pieces to be produced, and the available tooling and attachments. A taper may be produced with the use of the compound rest.

Since the linear movement of a compound rest slide is limited, this method is suitable only for tapers no longer than this movement.

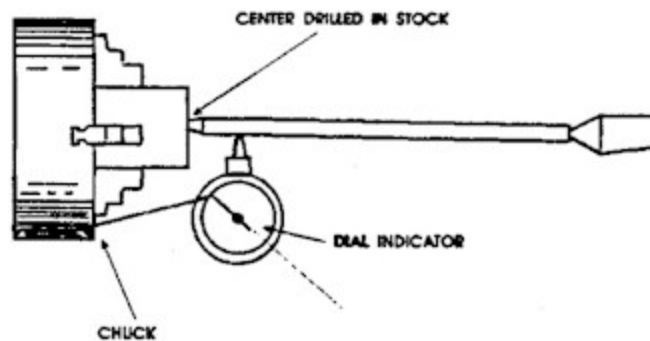
GUNSMITHING AND TOOL MAKING BIBLE

LESSONS IN TOOL MAKING

Turning stock usually makes up the majority of lathe work. The work usually is held between centers or in a chuck, and a right-hand turning tool is used, so that the cutting forces, resulting from feeding the tool from right to left, tend to force the work piece against the head stock and thus provide better work support.

TEST BAR

Before you start the turning operation, set the tail stock back to 000 using an 18-inch bar that is turned to exactly the same diameter on each end. To make this bar, get a 1-inch bar 18 inches long, center it and set it up between centers.



SETTING ANGLE FOR TURNING TAPER

MAKING A TEST BAR

Make a light pass and check both ends to see if they measure the same. If not, adjust the tail stock and make another pass. Repeat the above operations until the bar measures the same on both ends.

This bar, you save, as you will be using it again each time you true up the tail stock. Once you have the bar completed, all that is necessary is to put it between centers. Clamp a dial indicator to the carriage on the lathe.

With the plunger of the indicator on the bar, start from the head stock end (without the lathe being turned on) and move the carriage to the tail stock end. If there is any difference in size, adjust the tail stock and repeat until the dial indicator reads the same on each end.

GUNSMITHING AND TOOL MAKING BIBLE

MAKING A KEYWAY CUTTER

We will start out by making a 3/4 inch keyway cutter. By doing so, this project though a simple one will go through all the operations that are normally done in a machine shop.

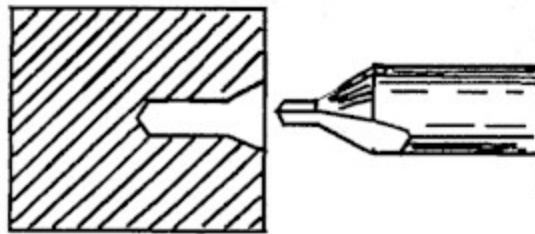
First, you will need a piece of tool steel, usually 01, which can be purchased from about any machine shop supply house. If you do not have one in your area, in the Appendix in the back of the book will give you the location of these. Wholesale Tool will have most all of the tools and supplies that you will need.



CENTER DRILL

High Speed Center Drill

Once you have the 1-inch tool steel, cut off a piece 2 inches long. You will next need to cut centers in both ends for turning. Before a work piece can be mounted between lathe centers, a 60° center hole must be drilled in each end. This can be done in a drill press or in a lathe by holding the work in a chuck.



THE CENTER DRILL AND CENTER

Center Drilled Stock

A combination center drill and countersink is used, taking care that the center hole is deep enough so that it will not be machined away in any facing operation, and yet is not drilled to the full depth of the tapered portion of the center drill. To cut the center in the lathe, chuck up the stock in a three-jaw chuck, or if you are using a four jaw chuck center the stock using a Dial Indicator.

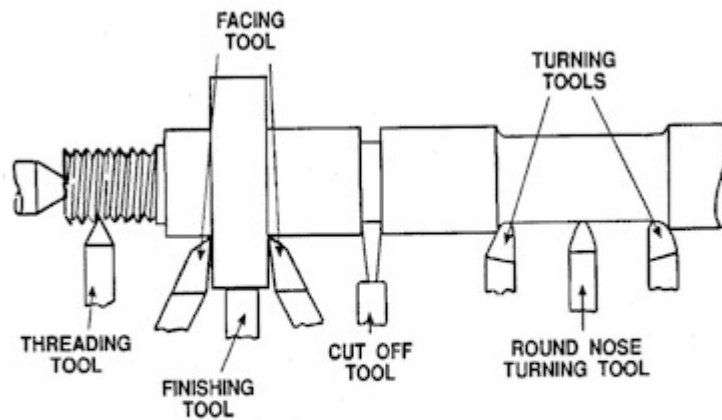
Set up a cutting tool in the lathe and face off each end of the tool steel stock. This is necessary so that when you center drill the stock the center drill will not cut off center. Once you have the stock trued, place a drill chuck in the tail stock of the lathe (the taper on the chuck will match the taper of the tail stock center.)

Centers have shanks with self-holding tapers, and they fit accurately into the tapered holes in the spindle and tail stock quill. When inserting a center, both the tapered shank and hole must be clean, because small chips or dirt particles will cause misalignment.

The centers of a lathe must be accurately concentric with the rotational axis of the spindle, if accurate

GUNSMITHING AND TOOL MAKING BIBLE

cylindrical surfaces are to be turned. Otherwise, a slight taper will be turned.



DIFFERENT TYPES OF CUTTING TOOLS

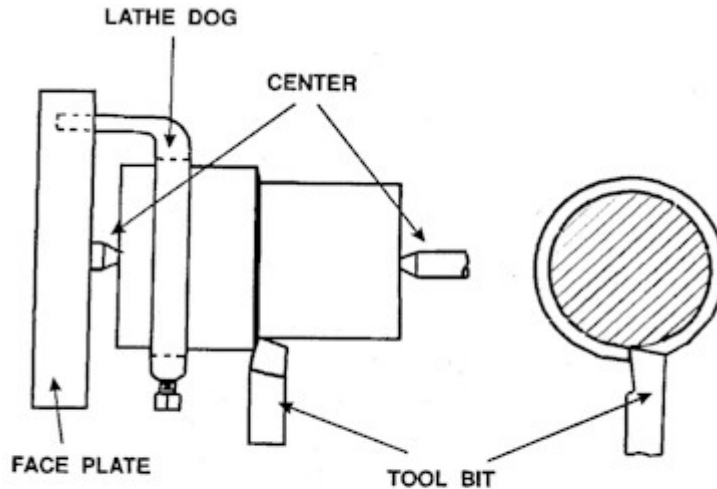
Use a small center drill to cut these centers. Put the center drill in the chuck in the tail stock and clamp it tight. Turn the lathe on with the speed set on the lowest speed (not in back gear) and move the tail stock so that the center is within 1/2 inch of the stock. Clamp the tail stock, and drill a center just deep enough so there is just about a 3/32-inch bevel on the edge of the center hole.

When you have the center cut on one end, turn off the lathe, turn the stock around, and repeat the process on the other end. When both centers are cut, you can start to turn the tool steel to its correct shape.

A Face Plate can now be installed in place of the three or four jaw chuck and centers set in place. The work and the center at the head stock end rotate together, so no lubricant is needed in the center hole at this end. However, because the center in the tail stock quill is dead with respect to the rotating work piece, adequate lubrication must be provided. This usually is accomplished by putting a mixture of white lead and oil, or with another type of lubricant in the center hole before the dead center is tightened in the hole. If you do not provide proper lubrication at all times, you will result in scoring of the center hole and the center, and inaccuracy and serious damage may occur to the centers.

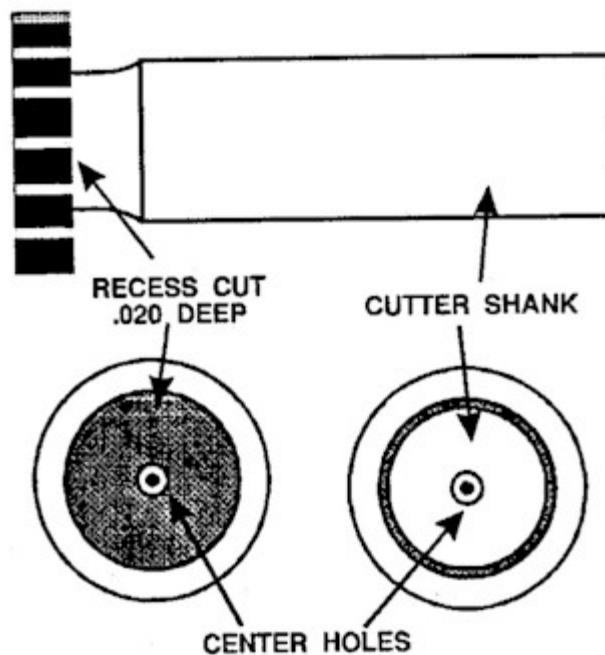
A connection must be provided between the spindle and the work piece to cause it to rotate. This is accomplished by a lathe dog and a faceplate. For this project, you will need a 1-inch, and a 1/2 inch lathe dog. The dog is a forging that fits over the end of the work piece and is clamped to it by means of a setscrew. The tail of the dog enters a slot in the dog plate, which is rigidly attached to the lathe spindle in the same manner as a lathe chuck. If the dog is attached to work that has a finished surface, a piece of soft metal, such as copper or aluminum, can be placed between the work and the setscrew to avoid marring.

GUNSMITHING AND TOOL MAKING BIBLE



TURNING WORKPIECE WITH CENTERS

Proper tightness must be maintained between the centers and the work piece. The work piece must rotate freely, yet no looseness should exist. Looseness usually will be first noticed by chattering of the material during cutting.



WOODRUF KEY CUTTER

Tightness of the centers should be checked after cutting has been done for a short time. The resulting heating and thermal expansion of the work piece will increase the tightness.

GUNSMITHING AND TOOL MAKING BIBLE

Live Centers are sometimes used in place of the dead center in the tail stock quill. The end that fits into the work piece is mounted on ball or roller bearings so that it is free to rotate; thus, no lubrication of the center hole is required. In most cases, they may not be as accurate as the solid type, so they often are not used for precision work.

Clamp the 1-inch lathe dog to the stock. It is best to leave the dog loose around the stock for now. Put the stock between centers, and adjust the centers to where they are just snug. Now clamp the lathe dog as far back on the stock as you can. The reason for this is that you need to turn the shank end down to .0500 inch and 2 inches long. If you cannot turn the stock to 2 inches long, turn to 1-1/2 inches in length. The other 1/2 inch can be turned later.

If good finish and accurate size are needed, one or more roughing cuts usually are followed by one or more finish cuts. Roughing cuts may be as heavy as proper chip thickness, tool life, and lathe capacity permit. Large depths of cut and smaller feeds are preferred to the reverse procedure, because fewer cuts are required and less time is lost in reversing the carriage and resetting the tool for the following cut.

CUTTING

SPEEDS

| | |
|----------------|---------|
| Cast Steel | 50 fpm |
| Bronze | 70 fpm |
| Cast Iron | 70 fpm |
| Malleable Iron | 100 fpm |
| Mild Steel | 100 fpm |
| Soft Brass | 200 fpm |
| Aluminum | 300 fpm |

TURNING THE STOCK

Mark on the stock from the end (tail stock end) a mark with a file at 2 inches. Set the cutting tool for turning and just touch the point on the stock. Move the carriage back far enough to clear the work piece and move the compound feed in .020 of an inch. In most cases this will remove .040 from the stock on each pass.

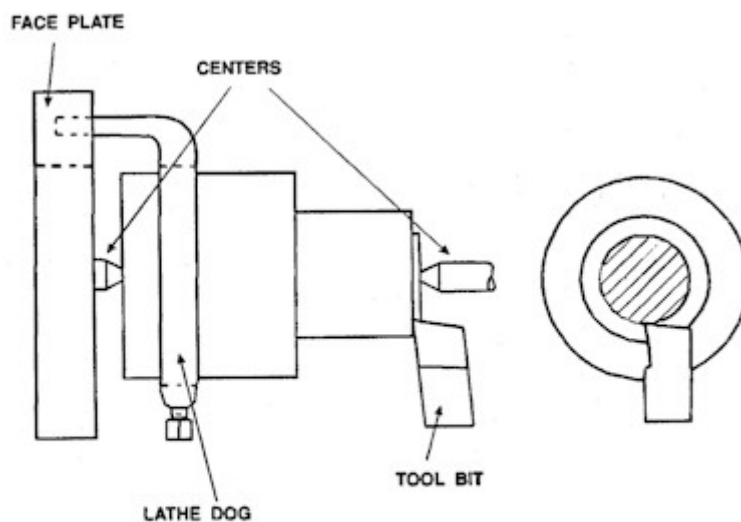
Having the lathe running at the slowest speed in direct belt drive, engage the feed lever and start removing the stock. When the cutting tool reaches the mark you put on the stock, disengage the feed. Now, run the carriage back to where it just clears the work, set it in another .020 and repeat the process.

GUNSMITHING AND TOOL MAKING BIBLE

In turning operations, diameters usually are measured with micrometers, although spring calipers may be used to check roughing cuts or where close accuracy is not required.

The method of making length measurements is made by spring, hermaphrodite, veneer, or micrometer calipers or micrometer depth gages can be used.

The shank will be finished to .500 or 1/2 inch, however when you get the stock down to within .030 you need to take a .010 pas at a slower feed to clean up the work, If you have a Tool Post Grinder and plan to finish the work by grinding, stop about .010 to .015 oversize. If you do not have a grinder, you can take a fine cut at the slowest feed, finish the work to .003 to .005 oversize, and use as is.



FACING THE END OF BAR

Remove the turned part around, remove the 1-inch dog and put the 1/2 inch dog on the turned end. Set the work piece back between the centers, adjust the dog and tighten it. Touch the point to the stock and move it slightly past the work, and set it in .020. Engage the feed and take the stock down 10.780, then take the finer feed to finish it to .015 over finish size. If you are going to use without grinding, take the stock down to about .005, or .755.

Next, we have to finish the width to .187 for the cutter. You need make a groove or recess on the shank next to the large end. This can be done with a cut off tool, or a square end-cutting tool. Run the recess or groove to a depth of .025 per side. Use a right hand tool holder and face off the inside of the large end to get a thickness of .190. An undercut is also made on both sides for clearance.

Finishing cuts are light, usually being less than .005 inch in depth, with the feed as fine as necessary to give the needed finish.

Sometimes a special finishing tool is used, but often the same tool is used for both roughing and

GUNSMITHING AND TOOL MAKING BIBLE

finishing cuts. In most cases, one finishing cut is all that is required.

Where exceptional accuracy is required, two finishing cuts are usually used. If the diameter is controlled manually, make a short finishing cut about 1/2 inch long and check the diameter before completing the cut.

Because the previous micrometer measurements were made on a rougher surface, some readjustment of the tool setting may be necessary in order to have the final measurement, made on a smoother surface, check exactly.

Turning is a lathe operation in which an external cylindrical surface is produced by cutting action of the tools. The cutting tool is first adjusted for the desired depth of cut, using the cross slide. Then, as the work piece rotates, the cutting tool is advanced slowly in a direction parallel to the rotational axis of the spindle and this motion is known as the feed.

By adjusting the feed so that the helical path, and if the tool tip overlaps sufficiently, the cutting tool removes the excess material and generates a cylindrical surface on the work piece. A spindle rpm that gives a desired cutting speed at the circumference of the cylindrical surface should be selected. This may be calculated using the following:

$$12 \times \text{cutting speed, ft/mm}$$

$$\text{Spindle rpm} = \frac{\quad}{\quad}$$

$$\pi \times \text{work piece diameter (in.)}$$

Feed is measured in thousandths of an inch advance of the cutting tool per revolution of the work piece.

FACING.

Facing is the removing of metal on a flat surface as the result of the tool being fed across the end of the rotating work piece. The work may be held in a chuck, a faceplate, or between centers. Both ends of the work that is to be faced must be turned end for end after the first end is completed and the facing operation repeated.

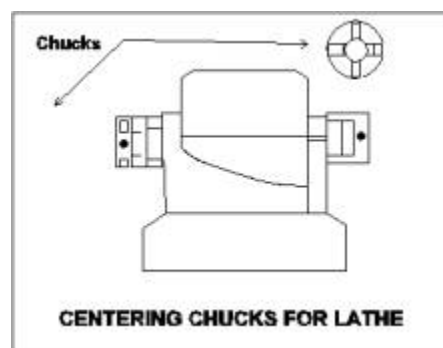
Because most facing operations are performed on surfaces that are away from the head stock, a right-hand tool is used most frequently. The spindle speed should be determined from the largest diameter of the surface to be faced. Facing may be done either from the outside inward or from the center outward. The point of the tool must be set exactly at the height of the center of rotation. Because the cutting force tends to push the tool away from the work, it usually is desirable to clamp the carriage to the lathe bed during each facing cut to prevent it from moving and thus producing a surface that is not flat.

GUNSMITHING AND TOOL MAKING BIBLE

DEEP HOLE DRILLING

Normally in any deep hole drilling operation, the barrel turns, and the drill is stationary. The reason for this can be seen easily. You will notice that with the single lip gun drill that it only cuts on one edge. As it drills in the barrel, it only cuts on one edge, and as it drills, it drills in the barrel its makes its own center. Due to the high RPM of the barrel, it makes its own center as it drills. This is the reason why an accurate starter bushing is so important.

The drilling of a rifle barrel is actually the simplest and most trouble free operation of all. When the drill is not started straight it will try to pick up the center of rotation, and the hole is one long curve.



We normally turned out 100 or more completed rifle barrels per week, and in the drilling operation, we could use low skill help. All that was necessary was for the operators were to set up the machine, turn it on. They had to watch so the drill wouldn't plug up with chips, shut it off when done, and then reload it and start again. When you get everything set up right, you will be able to turn out 3-4 completed barrels a day with no problem on ONE lathe. This completed barrel is drilled, reamed, and rifled.

STEADY REST

Now about the last thing that will be needed is a special. Steady Rest to support the drill tubing as it drills. This will help cut down the vibrations that will some times start in the drill.

You **CAN NOT** allow these vibrations to start. If it does, it can cause the carbide drill tip to chip, and if you do not catch it in time, it can cause the drill to plug up and twist the tip off. Will give you a good idea of what a Deep Hole Drill looks like.

I want to point out that this drilling setup is not limited to just barrels. It can be used for quite a bit of other industrial operations, where extremely accurate holes are needed. In addition, with carbide drill tips, very hard steel can be drilled. For odd shaped items where you are unable to rotate the drill, you can set up the operation where the drill can be rotated using special tooling.

GUNSMITHING AND TOOL MAKING BIBLE

TOOLS FOR REAMING

You will have to make a few additional fixtures for the reaming operation now. This will not have to be much of a job, as everything that you have done so far will work with the reaming operation. About the only thing that will be needed is a reaming adapter for the chip box housing. When this adapter is done it will fit in place where the chip box housing was.

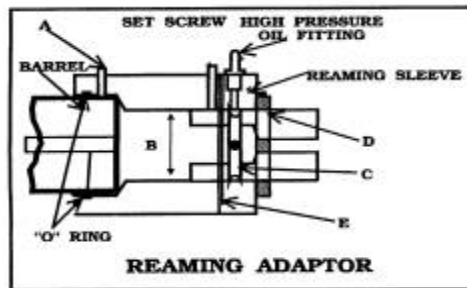
The high-pressure oil line that was fitted to the drill driver on the Deep Hole Drill will now be fitted to the reaming adapter. The reamer rod will have to be made. Cut it now to correct length. A drill driver will need to be made to fit the reamer rod. This is the same size as the deep hole drill driver.

REAMING FEED

With this done and in place you will have to change the feed of your lathe to a faster feed, somewhere in the range of .015 to .004 inch feed PER FLUTE PER REVOLUTION. The speed of the lathe will have to be changed to the back gear for slow RPM. In reaming, the reamer is pulled through the barrel.

REAMER ADAPTER

Now for the construction of the reamer adapter. First, you will need a short bar of steel 1 1/2 inch in diameter if you are using 1 1/8-inch steel for your barrel blanks. This piece when completed should be 7 to 8 inches long. The end that fits over the barrel blank should be a very close fit to the barrel, just a few thousands larger. Next cut an "O" Ring groove to fit an "O" ring, this is used to seal the oil from leaking.

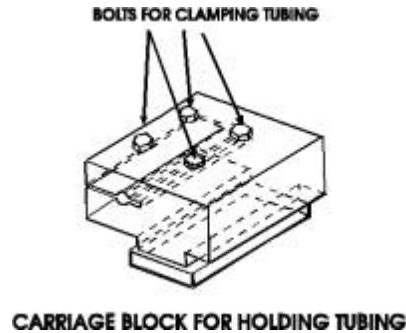


The bore (B) should be bored to .755 to fit the reamer guide (C). This guide should be made out of tool steel. The fit over the reamer rod should be very close, as this is what seals the oil. I have in the past tried to use "O" rings to seal the oil but they do not last long. Drill Rod size .750 works very well, as there is no turning of the outside to fit the sleeve (A).

Another way to do this is to bore (D) to 1/2 inch and make a harden bushing to fit inside it, so the bushing can be changed to the different size rods. When the bushing wears out, it can be easily changed, without the expense of the higher priced 3/4 inch Tool Steel. The bushing bearing (E) is a very close fit in the bushing.

GUNSMITHING AND TOOL MAKING BIBLE

The bushing has a groove turned on the O.D. and 4, 1/8 holes drilled to let the oil be pumped inside (B). The sleeve (E) has a fitting tapped into the outside so the high-pressure hose can be screwed on. There is also a retaining sleeve (F) to hold (E) in place. The sleeve (E) is free to rotate when the lathe is turning.



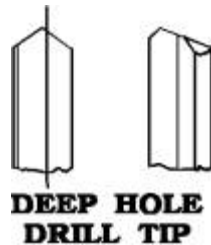
All of the parts when completed are heat treated and drawn at 500 degrees. This will just about complete the setup for drilling and reaming.

Except for one other item, you will want to mount a high-pressure oil gauge in the line to the Drill and Reamer fittings. Have this handy so you will be able to see it always. Oil pressure will tell you quite a bit what is going on inside a barrel. If a Drill or Reamer is plugging up the pressure will go up. For information on carbide tips, write the Metallurgical Products Dept, General Electric Co, Detroit, Michigan.

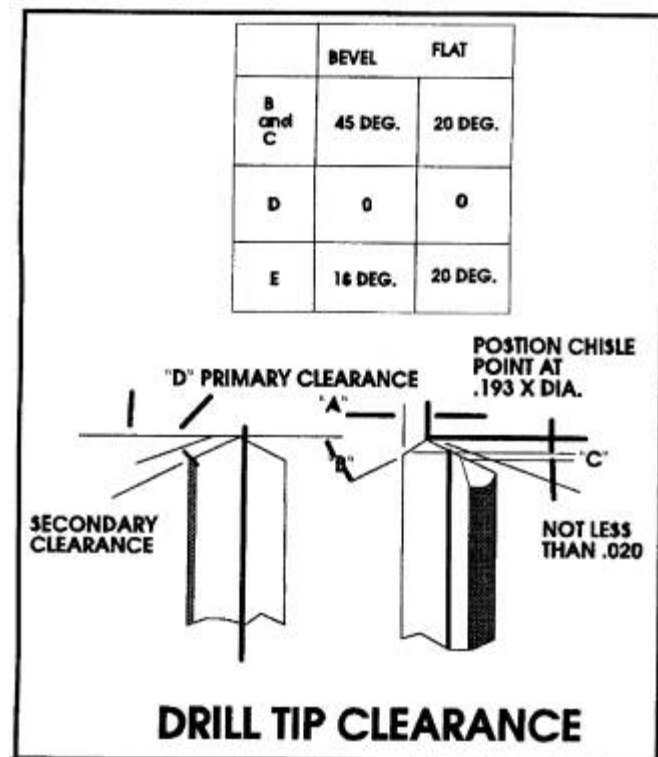
GUNSMITHING AND TOOL MAKING BIBLE

DEEP HOLE DRILLS

Let us talk a little about the Deep Hole Drill, Sizes, and the Grinding of the drill. What a Deep Hole Drill look like, and some of the terminology of the carbide drill.



I will not go into the grinding too much of the Deep Hole Bits, as most will buy the sizes that they need. When you have to buy the 'V' tube, and the drill tips, and install the drill driver, and tip, it is just about as cheap to buy the completed drill. If you want to grind your drill tips, the various makers of carbide tools will be able to supply you with the several sizes of Carbide deep hole drill tips that you will need. The grade of carbide usually supplied for deep hole tips is 883.



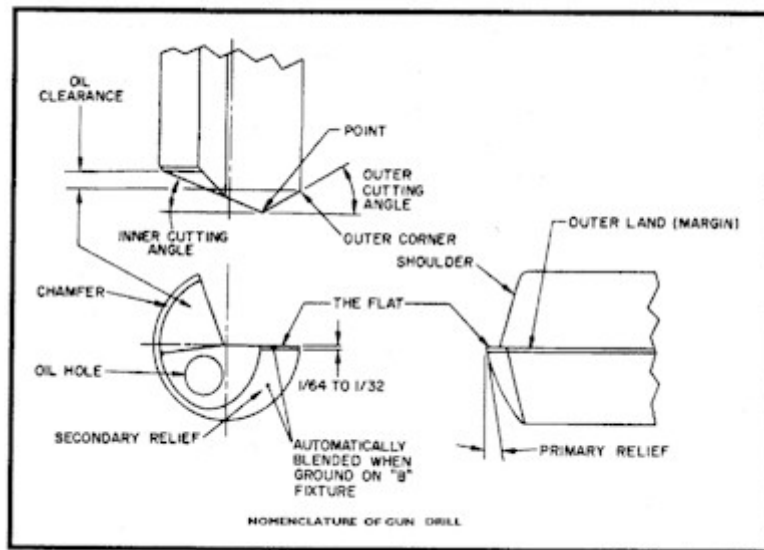
GRINDING THE TIPS

To set up for grinding the deep hole tips, all that is necessary is to turn 2 short pieces of drill rod, about 1 inch long, center one end of each piece. The drill rod should be the same size as the drill tip that you are planning to grind. Get a small V way, or a piece of finish angle. Lay the tip and the 2 pieces of drill rod,

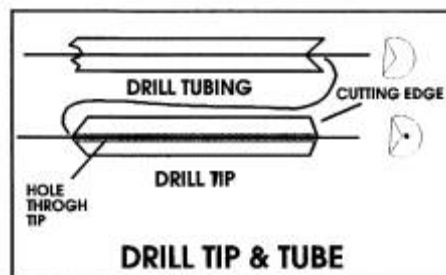
GUNSMITHING AND TOOL MAKING BIBLE

with the centers out to each end of the tip. Get some low melting silver solder and join the 3 pieces. Use the lowest flame possible to melt the silver solder, as too much heat will or can crack the carbide tip. When done let cool in the fixture. When cool set up between centers of the lathe, set tail stock over so you will have a 1 degree included taper per inch from the front or cutting edge of tip to the back.

After this, grind the primary land. This will have to be ground to absolute center. After this is done, heat the drill tip up and remove the centered ends. Grind the remaining silver solder from the carbide tip, if the holes are plugged, drill them out. I have found that welder's chalk rubbed into the holes of the tip will help to keep the solder from plugging it. The drill can now be mounted to the drill tubing.



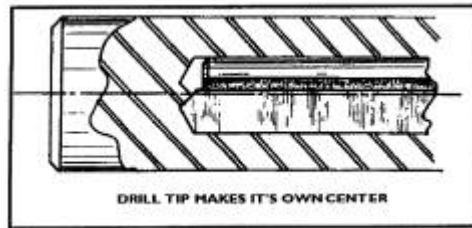
The V tubing can be purchased from High Standard, or Danjon, address is in the back of the book under suppliers. I would recommend that you buy the first one from the suppliers. This will save you some headaches on your first barrel. The drill will last for several hundred barrels if you have no accident, and you take care of them.



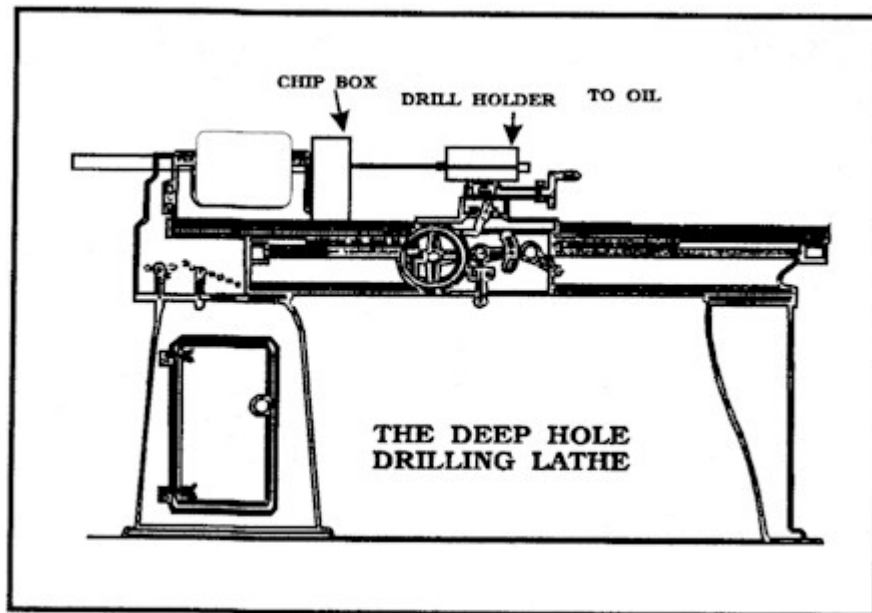
GUNSMITHING AND TOOL MAKING BIBLE

DRILLING THE RIFLE BARREL

In this chapter, we will cover the process of making the rifle barrel. By now you know how the tools are constructed, and have a basic idea of how rifle barrels is made. I will now tell you step by step how to go about making a rifle barrel.



First, I would start with a 1 1/8 inch x 26-inch long piece of 1350 or stress proof. This steel will drill, ream, and rifle beautiful, and almost never gives any trouble. The first thing to do is to put this bar in the lathe, face off one end, and center drills it. On the other end, it is best to face it off also.



Make sure that the end that you center drilled is flat and smooth. After the barrel is faced off, leave it extended, from the chuck about 6 inches.

If the barrel is sticking from the end of the lathe, make a collar, with four setscrews, so the barrel can be centered and rigid. At the high speed that the barrel is drilled, the end of the barrel will start to run out and vibrate.

GUNSMITHING AND TOOL MAKING BIBLE

The chip box is installed with the starter bushing in place, and the starter bushing is very carefully flushed up against the barrel blank.

Connect all the shields; don't forget about the one on the end of the lathe that will return the oil when you go through the barrel with the drill. Bolt the drill driver holder, centering it with the center of the tail stock. It would be more accurate if it would be done with a shaft chucked in the head stock, through the opening that holds the drill driver.

Set the deep hole drill in the drill driver on the carriage; connect the hydraulic hose to the fitting. Now very carefully start the drill tip into the starter bushing. Before you turn on the oil to test it out, double-check the setscrews that hold the drill in. If you turn on the oil and turn up the pressure, you will blow out the drill and possibly chip the tip, and get an oil bath.

Turn on the oil, but before you do make sure that the valve is open all the way, so there is no pressure in the line. If everything is OK you are pumping the oil back to the tank, with very little oil going through the drill. Now close the valve slowly, watching the pressure on the gauge, when it gets up to 600 to 700 lbs., which is about the right pressure for 30 caliber barrels.

Let it run for a minute or so to check for leaks. Look and see how much oil is coming out of the tip. There should be quite a bit. This is important, as when you are drilling this is one way that you watch to see if your drill is plugged up. Any time the flow slows down, or stops, or pressure goes up, shut down the feed fast, or you will ruin the drill. I will assume that you have already changed the quick-change gears so you can get a slower feed. A good starting point would be .0008 feed per revolution.

Now if you are ready, have all the shields up, no leaks, turn on the lathe. Before you do this, make sure that the drill tip is not touching the barrel. The lathe should be running about 4000 rpm, but you can run it at its regular speed. It will take longer to drill the barrel, and the drill might tend to wander a little on the slower RPM. Now with the oil on, feed the drill into the barrel blank very slowly by hand. The drill and tubing will probably chatter. Unless the drill tube starts to buckle, keep feeding it in and after it goes in 1/8 in or so it will stop chattering.

Once it stops chattering, engage the feed. It should start drilling with no chatter. I would recommend that you keep your hand on the drill tubing for two reasons. (1) - If your hand is on the tubing, you will be able to feel what is going on in the barrel. There is a certain feel to the tubing when the drill is cutting right. (2) Your hand will act as a vibration damper for the drill.

Remember to keep your hand on the drill all the time to feel the vibrations on the drill. After a short while you will be able to tell exactly how the drill is doing. After a few barrels, you will be able to tell when the drill is dull, or it is chipped. Under normal conditions, the drill should be sharpened about every two barrels.

To sharpen it is only necessary to just touch the cutting surface with the silicon carbide (green wheel), or diamond wheel, rather than grinding all the surfaces.

GUNSMITHING AND TOOL MAKING BIBLE

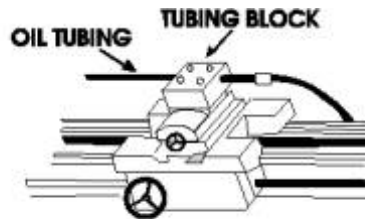
The angles on the face of the drill are fairly critical, as they will change. There may be spots rubbing the drill because lack of clearance, may cut curved holes, or may turn out ribbon chips. These problems can be usually be traced to an improperly sharpened drill. You shouldn't have any trouble on the drilling if you have followed instructions. By now, you will have probably noticed that as the pressure of the oil goes, so does the temperature.

On small calibers the drill tubing gets very warm. This is normal. By now, you should be about all the way through the barrel. When the drill comes through the end of the barrel, your flow of oil in the chip box will stop abruptly. Open the valve on the bypass line to drop the oil pressure. Let the drill travel about another 1/4 inch and disengage the feed lever and back out the drill, when it all the way out shut everything down.

Well you have done it. You have drilled your first barrel. The rest should be easy now. If everything was done right, the barrel should be perfectly straight. Leave the barrel in the lathe, as the next operation will be reaming the drilled barrel.

REAMING DRILLED BARRELS

Change the feed on the lathe to the proper feed. Usually start a little slow and increase it to where you are getting a good job and yet not plugging up. Sometimes if you have too fast a feed, you will have trouble with the reamer plugging up.

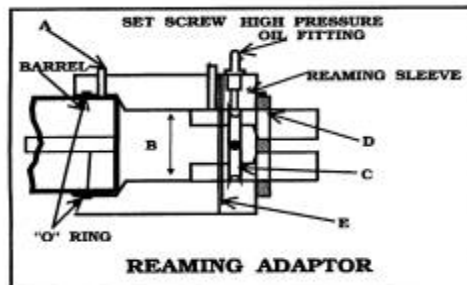


LATHE CARRIAGE WITH TUBING BLOCK

Remove the starter bushing and the chip box. Install the reamer adapter to the barrel blank, and tighten the setscrew. Connect the oil line to the fitting on the reamer adapter. On your reamer pull rod; unscrew the driver from the end of the rod. Now slip the rod into the barrel, all the way through the barrel, and out the bushing on the reamer adapter.

Screw the driver back on the rod and slip into the driver holder on the lathe carriage, and tighten setscrews. Replace the shields on the end of the lathe. Be very sure it is on good as there will be a lot of oil coming from the barrel in reaming. You should now be ready to start. The first reamer is the rough reamer, its purpose is to remove the excess metal from the bore, and smooth and true up the bore.

The finish reamer doesn't remove much; it takes the bore to size, and gives the mirror finish to the bore. Double check to see if the oil pressure valve is opened all the way. Double check the hoses to be sure they are tight, and turn on the oil. Let it run for a few minutes and turn the pressure up to about 300 lbs. The pounds of pressure are not important as the amount of oil coming from the end of the barrel.

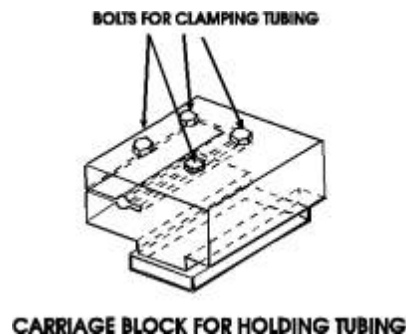


It has to be shooting out under enough pressure to get rid of the chips so they won't plug up the reamer. If it plugs up it could ruin the barrel, and probably break the reamer. Start up the lath in back gear. Make sure that the pilot of the reamer is inside the barrel, and engage the feed lever. As the reamer is starting to feed into the barrel, it may cut a little rough but it should straighten out soon.

It will, if sharpened right and start cutting smooth from the start, or after it is in the barrel about 1 inch.

GUNSMITHING AND TOOL MAKING BIBLE

Keep your fingers on the reamer rod, as through the rod you will be able to know if everything is cutting well. If it is cutting smooth set back and let it ream.



It is a wise practice always to keep your fingers on the reamer rod, as the flute could plug up. If the reamer plugs up, more than likely the oil pressure will go up slightly.

If for any reason the reamer plugs up or starts to act up, disengage the feed lever and while the lathe is still running, back out the reamer. It is wise to have something lying across the ways of the lathe. As the carriage travels down the ways of the lathe, it will move it along with it. I use a wrench. This way if you have to take out the reamer you will know where to start the reamer cutting again.

DULL REAMERS

When you back out the reamer do not shut off the lathe; if you do you will leave long marks in the barrel. As you back the reamer from the barrel, you will be able to see if it was plugged or not. If it is not plugged, it is probably getting dull, and rubbing instead of cutting.

Remember when looking for trouble spots on the reamer, get it in a good light and look for bright spots.

This will usually show you where the trouble spots are. If everything is OK, as it should be, you should be about through by now. As the reamer starts to come out of the barrel, it will start to chatter slightly, as the pilot is not supporting the reamer any more. This is common but do not let the reamer travel so far that it will stick in the bushing.

When the pilot leaves the bore the oil pressure will drop and there will be more oil coming from the end of the barrel. When the oil pressure drops, let it go about 1 inch and disengage the feed. Shut off the oil and slide the reamer back down the barrel to where it was sticking out. Shut the machine off now. Disconnect the driver, or if you want unscrew the reamer rod from the driver, and remove the reamer.

Put the finish reamer in the barrel, screw in the driver and repeat the process. When you finish the final step of reaming shut everything down. Loosen the setscrew, from the reamer adapter, and remove the reamer. Do not take the chance of the reamer marking the barrel by sliding it back down the barrel.

When the last reaming operation is completed, you will remove the barrel. Let the oil drain from it for a few minutes, wipe out, and inspect. Hold the barrel up to a light, a window is best and check for

GUNSMITHING AND TOOL MAKING BIBLE

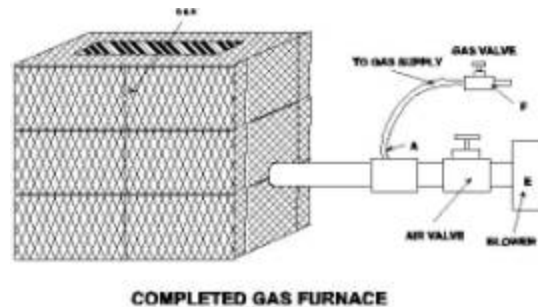
smoothness. Also, make up a go-no-go gauge to check for correct size. If everything is OK, you are ready to rifle.

GUNSMITHING AND TOOL MAKING BIBLE

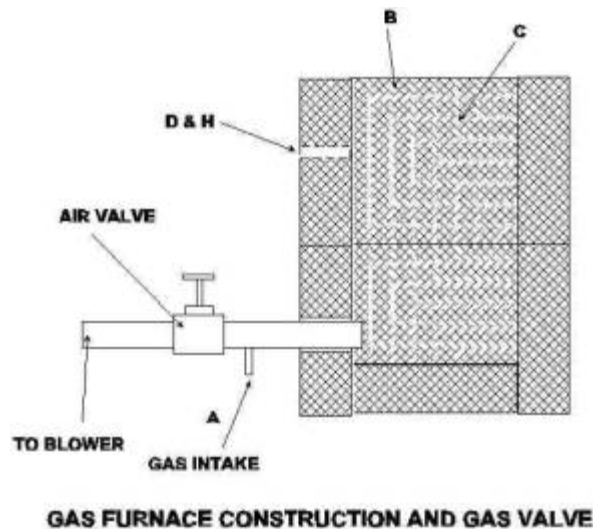
BUILDING A HEAT TREAT FURNACE

Building a small heat-treat furnace for the shop. This furnace is made from standard fire brick, 2 1/2 x 4 1/2 x 8 inches. Fire brick does vary in size, so the size shown in the drawing may have to be changed to fit your needs. Another style of furnace is where the main opening is at the top, and the part hangs down on the inside. This seems to give a uniform heating.

A-Gas/Air outlet; B-Furnace opening; C-Side view; D-Opening for temperature sensor; E-Blower; F-Gas intake; G-Heat sensor pipe; H-Heat sensor opening; <D>



You will need eight firebricks to make this. When completed you will have a furnace with an inside size of 4 1/2 x 3 x 8 inches. This size will handle just about any job in the shop.



The firebrick is mortared together with the cement used in fireplaces, and it should not be any problem to get from any business that sells fireplaces or wood burning stoves. The brick is placed 2, flat side by side, mortared, and then one brick on each side is stood on edge, (see drawing) mortared to the two laying flat.

GUNSMITHING AND TOOL MAKING BIBLE

Two more are then placed on top of the first two. To finish it off, two more are mortared and set on edge on one end, as per drawing. Let it set for 24 hours before starting any more work on it"

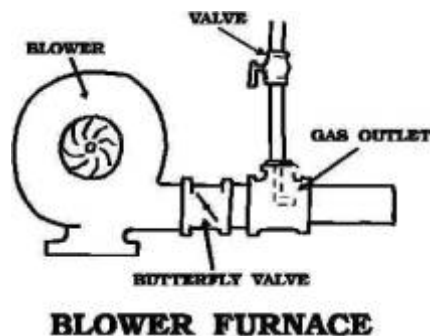
Next you will have to get a cement drill 1 1/2 inch, and drill one hole 1/4 inch above the base in the center on the side. This is where the 1-inch pipe from the blower will be inserted.

You will need to get your pipe cut and threaded to the correct length. Connect a 2-inch pipe to the 1-inch pipe; this will go to the blower.

Next, you will need to cover the firebrick on the outside. Cut 1/8 inch metal to fit to the outside and top and weld this together, to form a box for the firebrick. Be sure to have a metal bottom already cut out to put under the brick so the sides can be welded to it.

You can when building this go with the opening in the top, and then you need not make a door for the front. This is the simplest way to go and I believe the best. You hang the part down through the opening in the top. At the front, there is a small opening for the temperature probe. This is a 1/4 or 3/8 inch hole.

If you decide to build a front-loading furnace, you will need a 2-inch opening in the top of the furnace for the gas. In addition, you will have to build a metal door for the front and line it firebrick. You now will need to find a used Kirby vacuum cleaner blower, or any other type of high-speed blower to provide the air for the furnace.



A shop Vacuum blower also works great. You will need to find an adjustable rheostat to control the speed of the blower. The speed that it runs would make it impossible to light the oven. The final step is to tap into the airline with a line from your gas supply.

The basic tools for heat-treating are the gas torch. The torch is a simple apparatus consisting of a mixing tube into which fuel gas and a blast of air are introduced to be mixed and burned at the end of the tube. An old vacuum cleaner can be used for the air blast.

The hose used for the various attachments for the cleaner can be used to deliver the blast of air to the torch.

GUNSMITHING AND TOOL MAKING BIBLE

You will have to make a fitting for attaching the hose at the dust-bag outlet and arrange the cleaner so that air can enter at the suction end.

At the torch, a gate of sheet metal is arranged to regulate the amount of air entering the mixing tube. You can also reduce the airflow by reducing the speed of the blower. A simple light dimmer found at any hardware store would do the job very good if you have a DC blower motor.

The fuel is supplied through a rubber tube of a size to fit the supply pipe and the fitting on the torch. You should have a 1/4 inch needle valve to adjust the gas to air mixture. Using Butane or Propane from a 5-gallon bottle works better as there may not be enough pressure from natural gas. If you use butane, make sure all your fittings, and hose are for high pressure.

It has rubber ends that will fit on the gas nipples at each end. Any other good rubber tube can be used, such as a 3/8-inch garden hose. The mixing tube must be long enough so that the gas and air are thoroughly mixed by the time it gets to the burner end.

Artificial gas will burn at the end of a plain mixing tube, but for natural gas there must be a special tip on the burner end to maintain the flame, or else the air blast will snuff it out.

This special tip consists of a jacket fitted around the end of the mixing tube with several small holes drilled into the mixing tube. This gives a low-velocity supply of gas and air to the jacket.

This will maintain a small circular flame around the end of the mixing tube, which will keep the mixture ignited as it comes out of the end of the main burner tube.

The air blast tends to blow the main flame so far away from the end of the mixing tube that it will mix with so much outside air that it will no longer be a combustible mixture and will be snuffed out. This annular ring of low velocity flame surrounding the outlet of the mixing tube will keep the main flame ignited unless so strong an air blast is used that the entire flame is blown away from the end of the mixing tube.

When you start up the burner, shut off the gas until you have the air adjusted, and then slowly turn on the gas, while holding a lit Butane torch over the opening of the furnace. It is best to reduce the air blast until the gas is ignited and then slowly open it until the desired flame is obtained. The flame should burn with a firm blue center cone, and the hottest spot will be at the tip of the blue cone. A yellow flame is not as hot and is very sooty. After the bricks of the furnace have become well heated, the air blast may be opened a little farther, and the blast will thus be increased.

The flame from this torch is very hot and will heat steel to a white heat for forging, but it is not hot enough for welding, however a supply of oxygen for the air intake will increase the temperature.

Get a large enough cement drill to drill a hole through the firebrick about 2 inches from the top. The heat sensor will fit in there. I find a short length of iron pipe that is large enough on the ID to allow the sensor to fit inside. This pipe is then mortared in place. See Drawing.

GUNSMITHING AND TOOL MAKING BIBLE

A High Temperature gauge can be purchase from an industrial supply dealer. If you can find one, a 2000-degree gauge is best.

In the air intake pipe, (A) you will need some kind of manually controlled valve. You will have to be able to shut the air down quite a bit. If you tried to use the full amount of air, it would blow out the flame.

When you are ready to start the furnace, hook up the gas, check for leaks with soap, and if OK, you are ready to fire up.

NOTE - It is important to do things at first very carefully to prevent an accident. This is the way I have my furnace set up, and have had no problems. I have no control over what is done by other people, and cannot accept responsibility for what some other person does. If you build a gas furnace, you are on your own. Check it outside of the building for safety's sake.

Turn on the air, and close down the valve until there is almost no flow through the pipe. Now take a butane torch and light it. Open the main valve on the gas tank.

BE SURE THAT THE SMALL ADJUSTING VALVE IS CLOSED ALL THE WAY.

Holding the lit torch over the opening, slowly turn on the gas. In a few seconds it should light. There probably wont be much flame, so slowly open the air valve/gas valve until the furnace has a "roar" to it. Don't open the air valve to much as you need a slow heat. Adjust the fuel so that you get 3 to 4 inches of flame from the top. Let it heat up to dry out, and then it is ready to use.

Once it has cooled down, it can be moved back in the shop. This furnace can be changed to where it is front loading, made larger or altered for what ever is needed.

This furnace is very fast. Normally it takes only 10 to 15 minutes to get to operating temperature. I find that hanging the knife parts down from the top will cause even heating. You can use two bricks to close down the opening more to confine the heat better. When through heat-treating, close the top up with the bricks, and let cool down to tempering temperature.

This furnace works great with 01 and other tool steels. It can be used for forging steel as well.

COLORS FOR TEMPERING

430 degrees,
off tools.

Very pale yellow, extra file hard, dies, milling cutters, cut

440 degrees,
cutters, hollow mills.

Light Yellow, file hard, reamers, thread chasers, fly

450 degrees,

Pale straw yellow, profile cutters for milling machines,

GUNSMITHING AND TOOL MAKING BIBLE

rolling dies, knurling tools.

| | |
|--------------|---|
| 460 degrees, | Straw yellow, knife hard, swages. |
| 470 degrees, | Deep straw yellow. |
| 480 degrees, | Dark yellow, cutting dies. |
| 490 degrees, | Yellow brown, extra hard, taps, dies. |
| 500 degrees, | Brown yellow, thread dies for general work. |
| 510 degrees, | Spotted red brown. |
| 520 degrees, | Brown purple, hard. |
| 530 degrees, | Light purple. |
| 540 degrees, | Light purple. |
| 550 degrees, | Dark purple. |
| 560 degrees, | full purple. |
| 570 degrees, | Dark blue, half hard. |
| 620 degrees, | Blue gray, spring temper. |

HIGH TEMPERATURES BY COLOR

| | |
|---------------|------------------------------------|
| 752 degrees, | Red heat, visible in the dark. |
| 885 degrees, | Red heat, visible in the twilight. |
| 975 degrees, | Red heat, visible in the daylight. |
| 1077 degrees, | Red heat, visible in the sunlight. |
| 1292 degrees, | Dark red. |
| 1472 degrees, | Dull cherry red. |

GUNSMITHING AND TOOL MAKING BIBLE

| | |
|---------------|-------------------------------|
| 1652 degrees, | Cherry red. |
| 1832 degrees, | Bright cherry red. |
| 2015 degrees, | Orange red. |
| 2192 degrees, | Orange Yellow. |
| 2372 degrees, | Yellow white. |
| 2552 degrees, | White-welding heat. |
| 2732 degrees, | Brilliant white. |
| 2912 degrees, | Dazzling white, bluish white. |

In tempering, I let the oven cool down to the temperature that I need to draw the temper for the job that I need. I then put the part in the oven, then let it cool down over night.

GUNSMITHING AND TOOL MAKING BIBLE

RIFLE BARREL STEEL

There have been many different types of steel used in rifle barrels over the years. There is much claims by individual barrel makers that there steel that they use in there barrels is better and give more life and accuracy than other makers. Most if not all people are greatly mislead on rifle barrels and the type of steel that is used in there manufacture.

You may be surprised that the steel used in the past is very similar or are the same to what is used today. Most manufactures use steel that works easily, machines good, one that gives good tool life, and good barrel life. Most of the steels that was used 70 to 80 years will be suitable for the barrels today.

In the old days, where lead bullets were being used, almost any bar of iron was satisfactory for a barrel for black powder and lead bullets, as long as it was easy to work.

Black powder gave a breech pressure of about 25,000 pounds per square inch, and the lead bullets gave little wear. Wear came from the black powder and corrosive primers in the form rusting.

They did not have to worry about pressure, just corrosion. Now at the present, smokeless powder will give pressures more than 70,000 pounds per square inch, extremely hot gases, and bullet jackets of much harder material than lead.

Now they need steel that will machine good so a very smooth finish can be achieved in the bore to eliminate fouling from the jacketed bullets. This requirement is easy to meet in the steels of today, and the early 1900's.

THE REQUIREMENTS ARE

It must be free machining, stress free, and a hardness of 28 to 33 Rc.

The barrel for the old Krag Model of 1898 was made of the following,

| | |
|------------|----------------|
| Carbon | .45% to 55% |
| Manganese | 1.00% to 1.30% |
| Sulfur | Not over .05% |
| Phosphorus | not over .05% |

Springfield Barrels

GUNSMITHING AND TOOL MAKING BIBLE

| | |
|---------------|----------------|
| Carbon | 1.10% to 1.35% |
| Silicon | .25% to .35% |
| Resulphurized | to .06% |
| Phosphorus | not over .06% |

1917 Einfield Barrel made of smokeless barrel steel.

| | |
|------------|----------------|
| Carbon | .45% to .50% |
| Manganese | 1.10% to 1.35% |
| Silicon | .20% to .30% |
| Phosphorus | under .06% |
| Sulfur | under .06% |

Garand Barrel made of 4150 Modified

| | |
|--------------|---------------|
| Carbon | .45% to .60% |
| Manganese | .60% to .90% |
| Chromium | .80% to 1.10% |
| Molybdenum | .15% to .25% |
| Silicon | .15 to .35% |
| Phosphorus | not over .04% |
| Resulphurize | .04% to .09% |

M-1 Carbine Material 1350 (Stress Proof)

GUNSMITHING AND TOOL MAKING BIBLE

| | |
|---------------|----------------|
| Carbon | .50% to .60% |
| Manganese | 1.35% to 1.65% |
| Silicon | .10% to .15% |
| Resulphurized | .04% to .09% |
| Phosphorus | not over .045% |

You will notice that most of the steels were very similar in composition, and you will also notice as we go along that all the steels that are used in barrel making is all about the same, except the trade names tacked to them to give the shooter the idea it is something special. All steels today are manufactured under SAE or WD numbers. The SAE numbers refer to standard specifications issued by the Society of Automotive Engineers and publish in the SAE Hand book.

What does this tell you? It simply states that when a barrel maker wants steel for rifle barrels, he picks up a phone book and orders the type of steel that meets the requirements for a rifle barrel. If he buys standard steel such as Stress Proof, 1350, 4140, 4142, or 4150, it won't make much difference, which steel company he buys it from as it is regulated by the SAE.

It might have a different trade name, but it will be the same as the other steel manufactures. Steels and Irons To help you understand steels better I will use the following information on how steel is graded. Steels may be classified into five categories,

1. Carbon,
2. Alloy,
3. High Strength,
4. Low Alloy,
5. Tool Steel

As we are dealing with rifle barrels, I will cover items 2 and 4.

ALLOY STEELS

| | | |
|------|-----------|-----------------|
| 13xx | Indicates | Manganese steel |
|------|-----------|-----------------|

GUNSMITHING AND TOOL MAKING BIBLE

| | | |
|------|---|-----------------------|
| 14xx | " | Carbon Steel |
| 23xx | " | Nickel Steel |
| 33xx | " | Nickel Chromium Steel |

Nickel Chromium Steel

| | | |
|------|---|----------------------------|
| 40xx | " | Molybdenum Steel |
| 41xx | " | Chromium, Molybdenum Steel |
| 43xx | " | Nickel, Chrome, Molybdenum |
| 46xx | " | Nickel, Molybdenum Steel |
| 50xx | " | Chrome Steel 61xx " |

Chrome, Vanadium Steel is considered to be an alloy when the maximum of the range given for the content of alloying elements exceeds one or more of the following limits,

Manganese 1.65%, Silicon 0.60%, Copper 0.60%, or in which a definite range or a definite minimum quantity of any of the following elements is specified or required within the limits of the recognized field of constructional alloy steels,

Aluminum, boron, chromium up to 3.99%, cobalt, and so on.

Manganese, Contributes to strength and is major importance in increasing hardening ability.

Silicon increases the resiliency of steel for spring applications and raise the critical temperature for heat treatment.

Nickel, Lowers the critical temperature of steel, and widens the temperature range for successful heat treatment.

Nickel is used to promote resistance to corrosion. Chromium, Is used in steels to increase hardness, improve harden ability, and is the essential element in stainless and heat resisting steels.

Molybdenum, In common with manganese and chromium, has a major effect on increasing harden-ability, and a strong effect in increasing the high temperature tensile strength. Vanadium Produces a fine grain.

GUNSMITHING AND TOOL MAKING BIBLE

STAINLESS STEELS

I will not go into this type of steel too much as we find that barrel life with stainless is not much greater than other barrel steels such as 4150.

Its value comes in with the over bore cartridges, where barrel life is a little better. Stainless steel is also harder to drill, ream, and will give lots of trouble in rifling.

It has a tendency to gall, when it is button rifled. I have not found there is enough barrel life gained from its use, except for a person that insists on it, and is willing to pay the added cost. A barrel maker can use any kind of steel and call it any name he wants.

To state a particular type of steel is Chrome-Moly, chrome-nickel, or similar term, is more illuminating, because a trace of the alloying elements in the smallest amounts can justify using these terms. There are trade names such as Ryerson, Crucible, and many others, which does not mean anything except that it tells of the company that made the steel.

Types of Steel,

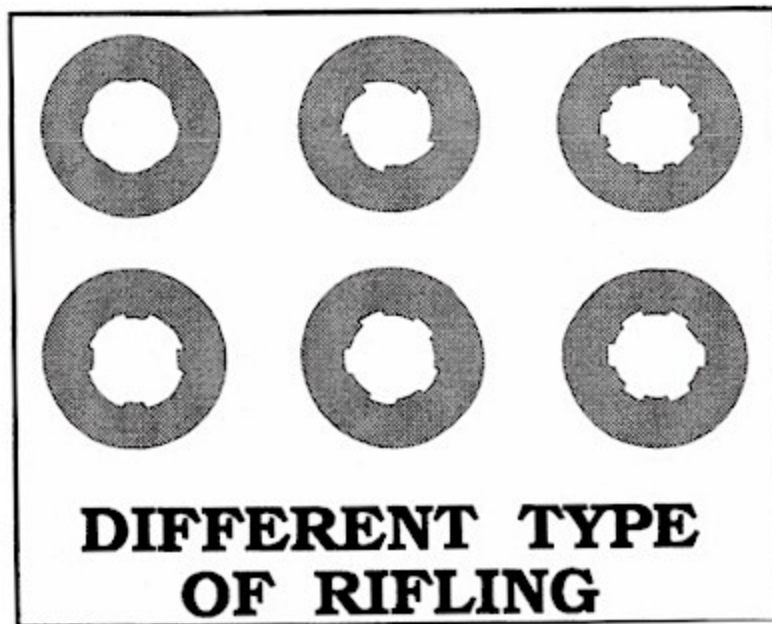
I will give you some of the commonly known names of the better steels used in barrel making, all of these I have used. Ryax or Stress Proof are commonly designated as carbon manganese (1350), and are very free machining but at the same time possess the required physical requirements needed for rifle barrels.

Rycut 40 or Rycut 50 is a modified 4140 or 4150. Modified 4150 contains about 1.65% manganese. This manganese definitely increases the machine ability. For a barrel maker to say his barrels cost more does not mean he is using better steel than his competitors.

Steel cost about the same from all suppliers. The bottom line is that it hardly pays the average shooter to worry about the steel in his barrel. If a certain type, or make of barrel is what you want, then get what makes you happy.

IMPORTANCE OF RIFLING

In a rifle the grooving is of the utmost importance; for velocity without accuracy is useless. To determine the best kind of groove has been, accordingly, the object of the most laborious investigations. The projectile requires an initial rotary motion sufficient to keep it spinning up to its range, and is found to gain accuracy by increasing this rotary speed. If the pitch of the grooves be too great, the projectile will refuse to follow them, but being driven across them, strips the lead in the grooves is torn off, and the ball goes on without rotation.



The English gunsmiths avoided the dilemma by giving the requisite pitch and making the Rifling grooves very deep, and even by having wings or lugs cast on the ball to keep it in the grooves expedients which increase the friction in the barrel and the resistance of the air enormously.

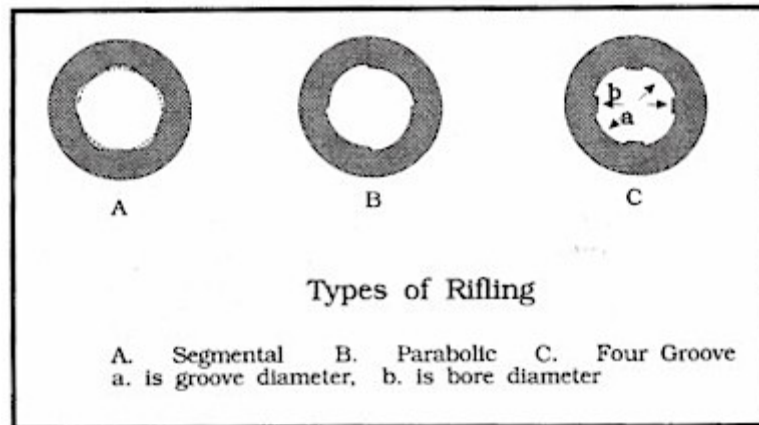
The American gun-makers solved the problem by adopting the gaining twist, in which the grooves start from the breech clearly parallel to the axis of the barrel, and gradually increase the spiral, until, at the muzzle, it has the pitch of one revolution in three to four; the pitch being greater as the bore is less. This gives, as a result, safety from stripping, and a rapid revolution at the exit, with comparatively little friction and shallow groove marks on the ball, accomplishing what is demanded of a rifled barrel, to a degree that no other combination of groove and form of missile ever has.

There is no way of rifling so secure as that in which the walls of the grooves are parts of radius of the bore. They should be numerous, that the hold of the lands, or the projection left between the grooves, may divide the friction and resistance as much as possible, and so permit the grooves to be as shallow as may be.

GUNSMITHING AND TOOL MAKING BIBLE

THE AMOUNT OF TWIST IN THE RIFLE BARREL

A rifle bullet is much like a top. It has to be spun at a certain rate of speed in order to remain stable and point on. Spin the top too fast and at first it wobbles, before it settles down to a smooth spin. Then as its speed of rotation diminishes, it finally begins to wobble once more. The forward velocity of a bullet, however, diminishes more rapidly than its rotational speed.



The longer the bullet and the slower it leaves the muzzle, the faster the pitch of the rifling must be in order to keep the bullet point on and accurate. Short bullets like the 30-30 Win. which weighs 150 grains, can be stabilized in a twist having one turn in 12 inches. In other words, 1-12. The twists in barrels chambered for the old black powder cartridges, that used bullets that were relatively short in proportion to their diameter, were quite slow. The standard twist for the .45/70, for example, was 1-20. The twist for the Winchester .50/95 was 1-60 and for the .50/1 10 1-54.

Here is a list of finish sizes of the sizing button, the rifling button, and the degree of angle to get the twist that is listed.

RIFLE BARREL TWIST

| CALIBER DIA. | MAKE DIA | BORE | GROOVE | TWIST |
|-----------------|--------------------|------|--------|-------|
| .30 WCF (30-30) | Winchester | .300 | .308 | 12" |
| .30 Remington | Remington | .300 | .308 | 12" |
| .30 US (30-40) | Springfield Armory | .300 | .3085 | 10" |
| .30-06 | Springfield Armory | .300 | .308 | 10" |
| .30 Newton | Newton | .300 | .309 | 10" |

GUNSMITHING AND TOOL MAKING BIBLE

| | | | | |
|------------------|------------|-------|-------|---------|
| .300 Savage | Savage | .300 | .308 | 12" |
| .300 H & H | Winchester | .300 | .308 | 10" |
| .303 British | British | .303 | .312 | 10" |
| .303 Savage | Savage | .300 | .308 | 12" |
| .32-20 WCF | Winchester | .300 | .311 | 20" |
| .32-40 | Winchester | .312 | .320 | 16. |
| .32 RF | Stevens | .2985 | .314. | 25" |
| .32 Remington | Remington | .312 | .319 | 14" |
| .32 Win. Special | Winchester | .315 | .320 | 16" |
| .32 Win. S.L. | Winchester | .312 | .321 | 10" |
| 8mm Mauser | Mauser | .312 | .324 | 10" |
| .33 Winchester | Winchester | .330 | .338 | 16" |
| .348 Winchester | Winchester | .340 | .348 | 12" |
| .35 Winchester | Winchester | .350 | .358 | 16" |
| .35 Remington | Remington | .349 | .356 | 16" |
| .35 Win. S.L. | Winchester | .344 | .351 | 12" |
| .351 Win. S.L. | Winchester | .345 | .351 | 16" |
| .35 Whelen | Private | .350 | .3575 | 14" |
| .35 Newton | Newton | .350 | .359 | 12" |
| .375 H & H | Winchester | .368 | .375 | 12" |
| .38-40 WCF | Winchester | .395 | .400 | 36" |
| .38-40 WCF | Remington | .395 | .4-00 | 20" |
| .38-55 | Winchester | .370 | .379 | 36"-20" |

GUNSMITHING AND TOOL MAKING BIBLE

| | | | | |
|-------------------|--------------------|-------|------|-----|
| .38-56 | Marlin | .370 | .379 | 20" |
| .38-70 WCF | Winchester | .370 | .380 | 24" |
| .38-72 WCF | Winchester | .370 | .380 | 22" |
| .38-90 WCF | Winchester | .370 | .380 | 26" |
| .40-50 Sharps | Winchester | .397 | .404 | 18" |
| .40-60 Win. | Winchester | .397 | .404 | 40" |
| .40-65 Win. | Winchester | .397 | .403 | 20" |
| .40-70 Win. | Winchester | .397 | .403 | 20" |
| .40-82 Win. | Winchester | .397 | .403 | 28" |
| .40-90 Sharps | Winchester | .397 | .403 | 18" |
| .40-110 1n. | Winchester | .397 | .403 | 28. |
| .400 Whelen | Private | .400 | .410 | 14" |
| .401 Win, S.L. | Winchester | .400 | .408 | 14" |
| .405 W1n. | Winchester | .405 | .413 | 14" |
| .44-40 WCF | Winchester | .4225 | .429 | 36" |
| .45-60 Win. | Winchester | .450 | .457 | 20" |
| .45-70 U.S. | Springfield Armory | .450 | .457 | 22" |
| .4-5-75 Win. | Winchester | .450 | .457 | 20" |
| .45-90 Win. | Winchester | .450 | .457 | 32" |
| .45-125 Win. | Winchester | .450 | .457 | 36" |
| .45-3 1/2" Sharps | Sharps | .450 | .458 | 18" |
| .50 Sharps | Sharps | .500 | .509 | 36" |
| .50-95 Win. | Winchester | .500 | .512 | 60" |

GUNSMITHING AND TOOL MAKING BIBLE

| | | | | |
|--------------|--------------------|------|------|-----|
| .50-110 Win. | Winchester | .500 | .512 | 54" |
| .50-70 U.S. | Springfield Armory | .500 | .515 | 42" |
| .505 Gibbs | British | .495 | .505 | 16" |

PISTOL & REVOLVER

| Caliber Dia. | Bore Dia. | Groove | Arm | Twist |
|---------------------|--------------|--------|--------|---------------|
| .22 L.R. | .2175 | .223 | Colt | 14" Left |
| .22 L.R. | .2175 | .2235 | S&W | 15" Right |
| .25 ACP (6.35mm) | .24.95 | .2515 | - | 16" either |
| .30 Luger (7.65mm) | .300 | 10 | DWM | 9.85" Right |
| .30 Mauser (7.63mm) | .300 | .310 | Mauser | 8" Right |
| .32 ACP (7.65mm) | .300 | .311 | - | 16" L (Colt) |
| .32-20 | .300 | .311 | S-W | 12" Right |
| .32-20 | .300 | .311 | Colt | 16" Left |
| .32 S & W | .300 | .312 | S&W | 18 3/4" Right |
| .32 Colt | .300 | .311 | Colt | 16" Left |
| .357 Magnum | .350 | .357 | S&W | 18 3/4."Right |
| .38 Special | .350 | .357 | S&W | 18 3/4" Right |
| .38 Special | .348 | .354 | Colt | 16" Left |
| .38 S&W | .351 | .361 | S&W | 18 3/4" Right |
| .38 ACP | .350 | .356 | Colt | 16" Left |
| .380 ACP | .350 | .356 | Colt | 16" Left |
| 9mm | .348 | .354 | Luger | 10,6" Right |

GUNSMITHING AND TOOL MAKING BIBLE

| | | | | |
|-------------|-------|------|------|-----------|
| .38-40 | .395 | .40l | Colt | 16" Left |
| .41 | .395 | .40l | Colt | 16" Left |
| .44-40 | .4225 | .427 | Colt | 16" Left |
| .44 Russian | .425 | .427 | S&W | 20" Right |
| .44 Special | .4225 | .427 | s&w | 20" Right |
| .45 ACP | .445 | .451 | Colt | 16" Left |
| .45 Colt | .445 | .452 | Colt | 16" Left |
| .455 Webley | .450 | .455 | Colt | 16" Left |

MAKING RIFLING BUTTONS

The invention of the rifling process using a swaging button to impress the rifling into solid metal has been the biggest boon to the barrel making industry since the invention of gunpowder. Where it normally took hours to rifle, a barrel now it will only take seconds.

Button rifling is a cold forming process in which a small carbide button or swage, with lands cut in the button. It pulled through the gun barrel bore embosses the rifling in the bore. The button is made a few thousands larger than the finish size that is required, since the metal will return .001 to .0015 thousands.

Button rifling is a surface forming process; no metal is removed in the rifling process. With button rifling, barrels can be rifled much more efficiently and much cheaper than any other process except possibly with hammer rifling, or forging.

All rifling styles can be duplicated by this method. Oddball rifling styles that would be difficult to attain with any other type of cutting or scraping process can be easily done with carbide swaging process. Button rifling will give a much smoother, harder, and more uniform bore than can be obtained with cut rifling, and in turn give much longer barrel life.

On cut rifling the barrel has to be shot several hundreds rounds to get lapped in, or has to be lapped by hand to get top accuracy.

With button rifling, the barrel will shoot from the very first, and there is no wasted shots trying to get it to group good. The old way of rifling that was done in the past hundred or so years was done with single cutters.

They cut out each groove separately, and required several passes to remove the required of metal. It is an extremely slow process and the finish so produced is not that good.

The main improvement in cut rifling came just about at the start of World War 1. This was the start of using broaches. Since far more metal must be removed from the grooves than can be cut out with a single broach, a series of broaches, each a trifle larger than its predecessor was used. This varied in number from 15 to 50, and could be pushed or pulled through the bores.

These gang broaches are formed from a single piece of tool steel. Gang broaching, although much either faster than the older single cutter method or single broaching is costly in tools. Gang broaches are difficult and complicated to make, expensive to keep sharp, sharpen, and easily damaged.

With button rifling, you can rifle the hardest barrel steels, with very little difficulty. It produces the smoothest and most uniform surface yet attained. A single pass is sufficient to finish the entire bore. The button is difficult to fashion accurately and is sensitive to breakage. Nonetheless simple and normally has a long life.

GUNSMITHING AND TOOL MAKING BIBLE

The machinery required for button rifling is similar to that required for broaching, or cut rifling. With the exception that far more power is required for operation with the buttoning process. Because of the high speed at which button rifling may be done, a single machine can turn out many times the maximum number of finish barrels produced by banks of rifling machines.

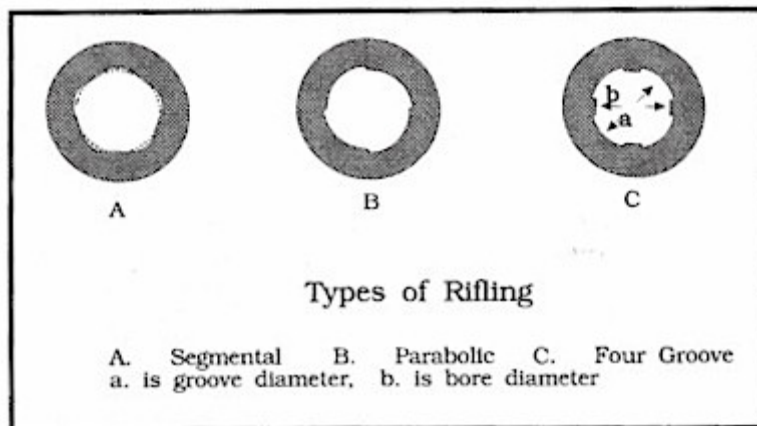
The normal time including setting up to rifle a barrel with buttons is about 3 minutes. There is another process that is used along with button rifling, and that is button reaming. Most button rifling processes call for button reaming, or cold sizing of the bore surface.

By button reaming, you can keep a precise bore size from one barrel to another. This area becomes the top of the lands. This is the same as the rifling button with the exception that it doesn't have any grooves cut into it. Its purpose is to size the barrel and to close the pores in the metal. This button is usually made .0015 larger than the finish bore. The metal will close back about .0015 after the button passes through it.

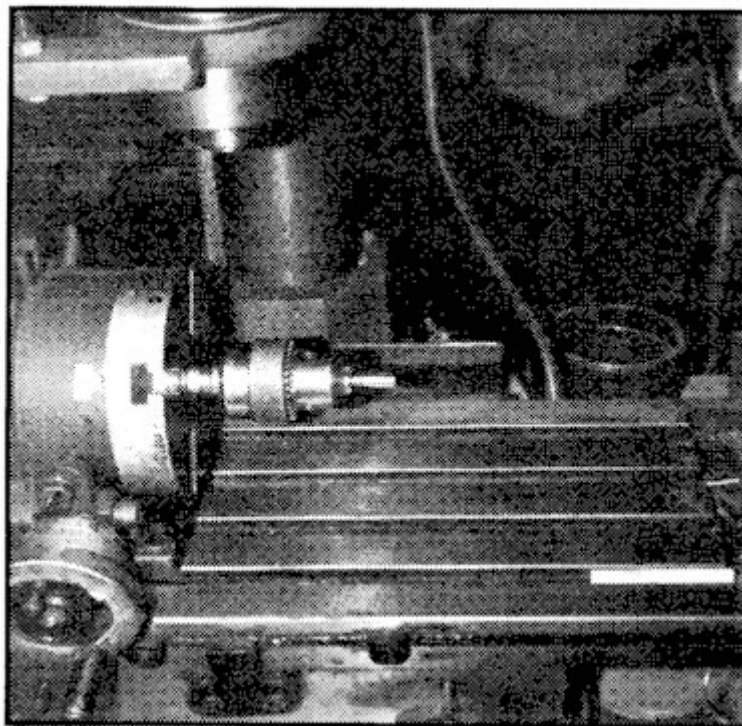
The pull method for rifling seems to be more popular, and must to have the lead on the button exactly matched to the lead on the head of the rifling machine doing the pulling. However, there is another way to make the machine so you can use thrust bearings to allow the button to rotate in the bore. More on this later.

DIFFERENT TYPES OF RIFLING

Do you want to find out what kind of rifling your barrel has? Most of the barrels manufactured today either are hammered rifled or button rifled. In the older guns they used various processes to rifle. To find the different processes may sound difficult, but it isn't.



The button process leaves a definite indication of the manufacturing method clearly visible. Since the original surface of the bore left by the finish reamer is formed into the new groove surface, the reamer marks remain continuous. Not only on the top of the lands but also in the bottom of the grooves.



Cutting the Grooves in the Rifling Button

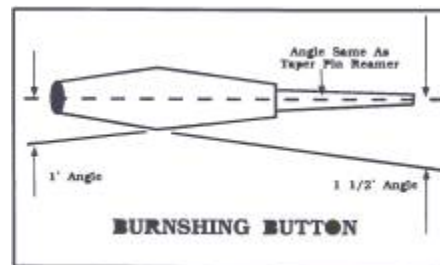
These reaming marks encircle the bore on both land and grooves. In the cutting process, where the

GUNSMITHING AND TOOL MAKING BIBLE

grooves are cut with a tool, you will see tool marks the full length of the barrel in the grooves, running length-ways of the barrel. The reamer marks will still be visible on the top of the lands.

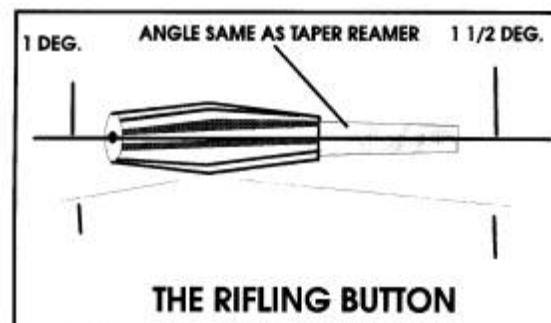
In most cases you can simply remove the bolt and get a suitable light. Look through the barrel from the muzzle end and be able to see what type of rifling it is.

In cut rifling the barrel is just reamed, then the rifling is cut into the bore, and this reamed surface shows to be quite rough when magnified.



The top of the lands in conventional rifled barrels is covered with circular tool marks. These are approximately at right angles to the motion of the bullet.

They tend to wipe off metal from the bullet and create high friction and barrel fouling. The surfaces of the grooves, having been cut out by single tools or broaches moving in the same direction as the bullet will move, have tool marks, which are rough, but will usually not create anywhere near so much friction. Also after it is shot a while will very seldom foul up.



So knowing this it is obvious that the smoother the inside of the barrel, so far as friction and metal fouling are concerned, would be the widest possible grooves, and narrow lands. There is a trade off on this theory however, as the narrow land, is more prone to wear excessively, and to erode at the throat.

So we have to make a compromise and keep the lands wider to attain good barrel life. It can therefore be said that button rifling and button burnishing of bores leave both land and grooves far smoother than any finished reamed bore with grooves cut from it.

Button rifling has lead to new designs of rifling. Many shallower grooves may have advantages, or some

GUNSMITHING AND TOOL MAKING BIBLE

type of special rifling that would have been impossible with the older cutting process.

Some steels give trouble in cut rifling, but can be rifled easily and better with button rifling. Stainless steel is of this type, though it can cause trouble with button rifling through galling. There is one big advantage in button rifling, and that is that a button reamed and rifled barrel is burnished in both lands and grooves, and is **WORKED HARDENED**.

In several barrels that we ran test on we found that the steel tested out about 30 Rc before rifling and almost 60 Rc after rifling. In addition, where the work hardening is especially great was where it is need most, on the driving surfaces of the grooves. The reason for this fact is the maximum rearrangement of metal takes place at the leading corners and sides of the grooves in cold swaging by the button.

Whereas the technical aspects of rifling are usually a guarded secret. We will go into some of the details of rifling and try to make it easy to understand what has been held in secret in the past. Buttons Specifications (burnishing) Buttons are generally made of high tensile strength tungsten, or carbide, usually grade 883 or equivalent. These are ground to size with diamond wheels, on tool-room grinders, or on tool post grinders. The smooth buttons used for burnishing bores, generally used before rifling, have a leading included angle of about 3 degrees.

The flat burnishing surface is .125 in width. The trailing angle is 2 degrees, but it is not too important. Depending on the hardness of the steel, 30 caliber buttons are usually left about .003 larger. Smaller buttons such as 17 calibers usually are left about .002 larger. This based on the barrel steel being 30 to 32 Rc.

The bore closes in behind the button precisely predictable degree, so we can control the tolerance within a few ten thousands of an inch.

GUNSMITHING AND TOOL MAKING BIBLE

RIFLING BUTTONS

The rifling buttons are harder to make than the reaming or swaging buttons. They are made the same except for the grooves are cut in the button (Lands). For example a six-groove button, the included angle on the diamond wheel forming the groove must be no more than 60 degrees, so the sides of the Impressed groove in the rifle barrel are not undercut.

The plane of revolution of the diamond wheel in the grinding process must lie precisely along the helix of the groove in the button.

BUTTON SIZES

The diamond wheels used for grinding the carbide buttons can be purchase from Ash and Co, or Wholesale Tool. If you have an indexing attachment for your mill, you will be able to make your own buttons. If you desire to buy the first ones, they can be purchase from Danjon Corp.

SIZES OF BUTTONS

Here is a list of finish sizes of the sizing button, the rifling button, and the degree of angle to get the twist that is listed.

RIFLING BUTTON SIZES

| CALIBER | SIZING | RIFLING | TWIST | ANGLE |
|--------------|--------|---------|-------|--------------|
| 172 | .169 | .1735 | 10 | 3 deg 10 min |
| 22 short | .2195 | .2255 | 20 | 2 " " |
| 22 LR | .2195 | .2255 | 16 | 2 " 30 " |
| 22WRF | .2205 | .2285 | 14 | 2 " 55 " |
| 22WCF | .2195 | .226 | 16 | 2 " 31 " |
| 22 Hornet | .2195 | .226 | 16 | 2 " 31 " |
| 218 Bee | .2195 | .226 | 12 | 2 " 31 " |
| 221 Fireball | .2195 | .226 | 12 | 3 " 25 " |
| 222 Rem | .2195 | .2265 | 14 | 2 deg 53 min |

GUNSMITHING AND TOOL MAKING BIBLE

| | | | | |
|-----------------|-------|-------|-----|----------|
| 223 Rem | .2195 | .2265 | 12 | 3 " 25 " |
| 222 Mag | .2195 | .2265 | 14 | 2 " 53 " |
| 219 Wasp | .2195 | .2265 | 14 | 2 " 53 " |
| 219 Zipper | .2195 | .2265 | 14 | 2 " 53 " |
| 224 Wea. | .2195 | .2265 | 14 | 2 " 53 " |
| 225 Win | .2195 | .2265 | 14 | 2 " 53 " |
| 22-250 | .2195 | .2265 | 14 | 2 " 53 " |
| 220 Swift | .2195 | .2265 | 14 | 2 " 53 " |
| 22 Savage | .2225 | .2285 | 12 | 3 " 50 " |
| 243 Win | .2375 | .246 | 10 | 4 " 20 " |
| 244 Rem | .2375 | .246 | 10 | 4 " 20 " |
| 6mm | .2375 | .246 | 9 | 4 " 46 " |
| 6mm284 | .2375 | .246 | 10 | 4 " 20 " |
| 25-20 | .2515 | .260 | 14 | 3 " 20 " |
| 25-35 | .2515 | .260 | 10 | 4 " 33 " |
| 256 Win | .2515 | .260 | 14 | 3 " 20 " |
| 250-3000 | .2515 | .260 | 15 | 3 " 20 " |
| 257 Roberts | .2515 | .260 | 10 | 4 " 33 " |
| 257 Roberts Imp | .2515 | .260 | 10 | 4 " 33 " |
| 25-06 | .2515 | .260 | 10 | 4 " 33 " |
| 257 Wea. Mag. | .2515 | .260 | 12 | 3 " 49 " |
| 6.5 Jap | .2575 | .266 | 9 | 5 " 15 " |
| 6.5mm M.S. | .2575 | .266 | 8.5 | 5 " 31 " |

GUNSMITHING AND TOOL MAKING BIBLE

| | | | | |
|---------------|-------|-------|-----|----------|
| 6.5x55 | .2575 | .266 | 7.5 | 6 " 20 |
| 6.5 Rem Mag. | .2575 | .266 | 9 | 5 " 15 |
| 264 Win Mag. | .2575 | .266 | 9 | 5 " 15 " |
| 270 Win | .2715 | .2805 | 10 | 5 " |
| 270 Wea Mag. | .2715 | .2805 | 12 | 4 " 12 " |
| 7mm Mauser | .2775 | .287 | 10 | 5 " 5 " |
| 284 Win | .2775 | .287 | 10 | 5 " 5 " |
| 280 Rem | .2775 | .287 | 10 | 5 " 5 " |
| 7x61 S&H | .2775 | .287 | 12 | 4 " 15 " |
| 7mm Rem Mag | .2775 | .287 | 9.5 | 5 " 23 " |
| 7mm Wea Mag | .2775 | .287 | 12 | 4 " 15 " |
| 7.5 Swiss | .3015 | .311 | 10 | 5 " 30 " |
| 30 Carbine | .3015 | .311 | 16 | 3 " 29 " |
| 30-30 Win | .3015 | .311 | 12 | 4 " 35 " |
| 300 Sav | .3015 | .311 | 12 | 4 " 35 " |
| 308 Win | .3015 | .311 | 12 | 4 " 35 " |
| 30-40 Krag | .3015 | .311 | 10 | 5 " 30 " |
| 30-06 | .3015 | .311 | 10 | 5 " 30 " |
| 30-06 Imp | .3015 | .311 | 10 | 5 " 30 " |
| 300 H&H Mag. | .3015 | .311 | 10 | 5 " 30 " |
| 308 Norma Mag | .3015 | .311 | 10 | 5 " 30 |
| 300 Win Mag. | .3015 | .311 | 10 | 5 " 30 |
| 300 Wea Mag. | .3015 | .311 | 10 | 5 " 30 " |

GUNSMITHING AND TOOL MAKING BIBLE

| | | | | |
|---------------|-------|-------|------|--------------|
| 7.65mm Mauser | .3045 | .315 | 9.8 | 5 " 40 " |
| 303 British | .3045 | .315 | 10 | 5 " 43 " |
| 7.7 Jap | .3045 | .315 | 9.5 | 5 " 53 " |
| 32 Win Spc. | .3165 | .323 | 16 | 3 " 35 " |
| 8mm Mauser | .3135 | .327 | 9.25 | 6 " 7 " |
| 8mm-06 | .3135 | .327 | 9.25 | 6 " 7 " |
| 338 Win Mag. | .3315 | .341 | 10 | 5 " 30 " |
| 340 Wea Mag. | .3315 | .341 | 10 | 5 deg 30 min |
| 348 Win | .3415 | .351 | 12 | 5 " 12 " |
| 35 Rem. | .3515 | .361 | 16 | 4 " |
| 358 Win | .3515 | .361 | 12 | 5 " 22 " |
| 350 Rem Mag. | .3515 | .361 | 16 | 4 " |
| 35 Whelen | .3515 | .361 | 16 | 4 " |
| 358 Norma Mag | .3515 | .361 | 14 | 4 " 32 " |
| 375 H&H Mag | .3695 | .3785 | 12 | 5 " 33 " |
| 378 Wea Mag. | .3695 | .3785 | 12 | 5 " 33 " |
| 44 Rem Mag | .424 | .430 | 38 | 2 " |
| 444 Marlin | .424 | .430 | 38 | 2 " |
| 45-70 | .4515 | .4605 | 22 | 3 " 41 " |
| 458 Win Mag. | .4515 | .4605 | 14 | 5 " 48 " |
| 460 Wea Mag. | .4515 | .4605 | 16 | 5 " 8 " |

PISTOLS AND REVOLVERS

| | | | | |
|---------|--------|---------|-------|-------|
| CALIBER | SIZING | RIFLING | TWIST | ANGLE |
|---------|--------|---------|-------|-------|

GUNSMITHING AND TOOL MAKING BIBLE

| | | | | |
|------------|-------|-------|----|--------------|
| 22 LR | .2195 | .2255 | 14 | 2 deg 52 min |
| 25 ACP | .251 | .2525 | 16 | 2 " 49 " |
| 30 Luger | .3015 | .313 | 9 | 6 " 12 " |
| 32 ACP | .3015 | .314 | 16 | 5 " 37 " |
| 32-20 | .3015 | .314 | 16 | 5 " 37 " |
| 32 SW | .3015 | .315 | 18 | 5 " 34 " |
| 357 Mag. | .3515 | .360 | 18 | 6 " 28 " |
| 38 Spec. | .3515 | .360 | 18 | 6 " 28 " |
| 38 SW | .3525 | .364 | 18 | 6 " 26 " |
| 38 ACP | .3515 | .359 | 16 | 4 " |
| 380 | .3515 | .359 | 16 | 4 " |
| 9mm | .3495 | .357 | 11 | 5 " 45 " |
| 38-40 | .3965 | .404 | 16 | 4 " 30 " |
| 41 | .3965 | .404 | 16 | 4 " 30 " |
| 44-40 | .424 | .430 | 16 | 4 " 45 " |
| 44 Russian | .424 | .430 | 20 | 3 " 52 " |
| 44 Spec. | .424 | .430 | 20 | 3 " 52 " |
| 45 ACP | .4465 | .454 | 16 | 5 " 2 " |
| 45 Colt | .4465 | .455 | 16 | 5 " 2 " |
| 455 Web. | .4515 | .458 | 16 | 5 " |

The twists that are used in the above listing are standard factory twist. The finish groove size given by the rifling button will give the correct diameter if the steel that is used falls in the range of 30 to 32 Rc. If you use a steel of 28 to 30 Rc, the groove diameter will be slightly larger, and harder steel will be slightly smaller Diameter.

GUNSMITHING AND TOOL MAKING BIBLE

The twists given are standard, but the button could be made with any twist. You will find there are far more accurate combinations than the factory twist, but they are a good starting point.

TWIST FORMULA

The formula for finding the correct angle for the twist that you want for the rifling button is the diameter of the groove, which is .308 (30 Caliber); $308 \times \pi$ is 96761054, this answer divided by the twist gives you an answer of .080634.

Now look at a sine chart and find that figure, it will be 4 degrees and 37 minutes. That is the angle that you want to cut the grooves on the button to get a 1 in 12 twist.

In a 17 caliber for example you will find that the 1 in 10 twist is fairly well standard. I have done quite a bit of experimenting and have found that a 1 in 14 twist for me has been very accurate. It has given me consistently 1/2 minute or under groups at 100 yards. The main trouble in accuracy in 17 calibers seems to be the bullets.

I have found that the slightest air pocket in the bullet had a tendency to throw the bullet off in the 1-14 twist. With good bullets, the 1-14 will be found superior for top accuracy.

The 1-10 twist will usually shoot the poor made bullets better with considerable accuracy on the average. This is also true of the other calibers. Take the 30 calibers for example. The 150-grain bullet will shoot like a house afire with the 1-14 twist.

One of my most accurate and favorite game rifle was a 243 with a 1-14 twist. The rifle was used for long range on coyotes, crow, etc. I used a 75-grain bullet for the best accuracy.

If you want to experiment, you will probably come up with a far more accurate rifle by doing this. You can tailor your rifle to shoot the bullets and speed that you want. The main problem you may have is with bore tolerance. This will be with the steel that you use. Every barrel maker is plagued with this problem.

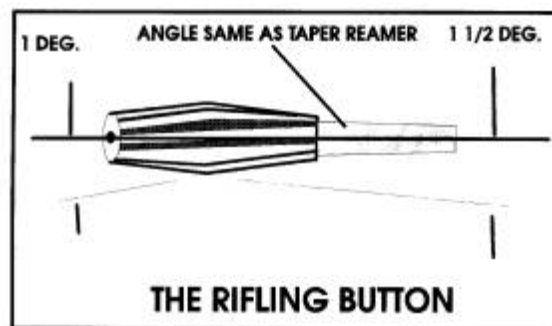
If you have hard spots in the barrel, you will come out with tight spots in the barrel, and if there are soft spots, there will be loose spots. I have got such bad steel that when the barrel push it a short ways, and then it would drop 8 to 10 inches before stopping. What you had is a junk barrel.

GUNSMITHING AND TOOL MAKING BIBLE

MAKING THE BUTTONS

Let us go into the design of the button and how it is made. I will assume that you do not have tool-room equipment so we will use what is normally found in a small shop. We will make a 30-caliber button first. Get a few pieces of 5/16-inch grade 883 carbide, 1 1/2 inch long.

Wholesale Tool should be able to supply you with the carbide. In addition, you will need a piece of 5/16-drill rod, a 1/4 diamond-grinding wheel, and a 1/8 inch 60 degree diamond wheel. The 1/8 wheel that is 4 inches is for the milling machine, the 1/4 x 6 inches is for the tool post grinder. You will also need some diamond-lapping compound for finishing the buttons, coarse, medium, and fine.



Now cut 2 pieces of the 5/16-drill rod, 1/2 inch long, square and true the ends, center drill one end. You will need a small V center bar. Lay the carbide piece in the V, and the short drill rod, with the centers to the outside. Put some low melting silver solder paste on the ends, press them together and heat them up until the silver solder melts, and let cool. Be careful that you do not over heat the carbide or heat it up too fast, as it will crack.

When soldered good, let it cool in the V ways. It is now ready to grind. You will need a small lathe dog to hold the drill rod/carbide to the faceplate, while it is between centers.

You will need to set up a can of water-soluble oil to be used when you grind the carbide. This will also be needed for the milling machine when you grind the land grooves in the buttons. It would be best if you can use a mist type, as the carbide must not get hot.

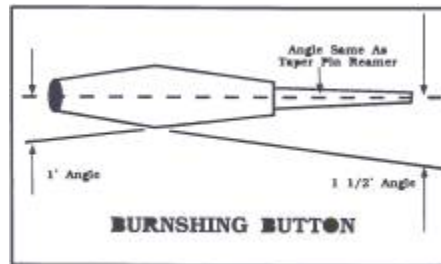
GRINDING THE CARBIDE

When grinding the carbide use as high an rpm as possible, on the wheels. Keep plenty of coolant on the work piece, and the wheel to keep the carbide cool and the diamond wheel from plugging up. The lathe should be in back gear, and the feed slow.

GUNSMITHING AND TOOL MAKING BIBLE

TAPER PER INCH

To get the correct taper per inch, for the included 3 degrees taper per inch. We will use 1-1/2 degrees, as the 3 degrees is included angle, or 1-1/2 degrees on both sides. Now look at the taper per inch chart. In the left column go down to the 1 degree and then across to 30'. This is 1 1/2 degree, and you will see a figure of 0.02618. This is taper per inch.



Now to set up the lathe for this taper, you will need 2 dial indicators; one will need to be at least a 1-inch travel. You will need a piece of tool steel the exact length as the carbide and end pieces. So both have to be the exact length, if not the angle will change. Make sure the tool steel is running true and center both ends.

It would be wise to heat treat it, and grind it to exact size so there will be no run out. Be sure that is no taper after grinding. Once this is ground and completed, leave it between the centers. Set the 1 dial indicator on the carriage, and set tip on the tool steel.

Set the other so it will measure the travel of the carriage. Loosen up the setscrews on the tail stock, and turn the one in that moves the center towards you. Move it over a bit, reclamp the tail stock, and reset the center. Now zero both indicators, and move the carriage toward the head stock.

When it has traveled 1 inch, see how many thousands the other indicator reads. When you have set the tail stock over so it reads .026 in a 1-inch travel, you have it set for 1-1/2 degrees, or 3 degrees included angle.

Replace the piece of tool steel for the carbide, and then turn on the lathe. Be sure it is in back gear, turn on the grinder and move it in so it is just touching the carbide at the tail stock end.

DO NOT TRY TO TAKE OFF OVER .005 PER EACH PASS.

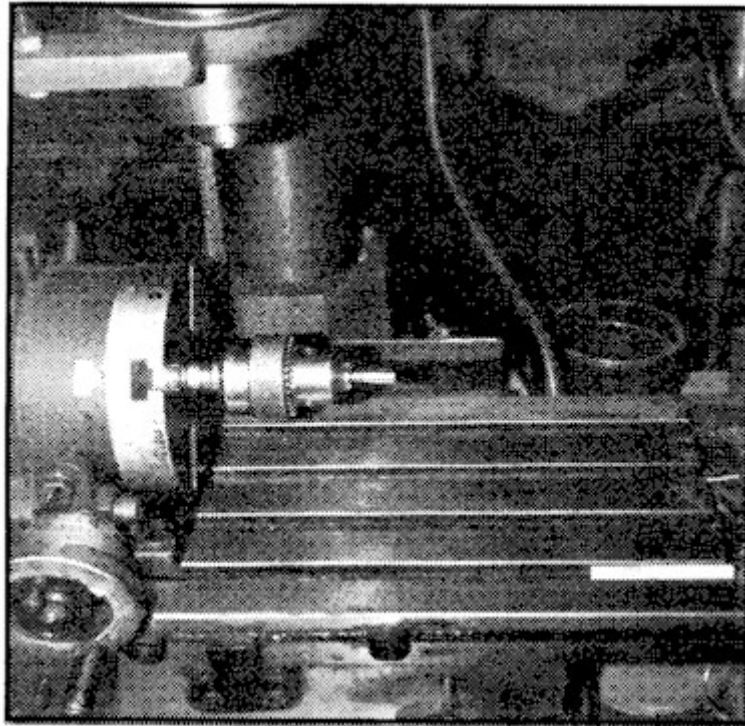
The feed should be slow or you will wear out the diamond wheel too fast. When you have ground both angles, to size, stop and check the O.D. of the work piece. You should leave about .0005 for final finishing. Now you will have to grind the shank to fit the pull rod. You will grind this to the standard No. 5 taper reamer. No. 5 is the size that you want to use for the 30 calibers, and it will give you a diameter of .2409 on the small end.

Reset the angle on the tail stock for the correct taper per inch of the taper pin reamer. Grind the shank

GUNSMITHING AND TOOL MAKING BIBLE

end to the size shown, but I would recommend leaving the small end of the shank about .005 larger than shown, so the button won't bottom out.

When completed, remove the tool post grinder, and reset the tail stock back to 00. Put the ground button back into the lathe, and finish it to the correct size. Turn the lathe back with a fairly high RPM. Use the diamond files, starting with the coarse and smooth the carbide.



Cutting the Grooves in the Rifling Button

Be careful as you only have .0005. After smoothing up with the coarse grit, use the medium, then the fine. Finish with the fine to get the final size. Now with the very fine diamond compound, get a small tongue stick, and coat it with light oil and diamond compound and finish lapping the button. You need only be concerned with the leading edge and the top.

Finish as fine as possible. You will need a different taper pin reamer for each different size button that you make. These reamers will be used to put the correct taper in the pull rod for the button.

You will need a different taper pin reamer for each different size button that you make. These reamers will be used to put the correct taper in the pull rod for the button. The sizing button is made the same way.

With stress proof, the finish is so good that I usually did not use the sizing button. In addition, with stress proof, I found that the sizing button worked hardened the bore so much that it was difficult to pull the rifling button through the barrel.

On the 4140-4150 steels, you will need to button ream to size the bore.

GUNSMITHING AND TOOL MAKING BIBLE

INDEXING HEAD

Now that this is done it is time to cut the land grooves in the button. Set up the indexing fixture on the milling machine. You will need some way to set an angle to the indexing head.

They have special angle plates for this purpose. If your indexing head is set up for collect or drill chuck, you can make a short piece of drill rod, drill. Then ream for the No. 5 taper pin reamer, and solder the button in place. When cool chuck the drill rod and button.

The angle is set the same way on the milling machine as it was done on the lathe. Your 30-caliber button with 1 in 12 twist, the angle is 4 degree and 35 minutes, or referring to the Taper per inch chart it would be .0795. Set this angle of taper on the indexing head and it is completed.

Put your arbor with the 1/8-inch wide 60-degree diamond wheel in the collet of the mill. Now this is tricky. You will have to lower the grinding wheel to where it just touches the large diameter of the button.

One half of the button is .555; add .062, which is half of 1/8, which is .218. Now set up the dial indicator and run down the diamond wheel to .218.

If everything was done right, it will be on the exact center. Turn on the mill at the highest speed it will run, and the mist coolant. Bring the diamond wheel to the edge of the carbide to where it just touches. Set it for a .005 cut, and feed it across very slow.

Keep track of how many thousands that you have fed in on the first groove. The only thing that you have to do now is to figure how many lands and grooves you want and how wide the grooves should be.

SWEATING BUTTON TO PULL ROD

After all the grooves are cut, the button is ready to sweat to the rod. The rod is .281 in dia. and is drill rod. The drill rod should be chucked in the lathe, centered, drilled to depth with a drill slightly larger than the small end of the carbide. It is then reamed with the No. 5 taper reamer.

While still in the lathe, coat the inside of the finished reamed hole with silver solder paste; stick the button in the reamed hole. Put the lathe in back gear and start up. Take the torch and with a cool flame, heat the button, shank, and rod until the silver solder melts.

Hold the button for a few seconds so the entire inside surface is tinned, and turn off the lathe while pressing the button in hard in the reamed hole. Let it cool slowly.

The button is now attached to the pull rod. The next step is to cut the rod to the right length, turn, and thread the rod to a 1/4 x 20 thread. This will be attached to the rifling head. This end should be hardened and brought back to a light blue (700 degrees). If you fail to do this, the threaded end will break the first time you use it.

GUNSMITHING AND TOOL MAKING BIBLE

Now we have all the necessary tools made for rifling the barrel, except the rifling machine.

RIFLING CUTTER

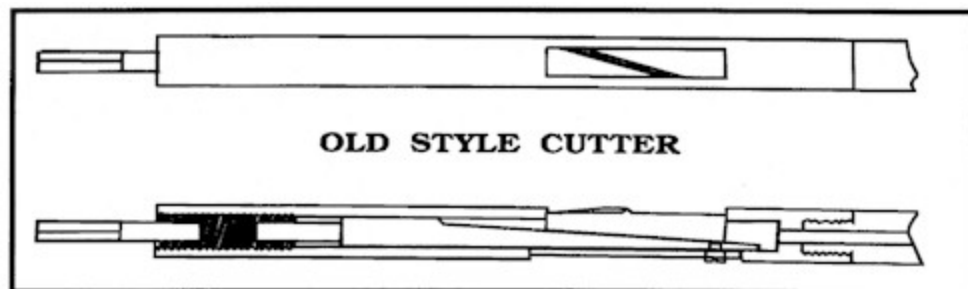
In rifling barrels, a rifling head to hold the cutter is used. This is attached the rod or tube which draws the cutter through the barrel. The rifling head is a steel cylinder, three to 6 inches in length, which will just pass through the drilled and reamed barrel blank.

On the side a slot is cut lengthwise of the cylinder, just wide enough to accept the cutter, which fills the slot from side to side and end to end closely enough so that it has no movement. The slot is cut nearly through the cylinder, seating the cutter as deeply as possible.

The rifling cutter is made from a good tool steel, such as O1 tool steel. It is flat-bottomed and its cutting edge is of the hook type, like a file tooth. The cutting edge has a rake of five to six degrees, both on the face and on the top. The top of the cutting edge is slightly rounded which will fit the radius or diameter of the barrel. The steel cutter is usually about 1 1/2" long and the cutting edge is slightly back of center.

This will leave a space in front of it large enough to hold the chips that are cut in one pass.

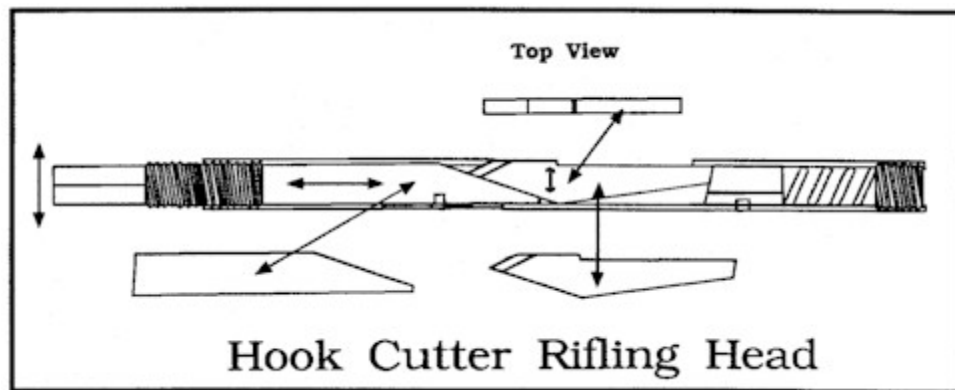
When the cutter is setting on the bottom of the slot the top of the cutting edge is just below the surface of the rifling head. The cutter is raised to rifling position by placing very thin brass shims underneath of it in the slot. The brass shims should be .0002" to .0003" in thickness.



After the rifling cutter makes a cut in each groove, another shim is placed beneath the cutter. Another cut is then made in each groove until all the grooves are cut to the proper depth. A small hole is first drilled through the rifling head on the bottom of the cutter slot so a small punch can be inserted through the hole to remove the cutter out of the slot in the rifling head.

The rifling head is a hollow or tubular piece of high-carbon tool steel that is hardened. The hook-type cutter is set in a port within this tube and the hook or cutting edge is about one fourth of the length of the cutter from the rear end. The rear end of the cutter is beveled off at a thirty-degree angle on the top side and the rear end in the rifling head is beveled at this same angle. The cutter must be beveled on each end at the bottom from a point directly beneath the cutting edge. The bottom bevel is normally ten degrees. At the rear of the rifling head, a beveled wedge rests beneath the beveled rear of the cutter.

GUNSMITHING AND TOOL MAKING BIBLE

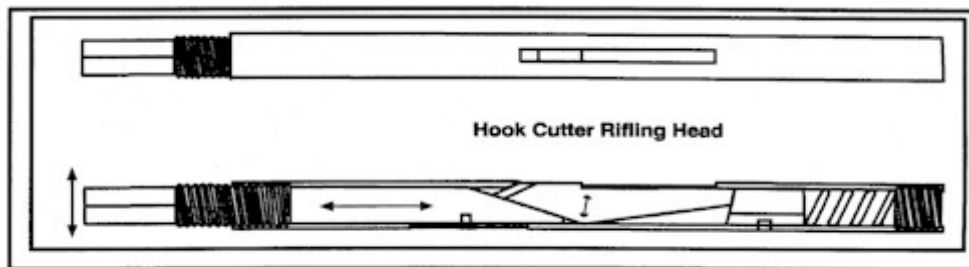


The bevel of the wedge is the same as the bevel on the bottom of the cutter, ten degrees. This beveled wedge is pushed forward by a screw. The rear of the rifling head has fine threads and is tapped into the rear of the rifling head. Turning this screw forward in the rifling head results in pushing the beveled wedge farther forward under the cutter and raises the cutting edge.

A cut is made in each groove of the barrel before moving the wedge farther forward to raise the cutter for a deeper cut. The front end of this hook-type cutter, which is three-quarters of the length of the cutter. This seats against a steel plunger within the tube that has a coil-spring in front of it.

The front end of the cutter is beveled back from the top at about ten degrees. The end of the spring-backed plunger is beveled at ten degrees in the opposite direction, so that its included angle with its top surface is 100 degrees. The front end of the cutter is held upward against the top surface of the rifling head. The cutter is normally about 2 to 2 1/4 inches long over all and the rifling head 6 to 8 inches long depending on the caliber. The top or cutting edge of the hook is cut on a radius to fit the bore.

The cutting edge of a rifling cutter is ground and honed to a template. When it is resharpen or honed during the rifling operation its form will not be changed at any point. The cutting edge has to be kept very sharp and very smooth to do a good job. The barrel steel is tough and tends to tear, rather than cut clean, unless the tool is kept sharp.



The scrape-type of rifling head leaves a better finish in the grooves than does the hook-type but it is more difficult to keep sharp and requires very careful honing to do a good job. Its cuts by scraping rather than a shearing cut and the shavings are fine.

GUNSMITHING AND TOOL MAKING BIBLE

The rifling head is a hollow cylinder, and is made of high-carbon steel with a slot for the cutter cut lengthwise, about two inches long, on one side. The port has to be cut very accurate, as the scrape cutter must fit it closely with no movement. The cutter cuts in both directions while traveling through the barrel. The rifling head is about 6 to 8 inches long and is threaded internally on both ends. There is a thread at one end for attaching the pull tube, which is used to carry a supply of oil to the cutter.

On the other end, a fine thread is used for the adjusting screw to raise the cutter. In the bottom of the rifling head between the port for the cutter, and on the opposite side, the fine threads for the adjustment screw, a narrow slot is cut length-wise of the head. This is for the head of a screw to set in which is screwed into the bottom of the adjusting wedge.

The cutter body is fitted very close in the slot in the rifling head and the bottom of the cutter body is ground on a taper of about ten degrees from one end to the other. The front edge of this taper is at an exact right-angle fit to the sides of the cutter body. The cutting edge of the scraper on top of the cutter body is not cut at right angles to the sides of the cutter body and rifling head. It extends across the top of the cutter body at a forty-five degree angle to give as much shearing effect to the scrape as possible.

The scraper is at the central point of the cutter body and the body of the cutter is cut away at each side of the scraper to give chip space. The edge that does the scraping has an included angle of eighty degrees, and the sides sloping down and away from the edge equally in both directions to the top of the cutter body. This scraping edge also has the contour of the circle of the groove diameter of the barrel. The edge should be ground and honed to a template. By doing this its shape will be true and will remain so. The template is cut from thin 01 tool steel.

The wedge, which raises the cutter in its slot in the rifling head, is turned with a circular contour on the bottom to fit the contour of the inside of the rifling head. The top of this wedge is also ground off on a ten-degree taper to match that on the bottom of the cutter body. The thickness of the wedge has its thin end that extends slightly beyond the thick end of the cutter body. This is toward the end of the rifling head to which the pull-rod is fastened.

The thin end of the tapered wedge is ground square on the end. The square end then sets against the square-ended plug, which is backed by a spring. The spring is backed by the end of the pull-rod inside the rifling head. In the bottom of the wedge a hole is drilled and tapped for a small screw. The head of which fits the slot cut in the bottom of the rifling head.

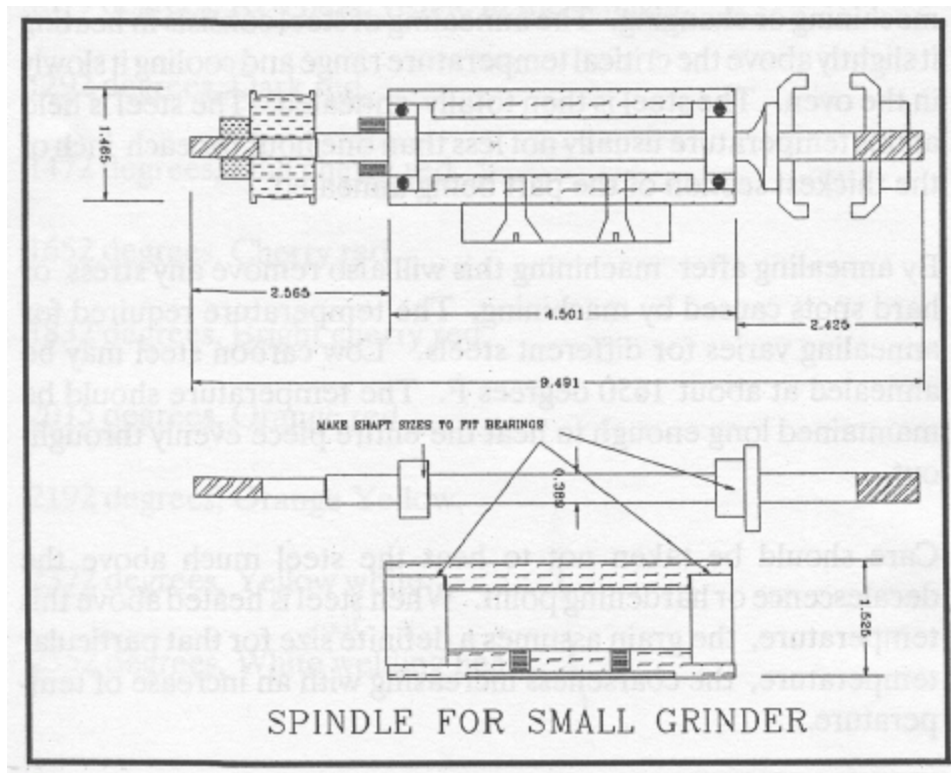
The screw prevents the wedge from turning and is made from 01 tool steel, should be hardened to prevent wear. The adjusting screw for the wedge has an unthreaded portion beyond the threaded part, smaller than the threads. The end of this unthreaded portion is ground square and fits against the large end of the adjusting wedge. When the adjusting screw is screwed forward in the rifling head, it moves the tapered wedge forward and upward under the cutter, raising it as necessary.

THE TOOL GRINDER

If you need to do tool making in the shop, you will need a tool post grinder. It is a simple matter to make a small grinder for small tools. You will have to do a little looking around in some appliance shops to find a motor that will run at a speed of 15,000 to 20,000 RPM. You can also find new high-speed electric motors sold by W.W. Granger. Most large cities have a store, or an appliance store will be able to give you an address of the nearest store.

Most vacuum cleaner motors will run at this speed. It will require a bit of work to cut down the housing to be able to make one work.

There are several types of small motors that will run at this speed, and they will mount directly to the base with very little alternations.



The bearing housing is made from a piece of mild steel shafting, bored and turned as indicated. You might be able to find a ready built mandrel from some bearing supply business, or a tool supplier. This piece cannot be held in a chuck while boring, as it projects too far out. Hold the head end in the three-jaw chuck and support the tail end in the steady rest. This means that the ends must be centered and the outside finished before you bore and finish the inside.

The recess for the bearings should be a good push fit on the outer races.

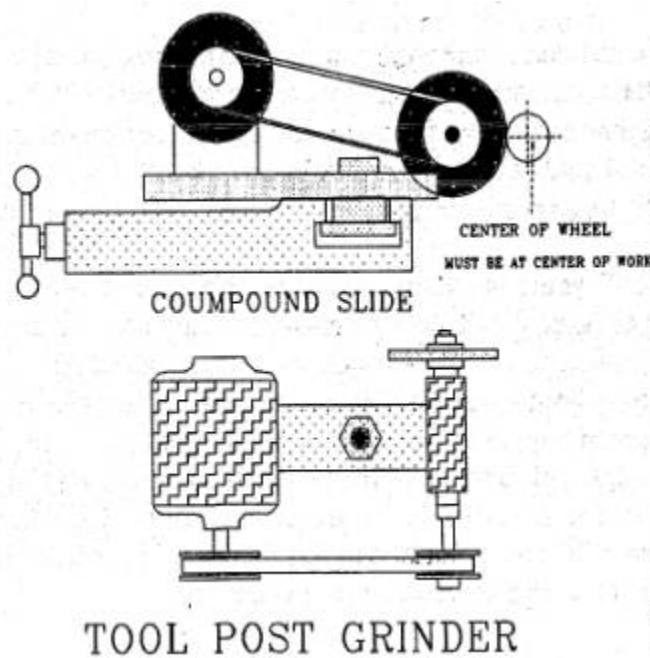
The pulleys are made from mild steel. Since it is desired to use a flat belt, they should have a crown

GUNSMITHING AND TOOL MAKING BIBLE

turned on the face under the belt. A flat belt always tries to run on the highest place on the pulley; if there is a crown in the center, making it the highest place, the belt will run there and not need the flanges on the sides. These are only to help if the belt stretches out of shape and one edge gets longer than the other, in which case it will run to the side off the crown. When the belt starts to do this, discard it, as it can start to whip at the high speed and cause vibration.

Make a pulley for the spindle, and a similar one for the motor, but fitted to the motor shaft. As these very small mounted grinding wheels must run very fast, you may have to make several sets of pulleys to find the maximum speed you can run it. This will be limited by the belt action.

Because of the high Speed required, it is not possible to use a belt of much weight, such as a "V" belt. Such a belt would stand out away from the pulleys, due to centrifugal force, and would not only do very little work but would be apt to start whipping. The small flat rubber belts, made for some floor polishing machines, work very well at this speed. Since the total length of the belt is about 16 inches, you should get one before making the base of the grinder.



Then, when the pulley diameters are known, the distance between pulley centers can be worked out. This will govern the length of the 7/16-inch slot and the position of the bolt to the "T" slot of the compound slide.

Make up two collars with parallel faces to grip the grinding wheel. After boring and reaming the hole, mount them on a mandrel and finish both faces at the same setting. Use very light cuts so that the collars will not slip on the mandrel. The face of the collar that bears on the grinding wheel is relieved so that pressure on the wheel is concentrated well out on the wheel.

A layer of onionskin paper should be placed between wheel and collar to equalize the pressure. If the collars are not relieved, one collar may put pressure on the wheel near the shaft while the other bears

GUNSMITHING AND TOOL MAKING BIBLE

near the rim. This could put a strain on the wheel and damage it.

MAKING REAMERS AND BARREL REAMING

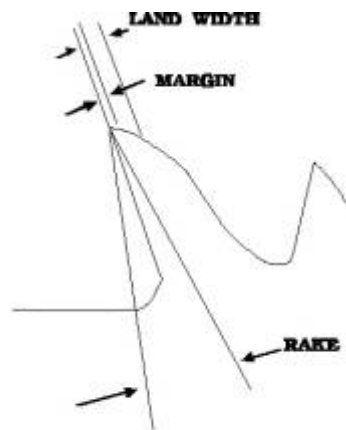
This is the most important part of making the rifle barrel. If you don't have a true and smooth bore, you don't have anything. I will show you how to make reamers for finishing the barrels. On barrel reamers, you will need two reamers. One a rough reamer for removing and cleaning up the drilled bore, and the finish reamer to take the bore to the correct size.

INFORMATION ON REAMERS

Reamers are made with both straight and helical flutes. The latter provided a shearing cut and are especially useful in reaming holes having key ways or grooves. These are bridged over by the helical flutes, thus preventing binding or chattering. Hand reamers are made in both solid and expansion forms.

SHAPE OF FLUTES

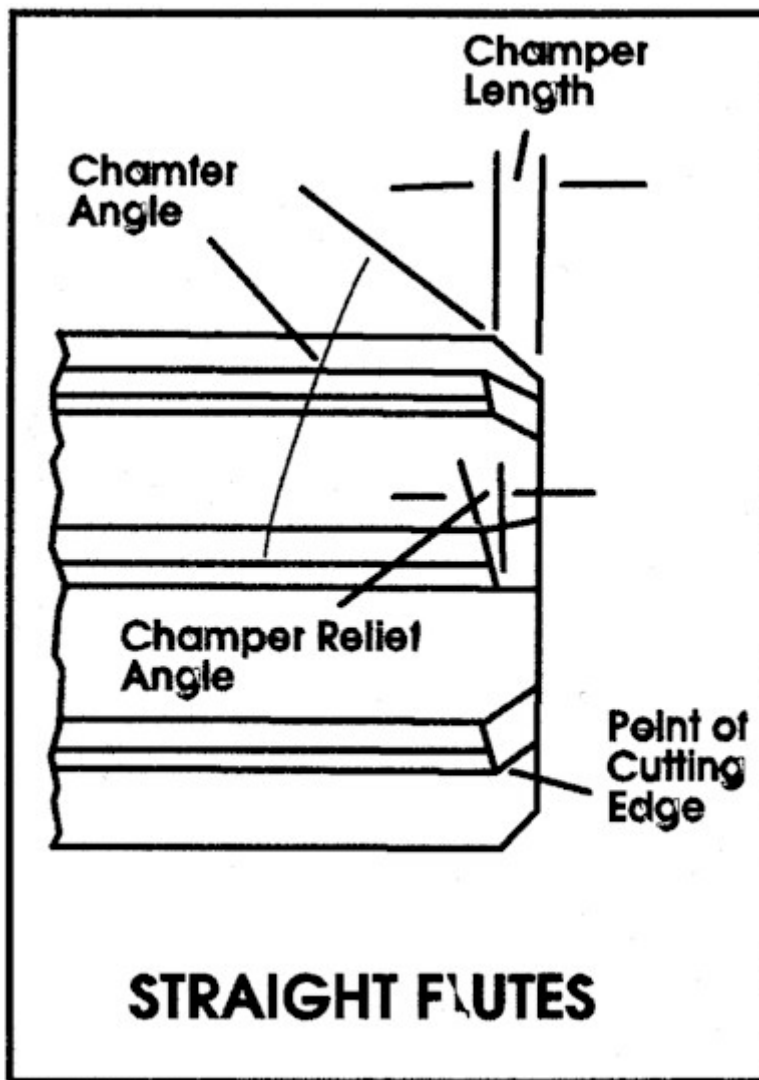
Style and shape of the flute determine its ability to carry away chips and the relative strength of the tooth. For manufacturing, a straight shank may be used. With fluting reamers, the cutter is so set about to the center of the reamer blank so the tooth gets a slight negative rake, the amount is so selected that a tangent to the circumference of the reamer at the cutting point makes an angle of about 95 degrees with the front face of the cutting edge.



REAMER FLUTE SHAPE & DESIGN

When fluting reamers, it is necessary to break up the flute, which means to space the cutting edges uneven around the reamer. The difference in spacing should be very slight and need not to exceed about .004 either way.

The manner, which you use to break up the flutes, is if the reamers are made on a mill is to set the cutter anywhere from .002 to .004 in front of the center of the reamer blank, and changing it a .001 or so on each flute.



The relief of the cutting edges should be comparatively slight. They can be ground close on the tool post grinder and stoned flat with an Arkansas stone. The flat relief is what I have used all along, because the reamer has a keener cutting edge.

CHATTER

This will be the one thing in barrel making that will cause you the most trouble. Even if the reamer and relief are perfect, you can still get chatter. The first thing you need to do when using a new reamer is to spray the reamer with layout fluid. If the reamer is chattering, when you remove the reamer, be able to see if you have enough clearance, etc.

Sometimes a too sharp a reamer will chatter, or it may have too much clearance. If the pilot on the reamer is not a close enough a fit, that can cause chatter. Sometimes reducing or increasing the speed or feed will help. I cut all of my reamers on zero rake, and have very little trouble. If you are using commercial reamers, there can be too much positive or negative rake, and that can cause chatter.

GUNSMITHING AND TOOL MAKING BIBLE

REAMING SPEEDS

In most of my reaming I find that a good starting point is about two-thirds the drilling speed for a given material. If you ream too slow, it takes too long to ream a barrel, and very few barrels can be turned out. If too high a feed or speed premature dulling, chatter, and usually a rough finish is the result.

REAMING FEEDS

In reaming, feeds are usually much higher than those employed for drilling, often being 200 to 300% greater. Too low a feed may result in excessive reamer wear. Always, the feed must be high enough so that the tool cuts, rather than rubs. I find that too high a feed will cause the hole to be oversize, and rough. I also have that a good starting point is somewhere between .0015 to .004 feed per flute per revolution. The smaller bores such as .17- .224 a .001-.003 per revolution is a good start. I can only recommend that you find the highest feed that will produce the required finish and accuracy.

STOCK ALLOWANCES

This is covered in the chapter on barrel reaming and reamers.

LUBRICANTS

This is very an important item in barrel making, as the type of lubricant that you use for reaming will determine the quality of the reamed bore. The lubricant is used to cool the reamer, remove the chips from the barrel, and to improve the finish of the work. Normally for most steel a sulfurized oil, or a high E.P. value mineral oil. Contact a business that supplies cutting oil and they will be able to help you. You will have times when you are unable to get a smooth reamed hole.

THE MOST COMMON ARE;

CHATTERING

When the flutes are not evenly stoned, or the flutes are cut back of centerline, stoned with too great a clearance. Chips clinging to the flutes - caused by too high a revolving velocity.

REAMER PLUGGING

Reamer plugging up by not having enough oil pressure and flow through the flutes, or flutes not being stoned out, and allowing saw teeth to form on the cutting edge. Enlarged holes caused by the reamer being oversized.

GUNSMITHING AND TOOL MAKING BIBLE

ARKANSAS STONE

The cutting edge of the reamer is kept sharp by honing with an Arkansas stone over the cutting edges. The reamer should be touched up about every two barrels.

SURFACE SPEED

The surface speed for reaming should be rather slow, on a regular barrel-reaming machine; the reamer turns, but on the lathe the barrel turns and the reamer is stationary. Instead of using an open belt and higher speed, the lathe is set in back gear, and run at the slowest speed.

The feed can be made faster than that used for drilling. The barrel reamer is pulled through and used for a greater depth, with more cutting edges in contact with the barrel.

For the roughing reamer you can use a feed twice as fast as that for finishing. After the drills and reamer are made, and kept in good shape, many barrels can be turned out with them. Reaming is a simple operation, and with this information and the tools to produce the barrels, you will turn out high-grade barrels.

BARREL REAMER SIZES

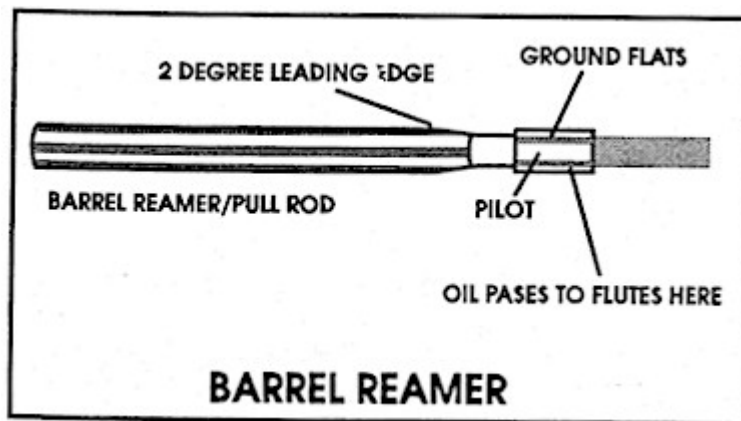
Listed below are the Caliber, size of the rough Reamer, and the size of the finish reamer.

| Caliber | Rough Reamer | Finish Reamer |
|---------|--------------|---------------|
| 172 | | .168 |
| 224 | .215 | .218 |
| 244 | .233 | .236 |
| 257 | .248 | .250 |
| 264 | .254 | .256 |
| 270 | .268 | .270 |
| 284 | .274 | .276 |
| 308 | .298 | .300 |
| 303 | .301 | .303 |

GUNSMITHING AND TOOL MAKING BIBLE

| | | |
|-----|------|------|
| 32 | .309 | .311 |
| 358 | .348 | .350 |
| 375 | .365 | .367 |
| 44 | .419 | .422 |
| 457 | .448 | .450 |

I will go through all the steps of making reamers, from the start of reamer blanks from a piece of tool steel, to the finish reamer, ready to be used to ream the barrel. To start you will need a vertical milling machine, and an indexing fixture. These two items are the two main pieces of equipment necessary to make cutting tools.



I will go through with you on making a complete set of tools for a 308-barrel. You will need two each, 5/16-inch (.312) drill rod, and 6 inches long. Once you have the two - 5/16 inch drill rod cut, go to the lathe. Chuck up one of the pieces and using a 1/4 inch center drill, center one end just deep enough to get a good center. The other end uses 3/8-inch center, and center it to the outside edge of the drill rod.

The reason for this is that on this end you will attach the pull rod to the reamer. In most reamer operations, using the lathe you will note that tubing is used instead of a solid rod. The reason that I use a solid rod is that, (1) it is much cheaper, (2) it is more rigid than tubing and seems to eliminate the chattering that you get from time to time.

Also if the reamer gets dull or it should plug up, with the tubing, it would wind up the tubing and ruin it. With a solid rod, you will be more able to stop the machine before it ruins the reamer. If it should freeze up in the barrel, the worst that will happen is that the reamer will pull out of the sweat joint that attaches the rod to the reamer.

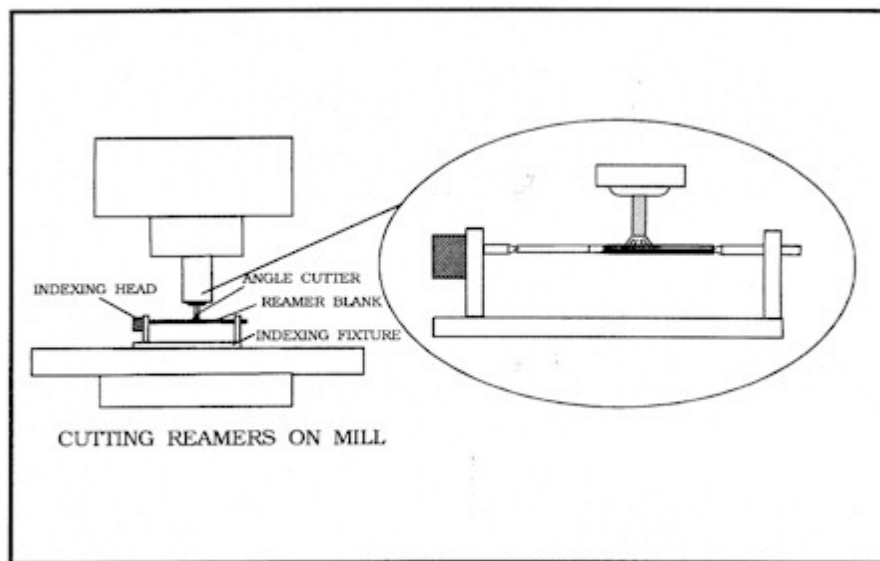
GUNSMITHING AND TOOL MAKING BIBLE

Then all that is necessary is to drive the reamer from the barrel, resharpened, and sweat the reamer to the pull rod.

Once you have the centers in the drill rod, you will need to drill the end of the drill rod that you centered with 3/8-inch center drill to 1/4 inch by 3/4 inch deep.

You will need to drill the hole first with a next smaller drill size. Then clean it up with a 1/4 inch drill. Now do the second one and the drill rod is ready for rough turning.

Center up the drill rod between centers on the lathe, with the counter bored end next to the tail stock, with a small lathe dog holding the other end. The .312 drill rod is just about the right size for the .308-fluted end, so it will not need to have anything done to it.



The other end where the pull rod is attached will have to be turned. The drilled hole will measure .293 in the rifle barrel, so you will end up with a .290 pilot on the reamer. Turn the pilot (the end where the pull rod is attached) to about .010 larger than the finish size, and the recessed area between the pilot and where the reamer flutes start at about .280.

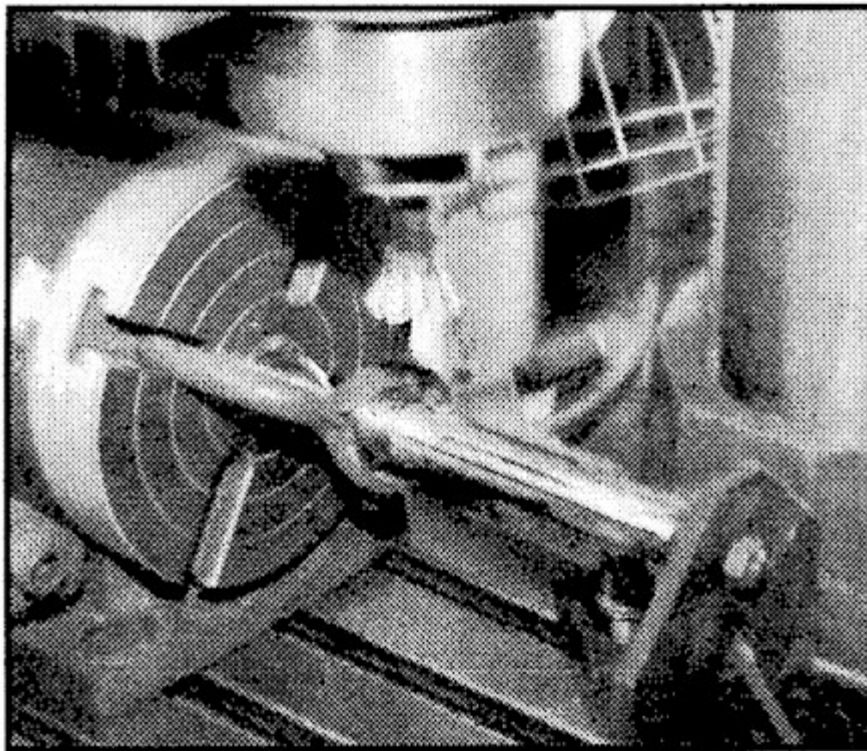
The pilot area will be on most of the reamers about 1-1/4 inches long, the recess will be about 1/2 inch long. If you make the reamers for smaller calibers, they can be made shorter.

GUNSMITHING AND TOOL MAKING BIBLE



OLD STYLE BARREL DRILLS

The .224 calibers the overall length of the reamer would be 4 inches, the pilot would be 1 inch, and the recess would be 3/8 inch wide. The recess should be about .040 smaller than the pull rod when completed, after grinding. The recess is there to get an even oil flow to the flutes when reaming.



Cutting Flutes On Mill

Once you have the reamer blank completed, go to the milling machine and set up the indexing head. This should have centers also with some way to attach a small lathe dog to hold the reamer blank solid. If the indexing head supports a collet, the stock can be held with a collet.

ANGULAR CUTTER

Next, chuck up a 60-degree angular cutter in the mill. The diameter of the cutter should be at least 1 1/2

GUNSMITHING AND TOOL MAKING BIBLE

inch. Slow down the mill to about 100 to 150 rpm, as the tool steel tends to get hot.

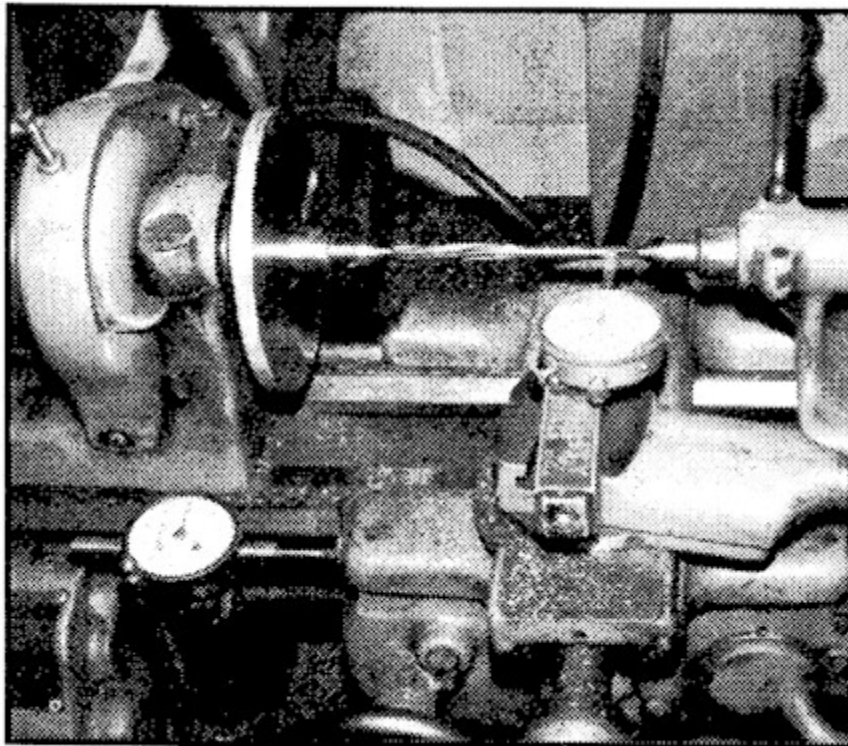
Measure the drill rod on the flute end; in this case, it has not been turned so it is .312. Bring down the cutter on the milling head while it is running and just touch the drill rod and stop.

Half of that size is .156; we do not want to cut the flutes half way as the reamer would probably chatter. The first flute should be cut .002 in front of center, the next should be cut .004 ahead of center, and the third should be cut .006 ahead of center.

After the third flute is cut, the fourth should start back at .002, then .004 and the finish cut is .006 ahead of center.

THE FLUTE THICKNESS

The flutes wall should have a thickness of about .060 to .080. This would be thinner on the smaller reamers and thicker on the larger reamers. You do not want to make flute walls too thin as they tend to break if the reamer gets too dull, and when this happens the barrel will more than likely be ruined.



Setting up Lathe for Cutting Reamers

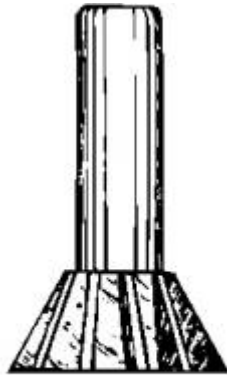
DEPTH OF FLUTES

You want to use an ample supply of coolant when cutting the flutes. Depending on the reamer size you will go in about 3/4 of the depth on the first cut and then finished to the correct depth the second pass. Watch for bowing as you cut the flutes. If it is bowing, you are either taking too big a cut, the cutter is dull,

GUNSMITHING AND TOOL MAKING BIBLE

or you may be cutting too fast.

Whatever the reason you do not want this to happen as it is putting a lot of internal stress in the reamer blank. When heat-treating the blank will probably warp badly. If you feel there is stress in the reamer blank, I would suggest that when you get ready to heat-treat the reamer, that you put the reamer in the furnace when you turn it on.

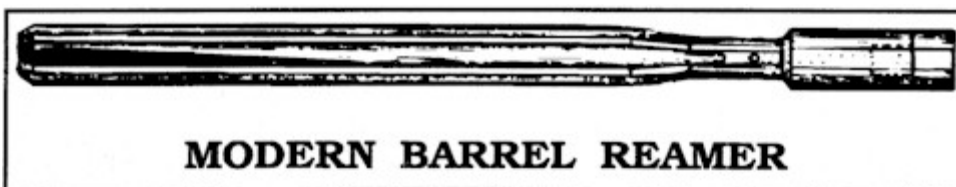


**THE DOVETAIL
CUTTER**

Bring the temperature up to 1000 degrees, and let it set for 30 to 40 minutes. Remove and bury it in lime until cool, or turn off the furnace and let it cool over night.

HEAT TREATING THE REAMER

Bring the temperature of the furnace up to the temperature that is recommended by the maker of the tool steel. Coat the reamer blank with some decarbonizing powder, and put the reamer blanks in the furnace and let set for 10 minutes. Remove and quench in the oil tank, or what other quenching medium the manufacture recommends.



MODERN BARREL REAMER

When you quench the blank make sure that you go straight in the quenching tank, if you quench the reamer at an angle, you will warp it. If you do warp a reamer you will have to bring the reamer up to 1500 degrees and let it cool in the oven, then straighten it when cool.

When you have both reamers quenched, lay them down on something where they won't roll off. They are very hard and brittle, and if they fell on the cement floor, they would probably break.

GUNSMITHING AND TOOL MAKING BIBLE

TEMPERING THE REAMERS

Turn off the furnace, close it up, and let it cool down to 350 degrees. We will then put the hardened reamers into the furnace to draw the hardness, and remove internal stress. Leave the blanks in the furnace until the furnace reaches 100 degrees, or better yet leave them in over night. The reamers will be about 61 to 62 Rc in Hardness.

GRINDING THE REAMER

The reamer blanks are now ready to be ground to size. We will grind the flutes first. Set up the tool post grinder on the lathe. Get everything lined up, put the small lathe dog on the reamer blank, on the pilot end, and grind the flutes end first.

Clean out the centers on the blank, and set between the centers. Cover the bed of the lathe up to keep the grinding dust off the ways. Set the lathe in back gear drives; turn on the lathe so it will run in reverse. Then, turn on the tool post grinder, and starting at the tail stock end, just touch the grinder to the blank.

Move the grinder past the blank, then set it in about .005, and engage the feed. It will not clean up completely, but it will start to clean up any part that is warped. Make one pass and if it is cleaned up enough so you can get a measurement, check the size of both ends. There should be about .002 taper from the pilot end to the end of the blank.

The tail stock end should be the smaller end. This is very important to have or you will get a rough bore. We are grinding the rough reamer first, so you want to end up with the pilot end of the reamer .298. When you get this size, remove the reamer blank from the lathe. While the lathe is set for the .002 taper, we will do the other blank. It is done the same way except that the final size should be .3005. We will allow the .0005 to hone in to size.

Now that the second reamer blank is ground, we will grind the leading edge taper. Set the compound on the lathe to 1-1/2 degrees. This will be your cutting edge next to the pilot. Turn the lathe on in reverse and the grinder and start feeding the wheel by hand on the cutting edge of the reamer. Grind this angle down a few thousands into the recess. Do the other reamer also. It will take several passes to do this. Take light passes not much over .005 so you will get a good finish.

GRINDING THE PILOT

When you have completed this on both reamers, take the blank from the lathe. Turn it around, put the dog on the other end, and put it back in the lathe. Before doing this, make sure you bring the tail stock back to center.

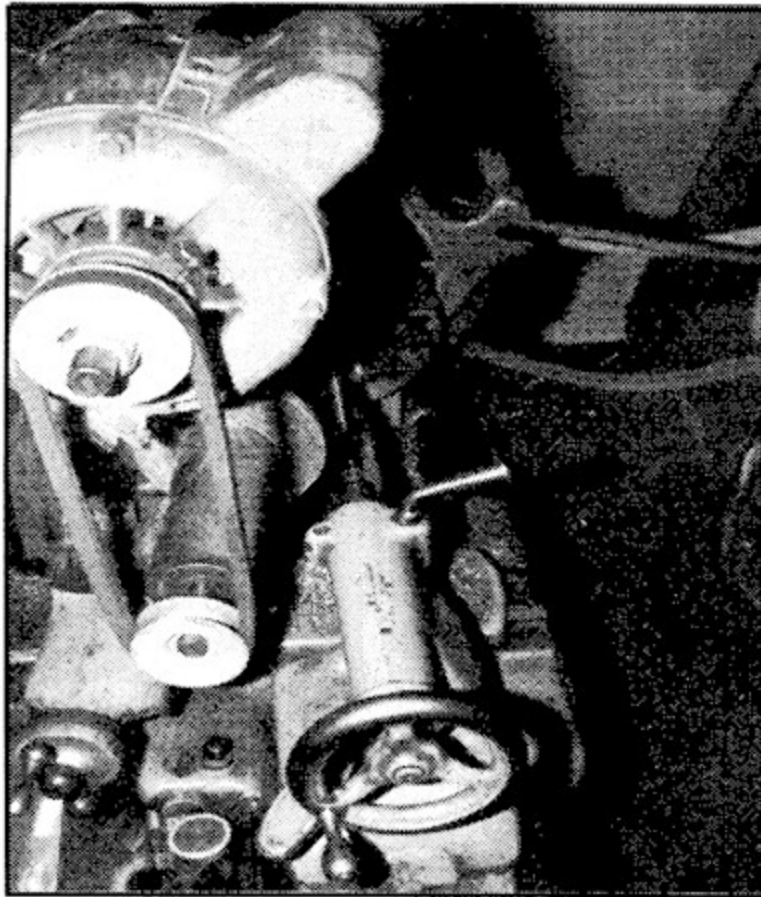
Square the grinding wheel up, and where the recess is grind this down to about .040 smaller than the pull rod, which will be .250. When the recesses are completed, it is time to grind the pilots to correct size. The roughing reamer which is .298 diameter, the pilot will be ground to .290.

GUNSMITHING AND TOOL MAKING BIBLE

Do not take over .003 per side, as it will heat the metal too much. Go slow and easy. The pilot on the finish reamer will be ground the same way, and the size of the pilot will be .003 smaller than the O.D. of the rough reamer, which will be .295.

When completed with the pilots there is one more operation to do. This is to grind four flats length ways on the pilot for the oil to pass. These flats can be ground on the lathe if the lathe is equipped with an indexing head, or you can grind them by hand if your careful.

You should leave about .060 on each corner of the pilot. This is usually enough to give good oil flow to the reamer. If this should give trouble on chips plugging up the reamer flutes, turn up the oil pressure to get more flow. The finish reamer will give no trouble if it is sharpened well.



Grinding the Reamer

GRINDING THE CLEARANCE

Now comes the time to relieve or grind the clearance on the back of the flutes for clearance. If you do not have indexing on your lathe, it will have to be ground by hand. If you have indexing on the lathe, the tool post grinder will grind this clearance. To grind the relief by hand you will need a small hand grinder. Coat the reamer flutes with a lay out fluid.

GUNSMITHING AND TOOL MAKING BIBLE

This will darken the metal so you can see how close you are getting to the cutting edge.

Grind the relief just back of the cutting edge, and up to within .005 to .010 of the cutting edge. It won't take much to give the necessary relief, as all you need is clearance so the reamer won't rub.

STONING THE CUTTING EDGE

Once the face has been honed, it will be necessary to hone the flutes. Hone right up to the edge watching the lay out fluid coating. This will tell when you have got it honed tight.

Start from the area where you ground the relief, and slowly go up to the cutting edge. It should feel sharp when completed.

ATTACHING THE PULL ROD

When you have both honed, it is time to sweat the pull rod to the reamer. It is best to use a 1/4 inch drill rod for this purpose, as it is smooth and uniform. Clean out the 1/4 inch hole in the reamer with some rolled up emery cloth, then put some paste solder in the hole. Insert the drill rod into the hole, and heat the shank up until the solder melts.

When it melts, rotate the drill rod in the hole to get a good tinning job. Let cool and job is completed. This is one important reason for stress relieving the reamer while heating in the furnace. If the reamer warps then it will be crooked on the pull rod, which in turn will cause a rough and oversize bore.

Before using the reamer the first time, recoat the flutes and cutting edges with the layout fluid. The reason for this is that when you use the reamer the first time. If it gives you trouble the lay out fluid will show up any rub spots, and any place you do not have enough clearance.

The main problem that you may experience will be chatter.

A new reamer has more tendencies to chatter than one that has been used for some time. Chatter may often be reduced by closer fitting pilots and guide bushings, or reducing the speed, also sometimes increasing the feed will eliminate chatter. If for some reason there should be too little clearance, the reamer will not cut freely, as the lands or margin will rub instead of cut against the walls of the barrel. In most cases the reamer will either lodge or break off a flute or two, or break off. In the case of a finish reamer, the barrel will be ruined. This is why I always soft solder the pull rod on, rather than fastening it on solid.

MAKING THE CHAMBERING REAMER

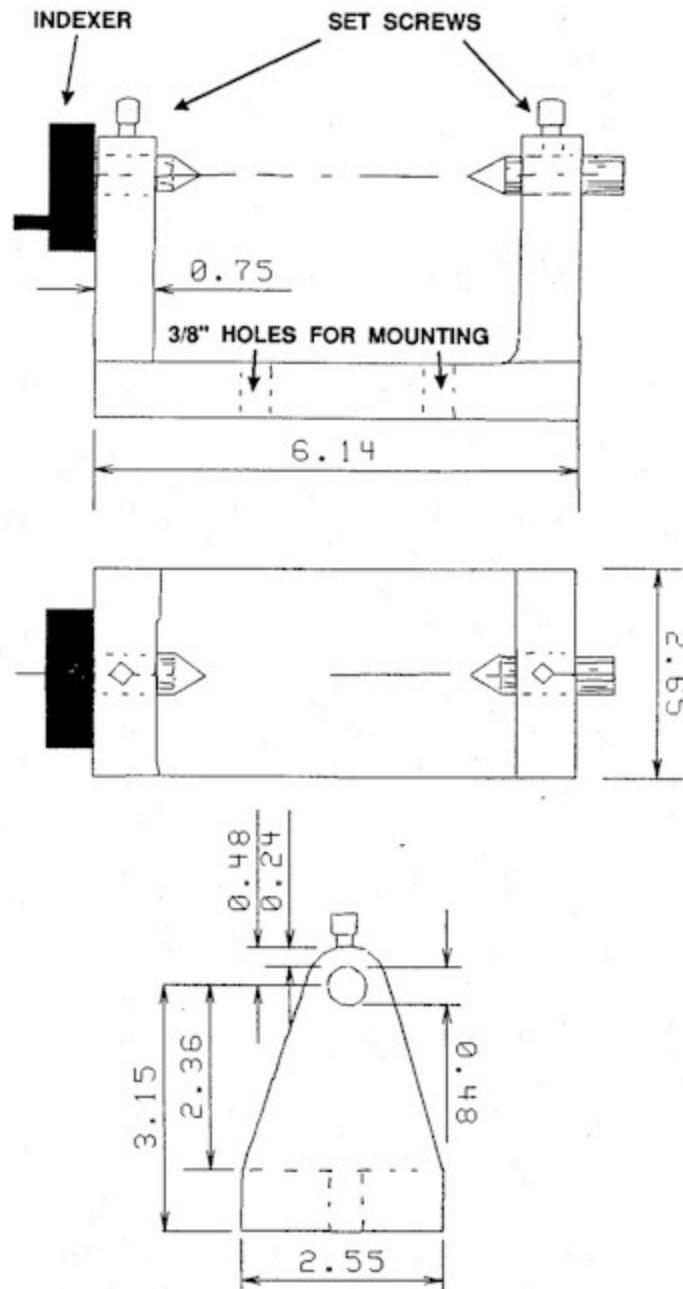
The chambering reamer is no different in grinding than the barrel reamer, except there are more angles, etc. First look at the following drawings to see how to turn the tool steel blank to shape. The blank does not have to have the angles turned on as shown in the drawings; this will be done during the grinding process.

Leave all diameters about .020 larger than shown. The tool steel blank should be cut 6 1/2 to 7 inches long. Use the smallest center drills for center drilling the blank. When turning the shoulder can be left square, but there should be a recess cut in front of the shoulder, end of neck, etc. for clearance when grinding.

ANGLE CUTTERS FOR MILLING FLUTES

The flutes should be milled with a 60-degree x 1 7/8-inch angle cutter. This should be used on all fluting of reamer blanks. The blank should be set up in the indexing attachment on the mill.

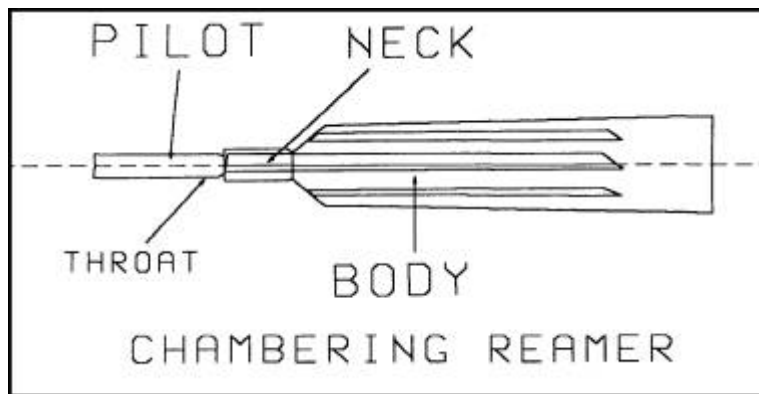
GUNSMITHING AND TOOL MAKING BIBLE



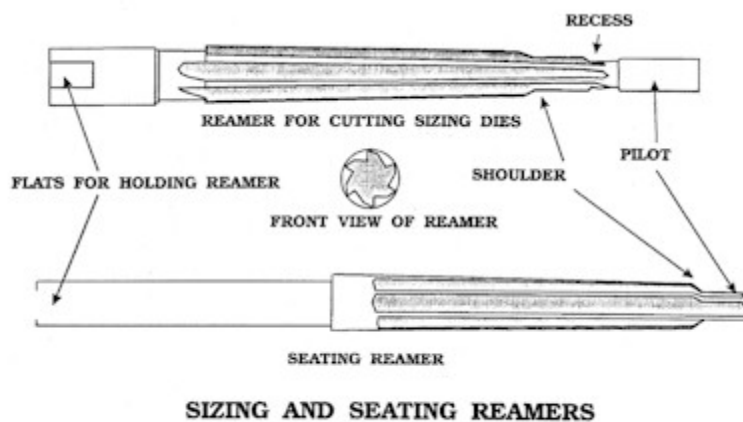
INDEXING FIXTURE

When cutting the flutes on the body of the reamer, be careful that you do not go under .062, as this will weaken the reamer. When cutting the flutes on the neck, you will have to go deeper than the setting on the body. Use plenty of cutting oil, and cut about a 1/2 to 3/4 inch past where the neck of the reamer ends.

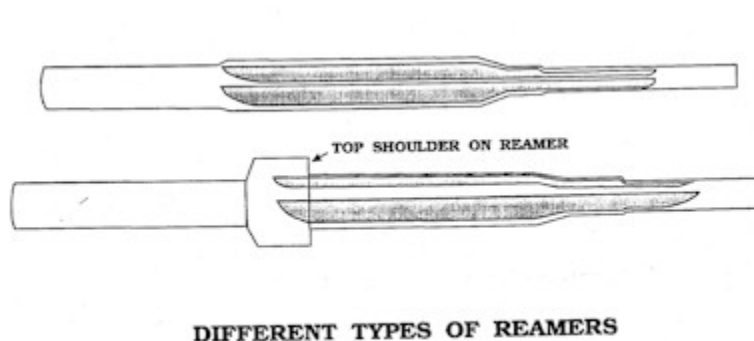
GUNSMITHING AND TOOL MAKING BIBLE



When you first start grinding, grind the pilot first. You want to decide if you want to have a throat on the reamer or not. If you want a throat, now is the time to grind it. The pilot should be ground about .001 smaller than the bore diameter.



All of these sizes are shown on chamber dimensions. After grinding the pilot to size, grind the angle shown for the end of the neck of the cartridge, going slightly deeper to give a recess.



The angle can be set using the compound on the carriage. From there, grind the neck of the case. The

GUNSMITHING AND TOOL MAKING BIBLE

neck can be ground slightly shorter than shown.

The reason for this is that when you grind the shoulder, the neck then can be set to the proper length by taking the shoulder back a little at a time.

The shoulder angle is next, and it IS VERY IMPORTANT TO GET RIGHT, as this is where the head space is taken from on rimless cases.

This can be set from the taper and angle charts. If you fill that you can set it properly from the angle setting set on the compound of the lathe do so?

Grind now the taper on the body of the case. This is also set from the angle and taper charts. This is important to have this right so cartridges will fit in other guns of the same caliber. If you are making a reamer for a belted cartridge, this will have to be ground next.

GRINDING THE CUTTING EDGES

All the edges of the reamer have to be sharpened so the reamer will cut freely. This is the throat (if you use one) the start of the neck, the shoulder, the body of the case, and the start of the belt (if you are making a magnum). It is done the same way as shown in the chapter on barrel reamers. After making one or two reamers, you will understand fully how to do this.

RIFLING CUTTER

In rifling barrels, a rifling head to hold the cutter is used. This is attached the rod or tube which draws the cutter through the barrel. The rifling head is a steel cylinder, three to 6 inches in length, which will just pass through the drilled and reamed barrel blank.

On the side a slot is cut lengthwise of the cylinder, just wide enough to accept the cutter, which fills the slot from side to side and end to end closely enough so that it has no movement. The slot is cut nearly through the cylinder, seating the cutter as deeply as possible.

The rifling cutter is made from a good tool steel, such as O1 tool steel. It is flat-bottomed and its cutting edge is of the hook type, like a file tooth. The cutting edge has a rake of five to six degrees, both on the face and on the top. The top of the cutting edge is slightly rounded which will fit the radius or diameter of the barrel. The steel cutter is usually about 1 1/2" long and the cutting edge is slightly back of center. This will leave a space in front of it large enough to hold the chips that are cut in one pass.

When the cutter is setting on the bottom of the slot the top of the cutting edge is just below the surface of the rifling head. The cutter is raised to rifling position by placing very thin brass shims underneath of it in the slot. The brass shims should be .0002" to .0003" in thickness.

After the rifling cutter makes a cut in each groove, another shim is placed beneath the cutter. Another cut is then made in each groove until all the grooves are cut to the proper depth. A small hole is first drilled through the rifling head on the bottom of the cutter slot so a small punch can be inserted through the hole to remove the cutter out of the slot in the rifling head.

The rifling head is a hollow or tubular piece of high-carbon tool steel that is hardened. The hook-type cutter is set in a port within this tube and the hook or cutting edge is about one fourth of the length of the cutter from the rear end. The rear end of the cutter is beveled off at a thirty-degree angle on the topside and the rear end in the rifling head is beveled at this same angle. The cutter must be beveled on each end at the bottom from a point directly beneath the cutting edge. The bottom bevel is normally ten degrees. At the rear of the rifling head, a beveled wedge rests beneath the beveled rear of the cutter.

The bevel of the wedge is the same as the bevel on the bottom of the cutter, ten degrees. This beveled wedge is pushed forward by a screw. The rear of the rifling head has fine threads and is tapped into the rear of the rifling head. Turning this screw forward in the rifling head results in pushing the beveled wedge farther forward under the cutter and raises the cutting edge.

A cut is made in each groove of the barrel before moving the wedge farther forward to raise the cutter for a deeper cut. The front end of this hook-type cutter, which is three-quarters of the length of the cutter.

GUNSMITHING AND TOOL MAKING BIBLE

This seats against a steel plunger within the tube that has a coil-spring in front of it.

The front end of the cutter is beveled back from the top at about ten degrees. The end of the spring-backed plunger is beveled at ten degrees in the opposite direction, so that its included angle with its top surface is 100 degrees. The front end of the cutter is held upward against the top surface of the rifling head. The cutter is normally about 2 to 2 1/4 inches long over all and the rifling head 6 to 8 inches long depending on the caliber. The top or cutting edge of the hook is cut on a radius to fit the bore.

The cutting edge of a rifling cutter is ground and honed to a template. When it is resharpen or honed during the rifling operation its form will not be changed at any point. The cutting edge has to be kept very sharp and very smooth to do a good job. The barrel steel is tough and tends to tear, rather than cut clean, unless the tool is kept sharp.

The scrape-type of rifling head leaves a better finish in the grooves than does the hook-type but it is more difficult to keep sharp and requires very careful honing to do a good job. Its cuts by scraping rather than a shearing cut and the shavings are fine.

The rifling head is a hollow cylinder, and is made of high-carbon steel with a slot for the cutter cut lengthwise, about two inches long, on one side. The port has to be cut very accurate, as the scrape cutter must fit it closely with no movement. The cutter cuts in both directions while traveling through the barrel. The rifling head is about 6 to 8 inches long and is threaded internally on both ends. There is a thread at one end for attaching the pull tube, which is used to carry a supply of oil to the cutter.

On the other end, a fine thread is used for the adjusting screw to raise the cutter. In the bottom of the rifling head between the port for the cutter, and on the opposite side, the fine threads for the adjustment screw, a narrow slot is cut length-wise of the head. This is for the head of a screw to set in which is screwed into the bottom of the adjusting wedge.

The cutter body is fitted very close in the slot in the rifling head and the bottom of the cutter body is ground on a taper of about ten degrees from one end to the other. The front edge of this taper is at an exact right-angle fit to the sides of the cutter body. The cutting edge of the scraper on top of the cutter body is not cut at right angles to the sides of the cutter body and rifling head. It extends across the top of the cutter body at a forty-five degree angle to give as much shearing effect to the scrape as possible.

The scraper is at the central point of the cutter body and the body of the cutter is cut away at each side of the scraper to give chip space. The edge that does the scraping has an included angle of eighty degrees, and the sides sloping down and away from the edge equally in both directions to the top of the cutter body. This scraping edge also has the contour of the circle of the groove diameter of the barrel. The edge should be ground and honed to a template. By doing this its shape will be true and will remain so. The template is cut from thin 01 tool steel.

The wedge, which raises the cutter in its slot in the rifling head, is turned with a circular contour on the bottom to fit the contour of the inside of the rifling head. The top of this wedge is also ground off on a ten-degree taper to match that on the bottom of the cutter body. The thickness of the wedge has its thin

GUNSMITHING AND TOOL MAKING BIBLE

end that extends slightly beyond the thick end of the cutter body. This is toward the end of the rifling head to which the pull-rod is fastened.

The thin end of the tapered wedge is ground square on the end. The square end then sets against the square-ended plug, which is backed by a spring. The spring is backed by the end of the pull-rod inside the rifling head. In the bottom of the wedge a hole is drilled and tapped for a small screw. The head of which fits the slot cut in the bottom of the rifling head.

The screw prevents the wedge from turning and is made from 01 tool steel, should be hardened to prevent wear. The adjusting screw for the wedge has an unthreaded portion beyond the threaded part, smaller than the threads. The end of this unthreaded portion is ground square and fits against the large end of the adjusting wedge. When the adjusting screw is screwed forward in the rifling head, it moves the tapered wedge forward and upward under the cutter, raising it as necessary.

HEAT TREATING TOOL STEEL

We will now cover as much as possible the heat-treatment of the tools and cutters that you will be making. To prevent the spoilage of tools during heat-treatment, you must understand the changes that take place in the steel when it is heated, quenched and tempered.

That part of this chapter which deals with the heating cycles for typical tool steels, the quenching or cooling procedure, and the effects of single tempering operations on the structure and properties of the steel.

In most cases, the life of tools if proportional to their hardness can be developed in plain carbon steel by heat-treatment if the steel contains over about 0.50 % carbon, provided the section is not very large.

When tools are made in large sections, plain carbon steel cannot be hardened adequately, and it is necessary to add allowing elements in order to increase harden-ability.

The elements usually used for this purpose are chromium, manganese, and molybdenum.

Steel becomes hard during heat treatment because of the formation of a micro structure called martensite. For some tool applications, the wear resistance provided by the martensite structure alone is not sufficient, and therefore, tungsten and vanadium as well as chromium and molybdenum, are introduced into tool steel.

These elements combine with some of the carbon in the steel to form very hard particles of carbides. These gives the heat-treated steel much better abrasion resistance than can be developed without the presence of alloy carbides.

When the tool operates at high speed or under high pressure or is in contact with hot metal, as in forging, etc., special tool steels must be used that are resistant to the high temperatures encountered.

Vanadium, cobalt, and chromium combined with tungsten or molybdenum give the steel the necessary resistance to softening at high temperatures.

Finally, in some applications, the life of the tool is more dependent on toughness than on hardness.

TYPICAL TOOL STEELS

The compositions of tool steels that we use for tool making are as follows.

PLAIN CARBON TOOL STEELS, Carbon 1.14, Manganese 0.22, Silicon 0.16 per cent.

GUNSMITHING AND TOOL MAKING BIBLE

OIL HARDENING TOOL STEEL, Carbon 0.85, Manganese 1.18, Silicon 0.26, Chromium 0.50, and Tungsten 0.44 per cent.

HIGH CARBON HIGH CHROMIUM TOOL STEEL, Carbon 1.55, Manganese 0.27, Silicon 0.45, Chromium 11.34, Vanadium 0.24, Molybdenum 0.53 per cent.

MOLYBDENUM HIGH SPEED STEEL, Carbon 0.80, Manganese 0.24, Silicon 0.29, Chromium 4.15, Vanadium 1.89, Tungsten 6.64, and Molybdenum 4.94 per cent.

CHROMIUM MOLYBDENUM HOT WORK STEEL Carbon 0.38, Manganese 0.40, Molybdenum 1.35, Nickel 0.30 per cent, Steel of the first analysis listed is usually referred to as plain carbon steel, and is also frequently a water hardening or shallow hardening tool steel.

The next analysis is characteristic of Steels referred to as Oil Hardening, and differs from the first type primarily in harden ability. This is the basic type of tool steel that I have used for over 30 years. Because of its greater harden-ability, relatively large tools made of this steel can be hardened by an oil quench rather than a water quench.

Tools made of the oil hardening tool steels do undergo as much size change and distortion during hardening as those made from plain carbon steels.

STEELS OF THE THIRD ANALYSIS

Is referred to as a high carbon, high chromium steel or as an air hardening tool steel.

The last two steels are not used in the small shops, as they require special equipment to process them.

HOW HEATING CHANGES THE STRUCTURE OF TOOL STEEL

The first step in the heat treatment of steel is the heating. The purpose of the heating is to form austenite and to dissolve carbon in the austenite. The solution of the carbon is necessary so in the second step of heat treatment, when the transformation of austenite takes place, the steel will develop the desired hardness.

You must remember that although a large amount of carbon is in the steel, it is not effective in developing hardness unless it is first dissolved in the austenite. The hardness increases rapidly up to 60 Rc as the carbon increases to 0.40 to 0.70%. Above about 0.70 % carbon, the hardness remains practically constant.

For maximum hardness in the steel, therefore, approximately 0.70 % of carbon must be dissolved in the austenite. All of the steels being discussed except the chromium molybdenum hot work steel have sufficient carbon in the analysis to attain a hardness of 65 Rc.

GUNSMITHING AND TOOL MAKING BIBLE

GRAIN SIZE AND TOUGHNESS

Two other factors are involved in the heating of tool steels, besides the formation of austenite and the solution of carbides.

These are grains coarsening and melting of the steel. In tool steels, the grain size should be as small as possible, because a fine-grained hardened steel is inherently tougher than a coarse grained steel.

Usually there is little concern about coarse grain in tool steel because coarsening of the steel does not occur until the temperature is well above the usual austenitizing temperatures.

RYERSON TOOL STEEL

Over the years, I have used Ryerson Tool Steel in 90% of my tools and reamers with great satisfaction with long life of tools, and overall good results.

WATER HARDENING

AISI-SAE W2-1.00 Carbon-Vanadium. This is an all-purpose water hardening Carbon-Vanadium Tool Steel with remarkable hardening characteristics that permit a wide variation in treatment with uniformly good results. Used for punches, blanking and forming dies shear blades, bending dies, etc.

Effects of tempering on a 2-inch disc 5/8 inch thick, water quenched at 1450 degrees.

TEMPERING TEMPERATURE

ROCKWELL C

| As | 100 deg | 200 deg | 300 deg | 400 deg | 500 deg | 600 deg |
|----|---------|---------|---------|---------|---------|---------|
|----|---------|---------|---------|---------|---------|---------|

Quench

| | | | | | | |
|----|----|----|----|----|----|----|
| 67 | 67 | 67 | 65 | 62 | 59 | 55 |
|----|----|----|----|----|----|----|

Hardening - AISI SAE 02,

This is one of the tool steels that I used, along with 01. This is an oil hardening tool steel, which combines high hardness and deep hardness with minimum distortion, freedom from cracking and good machine-ability. Used for cams tolls, thread-rolling dies, thread chasers, blanking dies and punches, bushings, etc.

Working Temperature Forging, 1800 to 1925 degrees F., never below 1550 degrees F. Hardening,

GUNSMITHING AND TOOL MAKING BIBLE

1400 to 1475 degrees F. Annealing, 1375 to 1425 degrees F.

TEMPERING TEMPERATURE

| As Quenched | 300 deg | 400 deg | 500 deg | 600 deg | 700 deg |
|-------------|---------|---------|---------|---------|---------|
| 64 | 62.5 | 60 | 57 | 53.5 | 51.5 |

HEAT-TREATMENT OF TOOL STEEL

The rate of heating for hardening should be slower for alloy steels than for plain carbon steels. The higher the alloy content, the slower the heating rate should be. Much difficulty with warping or size change can be reduced or eliminated by slow uniform heating.

If you have a gas furnace start the heat low, and bring up the temperature in steps. This takes about 30 minutes. Always put the tools in the oven before it is started. This preheating is not always necessary for the water hardening or oil hardening groups, but I have found that this usually eliminates warping. I have found also that this preheating will reduce the time in a hardening furnace without atmosphere control and reduce scaling and decarburization.

Commercial compounds can be bought for temperatures up to 1550 degrees, to eliminate decarbonizing of the surface Brass-brazing flux can be used also, and it works up to 2200 degrees.

The steel must be held at a temperature long enough to ensure uniform temperature throughout the entire piece. Longer time at temperatures is required for the high alloy steels. When heating 01 or 02 steel it is best to hold a slightly rich flame on the gas furnace to keep from getting a soft skin on the surface after quenching.

QUENCHING MEDIA

I have used quite a variety of liquids to quench the tools in over the years, here are some that I have used

WATER

Water as it comes from the faucet, but I have not got to good results, as there seems to be too much air in the water. If you use water, keep the temperature at 60 to 80 degrees.

BRINE

This will produce a more uniform quench if not over 10% salt by weight is added to the water. I have found that it will produce a much cleaner and uniform surface on the tools. As with tap water, temperatures should be held at 60 to 80 degrees. After quenching, dip in oil to eliminate rusting.

GUNSMITHING AND TOOL MAKING BIBLE

OIL

I normally use 5-weight oil for all my quenching, but any mineral oil 5 weight or less will work fine. The temperature of the oil should be held 100 to 130 degrees F.

LYE

Carbon Steels may be quenched in a 5% lye solution with very good results. I have found that it will eliminate soft spots in the steel. It will give a bright finish; in addition, it will not rust the tools if they are not dipped in oil.

TEMPERING

Now comes the most important part of heat-treating process and that is of tempering of the metal. Harden steel can be tempered or made softer and less brittle by re-heating it to a predetermined temperature. Depending upon the nature of the steel and its intended use, and then the cooling.

When the tempering is done by the color method, the temper is gauged by the colors formed on the surface of the polished metal as the heat increases. The color method of gauging temperatures is not dependable, as the color is affected, to some extent, by the composition of the metal. Tempilaq is a compound that you can buy, in any temperature range, to put on the metal.

When it melts you, have the metal at the proper temperature. It is better to have a temperature gauge to get the correct temperature. After you have worked with a certain type of steel for a while, you will be able to judge the correct temperature by the color. It is best to polish the metal to a bright finish so the color can be seen clearly.

COLORS FOR TEMPERING

430 degrees, Very pale yellow, extra file hard, dies, milling cutters, cut off tools.

440 degrees, Light Yellow, file hard, reamers, thread chasers; fly cutters, and hollow mills.

450 degrees, Pale straw yellow, profile cutters for milling machines, rolling dies, knurling tools.

460 degrees, Straw yellow, knife hard, swages.

470 degrees, deep straw yellow.

480 degrees, Dark yellow, cutting dies.

GUNSMITHING AND TOOL MAKING BIBLE

490 degrees, Yellow brown, extra hard, taps, dies.

500 degrees, Brown yellow, thread dies for general work.

510 degrees, Spotted red brown.

520 degrees, Brown purple, hard.

530 degrees, Light purple.

540 degrees, Light purple.

550 degrees, Dark purple.

560 degrees, Full purple.

570 degrees, Dark blue, half hard.

620 degrees, Blue gray, spring temper.

HIGH TEMPERATURES BY COLOR

752 degrees, Red heat, visible in the dark.

885 degrees, Red heat, visible in the twilight.

975 degrees, Red heat, visible in the daylight.

1077 degrees, Red heat, visible in the sunlight.

1292 degrees, Dark red.

1472 degrees, Dull cherry red.

1652 degrees, Cherry red.

1832 degrees, Bright cherry red.

2015 degrees, Orange red.

2192 degrees, Orange Yellow.

GUNSMITHING AND TOOL MAKING BIBLE

2372 degrees, Yellow white.

2552 degrees, White welding heat.

2732 degrees, Brilliant white.

2912 degrees, Dazzling white, bluish white.

In tempering, I let the oven cool down to the temperature that I need to draw the temper for the job that I need. I then put the part in the oven, then let it cool down over night.

ANNEALING

In some cases, you may need to anneal the tool to do some machining or changing. The annealing of steel consists in heating it slightly above the critical temperature range and cooling it slowly in the oven. The steel is then totally annealed. The steel is held at this temperature usually not less than one hour for each inch of the thickest section of the part being annealed.

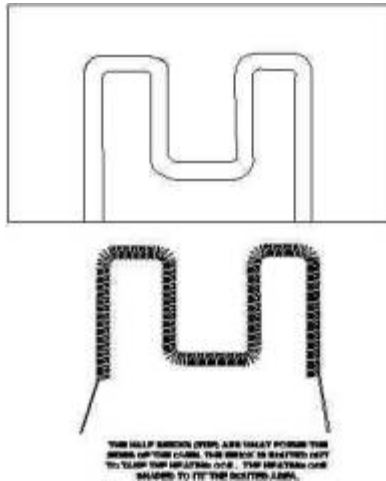
By annealing after machining this will also remove any stress or hard spots caused by machining. The temperature required for annealing varies for different steels. Low carbon steel may be annealed at about 1650 degrees F. The temperature should be maintained long enough to heat the entire piece evenly throughout.

Care should be taken not to heat the steel much above the decalescence or hardening point. When steel is heated above this temperature, the grain assumes a definite size for that particular temperature, the coarseness increasing with an increase of temperature.

Moreover, if the steel that has been heated above the critical point is cooled slowly, the coarseness of the grain corresponds to the coarseness at the maximum temperature. Hence, the grain of annealed steel is coarser, the higher the temperature to which it is heated above the critical point.

MAKING AN ELECTRIC HEAT-TREAT OVEN

The tools required for making an electric oven are usually found in your shop or garage. At a cost of about twenty to thirty dollars and in a few evenings, you can own an oven of which you can be proud.



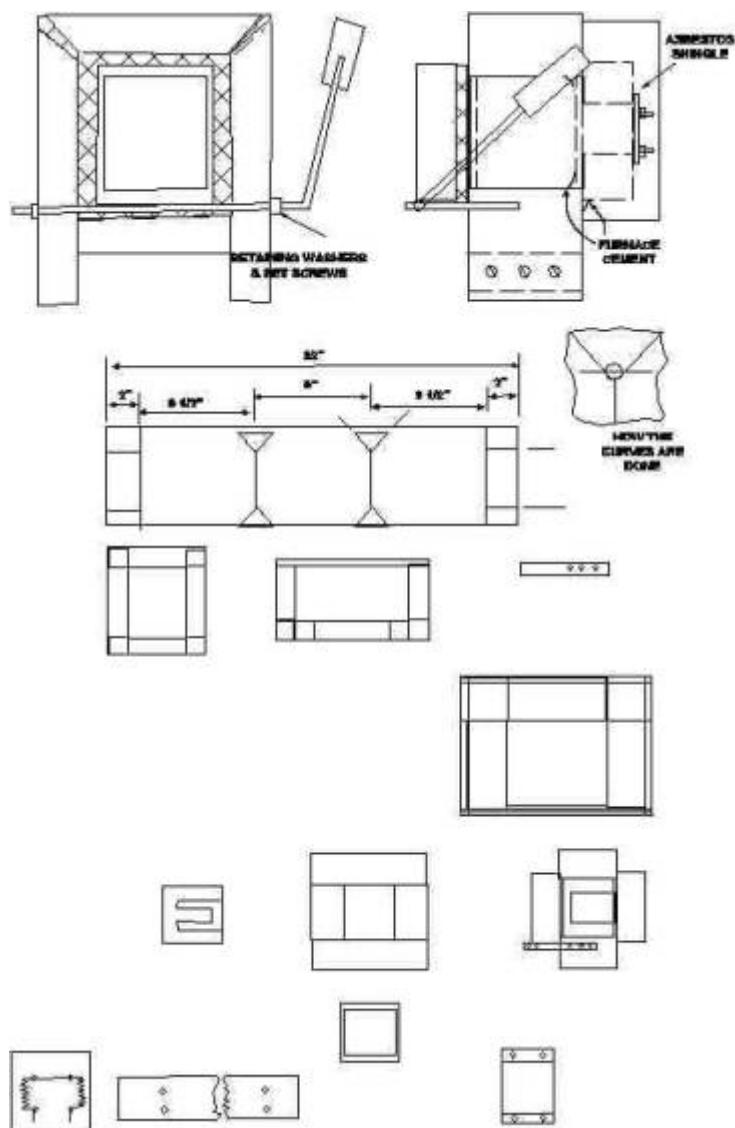
The oven that you can make is capable of temperatures up to 1900° and, if equipped with both a pyrometer and power control, it can maintain near constant temperatures over this range.

Once you have established the power setting that you need for a given temperature, setting up a time/power ratio is simple so you can duplicate the temperatures.

The power ratings for this oven, is based on the availability of heating elements, which we will use the electric elements for a 1000 watt oven. The heating element used is the type normally sold in appliance and electric supply stores. The heating element for appliances such as the cloths drier coil needs only to be stretched to the required length for use with this oven. It is made of Nichrome wire that offers resistance to current flow, thus producing the necessary heat. If the element does burn out, replacement is simple and a fraction of the cost of a commercial unit.

The oven can be used as for a heat-treating and tempering oven for steel tools, enameling and other similar applications. With imagination, you can find many other applications and uses for this piece of equipment.

GUNSMITHING AND TOOL MAKING BIBLE



MATERIALS

Galvanized Iron Sheet, 26 Gauge

1 Piece. 7 1/2 X 32 (Top & Sides)

1 Piece. 7 1/2 X 8 1/2 (Door)

1 Piece. 6 1/2 X 12 (Bottom)

1 Piece. 11 X 15 (Back Cover) (Light Gauge)

2 Pieces. 2 X 3 1/4

GUNSMITHING AND TOOL MAKING BIBLE

5 Insulating Firebrick, 2300°f, 9 X 2 1/2 X 4 1/2

24 Round Head Sheet Metal Screws, #6 X 3/8

1 Piece. Asbestos Shingle or Sheet Asbestos, Approx. 2 X 6

2 Pieces. Flat Steel, 1/8 X 1/2 X 6

1 Pint High Temperature Furnace Cement

1 Heating Element, Nichrome, Coiled, 1000 Watts at 110 Volts

1 Piece. Round Steel, 1 1/4 X 18

4 Brass Machine Screws, Round Head, 10-24 X 3/4

8 Hex Nuts, Brass, 10-24

1 Piece. Round Metal Stock, Any Material, 1 1/2"x 4 (For the Counterweight)

1 Heavy Duty Line Cord (Type Used on Electric Irons)

4 Machine Screws, Round Head, 6-32 X 1 1/4

4 Hex Nuts, 6-32

1 Power Control, Type C.r.s., Rated 1000 Watts (Minimum)

1 Pyrometer

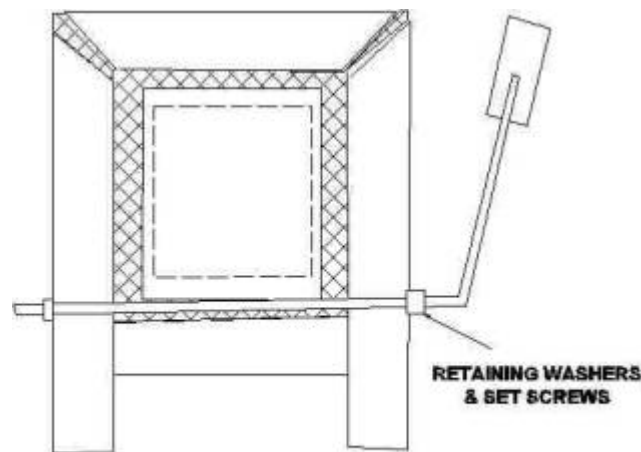
1 Can, Heat Resistant Lacquer or Enamel

You can begin construction by cutting the galvanized sheet, to the required dimensions given. We should now lay out the individual pieces for further cutting, folding and bending. You will note from the drawing details that I have shaded the areas that are to be removed. For neater looking corners, we have drilled 3-inch holes on centers at the intersections of the areas to be removed. These holes permit much easier bending and allow for the slight miss cutting of angles. Look at the metal layout details for dimensions and areas to be removed.

All pieces must be bent to 90° as shown by an "x" on the metal layout detail sketch. If you have a sheet metal shop in your town, it is better that we take it to the shop and let them do the bending. If there is not a sheet metal shop in your town, clamping the pieces in a vise we can do the bending between two

GUNSMITHING AND TOOL MAKING BIBLE

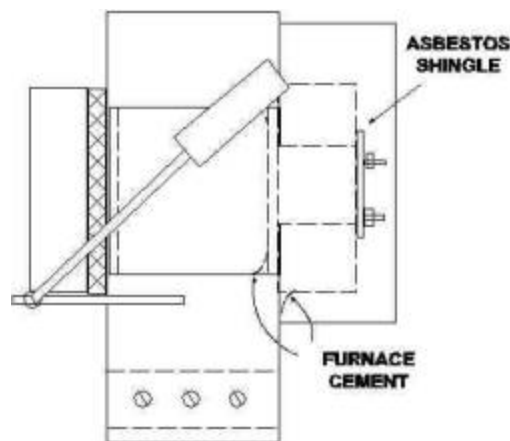
boards that are cut to the length needed. Bending the pieces with the above method is slightly more difficult, and they can achieve a neat bend with a little care.



FRONT VIEW OF FURNACE

The bending sequence should be well thought out before starting of any bends to avoid interference of one bend with another. This is all there is to the metal portion of the oven.

Next refer to the sketch titled, Furnace Layout. Two firebricks are left whole, we cut two bricks to 5 2 inches long and we cut one brick exactly in half. You can make all cuts with a thin bladed hacksaw. The two full-length bricks will be the top and bottom of the oven. The brick cut in half will furnish the two sides that have the heating element. The 5 2 inch bricks will be the door and the back of the even.



SIDE VIEW OF ELECTRIC FURNACE

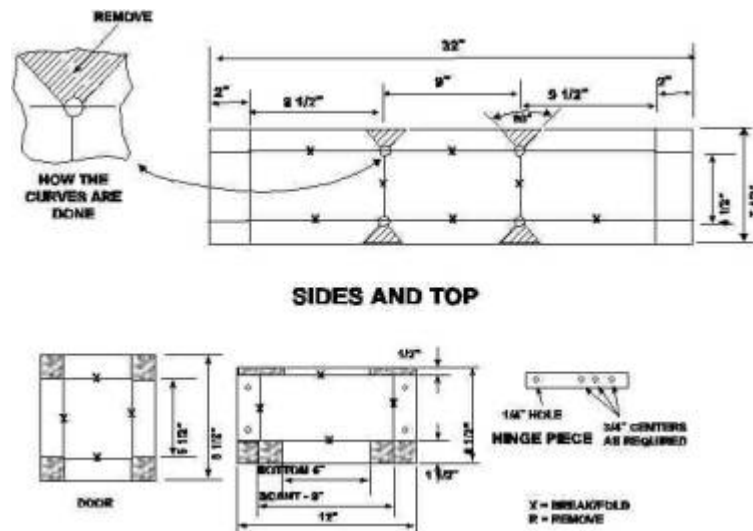
This type of insulating firebrick is very soft and should be handled with care; a fingernail has sufficient hardness to gouge the brick. For this reason, and its high temperature properties, it was chosen for making this furnace. This type of insulating brick is normally used in many commercially made ovens.

Several suppliers make this brick, and it can be bought in a suitable grade to withstand various temperatures. The 2300°F brick is sufficient for this type of furnace, and should be specified as the type

GUNSMITHING AND TOOL MAKING BIBLE

you want.

Take the two half bricks and looking at the coil layout, route the bricks so the heating elements will fit. The routed width should be slightly under the outside diameter of the Nichrome coil and sufficiently deep to contain the coil below the surface of the brick. The heating coil placement in the furnace is not critical, but it should be close to the place shown in the drawings.



THE DOOR

The door and back brick must also be routed to a depth of 3 inch along all four sides so part of the brick protrudes into the oven openings for better heat retention. This also can be done on a drill press using a flat-ended bit as a router or by carefully cutting and scraping away the excess material with a knife. Refer to the brick and coil drawing for the width of these cuts.

If you have a drill press or milling machine, the routing can be done by simply using a drill or router bit of the required diameter. We can carefully outline the coil layout on the brick in a soft pencil, the drill or router bit set to the required depth, and the brick pushed into the revolving bit, following the pencil outline. If you do not have a drill press, the routing can be done with a piece of round steel stock by pressing the end of the steel into the brick and using die rod as a scraper. This may seem difficult, but the brick is relatively soft and can be cut easily.

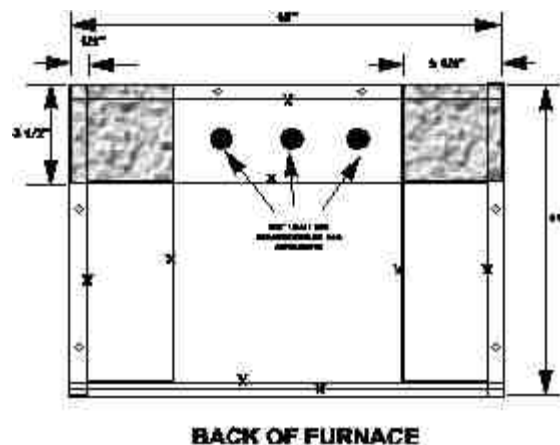
Setting up the heating coil is next. Cut the coil exactly in half, this can be done by simply counting the number of coil loops and cutting it at the midpoint. At both ends of each coil half, the coil must be straightened by stretching the coil loops out, so there is a 4-inch length of straight wire.

We will fasten the straightened ends to the terminal screws at the back of the oven. About 6 to 8 straightened coils are sufficient to produce the above length. The total length of the routing should now be determined and each coil stretched about one inch short of this length. Lay a yardstick on a flat tabletop, grasp both ends of one coil and stretch the coil using the yardstick as a guide.

GUNSMITHING AND TOOL MAKING BIBLE

AMOUNT OF COILS

The amount to which the coils return should be the length needed as determined above. Starting 3 inch from the edge of the routed firebrick, press the coil into place. Get some staples 2 inch long with a radius of 1/16 inch and push these staples into the brick along the length of the Nichrome coil at points to hold the coil in place in locating the staples. Be sure they are pressed between the individual coils so as not to short out any adjacent coils. Once the Nichrome wire has been heated, it will take a permanent set. The use of the staples is to aid assembly.



ASSEMBLING

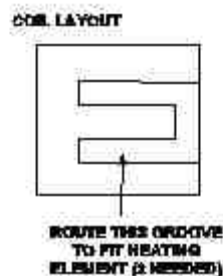
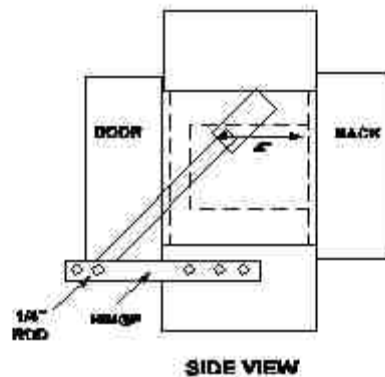
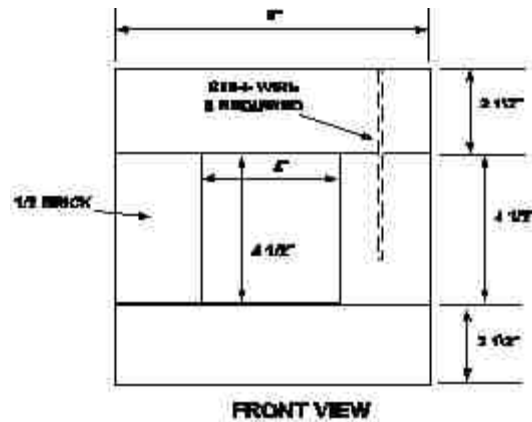
Assemble the bottom, top and sides of the brick portion of the oven. Put one full brick on a solid flat surface. Then, position the two side bricks containing the heating elements flush with the front and side edges of the full brick and place the remaining full brick on the top of this assembly. Get some light, 4-inch pieces of stiff c inch diameter wire, and sharpened one end of each piece to a point. Drive two of these wires, as you would a nail, through each full brick into each side brick, both top and bottom.

The wires should be located through the full brick so they will be driven into the middle of the side brick one-inch from both the front and back edges of the assembly. You need the reinforcement of the bricks to hold them together for the assembly into the metal case. Drill pilot holes a little under the diameter of the wire used is drilled into the full brick. This will help in driving the wire into the side brick. When you pre drill the holes, the wire is less apt to be driven into the sides at an angle. The firebrick is soft enough to accept the wires without breaking, if drive them in carefully.

When ready slip the completed brick assembly into the formed metal case. Turn the case containing the assembled bricks over so it rests on its top. Next, locate and drill two holes through the outside of the metal case. This should be one inch from the front and back edges of the oven, and is centered with relation to the flange of the bottom piece.

GUNSMITHING AND TOOL MAKING BIBLE

We should put the bottom piece in position to check the locations where we should drill the holes. The holes should be the same size as the outside diameter of the sheet metal screws used. Now place the bottom piece in position again and locate the drilled holes on the side flanges of the bottom piece. When located, remove the bottom piece and drill the holes the root diameter of the screw where you marked them. Assemble the bottom piece to the case using sheet metal screws.

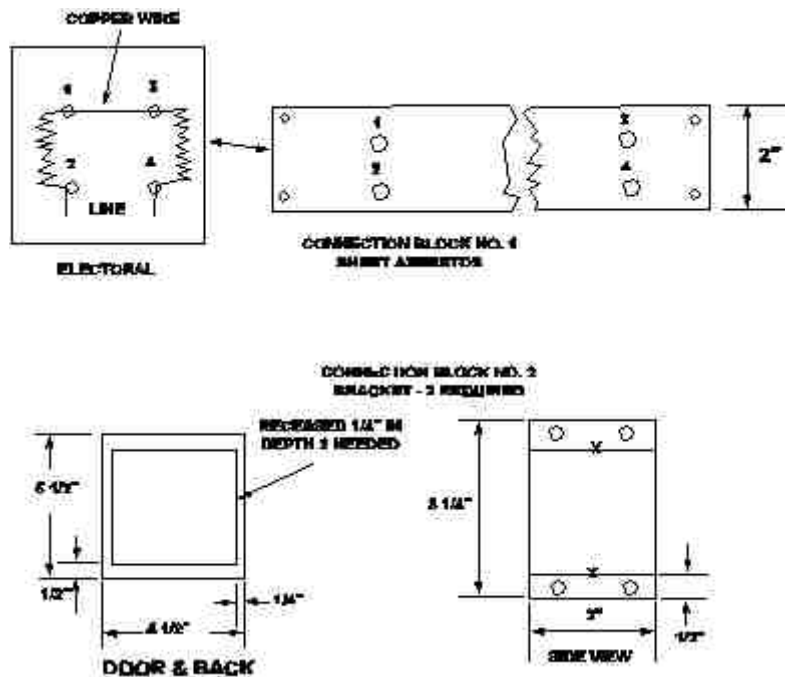


Sheet metal screws are self-tapping so to fasten two pieces of light gauge metal. The outer piece of metal is drilled to the outside diameter of the sheet metal screw and the inner piece drilled to the root diameter of the screw. By drilling the holes this way the sheet metal screw will bring the two pieces together and hold them tightly.

GUNSMITHING AND TOOL MAKING BIBLE

Take the two pieces of 2 x 3 2-inch sheet metal and bend them into a bracket for the terminal board. Bend a 2-inch flange on each 2-inch end in the directions indicated by the side view of the sketch. Drill the foot of the flanges for sheet metal screws and the tops to take 632 machine screws.

Locate the foot holes on the sheet metal on the back of the oven so the bracket will just clear the back brick. These brackets and the terminal board form the clamp to hold the brick in place. Fasten the brackets in place with sheet metal screws.



Cut and prepare the asbestos shingle and attach it to the brackets using the four, 6-32 machine screws. The asbestos can be broken successfully if it is first scored deeply with a scratch awl, and then snapped over a sharp edge. The asbestos sheet is the type normally used as siding to protect wooden structures. Before assembling the asbestos to the bracket pieces, drill four holes into the asbestos to accept the brass machine screws that will be the electrical terminal posts for both the Nichrome wire elements and the line cord. (See illustration.)

The brass machine screws should now be inserted and the hex nuts tightened. Next, remove this assembly, place the back brick into position and reassemble. Be careful so you do not disturb the Nichrome wire leads, as each Nichrome wire lead should reach one of the brass terminal posts.

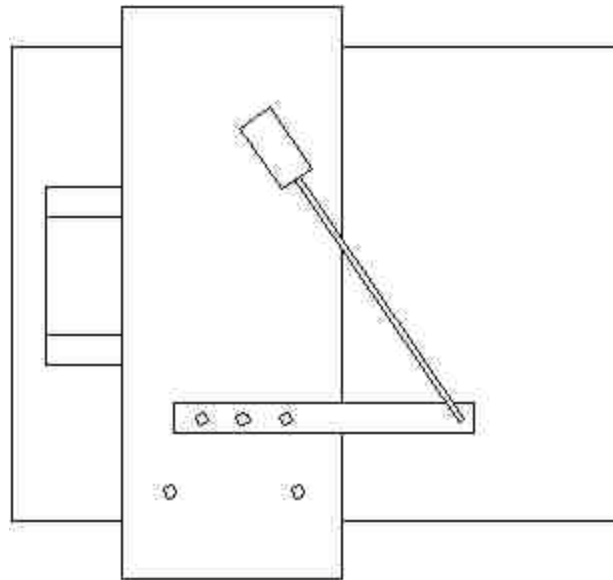
We should fillet all the firebricks on the inside with high temperature furnace cement; this is done by spreading a fillet of cement with the tip of the finger to form a 3-inch fillet radius.

Place the metal door piece face down on an insulated surface. We can position and weld the 3 inch steel rod or brassy in the correct position. The end of the rod should extend three inches beyond the width of the door and should be flush with the face of the door.

GUNSMITHING AND TOOL MAKING BIBLE

Use clamps to hold the door piece down against the insulated surface to prevent warping during welding or brassing. About 1-inch area at each edge of the door and rod contact points, are all that is necessary to hold the door securely to the rod. Bending the rod now is not necessary, but when ready the door handle can be either to the left or to the right of the oven.

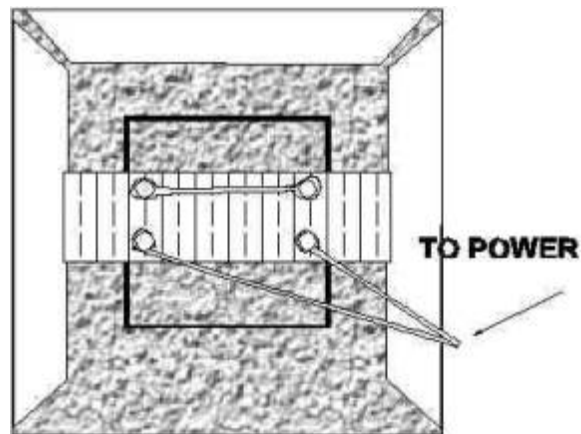
Position the oven between two bricks placed at the top and bottom of the oven so the oven is level and we hold the back bracket above the working, surfaces of a workbench.



SIDE VIEW DOOR HINGE

Take the front door firebrick, place it into the metal door piece, and center this assembly on the oven with relation to the oven opening. Now drill 3-inch holes into the hinge bracket piece. These hole, should be centered and 2 inch from the end of each piece, and from the opposite end, drill three holes on: inch centers to accept sheet metal screws.

GUNSMITHING AND TOOL MAKING BIBLE



**REAR OF OVEN WITH
BACKCOVER REMOVED**

Set the two bracket pieces on the positioned door rod and locate the three screw holes on the sides of the metal case. Drill holes in the case to the root diameter of the sheet metal screws and assemble. The door can be opened and closed now to check any points of binding. If you have binding points, they can be relieved by further cutting away the firebrick.

Take two 3 inch retaining collars should be used to keep the hinge rod from sliding back and forth. The retaining collars can be 3 x 20 hex nuts drilled to a full 3-inch opening. Take one of the hex nut faces on each nut, drill, and tap them to accept a setscrew. Put the retaining collars on the rod, with one on each side of the hinge bracket, and center the door, position and tighten the collars in place.

Use a gas torch with a small flame to bend the rod, at a point, 2 inches from the hinge bracket. Heat the hinge rod to a cherry red and bend the rod up toward the top of the oven at an angle slightly less than 90°. This rod also should be bent back about 35° in relation to the front face of the oven.

Finish the counterweight by drilling a 3-inch diameter hole to a depth of about 2 inches. The counterweight can be made of any round stock with sufficient weight to hold the door tightly closed. The counter weight can be secured to the end of the rod by epoxy glue or a setscrew.

FINISHING

Now to the back of the oven, attach one Nichrome wire lead to each of the four brass terminals screws. Attached across the two upper screws, a piece of heavy gauge copper wire that acts as a jumper to give continuity to the two heating elements.

On the bottom two brass terminals, attach the heavy-duty line cord. Position and fasten the back cover using the remaining sheet metal screws. This will complete the oven assembly except for painting. Use aerosol wrinkled finish paint in either black or gray to give the oven a professional finish.

GUNSMITHING AND TOOL MAKING BIBLE

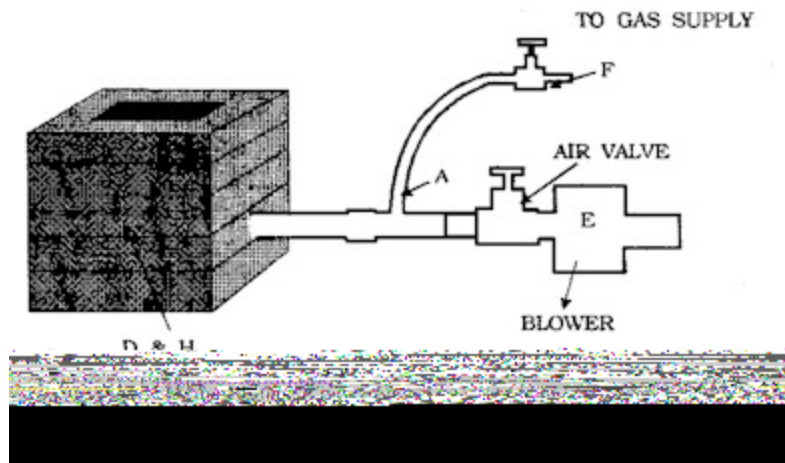
In mounting a pyrometer, the vent holes in the back cover can be used to pass the thermocouples through to the back firebrick and into the oven chamber. Mount the pyrometer on top the oven, and a silicone controlled power rectifier of the proper wattage can be used with this oven. By controlling the input of current, you can achieve an infinite range of heat adjustment over the range of the 1000-watt model.

Leftover firebrick pieces can be cut into slices 2 inch thick and used to set your tools on.

BUILDING A GAS HEAT TREAT FURNACE

Building a small heat-treat furnace for the shop. This furnace is made from standard firebrick, 2 1/2 x 4 1/2 x 8 inches. Firebrick does vary in size, so the size shown in the drawing may have to be changed to fit your needs. Another style of furnace is where the main opening is at the top, and the part hangs down on the inside. This seems to give a more uniform heating.

A-Gas/Air outlet; B-Furnace opening; C-Side view; D-Opening for temperature sensor; E-Blower; F-Gas intake; G-Heat sensor pipe; H-Heat sensor opening; <D>



You will need eight firebricks to make this. When completed you will have a furnace with an inside size of 4 1/2 x 3 x 8 inches. This size will handle just about any job in the shop.

The firebrick is mortared together with the cement used in fireplaces, and it should not be any problem to get from any business that sells fireplaces or wood burning stoves. The brick is placed 2, flat side by side, mortared, and then one brick on each side is stood on edge, (see drawing) mortared to the two laying flat.

Two more are then placed on top of the first two. To finish it off, two more are mortared and set on edge on one end, as per drawing.

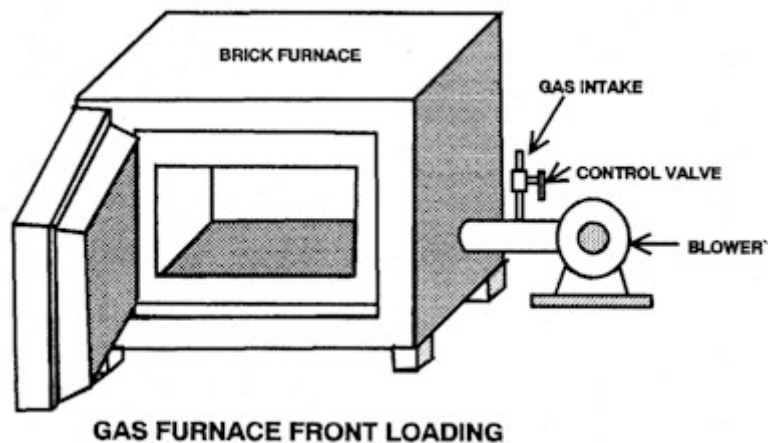
Let it set for 24 hours before starting any more work on it"

Next you will have to get a cement drill 1 1/2 inch, and drill one hole 1/4 inch above the base in the center on the side. This is where the 1-inch pipe from the blower will be inserted.

You will need to get your pipe cut and threaded to the correct length. Connect a 2-inch pipe to the 1-inch

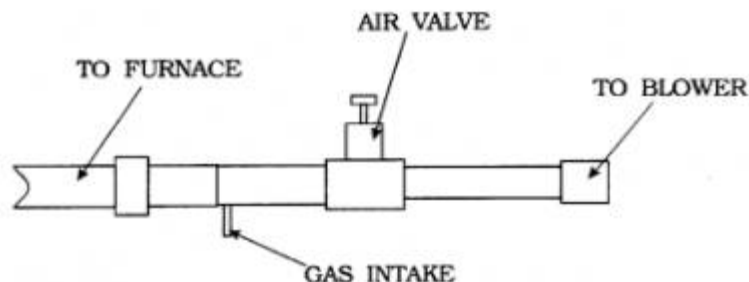
GUNSMITHING AND TOOL MAKING BIBLE

pipe; this will go to the blower.



Next, you will need to cover the firebrick on the outside. Cut 1/8 inch metal to fit to the outside and top and weld this together, to form a box for the firebrick. Be sure to have a metal bottom already cut out to put under the brick so the sides can be welded to it.

You can when building this go with the opening in the top, and then you need not make a door for the front. This is the simplest way to go and I believe the best. You hang the part down through the opening in the top. At the front, there is a small opening for the temperature probe. This is a 1/4 or 3/8 inch hole.



FURNACE TORCH VALVE

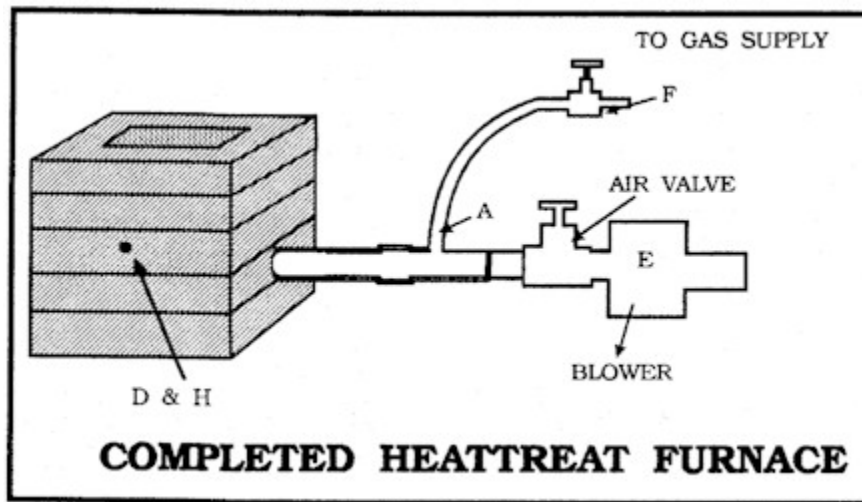
If you decide to build a front-loading furnace, you will need a 2-inch opening in the top of the furnace for the gas. In addition, you will have to build a metal door for the front and line it firebrick.

You now will need to find a used Kirby vacuum cleaner blower, or any other type of high-speed blower to provide the air for the furnace.

A shop Vacuum blower also works great. You will need to find an adjustable rheostat to control the speed of the blower. The speed that it runs would make it impossible to light the oven. The final step is

GUNSMITHING AND TOOL MAKING BIBLE

to tap into the airline with a line from your gas supply.



The basic tools for heat-treating are the gas torch. The torch is a simple apparatus consisting of a mixing tube into which fuel gas and a blast of air are introduced to be mixed and burned at the end of the tube. An old vacuum cleaner can be used for the air blast.

The hose used for the various attachments for the cleaner can be used to deliver the blast of air to the torch. You will have to make a fitting for attaching the hose at the dust-bag outlet and arrange the cleaner so that air can enter at the suction end.

At the torch, a gate of sheet metal is arranged to regulate the amount of air entering the mixing tube. You can also reduce the airflow by reducing the speed of the blower. A simple light dimmer found at any hardware store would do the job very well, if you have a DC blower motor.

The fuel is supplied through a rubber tube of a size to fit the supply pipe and the fitting on the torch. You should have a 1/4 inch needle valve to adjust the gas to air mixture. Using Butane or Propane from a 5-gallon bottle works better as there may not be enough pressure from natural gas. If you use butane, make sure all your fittings, and hose are for high pressure.

It has rubber ends that will fit on the gas nipples at each end. Any other good rubber tube can be used, such as a 3/8-inch garden hose. The mixing tube must be long enough so that the gas and air are thoroughly mixed by the time it gets to the burner end.

Artificial gas will burn at the end of a plain mixing tube, but for natural gas there must be a special tip on the burner end to maintain the flame, or else the air blast will snuff it out. This special tip consists of a jacket fitted around the end of the mixing tube with several small holes drilled into the mixing tube. This gives a low-velocity supply of gas and air to the jacket.

This will maintain a small circular flame around the end of the mixing tube, which will keep the mixture ignited as it comes out of the end of the main burner tube.

GUNSMITHING AND TOOL MAKING BIBLE

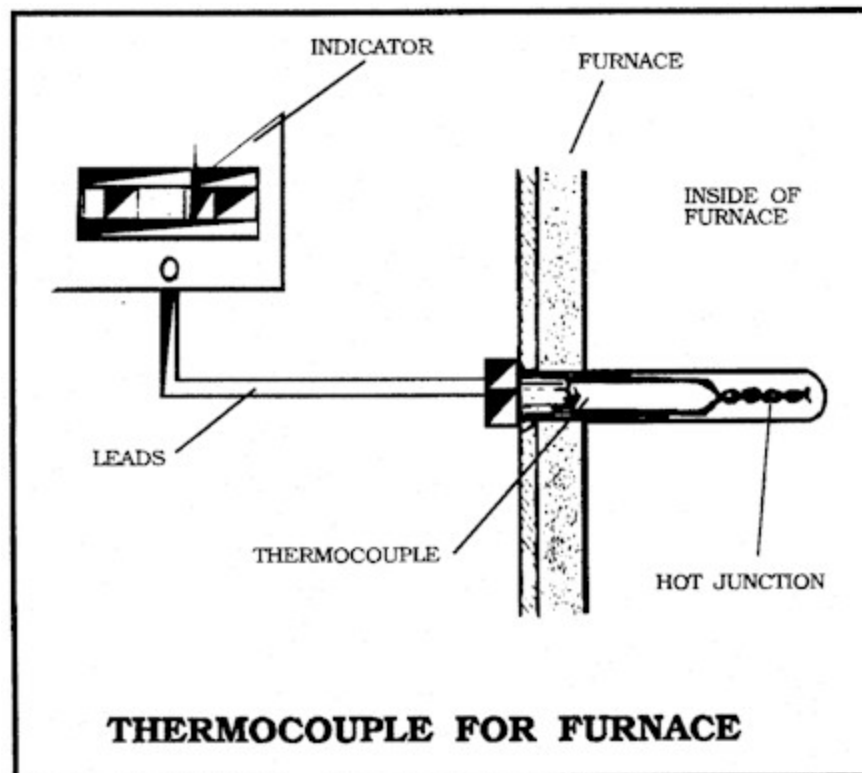
The air blast tends to blow the main flame so far away from the end of the mixing tube that it will mix with so much outside air that it will no longer be a combustible mixture and will be snuffed out. This annular ring of low velocity flame surrounding the outlet of the mixing tube will keep the main flame ignited unless so strong an air blast is used that the entire flame is blown away from the end of the mixing tube.

When you start up the burner, shut off the gas until you have the air adjusted, and then slowly turn on the gas, while holding a lit Butane torch over the opening of the furnace. It is best to reduce the air blast until the gas is ignited and then slowly open it until the desired flame is obtained. The flame should burn with a firm blue center cone, and the hottest spot will be at the tip of the blue cone. A yellow flame is not as hot and is very sooty. After the bricks of the furnace have become well heated, the air blast may be opened a little farther, and the blast will thus be increased.

The flame from this torch is very hot and will heat steel to a white heat for forging, but it is not hot enough for welding, however a supply of oxygen for the air intake will increase the temperature.

Get large enough cement drill to drill a hole through the firebrick about 2 inches from the top. The heat sensor will fit in there. I find a short length of iron pipe that is large enough on the ID to allow the sensor to fit inside. This pipe is then mortared in place. See Drawing.

A High Temperature gauge can be purchase from an industrial supply dealer. If you can find one, a 2000-degree gauge is best.



In the air intake pipe, (A) you will need some kind of manually controlled valve. You will have to be able

GUNSMITHING AND TOOL MAKING BIBLE

to shut the air down quite a bit. If you tried to use the full amount of air, it would blow out the flame.

When you are ready to start the furnace, hook up the gas, check for leaks with soap, and if OK, you are ready to fire up.

NOTE - It is important to do things at first very carefully to prevent an accident. This is the way I have my furnace set up, and have had no problems. I have no control over what is done by other people, and cannot accept responsibility for what some other person does. If you build a gas furnace, you are on your own. Check it outside of the building for safety's sake.

Turn on the air, and close down the valve until there is almost no flow through the pipe. Now take a butane torch and light it. Open the main valve on the gas tank.

BE SURE THAT THE SMALL ADJUSTING VALVE IS CLOSED ALL THE WAY.

Holding the lit torch over the opening, slowly turn on the gas. In a few seconds it should light. There probably won't be much flame, so slowly open the air valve/gas valve until the furnace has a "roar" to it. Don't open the air valve too much as you need a slow heat. Adjust the fuel so that you get 3 to 4 inches of flame from the top. Let it heat up for a few minutes to dry out, and then it is ready to use.

Once it has cooled down, it can be moved back in the shop. This furnace can be changed to where it is front loading, made larger or altered for whatever is needed.

This furnace is very fast. Normally it takes only 10 to 15 minutes to get to operating temperature. I find that hanging the knife parts down from the top will cause even heating. You can use two bricks to close down the opening more to confine the heat better. When through heat-treating, close the top up with the bricks, and let cool down to tempering temperature.

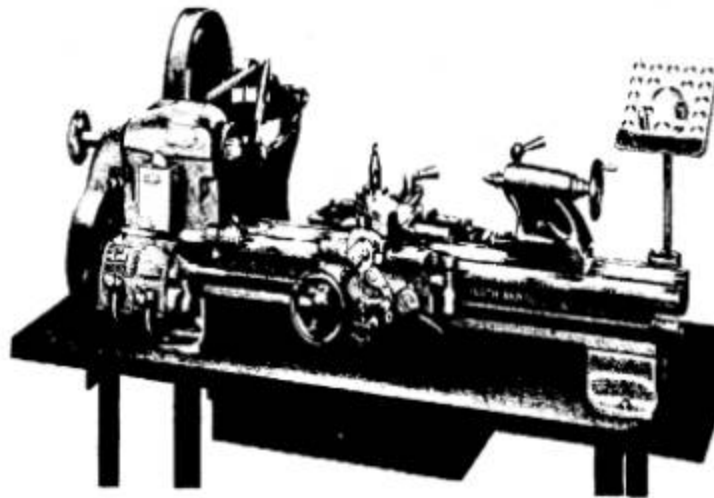
This furnace works great with O1 and other tool steels. It can be used for forging steel as well.

GUNSMITHING AND TOOL MAKING BIBLE

LATHES

TYPES OF LATHES.

Lathes used in manufacturing can be classified as speed, engine, and tool room. Special types of lathes have only a head stock, tail stock, and a simple tool post mounted on a light bed. They ordinarily have only three or four speeds and are used primarily for wood turning, polishing, or metal spinning. Spindle speeds up to about 1000 rpm are common.



Engine Lathes are the type most frequently used in manufacturing. They are heavy-duty machine tools with all the components described previously and have power drive for all tool movements except on the compound rest.

In most cases the bed is mounted on two pedestal legs. They commonly range in size from 12 to 24 inches swing and from 24 to 48 inches center distances, but swings up to 50 inches and center distances up to 12 feet. Most have chip pans and a built-in coolant circulating system. Smaller engine lathes-with swings usually not over 13 inches also are available in Engine type, designed for the bed to be mounted on a bench or cabinet. Tool Room Lathes have somewhat greater accuracy and, usually, a wider range of speeds and feeds than ordinary engine lathes. Designed to have greater versatility to meet the requirements of tool and die work, they often have a continuously variable spindle speed range and shorter beds than ordinary engine lathes of comparable swing, since they are generally used for machining relatively small parts. They may be either bench or pedestal type.

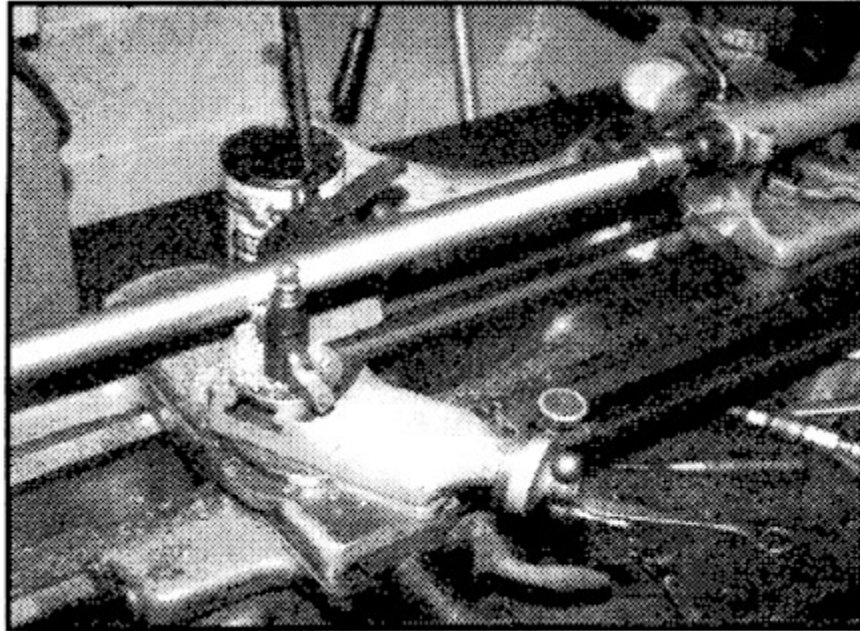
PREPARING THE BARREL BLANK

You have the barrel cut to the length that you want, plus 1 inch, so now chuck the barrel in the lathe and face off both ends of the barrel. If the bore has run quite a bit off center, you will need to repeat this

GUNSMITHING AND TOOL MAKING BIBLE

process after a few passes on the O.D.

Turning constitutes the majority of lathe work. The work usually is held between centers or in a chuck, and a right-hand turning tool is used, so that the cutting forces, resulting from feeding the tool from right to left, tend to force the work piece against the head stock and thus provide better work support.



Turning the barrel

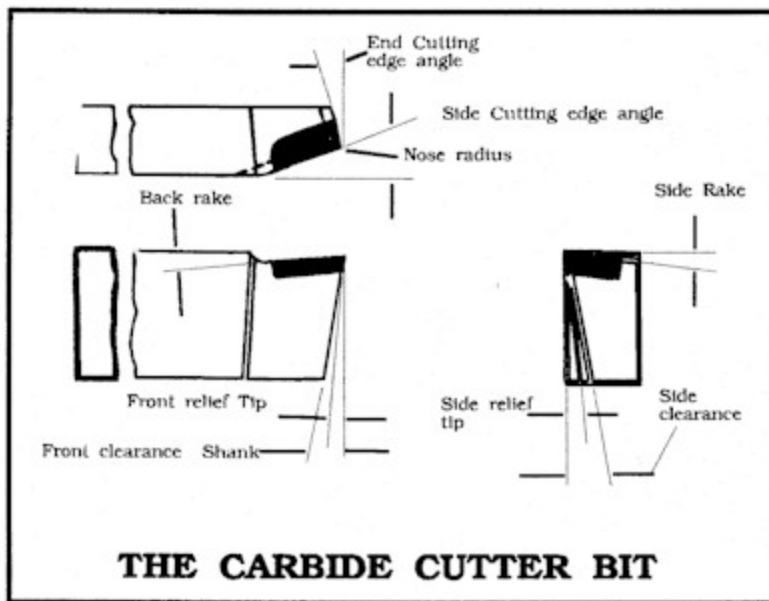
If good finish and accurate size are desired, one or more roughing cuts usually are followed by one or more finish cuts. Roughing cuts may be as heavy as proper chip thickness, tool life, and lathe capacity permit. Large depths of cuts and smaller feeds are preferred to the reverse procedure, because fewer cuts are required and less time is lost in reversing the carriage and resetting the tool for the following cut.

On work pieces that have a hard surface, such as castings or hot-rolled materials containing mill scale, the initial roughing cut should be deep enough to penetrate the hard material. Otherwise, the entire cutting edge operates in hard, abrasive material throughout the cut, and the tool will dull rapidly. If the surface is unusually hard, the cutting speed on the first roughing cut should be reduced accordingly.

Finishing cuts are light, usually being less than .015 inch in depth, with the feed as fine as necessary to give the desired finish. Sometimes a special finishing tool is used but often the same tool is used for both roughing and finishing cuts. In most cases one finishing cut is all that is required.

However, where exceptional accuracy is required, two finishing cuts may be made. If the diameter is controlled manually, it usually is desirable to make a short finishing cut of .005 and check the diameter before completing the cut. Because the previous micrometer measurements were made on a rougher surface, some readjustment of the tool setting may be necessary in order to have the final measurement, made on a smoother surface, check exactly.

GUNSMITHING AND TOOL MAKING BIBLE



In turning operations, diameters usually are measured with micrometer calipers, although spring calipers may be used to check roughing cuts or where close accuracy is not required. The method of making length measurements is controlled, primarily, by the shape and accessibility of the surfaces over which measurement must be made.

Spring, hermaphrodite, venire, or micrometer calipers or micrometer depth gages can be used.

The reason for this is that if the angle on the end of the barrel is off, one side of the barrel will be thicker than the other. In turning, the barrel will probably warp. Now that the barrel is squared, put the faceplate on the lathe.

Take a bar of steel that is 24 inches long that has centers in each end and has been turned true.

You will need to set the tail stock to an exact .0000 setting so that there is no taper in the OD of the liner when finished. Set the dial indicator on the carriage of the lathe, set it to 000, and set the tail stock over a bit. Crank the carriage down towards the head stock to where the mark is on the barrel. Check the reading on the dial indicator, and if it is not right, reset the tail stock and repeat the process until you get 0.0104.

Having now completed setting the tail stock to .0000, set the barrel blank between the centers, and clamp a lathe dog on the head stock end.

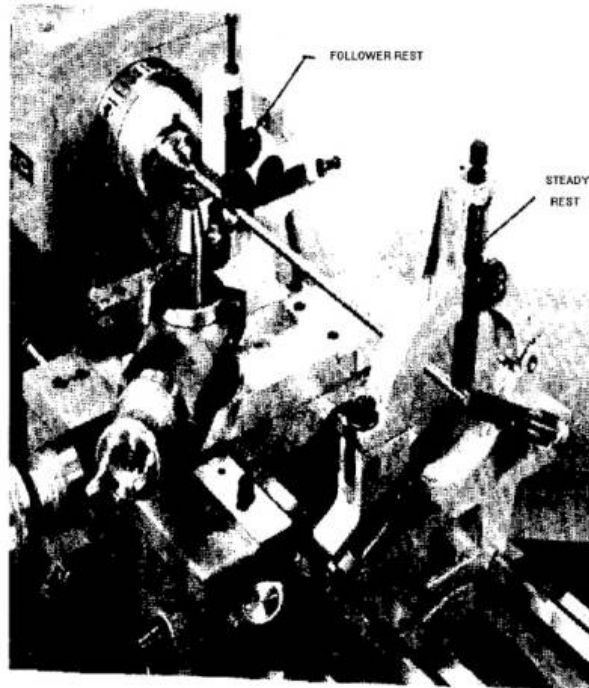
Use a standard faceplate with the centers to hold the barrel.

LATHE CHUCKS

Lathe chucks are used to support a wider variety of work piece shapes and to permit more operations

GUNSMITHING AND TOOL MAKING BIBLE

to be performed than can be accomplished when the work is held between centers; Two basic types of chucks are used. The tail stock center, I have found over the years work better if it is carbide. If you are careful, you can use the standard high-speed center. Put a little grease on it that contains MolyKote Z before setting it up.



Steady and Follower Rest

I have tried to use live centers off and on, but I have found that I get too much chatter, and that will cause stress to build in the barrel, and thus warp the barrel.

It is very important to keep any stress from build up in the barrel (Live centers, too tight centers, dull tool bit, improperly sharpened tool bit, etc.) Now for the tool bit. I have used carbide most all the time in turning barrels. I prefer a good grade of high-speed steel as they are sharper and cut better, but require sharpening every pass, to keep a good edge. I had to use carbide due to the time saved.

LATHE TOOLS

Most lathe operations are done with relatively simple, single point cutting tools. On right-hand and left-hand turning and facing tools the cutting takes place on the side of the tool so that the side rake angle is of primary importance and deeper cuts can be made. On the round-nose turning tools, cutoff tools, finishing tools, and some threading tools, cutting takes place on or near the end of the tool, so that the back rake is of importance. Such tools are used with relatively light depths of cut.

Most lathe work is done with high-speed steel, carbide, or ceramic tools. For mass-production work, the throwaway types of carbide or ceramic tips are used, with either integral chip breakers or the adjustable type.

GUNSMITHING AND TOOL MAKING BIBLE

STEADY AND FOLLOW RESTS.

If one attempts to turn a slender piece between centers, the radial force exerted by the cutting tool, or the weight of the work piece itself, may cause it to be deflected out of line. Steady and Follow rests provide means for supporting such work between the head stock and the tail stock. The steady rest is clamped to the lathe ways and has three movable fingers that are adjusted to contact the work and align it. A light cut should be taken before adjusting the finger's to provide a smooth contact-surface area.



Lathe Face Plates

A steady rest also can be used in place of the tail stock as a means of supporting the end of long pieces, having too large an internal hole to permit using a regular dead center, or work where the end must be open for boring. In such cases the head stock end of the work must be held in a chuck to prevent it's moving longitudinally, and tool feed should be toward the head stock.

The follow rest is bolted to the lathe carriage. It has two contact fingers that are adjusted to bear against the work piece, opposite the cutting tool, so as to prevent the work from being deflected away from the cutting tool by the cutting forces.

TOOL HOLDERS

Because cutting-tool materials are expensive, it is desirable to use as small amounts as possible. At the same time, it is essential that the cutting tool be supported in a strong, rigid manner to minimize deflection and possible vibration. Lathe tools are supported in various types of heavy forged tool holders. The tool bit should be clamped in the tool post with minimum overhang. Otherwise, tool chatter and poor surface finish may result.

GUNSMITHING AND TOOL MAKING BIBLE



Carbide Cutting

Where large tool bits are required, the type of forged tool holder may be used. It provides a more adequate method of clamping and supporting the tool than is provided by an ordinary tool post. The tools used in such cases have a heavy shank of forged or hot-rolled bar stock in which a carbide tip is brazed, thus reducing the amount of expensive tool material required.

Where several different operations on a lathe are performed repeatedly in sequence, the time required for changing and setting tools may constitute as much as 50 per cent of the total time. As a consequence, quick-change tool holders are being used increasingly. The individual tools, preset in their holders, can be interchanged in the special tool post in a few seconds. With some systems a second tool may be set in the tool post while a cut is being made with the first tool, and then be brought into proper position by rotating the post.

In lathe work the nose of the tool should be set exactly at the same height as the axis of rotation of the work. However, because any setting below the axis causes the work to tend to "climb" up on the tool, most machinists set their tools a few thousandths of an inch above the axis, except for cutoff, threading, and some facing operations. I ground all my tools to the general shape. On high speed bits I used only about .010-nose radius, stoned on by hand. Set the tool up so it is about .010 above the tail stock center. If I have the time, I usually use a feed of .004, but you will need to experiment to see which feed works the best.

Usually I do not take over .020 passes per each side on each pass.

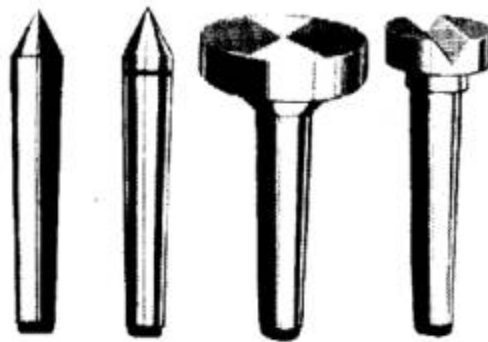
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What you have to watch for is that the Cut is not heavy enough that it will cause the barrel to spring, especially on the barrel that is halfway turned down. This springing causes stress. Here is where a good

GUNSMITHING AND TOOL MAKING BIBLE

steady rest or a follower rest becomes important. With a follower rest, you will be able to cut the outside of the barrel with no taper, which is caused by springing.

The tool must cut clean, for if it drags, or it is slightly dull it will cause the barrel to heat as it is turned. When the bit is sharpened right you will get some heat build up, but not much. Watch the chips, as they are coming off the barrel. If they turn a dark blue, you are taking too much a cut, or the tool is dull.



Types of Lathe Centers

Set the dial indicator on the carriage of the lathe, set it to 000, and set the tail stock over a bit. Crank the carriage down towards the head stock to where the mark is on the barrel. Check the reading on the dial indicator, and if it is not right, reset the tail stock and repeat the process until you get 0.0104.

Having found the correct angle, set the barrel blank between the centers, and clamp a lathe dog on the head stock end. The tail stock center, I have found over the years work better if it is carbide. If you are careful, you can use the standard high-speed center. Put a little grease on it that contains MolyKote Z before setting it up.

What you have to watch for is that the cut is not heavy enough that it will cause the barrel to spring, especially on the barrel that is halfway turned down. This springing causes stress. The tool must cut clean, for if it drags, or it is slightly dull it will cause the barrel to heat as it is turned. When the bit is sharpened right you will get some heat build up, but not much. Watch the chips, as they are coming off the barrel. If they turn a dark blue, you are taking too much a cut, or the tool is dull.

Keep close of the pressure on the tail stock. It must be snug on the barrel, but not tight. As the barrel heats its lengthens, and the tail stock must be loosened. If the tail stock center loosens too much, the tool bit will chatter. After the contour is turned up to where the shoulder will end, you will need to remove the barrel. You will then check to see if the bore is straight, and straighten if necessary.

If you have kept a sharp tool and a light feed, it should be straight. You must, after ever pass from now on the barrel should be checked to see if it is straight. If the barrel has warped, take a lighter pass after it is straighten.

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GUNSMITHING AND TOOL MAKING BIBLE

the tool bit will chatter. After the barrel is turned to about 3/4 finished, you will need to remove the barrel. You will then check to see if the bore is straight, and straighten if necessary.

If you have kept a sharp tool and a light feed, it should be straight. You must, after every pass from now on the barrel should be checked to see if it is straight. If the barrel has warped, take a lighter pass after it is straighten.

When you have finish turning the barrel down to within a few thousands of the finish size, set the feed to the lightest feed. Sharpen the tool bit, hone it very good, and make a finish pass. This should finish the liner, and it will be ready for inserting into the bored out barrel.

When you start cutting the contour of the shoulder, unless you have a tracer attachment for your lathe, you will have to cut it by hand. This may sound hard, but with a little practice you will get a perfect contour. To this, as you get where the contour starts, you will start to back the feed out by hand. With pass put a little more contour to the shoulder.

Remember to take the shoulder back a little farther than where it should be when finish, as you have to turn down the shank of the barrel. If the barrel should start to chatter when turning, lay a barrel blank on the barrel behind the cutter and that will usually stop the chatter.

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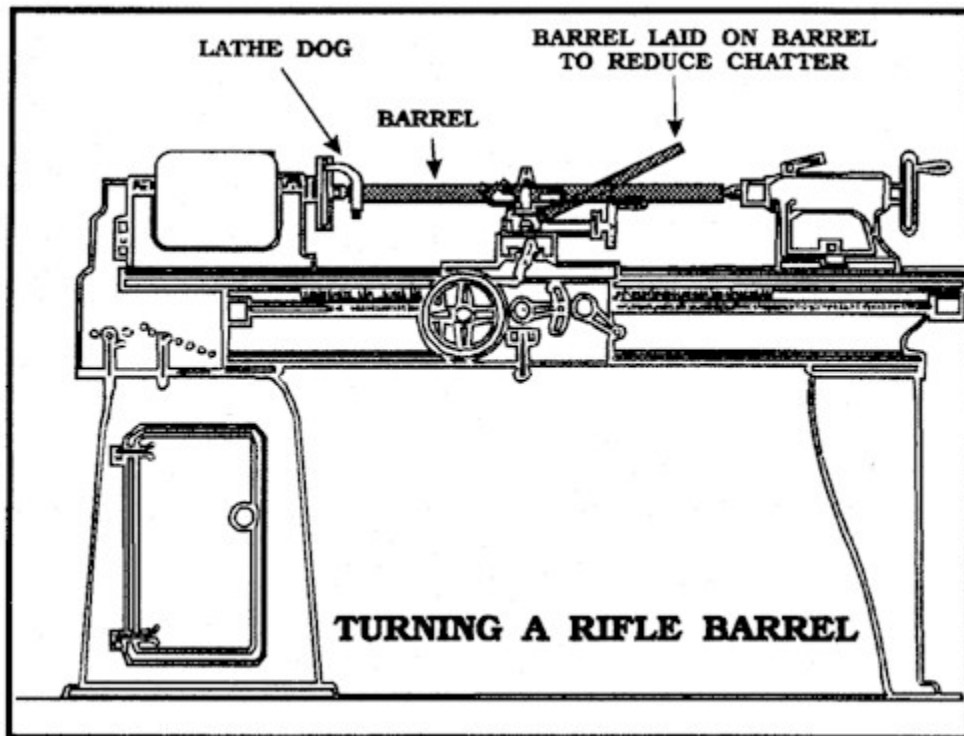
ACTUAL TURNING

Now we will take the barrel that you drilled, reamed, and rifled and turn it into a finished rifled barrel. I will try to cover the process systematically up to the finish. I will assume that this barrel is a 308 caliber.

I will give you instructions for a 24-inch barrel. The first thing to do is cut the barrel to 24 1/2 inches long. You will need the extra 1/4 inch in truing up each end, and the final finishing of the barrel.

You have the barrel cut to 24 1/2 inches, so now chuck the barrel in the lathe and face off both ends of the barrel. If the bore has run quite a bit off center, you will need to repeat this process after a few passes on the O.D.

GUNSMITHING AND TOOL MAKING BIBLE



The reason for this is that if the angle on the end of the barrel is off, one side of the barrel will be thicker than the other. In turning, the barrel will probably warp. Now that the barrel is squared, put the faceplate on the lathe. Take a bar of steel that is 24 inches long that has centers in each end and has been turned true.

You will need a trued barrel for each length of barrel you turn. What this is for is to give you a means to duplicate any taper that you want. Example, if you found that the old barrel that you wanted to duplicate, had a taper of .125 from the muzzle, to 12 inches from the muzzle.

Go to the taper per foot chart. In the taper Per Foot column at the top, find $1/8$. Follow this column down, and when you come to where the left column says - Length of Tapered Portion, at 1 foot, or 12 inches. Where these two meet, find a figure of 0.0104. Now mark the 24-inch bar of steel exactly 12 inches from the tail stock end, to a point in the middle of the barrel. This is the distance you will need to travel with the dial indicator.

Set the dial indicator on the carriage of the lathe, set it to 000, and set the tail stock over a bit. Crank the carriage down towards the head stock to where the mark is on the barrel. Check the reading on the dial indicator, and if it is not right, reset the tail stock and repeat the process until you get 0.0104.

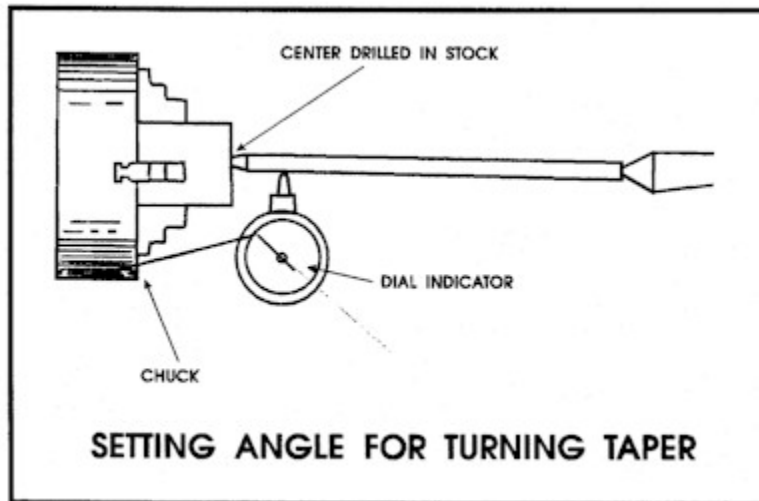
It would be wise to keep all of these figures on notes, or stamp the barrel with the correct figures, for future reference.

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GUNSMITHING AND TOOL MAKING BIBLE

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GUNSMITHING AND TOOL MAKING BIBLE

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CHANGING BARRELS

To change a Springfield, Enfield or Mauser type barrels is usually a simple matter. To replace these barrels, you need a sturdy barrel vise, as well as an action wrench. Always clamp the barrel in the vise and turn the receiver. Two or three good commercial barrel vises are on the market, but I find it is easy and much cheaper to make your own, as shown in the drawing. You can use the regular style rigid base machinist's bench type vise for barrel work. A vise, of the size and strength necessary for barrel removal and replacement would cost at least twice as much as a commercial barrel vise. Do not try to remove Mauser or Enfield barrels in your regular four or five-inch bench vise, as they are not stout enough.

The barrel vise or clamp must be mounted very rigidly, and if you can, in cement. A very heavy, solid bench that is bolted to the floor will work also. The jaws for these vises may be of very good grooved hardwood that is covered with powdered rosin before fitting to the barrel.

Better yet, of lead or Babbitt metal, cast to the contour of the barrel involved. You have to hold the barrel tight enough to prevent it turning when you bear down on the wrench. Jaws should be smooth for fitting finished barrels without marring them, but can be of drilled steel for removal of unusable military barrels, which are usually set in very tightly. A barrel should be clamped as close to the receiver as conveniently possible, to minimize twisting action.

When the barrel just will not unscrew, the welding torch can sometimes be applied, the receiver ring over the threads and given a fast heating to expand it slightly. Only a little heat is necessary-not enough to change the color of the metal, but it should be fast, so the receiver gets the benefit and not the barrel shank. A butane torch can be used, but it spreads a lot of heat around and does not concentrate it, as

GUNSMITHING AND TOOL MAKING BIBLE

does the acetylene tip. Keep the receiver just hot enough so the color does not change, until the barrel is cool to the touch. Quickly place the wrench on the receiver and give it a sudden, heavy pull-which will usually break it loose.

If this method fails to loosen a stubborn barrel, the only thing left to do is cut a groove at the front of the receiver. A cut off tool can be used to cut a recess in front of the receiver, this being done while the barrel is clamped in the lathe, and running at slow speed. Nearly all rifle barrels are fitted to the receiver with a right-hand thread; but there is always the exception, as I once found out when removing the barrel from a 6.5 MM Norwegian Krag rifle. As it happened, I was able to move this barrel slightly in a left-hand direction and then it tightened up and would move no farther so, in spite of disbelief, I reversed operations and the barrel unscrewed to the right. The old, hammer model, Marlin shotgun is also a left hand thread.

Setting new barrels in bolt-action receivers is simply the reverse of removing the old one, naturally, and as a rule is much easier, the principal problem is keeping the barrel clear of marks from the blocks. Hardwood blocks are almost the only type, which will not mar a finished barrel. The ideal fit is to have the barrel thread into the receiver so that it can barely be started by hand but turned easily by the

GUNSMITHING AND TOOL MAKING BIBLE

receiver wrench until within 3/16 to 1/8" of lining up. If going by the index marks on the barrel and the receiver.

It should then tighten until the marks line up. A 30" length of pipe for a cheater handle can be used to bring the shoulder of the barrel against the receiver ring tightly. The shoulder should seat firmly against the receiver all the way around. This is important in .22 rim-fire match rifles, or any target arm. It can be spotted by painting the shoulder with layout fluid, or shoe polish and turning in until the shoulder bears against the receiver lightly. Then removed for inspection, the spots showing wear being reduced slightly. The barrel shoulders will be more accurately machined than the front of the receivers, on large caliber rifles, so clean the front of the action good before fitting the barrel.

SHOTGUN BARRELS

Shotgun barrels usually unscrew easier than rifle barrels do and, as they are round, the same method is used as for round rifle barrels. A hardwood block is bored out to fit the shotgun barrel, and then split.

Before clamping a barrel in one of these clamps, coat the surface of the sleeve that is to be against the barrel with powdered rosin. This gives it a much better grip and protects the surface of the barrel, not even marring the bluing. This rosin may afterwards be cleaned from the surface of a barrel with high-test gasoline or turpentine.

Be careful not to set the clamp up too tightly on a shotgun barrel if it is a new barrel, or a barrel you are going to use again, as you may crush it. When setting it up on a high-power rifle barrel, oil the threads on the bolts holding the two parts of the clamp together, and pull the nuts up tightly with a long-handled socket wrench.

A shotgun barrel has a fairly straight taper from the breech, so the clamp can be fitted back close to the receiver.

After the old barrel has been removed, clean out the threads in the receiver with an old toothbrush, dipped in solvent. Also, clean the threads on the new barrel with brush and solvent, to remove the heavy oil and any dirt that may have collected upon them. Oil the threads of the new barrel with a light oil, and screw the barrel into the receiver as far as it will go by hand. Place the shotgun barrel in the barrel vise and screw the receiver up to place with the crescent wrench. If you cannot make the receiver screw quite up to the mark on the barrel, unscrew it from the barrel and, using a large, flat, dead smooth file or a large Carborundum stone, dress off the barrel, and, after cleaning it, screw it onto the barrel again.

Repeat this process until you can screw the receiver up to its proper position. If the receiver screws up too far on the new barrel, peen it slightly. The correct procedure is to place the barrel in the lathe, face-off the end of the barrel and the barrel shoulder far enough so that the barrel can make another complete turn. This is less the amount required to make the marks on receiver and barrel meet.

Knowing how many threads to the inch are on the barrel, it is easy to figure just how many thousands of an inch the barrel will move in the receiver in making one complete revolution in the threads. After the barrel is chucked in the lathe, bring the facing tool lightly against the end of the barrel, or against the

GUNSMITHING AND TOOL MAKING BIBLE

barrel shoulder, and set the micrometer carriage stop against the forward end of the lathe carriage.

Next, back off the micrometer stop the required number of thousandths of an inch for one revolution of the barrel, less the amount required to make the marks on receiver and barrel meet. This number of thousandths of an inch is then deducted from the number of thousandths of an inch the barrel moves in a full revolution. The answer is the amount the micrometer stop is to be backed away from the lathe carriage.

A thread must be machined from the rear end of the barrel, on such barrels, which have a shank section at the rear machined to a diameter of the root diameter of the thread.

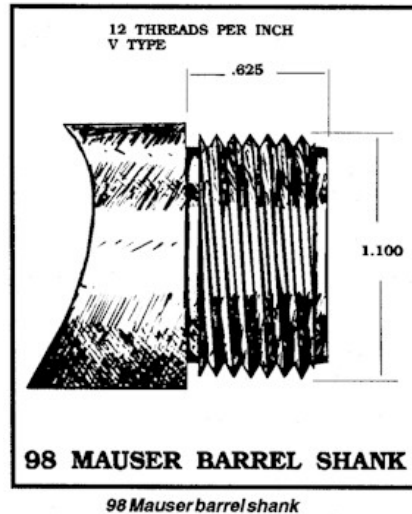
If the rear end of the barrel is slotted for an extractor, this slot must be deepened. This is done while the barrel is still in the lathe, using a tool post grinder, with a grinding wheel narrow enough to enter the extractor slot, or done on a milling machine. It may also be done on the milling machine.

This method of bringing a barrel to its correct place in the receiver when it screws past the register mark can only be used if a chambering reamer is available. After shortening the barrel at the breech end the chamber must be deepened the same amount.

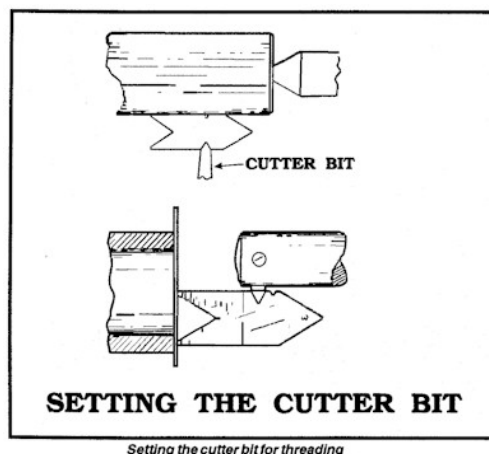
If no chambering reamer is available, instead of shortening the barrel so it can be seated one turn deeper in the receiver. A steel shim must be placed between the barrel shoulder and the part of the receiver against which this shoulder bears. When using steel shims, lubricate it either with oil or colloidal graphite to prevent it tearing under the twisting pressure.

THREADING AND FITTING

When you have finish turning the barrel, and double-checking it for straightness, it is time to turn the shank. Set the tail stock back to 000, take the lathe dog off, and put a smaller one on the muzzle end of the barrel. With a shim under the setscrew to keep the barrel from being marked by the setscrew. Put the barrel back in the lathe, and turn the shank to the correct diameter.



On a 98 Mauser, which we will thread to, take only a light clean up pass. This is assuming that you made your barrel out of 1 1/8 inch stock. It would be best if you have an old 98 Mauser barrel handy to look at, while you are doing this.



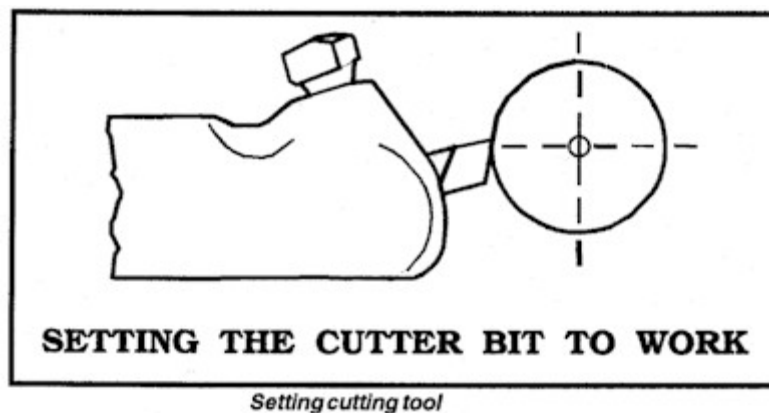
If you look at the chart for threading the 98 Mauser, See chapter on barrel thread dimensions, The O.D. of the shank is 1.100. That only leaves less than .020 for the shoulder.

This is OK as on the 98 Mauser we seat the barrel on the inside ring.

GUNSMITHING AND TOOL MAKING BIBLE

Turn the thread end down to 1.100 now. Using a dial indicator as you are turning cut a .625 long shoulder. When you have the thread shank turned to the correct size, take a small square end tool and relieve the threads on the front end of the shoulder, and the back end of the thread shank. This relief should be about .060 deep per side.

It is time to cut the threads on the 98 Mauser. The 98 has 12 threads per inch V type. Set up a V tool bit ground right for threading. This is a 60-degree tool. Set the point of the tool right on center, using the center on the tail stock. The Compound should be set at 30 degrees, when you clamp the tool. Set the quick change gears for 12 threads per inch, make sure your feeding dial is engaged, and you are ready to cut the threads.



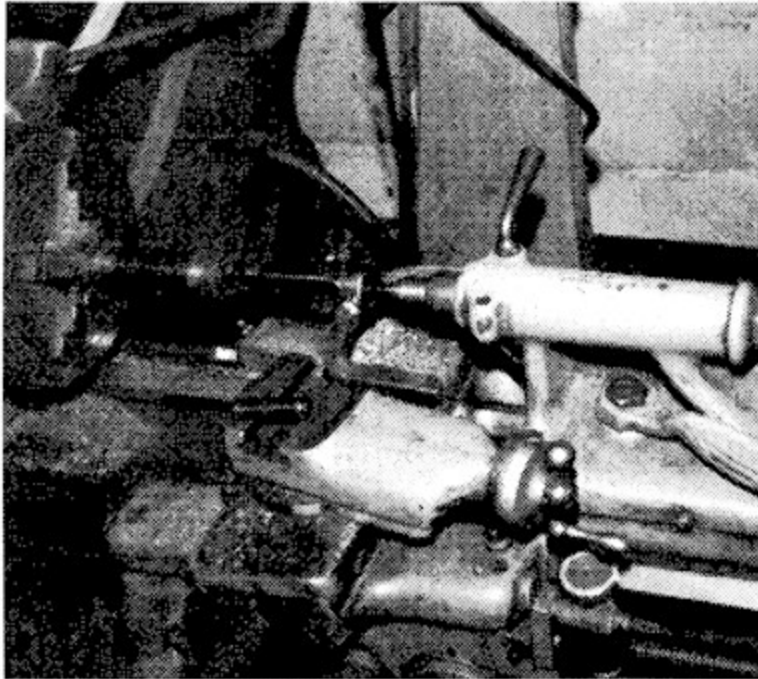
Set both dials to where the tool is just touching the shank. Set the dials on 000. Set the tool in so you will take a .005 cut. See chart for amount that you will have to turn in to get the proper depth. Have the lathe in back gear, running it at the slowest speed. When the threading dial comes around to 0 engage the feed. It feeds fast, so be ready to disengage the feed and back out the tool in one operation.

When it has completed set the tool in .010 and when the dial comes back to 0, engage the feed. Keep repeating the process until you have gone .062; make a clean up pass at the last setting. Use a good cutting oil when cutting threads. Always turn in the compound dial, leave the other at 0, and back this out each time.

FITTING THE BARREL TO THE ACTION

Take the action and see if it will screw on to the barrel. It should but if it doesn't take another pass until it does. **DO NOT TURN ON THE LATHE OR CHANGE ANYTHING UNTIL THE ACTION WILL SCREW ON.** The barrel screws on to the action and butts up against the shoulder on the inside of the action.

GUNSMITHING AND TOOL MAKING BIBLE



Chambering barrel

Take a depth mike and measure the depth from the front of the action, to the inside ring. Check this against the measurement of .062 that you turned on the thread shank. The thread shank should be .003 longer than the measurement from the face of the action to the ring.

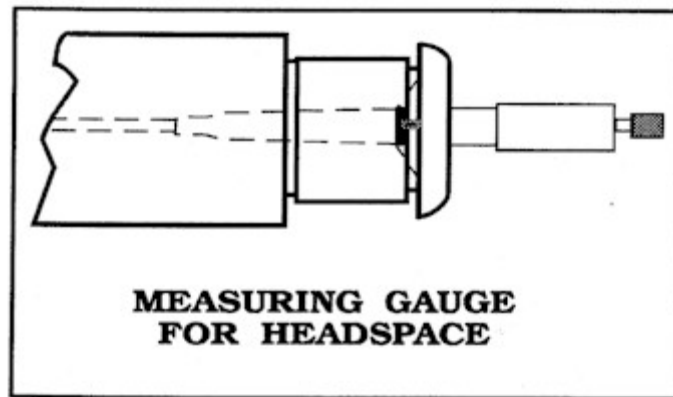
When you tighten the barrel up on the action, you will see the compression marks on the face of the barrel. When you have this, the barrel is completed except chambering.

CHAMBERING THE BARREL

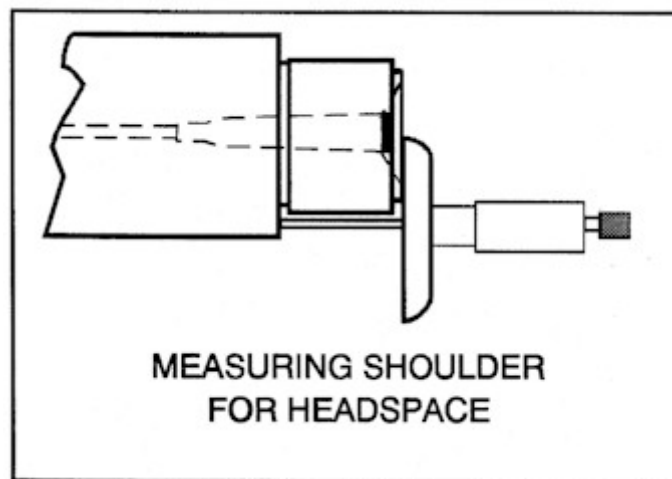
The reamers are easily made. If you can make barrel reamers, you can make chambering reamers. What you need now is a 308 Winchester chambering (finish), and head space gauges (go and no go).

You will need a 7/16 drill bit, unless you are planning to use a roughing reamer to remove the extra metal. You will need now to chuck the barrel on the shank in front of the threads. Using a dial indicator be sure the barrel is running true on both ends.

GUNSMITHING AND TOOL MAKING BIBLE



If it is not running true, you will cut an out of round chamber. Chuck the drill in the tail stock chuck, as you will have to drill out the chamber end about 1.250. This will remove enough metal so the finish reamer won't have to cut much.



Now set a small lathe dog on the reamer, and with a center in the tail stock, move the tail stock up close enough to the barrel so the reamer will be in the barrel next to the shoulder of the reamer. Have the reamer in the tail stock center. Leave the lathe in back gear setting that you used for threading and with the tail stock fastened down. Slowly feed the reamer into the barrel, keeping plenty of cutting oil on the reamer.

You can rest the lathe dog on the compound, while feeding in. Be sure that the reamer is on the tail stock center when you feed it in as if it isn't it can grab and break the reamer. **ALWAYS HOLD THE REAMER BACK AGAINST THE TAIL STOCK CENTER.** Usually at first you will be able to feed in for a depth of about 1/8 inch, before removing the reamer and blowing out the chips. As you get down to the shoulder area, the feed in is less.

GUNSMITHING AND TOOL MAKING BIBLE

CHECKING THE HEAD SPACE

When you get close, you will have to use the head space gauge. You will need to know what the correct head space will be.

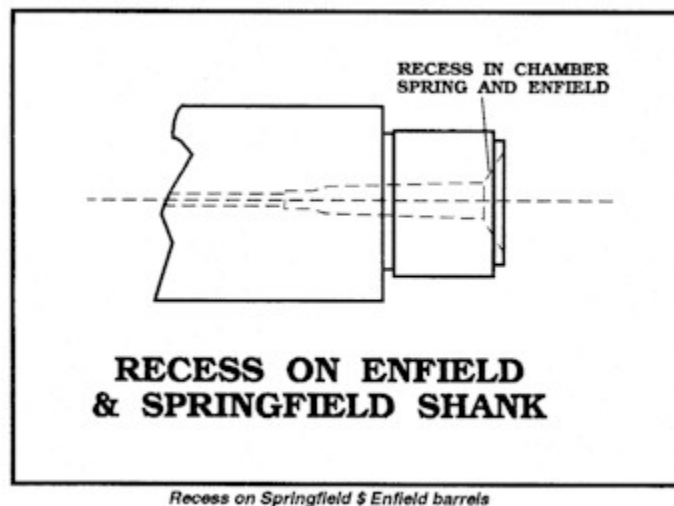
Take the action with the bolt cocked and closed, measure the distance from the inner ring, what the barrel is butted up against, and the bolt face. Take the difference, which in this case is .100.

Now knowing the depth is .100 we can keep feeding the reamer in until the head space gauge will be the right depth. The correct depth would be .095. Allowing for .003 for compression of the barrel to the action, this would leave .002 on the head space, which is about right. To set the depth, use a depth mike, placing the depth mike on the end of the head space gauge, and measuring the depth until it read .095.

When you get close it would be best to use a dial indicator to go the final few thousands. This is how the Mauser is chambered and head space. Other types of actions are done the same, with a little variation.

FITTING SPRINGFIELDS

On some barrels like Springfields or Enfields, we use the same way of measuring from the front of the action to the bolt face. Because the barrel is coned, we have to measure from the cone to the head space gauge. This distance is subtracted from the distance from the shoulder on the barrel, to the face of the cone.



POLISHING THE CHAMBER

After the barrel is correctly head spaced, the chamber should be finely polished. This is done with the lathe running at a high RPM.

GUNSMITHING AND TOOL MAKING BIBLE

Note-The barrel that is sticking out the back of the lathe should be centered with a collar that has set screws to hold the barrel from starting to run out of center with the high RPM. Use a fine polishing cloth on the end of a slotted rod.

Do not over polish, as this will change the dimensions of the chamber. You will be able to see all the scratches, and will be able to measure any part of the chamber.

Screw the barrel on the action, seat it real tight, remove the extractor, and the cocking piece. Drop a new loaded round into the chamber and close the bolt. It should close any pressure. Remove the loaded round, and drop the No Go gauge in the chamber.

It should not allow the bolt to close. If for some reason it does, remeasure and face a little off the face of the barrel.

FINISHING THE OUTSIDE OF THE BARREL

All that we have to do now is to polish the machine marks from the barrel and crown the muzzle. I find that I can chuck the barrel in the lathe, using a live center and remove the machine marks with coarse grit paper, then finish polishing with finer grit..

This does not take long if you have not left chatter marks on the outside of the barrel. If there is chatter on the outside, the barrel will need to be filed while it is spinning.

When the barrel is as smooth as you want it, remove the barrel, turn it around, chuck it up on the muzzle and crown it. The easy way is to face the muzzle off flush, and counter bore it to protect the bore. You are ready to polish and blue.

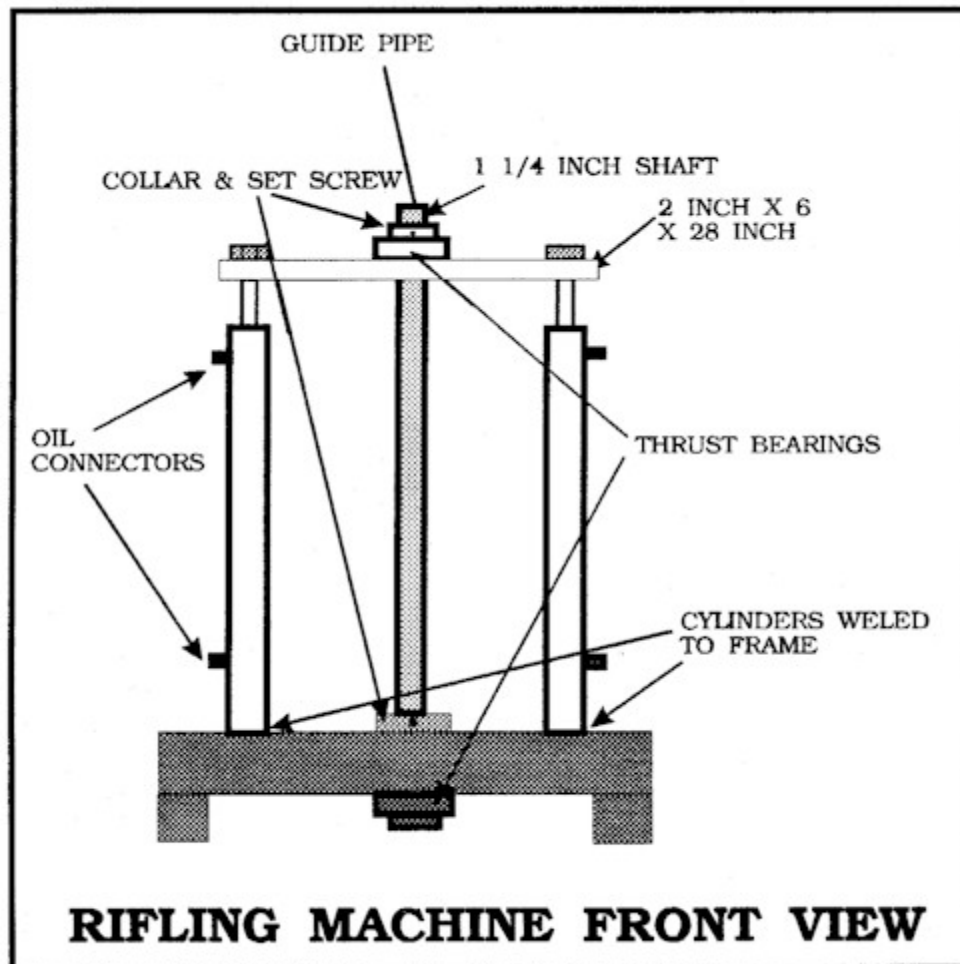
BUTTON RIFLING MACHINE

This machine is very simple in construction, easy to build, and has given years of trouble free service. You will first need to get a few items to build this machine. The main item is a good low volume hydraulic pump, with at least 1000 pounds of pressure.

In addition, you will need two hydraulic cylinders, each with a stroke of at least 30 inches. Also find at an automotive parts house, two heavy duties thrust bearings, with a 1 1/4: bore. See Drawing.

The thrust bearings are used to take care of the torque when rifling, and does a good job as the more expensive rifling head. You can buy a 2-way hydraulic control valve, which is used to raise and lower the hydraulic cylinders.

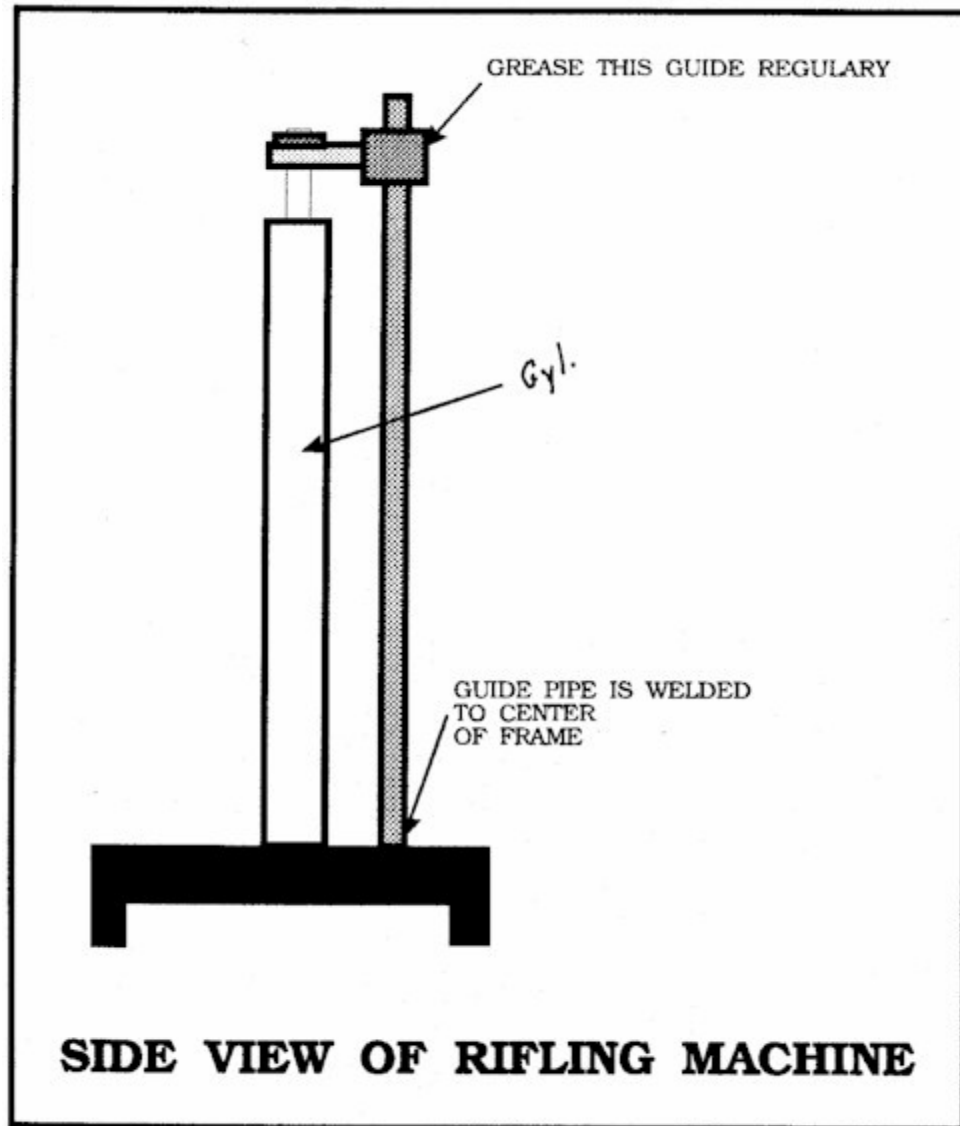
The metal that you use to make the frame should be rather heavy as it takes lots of pressure to rifle a 45-caliber barrel; two-inch material is a good start. All the holes, and alignment should be drilled very carefully, or the cylinders will pull crooked, and bind up in use.



Rifling Machine, Front View

GUNSMITHING AND TOOL MAKING BIBLE

If you plan to rifle barrels over 30 calibers, I would suggest using a rifling head. My rifling machine had a variable speed, heavy duty, and gear reduction electric motor. With this, we could reduce, or increase the rate of twist in seconds by use of a speed switch such as used by a light dimmer switch sold at any hardware store. For 30 caliber and smaller the thrust bearings was all that was needed.



Rifling Machine, side view

You will need at least a three-horse power electric motor to drive the hydraulic pump. It takes a lot of power to pull the rifling button through the barrel. The drawing shows the machine without the guide pipe.

It has been omitted so as not to confuse the drawing. You will see a side view of the drawing showing the rifling machine with the guide pipe. The guide pipe when in use should be well greased so it will not bind or chatter as it is being raised. The top brace that connects the two hydraulic cylinders should be level and parallel with the bottom support.

GUNSMITHING AND TOOL MAKING BIBLE

This is very important as when you are rifling a barrel the rod is pulling straight, instead of an angle. This is very important when rifling 22 liners, as they have a tendency to warp anyway when rifled due to the extreme swaging operation. When the machine is assembled, make sure all the air is bled out of the cylinders and lines. If not, they will pull crooked if air is in the lines.

RIFLING HEAD

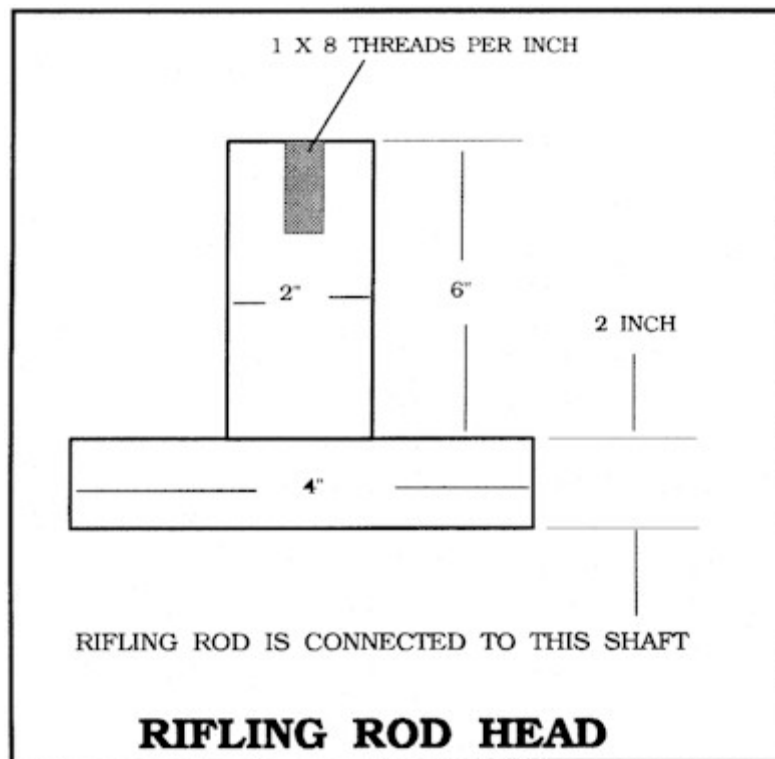
About the only other item that will have to be made and installed is the rifling head. The simplest one is the use of thrust bearings. This head will hold the rifling or pull rod, and the rod holder.

RIFLING ROD HEAD

You will need one for each size rod or caliber, such as 1/8" for 17 caliber, .187 for .224-.244-.257, and on up on the sizes. A heavy duty-bearing clamp, with at least 3 3/8" set screws to hold the barrel when rifling.

This is shown as a collar in the drawings. When rifling, the setscrew has to be **VERY TIGHT**.

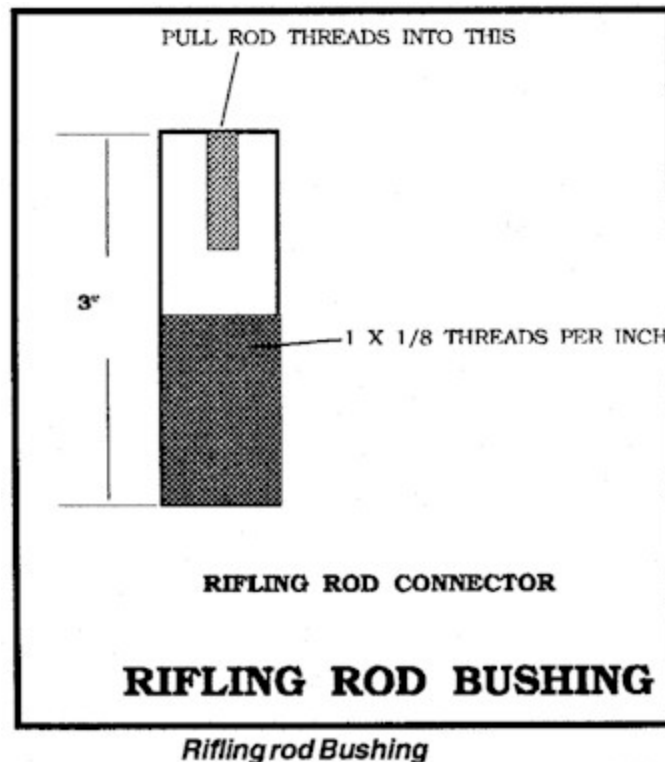
There is a tremendous pull on the machine when the barrel is rifled, as you are pulling an oversize button through a hardened piece of steel. Button rifling swages the rifling in the steel, rather than cuts out the grooves.



Rifling rod head

GUNSMITHING AND TOOL MAKING BIBLE

If you plan to rifle barrels over 30 calibers, I would suggest using a rifling head. My rifling machine had a variable speed, heavy duty, and gear reduction electric motor. With this, we could reduce, or increase the rate of twist in seconds by use of a speed switch such as used by a light dimmer switch sold at any hardware store. A small chain, such as a bicycle chain is used to drive the rifling head at the proper rotation. Slight changes in the construction of the head will be needed to adapt to the Rifling Head. The thrust bearings are still used when using the Rifling Head.



RIFLING THE BARREL

The rifling of the barrel is the climax of barrel making. In the past, this was a very time consuming operation. Not so with button rifling. It should not take over three minutes to do now what it took several hours or days in the past. The important part now is to get proper lubricant for the rifling operation.

Without this, when you start to rifle the barrel there will be a loud crack, as the rod PULLS in to and ruins the barrel.

LUBRICANT

I do not know of any commercial lubricant that will do the job, so after doing much experimenting and cutting many buttons out of the barrel. I came up with one that served me well for years. What happens is when the button starts down the barrel; it starts to gall then sticks. Therefore, if you decided to try some lubricant you will probably have to cut the end off the barrel. You will then split the barrel to get the button out, as the button will be in the barrel an inch or so.

GUNSMITHING AND TOOL MAKING BIBLE

The best lubricant that I have found is MolyKote Z, made by Dow Corning Corp, Midland, Mich. This can be purchase in various forms, but the powder is The best, and is what I always used, and with very good results. It looks like graphite, but don't let that fool you in think that graphite will work because it won't. It is necessary to mix it with oil and swab the bore.

This is a pressure lubricant, and they say it takes over 50,000 pounds of pressure to break it down. It works great on lathe centers too. If the rod the rod ever pulls off do not think you can get a rod and a big hammer and drive it out.

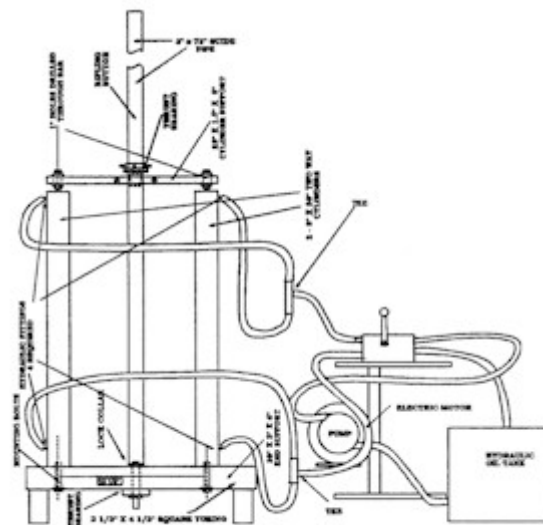


FIG. 9 TOP VIEW OF HYDRAULIC RIFLING MACHINE

Don't even be tempted to try. If you should be so lucky to drive the button out, it will be shattered. To remove a stuck button stick a short rod down inside the barrel to find where the button is, mark the outside of the barrel, add another 1 1/2 inch and saw it off. Then saw the back end off so you will have a short piece of barrel with the button in it. Next, get old hacksaw out, split it length ways on both side, and remove the button. You will notice there will be metal welded on the button, which you will have to remove very carefully.

When you saw it out be careful that you don't hit the button with the blade, as it will ruin the blade. All that is necessary is to redo the rod and resweat the button back on. In button reaming, you will not need any special lubricant, just some heavy oil like STP. If you have not left the barrel undersize, you should not have any trouble. It is wise to check each bore with a go-no-go gauge before rifling.

After checking the bore, and lubricating the bore, you are ready to rifle the blank. Set the barrel in the center hole in the rifling machine. Tighten the clamp around the barrel to hold it in place. Make sure the thrust bearing is centered and in place. Turn on the machine, and pull the control lever back and hopefully watch the barrel being rifled.

GUNSMITHING AND TOOL MAKING BIBLE

DO NOT STOP ONCE YOU STARTED, AS WHEN YOU START UP AGAIN YOU WILL PROBABLY PULL THE BUTTON INTO.

On the smaller caliber's you will see the barrel rotating on the thrust bearings as the rifling button makes the proper twist in the barrel, but in button reaming they won't move. When through lift the barrel from the top frame, without removing the clamps unscrew the button and remove from the machine. Then lower the frame back down. The barrel is through with button reaming.

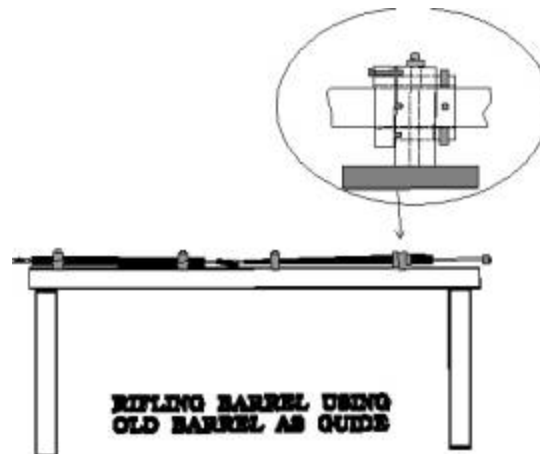
If you are using 1350 or Stress proof, don't button ream, only on 4150 or 4142 do you need to do this.

Lubricate the bore with MolyKote Z, put the barrel back in the machine, slide the rifling button back down the bore, and screw it into the head. Be sure the thrust bearing is centered under the clamp. Pull the lever back, and the barrel will rotate by itself as the button passes through the bore. If the barrel doesn't rotate, help it. If you have a rifling head, this won't be necessary. The smaller calibers do not pull that hard, but on 45's; the motor slow and breathing will cease until the button comes out the barrel.

I would not recommend that you try to rifle any stainless steel at first, as on them you will need to leave the bore slightly oversize. When the button has come out of the barrel, remove the barrel, wipe it out and you should have as good a barrel as any produced by a manufacture.

BENCH RIFLING

We will look at the simplest type, the hand-rifling machine first. In this type, the most intricate fixture is the rifling guide, and probably one of the simplest guides is another rifle barrel of the same twist as you wish to use. It need not have the same number of grooves however. A good solid clamp or preferably a pair of clamps is bolted to a good solid bench to hold the barrel. In line with these, and at the same center height, a third clamp is bolted to hold one end of the barrel that is to be used as a guide.



The fourth clamp is also used on the barrel being used for a guide. This must be a different type from the other, for this clamp must hold a flanged sleeve, which is clamped, tightly to the guide barrel. In this sleeve are as many holes drilled in a line around its circumference, as you desire grooves in the barrel to be rifled. A pin passes through this last clamp at a point in line with the holes drilled in the sleeve.

When the guide barrel is loosened in its clamps, the guide barrel and sleeve can be turned. This will bring one of the pinholes in the sleeve in line with the pinhole through the clamp in which the sleeve operates. This pin must fit the holes in clamp and sleeve very closely, the sleeve must fit closely in the clamp, and it can also be locked by having the clamp split at one side and a clamp bolt passed through the two sections. The flange on the sleeve is to prevent end motion of the guide barrel.

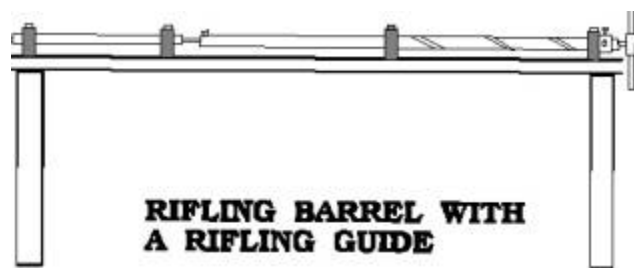


A rod or tube long enough to pass through both the barrel to be rifled and the guide barrel, with some several inches to spare, is attached to the rifling head. This rod or tube must have a guide block upon it to ride in the grooves of the guide barrel to cause the rifling cutter to turn. The simplest way to make this is to place the rod inside the guide barrel, packed with waste at a point four or five inches below the muzzle.

GUNSMITHING AND TOOL MAKING BIBLE

Fastening the barrel muzzle-up, heat the barrel and the rod from the muzzle down to the packing point, with a torch until it is hot. Make sure that the rod is central in the bore; pour in melted nickel-Babbitt around the rod until the barrel is full to the muzzle. After it has cooled, withdraw it partly from the barrel and shave off the outer end, where it overflowed the muzzle.

Make a punch mark on the muzzle of the barrel at one of the grooves and mark the Babbitt slug on the end opposite this mark on the barrel. If this guide block is removed from the guide barrel, you will get it back in the same position in which it was cast. Remove the waste from the barrel and clean the barrel out well. Reinsert the rod and guide block in the guide barrel, and then attach to the rear end of the rod a cross-handle, mounted on the rod on ball bearings.



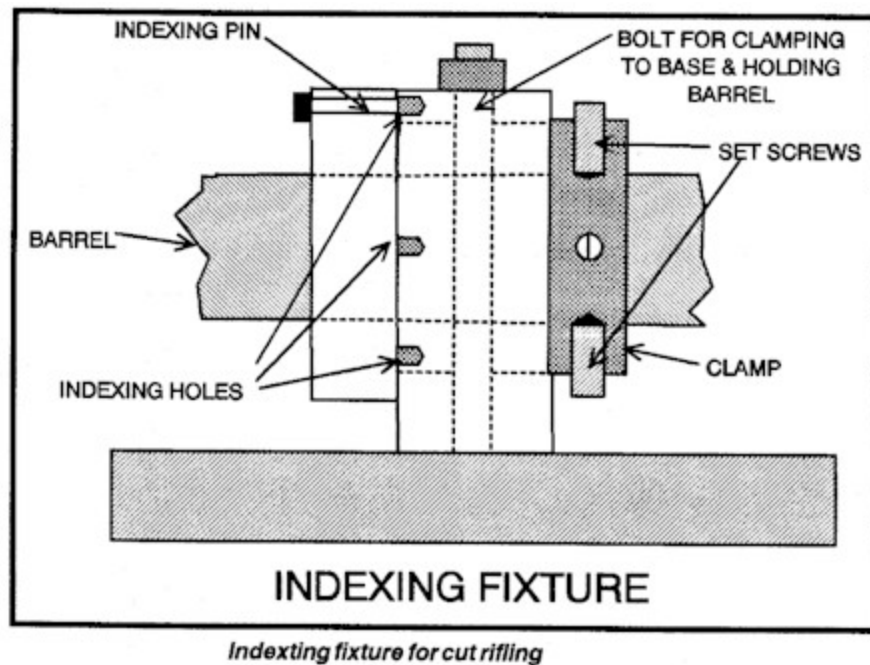
The rod, with the guide in place in the guide barrel near the end closest to the barrel to be rifled. This should be long enough so the rifling cutter clears by an inch or more the opposite end of the barrel to be rifled. With the clamps all locked and the rifling cutter in position in the head, the rifling cutter is now drawn through the barrel to be rifled, making the first cut.

The cutter is then dropped down, or, if it is the shimmed-up type of hook cutter, it is removed from the rifling head and the head is pushed back through the barrel. The cutter is replaced and the clamps on the guide barrel are loosened. Then the index pin is withdrawn and the guide barrel revolved in the clamps to the next pinhole, the pin is replaced. The clamps are tightened and the cutter is again drawn through the barrel to make a cut for the second groove.

This process is repeated with the same cutter setting until one cut has been made in each groove. The cutter is then raised and a second cut is made in the first groove, and all this is repeated until the grooves are all cut to the proper depth. The guide barrel must be kept well oiled on the inside and the barrel being rifled must have with cutting oil, either lard-oil or black sulfur oil compound pumped through it.

This cutting oil should be pumped into the barrel under pressure so that it will wash out the chips. It is better to use a tube for a pull-rod, as the oil line from the pump can be attached to the end of the tube opposite the rifling head. The oil can be pumped into the barrel by this method by having oil outlet holes drilled in the rifling head. A pump can be purchased from a machine shop supplier for this purpose. As the oil leaves the barrel it is screened to remove chips and is returned to the sump from which it is pumped.

GUNSMITHING AND TOOL MAKING BIBLE



A steel shaft will work much better. The steel shaft has a groove on the out side with spiral grooves and run through an indexing fixture held in a clamp. The barrel to be rifled is clamped in a fixture on the rifling bench, in the same way as the barrel was held by the above method. The spiral cut shaft is clamped by two clamps, in line with the barrel to be rifled. One of these clamps, which are also a guide for the spiral shaft, is plain and the shaft must be a close fit, but must not bind, as it passes through it with a twisting rotation.

The indexing fixture, which has as many pinholes, that is equally spaced around its circumference, as many as the desired grooves in the barrel. A harden steel pin fits tightly in these holes, and only one pin being used, all holes being the same size. This pin passes through the fixture rim and engages the spiral groove in the shaft.

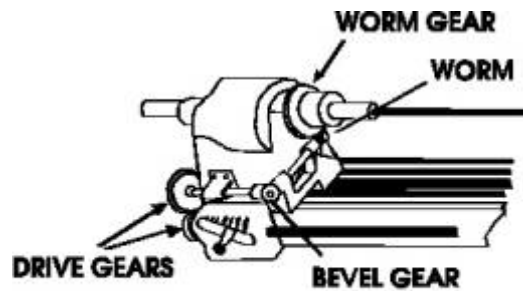
A ball-bearing handle is fastened to the end of the spiral shaft. On the opposite end of the spiral shaft from that to which this handle is fastened, the tube that is connected to the rifling head is screwed in place. Only one groove is cut in the guide shaft. The spiral guide shaft is made about 2" in diameter, if too small in diameter, it will not move as freely.

A fairly heavy-walled steel tubing may be used for this purpose. The spiral groove can be cut in the guide shaft with a milling machine, which is equipped with a spiral-cutting setup. The milling machine must have a table long enough and with enough travel to cut this long spiral.

LATHE FOR RIFLING

The screw-cutting lathe can be used to rifle barrels and the setup is not that expensive. Some makers of lathes supply spiral attachments for their lathes. These have a set of gears with them and these gears, in connection with the gears regularly supplied with the lathe, will cut almost any required spiral.

GUNSMITHING AND TOOL MAKING BIBLE



SPIRAL ATTACHMENT FOR LATHE

The lathe should have a large hollow spindle, so the barrel can be passed through the spindle and held with the regular barrel chucks mounted on each end of the spindle. The oil tube, which is attached to the rifling head, can be held in a clamp fixture mounted upon the tool rest of the lathe.

This is the best method for rifling barrels and requires the least fixtures. If the spindle of the lathe is too small to allow the barrel to pass through it, the rifling head may be driven by the lathe spindle. The barrel can be held in a clamp fixture mounted upon the tool rest. The clamp fixture holding the barrel should be long and heavy, so that it may grip the barrel at two rather widely separated points.

If you use this method, you need a longer lathe bed than the first method. The bed must be long enough to accommodate the barrel length, and it must also have sufficient length for the rifling head with enough length of tube or pull rod on the rifling head so that it can pass clear through the barrel.

Lower priced lathes are not supplied with spiral attachments by their manufacturers. These spiral attachments usually include an indexing attachment. If it does not have the spiral attachment, a simple one may had in the barrel with the spindle locked in the correct position each time. An accurate protractor mounted on the spindle nose will help you align the barrel.

A spiral attachment may be built for screw cutting engine lathe of the quick-change gear-type. The barrels may be rifled upon the lathe, driving it either by power or by hand. To make this spiral attachment, obtain a stock worm gear and worm, the gear being large enough so that it may be bored out to slip over the lathe spindle nose with a close fit.

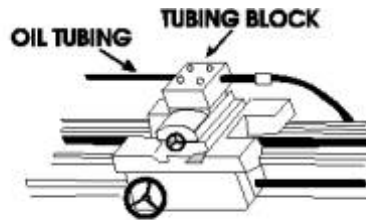
The gear is held in place with a barrel chuck screwed tightly up against it. A bracket is now made to fit the lathe bed, as a center rest does, and on the upper part of this bracket. This can be clamped to the lathe bed with the clamp plate used with the center rest. A shaft is then mounted, at right angles to the centerline of the lathe.

The shaft the worm that mates the worm gear on the spindle nose is mounted so that it meshes with the worm gear.

This worm shaft is long enough so that it extends to the front of the lathe, and a little past the head stock. On this outer end of the shaft, a standard miter or level gear is mounted and a second miter or bevel gear meshes with this and is on a shaft extending to the head end of the lathe. A bracket for this shaft is

GUNSMITHING AND TOOL MAKING BIBLE

bolted to the side of the head stock.



LATHE CARRIAGE WITH TUBING BLOCK

At the head or gear end of the lathe, a gear is mounted on this shaft so that it meshes with the gear train leading from the lathe spindle to the quick-change gear box. This gear may have to be a special gear, if the gears on your lathe do not happen to be standard gears, which can be purchased from some gear manufacture.

You might have to use two gears at this point to reach the lathe gear train. The ratio of these gears, and of the worm and worm gear, must be figured out for your particular lathe. This is necessary to bring the spiral produced within reach of the gear box gears of the lathe. By doing this all the common twists in rifling may be reached by simply shifting the gears,

When you use it, the belt pulleys of the lathe are disconnected from the spindle so that the spindle turns freely and the drive is applied at the tail end of the lead screw of the lathe.

A hand crank may be applied to the end of the lead screw and after the half-nuts of the lathe carriage are closed upon the lead screw, the carriage is moved as the lead screw is turned. The lead screw in turning operates the gears at the head of the lathe and through the special shafts added, which turns the spindle with the worm and worm gear.

A pulley may be placed upon the end of the lead screw and an electric motor used to drive the lead screw. Use V pulleys and V-belts at this point will make the best drive. A good supply of cutting oil is supplied under pressure to the barrel being rifled. You need the oil to lengthen the life of the rifling cutter, to make a smoother cut and to keep the barrel clean of chips.

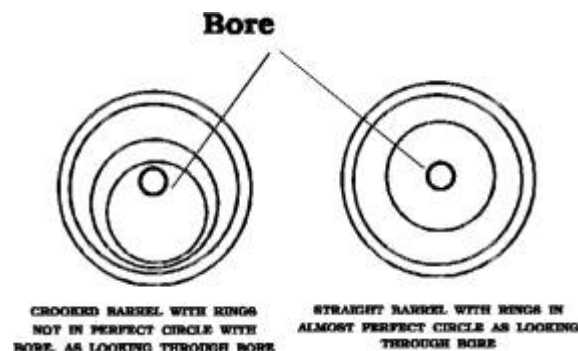
When you cut the grooves, they should not be deeper than is necessary to grip the bullet well. To deep grooves lead to rapid throat erosion and will sometimes put fins upon the base of bullets.

GUN BARREL STRAIGHTENING

If your drill was properly sharpened a good starter bushing, and the starter bushing was in good alignment, the bore should be straight. In most cases the barrel will shoot as good if it is slightly crooked, as it would if it was straight, but if it was very slightly crooked and turned and finish that way, it would tend to walk the bullets as the barrel heated up.

In turning a barrel if you do not get the cutting tools sharp, take too heavy a cut, let the barrel get too hot, let the centers get too hot, or out of round, the stress will warp the barrel. Then you will have to straighten the barrel.

I will try to cover the main points in barrel straightening, and give you a guideline as what to do and what to look for. You must realize that barrel straightening must be self-taught, and to accomplish this, it will be advisable to practice on old barrels.



A shotgun barrel is good to practice on, as it is big, and smooth with no rifling to confuse you. It is next to impossible to straighten a barrel with a rough bore. I will also show you here how to make barrel-straightening equipment necessary to straighten the barrels.

Let me point out that a large percentage of the factory barrels, to the trained eye are not perfectly straight. Any barrel maker will tell you that a slightly crooked barrel will shoot as well as a straight one, and a rifle used for hunting a crooked barrel makes little difference.

As long as, (1) you let the barrel cool between shots when sighting in, (2) as long as you do not shoot more than three consecutive shots, as it will then start to walk.

No amount of bedding will stop this. Now this book was original written in the late 50's before the coming of computer machines for turning barrels. Before, the barrels when turned were checked at ever pass on the turning lathe, but now the complete blank is turned complete on tape machines before being removed from the machined. Then it is checked for straightness, and if crooked will be straighten.

I have gotten several factory barrels in the last few years that when put between centers of the lathe ran

GUNSMITHING AND TOOL MAKING BIBLE

out as much as 1/8 inch on the OD, even though the bore was straight. These barrels would walk as much as 6 inches at 100 yards after five shots.

BARREL WALKING

Why does a barrel walk? If the bore is concentric to the outside, the thicker side will lengthen more than the thin side and the barrel will bend. In most cases there was enough metal on the barrel to return the barrel to make it even. See the other file on Accuracy on the Gunsmith Bible II on the disk.

PREMIUM BARRELS

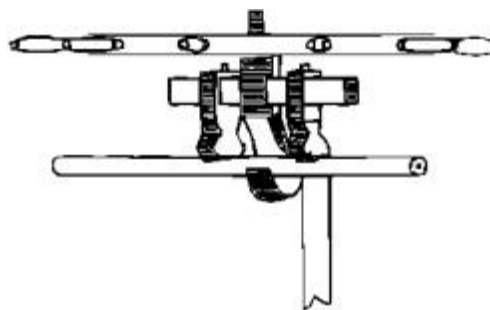
Let me point out that premium barrels are barrels that are straight after drilling. They have no loose or tight spots in the bore due to hard or soft spots in the barrel, and they do get a higher price. Even with good steel, some times you find some bars with much stress left in the bar. This steel will warp with every pass of the cutting tool. There is not much you can do to stop it, except straighten it on every pass.

These if you keep them straight up to the final pass will shoot good and will never give any problems later. They are just a pain in you know where. On barrel straightening equipment, the one type that I used is the overhead screw press. You can see the bore as you are making corrections on it.

BARREL PRESSES

This type of press can be made quite easily in the shop with nothing more than a CUTTING TORCH, ARC WELDER, AND SOME OLD FARMING EQUIPMENT. WHY THE FARMING EQUIPMENT? ALMOST EVERYTHING NEEDED CAN BE FOUND IN USED FARMING EQUIPMENT.

Another is the type that you use an overhead hydraulic press to make correct it. This is a good type but I have found that it is better if you can feel the pressure when you straighten the barrel. Both will do a good job, but the overhead screw press is faster. If you plan to make quite a few barrels, certainly go to the overhead press.

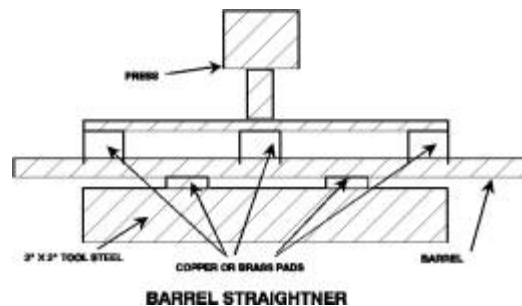


BARREL STRAIGHTING PRESS

GUNSMITHING AND TOOL MAKING BIBLE

The oldest method employed by the old time barrel makers was to stretch a fine wire inside the barrel. This is stretch from one end to the other, and touching the sides at each end. One side of the barrel was hammered until the wire touch all the way.

This was used on barrels that was soft, and used lead bullets. The methods that I will describe in this chapter will be the one I have used for years, and have found it easy for others to use. Lets put a barrel to test to see if it is straight.



When you look through a bright finish barrel, the interior surface appears to be spread out in a circular disc as far from the eye to the other end of the barrel. As you look through the center of the disk, is a circular (the bore) orifice, and surrounding it, like the rings of a target, at equal distances, (if it is straight).

These circles are well-defined circles around the bore. When you do this look at the edge of a door or window, not an open light. If the second, third, or fourth rings are a perfect circle around the inside of the bore, the barrel is straight.

It will be seen that these images are located at a certain point in the bore nearest to the eye. In two thirds of the length of the barrel, this is the part of the bore that you must direct your attention to. This is where by using the reflection, which will show you where the bore is crooked.

LONG BENDS

In long bends you will work from 1/2 to 2/3 of the bore, then turn around the barrel and repeat the process. If a distortion of the circle or rings is noticed, revolve the barrel slowly, and you will see what side the bend is on. The hardest part is next.

It will take a little practice and time to tell exactly how far, and at what point the bend is. This is done by looking down the barrel, and at the same time touching on the outside of the barrel. When you think you have the correct spot where the center of the bend is, move the barrel so that the center jaw or hook is in that spot, rotate the barrel so the big part of the rings is at the bottom, and apply a little pressure.

If you are at the correct place in the barrel, you will see as you apply the pressure, the barrel goes

GUNSMITHING AND TOOL MAKING BIBLE

straight. The rings will form a perfect circle around the bore. If this does not happen, release the pressure. Rotate or move the barrel forward or back and repeat the process.

When you get the perfect circle put more pressure until when you release the pressure the barrel will remain straight. The barrel is like a spring and it will take quite a bit of pressure. When done the interior will look like the above drawings. When you mount the screw press, have it face the window, so you will see half of the edge of the window in the bore.

With a little practice, you will be able to straighten the barrel in a few minutes. The second method is with the blocks. This method works fine but is more difficult to get the barrel straight and is time consuming. This method is best used for full size barrel blanks, or if you do not have an overhead press.

A large lead hammer can be used on liners to bend the liner. Find where the bend is, and set the liner on the blocks with the bend to the top. Now give the barrel a good tap with the lead hammer. Check to see if you have made any progress, if not repeat the above with a harder tap.

The secret of this process is to hit the barrel hard enough to straighten it past its elastic limits.

Your skill in using this process lies in your ability to judge by the eye, the exact location where the bend, its proper location, and then slide the barrel to that location.

To straighten the barrel it must be bent past its elastic limits, so when it springs back it will be straight. If you bend it to far it will be bent the other way, then you will have to rotate the barrel and straighten it back.

With a little practice, you will be able to straighten the barrel in a few minutes. The second method is with the blocks. This method works fine but is more difficult to get the barrel straight and is time consuming. This method is best used for full size barrel blanks, due to their large size.

THREADING AND FITTING THE BARREL

When you have finish turning the barrel, and double-checking it for straightness, it is time to turn the shank. Set the tail stock back to 000, take the lathe dog off, and put a smaller one on the muzzle end of the barrel. With a shim under the setscrew to keep the barrel from being marked by the setscrew. Put the barrel back in the lathe, and turn the shank to the correct diameter.

On a 98 Mauser, who we will thread to, take only a light clean up pass. This is assuming that you made your barrel out of 1 1/8-inch stock. It would be best if you have an old 98 Mauser barrel handy to look at, while you are doing this.

If you look at the chart for threading the 98 Mauser, See chapter on barrel thread dimensions. The O.D. of the shank is 1.100. That only leaves less than .020 for the shoulder. This is OK as on the 98 Mauser we seat the barrel on the inside ring.

Turn the thread end down to 1.100 now. Using a dial indicator as you are turning cut a .625 long shoulder. When you have the thread shank turned to the correct size, take a small square end tool, and relieve the threads on the front end of the shoulder, and the back end of the thread shank. This relief should be about .060 deep per side.

It is time to cut the threads on the 98 Mauser. The 98 has 12 threads per inch V type. Set up a V tool bit ground right for threading. This is a 60-degree tool. Set the point of the tool right on center, using the center on the tail stock. The compound should be set at 30 degrees, when you clamp the tool. Set the quick-change gears for 12 threads per inch, make sure your feeding dial is engaged, and you are ready to cut the threads.

Set both dials to where the tool is just touching the shank. Set the dials on 000. Set the tool in so you will take a .005 cut. See the chart for amount that you will have to turn in to get the proper depth. Have the lathe in back gear, running it at the slowest speed. When the threading dial comes around to 0, engage the feed. It feeds fast, so be ready to disengage the feed and back out the tool in one operation.

When it has completed set the tool in .010, when the dial comes back to 0, engage the feed. Keep repeating the process until you have gone in .062, make a clean up pass at the last setting. Use a good cutting oil when cutting threads. Always turn in the compound dial, leave the other at 0, and back this out each time.

FITTING THE BARREL TO THE ACTION

Take the action and see if it will screw on to the barrel. It should but if it doesn't take, another pass until it does. **DO NOT TURN ON THE LATHE OR CHANGE ANYTHING UNTIL THE ACTION WILL SCREW ON.** The barrel screws on to the action and butts up against the shoulder on the inside of the action.

Take a depth mike and measure the depth from the front of the action, to the inside ring. Check this

GUNSMITHING AND TOOL MAKING BIBLE

against the measurement of .062 that you turned on the thread shank. The thread shank should be .003 longer than the measurement from the face of the action to the ring.

When you tighten the barrel up on the action, you will see the compression marks on the face of the barrel. When you have this, the barrel is completed except chambering.

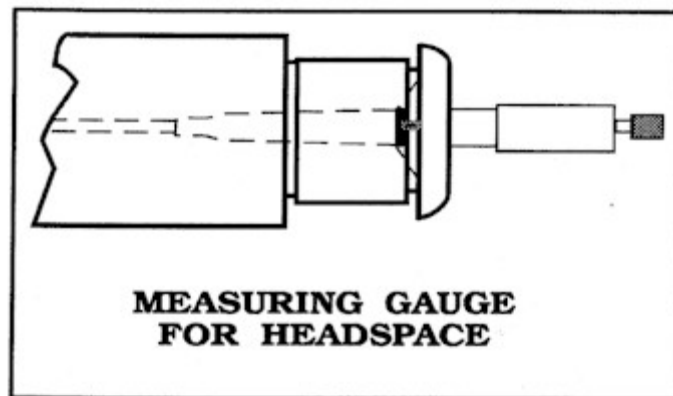
CHAMBERING THE BARREL

The reamers are easily made. If you can make barrel reamers, you can make chambering reamers. What you need now is a 308 Winchester chambering (finish), and head space gauges (go and no go).

You will need a 7/16 drill bit, unless you are planning to use a roughing reamer to remove the extra metal. You will need now to chuck the barrel on the shank in front of the threads. Using a dial indicator be sure the barrel is running true on both ends.

If it is not running true, you will cut an out of round chamber. Chuck the drill in the tail stock chuck, as you will have to drill out the chamber end about 1.250. This will remove enough metal so the finish reamer won't have to cut much.

Now set a small lathe dog on the reamer, and with a center in the tail stock, move the tail stock up close enough to the barrel so the reamer will be in the barrel next to the shoulder of the reamer. Have the reamer in the tail stock center. Leave the lathe in back gear setting that you used for threading and with the tail stock fastened down. Slowly feed the reamer into the barrel, keeping plenty of cutting oil on the reamer.



You can rest the lathe dog on the compound, while feeding in. Be sure that the reamer is on the tail stock center when you feed it in as if it isn't it can grab and break the reamer.

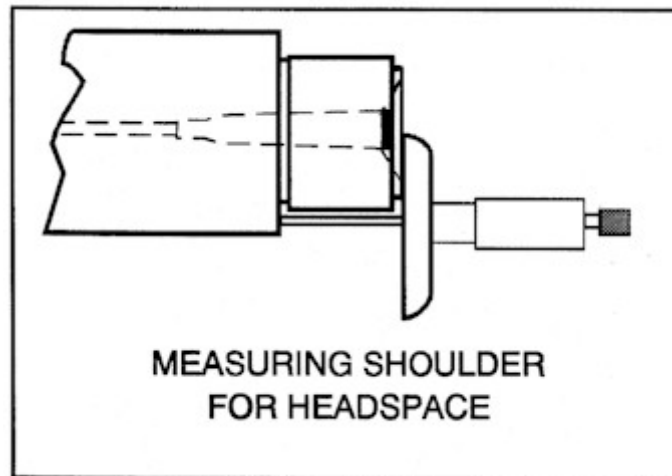
ALWAYS HOLD THE REAMER BACK AGAINST THE TAIL STOCK CENTER.

Usually at first, you will be able to feed in for a depth of about 1/8-inch, before removing the reamer and blowing out the chips. As you get down to the shoulder area, the feed in is less.

GUNSMITHING AND TOOL MAKING BIBLE

CHECKING THE HEAD SPACE

When you get close, you will have to use the head space gauge. You will need to know what the correct head space will be. Take the action with the bolt cocked and closed, measure the distance from the inner ring, what the barrel is butted up against, and the bolt face. Take the difference, which in this case is .100.



Now knowing the depth is .100 we can keep feeding the reamer in until the head space gauge will be the right depth. The correct depth would be .095. Allowing .003 for compression of the barrel to the action, this would leave .002 on the head space, which is about right. To set the depth, use a depth mike, placing the depth mike on the end of the head space gauge, and measuring the depth until it read .095.

When you get close, it would be best to use a dial indicator to go the final few thousandths. This is how the Mauser is chambered and head space. Other types of actions are done the same, with a little variation.

FITTING SPRINGFIELDS

On some barrels like Springfields or Enfields, we use the same way of measuring from the front of the action to the bolt face. Because the barrel is coned, we have to measure from the cone to the head space gauge. This distance is subtracted from the distance from the shoulder on the barrel, to the face of the cone.

POLISHING THE CHAMBER

After the barrel is correctly head spaced, the chamber should be finely polished. This is done with the lathe running at a high RPM.

Note - The barrel that is sticking out the back of the lathe should be centered with a collar that has set screws to hold the barrel from starting to run out of center with the high RPM. Use a fine polishing cloth on the end of a slotted rod.

Do not over polish, as this will change the dimensions of the chamber. You will be able to see all the scratches, and will be able to measure any part of the chamber.

Screw the barrel on the action, seat it very tight, remove the extractor, and the cocking piece. Drop a new loaded round into the chamber and close the bolt. It should close any pressure. Remove the loaded round, and drop the No Go gauge in the chamber.

It should not allow the bolt to close. If for some reason it does, remeasure and face a little off the face of the barrel.

FINISHING THE OUTSIDE OF THE BARREL

All that we have to do now is to polish the machine marks from the barrel and crown the muzzle. I find that I can chuck the barrel in the lathe, using a live center and remove the machine marks with coarse grit paper, then finish polishing with finer grit.

This does not take long if you have not left on the outside of the barrel. If there are chatter marks on the

GUNSMITHING AND TOOL MAKING BIBLE

outside, the barrel will need to be filed while it is spinning.

When the barrel is as smooth as you want it, remove the barrel, turn it around, chuck it up on the muzzle and crown it. The easy way is to face the muzzle off flush, and counter bore it to protect the bore. You are ready to polish and blue.

THREAD FACTS

The following will give you information on the threads so they can be better understood. Thread cutting on the lathe is the most common way to make screws, etc. in the shop. Just about any type of screw, and thread that is needed in the shop, can be made on a lathe.

The major or outside diameter (O.D.) of an external thread is the diameter of the piece on which the thread is cut. LTL is the largest diameter of the thread.

The depth of a thread is the distance from the top or crest of the thread to the root measured vertically.

The minor diameter is the smallest diameter of the thread of the screw. LTL is sometimes called the root diameter (R.D.) and can be found by subtracting twice the depth of the thread from the major diameter.

The number of threads per inch (N) can be counted by placing a rule against the threaded part, and counting the threads in one inch. The first thread is not counted since, in reality, not the crests but the spaces between the crests are what are being counted. A second method is to use a screw pitch gage. This method is more suitable for checking the finer pitches of screw threads.

The pitch (P) of a thread is the distance from a point on a screw thread to a corresponding point on the next thread, measured parallel to the work axis. The pitch of a thread in inches can be found by dividing the whole number 1 by the number of threads per inch (N).

On a screw thread, the pitch diameter is that of an imaginary cylinder. The outer surface of this cylinder would pass through the threads at such points as to make equal the width of the threads and the width of the spaces. On a 60-degree V type thread and on National form threads, the pitch diameter can be found by subtracting the single depth of the thread from the major diameter of the thread.

The lead of a thread is the distance a screw will advance into a nut in one complete revolution. The lead is the same as the pitch on a single-thread screw.

The formula for the lead of a single thread screw, then, is:

1 P (in inches)

N (per inch)

The lead for a screw with nine threads per inch is .1111, which is the same as the pitch in inches (.1111).

On a double-thread screw, the lead is twice the pitch. On a screw with nine threads per inch with a double-thread screw the lead would be doubled or .2222. On a triple-thread screw, the lead is three

GUNSMITHING AND TOOL MAKING BIBLE

times the pitch, and so on.

Most screw threads are single. The single screw thread has a single ridge and groove.

The thread angle is the angle included between the sides of the thread. The thread angle of the Unified National Form is 60 degrees.

Screw threads are so widely used to connect parts that they are of prime importance when produced in the machine shop.

Great amounts of study and research have been devoted to the standardization of screw thread forms.

The basic form of the screw and nut, with a 60-degree angle of thread 55. The crest of the thread may be flat or rounded. The flat crest is preferred in American practice, and the rounded crest is given preference in British practice.

Over many years, different screw thread forms and standards have been adopted in the United States. These different forms originated chiefly because of special requirements or because they were considered superior to other forms. In addition to the American Standard thread, they are the Acme, Square, and the 29-Degree Worm threads.

The American Standard thread form is used as the standard locking thread form in the United States. This thread form is used on practically all-mating parts in modern machine construction. The Unified thread form is essentially identical to the former standard, the American National thread form. The two forms are interchangeable for most diameter-pitch combinations. A 1-64 National Coarse thread is interchangeable with a 1-64 Unified National Coarse thread.

Unified National Coarse (UNC)

Unified National Fine (UNF)

Unified National Extra-Fine (UNEF)

Unified National 8-Pitch (8 UN)

Unified National 12-Pitch (12 UN):

Unified National 16-Pitch (16 UN)

In the coarse, fine, and extra-fine series, the number of threads per inch increases as the diameters decrease. The coarse and fine threads are widely employed for general use.

In order to produce an American Standard thread on the engine lathe, the ratio of tool feed to work

GUNSMITHING AND TOOL MAKING BIBLE

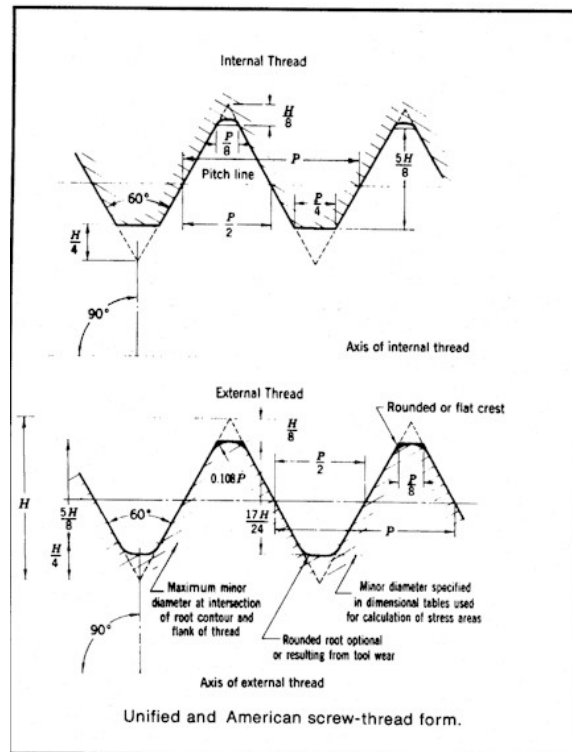
piece speed must be adjusted. The width of the crest will correspond with the width of the tool's nose when the thread is cut to its full depth. Thus, the root and crest are the same width.

THREAD-CUTTING TOOLS

For each of the types of thread a tool bit to form that particular thread must be ground. Since the form of thread is the end product the grinding of the tool bit must take into consideration the clearance angle side rake form and other factors to achieve the result desired.

CLEARANCE

Because of the rapid advance of the cutting tool across the work piece, the clearance angle is an important factor. Clean, accurate threads are impossible unless both sides and front of the tool are given enough clearance to permit the tool to move freely in the groove being formed. When the tool is fed into the work at an angle, as for form threads, the tool should have 3 to 5 degrees of side clearance.



V thread tools are ground flat across the top, with about a 5-degree side-clearance angle. If the top of the tool is at an angle, the thread will be incorrect.

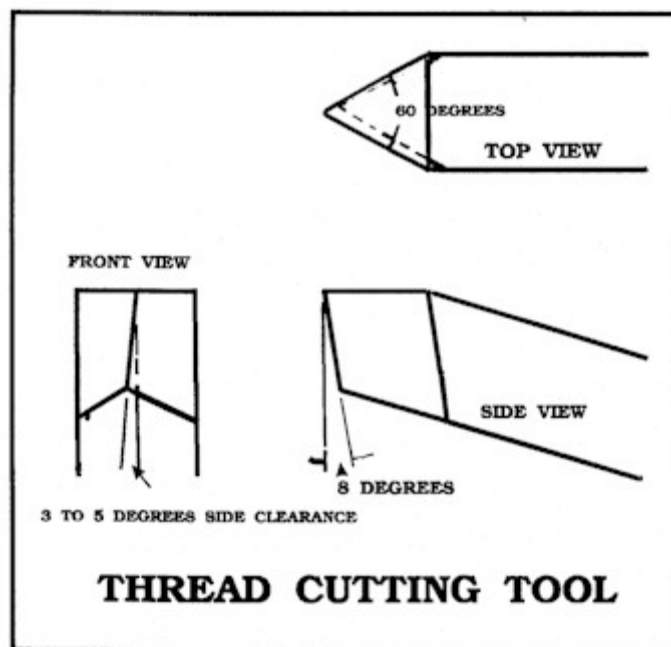
The center gage is a tool used for checking the points of cutter bits for the American standard screw threads, which must be ground to an angle of 60 degrees. The 60-degree included angle on one end of the gage is used when grinding the tool to the exact angle. This same tool is useful in checking the angle of lathe centers.

GUNSMITHING AND TOOL MAKING BIBLE

The V on the edge of the gage is used for setting the tool in the tool post of the lathe. The centerline of the V-point is perpendicular to the axis of rotation of the cylinder to be threaded. This setting will give the correct thread form.

The two opposite sides of the gage are parallel and have graduations on the edges for checking the number of threads per inch. One side of the gage at the point is engraved to show the sizes of tap drills for 60-degree V-threads (internal threads), and to show, in thousandths of an inch, the double depth of commonly used threads.

The 60-degree angle at the point is useful to gage the thread after it is cut.

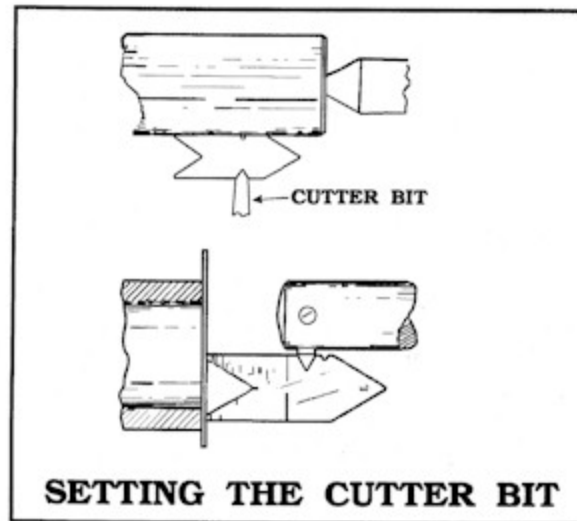


Before the threading operation is begun, the work piece needs to be turned to the maximum or major diameter of the thread specified on the blueprint or other specifications. This size is usually given as O.D. (outside diameter) expressed in inches and decimal parts of an inch. When cutting V type threads, it is also good practice, to chamfer or bevel the ends of the shaft to be threaded. The chamfer can be at any angle from 30 to 4-5 degrees. For instructions on straight turning, see the section on that operation.

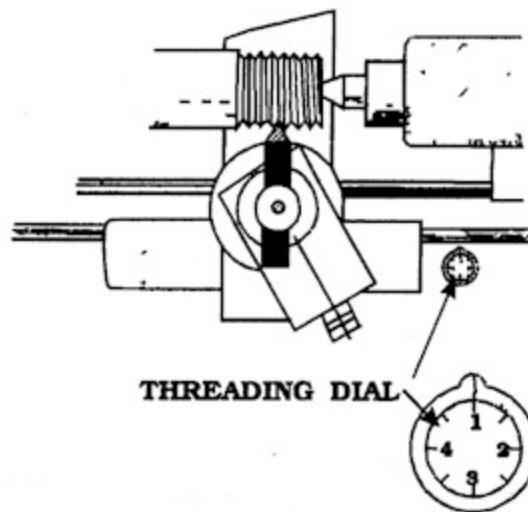
SETUP FOR CUTTING AN EXTERNAL (V) THREAD

The setup for external threading will depend largely upon the shape and size of the work piece. Threads are often turned on shafts mounted between centers and revolved by a lathe dog.

GUNSMITHING AND TOOL MAKING BIBLE



After this setup is made and the work is turned to the proper outside diameter, the work piece is left right in the lathe and the threading operation is performed. The jobs are threaded while held in a three or four jaw chuck in which they were mounted to be turned to size.



THREADING SETUP

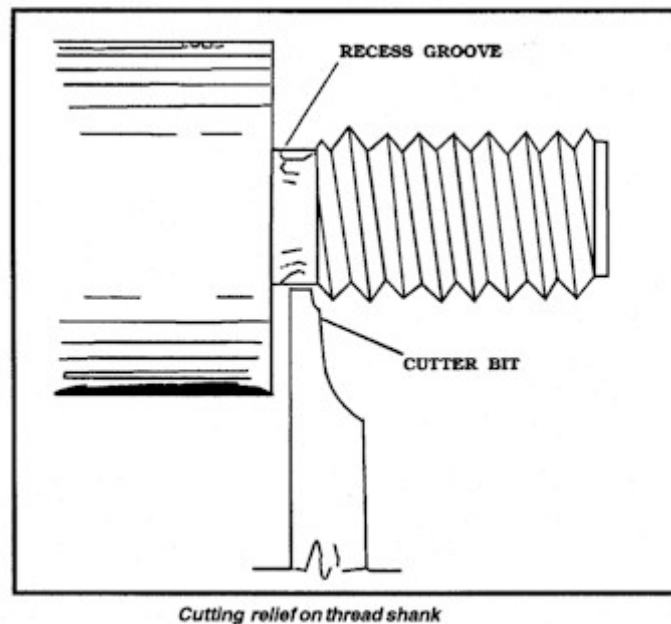
Due to the pressure exerted by any threading tool, it is necessary, when threading long, narrow shafts, to use a steady rest.

THREAD CUTTING IN A LATHE

Threads that must be accurate with some turned part must be turned in the lathe at the same setting used to turn the work. For this work, a proper cutting tool is set up in the tool post, and the lead screw is geared to the head stock spindle to give the required lead to the thread.

Cutting threads on the engine lathe is usually done when only a few threads are to be cut or when special forms of threads are necessary. For the operation, the lead screw is revolved at a desired ratio with the spindle of the lathe through a series of gears. Quick-change gearboxes enable the operator to produce various pitches of threads, using control levers.

In the thread-cutting operation, the lathe should be set at the correct ratio of feed to speed for the desired thread to be cut.



Next, the compound is adjusted so the micrometer dial on its collar is at zero. The tool is then brought into contact with the work piece by adjusting the cross-slide and setting its micrometer dial to zero. All adjustments for depth of cut can be made from these settings.

It is common practice to use both the cross-slide, and the compound. The tool is backed off the work piece and the carriage is moved to where the tool is, at a point beyond the end of the work piece. The cross-slide is then advanced until the micrometer dial reads the same as where the tool was touching the work piece.

Next, the compound is advanced .002 to .003" and a trial cut is taken. At the end of the cut, the cross-slide is backed off and the tool returned to its starting point.

GUNSMITHING AND TOOL MAKING BIBLE

The cross-slide is then adjusted to its zero reading and the compound advanced a distance equal to the next cut. The operation is repeated until the proper depth of thread is obtained.

The gears to use for each thread are shown on a plate attached to the lathe by the maker. You should know how to gear the lathe without the plate. There is a gear of a known number of teeth permanently attached to the head stock spindle.

If the lead screw can be made to advance the cutting tool one thread-space, or thread-pitch, per revolution of the work, the result will be a thread of that pitch.

The rule for finding the ratio of teeth in the lead-screw gear to the teeth in the stud gear is to multiply the pitch of the thread to be cut by the teeth in the stud gear and divide by the pitch of the lead screw, which will give the number of teeth in the lead-screw gear.

A gear with 40 teeth on the screw will cut a thread with a pitch of 10 threads per inch.

Pitch of lead screw, multiplied by the product of all the driving gears, divided by the product of all the driven gears will give the pitch of the thread to be cut.

With lathes equipped with quick-change gears, most common threads can be set up by moving the required gears. When it is necessary to cut a thread of an odd pitch, the train of gears between the stud gear and the quick change-gear box will have to be changed. Metric threads can be cut on a lathe having a lead screw with the pitch in inches by using the ratio of 50 on the stud to 127 on the screw. This is because there are 127 centimeters in 50 inches.

The cutting tool is ground to the shape required for the form of screw thread being cut. For cutting 60° V threads, a center gage is used for checking the angle when grinding the tool to shape.

In cutting a right-hand exterior thread, the compound is turned in the direction of the head stock and set at an angle of 29°.

The tool is set so its centerline is at a right angle to the axis of the work piece. This setting can be obtained by the use of the center gage as shown.

When the tool point fits uniformly into the v notch of the gage, the tool is at a 90° angle.

NOTE: The point of the tool should be at the same elevation as the centerline of the work piece.

The compound slide is set to an angle of 60°, and the tool is set square with the work, using the "V" notch of the thread gauge to set the tool. The point of the tool must be at the same height as the lathe centers. The tool is run up to the work with the cross feed, and the cross-feed stop is set to always bring the cross feed back to the same position after backing out the tool to return for another cut.

GUNSMITHING AND TOOL MAKING BIBLE

The compound slide is used to feed the tool into the work. By feeding the tool on the 60° angle to which the compound slide is set, the tool cuts on one side only, and it can be given a side rake to make the chip clear the thread groove. If the tool is fed in square with the work, it will have to cut on both sides. No side rake can be used, and the two opposing chips will interfere and jam in the cut.

The carriage is attached to the feed screw by closing the half-nuts. There is a safety interlock between the friction feed for turning and the half-nuts for thread cutting, so the two cannot be engaged at the same time, which would wreck something.

At the end of each cut, the half-nuts are opened, and the tool is withdrawn from the cut, so the carriage can be returned to the start for another cut. If the tool were not withdrawn from the cut, the backlash of the feed gears would leave the tool out of line with the thread and if the lathe were reversed, the tool would damage the thread.

If your lathe is not equipped with a thread-cutting dial, you will have to reverse the lathe to return the tool to the start for another cut. Without the thread dial, the half-nuts cannot be opened until the thread is completed,

The thread-cutting dial indicator is a dial geared to the lead screw. When the carriage is stationary, the dial revolves, but when the carriage is cutting a thread, the dial is still. There are several graduations on the dial, each numbered. As the dial revolves, the half-nuts are closed when the correct number comes up to the index mark. For most even numbered threads, there are several places on the dial that can be used to close the half nuts. For odd-numbered threads, there is only one position, and the half-nuts must always be closed on the same number used to start the first cut.

After making the first cut return the tool until it nearly touches but does not cut and try the several numbers on the dial to see which ones track the tool in the first cut. Then any of these can be used for the rest of the job.

In starting the first cut, close the half-nuts on the number one line of the dial, and feed the tool with the compound until the tool just scratches a fine line, indicating the thread. Shut down the lathe and test this line with the thread-pitch gauge to see that the lathe is cutting correctly. The cross feed of the carriage must always be up tight to the cross-feed stop before moving the tool with the compound feed.

At the end of the cut, if the thread just fades out, it is necessary to withdraw the tool while the feed is still on so that the thread will finish with a taper. To do this requires working at slow speed, and it helps to put a chalk mark on the work so the tool can be backed out at the same place each revolution.

When the thread finishes close to a shoulder, turn a small groove next to the shoulder as deep as the bottom of the thread so the tool can finish in this groove. Leaving a complete thread up to the shoulder so the nut will tighten up tight to the shoulder. It is wise to set the carriage stop so the tool cannot run into the shoulder. The cutting tool should be ground so the point will be in the groove while the side clears the shoulder.

GUNSMITHING AND TOOL MAKING BIBLE

When it is not necessary that the nut run up tight against a shoulder, the tool can cut its own finishing groove if you open the half nuts at the same place each time.

To use successfully any of these methods of finishing a cut, you must work quickly with both hands, back the tool out with one hand while you open the half-nuts with the other. When you return the tool for another cut, advance the compound slide by the amount of the chip. Never change the setting of the cross-feed stop after you have started to cut a thread or you will throw the tool out of alignment with previous cuts.

Since the tool is traveling on the 60° angle of the compound, you must divide half the DD figure by the sine of 60°, or .866; the resulting figure will be the amount by which the tool is to be advanced on the compound slide.

Since there is always some springiness or backlash in both the cutting tool and the work, you will have to take several finishing cuts with the tool at its final setting, without advancing it any deeper, so it can work out the oversize cutting when possible, keep handy a nut of the required size that has an accurate thread, and use this to test the new thread.

If the work is driven by a lathe dog while on centers, be sure the slot in the driving plate is marked so the dog will be replaced in the same slot each time after removal for testing.

Use plenty of cutting oil when cutting steel. Brass and cast iron can be cut dry, but aluminum tends to stick to the tool and leave a rough surface unless a little oil is used.

THREAD DIAL INDICATOR

Most modern lathes are equipped with a thread dial indicator, which saves time when cutting long screw threads. The thread-chasing dial is an indicator with a revolving dial. It is either fastened to the carriage of the lathe or built into it. The dial of the indicator serves as a guide to the operator. It tells him when to close the half-nut in the apron onto the lead screw so he may take successive cuts in the same groove, or to space grooves properly for multiple threads.

When this is done, the lead screw and carriage bear the same relative positions as before. In other words, when the operator engages the half-nut as the proper mark on the dial comes into position, the threading tool moves into the same groove made on previous cuts.

The face of the dial is numbered to indicate positions at which the half nuts may be engaged. When the lathe is set up for cutting screw threads, the thread dial indicates the relative position of the lead screw, spindle, and carriage of the lathe.

This permits disengaging the half nuts from the lead screw at the end of the cut, returning the carriage quickly to the starting point by hand, and re-engaging the half nuts with the lead screw at a point, which will assure that the tool follows exactly in the original cut.

GUNSMITHING AND TOOL MAKING BIBLE

The position at which the half nut should be closed depends upon the pitch of thread.

For odd-numbered threads, close half nuts on any numbered line, such as 3 1/2 threads per inch, the half-nut must be engaged at any odd-numbered line on the dial.

For quarter-threads, such as 2 1/4 or 3 1/4 threads per inch, the half-nut must be engaged at the same point on the dial each time a cut is started.

For all numbered threads, close half nuts upon any line on the dial.

For threads involving half threads-any numbered line.

For threads involving quarter threads-return to the original starting point before closing half nuts.

The dial is engaged to the lead screw, as the operator desires, by a feed lever on the apron. This lever is called a half-nut lever. When the lathe is running but the half-nut lever is not engaged, the dial revolves. When the half-nut lever is engaged, the carriage moves but the dial remains motionless.

Before you can start the thread-cutting operation, you must decide, from the number of threads required per inch, at what point on the dial to engage the half-nut. For chasing all even numbers of threads per inch, such as 4, 6, 8, 10, etc., the half-nut is engaged for the first, and for all successive cuts, at any of the eight graduation marks on the face of the dial.

For an odd number of threads per inch, engage the half nut at any quarter-turn or numbered line on the dial (the main graduation marks),

SETTING THE COMPOUND FOR RIGHT AND LEFT-HAND THREAD

To cut right-hand external threads on the lathe the compound rest is turned at a 29-degree angle. This prevents tearing of the thread and makes it easier to rechase the thread if the tool must be reset. The carriage is made to travel from right to left or, toward the head stock.

Before each successive cut, the tool is fed in with the compound rest. To cut a left-hand thread, the compound is turned at a 29-degree angle toward the head stock, and the carriage is made to travel from left to right.

The threading tool is mounted in the tool post. Adjust the cutter point vertically to the exact center of the work. Then place a center gage with its back edge in contact with, or parallel to, the work or the tail stock spindle.

Now adjust the tool horizontally by fitting the cutter point exactly into the 60-degree angle notch in the front edge of the center gage.

GUNSMITHING AND TOOL MAKING BIBLE

Tighten the tool post screw. Be sure not to change the position of the holder. Recheck the tool setting after tightening the tool post screw.

CUTTING AN EXTERNAL THREADS

After setting the compound rest and positioning the threading tool properly in relation to the work, it is necessary to select the proper speed and feed. Good thread-cutting practice requires that the back gears be engaged for this operation.

This reduces the r.p.m. or speed to a minimum, and is necessary if best results are to be obtained. The correct selection of feed is determined by a gearbox on all modern lathes. Directions are shown on the gearbox regarding the setting of levers to obtain the correct feed, depending upon the threads per inch to be cut.

Now the compound feed-screw graduated collar is set to zero and the tool point is brought into contact with the work by turning the cross feed screw. The tool point should contact the work lightly. Then run the carriage to the right, using the carriage hand wheel, until the tool clears the end of the work. Notice what the setting is on the cross-feed collar.

This adjustment must be remembered so, at the end of each cut, the cross-feed is always brought back to the same number or setting. Feed in on the compound .002" and then start the machine and take the first trial cut.

If using the thread dial, be sure to engage the half-nut lever at the correct line on the dial, depending upon the threads per inch you are cutting. This causes the carriage to start in motion.

A check should be made after this first trial cut to see that the correct pitch of thread is being machined. This is done by using a thread-pitch gage or a rule.

To determine the total number of thousandths of an inch that the threading tool must be fed in by the compound feed screw, and in order to cut the thread to the desired depth, a simple formula is used. This formula is: divide the constant .750 by the number of threads per inch.

If it is required that eight threads per inch are to be cut, then divide .750 by 8, which gives a result of .0937" (.094" can be used).

This is the total number of thousandths of an inch the tool is to be fed into the work to cut eight threads per inch. However, the compound feed is used until the tool has been fed in .090". Then the cross-feed is used to remove the final four thousandths of an inch from the thread, making four cuts and feeding the tool in .001" on each cut. This will help to polish the right side of the thread.

GUNSMITHING AND TOOL MAKING BIBLE

A good grade of lubricant should be used on the tool when threads are being cut. Mineral lard oil is a very good lubricant for threading.

RESETTING THE TOOL

If it is necessary for any reason to remove the tool before the thread is finished, reset the tool to the gage regardless of the part of the thread already cut. Having the compound rest at an angle of 29 degrees makes it easy to reset the tool if it needs regrinding. The tool is clamped in the tool post after it is reground. Then it can be set with the center gage as before.

In resetting the tool, proceed as follows: first, reset the tool to the gage; then back the tool away from the work piece. Start the machine and engage the thread-chasing lever as before. Let the work piece make two or three turns and shut off the power with the threading lever still engaged.

Adjust the tool into the thread previously cut by moving the compound and cross-feed until the tool is lined up properly in the thread groove. Back the tool out from the work piece slightly and turn on the power. When the tool is aligned properly, proceed as before.

There are three classes of fit designated by American Standards now being used. Classes 1A, 2A, and 3A apply to external threads only, and class 1 B, 2B, and 3B apply to internal threads only. The three classes of fit are:

Class 1. Loose Fit

Class 2. Medium Fit

Class 3. Close Fit

LOOSE FIT

This class possesses the largest allowance and is used where rapid assembly of parts is required and looseness is not objectionable.

MEDIUM FIT

This is used on the bulk of standard screws, bolts, and nuts. A very small amount of looseness or shake may be present or if the parts are carefully made no movement can be noted; yet the nut can be screwed on by hand.

CLOSE FIT

This is used on fasteners where accuracy of fit is highly important, and where no looseness is permitted.

GUNSMITHING AND TOOL MAKING BIBLE

A wrench or some other tool must be used to force the nut onto the bolt.

Tighter fits than those mentioned require special fabrication, and are carefully specified for the job being assembled.

TAPS AND THREADING

The tap is used to cut internal threads. There are many forms of taps used in manufacturing work, but the hand tap is the only one used in a home workshop. Three taps are used for each size of thread. The Taper Tap is used to start the thread. This has a long taper ground on the point that will enter the drilled hole and act as a pilot to guide and center the tap. Even with this self-guiding feature, you must hold it in line with the hole or it will start crooked.

The tapered end will try to get it back to the center of the hole, and this will bend the tap and is liable to break it.

Due to the long taper of the starting, or taper, tap, it cannot reach very far into the hole. A tap with a shorter taper, called a Plug Tap, is used after the thread has been started with the taper tap.

It is possible to start a thread with a plug tap by carefully guiding it and using sufficient pressure. It is not possible to start a thread with a bottom tap. If your budget does not permit the purchasing of the three taps, get a plug tap and a bottom tap.

Taps are easily broken and must be handled very carefully. Never use a tap wrench too large for the tap and do not force it as it cuts a chip. After the chip has formed, turn the tap backwards until it breaks the chip. With very small taps, it helps to run the plug tap in as far as it will stand without breaking. Then back it out and cut with the bottom tap until it reaches its limit.

This way, each tap cuts less metal each time and is less liable to be broken by twisting. It takes longer, but is worth the extra time by saving broken taps.

It helps to have two small tap wrenches so the two taps can be left set up in the wrenches. Bending a small tap sideways is one of the easiest ways of breaking it. Turn the tap with the finger tips of one hand and use the other hand to steady the first by resting your wrist on the vise.

When tapping a hole where the tap must line up with a clearance hole, place the two parts together and tap the thread through the clearance hole, which acts as a guide. If the two holes are not in line, the tap will be forced against the tight side of the clearance hole and will cut threads that will allow the screw to enter the threaded lower part.

These part threads cut in the clearance hole may prevent the screw from clamping the two parts tight, and it may be necessary to remove them with a round file.

When a thread must be exactly parallel to a drilled hole, it is best to start the tap in the drill press before the work has been released from the clamps used to drill the hole. Insert the tap in the drill chuck and adjust the chuck so the tap will slip if it is biting too hard. Use a short rod that will fit into the keyholes of the chuck to turn it, at the same time using a little pressure on the drill press feed to start the tap.

GUNSMITHING AND TOOL MAKING BIBLE

The entire thread can be cut this way, which is rather slow or, after it is well started, the work can be removed from the drill press and the thread finished by hand in the vise.

If it was necessary to move the drill-press table to remove the drill and insert the tap, make sure it is returned to the exact position used to drill the hole. Adjust the collar on the column so the table will not drop down and fix the turn indicator to its position, before moving the table.

If there is no turn indicator, make a chalk mark on the column. This same method of starting a tap in a drilled hole applies to holes drilled in the lathe. In this case, the tap is placed in the tail stock chuck, and the work is turned by hand, using a wrench on turn with and feeding with the tail stock.

Larger taps, like pipe taps, cannot be held in the drill-press chuck. These taps generally have a center reamed in the head end, and a 60° stub center can be set up in the drill press to line up the tap. Then the tap is turned with a wrench on its square end. This stub center is a piece of 1/2 inch stock turned to a 60° point. It does not need to be hardened, although it would last longer if it were hard. This stub center is very useful in locating a punch mark under the center of the drill. Set the stub center in the drill chuck and center the work under it before clamping to the table.

Many firms supplying drills have printed cards showing the size of hole to be drilled for taps and the clearance holes for threads. These also show the size of drills and their decimal equivalent.

Get two of these cards, one showing the tap drills and the other the decimal equivalents. Mount them on the wall near the drill press.

Dies are used to cut external threads. The small button dies of 1-inch diameter are very handy for threads up to 1/2 inch, but for threads over 1/2 inch, larger dies are required. Even the button die of 1 inch for 1/2 inch threads is so narrow that only a few teeth can cut the thread. This size is very useful for rerunning a thread that has been damaged.

Only one die of each size is needed. One side of the die has a taper for starting and is used for cutting the thread. The other side has the full thread clear to the face of the die, and the die can be turned this side to the work to finish the thread up to a shoulder.

It is difficult to start a die square with the work. If it is not started square, it will try to follow its own threads, while at the same time running off-center to the work, which tries to force it back to center. The result is a very crooked thread. Die stocks have three adjustable fingers on the starting side.

These can be set to bear on the work and guide the Die Square. You should also have a plain diestock to finish threads in close quarters where the stock with the guide is too wide to use.

When you purchase the dies, get the kind that is split on one side so the size can be adjusted. There are many of these button dies sold at bargain stores that are not true to size. These can cause a lot of trouble by cutting an over sized thread. Get dies made by one of the recognized, nationally established firms, so you will be sure of getting good ones. It is often required to cut a thread a little under size, say,

GUNSMITHING AND TOOL MAKING BIBLE

for a free-running nut, and the adjustable die can do this.

It is also possible to cut an undersize thread by rerunning the thread with the die held at an angle. This makes the die cut some off the side of the previously cut thread, but it will not be a true and even thread. It is to be used only when an adjustable die is not at hand and never where accurate threads are required.

For cutting threads in the lathe with these button dies, use a die holder that it's in the tail stock. This has a guide portion on which the die can slide as it feeds onto the work. The thread is started by putting pressure on the die with the tail stock.

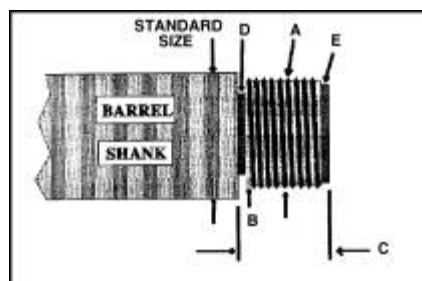
After it is started, the die will feed itself. The lathe can be run under power, using the slowest speed of the back gears. On completion of the thread, the lathe is reversed and backed off the die.

When backing off the die, be sure to remove the amount of feed used to start the die, or the die will stop backing off when the free travel is used up and will chew up the threads.

It is best to unclamp the entire tail stock from the bed as you start to back off, you can then be sure the die can work all the way off without doing any damage. A little sulfur-base cutting oil should be used on both taps and dies. With brass and aluminum, the taps and dies tend to stick to the metal unless oil is used.

THREAD DIMENSIONS

All of the thread sizes shown here were taken from the workbook that we made up as we threaded new barrels, and came directly from the old barrel. They may or may not agree with some of the factory specifications found in some books. The sizes given below were what we cut on the new barrels and reinstalled back on the old action.



GUNSMITHING AND TOOL MAKING BIBLE

| Action | A | B | C | D | E | Threads |
|----------------|-------|------|------|------|---|---------|
| Stevens .875 | 1.425 | .500 | | | | 16v |
| Krag M 92 | 1.050 | .700 | | | | 12lhsq |
| Fv 10 Semiauto | 1.058 | .825 | .100 | .100 | | 18v |
| Marlin 1894 | .780 | .725 | .100 | | | 12sq |
| Win 43 | .930 | .840 | | | | Recs16v |
| Win High Wall | .935 | .850 | | | | Recs16v |

| Action | A | B | C | D | E | Threads |
|----------------|-------|---|-------|-------|------|-----------|
| Jap 7.7 | 1.050 | | .700 | .125 | | 17v |
| Manlkr. Steyer | 1.060 | | .600 | .125 | | 12v |
| Rem. Rol. Blk | 1.053 | | 1.400 | .145 | .425 | 12sq |
| Martine Small | .745 | | .625 | | | 14v |
| Sako L 461 | .860 | | .825 | .100 | | 16v |
| Swedish Mauser | .990 | | .620 | .100 | .100 | 12v |
| 600 Rem. | 1.058 | | .875 | | | 16v |
| Stevens 322 | .875 | | 1.950 | .100 | | 18v |
| Sako L 579 | 1.00 | | .780 | | .150 | 16v |
| Win Mod 70 | 1.00 | | .740 | | .100 | 16v |
| Savage 99 | .900 | | .875 | | .125 | 12sq |
| Savage 110 | 1.065 | | .756 | | .312 | 20v |
| Peru Mauser | .998 | | .835 | | .125 | 12v |
| Rem. Rol. Blk | 1.430 | | 1.00 | 1.055 | .430 | 12sq |
| Win 95 | .933 | | .750 | .125 | | 16v |
| Sako Rihimak | .862 | | .862 | .845 | .100 | 16v |
| Mauser G33/40 | .980 | | .635 | .100 | .100 | 12v |
| M1 Garand | .970 | | .700 | .100 | .100 | 12sq |
| Win 92 | .805 | | .635 | .100 | | 20v |
| Sa Colt 45 | .708 | | .707 | | .124 | 20v Tap |
| Brno Mauser | 1.100 | | .625 | .100 | .100 | 12v |
| M 30 Rem | 1.115 | | .800 | .100 | .100 | Coned10sq |
| 93 Mauser | .985 | | .625 | | | 12v |
| Ruger No 1 | 1.00 | | .850 | | .160 | 16v |
| Jap Ariska | 1.017 | | .720 | .125 | .125 | 14v |
| Savage | .870 | | .725 | | | 18v |
| Rem 722 | 1.060 | | .875 | | | 16v |
| Win 86 | .880 | | .730 | | | 20v |
| Shutz & Larson | 1.040 | | .982 | | .100 | 14v |
| Bsa Hertor | 1.122 | | .980 | .905 | .100 | 12v |
| 6.5 Ital.Maus. | 1.062 | | .762 | .120 | .120 | 14v |
| Tex Mag. | 1.00 | | 1.100 | .120 | | 14v |
| 98 Mauser | 1.100 | | .635 | .100 | .100 | 12v |
| Sr Mauser | .980 | | .635 | .100 | .100 | 12v |
| Springfield | 1.040 | | .740 | | .100 | Cone10sq |
| Enfield | 1.115 | | .800 | | .100 | Cone10sq |
| Ww Greener | 1.080 | | .690 | | .120 | 14v |
| Lee Enfield | .995 | | .685 | | .120 | 14v |
| Win 43 | .805 | | .641 | | .100 | 20v |
| Sharp B | .940 | | 1.100 | .100 | .100 | 16v |
| Brno | .990 | | .600 | .100 | .100 | 20v |
| Martini | 1.00 | | .675 | .100 | .120 | 14v |
| Manlkr. G98/40 | 1.055 | | .570 | .100 | .100 | 12v |
| Win 94 | .809 | | .504 | | .100 | 20v |
| Sako L61 | 1.100 | | .695 | | .100 | 16v |
| Sako L61 Mag. | 1.050 | | .695 | | .100 | 16v |
| Sav. Mod 20 | .895 | | .930 | | .120 | 12sq |

GUNSMITHING AND TOOL MAKING BIBLE

| Action | A | B | C | D | E | Threads |
|---------------|-------|------|-------|------|------|---------|
| Krag Jorg. | .980 | | .750 | .100 | .100 | 10sq |
| Rem Xp 100 | 1.060 | .900 | .875 | | .340 | Recs16v |
| Rem 740 | .874 | | .330 | .551 | .100 | Recs20v |
| Wtb Mk V | 1.055 | | .700 | | .130 | Recs16v |
| Win 670 | 1.00 | | .700 | | .100 | 16v |
| Savage 99 F | .900 | | .920 | | .125 | Recs14v |
| Rem Rol.Blk. | | | | | | |
| Small Shank | .975 | | 1.425 | | .350 | 12sq |
| Manlicker Grk | 1.065 | | .580 | .100 | .100 | 12v |
| Rem 40x | 1.045 | .995 | 1.650 | | .875 | Recs16v |
| Win 88 | 1.00 | | .715 | | .100 | 16v |

NOTE - The above dimensions were taken directly from the barrel and not from factory specifications.

RELINING BARRELS

Many old guns are around that have barrels that are rusted out, but otherwise the rest of the gun is in workable condition. Others have bores that are larger than the individual would like, and would like to change them to a smaller caliber to make them more serviceable.

There is a solution to correct the above problem. This is to rebore and reline the barrel to the caliber that you want. It is a simple matter to do this, as all that is necessary is to purchase tubing that has the correct ID, or slightly smaller. The bore is then reamed to the correct size, and then rifled. In relining barrels, the original barrel is bored out by a drill with a pilot to fit the original bore.

The drill being started at the chamber end of the old barrel so that it will be well centered. The barrel is then reamed with a barrel reamer to bring it to the size of the tube to be inserted in it.

Once this is done, the old barrel is then drilled out to the size of the OD of the liner tube. If you cannot find the tubing the size that is required, a rifled barrel or blank is made or purchased and turned down to the OD that is required.

Be forewarned that to turn a barrel down to a smaller size does have certain problems such as warping, but it is still a simple operation. Sharp tools and a follower steady rest will eliminate much of the chances of warpage.

TUBING FOR RELINING

Most of the barrel liners for relining are long, and if possible it is best to get seamless tubing for the operation. The tubing can be purchased from any steel supply house, and of many different makes of manufactures. Superior Tubing manufactures the best tubing that I have found, and it has excellent interior surface finish. The surface finish is very good, and is usually better than the other tubing manufactures. This is very important as if the ID of the tube is rough and looking like an 1800-century washboard. It will be difficult to ream it and get the interior finish that is needed for the bore.

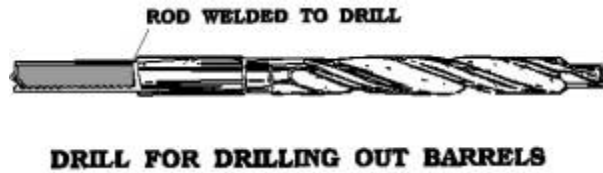
When you buy the tubing you may have to buy the tubing with a smaller ID than is desired, and bore it out to the size that you want, and then ream it to the correct size. It is best to use a short piece of tubing, and bore and ream it to be sure it will do a good job and get the desired interior finish. Most of the tubing will be 4130, which is Chrome-Moly steel. This steel will give good wear, but it is more difficult to get a good finish. If you are able to get the desired results, you can now bore out the old barrel to fit the OD of the tubing.

BORING TOOLS

The boring tool that I mostly used was the standard drill bit with a pilot ground on it that was a close fit to the bore. This was done on the lathe with a Tool Post Grinder. Chuck the back end of the drill in a collet or three jaws chuck, and use a hardened female center in the Tail Stock. Grind the pilot at least 1/2" long, but 3/4" is better. A recess is cut at the shoulder of the pilot to make sharpening the drill easier.

GUNSMITHING AND TOOL MAKING BIBLE

The drill is then removed from the lathe and the shoulder is resharpener to the correct angle of the original drill. It is wise to select the drill size to about .0025 thousands smaller than the finish size of the bore. The reamer will remove the extra stock, and finish the bore to a close fit for the liner.



A shaft close to the size of the drill is now brassed to the end of the drill. The shaft is slightly beveled, and the drill and shaft is laid in a piece of angle iron. The shaft has to be raised slightly to be centered with the drill. After all is lined up the two are brassed together, and let cooled slowly to relieve any stress. Grind off any extra brass and drill is ready to use.

BORING THE BARREL

Remove the barrel from the action, and any other attachments such as sight, etc. that may be on the barrel. The barrel is then centered in the lathe using the lath chuck if the spindle is large enough for the barrel will fit inside the Head stock Spindle. If the spindle hole is too small. The barrel will have supported with a steady rest on the chamber end, and the chuck on the muzzle end.

Insert the drill in the tail stock chuck, or in a special holder on the carriage. The carriage is the best way to rebore the barrel, as the drill has to be with drawn about every half inch to clean the drill.

Start the lathe up, lubricate the bore with a good grade of cutting oil, and adjust the speed for the drill size that you are using. Start the pilot in the chamber end, and engage the feed on the carriage. Have the feed set for a slow feed rate, or the drill can be fed in by hand if so desired. Feed the drill in the barrel for about a half an inch, remove from barrel, and clean the chips from the drill.

RELINING THE BARREL

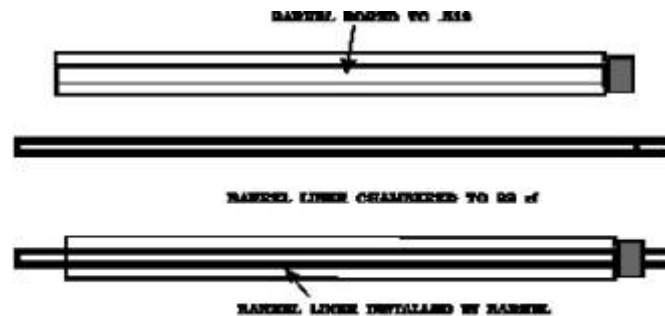
The barrel to be relined is placed on a soldering stand, while gas burners heat it along its full length, from each side. When it reaches the proper heat it is tinned all over, insides, with a stiff wire brush. If the brush is used, it is dipped into and saturated with regular tinnings solder and the barrel is tinned by running the tool or brush through the barrel.

The liner has its ends plugged with wood plugs and is tinned on the outside. It is inserted in the barrel and worked back and forth so excess solder is worked out. The surfaces of both barrel and liner are evenly tinned. The liner is left about three inches longer than the barrel, an even amount being allowed to extend from each end of the barrel.

Stand the barrel upright while cooling. After it is cold, hang it up with a wire and strike it with a small hammer. If you have a good soldering job, it will ring. If it does not ring, the liner will have to be removed

GUNSMITHING AND TOOL MAKING BIBLE

and the soldering operation repeated until it does ring.



THE STEPS IN LINING

FINISHING THE BARREL

After the liner is cut off flush with each end of the barrel and fitted to the action, the extractor cut is made, the liner is then chambered for the cartridge and the muzzle end is finished with a countersink equipped with a pilot fitting the bore.

RIFLING THE LINER

After rifling the tube, the rifling cutter sets up a small burr along the edges of the grooves and these must be removed by lapping. Insert a grooved lapping rod in the barrel after wrapping about two of the lower grooves with string, the rod being inserted from the breech end of the barrel and stopped just a little short of the muzzle.

LAPPING THE BARREL

In casting a lap in a relined barrel in which an unrifled tube has been inserted and later rifled, the barrel cannot be heated as hot as the one-piece barrel, or the solder holding the tube in place will be melted, therefore keep temperatures to not much over 250 degrees.

The barrel is held upright in a vise, muzzle-up, and in the case of a new barrel, is heated so that the lead casts a full lap. If it is heated to just a light straw color, it will be sufficient and the heating is done only for the length of the lap at the muzzle, about two inches. The melted lead is poured into the muzzle and is just allowed to come flush with it. As soon as the lead cools, the lap is pushed out of the muzzle just a short distance and examined to see that it is perfect. Any overflow at the muzzle is trimmed off with a sharp knife. Be careful to not allow the lap to come entirely out of the barrel at any time until the lapping work is finished.

Give the lap a coating of light oil and withdraw it to the breech end of the barrel, allowing it to extend slightly from this end, so that the string may be removed and the lap coated with a fine grade of optical emery. While the lap is at the rear end of the barrel, coat the barrel from the muzzle end with oil.

GUNSMITHING AND TOOL MAKING BIBLE

The lapping rod is equipped with a ball bearing cross-handle at the opposite end from the lap so that it may easily be grasped and worked back and forth through the barrel. Stops are placed at both the muzzle and breech end of the barrel so the lap will never be pushed or pulled entirely from the barrel. Lap the barrel for eight or ten minutes, adding fresh emery, and oil frequently.

At the end of this time withdraw the lap from the barrel and wash the barrel out with solvent and examine it to see that all burrs have been removed. If further lapping is necessary, an entirely new lap must be cast on the rod in the barrel, as before, for the old lap cannot be reinserted.

If you desire an extra high polish, as is often given to target barrels, the barrel can be polished with rouge and light oil after the lapping operation. Leather washers about two or three thousandths of an inch larger than the groove diameter of the barrel is placed upon a polishing-rod with ball bearing cross handle. The leather washers being separated from each other with small brass washers and retained in place by a brass nut on the end, which is made the bore diameter. During the polishing operation, this nut can be tightened a little from time to time, to swell the leather washers slightly. The polishing operation may be kept up for an hour or more.

MAKING 22 RF LINERS

In this chapter I will show you how to make 22 RF liners, for relining shot out 22's. I first came up with the process in 1958, and at that time, no one made any liners, except an outfit in England. I sold over 5000 liners in the first 6 months. At that time, I realized there was a need for a low price liner to take care of the thousands of 22 barrels that were shot or rusted out. I set about trying to come up with a suitable method to mass-produce a liner that would be fast to make. Give the desirable interior finish without any mechanical reaming, and a material and method that would give a superior rifled finish.

LINER TUBING

I spent quite a bit of time experimenting with various methods of manufacturing, tried many different types of steels. Right off, I ran into one big problem with the liners. The interior finish was very bad. It seems the manufacture was unable to hold good I.D. finish or size on the tube. Most often, the tubing had chatter marks inside the tube, as well as uneven bore. Some of the tubing ran as much as .015 oversize in the bore (in places). They were supposed to be .187 on the I.D., but I found that some ran so large that a .219 button would fall through the bore.

I just about gave up on the idea. I even tried to ream the bore to remove the roughness, and did get a very smooth and shiny bore. When I rifled it all of the chatter marks reappeared. The inside looked like a washboard. I had been in contact with various tubing makers across the country, and had several samples of tubing to try. One was from Superior Tubing. When I wiped the grease from the bore, it was like a mirror. Boy, these people had their act together. I cut off a small piece, lubricated it, and rifled it. It was a perfect barrel. Size was perfect, finish was perfect, and was what I was looking for.

If you get tubing, you must specify that you want tubing from Superior Tubing. I know of no other manufacture that has their quality. When you order you need 5/16 x .187, plus or minus .003. You should also specify that the tubing should be free from interior chatter.

The process I will describe here will give you a very high-grade liner as long as you use good tubing. In addition, this process works great for making larger calibers. I have turned out several muzzle-loading barrels using this process. The only difference in making muzzle-loading barrels is that you need a longer stroke on the rifling machine. You can buy just about any size tubing that you need. With button reaming, you will be able to size most slightly undersize tubing to the correct size the first pass.

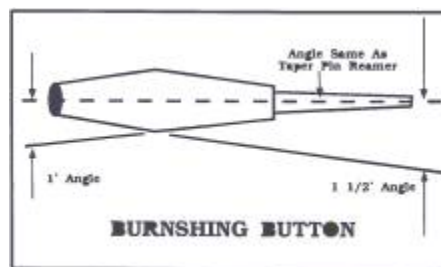
GUNSMITHING AND TOOL MAKING BIBLE

22 RF BUTTONS

The first thing that you will need is the sizing button and rifling button. Sizes are given in the chapter on rifling buttons. When you get the tubing, you will need to soak them in solvent to get the grease out of the bore. After the tubing is cleaned it will need to be counter bored, and special holders made. After counter boring, wipe the barrel with a light grade of oil for button reaming. The counter bore is 1/4 inch. You need a 1/4 inch piece of drill rod that is hardened and about 2 inches long. A sleeve is needed to hold, and clamp to the tubing. Set the liner in the rifling machine, slide the sleeve over the tubing, insert the reaming button, then the drill rod and tighten the setscrews, and you are ready to button ream. After button reaming the bore, swab with MolyKote Z and rifle the liner.

22 SIZING BUTTON

The correct size for the swaging button is .216. This is undersize for a 22 barrel but is necessary for liners. When they are rifled the size will be OK. When you are rifling just make sure the liner or rod is rotating.



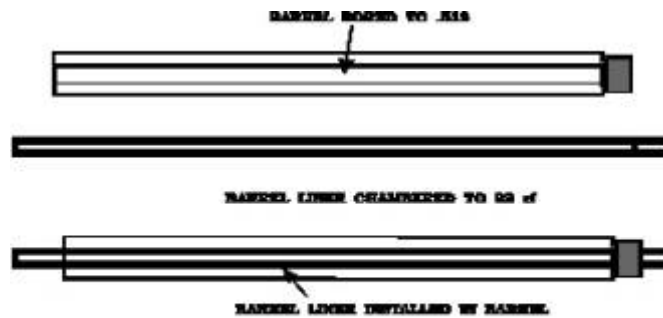
LINER WARPAGE

During the swaging process, the liners sometimes warp so these that warp will have to be straightened. The rifling button creates a lot of stress in the swaging process. When you make the rifling button, it should be .223. I find that six or 8-groove button works well on accuracy. You can use these liners for 22 RF or 22 RF mags.

The counter bore should be cut off the liner, and it is ready to be chambered and installed. To install, all that is necessary is to measure the liner, get a twist drill the same size or a few thousands larger than the liner, and grind a pilot on it (.218) and sharpen the cutting edge.

Then a 1/4 inch piece of drill rod is brazed to the end of the drill. The old barrel can be put in the lathe, and rebored to the liner size. Drill from the muzzle to the chamber. You will have to clean the drill every 1/2 inch or so, and keep it well oiled.

GUNSMITHING AND TOOL MAKING BIBLE



THE STEPS IN LINING

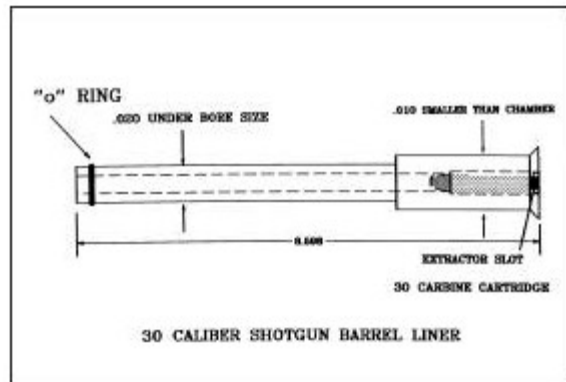
INSTALLING THE LINER

When done, clean the oil from the barrel with solvent. You can the liner in the barrel already chambered. If you want now put the action back in the barrel, remove the extractor from the bolt. Insert a 22 case in the chamber of the liner. Now coat the inside of the barrel and the outside of the liner with epoxy. Slip the liner up to 1/8 inch of the bolt, or where the end of the chamber is. Wipe off all the excess epoxy from the chamber end, close the bolt, and push the liner up flush against the bolt. Once it is flush on the bolt, open the bolt and wipe off any extra epoxy. If you are careful, the case can be removed also. All that is left to do is cut the extractor slot, etc.

GUNSMITHING AND TOOL MAKING BIBLE

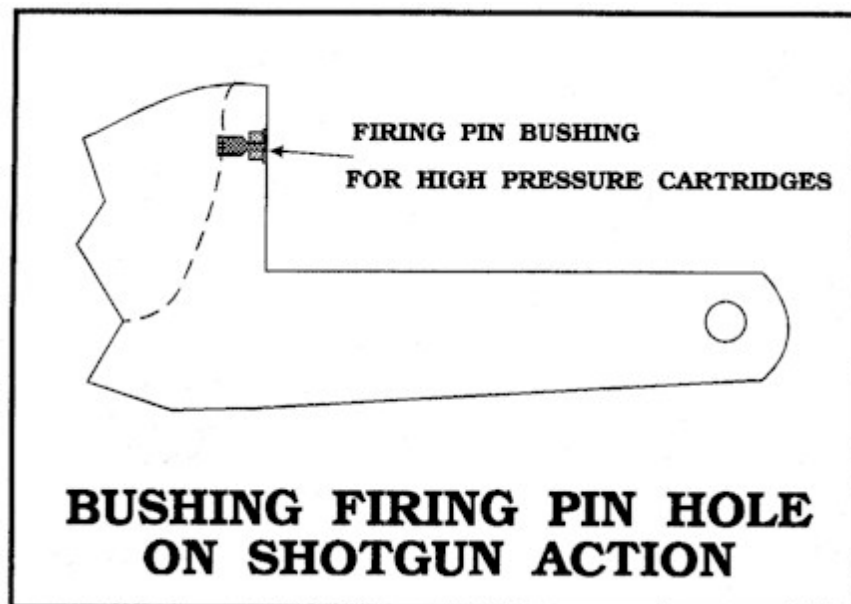
BARREL INSERTS & LINERS

You are out hunting with your shotgun and all you are using is No. 6 shot. Up ahead you see some game but they are all out of range for your shotgun. You shrug your shoulders and walk on; wishing you had your high power rifle.



This has happened to me many times while hunting birds. Many a time I could have got me a Fox or Coyote if I had just had a rifle. I got an idea one day that I could have a rifle barrel in the double barrel, and much the same as a German Drilling.

When I got home, I found an old 30 Carbine barrel that would be ideal for a barrel insert for a shotgun. I cut the carbine barrel off right behind the gas port. I then turned the barrel down to where the barrel would just slip into the barrel on my 20 gauge double barrel.



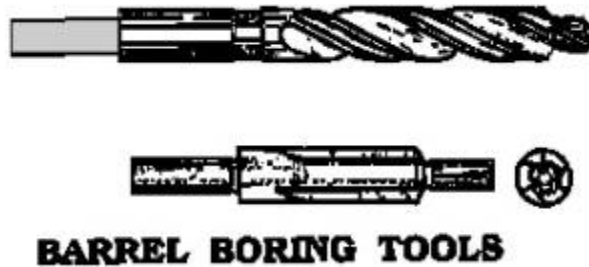
I then turned the back end of the barrel down to the shape of a 20 gauge shot gun shell casing, but

GUNSMITHING AND TOOL MAKING BIBLE

where it would just slip into the chamber of the shotgun. I carefully trimmed a little at a time off the front of the rim until I could just close the barrel up with a 30-carbine case chambered in the chamber.

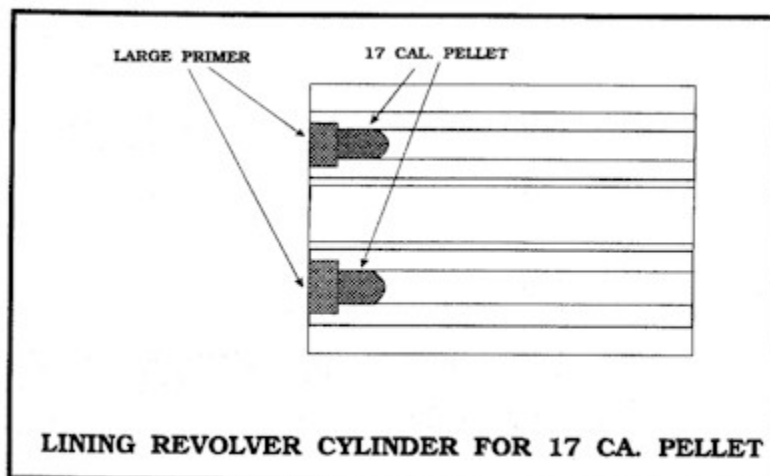
You can also make a chamber liner for a 38 or 357 cal. This is a chamber insert made like the long insert; with the exception it is only 6" long. Use a "0" on the front to center it.

On a high-pressure cartridge the firing pin hole in the breech block needs to be bushed, to keep the primer from flowing back and locking the action closed. Also any time that the primer flows back, there is always the chance that the primer will rupture. If that should happen, high-pressure gas may wreck the stock and action. There is always the chance of personal injury from the high-pressure gas. If you are using a cartridge with pressure over that of the 45-70 or 38 Special, and always **BUSH THE BREECH BLOCK**.



The best cartridges for shotgun inserts are rimmed cases. The lower pressure cartridges will give good accuracy up to 100 yards with plenty of power for most game.

The liner inserts give fairly good accuracy up to 100 yards, and have had many 5-inch groups from a 0/U shotgun. Some type of sights needs to be installed to get this type of accuracy. For close shooting good groups can be achieved with the front bead.



If you use the shotgun regularly, you can install an adjustable rear sight.

REVOLVER INSERTS

GUNSMITHING AND TOOL MAKING BIBLE

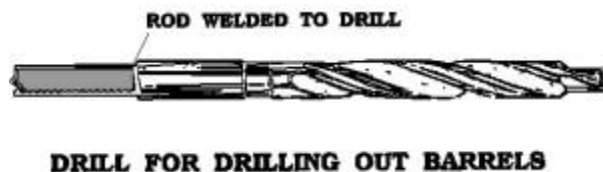
There is another type of insert that I use in my 357 revolvers. Each of the chambers has a .177 Cal. insert install in it. A old "177 pellet rifle will supply you with the necessary rifled barrel for this project. There is two ways of doing this project. One is to use only the inserts in the chamber, and the other is to also line the barrel. Lining the barrel with a rifled liner gives the best accuracy, but the chamber method will give satisfactory accuracy up to 30 yards.

The short piece of barrel is centered in the lathe and is shaped just like a 38 or 357 case. It is made to just slip full length inside the chamber in the cylinder, with no play. The primer end is drilled to accept a large pistol primer. Drill just deep enough that it will be flush. Using a taper reamer, just ream the barrel in front of the primer so a .177 pellet will just start inside the barrel.

22 CAL. BARREL LINERS

When you have an old 22 of your Grand Dads that is in good shape, but the barrel is worn out there is still hope. Brownells and a few other suppliers have a 22 RF liner, which will when installed give new barrel accuracy when properly set in the barrel.

The liner should be carefully chambered and then the chamber polished to remove the reamer marks. It should be chambered deep enough so when a cartridge is inserted in the chamber it will be flush with the end of the liner.



To install, all that is necessary is to measure the liner, get a twist drill the same size or a few thousandths larger than the liner, and grind a pilot on it (.218) and resharpen the cutting edge. Then a 1/4 inch piece of drill rod is brazed to the end of the drill. You will need some type of "V" groove fixture to hold the drill and rod in perfect alignment while brazing.

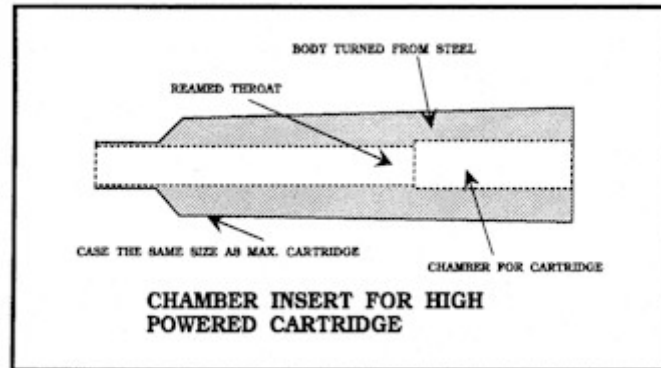
The old barrel can be put in the lathe, and rebored to the liner size. Drill from the muzzle to the chamber. You will have to clean the drill every 1/2 inch or so, and keep it well oiled with a good cutting oil.

INSTALLING THE LINER

When done, clean the oil from the barrel with solvent. You can the liner in the barrel already chambered. If you want now put the action back in the barrel, remove the extractor from the bolt. Insert a 22 case in the chamber of the liner. Now coat the inside of the barrel and the outside of the liner with epoxy. Slip the liner up to 1/8 inch of the bolt, or where the end of the chamber is.

Wipe off all the excess epoxy from the chamber end, close the bolt, and push the liner up flush against the bolt. Once it is flush on the bolt, open the bolt and wipe off any extra epoxy.

GUNSMITHING AND TOOL MAKING BIBLE



If you are careful, the case can be removed also. All that is left to do is cut the extractor slot, and crown the barrel. This can be done by very carefully filling the liner flush with the muzzle, and then removing any burrs from the edge of the bore with a sharp knife.

TURNING LINERS

To prepare a barrel that you drilled, reamed, and rifled, for insertion into a bored barrel it must be turned to size.

The first thing to do is cut the barrel to the length that you need plus 1 inch for cleaning up. You will need the extra 1-inch in truing up each end, and the final finishing of the barrel.

You have the barrel cut to the correct length, so now chuck the barrel in the lathe and face off both ends of the barrel. If the bore has run quite a bit off center, you will need to repeat this process after a few passes on the O.D.

The reason for this is that if the angle on the end of the barrel is off, one side of the barrel will be thicker than the other. In turning, the barrel will probably warp. Now that the barrel is squared, put the faceplate on the lathe. Take a bar of steel that is 20 inches long that has centers in each end and has been turned true.

You will need to set the tail stock to an exact 0000 setting so that there is no taper in the OD of the liner when finished. Set the dial indicator on the carriage of the lathe, set it to 000, and set the tail stock over a bit. Crank the carriage down towards the head stock to where the mark is on the barrel. Check the reading on the dial indicator, and if it is not right, reset the tail stock and repeat the process until you get 0.0104.

Having now completed setting the tail stock to 0000, set the barrel blank between the centers, and clamp a lathe dog on the head stock end. The tail stock center, I have found over the years work better if it is carbide. If you are careful, you can use the standard high-speed center. Put a little grease on it that contains MolyKote Z before setting it up.

I have tried to use live centers off and on, but I have found that I get too much chatter, and that will cause

GUNSMITHING AND TOOL MAKING BIBLE

stress to build in the barrel, and thus warp the barrel.

It is very important to keep any stress from build up in the barrel (Live centers, to tight centers, dull tool bit, improperly sharpened tool bit, etc.) Now for the tool bit. I have used carbide most all the time in turning barrels. I prefer a good grade of high-speed steel as they are sharper and cut better, but require sharpening every pass, to keep a good edge. I had to use carbide due to the time saved.

I grind all my tools to the general shape. On high-speed bits I used only about .010-nose radius, stoned on by hand. Set the tool up so it is about .010 above the tail stock center.

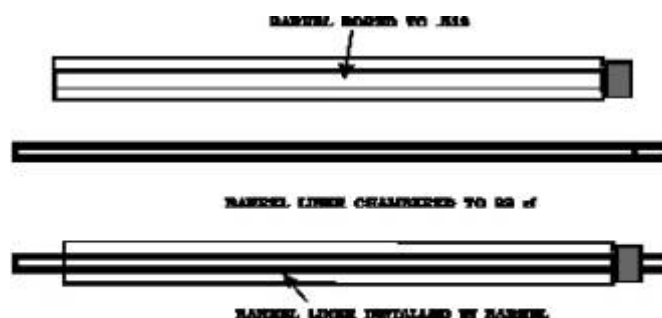
If I have the time, I usually use a feed of .004, but you will need to experiment to see which feed works the best. Usually I do not take over .020 passes per each side on each pass.

What you have to watch for is that the cut is not heavy enough that it will cause the barrel to spring, especially on the barrel that is half way turned down. This springing causes stress. Here is where a good steady rest or a follower rest becomes important. With a follower rest, you will be able to cut the outside of the barrel with no taper, which is caused by springing.

The tool must cut clean, for if it drags, or it is slightly dull it will cause the barrel to heat as it is turned. When the bit is sharpened right you will get some heat build up, but not much.

Watch the chips, as they are coming off the barrel. If they turn a dark blue, you are taking too much a cut, or the tool is dull.

Keep close watch on the pressure on the tail stock. It must be snug on the barrel, but not tight. As the barrel heats its lengthens, and the tail stock must be loosened. If the tail stock center loosens too much, the tool bit will chatter. After the barrel is turned to about, 3/4 finished; you will need to remove the barrel. You will then check to see if the bore is straight, and straighten if necessary.



THE STEPS IN LINING

If you have kept a sharp tool and a light feed, it should be straight. You must, after ever pass from now on the barrel should be checked to see if it is straight. If the barrel has warped, take a lighter pass after it is straighten.

GUNSMITHING AND TOOL MAKING BIBLE

When you have finish turning the barrel down to within a few thousands of the finish size, set the feed to the lightest feed. Sharpen the tool bit, hone it very good, and make a finish pass. This should finish the liner, and it will be ready for inserting into the bored out barrel.

GUNSMITHING AND TOOL MAKING BIBLE

REPAIRING SHOTGUN BARRELS

There are times when something gets into the end of the shotgun barrel that causes an obstruction. When fired there may be a bulge formed, or the end is blown off.

To repair such a barrel, there are three choices:

1. Cut off the barrel and shoot as is.
2. Install some type of adjustable choke.
3. Add an extension to the barrel that has the choke in it already.

To do the latter, you will need a barrel that is as big on the OD as the old barrel, and one that has the choke that you want.

A lathe will be necessary to do this job, with at least a 36" distance between the centers. You will need two centers that are big enough to center the bore, and one a live center.

Cut off the barrel right behind the bulge, and true up the end in the lathe. A steady rest will be needed to hold the barrel unless the bore of the lathe is large enough to hold the barrel. When the barrel end is trued, center the barrel, and set up the steady rest about 2 inches from the cut off end of the barrel.

| SHOTGUN BORE DIAMETERS | |
|------------------------|-----------------------|
| Gauge | Bore Diameter, Inches |
| 10 | .775 |
| 12 | .729 |
| 16 | .662 |
| 20 | .615 |
| 28 | .550 |
| .410 Bore | .410 |

Once it is set up, you will bore the inside of the barrel 1/2 of it thickness, and 3/4" deep into the bore. Measure the ID very carefully so when you turn a shoulder on the extension barrel, as it will need to be a very close fit.

The shoulder angle has to be very accurate, so the fit between the two barrels will be exact. The length

GUNSMITHING AND TOOL MAKING BIBLE

of the shank on the extension barrel has to be exactly the right length, so it will but up on the shoulder on the inside of the barrel as well as on the outside.

When you have achieved this fit, and have the extension barrel turned so it will just fit the counter bore with no play it can be soldered.

You can get paste, low melting temperature silver solder from most gunsmith supply business. Coat the inside of the counter bore, as well as the outside of the shoulder of the extension. If you have a slightly loose fit, you may need to make a mandrel that will just slip inside of the bores of the two barrels. This will keep both in line while soldering and cooling.

Carefully heat up the outside of the barrels after they have been combined. Be sure to keep the heat uniform all around the barrels, and when the solder melts evenly, let cool. Test the barrel after it is cleaned out to make sure you have a good soldering job.

On all of the different lining jobs that are listed above, be extra careful when first testing. All of these methods has been used many times, and have been proven safe. I cannot however assume any responsibly for accidents or injury do to using improper methods or shortcuts.

SHOTGUN BORE AND CHOKE SIZE

12 GAUGES

Bore Diameter is .730

FULL CHOKE .694 AC. .036

MODIFIED CHOKE .712 AC. .018

IMPROVE CYLD. .721 AC. .009

CYLINDER BORE .665 AC. .000

16 GAUGE

BORE DIAMETER IS .673

FULL CHOKE .640 AC. .033

MODIFIED CHOKE .656 AC. .017

IMPROVE CYL. .665 AC. .008

GUNSMITHING AND TOOL MAKING BIBLE

20 GAUGE

BORE IS .619

FULL CHOKE .590 AC. .029

MODIFIED CHOKE .604 AC. .015

IMPROVE CYLD. .613 AC. .007

SHOTGUN REAMERS

| 12 GAUGE | Pilot | Body | Choke |
|---------------|-------|------|-------|
| Rough reamer | .656 | .694 | - |
| Finish reamer | .694 | .730 | .694 |

16 GAUGE

| | | | |
|---------------|------|------|------|
| Rough reamer | .562 | .640 | - |
| Finish reamer | .640 | .673 | .640 |

20 GAUGE

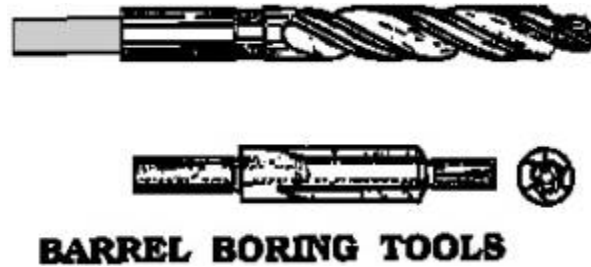
| | | | |
|---------------|------|------|------|
| Rough reamer | .531 | .590 | - |
| Finish reamer | .590 | .619 | .590 |

The dimensions I have given here are the ones that I have used with good results. These are more or less a happy medium on chokes and bores. For example a full choke browning has a bore diameter of .730, and a full choke, which is .699. Winchester is .730-bore diameter, and the full choke is .699. Who is to say which one is best. If you do much work on shotgun barrels you will soon find there are no two alike, and I have found that will vary as much as .042 from maximum to minimum. The old German shotguns are usually tighter yet. What this means if you haven't figured it out yet is that you will probably have to make special tools for each different barrel.

The old types of barrel reamers that were used in the past are usually used in the finishing of the choke. I have found that these give a good job, but took quit a bit longer and did not give the results that I wanted on the bore. With the reamers described, you will usually not have to hone or polish any part of the barrel, except the choke section. I will show you how the reamers are made and the oil tube clamp for

GUNSMITHING AND TOOL MAKING BIBLE

the lathe carriage. I will show you how to make a full choke barrel, but if you want to make a modified barrel, this can be made on the finish reamer.



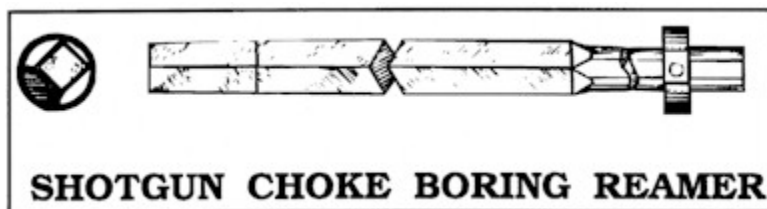
There is a lot of arguments from various shooters on chokes, lengths of barrels, etc. In the old Black Powder days a long barrel was needed for getting maximum power out of black powder. I don't know how many times I have been told about a person having a long tom shotgun that would shoot like a rifle, and out shoot other shotguns.

SHOTGUN CHOKES

To the average sportsman the term "**CHOKE BORE**" MEANS THAT THE DIAMETER AT THE MUZZLE (BORE) IS LESS THAN THE DIAMETER AT SOME POINT BEHIND THE MUZZLE. ANY SHOTGUN BARREL CONSTRICTED AT THE MUZZLE TO THE EXTENT OF .005 OF AN INCH MAY BE TERMED A CYLINDER BORE.

After passing a certain limit in reduction, the choke always defeat its main objective by giving erratic patterns with large holes in them. The larger the bore the greater the reduction of the bore must finish close to a given length, and that should be approximately 1 3/8, or better as a standard should be about 1 inch.

There is also another great misconception on chokes, and that is measuring the choke with a dime. How often we see a person take a dime from his pocket to see if it will enter the muzzle? Such a test doesn't tell him much. If you were to measure a dime you'll find that it measures about .705. Even on some American guns it would go into a full choke. If you were measuring a Browning modified choke barrel you would probably find the dime would not enter the choke, as it measures .701.

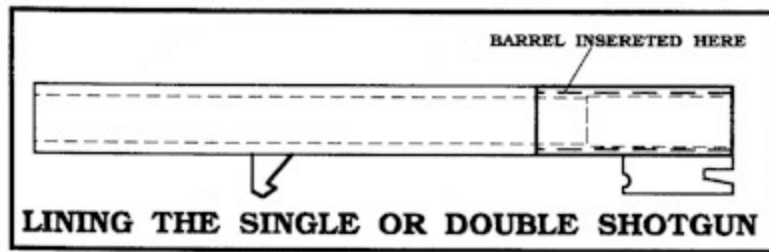


If you do very many pattern testing you may find that some modified chokes will shoot tighter than a lot of full chokes. Once you have the reamers made, now get some fairly heavy wall tubing. This should be 1/2 inch for the 12 gauges. You will need to thread one end so you can screw a fitting to that end, so the high-pressure oil line can be attached. All you need then is a fixture to mount in the carriage where the

GUNSMITHING AND TOOL MAKING BIBLE

tool blocks mounts.

This fixture clamps the tube to keep it from turning. The reamer you make it can be counter bored to a depth of 3/4 inch to accept the 1/2-inch oil line tube. This should be sweated together with soft solder. This is done by cleaning up the 1/2-inch counter bore. Then tinning it and the 1/2 tube, heating the tube and reamer shank together, slipping it into the counter bored hole rotating it a few times and letting the solder cool.



You will put the barrel in the lathe with the muzzle end in the chuck. Thus the reamer will be started at the chamber end, and pulled towards the muzzle. On the roughing and finishing the reamer will not come out all the way out of the barrel. The finish reamer will be stopped with the choke about 1 inch from the muzzle. You must hand feed the finish reamer for a few thousands out the choke. When having reached the desired length, disengage the feed and while the machine is still running back out the reamer.

In reaming the barrel the lathe should be in the slowest back gear position. You will have to find the best-feed rate. On the roughing reamer you will have to use the slowest feed as you are removing a greater amount of material.

WATCH FOR REAMER PLUGGING

One thing that is necessary is that on all tools, is that they must be attached absolutely solid and straight to the reamer oil tube. If not this can cause you a lot of grief in the form of ringed and rough barrels.

CUTTING THE CHOKE

Shotgun barrels are made from steel tubes and although they may be reamed to size with a series of barrel reamers, such as those used on rifle barrels, they are usually finished bored and choked with a long, four-sided, square reamer of O1 tool steel, ground to size on a surface grinder. These reamers are 10" to 12" long and have a tapered lead at the front end, about 1" long on the finishing reamer.

The driving rod for these reamers is brazed to the rear end of the reamer, the opposite end from that which has the tapered lead, and the reamer is pushed through the bore as the barrel tube revolves.

A wood packing strip, turned on one side to the contour of the barrel bore, is placed against one side of this reamer, its full length. Strips of paper are placed between the wood strip and the boring reamer to cause it to cut larger after each trip through the barrel.

GUNSMITHING AND TOOL MAKING BIBLE

A wood strip of the same type is used on one side of the finish or fine boring reamer but the leading edge of the opposite side has a small radius stoned upon it so that it does no cutting, which is all done with the trailing edge of this side opposite to that on which the wood strip is placed.

The choke boring reamer is used in shotgun barrels to cut the choke. After the finish or fine boring reamer is used the choke boring reamer which has a tapered Lead an inch long which tapers about .050" in this distance is used to bore out the choke portion of the barrel which is not bored out by the finish boring reamer. A wood packing strip is used, with paper shims on the tapered portion of this choke boring reamer and this reamer cuts on two edges.

The shotgun boring reamers are run at a low speed and plenty of cutting oil is supplied by a low-pressure pump. In making the reamers they are hand honed after being ground to shape by a surface grinder. They must be carefully checked for straightness. In doing the grinding, if much stock is to be removed, do not grind a lot off of one side and then off the opposite side but take a small amount off of the first side, then a like amount from the opposite side, then take the same from an adjacent side and the same from the last side and repeat this until the reamer is ground to size, as this method of grinding will prevent warping the reamer.

Choke boring is similar to quick-boring, except the cutting end of the rod does not go quite through the barrel, being withdrawn and again inserted with a slip of paper placed between the slip of wood and the cutter. This is worked not quite so far as the previous boring, being withdraws and another slip of paper placed between the wood and the chatter, and this is worked in as far as desired. Care must be taken that the choke be gradual and even. A finish can be given by folding a piece of fine emery cloth or emery paper around a rod, and by turning this in the barrel, equalize any unevenness that may occur.

To enlarge the interior of a barrel, boring it choked at both breech and muzzle, push the rod to the distance from the breech the enlarging is to start, and then start boring, leaving off where the muzzle choke is to start. If the bore of a barrel is to taper from muzzle to breech, it will scatter. If made to taper too much from breach to muzzle, it will compress the shot, and cause a very scattered pattern.

A very slight variation in the size of the bore of a gun-barrel at one of its ends often has a marked effect on its shooting. If the shotgun tends to scatter the shot too much, it can usually be corrected by enlarging the bore at the breech. Choke boring is another is another type of finishing the choke.

You will have to, or more than likely need to polish the choke area. This consists in dressing out the breech with fine emery paper or cloth, wrapped upon a round wooden rod. A little oil should be used in finishing the dressing, which will not extend above half the length from the breech to the muzzle.

No attention is needed to the slope of the choke, as the size of the bore, during this operation, is usually largest at the breech. To do this get a break cylinder hone will work very good with the finest grit stones you can get. It is usually necessary to hone the slope of the choke area, as the reamer will usually not do that well there. This is where the old style square shotgun reamers work well as they will do a better finish job there. You will need to braze a 1/4-inch rod to the hone so it can reach down the barrel to the choke area. Then finish with a fine lapping compound. With the hone you will be able to do quite a bit of alterations on the choke area. Be careful that you do not change the shape of the cone area as this will

GUNSMITHING AND TOOL MAKING BIBLE

throw off the pattern.

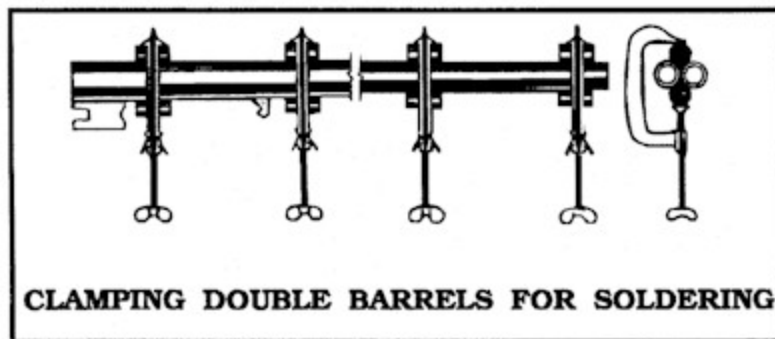
The final polish in the bore should be a mirror like finish, instead of the finish, we see in the bore of almost all guns completed with the finishing tools and never lapped. You should lap the barrel with 800 or 900 carbide powder. A barrel highly finish will be known by the remarkable closeness of its pattern. The only way to achieve this is with a lead lap. Along lead lap coated with fine carbide flower, and paraffin oil as a lubricant. This process is also done in the lathe, or it can be done with an electric drill. If used in the lathe, the lap should be held in the same holder as the reamer coolant tube, and is directly in line with the bore.

DIFFERENT SIZES OF SHOTGUN REAMERS

You will also be able to add short extensions to a shotgun barrel to replace the damage end that has a bulge or burst in it. There are a lot of choke adaptors made today that will mount to the finished reamed barrel, and making and testing a choke is eliminated. This will cut many hours from making the finish barrel, and I would recommend going this route.

BARRELS ON DOUBLE BARRELS

You will need to make quite a few different finishing reamers, as just about every barrel is different. Due to the simplicity of making the reamers, you should be able to make several different sizes at a time. You will need to make sizes starting from .008 over the sizes we recommended for the finish reamer, and down to .030 under the finish reamer, in .002 steps.



SOLDERING THE BARRELS TOGETHER

You will be able to install new barrels on old double-barrels, just about the same way. Cut off the old barrels, first removing the ribs, in front of the hinge. Then you have to rebores the chamber ends to fit the new barrels. In some cases this is the way they were assembled, and they can be heated and the old barrels can be removed. Lot of the old shotguns was made this way at the factory.

Take the finish barrel and turn the chamber end to the size needed to just slip in the old chamber section of the double barrel, or single shot. I might point out that the fit has to be very close, or you may get a bulged chamber. You can use a good low melting point SILVER

GUNSMITHING AND TOOL MAKING BIBLE

SOLDER OR HARD SOLDER TO SOLDER THE NEW BARREL IN PLACE. ONCE SOLDERED IN PLACE THE RIBS/SIGHTS CAN BE INSTALLED BACK IN PLACE.

It is best to chamber the shotgun barrels to at 95 percent completed before installing, and finish after installing. If you are careful the chamber ends can be completed and the head space finish before installing as the shoulder will regulate how far the liner can be inserted. In installing a special fixture should be made to hold the shotgun barrel end solid while inserting the new barrel/s. They are heated with a gas burner such as is found on gas stoves, or hot water tanks and when hot, all the surfaces are well tinned and all are assembled.

With all setting up work done, the rib is positioned against the barrels by means of "C" clamps placed about six inches apart along the length of the entire rib. A steel rod about 1/2" in diameter, and as long as the entire rib, should be placed between the clamp and the rib itself.

In this way the radius of the rod will bear more evenly on the convex surface of the rib than would the flat end of a "C" clamp. A square shaft 3/8" square is placed on the top rib the same length as the rib.

Now begin to carefully heat the work, commencing at the breech, and when sufficiently hot, don't heat too fast nor too hot, apply solder, using the muriatic acid, zinc, or a good past solder as a flux, to the joining of the ribs and barrels. Tighten up the clamps until the rib is positively against the barrels and properly in the center; then with a Butane burner apply the heat, but no more than is necessary to make the solder flow freely for solder that is over heated tends to become grainy when it hardens.

If the solder is hammered thin it will melt quickly by the heat of the barrels, and will be sucked in until the space between the different pieces is completely filled. Do this until the entire length of the barrels is gone over. At the muzzle fit and insert a small piece to fill the space between the barrels and the top rib.

Work from breech towards muzzle over a length of six inches at a time. As the solder melts and begins to flow freely the solder will seep out between rib and barrels, and the appropriate clamp screw should be tightened until the rib is fully against the barrel. Any excess solder which flows out from between the joint should be wiped off with a cloth before it has a chance to harden and set on a portion of either the barrels or rib where it is not wanted. Repeat this same operation all along the rib until the entire loose unit is fully and positively joined to the barrels.

Look at the muzzle of the barrels and see if any solder is needed at that point. If there is an opening between the top and bottom ribs. It is necessary that all the space between the top rib and the barrels be completely filled with solder, or rust will form there, which will cause problems later to the barrels, and in time work under the ribs, causing the ribs to come loose from the barrels. This opening should be filled in by flowing melted solder into the opening and then trimming off the excess with a piece of emery cloth laid against a flat stick or file.

Allow for normal cooling by the surrounding air and do not pour water on the barrels to induce rapid cooling as it might seep into some minute crack existing between the rib and barrels and form a steam pocket. Remove the clamps, and with a very narrow chisel scrape away all traces of solder that show

GUNSMITHING AND TOOL MAKING BIBLE

between the joined surfaces, being careful not to scratch the barrels.

When the work is soldered and is cool, wash it well with warm water, using a stiff brush to remove dirt and all trace of the acid flux that may remain on the work. With a chisel or scraper remove all surplus solder and brighten the work with emery cloth of different grades. Begin with the coarser and finishing with the fine or with flour and emery.

When the work is soldered and is cool, wash it well with warm water, using a stiff brush to remove dirt and all trace of the acid flux that may remain on the work.

With a chisel or scraper remove all surplus solder and brighten the work with emery cloth of different grades. Begin with the coarser and finishing with the fine or with flour and emery.

To stop any possible rusting that might occur as a result of using the solder or flux, the barrels should be cleaned with some good detergent, dried off, and coated with light oil. The insides of the barrels should be swabbed and a light oil applied.

REPAIRING SHOTGUN BARRELS

There are times when something gets into the end of the shotgun barrel. When fired there may be a bulge formed, or the end is blown off.

To repair such a barrel, there are three choices:

1. Cut off the barrel and shoot as is.
2. Install some type of adjustable choke.
3. Add an extension to the barrel that has the choke in it already.

To do the latter, you will need a barrel that is as big on the 00 as the old barrel, and one that has the choke that you want.

A lathe will be necessary to do this job, with at least a 36' distance between the centers. You will need two centers that are big enough to center the bore, and one a live center.

CUTTING THE BARREL OFF

Cut off the barrel right behind the bulge, and true up the end in the lathe. A steady rest will be needed to hold the barrel unless the bore of the lathe is large enough to hold the barrel. When the barrel end is trued up, center the barrel and set up the steady rest about 2 inches from the cut off end of the barrel.

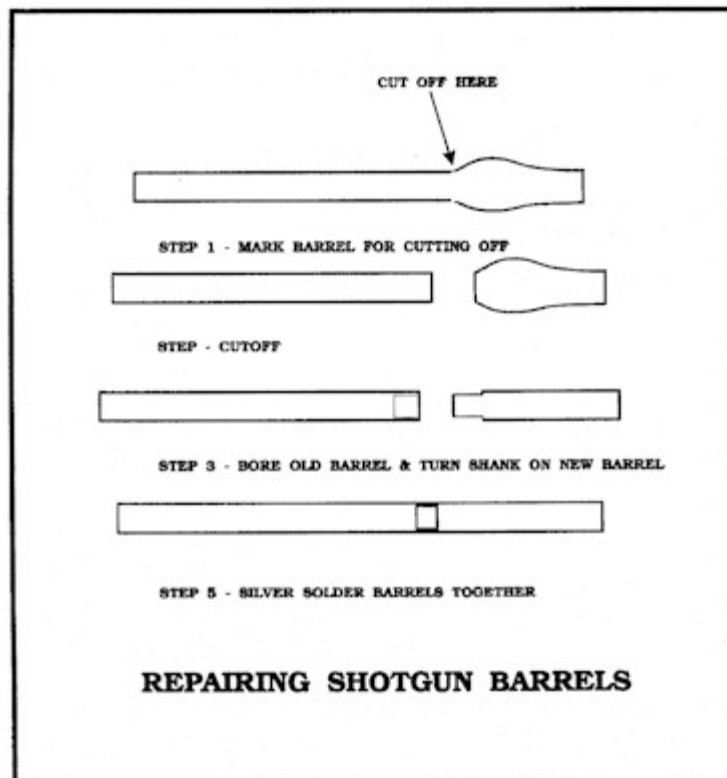
Once it is set up, you will bore the inside of the barrel 1/2 of it thickness, and 3/4" deep into the bore.

GUNSMITHING AND TOOL MAKING BIBLE

Measure the ID very carefully so when you turn a shoulder on the extension barrel it will be a very close fit.

SHOULDER ANGLE

The shoulder angle has to be very accurate, so the fit between the two barrels will be exact. The length of the shank on the extension barrel has to be exactly the right length, so it will but up on the shoulder on the inside of the barrel as well as on the outside.



When you have achieved this fit, and have the extension barrel turned so it will just fit the counter bore with no play, it can be soldered.

You can get paste, low melting temperature silver solder from most gunsmith supply business. Coat the inside of the counter bore, as well as the outside of the shoulder of the extension.

If you have a slightly loose fit, you may need to make a mandrel that will just slip inside the bores of the two barrels. This will keep both in line while soldering and cooling.

Carefully heat up the outside of the barrels after they have been combined. Be sure to keep the heat uniform all around the barrels, and when the solder melts evenly, let cool. Test the barrel after it is cleaned out to make sure you have a good soldering job.

On all the different lining jobs that are listed above, be extra careful when first testing. All of these

GUNSMITHING AND TOOL MAKING BIBLE

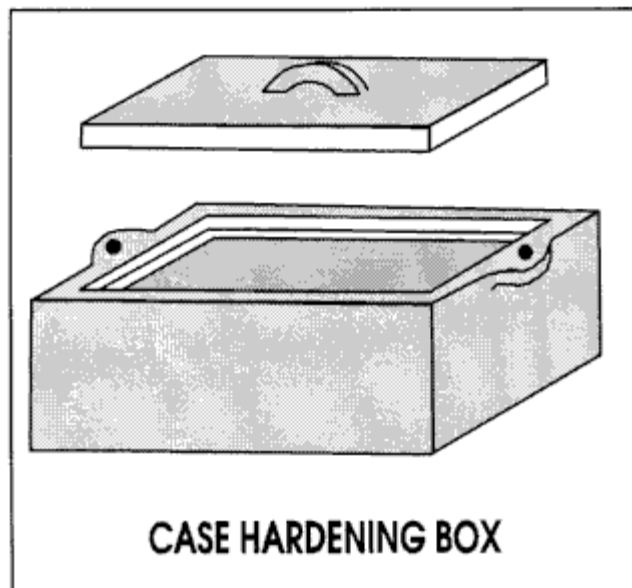
methods have been used many times, and have been proven safe. I can not however assume any responsibility for accidents or injuries due to using improper methods or shortcuts.

CASE HARDENING

One of the oldest known heat-treating processes is carburizing. History tells us that sword blades and primitive tools were made by the carbonization of low-carbon wrought iron. When you are making a firearm, case hardening is a good way to finish many of the parts. Color case hardening will give a very attractive finish.

The following carburizing processes are commonly used in industrial applications: (1) pack carburizing, (2) gas carburizing, and (3) liquid carburizing.

Most mild steels do not come with enough carbon to enable them to be hardened by heating and quenching, as are the higher-carbon-content tool steels. However, if carbon is added to the steel, it can be made to harden upon quenching. There are many methods of adding carbon. In the processes, the heated steel absorbs the carbon from the outside. The interior of the metal does not absorb the added carbon and so remains soft after quenching. A hard carbonous surface, or case, is formed on the metal.



Case-hardening is accomplished by impregnating the surface of steel with carbon, by heating it at high temperatures while packed in an iron or steel box with proper carburizing materials, or by heating the steel in potassium cyanide in an iron pot,

The only practical method for the home shop is one of the cyanide processes. Melted sodium cyanide is a very good carbonizing agent, but it is also very dangerous to use.

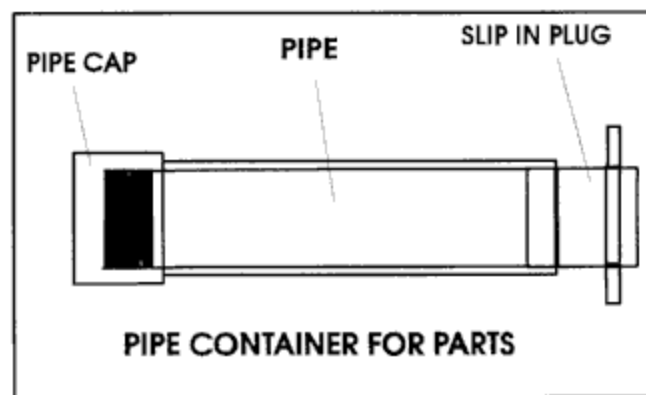
There are several patented compounds on the market, such as Kasenit, Hard and Tuff, which give the same results and are safer to use. The steel is heated to a cherry red, then covered with the hardening compound and allowed to soak in it.

GUNSMITHING AND TOOL MAKING BIBLE

This will form a paper-thin case that will be glass-hard when quenched.

The case will not be thick enough for grinding. To form a case that can be ground, the steel must be heated several times and let soak in the melted compound until cool after each heating. In shops that do a lot of case hardening, the article is surrounded with the carbonizing agent-bone charcoal, molten sodium cyanide, or a nitrogen atmosphere, and held in a furnace at the carbonizing temperature until a case of the desired thickness has formed upon it.

The various parts of gun parts such as guards, metal butt plates, etc., and the different parts of locks, such as hammers, tumblers, triggers and plates, that the Gunsmith has to make will need some type of hardening. Many gunsmiths, particularly those in the country, finish the parts with a file and then hand polish. These parts can then be finished through the normal heat-treating, or case hardening.



Triggers, sears and various other small parts can be finish in this manner. As these parts are almost always made of soft iron, they would soon wear and have to be repaired if not hardened.

The gunsmith will thoroughly case-harden the parts when they are fitted and finished, and will turn out a good piece of work that will wear as well as hardened steel. Some gunsmiths, when such work is finished, heat it red hot, smear it with a good case hardening compound such as Hard-tuff, and while hot, plunge it into cold water, letting it chill. This produces a superficially hardness surface that is not "skin deep," and as soon as this surface becomes worn through use it will wear away rapidly.

If the case hardening of the experience Gunsmith, you will see that the surface of such work has a fine grayish appearance, and in many places mottled with colored tints that are pleasing and beautiful to the eye. On these parts the hardness is of such depth that it will wear for a long time. In fact it will wear better than hardened tool steel. The condition of the case hardened part is that of a hardened steel surface stretched over and shrunk upon the iron body of the work. It is stronger and tougher than steel, for it has the tenacity of iron for its interior. It has the advantage of steel, in as much as it may be bent when cold to a limited degree, and case hardened it will not break as readily as steel.

The easiest and Perhaps the best way to case harden gun work is to have a number of short pieces of common gas pipe, such as will be adapted to the size or quantity of the work, and have one end of these pieces securely plugged or capped. A best way is to have a thread on the pipe and then screw on

GUNSMITHING AND TOOL MAKING BIBLE

a plug, such as are used to close ends of gas pipe.

In the pack carburizing process, the operation is carried out by packing the steel in suitable containers such as steel boxes or pots, with a carbonaceous material.

The substances used are generally commercial solid carburizers that vary in composition; They generally consist of a hardwood charcoal to which an energizer, such as barium carbonate, has been bound by molasses or oil tar.

Mixtures of coke and charred leather, bone, and charcoal are also used. The energizer usually represents about 20% of the mixture. To increase the rate of heat transfer through the compound, an additional 20% is made of coke. Since the compound decomposes with use, it is common practice to add 12% to 30% new material to used compounds for a new operation.

In this process, the box, which is made of heat-resistant alloys, is packed and sealed tightly, then placed in the furnace and heated to between 1500° and 1750°R Within this range a transformation takes place in the steel forming austenite which has the capacity to dissolve large amounts of carbon.

The best case-hardening is done by the pack-hardening method, that is, packing the articles to be hardened in iron boxes in which the article is surrounded by powdered charcoal, coke, leather or bone and heated at a rather low heat over a long period of time. This method gives a deeper hardening and the temperature is more easily controlled.

The time required varies with the size of the pieces. Temperatures may be held at 1550 degrees Fahrenheit. Green bone should never be used as a carburizing material, as it contains phosphorus. Pack the work with the powder, the same as bone dust. Bone black may be used the same as bone-dust, but it is not as good, and will not give as good a results. It is also dirty to use and to have around a shop.

Gun guards, straps and long pieces of work will become shorter after case-hardening, and it is best not to fit such pieces into the stock until after they are hardening.

Case-hardening by heating the articles in liquid potassium-cyanide to a temperature of 1562 degrees Fahrenheit gives a quick and very even case, but it is superficial and won't stand any further finishing after being case-hardened as the hardening will be cut through. Cyanide salts are violent poisons if allowed to come in contact with wounds or scratches and are fatal if taken internally. Poisonous fumes are generated when cyanides are brought into contact with acids.

As the cyanide gives off deadly poisonous fumes, this type of case hardening should be done in an open pot, under a hood attached to a flue with a good draft, and the operator should stand back from the pot.

Cyaniding is a process that involves the case hardening of machined steel parts by heating in contact with molten cyanide salt, followed by quenching in a salt bath, water, or mineral oil, depending upon the type of steel. The salt bath consists of a mixture of 30% sodium cyanide, 4-0% sodium carbonate, and

GUNSMITHING AND TOOL MAKING BIBLE

30% sodium chloride.

The cyaniding temperature is above the lower critical temperature of the steel, usually from 1400° to 1600°F. Direct quenching is employed. This process is capable of high production, as immersion periods require only 15 minutes to 2 hours. It requires about 30 minutes to case harden a part from 0.003" to 0.005". The maximum case depth is rarely more than about 0.020". A very thin surface case can be obtained by dipping in a powdered cyanide mixture, followed by quenching.

CAUTION: A method of venting gases is a must during the operation and molten cyanide should never be allowed to come in contact with sodium or potassium nitrates, used in tempering operations, as the mixtures are explosive, extreme care is necessary at all times when using the material

If you want to have an area of the work left soft and the other parts hardened, securely cover the places to be left soft, with a coating of moist clay, and this will prevent the hardening material from coming in contact. It may also be observed that articles that are case hardened will not rust so readily as those not so treated.

If the parts are quite thin, there may be a chance of their cracking by sudden chilling. To prevent this the water may be warmed a little, or a film of oil may be spread on the water, which will tend to prevent too fast cooling of the articles. If you want to have the work show the colors or mottled tints as seen on some kinds of case hardened gun work, the surface of the work before being put in the pipes containing the burnt leather, must be highly polished and then buffed. The higher the finish the more brilliant will be the colors.

In using a commercial compound to case harden, the work heated and dipped in, or if the work is large the compound must be spread over it. The work must be hot enough to fuse the compound, and if it become cold by removing from the fire it must be reheated, removed quickly from the fire and quenched in cold water.

Collect such articles cow's horns, or hoofs of either cows or horses, leather trimmings from about the local shoe shops, old boots or shoes, and burn them until sufficiently charred to admit of being easily pounded into a powder. Then finished up the parts to be hardened, and ready for the final polish, place them in an iron box, and surround it completely on all sides by a packing of the powder. Pour into the box, until the powder is moist, a solution of common salt. Then close the box and seal it until airtight, with wet and well-worked clay, then put it into the furnace and heat the furnace up gradually until it becomes a cherry red.

BLACKING FIREARMS

You will find as you get experience that over polishing is the main problem of most blue jobs, as most new inexperienced craftsmen bear down, and spend too much time with the parts against the wheels to shine everything up and round off corners, dish out screw holes, and in general change the appearance of the firearm.

Guns must be entirely taken apart to do a good job of bluing as when a gun is left partly assembled, bluing salts remain in crevices and after the bluing solution has been applied this salt will keep bleeding from the gun for a long period of time.

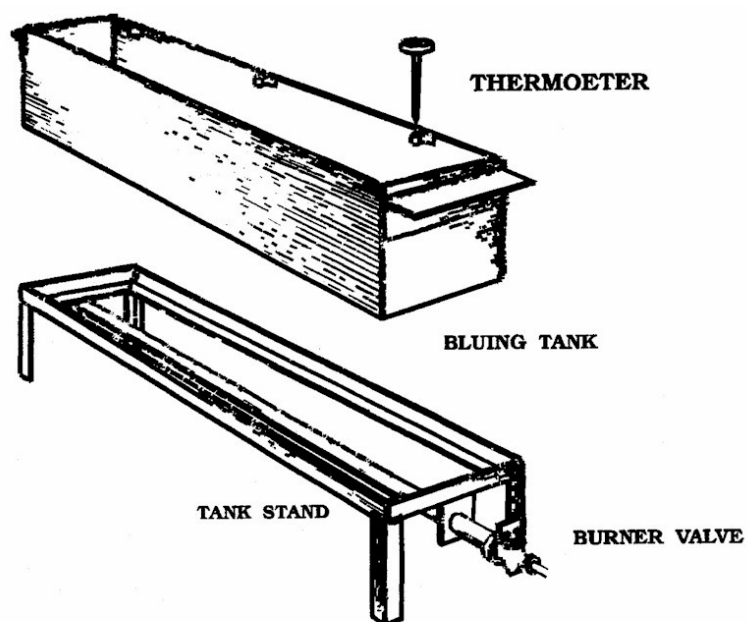
After the gun has been completely taken apart, wash all parts in solvent, using a stiff brush to get into all corners and if necessary use a small screwdriver to scrape away heavy grease and dirt. You can now see all scratches and cuts, which must be polished or filed out before the bluing is applied if the gun is to look well afterwards. Remember that after the gun is polished and blued, all dips, scratches, etc. will show up where you thought there were none.

Polishing barrels is more difficult than other parts, as they are usually polished incorrectly, even when barrel shape and lines are okay. Barrels, and practically all other gun parts as well, especially receivers and trigger guards, should be polished lengthwise, not crosswise. Preliminary cleaning up can be done in the easiest method, but final polishing and buffing should be in line with the bore.

Running a barrel back and forth parallel to the turning wheel is not so easy. Finishing the hand working over with crocus cloth helps a lot.

A lathe can save much time and be a great help to good bluing, as barrels can be cleaned up by jig or draw filing or hand scraping. In draw filing, a file of the vixen type can be used for the preliminary work, and short sections of coarse mill file for finishing. Filing of course is only necessary to clear off tool marks, rust pits and bulges. Many times if the barrel was rough on the outside, I set it up in the lathe and starting with the coarsest emery cloth removed the worst scratches, rust, etc. If you use the lathe, use a live center in the tail stock so the bore or rifling is not damaged. After using the coarse, use finer grits to polish the barrel, and on the final pass use crocus cloth to polish it.

A flexible shaft tool, a flexible shaft attachment for an electric motor, with chuck in the free end of 1/2" capacity, is very useful for polishing hard to get to places. Small felt hobs and wheels, mounted on a 1/4" and even 3/8" shafts can be purchased from Brownell and other suppliers. They can be charged with polishing compounds as the large wheels are, (Hobs are small cylinders and balls of felt with built in mandrels.) These wheels are a necessity for polishing inside trigger guards, in the small radius curves on receivers and revolver cylinders. They save much time, and do a quicker and much better job than the larger wheels.



BLUING TANK AND ACESSORIES

GUNSMITHING AND TOOL MAKING BIBLE

HAND POLISHING

Polishing a gun for bluing or rebluing can be done by hand without as much time and labor as a person would think. A hand polished firearm looks better than a power polished one, since corners and angles can be maintained, with no loss of outline. A higher polish by wheels is required for the same finished blue appearance than for the same appearance when done by hand.

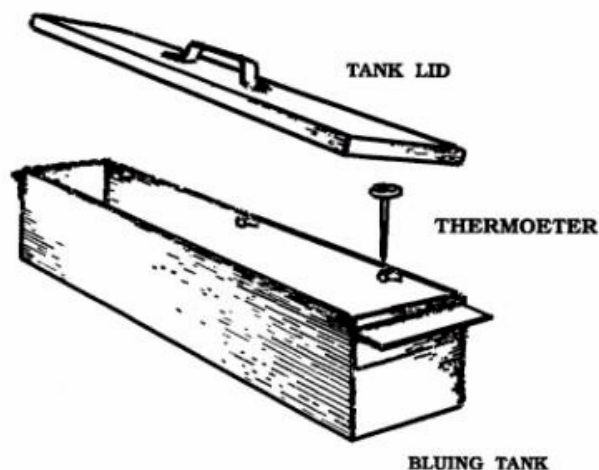
All the equipment necessary to do a hand polish job is your set of files, five feet of 1" or 1 1/2" grit abrasive cloth, six feet each of #240 and 320 strip and a couple of sheets of crocus cloth.

Use fine files to remove scratches and cuts, then polish the file marks out with Carborundum cloth, starting with coarse and finishing with fine grades, polishing lengthwise of the barrel and action, as cross polishing shows up badly after the bluing is finished. For power polishing, the metal parts must be free of oil before starting the job. Solvent combines with the free grit or cloth to form a sticky, mess. A good soap should be used to clean the hands and work when they become fouled up with the oil and residue.

There are a few places, as inside trigger guard loops, in the small curved depressions in bolt sleeves, etc., where the power driven felt hobs will do a better job than hand work. Bolt-action trigger guards proper, tangs and floor plates, are very easy to hand polish and should be so treated.

DEGREASING

Nearly all finishing processes require that the metal be absolutely free of any trace of oil or grease. However some of the blacking systems are so caustic they cut small amounts of oil and so are not critical on this point, however the oil or grease will soon cause the blackening solution to become contaminated.



BLUING TANK

GUNSMITHING AND TOOL MAKING BIBLE

By far the best hot water cleaner is Oakite, made by Oakite Products, Inc. This is one of the oldest detergents, or grease cutting cleaning compounds, we have. It emulsifies or absorbs grease and will not hurt hands or clothing, as it does not contain lye. The household variety is sold in grocery, and hardware stores. Four ounces should be used to each gallon of water. There are special industrial varieties of Oakite, which are cheap in quantity, and go further in use.

BLUING TANKS

Altitude increases water boils at a lower temperature, and as its sea-level boiling temperature of 212 degrees is none to high a heat for good results in bluing, when you are working at altitudes of 3000 feet and more the water temperature is hardly sufficient for a good job of bluing.

All the blacking processes call for immersion of the metal parts in the actual bluing solution or in the neutralization of chemical agents used in the process.

Stainless steel is the best tank material. These should be welded up, of fairly heavy gage sheet, about .050" thick and one of them will be needed. The degreasing tank can be of mild iron or steel.

Tanks can also be made of black iron strip, called "hot rolled," to a size most economical for your shop. Inside measurements for the minimum most useful size are 38" long, 8" wide and 5" deep. Remember, the bigger the tank, the more solution you will need. Smaller tanks, 15" by 7" by 5" should be made for pistol and small parts bluing. It is a waste of solution and heat to use the large tank for small parts. Three tanks of each size should be made up.

The purpose of three tanks is, one for boiling of parts in the degreasing solution, a second for the blacking solution, and the third to hold the clean water used for rinsing.

Some type of handles should be attached to each end of the tank, and small bars or rods of metal welded or wedged across the tank on the inside close to the bottom, to prevent the metal parts to be blued from contacting the tank bottom.

Gas is the most common heat used, and burners for bluing are easily arranged. Long burners are available commercially for the specific purpose; you can make them of pipe, or salvage a few old ordinary round burners from scrapped stoves, hook them in a line and support in an angle-iron stand or on a metal table. Propane gases are available in most areas, and the bluing setup can be operated from a propane tank, such as is used on your barbecue. A wooden table with a metal top can be used as well or better. If you make up one, the burner apertures and flame adjustments are not the same for all gases. The bottled gas uses smaller apertures and burns with a shorter and hotter flame than natural gas.

Use two parallel burners, each made of a 38" length of 3/4" pipe with holes drilled 3/8" apart in a straight line for the individual gas flames, preferably with the gas entering each pipe burner at the center. This is for one tank only, with the two pipe burners spaced about 2 1/2" apart. The tank is centered over the two.

GUNSMITHING AND TOOL MAKING BIBLE

Three such burner units should be enough for the ordinary shop, and can be arranged with regard to the space available in the bluing room. If sufficient space allows the burners and their tanks to be placed end-to-end, this is the most easily managed setup. If space is limited, one burner may be placed behind another.

Place the burners between 30" and 35" from the floor, and when making the tanks install iron faucets in on end of the tank. This makes emptying of tanks easier, and almost all the contents can be drained without lifting the tank at all. An deep fat thermometer call be used to check temperatures of hot liquids, but it is better to buy one of Brownell's thermometers, as they can be used to set the temperature closer.

The bluing or blacking tank should be cleaned and neutralized (by acid wash) when a solution is changed. If the same formula or mixture is to be used, washing with plain water is OK. Covers should be provided for the tanks, for keeping dust and dirt out.

BLACKING SOLUTIONS

The following is a formula that I have used for 20 years to blue or blacken firearms. This blacking solution is probably the most practical of all blacking processes, and I have found that it is almost foolproof in operation. The ingredients can be obtained at low cost in most any rural areas. I have found the finish is more durable than most I have seen. In appearance and wear resistance it resembles the finish used by Germany on military small arms.

Lye 2 parts

Ammonium Nitrate 1 part

Water see below

White Ammonium Nitrate Fertilizer, the 33% type used by farmers

The household lye or sodium hydroxide (ordinary Lye is approximately 94%, Sodium hydroxide) you can get at any grocery store. The ammonium nitrate you get at seed and farmers CO-OP stores, it is used by gardeners and farmers.

Solution:- 5 pounds lye

2 1/2 pounds ammonium nitrate,

Per gallon of water

I have found that the best working temperature is between 285 and 295 degrees F. The solution lasts almost indefinitely. Add a pound of lye every 10 or 15 jobs, or when you have trouble getting the temperature up, and water as necessary.

GUNSMITHING AND TOOL MAKING BIBLE

When adding lye, do not just dump it in, but scatter it over slowly over the whole length of the tank. What happens is that if you dump it all in one spot, it will cause it to boil over the tank. From 15 to 40 minutes in the bath is required, depending upon the amount of parts that are being processed.

The most unpleasant part of using this formula is that in mixing in the ammonium nitrate, a large amount of ammonia is given off, so have good ventilation in the finishing room. When adding more ammonia nitrate to a hot tank, take a good breath, pour it in and get out of the room. The ammonia fumes will put you down if you are not careful. Vent out the room and you can start bluing.

Lye is no problem to handle. In this formula, is not to aid in coloring the metal but to raise the boiling point of the solution and thereby prevent excessive loss by boiling away of the other ingredients. In this mixture the ammonium nitrate stays in the tank, and only water and a little lye are lost through boiling,

The black produced by this ammonium-nitrate-lye process is very durable, and I have some guns that have been in use for close to 20 years.

To use this solution, the metal parts are degreased either by Oakite solution and placed in the tank. After blacking, they are rinsed in water, either cold or warm, and dried and oiled in the regular manner.

All of the blacking processes that use lye attack lead and destroy soft solders, and can not be left in the solution for over 15 minutes, so remember this when bluing rifle barrels with sweated on ramp front sights.

The processes does not attack aluminum alloys, they devour them! Under no circumstances place a part made of aluminum in a steel blacking solution. It will be dissolved quickly. Silver, copper and brass are not affected at all by the blacking solution.

BUFFING AND POLISHING

POLISHING AND BUFFING WHEELS

Polishing wheels in general use are constructed of muslin, canvas, felt, and leather. By changes in construction, offer to the operator wheels of varying flexibility that best suit the particular object to be finished and the condition of its surface.

Polishing wheels in widest use are made of woven cotton fabrics, the hardest wheel of this type being made of individual discs of canvas cemented together. The softest being composed of discs of muslin sewn together between these extremes is the most popular wheels are composed of sewed sections of muslin discs fastened together by adhesives.

For economy, these sewed sections are often made of balanced pieces of muslin rather than full discs of cloth. As a class, cotton fabric wheels, because of their versatility and their relatively moderate cost, are the most commonly used medium for general all-around polishing.

Pressed felt wheels, available in densities from rock hard to extra soft, are indicated where the face of the wheel must be kept true and be absolutely uniform in density over its entire surface. The face of a felt wheel can be easily contoured to fit irregularly shaped articles. Because of their higher initial cost, they are generally restricted to the finer abrasive grit sizes.

Solid leather wheels of walrus and bull neck leather are tough but resilient, with a springy open grain, and are favored for the fine polishing required in cutlery and gun work. Wood wheels covered with leather belting are popular for flat surfaces where a minimum of flexibility is desired. Wheels made of sheepskin discs are used where great flexibility and less density are needed. In the harder sheepskin wheels, the individual discs are cemented together while in the softer types the discs are held together only by hand sewing.

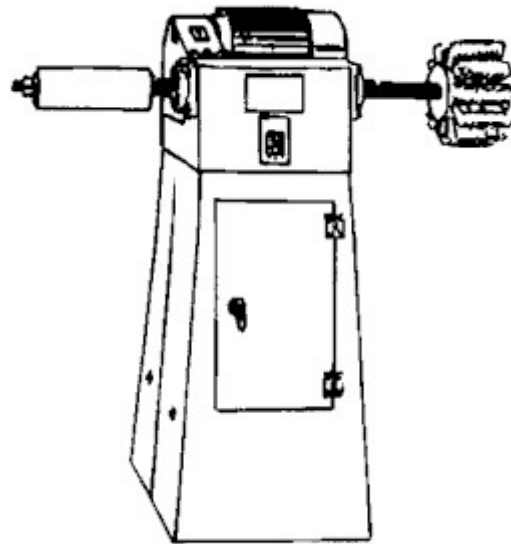
Practically all the materials mentioned above which are used in disc form for the production of polishing wheels can be used in a different manner in the production of the so-called compress wheel. In this wheel, small pieces of leather or woven fabric are placed in a rigid center section so their edges are perpendicular to the side of the wheel. Accordingly, there are no seams following the direction of rotation and more precise polishing can be done than with any other type of a built-up wheel.

Various grades of flexibility are available for each type of material used and, with the stiffer density woven fabric compress wheel in particular. A degree of fine polishing can be obtained that cannot be duplicated with wheels of different construction.

NITRIC ACID STRIPPING.

GUNSMITHING AND TOOL MAKING BIBLE

If the part you are going to buff has been plated, you will need to deplate it. The following is two methods that I have used.



POWER BUFFER

A method that I have used to strip nickel-plating is to immerse the desired parts in a glass container that is filled with Nitric acid. When using this chemical make sure that the parts are completely covered by acid, take extra care that the bore and chambers are plugged. Since this solution will dissolve a 0.001" thick nickel plate in 15 to 20 minutes, you must watch the stripping operation constantly and remove the parts as soon as they are stripped. When the parts are taken from the fuming nitric acid they must be dipped into a chromic acid solution for a minute and then very thoroughly rinsed in water. Do not put the part when you remove it from the Nitric Acid directly into water, as the water will cause the nitric acid adhering to the surface to etch the steel.

Like hydrochloric acid, nitric acid gives off fumes that settle on and rust everything within several feet of the container. Nitric acid should be stored, poured, and used either outdoors or in an unused room where there is nothing that will rust.

ELECTRO DEPLATING

This is another deplating setup that I used in my gun shop. Most of the plated guns are pistols and revolvers, so that you can get by on a small tank. When you have guns that come into the shop for bluing, you will be able to strip off the old plating from these guns. Plated guns that are to be refinished in blue or black must have all the old plating removed, and polishing on the buffing will not do this. The deplating tank also will remove grease, old bluing, dirt, rust, and the like.

An automobile battery will provide the electric current for deplating, but I prefer a battery charger. The wires should be insulated cables, with copper rods or heavy wires to contact cathode and anode in the

GUNSMITHING AND TOOL MAKING BIBLE

tank.

A glass container of around two or three gallons capacity is needed to hold the chemicals. The acid to use is one gallon of commercial sulfuric acid with one quart of distilled water. The acid is always poured into the tank first, and the water added slowly. A sheet of plumbers lead or weight, of surface area to equal or greater than that of the gun parts, is used as the cathode, and are connected to the minus battery post or cable on a battery charger. The anode is the metal to be deplated, and the gun parts are wired tightly to the anode, connected to the plus battery post. They are usually hung on the copper wires that are wound about them well enough to make good contact, and these wires connected to the anode. Stripping time is usually from five to ten minutes.

Sulfuric acid is hygroscopic, and that means that it absorbs water from the atmosphere and your solution will actually increase in quantity. A deep tank, will give a considerable increase in volume, but as the solution is weakened by the extra water taken in, more sulfuric acid must be added. This solution will deplate most plated items including nickel, chrome, and cadmium.

RAPID METAL REMOVAL

A need for rapid metal removal or where there are no contours and a flat surface is to be maintained. Conversely, the softer types of polishing wheels are used where there are irregularities in the surface and the fast removal of metal is not the prime requisite.

To remove pits, scratches and scale, and put a high finish on the surface of a barrel, receiver, part, or tool, various wheels must be used. For practical purposes the main wheels that the gunsmith needs are:

| | | |
|-----------------------|-----------------------------------|---------------------|
| 2 canvas wheels | 8" dia. X 1" wide | |
| 2 " | " | 8" dia. X 1/2" wide |
| 2 " " | | 6" dia. X 1/2" wide |
| 1 felt wheel | | 6" dia. X 1" wide |
| 2 cloth buffs (sewed) | 10" dia. X 3/8" wide or 1/2" wide | |
| 2 | " | 10" dia. X 2" wide |
| 2 (Loose muslin) | 10" dia. X 2" wide | |

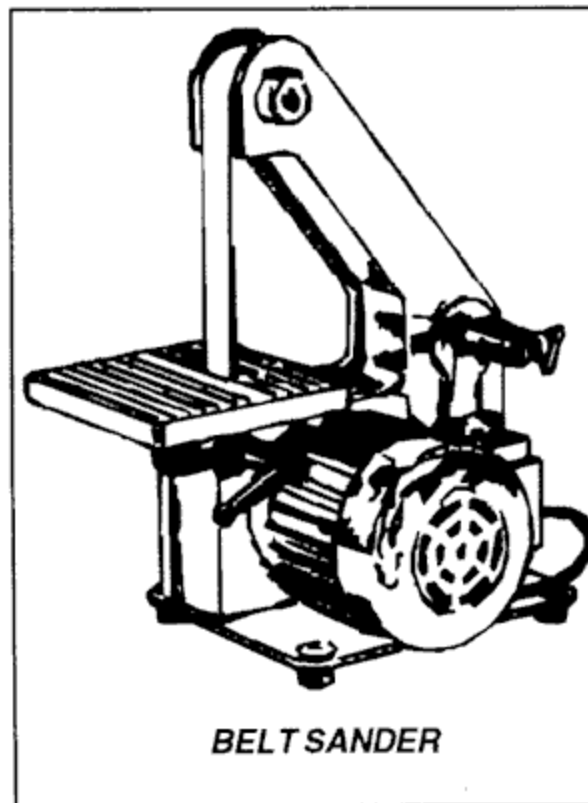
ADHESIVES:

GUNSMITHING AND TOOL MAKING BIBLE

Most widely accepted adhesives for fastening of abrasive grains to the surface of a polishing wheel are manufactured adhesives or cement compounds. They are replacing hide glues which, up to several years ago, were considered the ideal adhesives for preparing polishing wheels in all grit sizes. Polishing wheel cements are now formulated to give a wide range of viscosity's and flexibility, and can be used with a wide range of abrasives and grit sizes.

| BUFFING SPEEDS OF DIFFERENT MATERIALS | | | | | |
|---------------------------------------|--------|-----------|------------|--------|--------|
| | CARBON | STAINLESS | SOFT STEEL | STEEL | BRASS |
| Cutting down | 9,000 | 10,000 | 6-9000 | 6-9000 | 6-8000 |
| Color buffing | 7-9000 | 6-8000 | 6-8000 | 6-8000 | 6-7000 |

If hide glue is to be used, it should be a high-grade material selected for jelly strength, melting point, viscosity, and flexibility.



GUNSMITHING AND TOOL MAKING BIBLE

| BUFFING CALCULATOR | | | | | |
|-------------------------------------|--|------|------|------|------|
| R.P.M. of Arbor or spindle | DIAMETER OF BUFFING WHEEL IN INCHES | | | | |
| | 4 | 6 | 8 | 10 | 12 |
| 0800 | 837 | 1256 | 2094 | 2513 | 2932 |
| 0800 | 942 | 1413 | 1865 | 2356 | 2627 |
| 1000 | 1047 | 1570 | 2094 | 2616 | 3141 |
| 1100 | 1152 | 1727 | 2604 | 2880 | 3455 |
| 1200 | 1256 | 1864 | 2513 | 3142 | 3769 |
| 1300 | 1861 | 2042 | 2728 | 3404 | 4064 |
| 1400 | 1406 | 2199 | 2932 | 3666 | 4398 |
| 1500 | 1571 | 2356 | 3142 | 3927 | 4712 |
| 1600 | 1675 | 2513 | 3251 | 4189 | 5026 |
| 1700 | 1760 | 2670 | 3560 | 4451 | 5640 |
| 1800 | 1885 | 2227 | 3770 | 4713 | 5354 |
| 1900 | 1969 | 2964 | 3979 | 4075 | 5969 |
| 200 | 2094 | 3141 | 4189 | 5236 | 6283 |
| 2100 | 2199 | 3296 | 4396 | 5496 | 6597 |
| 2200 | 2304 | 3455 | 4606 | 5760 | 6911 |
| 2300 | 2406 | 3612 | 4617 | 6022 | 7225 |
| 2400 | 2513 | 3770 | 5027 | 6284 | 7540 |
| 2500 | 2618 | 3927 | 5236 | 6545 | 7854 |
| 2600 | 2722 | 4064 | 5445 | 6807 | 8165 |
| 2700 | 2827 | 4241 | 5655 | 7069 | 8482 |
| 2800 | 2932 | 4396 | 5864 | 7331 | 5796 |
| 2900 | 3037 | 4555 | 6074 | 7692 | 9110 |
| 3000 | 3141 | 4712 | 6283 | 7854 | 9425 |

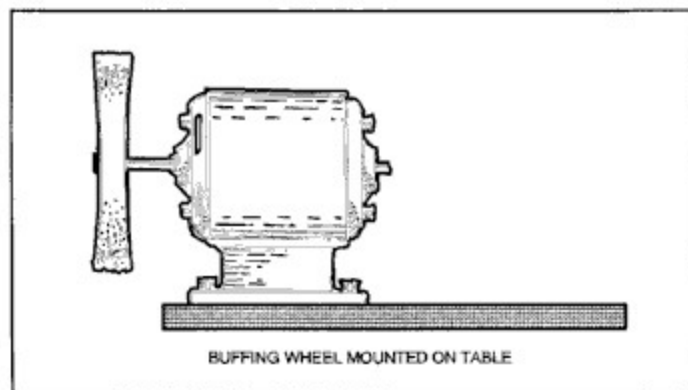
It should be free from excess bacteria content, which will decrease its strength. Melted glue should be made up only for the days needs and not in advance, to minimize the bacteria that will be picked up from the air.

GUNSMITHING AND TOOL MAKING BIBLE

Overheating and prolonged heating, even at low temperatures, quickly loses glue strength. It is advisable to have the glue pot thermostatically controlled to minimize the time that the glue is kept in the melted condition. At the end of the day the glue pot and brush should be sterilized so bacteria are not carried over to contaminate the next day's batch. The correct proportion of glue and water will vary with the strength of the dry glue and the size of the abrasive particles to be held. When the type of hide glue has been selected from a reputable supplier, exact proportions of glue and water should be decided upon for the size abrasive to be used. This proportion rigidly adhered to measuring the glue and water by weight rather than by guesswork.

The following condensed table gives approximate proportion, which will help in determining the final figures after the brand of glue has been selected.

When glue stirring is required, a preliminary coat should be applied by a bristle brush and allowed to dry before putting on the coating that is to hold the abrasive. New wheels should be rinsed on both the face and sides.



To prevent chilling the glue, the wheel and the abrasive should first be heated to approximately 1200° Fahrenheit. The coating for the first head should then be brushed on and the wheel immediately rolled in a trough of the proper abrasive.

After allowing to air dry well for one to two hours, the second coating if required is applied in a similar manner. In order not to contaminate the wheels with wild abrasive grains, separate brushes and separate glue pots should be provided for each size abrasive.

After the final coatings, the wheels are dried in a well-ventilated room at about 200(Fahrenheit, with a relative humidity of about 50%. Wheels should be dried for 24 hours for each abrasive head applied. After drying, the wheel is balanced and the surface broken up to provide resilience and free cutting by hitting with a round bar diagonally across the face of the wheel.

GRIT SIZES

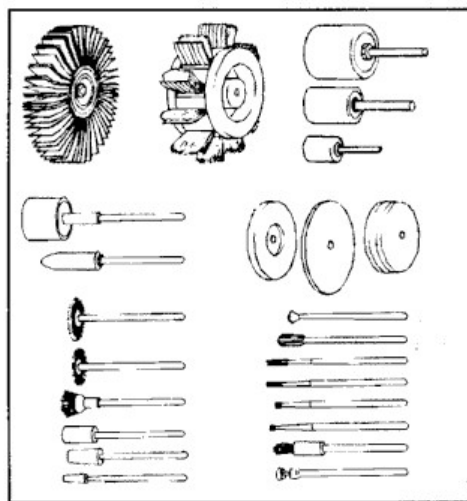
GRIT SIZE

% by weight

GUNSMITHING AND TOOL MAKING BIBLE

| OF ABRASIVE | Dry Glue |
|-------------|----------|
| #30 | 50 |
| #36 | 45 |
| #46 | 40 |
| #0 | 35 |
| #80 | 33 |
| #100 | 30 |
| #150 | 25 |
| #220 | 20 |

To prepare used polishing wheels for recoating; an abrasive stick is often used for reviving the old heads, which leaves the wheel trued up properly for reheading. Although the glue and abrasive can be removed by rotating the wheel on a pair of wet rolls, this method should be restricted to those wheels that will not be harmed by water soaking. If a polishing wheel lubricant is used, this grease must be removed before reheading and it is necessary in some cases to use organic solvents to effect this removal.



**DIFFERENT TYPES OF
POLISHING BUFFS**

Proprietary manufactured adhesives and cements, which have made great inroads in recent years into the field once held exclusively by polishing wheel glues, offer many distinct advantages. They can be

GUNSMITHING AND TOOL MAKING BIBLE

used at ordinary room temperature, as received from the manufacturer, thus eliminating special equipment, precautions, and preparations required for efficient use of hide glues.

LEA POLISHING COMPOUND

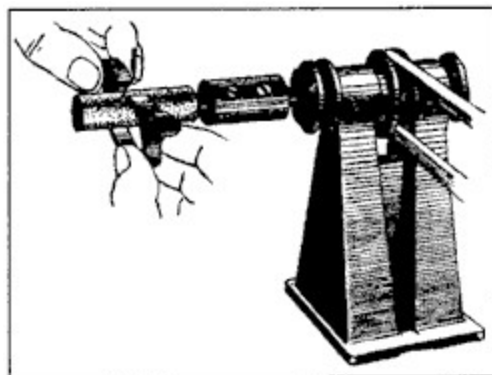
Some of the compositions used with these wheels are abrasive powders, Lea Polishing Compound, and, glue to bind the abrasive powder.

All polishing wheels, no matter what method of setup is used on them, should be broken up. This is done by striking a blow to the face of the wheel with a round bar at a 45° angle to the side of the wheel. By striking a blow every 1/2" completely around the periphery at this angle, and then by striking another blow every inch at 90 degrees to the first blow, a diamond pattern will be formed, which is the ideal pattern for good polishing.

Breaking up of a polishing wheel, after it has dried and just prior to its use, also serves to localize any tendency the bonded abrasive might have to rip off if a sharp corner of the piece being worked is thrust against it too quickly.

The cake lime, which comes molded in containers, is excellent for putting a high polish on rubber butt plates, fore-end caps, plastics, and non-ferrous metals.

Emery paste is used as a lubricant and cutting agent on wheels coated with abrasive. Emery paste comes in a molded paper container and is made in grit sizes from 90 to 180 inclusive.



**POLISHING TRIGGER
GUARDS**

Lea Compound, is one of the finest compounds that I have used. It is a greaseless composition that comes in a round solid bar about 10" long and 2" in diameter, and enclosed in a hermetically sealed metal foil container. In addition, although it comes in various grits and grades, the grade "C" (200 grit) is best for all around polishing on guns and gun parts.

Where applied to a revolving wheel, the frictional heat causes the compound to melt at the point of contact with the wheel and to transfer. It immediately sets up and dries on the wheel, forming a dry, grease-free, abrasive-coated wheel. After a gun has been Lea-buffed, it need not be cleaned with a

GUNSMITHING AND TOOL MAKING BIBLE

solvent, for Lea does not leave a greasy film on the metal surface. Another advantage of Lea Compound is the ease with which it cuts. With Lea, it is not necessary to apply much pressure to the work on the wheel. The artificial abrasives in it have sharp, fast cutting qualities and little or no lubrication to drag against the work.

Lea Compound can be used directly after the part to be blued has been deoxidized or, if deep pits are present, after they have been ground out by a canvas abrasive wheel. After the gunsmith has used Lea Compound, a few times he will no doubt appreciate what a useful addition it is to his polishing equipment.

In addition to its usefulness for pre-bluing work, it also does well as a deburring abrasive on small parts and springs that resist filing.

FOR MORE INFORMATION ON LEA COMPOUND CONTACT

Lea Mfg.

237 E Aurora St.

Waterbury, CT. 06720

The directions that come with Lea Compound must be followed to the letter, for when exposed to air it hardens to the point where it will not flow onto the buffing wheel. Here are the directions for using Lea Compound as recommended by the manufacturer:

USING LEA COMPOUND

1. Use a knife to cut the container close to the tapered end.
2. Remove the end.
3. Tear away a narrow strip of the container, exposing about 1/2" of Compound.
4. Do not remove entire container.
5. Hold the Compound against the revolving wheel until a uniform coating is produced.
6. Allow to dry a few seconds, after which polishing may be commenced.
7. Use mild pressure of gun parts against the wheel while polishing.
8. Place Humid cap over exposed end of the tube immediately after using. Never

GUNSMITHING AND TOOL MAKING BIBLE

leave the Compound exposed to the air, as it will become dry and hard.

9. On hot days place sealed bars in cold water for a few minutes before using.

10. In addition, store unopened bars of Compound in a cool place to prevent softening and deterioration.

Cement bonded wheels will withstand higher temperatures both in drying and use, can be dried more rapidly, and withstand the great frictional heat caused by high polishing speeds. Although most cements are formulated for fast, tough, coarse polishing, they have been used successfully for fine polishing.

More recently cements are being formulated which have some of the desired flexibility found in hide glues. As such cements and adhesives are, in the main, proprietary mixtures, it is best to follow the manufactures recommendation in each case rather than attempt to set general rules to cover all if them.

ABRASIVES:

The abrasive most widely used in polishing metals is fused aluminum oxide. The grain is normally heat treated to give it good capillarity and in addition many types are etched or coated to improve the adhesion to the bond used. Fused aluminum oxide is sharp, hard, fast cutting and long wearing.

Another abrasive used is silicon carbide, which fractures when dull to present new sharp cutting edges, and for this reason is selected in certain specialized operations. Silicon carbide grain, however, is more difficult to bond firmly to the wheel; its scope is limited. Before the advent of the electric furnace abrasives, Turkish emery, a natural compound of the iron oxides, was the standard polishing grain. The edges of Turkish emery tend to wear smooth without fracturing, and although this property decreases the spread of cut.

It is sometimes desirable for fine polishing operations, particularly in the cutlery field.

LUBRICATION:

Lubrication of the cutting face of a polishing wheel, with oil or grease, is desirable in a number of cases to prevent gouging when a fine polished surface is required. It is also used to minimize frictional heat when polishing some of the softer metals, particularly aluminum. The most popular method of lubricating is by a tallow grease mixture applied by friction from a bar to the rotating polishing wheel.

Special bar lubricants are now available, which have the unique feature of freeing abraded metals, particularly the softer nonferrous type, and prevent them from loading at the face of the polishing wheel. Where polishing wheels can be lubricated automatically, spray-able liquid lubricants are now available in formulations, which are easier to clean.

SPEEDS:

GUNSMITHING AND TOOL MAKING BIBLE

Speeds for the efficient operation of polishing wheels generally fall between the limits of 6,000 to 8,000 surface feet per minute when glue is the adhesive used. At higher speeds, because of overheating, the glue tends to break down although polishing wheels set up with cement can safely withstand this heat up to 9,000 surface feet per minute.

With too low a speed, the abrading operation is slowed down and, in addition, there is a tendency for the abrasive to be ripped out of the wheel. On certain metals susceptible to physical changes because of overheating, the ability of the adhesive to withstand heat is not the limiting factor but rather the heat tolerance of the metal.

POST WHEELS AND FLEXIBLE POLISHING:

In the polishing coatings, described above, dry abrasive grain is fastened onto the coating of adhesive covering the polishing medium. Although the adhesive covers the lower part of the individual abrasive particle to grip it properly, a large proportion of the area of this abrasive grain is exposed free and uncoated.

This open feature on the polishing face is highly desirable in many instances, particularly where fast cutting is desirable. However, in a number of fine polishing operations, it is more desirable to have a closed surface that is obtained by having intimate mixtures of the abrasive grain and the adhesive.

Paste wheels, where the melted glue is thoroughly mixed with abrasive and the mixture then troweled onto the face of the polishing wheel in multiple coatings. These have long been used in the cutlery industry particularly for double header polishing on steel knife blades. Silicate cements have also been mixed with abrasives for similar purposes. Special techniques have been developed so wheels of this type can be built up by frictional transfer of greaseless compound applied to the polishing wheel as it revolves on the spindle of the polishing arbor.

APPLYING THE ABRASIVE

Flexible polishing wheels of this type are headed up by the following procedure:

A glue-base sizing material in bar form is brought to the revolving wheel, pressure is applied, and the power is shut off. During deceleration the sizing coat is melted and flowed onto the surface of the wheel. The motor is then turned on and off to start drying at less than full speed. It is finally run at full speed for about two minutes or until the sizing coat is no longer sticky to the touch.

The bar of greaseless compound, also glue-base, is applied in the same manner with pressure when the power is shut off. During deceleration the heavy coating of greaseless compound is melted and transferred to the wheel with sufficient frictional heat, so the layer of greaseless compound is firmly bonded to the sizing coat.

This coating is dried in the same manner as mentioned for the sizing coat and for approximately the

GUNSMITHING AND TOOL MAKING BIBLE

same time.

A second coating of greaseless compound can be applied in like manner without additional sizing and in this manner, heads can be built up to 3/16" in thickness. In the formation of flexible polishing wheels of this type, it is essential that the stop and start technique be followed closely.

If the lathe were allowed to run at full speed and the compound applied at the necessary pressure, centrifugal force would throw most of the material off. During deceleration, however, the greaseless compound is flowed evenly onto the face of the wheel. With this procedure, true polishing wheels #80 grit and finer can be produced and reproduced, ready for use in less than ten minutes without the necessity of ever removing the wheel from the spindle.

By selecting the cloth polishing wheel of proper resiliency, flexible polishing wheels can be made up with greaseless compound that have many advantages over broken-down conventional polishing wheels which have long been used for certain fine polishing operations.

TYPES OF WHEELS TO USE

For removing pits-

Felt wheels or stitched buffs

For over-all polishing-

Loose muslin buffs

SIZE OF WHEELS TO USE

6" diameter at 3,450 r.p.m.

10" diameter at 1,750 r.p.m.

These wheels can be produced in the proper surface condition when wanted, rather than wait for preliminary polishing operations to break down the abrasive surface into the desired state. The technique in producing a flexible polishing wheel with greaseless compound is such that much softer cloth wheels can be employed than can be used by the conventional polishing wheel setup procedure.

Such wheels can call upon the resiliency of the cloth to cushion the cutting action of the abrasive grain, whereas with the conventional polishing wheel this effect can only be obtained by the use of excessive lubrication.

Advanced alkaline cleaning recommendations call for two complete cleaning cycles each with rinses and acid dips when greased wheels are used. One complete cleaning cycle is safely being eliminated in many shops when flexible polishing with greaseless compound is substituted for the final grease conventional polishing wheel procedure. Flexible polishing wheels operate most efficiently at 5,000 to 6,000 surface feet per minute.

GUNSMITHING AND TOOL MAKING BIBLE

BUFFING

Buffing, as the operation following polishing, can be divided into four operations, each of which can be an end in itself depending upon the finish required. These are Satin Finishing for producing satin, brushed or butler finishes, Cut down Buffing for producing a preliminary smoothness, Cut and Color buffing for producing an intermediate luster; and Color buffing for the production of a high gloss or mirror finish.

GRINDING AND POLISHING EQUIPMENT

Irrespective of what type bluing is used, the polishing and buffing remains essentially the same, for a bluing job can never look any better than the surface to which it is applied. In fact, the coloring of the metal has a tendency to show up in a more pronounced manner any scratches, waves or pits that are present on the metal's surface. A blemish-free surface must be produced before the gun or part is blued.

To achieve a good finish on metal, certain basic equipment and skill is necessary. Without the proper equipment, it is almost impossible to acquire the necessary skill, for skill comes from constant practice of the right kind with a good polishing head or polishing lathe and suitable wheels and polishing compounds.

POLISHING HEAD

A good polishing head can either be made or bought. In either case, it must meet certain basic specifications. In the first place, the shaft should be at least 1/2" in diameter and threaded for a length of 2 1/2" at each end. The shaft should be set in a heavy iron or steel unit equipped with roller bearings. Tapered roller bearings are the most economical and efficient, for a buffing motor.

The motor should be at least one-half horsepower and equipped with a two-place step cone pulley to match a similar pulley affixed to the shaft. The pulley should be placed in such a way as to achieve a 1 to 1 and 2 to 1 ratio, thus giving a shaft speed of approximately 1,750 and 3,500 r.p.m. When turned by a motor having a speed of 1,750 r.p.m. The low speed is for grinding operations and the high speed for buffing and polishing work. This provides an all-purpose setup suitable for all phases of gun work.

The shaft unit and motor must be bolted to a very sturdy and heavy stand, which in turn should be bolted to the floor. The height of the polishing head is important, which will have to be determined by the gunsmith, as all are the same height, nor do all choose to work at the same level. Generally ideal height, however, is when the shaft is at the same level as the operator's waistline.

A good arrangement for the motor switch is one so wired that it can be controlled either by hand or foot. This is especially handy when polishing rifle or shotgun barrels that require two hands to hold. In an emergency, the foot can be actuated to shut off the motor.

Metal guards placed around the ends of the shaft where the wheel rotates, and hooked up to a suction

GUNSMITHING AND TOOL MAKING BIBLE

blower arrangement. Exhaust blowers are good, because they prevent the abrasive and lint of the wheel from settling on tools and machines in the shop.

USING POLISHING WHEELS

The most important thing to remember when working with abrasive dressed wheels is that these wheels cut, and in cutting remove metal. Unlike hard-stone grinding wheels, the soft-back dressed wheels do not give off a great volume of sparks, which often fools the polisher into believing that practically no metal is being removed. Many a novice has almost ruin his first few guns to be blued by grinding hollows into the surface of a barrel thinking that there was metal being removed.

PRACTICING ON AN OLD GUN.

Unless the gunsmith has had some experience working with this type of wheel, it would be wise to do a bit of experimenting on an old gun. Select an old gun or receiver that is lying in the shop junk pile preferably one with deep pits and go to work on it. If the first job is a failure, then the gunsmith will not have to tell the customer why his favorite shotgun is not quite what it used to be. After grinding the old gun, polish it and blue it. Bluing, as mentioned earlier, will serve to show up any hollows, deep scratches, and round corners caused by the grinding and polishing operations.

A good ego deflator for self-satisfaction along these lines is to compare the finish on the experimental gun alongside of the finish on a high quality firearm. Note the sharp corners on a factory-finished weapon; also note that the flats are free of waves, ripples, and surface irregularities.

The beginner cannot expect to turn out as good a job as the experience polishers do but he can learn, and learning, as far as gun polishing and buffing is concerned, consists mainly of practice.

PRACTICING ON STEEL STOCK.

If you do have an old gun, the beginner can practice on a steel bar. The bar is a piece of flat cold rolled steel about 4" long, 2" wide and 1" thick and using various sizes and grits of dressed canvas wheels to grind the pieces. After they are ground to the satisfaction of the individual doing the job, the pieces should then be buffed, cleaned, and reblued. The same sort of exercise can be carried out on round, square, and octagon-shaped pieces until the beginner has gotten the feel of the wheels, so to speak.

When the gunsmith knows how each type canvas, felt, cloth, etc. of wheel will cut when dressed with any of the various abrasives, in different grades. He has pretty well mastered the basics of grinding or polishing, if you are using the very fine compounds with so-called dressed wheel.

CORRECT GRIT

Using too coarse a wheel to grind pits from a surface is poor practice because deep scratches are made which must in turn be obliterated by successively using finer grit wheels. On the other hand, using too fine a wheel makes for a slow job in which the metal gets very hot and breaks down the glue, which

GUNSMITHING AND TOOL MAKING BIBLE

tends to clog the normal space between the abrasive grains.

The gunsmith should remember to always use the widest wheel possible for the job being done. With a wide wheel, the chances of waves on a flat surface are greatly minimized and the job can be done faster.

Unless a barrel is badly pitted there is really no need to use anything except a muslin buff dressed with a fine grit abrasive. If the barrel is not pitted at all and there are no deep scratches or tool marks in it that must be removed. A buffing wheel headed with Lea compound will cut away all the metal that is necessary to produce a surface ready for high speed buffing.

While barrels can be ground lengthwise on a formed wheel, made by cutting a concave radius in a canvas wheel in the lathe, and then dressing it. I do not believe lengthwise grinding is necessary on anything but a set of double barrels or a single barrel that has a full-length rib on it.

Standard single barrels can be ground and polished around their periphery, and then given a high speed buffing in any direction that will eliminate the cross grain grinding marks.

Satin finishing operations are performed by greaseless compounds combining fast-cutting abrasives with a glue base binder. Numerous grades are available, employing abrasive from #50 and finer, for varying degrees of dullness of finish on all base metals and electro deposits. In the most popular all-around grades, artificial aluminum oxide and silicon carbide abrasives are used in grit sizes from #180 to #220. Silicon carbide grades are widely used for finishing aluminum and stainless steel and the aluminum oxide grades are favored for brass and other nonferrous metals, as well as for carbon steel prior to plating. For finer effects on brass and electro deposits, finer sizes of American emery and hard silica are employed.

For butler finishes on silver plate and sterling, fine buffing powders of unfused aluminum oxide and soft silica are used.

Bright butler finishes that challenge the luster produced by grease base coloring bars can be obtained on silver by extremely fine greaseless compositions made with a specially lubricated binder.

GREASELESS COMPOUNDS

Greaseless compounds are used at speeds of between 5,000 and 6,000 surface feet per minute. Higher speeds waste the composition without a proportionate increase in production rate.

Greaseless compositions do not penetrate the buff as does grease base compositions but lie on the surface, which favors buff life.

The buff should be allowed to run for 20 to 30 seconds after greaseless compound has been applied before the work is brought to the wheel, so there will be no back-transfer of compound. When used correctly the work will leave the greaseless compound wheel clean, dry and in proper condition for

GUNSMITHING AND TOOL MAKING BIBLE

inspection and finishing.

Certain metals, such as aluminum, are susceptible to dragging by dry abrading, but a light tip dressing of a low free-grease content buffing bar will sufficiently lubricate the surface and produce an even finish. In this case, care should be used so the lubricant does not penetrate the layer of greaseless compound and saturate the cloth, which will prevent the proper adhesion of subsequent additions of greaseless compound.

Binders for grease base buffing compositions are composed of fats and waxes of animal, vegetable, and mineral origin. Some of the more commonly used are stearic acid, hydrogenated fatty acids, tallow, hydrogenated glyceride, and petrolatum.

The fatty acids under conditions of buffing seem to have, in addition to their physical properties, a beneficial chemical effect in the formation of metallic stearates.

Cut-down buffing bars combine fast cutting buffing powders in a grease base binder formulated to give a great amount of grip to drag between the wheel and the metal surface. Powder to binder proportions varies with the type of work, the condition under which it must be done, and the oil absorption of the buffing powder.

Careful study of the individual buffing operation is necessary to decide on formulation. The metal being buffed in a cut-down operation determines which buffing powder to use. Cut down compositions for non-ferrous metals most frequently contain once ground Tripoli. It Performs very efficiently and is relatively inexpensive.

Cut-down buffing bars for carbon and stainless steels are generally based upon fused and unfused aluminum oxide. Such compositions are sometimes recommended for use on some of the aluminum alloys, particularly parts made by casting or extrusion. Under certain conditions, a cut-and-color buffing operation is used in place of the cut-down and the highest coloring operations. Since fast cut is not a prime requisite, the cut-and-color compound binder is of the same general type as above, but with less drag.

Moderately cutting abrasive powders are selected to give some brilliance with moderate cut, thus sacrificing both cutting and coloring properties to produce a general-purpose composition.

Cut-and-color compositions for nonferrous metals contain white silica powders, or a blend of these powders with Tripoli. Similar compositions for the ferrous metals contain coarse unfused aluminum oxide powders or a combination of fused and unfused aluminum oxide powders.

On certain nonferrous articles, cut-and-color buffing is done with a crocus bar containing a coarse graded iron oxide powder. Producing a color, luster, or mirror finish on metals requires the use of compositions composed of the finest abrasive powders so a minimum of scratches will show in the final finish.

Fast cutting is not required in such operations, and hinders are formulated primarily to hold the selected

GUNSMITHING AND TOOL MAKING BIBLE

abrasive powder to the wheel, allowing it to color or burnish out the scratch marks left by previous buffing operations.

Bars containing powdered lime as the abrasive are used for coloring nickel plate and, in some cases, for coloring brass. Compositions with fine unfused aluminum oxide powders are used in coloring stainless steel, nickel and chromium plate, and sometimes brass and aluminum.

However, brass and aluminum are generally colored with bars containing soft white silica powders in the finer sizes positions composed of the finest abrasive powders so a minimum of scratches will show in the final finish.

Fast cutting is not required in such operations, and binders are formulated primarily to hold the selected abrasive powder to the wheel, allowing it to color or burnish out the scratch marks left by previous buffing operations. Bars containing powdered lime as the abrasive are used for coloring nickel plate and, in some cases, for coloring brass.

Compositions with fine unfused aluminum oxide powders are used in coloring stainless steel, nickel and chromium plate, and sometimes brass and aluminum. However, brass and aluminum are generally colored with bars containing soft white silica powder in the finer sizes.

Fine chromium oxide powder is used in compositions for coloring stainless steel and chromium. Rouge compositions, containing the finest red iron oxide powders, are widely used in coloring gold and silver.

The fine red oxide powder has unique burnishing qualities to bring out the required high luster on the soft precious metals. Although the speeds for buffing with grease-bars will vary greatly from job-to-job and operator-to-operator, the following figures in surface feet per minute will serve as a starting point for hand buffing operations.

Buffing speeds may vary, as the contact of the work to the wheel can be more definitely fixed without depending upon the physical ability of the hand buffer to maintain the proper position and pressure.

FINISHING GUN STOCKS

By Harold Hoffman

The finishing of gun stocks whether it's a new stock or a old stock is not difficult. Very little equipment is needed to redo an old or new stock. If you're working with an old stock that has finished on it the old finish must first be removed. Usually this is done with sandpaper, and very seldom with a paint remover.

Before we do into the actual types of finish processes, I will go to the basics of refinishing a stock. Whether it is an old stock that has finish on it or a new stock the process will be the same.

1. If you have an old stock with a lacquer finish or some other type of thin finish you will need to remove this finish. You can use a varnish remover which will speed up the process of removing the old finish. A good paint or varnish remover will eliminate a lot of sanding if you try to remove it was sandpaper.
2. If the stock has a lot of nicks and dents in it, start with a medium grit flint or garnet paper. Go over the entire stock with medium grit until you have clean wood with no finish on it.
3. THIS IS VERY IMPORTANT -- when you sand up to a sharp edge such as the barrel channel, pistol grip, butt plate, or any other areas where there is a sharp edge, never let the sandpaper roll over that edge. If you do you will round off the sharp surface, which you need to retain. When you come to the sharp edge very carefully sand up to the very edge, but do not go over. I usually hold the sandpaper on my finger where I can't control it better. A sanding block might work out okay if you are careful. It would be wise to leave the butt plate, and pistol grip cap in place when you sand this area. This in the area where you will most likely round the edges, as well as the barrel channel.
4. After going over the complete stock with the medium grit paper, switch to a fine grit paper. Repeat the above process until you have the complete stock sanded.
5. Next, you want to take a damp rag and go over the complete stock, wetting to it thoroughly. The reason for this is to allow the grain to rise. Set the stock back and let it dry thoroughly. After it dries go over the complete stock again with fine sandpaper. If you have dents in the stock, see below information on how to remove these dents.
6. After the stock is thoroughly sanded with fine sandpaper you can now put a finish on it. The best finish that I have found in a oil finish is Tung oil. I have used Tung oil for many years, and had found that it is a very good finish that lasts good. I have guns that have been finish with Tung oil 40 years ago that still looks like new.
7. To use Tung oil you need to get some rubber gloves. The reason for this is that some individuals may be allergic to Tung oil. The way I apply Tung oil is to either use my fingers or a rag and rub the oil into the wood thoroughly. Do not take too much time doing this as the Tung oil will dry rather quickly and get sticky. As soon as you get the complete stock coated with Tung oil, let it set for a few minutes so the oil soak in. Then take a rag and wipe off all of the Tung oil. Set the stock back and let the oil dry thoroughly

GUNSMITHING AND TOOL MAKING BIBLE

before applying anymore. Repeat the above process five or six times to get a good finish. After the third application of Tung oil go over the complete stock with triple 0 steel wool. Polishes stock down good to remove all the surface oil. This will leave the oil in the grain of the wood.

8. Applied three or more coats of Tung oil, and steel wool lightly between applications. When you apply the final coats you'll get a light gloss finish that you can leave as is or polish with the triple 0 steel wool.

9. To finish off the stock I use a good taste floor wax that will protect the wood even further. About every year I apply another coat of wax. There are other finish that you can use that are described below. Use the above process from one to six to get the stock ready to finish. Then you can apply any type of finish that you like.

FLINT PAPER

Flint paper is the lowest price of all the sandpaper, but it loses its cutting qualities very quickly. However, for certain types of work like sand papering to remove an old finish, I would use Flint paper as it will do a good job. The reason for using Flint paper is that the old finish will clog the coating very quickly anyway. Therefore, the cheapest paper is the most economical. Flint paper are available as both cabinet papers and finishing papers. The cabinet papers range from very course to find. The finishing papers range from fine to extra fine. You will need mostly medium grit for removing the finish and fine for finishing out the stock. However, other grits may be used depending upon the type of standing being done

GARNET PAPERS

There are many decided advantages both in lasting qualities and in cutting qualities of garnet papers. Coated papers have gained much in popularity during the recent years. The garnet paper gets his name from the mineral that is use as a the abrasive coating. You can easily recognized in by its color, a tawny red cast. This mineral is noted for it's hard, sharp texture. It is one of the best available abrasive for fast cutting on either a raw wood surface or a finish surface.

Both cabinet papers and finishing papers are available with this mineral coating. The craftsman will find that the large choice in grit makes it suitable for any type of standing work. The grits range from No. 2 (very course) to No. 7/0 (very fine). This paper is durable, strong, and economical to use. If you have been accustomed to using Flint paper for all your standing, try garnet paper instead and you'll discover its advantages for yourself.

ALUMINUM OXIDE PAPER

Aluminum oxide paper is greatly replacing garnet paper heads and abrasive in wood finishing. This paper is coated electrically with a metallic oxide. It has a grayish color, and as a finishing paper, it is superior to the others because of its fast cutting action and long-lasting qualities. It can be used when standing July, barns, or other lacquer services. The grits or coarseness ranges from very fine (320A) to medium course (100). No. 200 is recommended for finishing standing.

GUNSMITHING AND TOOL MAKING BIBLE

WET-OR-DRY SILICONE CARBIDE PAPER

This is a synthetic abrasive new grains are very sharp and irregular, thus assuring a very fast cutting action. The grains are crystals are coated on the paper electrically, thereby making the abrasive waterproof. This is rather important from the finishers point of view, since he now has a paper that can be soaked in water before being used. Soaking the paper and water or in a solvent such as benzene makes it cuts quicker and easier. Silicone carbide paper is use essentially for fine standing. It is use where an extra fine smooth surface is required on raw wood or in sanding or rubbing the finish coats. The grains range from very fine (No. 400) to fine (No. 200).

HOW TO USE SANDPAPER

You will find after finishing wood for a while that there is an art in sanding. Although it is considered a very tedious job, it can be done whale and easily FAQs simple rules are followed. You must remember at the outset that assess of your finishing job whale began largely upon the care you exercise in sanding.

Tear a 9 by 11 inch sheet of sandpaper into quarters 4 1/2 by 5 and 1/2 inch sizes. This size makes the sandpaper easier to handle both when sanding with a block and when sanding with the palm of your hand. Limber up the sandpaper by rolling the paper side of the paper over the edge of your bench or chair. This step softens the paper, and makes it more pliable which helps prevent it from tearing when being used. When standing a flat surface, provide yourself with a block large enough to fit the palm of your hand. However, when finishing gun stocks there will be very few flat areas on the stock to sand. You can buy rubber standing locks at most hardware stores or Wal-Mart. The rubber sanding block has enough flexibility that it will better yet slightly curved areas of the stock.

FLAT SURFACES

Assuming that you have selected the correct paper for the sanding operation, you can now if start to sandpaper to surface in straight even strokes following the grains. You should never under any conditions sandpaper across the grains. Continue the operation using a medium grit until every trace of imperfection has been removed. When you come to the end of the wood be very careful that you don't let the sandpaper rollover and round the end of the wood. Occasionally check your sandpaper and block to make sure that no chips have embedded themselves in the paper or between the block and paper.

If any chips remaining, they will produce deep scratches on the surface as your sanding. From time to time for a the sandpaper best from the sandpaper by hitting the block against the edge of your bench, which you will find by doing is it will increase the cutting action of the sandpaper.

Turn the paper around the block from time to time to share or even wearing of the paper. Apply enough pressure to your block to obtain bid cutting, but never so much that assess the friction and he results. Avoid tearing the paper while sanding. This often happens when your sandpaper touches the sharp edges of your work. They slowly even stroke will prevent this unnecessary waste of paper.

CURVED SURFACES

GUNSMITHING AND TOOL MAKING BIBLE

You'll have to deal with this most of the time with gun stocks. When the irregular shapes or uneven surfaces are to be sanded, sanding procedure would differ somewhat. When special curved areas are involved shape the sandpaper so it matches the contour that you will be sanding. You can hold its shaped with your fingers and sandpaper the curved area being very careful, make sure that you do not alter the shape while your sanding.

REMOVING DENTS

On gun stocks you will have usually many dents as well as scratches. When you have to deal with the dents, and before the dents can be removed, the finish Overland must be removed. Care you will use a high-quality paint or varnish remover, scrape off much of the finish, white and sandpaper. In sanding down pass the dents will usually removed to much wood, so the dance must be raised until level with his surroundings surface of the stock.

A dent on the raw wood surface can usually be removed easily without having to scrape or sandpaper the area affected. Wood is composed of microscopic cells, and in a dent, the cells had been crushed out of shape. If the fibers of the wood and not been cut or damage, the problems is merely to restore the shape of these crushed cells. The process is very simple. You can do this by wetting the surface area with a few drops a water and in permitting this water to soak into the wood. As the wood this or the water, the sales expand and take their original shape. You now allow this area to dry thoroughly and in sandpaper with fine finishing paper to remove any unusual swelling left by the water.

Sometimes it's procedure would not produce the desired results, either because of the hard surface of the wood or the depths of the dent area in such cases place a few drops a water on the dent area then touch the water with the hot point of the knife or some other heated bar. This action will produce a small pocket of steam around the affected area. The moist, hot steam will penetrate the pores of the wood more readily and cause the affected cells to absorb this hot moisture and then expand. Repeat this operation several times until areas expanded sufficiently for you to sandpaper it flush to the adjacent area.

Sometimes even this does not work and it will then become necessary to fill a damage area with one of several types of fillers prepared for that purpose. In selecting the correct materials for filling holes, bruises and dents, you must use these that will adhere to the wood, and not shrank when dry as well as take stained well if he planned to apply a stained.

If the hole is to be filled, first clean out the gouge, removing all dirt and loose fibers. Next, collect a spoonful of sawdust from the stock you are working on and mix with epoxy glue until the mixture takes on the appearance of putty. Press the filler into the hole to overflowing. Be certain the mixture is pressed firmly to expel any air trapped in the dent, and add a little extra to allow for shrinkage.

Allow to dry, then sand the mound down even with the surface of the stock. The stock is ready to refinish. If the dent is deep, the hole will have to be patched. A common patch is a diamond patch of wood or plastic, which can be purchased from many gunsmith supply houses. Do not be concerned if the patch is not the same color as the wood of the stock. Contrasting colors add decoration to the stock. To insert the patch, lay it over the dent, mark the patch outline, and cut out the gouge to the shape of the diamond

GUNSMITHING AND TOOL MAKING BIBLE

about 1/8" deep. Clue in the diamond shaped patch with epoxy glue. After drying, sand the patch until it is even with the surface of the stock. There are several types of fillers that can be used to patch a stock, which are.

STEAMING OUT A DENT

A soft piece of flannel cloth also can be used to remove a dent by the steam method. The warming metal can be an electric soldering iron, or you can make a suitable substitute. One way is to put a handle on a 12" piece of 1/2" copper tubing. Drive the tubing up into a common handle, bend it slightly, and hammer the expected end until flat. In removing the dent, heat the electric soldering iron or metal rod until only slightly hot. The metal should be about as hot as a clothes iron, hot enough to iron clothes, but not so hot it will scorch them. The amount you warm the metal is extremely important, because you will scorch the wood of your stock if you get it too hot. You then wet the cotton flannel and lay it directly over the dent. Then touch the heated metal to the blotter or cloth at the point where the wood is dented.

The water will be turned to steam, which will penetrate the bent fibers of wood and will cause them to swell up. As they swell, they will return to their original shape, and the dent will be gone. If you can't remove it altogether the first time, repeat the process two or more times until the bent wood fibers are level with the rest of the wood. If the wood fibers are broken, they will not return to their original position, or if they do, they will look and feel rough because a clear abrasion remains. If this is the case, use the above method to patch it.

Make certain that every trace of excess putty is sanded off the surface, for traces of putty not essential will mar the surface not affected by the dents. Incidentally, this water putt, which has a light cream color when mixed with water, can be changed in shade by adding dry powdered colors to the mixture. These colors are available in many shades and can be gotten from your local paint dealer.

REFINISHING WITH LACQUER

Refinishing with lacquer is usually more difficult than varnish refinishing. Many inexpensive gun stocks are finished with sprayed on lacquer, which does not penetrate the wood and will chip and flake off in large chunks, leaving bare wood underneath.

Therefore, unless the lacquer needs only a little retouching, the total finish must be removed before the new one is applied. The steps in lacquer refinishing are.

1. Remove old finish with lacquer remover. Brush on, let soak, scrape off with a knife, wipe dry.
2. Sand entire wood surface, ending with #320 or #400 grit paper.

TYPES OF WOOD LACQUERS

The large variety of lacquers available makes it possible to perform practically any type of lacquer finishing. A description of each follows:

CLEAR GLOSS FURNITURE LACQUER

This is a transparent amber colored lacquer that dries hard with a very high gloss. It dries dust proof in a matter of minutes but should not be sanded for at least an hour after application. This lacquer, even if scratched or dented, will not chalk or scratch white. The lacquer will not be seriously damaged. The final coat may be rubbed with any of the common rubbing agents to a high gloss. It may be used successfully for any finishing job regardless of purpose. It may be used to finish all types of furniture, wood products, and surfaces that are subjected to moisture and heat. It is considered a general all round finishing material.

FURNITURE LACQUER SEALER

This is a special purpose lacquer that, because of its composition, is used exclusively for sealing the surface of the wood. It is not as clear and transparent as the clear lacquers, because of the solids added to it. However, when applied to the surface, it does not affect the color of the finish. It can be sanded smooth very easily, and the lacquer remaining seals the surface in preparation of the next operation. When several coats are sprayed on an open grain wood, the sealer acts as a filler and fills the open pores of the wood as well. Lacquer sealer should be applied to the surface after the stain or filler has dried. The succeeding coats of clear, glossy lacquer is applied directly over the sealer coat.

LACQUER THINNERS

Thinner is the liquid that dilutes the lacquer and makes it suitable for spraying or brushing. As has already been noted, these thinners are a combination of many chemicals. Each manufacturer of lacquer has his own peculiar formula for his thinners. So, best results are assured when the thinner used is made by the manufacturer of the lacquer. If another brand of thinner is used, it may not dilute the lacquer as required, with the consequent effect that the finish will not act properly on the surface. Good flowing, spreading, and covering qualities may be sacrificed when the correct thinners are not used. Lacquer thinner is water white in color, and it should be used to dilute whatever type of lacquer you may be using. Some lacquers, like sealers and undercoats, require more thinner than the transparent glossy or flat lacquers. Under normal conditions, about 30% of thinner should be added to a lacquer to get the correct spraying mixture. Of course, experience will dictate the correct proportion to

APPLYING LACQUER WITH A SPRAY GUN

The best lacquering results are gotten when the lacquer is sprayed to the surface. Primarily, lacquer is a spraying material. Its fast drying qualities make the sprayer indispensable for obtaining good results. Before the actual spraying technique is described, let us describe briefly the equipment and conditions necessary for adequate spraying.

A spraying outfit is an excellent piece of equipment to own, especially if you have the appropriate space and the appropriate ventilating system.

With either type of spraying, you can get pinholes by spraying too soon with the second coat, so the

previous coat is still emitting vapors. These cause, first, bubbles, then pinholes when the bubbles burst.

SAGS

Spraying too heavily causes sags and runs. You may be spared the vision of an entire finish softening and sliding off the wood because you sprayed too many coats too soon, and they softened and sagged at once.

BLEEDING

Rosewood, particularly, but also mahogany and some other woods contain pigments that are soluble in the solvents of lacquer. Also, some stains are softened and brought into solution by these solvents. To complicate things further, certain fillers and sealers are softened by lacquer.

These are the reasons you should always use a lacquer compatible system throughout. Commercial finishing involves lacquer base fillers and sealer. You cannot buy these materials at typical paint stores, however. So, the best practices involving easily procurable materials are as follows.

1. Use water or NGR stains. If you find it necessary to use a pigmented wiping stain, give it at least forty-eight hours to dry. Otherwise, the lacquer thinners may act in the manner of paint and varnish removers.
2. Give any standard paste filler forty-eight hours to set up hard, for the same reason.
3. A safeguard is the use of thinned shellac as a sealer after stains or filler or both.
4. Use a lacquer type sander sealer filler unless the wood is of such open grain that paste fillers are required.
5. Let everything dry thoroughly, before lacquering, especially any oil resin or petroleum derivative materials.
6. When you plan to use lacquer over rosewood or dark mahogany, use a thin shellac wash coat as a sealer and do not sand it. The shellac will seal the pigment, keeping it from bleeding, and you might cut through it if you sand, thus breaking the seal.

Lacquer rubs and buffs to a higher polish than you can get with varnish, which is one reason it is so often used for small, elegant projects that look best with a high finish. The good rubbing quality also accounts for speedy drying for the popularity of lacquer on most commercial furniture.

Whenever you want to keep the maximum natural wood color that is, without any of the darkening oil finishes produce don't forget that lacquer itself is the whitest and the least darkening of all. On top of that is the magical effect of lacquer lighteners, which leave the wood almost identical in color to its raw hue.

GUNSMITHING AND TOOL MAKING BIBLE

If the wood has an open grain, apply wood filler especially made for stocks and to go under lacquer. It is important that the correct type of filler be used. One made for varnish will be dissolved by lacquer. After filler is applied, repolish stock with very fine grit sandpaper.

In applying filler, rub it in both with and across the grain. Let it dry partially and continue rubbing until it takes on a light sheen. Apply more filler if necessary, to be certain all wood pores and cracks are filled. Wipe off excess only across the grain. If you wipe with the grain, you will remove the filler. Let dry thoroughly.

Apply a thin coating of lacquer especially made for gun stocks. A spray can or a paintbrush may be used. After drying, polish with #400 fine grit paper. Apply another coat of lacquer. Some workers prefer three or more coats, sanding in between.

Use your own judgment about the number of coats. Too many or too thick applications are likely to crack and peel, so be certain the coats are thin and well polished in between.

TIPS ON USING LACQUER

Since most people have had much more experience with varnish than with lacquer, the best way to explain the tricks of lacquer application is to contrast them with varnish.

1. Instead of laying the material on, then smoothing it, you should try to flow lacquer on in a good wet coat without too much brush back. Move fast, using long strokes. Keep a wet edge by working in small areas. Usually a relatively long and narrow area is easiest to handle. To keep the action fast, use a wider brush than you might like for varnish. Never apply lacquer with a tiny brush unless the project itself is tiny. Width rather than fullness is the mark of a good lacquer brush, which need not have bristles as long as are considered best for varnish.

2. Instead of using lacquer as thick as you can brush it comfortably, as you do with varnish, keep it thin enough to flow out well. This may mean some thinner, even in a material such as Satin lac, which is canned at a brushable consistency as it is. Be sure to buy a good thinner. There are many chemicals that will reduce the consistency of lacquer, but not all of them produce good results. Thin all coats, if necessary.

3. Sanding between coats is not necessary with lacquer to provide adhesion. Each coat tends to soften the preceding one minutely, bonding to it. Thus, scarifying for mechanical bond, as with varnish, doesn't help. However, you may want to scuff sand enough to knock off high spots and the few dust specks you'll you will be bound to get, even with lacquer.

If you are working toward a high rubbed finish, you will always sand to plane the surface, if application is rough. Do not use water on between coat sanding with lacquer. Be sure to give lacquer at least four hours to dry before sanding and re coating. Give the final coat overnight, before you do the last stages of rubbing with pumice.

GUNSMITHING AND TOOL MAKING BIBLE

When using lacquer, you may encounter any one of several difficulties, which can be handled if you know how.

THE PENETRATING RESIN FINISHES

These are manufactured by dozens of paint companies and sold at every paint store, have gained a place among the most popular clear finishes. There is a remarkable list of reasons why: They are by far the easiest of all finishes to apply.

They are among the most durable, so tough that they rank at the top in floor finishes. They have arrived with top designers in modern furniture; among them the more natural a wood can look the better.

They give the wood a fire and color unlike that produced by any other finish. Wood hues are intensified made more vivid, and there is no obscuring of the grain or wood texture. They are so foolproof and quick to use that they rank well at the top as finishes for large area surfaces such as wood paneling.

Penetrating resin finishes are like varnish, but instead of lying on the surface, they sink in. The resins harden between the fibers of the wood, in the air cells and other voids. When they are dry, the wood itself is measurably harder, and it is impervious to all ordinary damage. In a sense they impregnate the wood with a plastic like substance that turns the wood into plastic. However, there is no look of plastic.

WHERE TO USE PENETRATING FINISHES

Some penetrating resin finishes are intended primarily for floors, and these particularly rugged brands are superior for furniture, too. Penetrating resin finishes are not meant for outdoor use, but work fine for gun stocks.

HOW TO APPLY A PENETRATING FINISH

Flow penetrating resin on the wood thickly. Don't worry about fancy brush work. Many finishers don't even use a brush. They mop the material on with rags or pour it on, then spread it. You can even use your hands, if you want, rubbing the finish in as you spread it. Some experts use a pad of very fine steel wool to spread the puddles of finish and work it into the wood. This is one of the best techniques of all.

Keep the surface wet for about half an hour. Read the label, because some manufacturers ask for a full hour of penetration. If you see dull spots appear, indicating that all the material has soaked in, apply more to keep the surface wet.

After the wood has soaked up all the liquid it will take, use plenty of rags to wipe all the surface liquid off. Wipe it clean.

Do not leave a trace of the finish on the surface, for if you do, it will dry to an unpleasant sort of sheen. Should this happen and you catch it the next day, you can usually cut the dried material by brushing on

GUNSMITHING AND TOOL MAKING BIBLE

more finish, then wiping it in a few minutes.

The penetrating finish continues to soak in and permeate the pores and spaces in the wood after you wipe it. For that reason, a second application is usually a good idea, especially if the wood is porous. Do not wait until the first coat has dried and hardened completely.

Three hours or so is long enough to wait. Brush or swab on the second coat. Keep it wet for half an hour or longer and wipe it all off Again.

When this well wiped application is dry, the job is done. You can wax the wood if you want to, but this tends to clog the pores and steal some of the natural, textural beauty of the finish.

THE COLORS OF PENETRATING FINISHES

The natural look of the penetrating finishes is at its best on open pored woods such as oak, walnut, mahogany, pecan, chestnut, etc. It leaves their texture unfilled, and makes them look like wood. Maple, birch, cherry, and other close grained woods take the finish, of course, but are not so spectacular as the coarser textured species.

Darker colored walnut reaches its usual dark brown color. Rosewood's browns go almost black.

This degree of darkening is considered ideal for each species.

Stain is not usually required. If you want a penetrating finish that is lighter in color, use a wood bleach to lighten the natural color a shade or two. Of course, no filler is used with a penetrating resin finish.

Although the color given woods by a penetrating resin finish alone is usually appreciated by most people in the darker woods, you may want to stain some of the lighter species. If you use a pigmented wiping stain, then follow it with a penetrating finish. The finish will not change the color of the stained wood, other than to intensify it slightly. The reason for this is that most pigmented wiping stains are mixed in a vehicle that is much like a penetrating finish.

If you use water or a non-grain raising stain, however, you must expect a considerable intensification of the color, a shift in hue toward the reds, and some darkening.

HOW TO BUY PENETRATING FINISHES

There are two kinds, one is formulated on the phenolic resins, the other on alkyds. The phenolics tend to penetrate deeper. Look for the word penetrating and the word resin. Look for instructions that tell you to brush it on and wipe it off. Every major paint manufacturer has a penetrating resin finish.

There are materials that are similar in application based on oils, not resins. In situations where protection is not important, they can be used, although they offer no advantages in service or application

ease.

It is practically impervious to water and will stand much use, and even abuse, without cracking or peeling. It comes in either a high gloss or a soft or satin finish. It may be used as a wood sealer, and/or as a filler, or for the final finish as well.

No wood filler is required, since it is its own filler if several coats are applied, with excess rubbed and polished off between coats.

If the resin finish is to be used as a wood filler as well as a sealer, apply as above instructions. If you allow the resin to dry, it is so hard that subsequent coats will not stick to it. If you are using a final finish of something other than resin, allow the filler coat to dry a full 24 hours before polishing it back down to the base wood with steel wool. This should leave every wood pore filled completely so the regular, final finish can be applied.

APPLYING AN OIL FINISH TO THE STOCK

An oil finish is considered by many gun owners to be the most handsome of all, especially if the wood of the stock is especially fine. The reason an oil finish is not usually applied by commercial gun makers is that it is a time consuming process. However, the individual gun owner will get much pleasure out of refinishing his stock, and have a beautiful product as a result. While time consuming, the process is quite simple. The following suggestions should prove helpful.

Use a regular gun stock oil or Tung Oil rather than boiled linseed oil.

Linseed Oil, Trueoil, Tung Oil, and Genuine Oil are three of the better known brands. They are much easier and faster to use than linseed oil, and leave a handsome finish.

See Sanding stocks at the start of this article.

When the stock has been filled with oil, hang it outdoors in the sun and wind and let it dry completely. Apply a second and third heavy coat of oil, drying completely outdoors between coats. Allow the third coat to dry for a full twelve hours at least.

FINISHING THE STOCK

STEEL WOOL AND OIL - The steel wool pad is soaked with any light oil like machine or crude oil, and then used to rub the surface in the same manner as in the dry rubbing method. The surface must be dried clean of oil and grime after the rubbing operation has been completed. No other polishing device is necessary since the oil remaining on the surface serves as the polishing agent,

The width of the scratch produced by the abrasive determines the amount of luster resulting on the surface. Thus, if a series of very wide scratches is made on the surface, a very dull appearance will result, and if a series of very fine scratches is made, a gloss surface will result. No scratch at all should

GUNSMITHING AND TOOL MAKING BIBLE

produce a mirror like surface.

RUBBING TIPS AND SHORTCUTS

The fastest and easiest method of sanding the finish smooth is with No. 400 waterproof paper, such as Wet or Dry.

It is also the cheapest, despite the higher cost of the paper, since it doesn't clog when it is used with water, and it wears a long time.

The best sort of a block to use with wet sandpaper is rubber. Paint stores sell rubber blocks that are a nuisance to use. However, you can cut them down so they are a plain block of rubber, and they work well. Another way to get a rubber-sanding block is to use contact cement to fasten a piece of inner tube to a wooden block.

Sprinkle water on the surface and sand. Keep a piece of paper in saucer of water, so the backing will soften, and rotate the paper as its edges and backing dry. Many workers prefer to dip the paper in the saucer of water, letting it drain, thus washing the accumulation of varnish powder off the paper.

Now and then you hear recommendations to use soapy water, but this does no good, and actually slows the job down. Plain water gives you the fastest and cleanest cut.

Depending on how fine waterproof sandpaper you can buy, you may be able to do an entire rubbed finish without using pumice or rotten stone. The equivalent to rotten stone is crocus cloth.

CARVINGS.

Most finishers don't try to rub carved and coped surfaces as carefully as they do flat or mildly curved surfaces. For one thing, such a high finish is not necessary, because carved surfaces carry their own decorative weight.

Wet sandpaper, in fact any sandpaper is useless on carvings, although it can be used on some simple moldings. Try steel wool for early coats.

Then, toward the end of the finishing, use a small scrub brush to apply pumice and oil. Take special pains to clean the pumice out of small cracks and crevices. Any that you leave will dry white and give the carvings a scurvy look.

FINISHING THE OILED STOCK

Polish the stock with steel wool, rubbing until all the oil is removed and you are down to the bare wood again. The pores of the wood, however, remain completely filled with the surface smooth. If there are thin spots in the skin, repeat one or two more coats and cut the finish back to the wood again. Never start

GUNSMITHING AND TOOL MAKING BIBLE

the final finish until all the pores is filled.

Apply the final coat very lightly, using the fingertips, rubbing in and smoothing as you go along. To get a fine finish, smooth out each drop of oil over as broad a surface as possible. Rub each drop in completely until it starts to pull as you rub your finger over it. Cover each area of the stock turn, going on to the next without going back over a section already done. Make certain all the stock is covered completely.

Allow this coat to dry in the sun and wind. Apply a thin second coat as you did the first, and hang the stock up to dry again. Repeat this process until the stock takes on a sheen. Usually about five coats are required to get a good finish.

You might have to apply more coats on more porous woods.

If you prefer a high gloss, wipe the stock clean with a special stock rubbing compound, and apply one final coat of stock oil.

If you prefer a rubbed finish, rub the entire stock very lightly with pumice, rubbing just enough to remove some of the gloss but leaving a satin glow look to the finish.

Whether you prefer the high gloss or rubbed look, the final step is to wax the stock completely with good quality paste wax, rubbing until hard. I find that a good paste floor wax is hard to beat. Finish off by wiping with a soft flannel cloth.

ABRASIVES

Some of the abrasives we need are sandpaper, and steel wool. Sandpaper is a sheet abrasive and should include papers in grades from 1, 00, 220, 400, and 600. Steel wool to me is another very important to do for finishing. You should have steel wool in grades from 1, 00, and 0000. Also you in the masking tape and clean rags for cleaning up the finish.

SANDING THE WOOD

After you have applied the filler and sealer, the surface will be rough under your fingertips. The grain will have risen again and there will still be traces of the filler that you did not remove. When you sand, the sanding knocks down the high points of the range and smooth it out. If you are sanding by hand with a rubber or wooden block, start with 150-grade sandpaper. Remember, always sand with the grain, and never across it. After sanding thoroughly with the 150-grade sandpaper, switch to 280 or 300 grade paper and then go over the work again. After completing use a 400 or finer grade of wet or dry paper.

The final sanding must be done by hand. When you sand, wet the paper often to clear it. Have a bucket or container of water and get the paper in it before starting, then shake it once or twice and sand gently until the paper is almost dry then rinse the paper again and moved to a new area. After going over the complete surface, the surface will be as smooth as glass even before you have wipe it was a tack cloth.

GUNSMITHING AND TOOL MAKING BIBLE

Now that the surface is complete, the actual refinishing can start.

FILLING THE WOOD

If you decide that the wood need to be filled, now is the time to do it. Put some on a rag and rub it over the entire surface, spreading it and using a lot of pressure to force it into the pores of the wood. If you can get burlap this is a good cloth to use in applying the filler. The open mesh we will store as well as release the filler when it is rubbed across the surface.

Do not get into a hurry and apply the filler over too large and area at one time. It will dry before you can rub it in. The size of the area that you want to apply the wood filler should not be over eight or ten inch square area. After rubbing it in, wipe with a clean burlap, and then start on a new area. By applying it this way it will save you a lot of sanding later on. After completing the filling, you need to let the work stand for several hours, and better yet overnight, to allow the filler to dry. After drying, put on the sealer coat and let it dry an hour or so before starting the final sanding. Apply white shellac that is thinned with alcohol, and brush it on the filled surface. The sealer will sink deep into the raw wood and therefore cut down on a lot of sanding. If you plan on staining, it will allow the surface to except the staining more evenly.

GOUGES AND DENTS

If you make mistakes or the wood has dents or gouges and it is always better to pads these areas with real wood, then with wood putty. Be aware however that wood putty doesn't take stain as well as wood does. Wood putty is made with a wood flower, which is a very fine sawdust, and some type of finish that will cure and stick to the wood particles. You can make wood putty's from mixtures of sawdust and glue, usually quite glue or epoxy. Since neither of these finishes can absorb stain. It is impossible to make it would putty that will stain has naturally as wood.

The following wood putty is applied in a similar manner. Take a little of the putty out of the container with a putty knife or if the hole is small use a flat screwdriver. Now, we should press the down in the hole or the gouge, and smooth off the top by pulling the putty across the surface toward you. You want the putty to form a very slight mound so that it will leave the depression when it shrinks as it dries. On the depressions, it is best to apply several coats to build a putty level with the surface.

After the putty is thoroughly dry, sanded level with the surrounding wood. You can also get tinting colors, which is available that most paint or art supply stores. They are used to color any type of putty, commercial or homemade. You want to match the color of the wood after it is stained and finish. This may take some experimentation on scrap wood to arrive at this color while the putty is still damp, judge the color. When at this stage you will get a fairly good idea of how the putty will look after it is finishes. Be aware that the color of the stain or putty after it drives will not be accurate.

MAKING A GUNSTOCK

Years ago when I first start making stocks for rifles and shotguns we did have a choice of using blanks or semi inletted stocks. There were many stock making firms around such as Bishop, Fagen, and Herters even made stocks for quite a few years. None of the stock makers are now in business, as most stocks that you get nowadays are either plastic or some other type of plastic material.

If you want to make your own stock you will need a blank of hardwood to length that you'll need for your stock, and about three inches thick. After acquiring the necessary material the first thing is to make a profile stock blank. Take a piece of cardboard or thin plywood and make a template of the size that you want. You can get the pattern by laying a finished stock on a piece of plywood or cardboard and tracing it out leaving at least 1/32-inch oversize on all sides. When you mark out the pistol grip leave it a little sharper and deeper than the final proportions, for if you accidentally dent or chip the wood you will have a little extra to work with.

You will need to plane the blank or plank smooth on one side preferably is the right before you start profiling. You want to make as smooth as well as square although you do not need to get it totally smooth. This is why we want to leave at least 1/32-inch leeway around the actual stock profile.

After you have made the stock template carefully check all your dimensions to be sure they are right, then place it on your blank wood, so that you can take advantage of the grain structure and pattern as well as strain through the pistol grip, and the figure in the bus of the stock. Check both sides of the blank or plank for the grain pattern. Wetting down the wood with water will show you the pattern of the wood and where you want to put the template on it. With a carpenter's pencil draw around your pattern and then saw the blank out along the lines I would recommend a table saw for the straight up an advance saw for the curved or pistol grip's. If you don't have a table saw the band saw can be used for the whole job but it will not be as smooth as what is done with a table saw or straight blade.

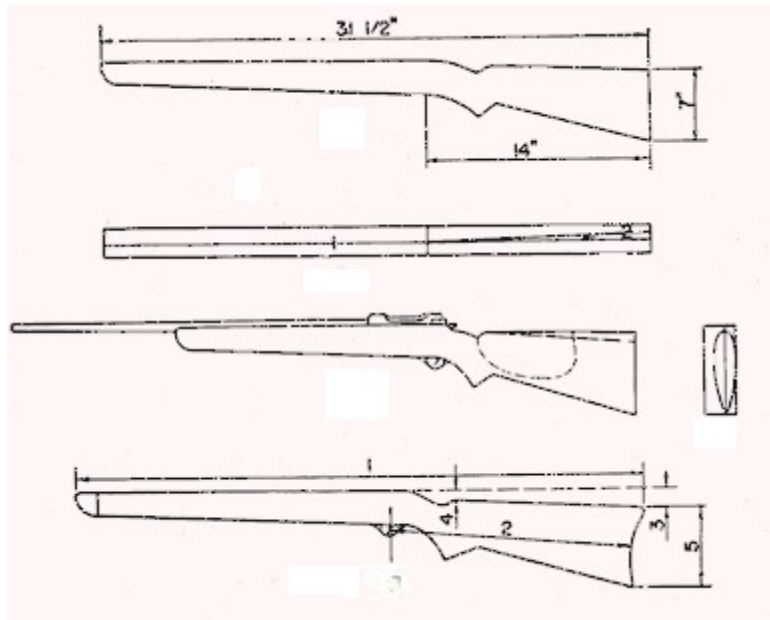
If you are making a plain straight stock, without a raised cheek piece or offset then the blank can be made from a two inch thick which will allow an outline of the cheek piece. Overall, I would suggest not having a blank less than 2 1/4 inches thick and not over 2 1/2 inches, as thicker blanks will mean more work shaping then down later.

LAYING OUT THE STOCK

Now you are ready to mark out the stock for the barrel and action. Mark a centerline for the barrel and action with a pencil on top of the profile blank, from the pistol grip to the end of the stock. Be sure to make this line parallel to the square side of the blank but not necessarily in the center of the blank. You can also check where the line will be by making a template out of cardboard to length and width of the receiver of a rifle that is being use, less the length of the tang by placing it on top of the blank you can then move it towards the left side and check the amount wood you must leave for the left side wall of the body of the stock. Then lay out your centerline for the barrel receiver using a small template. Make this line to the end of the forend. Make this line back over and around about stock, you can use a chalk line if you have everything lined up right before marking it. The next thing that you want to do is set your offset from your working centerline by measuring to the right of the line down across the end of the of the rifle

GUNSMITHING AND TOOL MAKING BIBLE

stock plank. You will find an offset of about $\frac{5}{16}$ inch is almost always possible and usually you can get more.



This offset or what they call were cast on in the case of the left-handed shooter is taken in the opposite direction and made the constant for left handed shooters, and I have found his most comfortable for the average shooter. When you have everything marked you now have a continuous line on which to base your layout for the leading of the stock. The first thing that you would do is established the location of the front guards grew whole which is easy because you can check the action against her stock profile template and then get a measurement from either the front for back of the blank. When you have the whole marked you can then drill the hole at right angles to the top of the blank in both directions. If you have it a drill press it would be the best way to drill the holes, but be sure to drill land that right angles to the top of the blank in both directions. If you have they angle vise and a drill press you can drill the holes almost perfect. Use a $\frac{9}{32}$ -inch drill bit if you are using a Mauser action or any other parallel guard action they can also be drilled at this time. Depending on the type of the action you will have to vary the size of your drill bit bus be sure the holder holes flow are located on the centerline of the blank.

When you have the holes drilled currently blank over and then let the rear guard first. You might need to make another template of the band thin metal or fiber so that you can have the outline of the rear guard and mark it on the stock in relation to your holes that you have drilled. After the template is cut out mark around it so you will have the size on the stock. In most trigger guards that have an integral magazine box on them, the first thing that you need to do is to outline the dimensions of the box on the bottom of the stock. This will be done on inside of the rearguard outline that you have drawn were traced on the wood. Next, you can then remove this would either with a chisel or drilling down the along the edges to remove the excessive wood. If you have it, you can use fairly small metal cutting bits in your drill press to drill out the magazine opening following the outline of the box closely to leave a minimum of chiseling and filing to shape it up the.

If you use the above the wood should come out after cutting in a block, and all you need to do is to smooth it up with a chisel and rough files enough to admit the magazine box hallway. I always have a

GUNSMITHING AND TOOL MAKING BIBLE

little space around the magazine box and bearing points on the wood at all points. If you are in making this stock for a rifle with a heavy recoil the rear of the magazine box can be fitted closely to bear against the wood, however be sure to leave a least 1/32-inch clearance at the corners of the box on all sides. You'll find that rasps and files do both of the work in inletting the box as well as other parts of the stock. After you have everything shaped, and magazine box will drop in place with the guard setting against the bottom of the stock, then check its outline against the outline you have drawn with the template. Now, check the guards screws holes to be sure that it lined up with a hole in the blank of the stock.

Now you would need flat chisels to cut the outline across the parks at the end and also at the corners of the magazine. Remove the wood to the depth of about 3/16 inch, and then use the curve chisel to cut and finish the full outline for the magazine. After you get the wood inletted you can apply wipe on a little oil to the bottom of the magazine and press into the place. This oil will show you by leaving a mark on the wood what you do have to remove. This also applies to all of the rest of the inletting of the barrel and action. Without this oil that is wiped on it would be extremely difficult to know where to remove wood and were not to remove wood.

INLETING THE RECEIVER

When you get ready to inlet the receiver you'll need to headless crews that can be threaded into the guards screws tapped holes. I have found that the screws need not be much over three inches long, and you can either make the screws or by them from any gunsmith supply house. The inletting of the receiver and barrel is basically the same as the inletting of the trigger guards. With the screws in place you can then mark out on the wood where you will need to remove the wood for the receiver and barrel. After you have remove the wood for your receiver part of the inletting the receiver should then now drop into the stock of approximately 5/16 of an inch. Once the receiver drops into place you can then draw the outline of the barrel channel canting the pencil inward while drawing it alongside of the barrel to ensure a smaller than the normal dimensions of the barrel.

INLETING THE BARREL

As you start inletting the barrel it will be necessary to keep cutting this channel deeper as the receiver sinks into the blank, but however make sure to keep the receiver going straight down. You will have to continue cleaning out the wood for your receiver as the barrels go deeper into the stock. Most of the work in inletting will be done with only straight chisels, however the barrel channel is finished with a round rasp or curve chisel.

After you have the barrel and receiver inletted to almost correct depth you'll need to get a barrel inletting rasps or scraper to smooth out the chisel marks that you have made in the wood and to make the channel perfectly round. Remember to wide oil on the receiver and barrel as you inlet so you know where the wood will be touching and has to be removed. Always work with the grain if you can however you may have to change directions sometimes every few inches as a grain changes in directions. When you have inletted the barrel and receiver, and the rear tang is almost below the surface of the wood, and barrel touching edges of channel so you can get a short rest now has the easy work is about over.

FINISHING THE RECEIVER AND BARREL

Now, wipe off all of the sawdust from the receiver and barrel and then wipe on a thin film of oil over the entire surface. Place the barrel action carefully into the stock and tapping it lightly on the receiver so that it will leave a mark on the wood where you'll have to remove a little extra wood. Now remove the barrel action and the coated steel has marked the wood you then use the chisels to clear the wood away with very light shavings. The recoil shoulder has probably already bottomed out on the receiver and the stock and has a slight recess cut for it. The recoil shoulder has to be fitted very closely or the stock may split. Anytime when the stock is fitted closely it is usually finished up with a glass-bedding compound. Glass bedding will give you a perfect fit of the action and barrel.

IMPORTANT--if you are going to glass bed the barrel action to the stock be sure to have everything coated with the release agent that comes with the glass-bedding compound. If you leave one part of the receiver uncoated you may possibly glue the action into the stock. If that happens it is almost impossible to remove the action without destroying the stock.

The instructions for glass bedding will be in the box. Follow it word for word.

This completes the inletting of the stock. The outside shape of the stock is removed mostly with wood rasps both fine and coarse. This takes quite a bit of time to shape up the outside of the stock the way you want it. Don't get in a hurry, take your time.

FITTING RECOIL PADS

In the gun shop one of the most common stock alterations is adding a recoil pad to a shotgun or high-power rifle. In most cases, very few gunsmiths turned out a good-looking job. When a gun owner brings in a good-looking weapon to have a recoil pads installed, he expects that installing the recoil pad should not mar the general appearance of his gun. In all the fitting of a recoil pad, they should fit flush against the butt of the stock at all contacting points. They should blend in with general lines of the stock itself, and above all the old finish should not be damaged while installing the pad.

SELECTING THE PROPER RECOIL PAD

When the customer brings in a gun to have a recoil pad installed, the gunsmiths should first find out from the customer just what make of pad he would like to have installed. In most cases, the shooter does have a definite preference as to what make of pad they want and it is advisable to satisfy him in using the pad of his choice. Sometimes, the customer brings in a particular recoil pad to be fitted, but before he leaves, make certain that the recoil pad is large enough, both in length and width to fit the gun.

When you buy a recoil pad, there will be three sizes, which are small, medium, and large. The pad that you select should conform has nearly to the finish butt size as possible. By selecting the pad that will fit closely to the butt of the stock, a good deal of unnecessary cutting of the pad will save much time.

THE STOCK LENGTH

Once you have selected the correct size of the recoil pad, find out from the customer the length of the stock that he wants to end up with on his gun. Find out if the stock as it is now is too short or too long for the tide of shooting that he does. If the stock is too long now, then a 1/4 of an inch may have to be removed from the stock to bring it down to proper size after the recoil pad is mounted. If it is too short, all that needs to be done is too square up the end of the stock before adding a recoil pad.

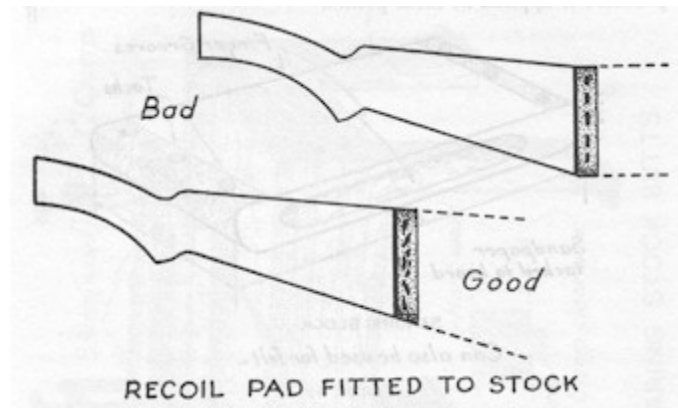
Two major up the stock carefully measure from front to back of the recoat pad (at its middles section) and marked this distance calls from the end of the butt plate on both sides of the stock. You also need to measure the distance from the trigger to the butt stock toe, as this must be taken into account for the proper pitch to be achieved.

After the centerline and pitch-line distances have been taken and marked off, a line should be scribed around the stock to show where the sawing off of the stock is to be done. By doing this, the original pitch and general measurements of the stock will be the same after the recoil pad is on the gun.

PITCH

The pitch is important stance it can affect the shooting qualities of a gun. Pay individual who is the custom to one particular pitch on his shotgun may find that the shotgun shoots different after the recoil pad is put on. Therefore, it is wise to not change the pitch of the stock very much.

GUNSMITHING AND TOOL MAKING BIBLE



Another problem that you will face is that the rubber butt plates on many models of shotgun are curved out at the butt toe and may be very helpful to some shooters. Where we run into a problem is the back of most recoil pads are absolutely flat, and the stock in to which they are fitted to must also be flat. On these types of stocks, quite a bit of wood is removed and the pitch is altered. So now being the pitch distance is different this should be taken into account before any cutting or shaping is done.

Sometimes a customer might desire to have the pitch change has been made toward improving his shooting. If this is so, the gunsmiths should bear in mind that the greater the pitch, the greater the tendency to under shoot. If a gun has little or no pitch, this will cause a gun to overshoot.

SAWING OFF THE STOCK BUTT

When sawing off the butt of the stock, always use a very narrow bladed hacksaw and always keep at least 1/16 of an inch to the butt side of the line. The reason for this is if the wood chips, which usually occurs, it will not affect the finish on the remaining portion of the stock. Use a hacksaw or saw blade having about fourteen teeth per inch. However using a hacksaw will produce an uneven face on the wood, which will require a lot of flattening out. A better choice to cut off the stock is to use a wide set crosscut handsaw, which will give you a straight cut. The trouble in using the common and crosscut saw blade is that it often causes a long splinter to rip off. When this happens, the entire stock must be refinished.

After all of my years in Gunsmithing and mounting recoil pads I believe the best set up for sawing off a piece of finish gun stock is a miter box and backsaw. The reason for this is that the fine pitch of the teeth on a backsaw gives less chance of wood splintering and the guide in a miter box keeps the saw in line. The big problem is that the gunstock is not flat, and not parallel to the miter box base. To use a miter box it is necessary to build up under the narrow end of the stock so that the saw will cut at 90 degrees to the end throughout the entire width of the butt stock.

I find that this method is very desirable when a gunsmith does a great deal of work on may already finish stock. You might even be able to mount some type of adjusting screw to the miter box to elevate the narrow end of the gun stock to obtain a 90 degree saw cut. It made properly a gunstock of any size or shape could be easily set up for cutting off.

FINISHING OUT THE SAWED OFF BUTT STOCK

When you have finished sawing off the butt stock it will be necessary to sand the butt end of the stock after sawing, and before installing the recoil pad. You have to make sure that the recoil pad will fit perfectly true so that there is no space or uneven in line between the wood and the pad. You can mount a piece of sandpaper on a flat woodblock, but you have to be especially careful that the block does not rollover on each end of the stock. You can place the stock vertically between the padded jaws of a vise. Then, true the butt end with one thickness of sandpaper tacked to a flat board. I usually use a piece of hardwood about eight inches long and two inches wide for sanding the butt. You can attach the abrasive paper with contact cement to hold it in place. You had to be especially careful to be sure you do not round off the tow and heel of the butt during the smoothing up operations.

CUTTING THE RECOIL PAD TO THE PROPER SIZE

When you have selected the proper size of the recoil pad, place it against the butt stock with the heel of the pad as near as possible in line with the heel of the butt stock, and be careful that the entire pad is centered on the gunstock. When you have the pad centered, punch a center mark through the top screw hole where a hole is drilled to take a screw. Now take a screw, lubricate it with a fine oil, and tighten it in place. Now with the pad partly in place, get a sharp scribe to mark the butt stock outlined on the hard rubber portion of the recoil pad. When that is done unscrew the pad from the stock and with a belt sander or some other type of grinder, grind all of the excess material from the pad. Be extra careful to shape the toe of the pad at an angle that will blend in with the stock lines when the pad is mounted in place.

After you have finished grinding the pad down to the scribe line, screw the pad to the stock and realign it into the proper position. At this point, the toe hole should be drilled into the stock and a screw tightened in place. Sometimes it is necessary to scribe a new line on the recoil pad since the earlier mark that you had scribed onto the pad will be slightly off when you have screwed in the second screw. You must be careful here and exert a little extra care in grinding since the position on the stock is now determined and you probably will not have very little room for correcting mistakes.

FINAL SHAPING OF THE PAD

After you have the pad screwed in place, I usually apply a strip of masking tape around the stock next to the recoil pad. What this does it is to keep you from making a mistake and put sanding marks on the finish of the stock. Use finer grit of sandpaper when you sand down the pad to the masking tape. Go around the butt plate with the sandpaper of about 120 grit. Keep sanding until you are just touching the masking tape. If you are careful, you can use a sanding desk in a drill or a drill press. Take the pad down until it is flushed with the masking tape. What ever you do, never shape the recoil pad while it is on the stock to finish it. There are very few, if any gunsmiths who can grind a recoil pad down while it is attached to the stock without scratching or marring the stock in some way.

A scratch stock is certainly no indication of the gunsmith's skill. After you have the recoil pad finished, rub a bit of linseed oil over the butt end before finally putting on the recoil pad. This will darken the edges of the wood slightly to help match the butt plate. Never use any type of glue to help fasten the butt

plate to the stock.

FIRST AID FOR WOOD

Many times finished wood that has simply been neglected or has been in storage will take on a drab, unattractive look that seems to indicate a need for refinishing. Sometimes the furniture has been exposed to a damp, humid atmosphere and it may have acquired light-colored streaks. Extremely hot, dry atmosphere, or exposed to heat from a nearby stove or fireplace, and even direct sunlight. The finish may have formed checks to give the pedals affect. The table or desk surfaces may have suffered from the stains and even have a white ring from a hot coffee mug or a glass of tea has rested.

Many times these conditions can be cured rather quickly, without either spot or partial refinishing. When you use a quick cure and it doesn't work, you will have to go to the full refinishing of the surface. Give the fast cure a try first. A piece of furniture that has cumulative several layers of dust and grime from setting in the background can sometimes be revived just by a good washing. To do this, use a soft rag and warm water in which a teaspoon of shavings from a mild bar of soap that has been dissolved. Do not use a detergent.

Get a soft rag and dip it in the soapy water, wring it out lightly, just enough to keep it from dripping. Now with gentle pressure, wash the piece, and dry at once. Look at it closely and if it is not cleaned up like you want you may need to rewash to remove all the dirt. If it is OK, then apply some good furniture wax and rubbed well.

Sometimes you may find a finish that has deeply embedded layers of dirt, along with different types of stains. To try to clean this up substitute medicinal soft so, USP XVI, for the toilet so. This medicinal soap is usually called "green soap." If you do not know what this is, it is what doctor's use when scrubbing for an operation. You can find it and most drugstores. To use it, soak a soft, lintless, clean cloth in lukewarm water, and wring it out gently. Put a teaspoonful of the soap on the cloth and fold it into a hand size pad. Next, wash the furniture with a rotating motion until it is covered with lather. Now take a clean cloth, and dip it into warm water. Wring gently, and wash off the lather, and then dry with a fresh cloth. If it looks OK, apply a good coat of furniture wax and work it into the grain of the wood.

Now, we are getting desperate, so next heat a quart of water in an old double boiler. The water must be quite hot, do not boil. Add a tablespoon of turpentine and two tablespoons of linseed oil to the water and stir well. Whatever you do, don't put the pan containing this mixture over a direct heat as it may ignite. If you don't have the double boiler, you can use an old saucepan inside a larger pan that is filled to within two inches of the rim. Next, you need to dip a clean cloth into the lukewarm mixture and wring it out to where it's almost dry. Now, wash with the grain of the wood, and when through dry at once by rubbing the wood with a clean, dry, lintless rag. If it looks OK, wax it was a good furniture wax.

Warning. Any of the foregoing methods used on a veneered piece, use only lukewarm water, and wring the washing clothe almost dry. Too much moisture and heat will probably cause the veneer to the lift. Work very fast in removing the wash water.

FADING

You probably know by now that finishes of every type may fade with age. They may also become cloudy or milky and have streaks or spots. You can frequently revive them. On varnish surfaces that have faded or has streaks, use raw linseed oil and turpentine in equal parts. Rub this mixture on with a cloth or a pad of 0000 steel wool. After doing this, apply a coat a thin varnish after wiping the surface dry.

Lacquered that has a fogged surface can sometimes be cured by rubbing with a polish cloth that is it into a mixture made by adding two tablespoons of white vinegar to a quart of water. Then dry and then apply a fresh coat of thin lacquer.

If you have a white ring or spots there are several mixtures, which can be used to remove them. All of them all work some of the time, however, none of them or work all the time. I would suggest starting with the mildest treatment and worked up to the toughest, and hope that you will find something that will work to remove the spots. To try to remove the spots begin with a teaspoonful of butter and a tablespoon full of cigar or cigarette ashes, never pipe ashes. Pipe ashes contain coarse dottle. Mix the butter in ashes together and rub the mixture over the spots or ring with a soft cloth always rubbed with the grain of the wood not round and round the ring. Tobacco ashes are an abrasive even milder than rotten stone, and the butter is a better lubricant for them than oil or wax.

After you clean and wiped the finish and a butter/ashes mixture fails to remove the wring, moved up the abrasive scale to rotten stone lubricated with light oil. The best oil that I have found is sewing machine oil or automotive break-in oil. Do not follow the pattern of the stain or rings when you rub, always work with the grain of the wood.

If the above did not get results, we will get tough. Try a paste of F F F-grade pumas stone and raw linseed oil. Use the same procedure above on the rubbing style using abrasive mixtures. Using this paste, you can't keep track of the progress you're making unless you clean the surface every now and then. For cleaning, wipe away the paste with a cloth dampened with a few drops of turpentine.

If you find that none of the above mixtures work to get the rings, etc., you'll have to strip the surface and refinish it. If any of the above processes were successful, clean the refreshed surface with a turpentine-dampen rag; follow up by wiping with a dry rag, and repolish.

If you have white marks on a varnish surface it will sometimes yield to a rag moistened with lemon oil or spirits of camphor. After the spots has been removed, wipe with a soapy cloth, then wipe with a cloth that is soaked in plain water, and follow up with a dry cloth before repolish.

Stains caused by the ink scales, a magic marker is, and similar dye loaded liquids are usually not removable. Some of the dyes found today strike to the finish and into the wood, and the only way to remove them is the strip, bleach, and refinish.

If you have a wood finish that is alligatorered, or even the entire surface that has gotten pebble- rough through aging or exposure to heat, they may also require stripping and refinishing. It might be worth a try

GUNSMITHING AND TOOL MAKING BIBLE

to cure this condition by wiping very slowly, with a cloth saturated with acetone or methyl alcohol along with a bit of linseed oil or Tung oil. Wipe very gently following the wood grain. Do not wipe the wood surface, let the surface dry naturally, and when its dry wipe it with a soapy cloth followed by a cloth dampened in clear water. Rub dry before flowing on a thin coat a varnish. Refinish the wood if this doesn't remove the alligating. Stripping and refinishing is the only answer.

STRIPPING WOOD

Sometimes, when everything else fails you will be faced with the job of stripping and refinishing. The piece that you want to strip, take outdoors, or if you want to work inside, opened all the windows, doors, in your workroom. Next, spread a drop cloth or a thick layer of old newspapers on the floor, and get ready for two or three days of work.

When you get ready to strip a piece, try to arrange your works set up so that you can turn the piece you're working on so to be able to apply the remover to horizontal surfaces. When you start to strip you should finish using the remover on one surface before turning the piece and starting with another. Always protect the already striped surfaces with a few sheets of newspaper held in place with masking tape, if you don't and the remover trickles or splashes onto their wood it can call is additional stains.

More than likely you will have to do the legs of chairs and tables with the work in a vertical position. If the legs have rounds or turned areas on them, work on the first. Always use paper held with masking tape to protect the areas below where you're working from any trickles. Use one of the sponge-rubber spreaders to spread and even coat of remover on the surface. Now let it stand for a while. Don't try to scrape as soon as your finish spreading the remover on. Most removers need at least ten minutes to penetrate and lift the old finish and others may need at two or three times that long. You can watch the spread surface, and if you see spots beginning to dry out, then apply a bit of fresh remover over the use. After the old finish begins to break up and swell, bubbling up like mud in a swamp, start scraping with your wooden paddle.

Treat it like you would pay small shovel, and make long passes over the surface to let off the sludge the remover has formed. You need to have an empty container handy in which to drop the goo mess that you pick the. Tap the paddle on its edge of the container to get it to drop off, and then wipe the scraper clean before beginning a fresh tasks. Strip the surface that you have covered with remover, then go back to the first surface you worked on an apply more remover to spots that didn't come clean when you scrape them the first time. Always keep in mind to keep the remover off bare wood to avoid stains. After applying the remover a second time the finish will give way in a few minutes. Do this with each surface. You will find there will be areas where the old finish has penetrated the wood so deeply that the remover won't let it.

If after applying to applications of remover and you find that it won't clean these areas, you can assume that anymore won't do it either.

On the spots they will have to be scraped, the before you scrape, make sure and washed all the area

GUNSMITHING AND TOOL MAKING BIBLE

where remover has been use so it will be neutralize and prevent any additional staining.

To make a neutralizer you have 8 oz. of trisodium phosphate, which is often called TSP in two quarts of very hot water. Now, add four ounces of laundry detergent such as Oxydol, Dash, or Cheer. Cool the solution by adding three quarts of cold water. Set this solution back and do not work within until it's completely cool. If you use any warm liquids where the surface has just been gone over with a paint or varnish remover, it will cause the already softened wood grain to rise and feather. This will give you real problems when you begin to smooth it for the final finish.

Rinse the surface with a neutralizer, and then rinse again. Use clean water supply with a cloth that is barely moist. Next, wipe the surface that once with a dry clothe and is back for two or three hours to let the wood dry. The wood is wet for a fraction of an inch below the surface, and now you can set up another piece to strip. It is best to let the piece dry overnight to be sure that it is completely dry.

Now you will need to scrape the wood. Use a cabinet scraper, which is a tool that is used by most professionals. This is a handy tool and its own way will do most of the work for you. Use very little pressure on hard dry woods as too much pressure will cause the Cabinet scraper to skid and there will be led a series of smalls parallel scratches that you will have a hard time to remove. Always use the scraper with the grain of the wood, and never against or across the grain. Use it with a straight long smooth strokes until you've gone over the entire surface. You need to remember why you're doing is a really scraping, but shaving. The scraper will remove the patches of fuzz on the surface of the wood.

You might encounter long stubborn streaks, and if you do switch from a straight scraper to one with a curved edge. If you're working on a curved surface such as at the see of a wooden chair, use a strong neck scraper to make the job go faster. Turn this scraper to write angles, and you can match almost any inside curved on a piece of furniture. On molding lines, grooves, turnings, and carvings, one of the little nooker's described is invaluable. You can get into some of these quite well with the Merit flex-0-sand tool used in your electric drill. I would avoid using the tool on intricate carvings has any sanding done on a carving is going to remove some of the surface as it gets into the nicks and cranny.

As you work, wipe away the scrape-off grit occasionally, for it will contain small glass-like needle-sharp bits of old varnish or lacquer that had escaped the remover and is practically invisible. Also if you do not wipe them off they will put small lines on the surface that you might not notice into you begin to apply the stains or varnish? Be careful and watch for what woodworkers call "crazy grain", which are little flaws in the wood, which are nobody's fault. They are caused by an accident of nature as the tree grew. You may need to go over the work on the spots with 000 four 0000 steel wool moistened with mineral spirits, and then go over it began with the scraper until it disappears.

PAINT AND VARNISH REMOVERS

You will probably use a paint or varnish remover that you will be doing a complete refinishing jobs.

GUNSMITHING AND TOOL MAKING BIBLE

However, you may want to use a paint or varnish remover to strip off the finish from a table leg or back of a chair.

When you go to a hardware or paint store, you'll see a lot of good paint and varnish removers there, and most of them are slightly different. Be sure to read the labels on them as some are hazardous to use unless you take precautions to ventilation and fire hazards.

You'll find that none of them will really remove the finish. They will soften the finish for you to remove with very little effort. Be sure to read the caution labels that are now required on products that are flammable or toxic, or produce toxic fumes. If you use a paint or varnish remover that has either a high flammability or a high toxicity rating, use it only outdoors and avoid breathing the fumes as much as possible. A good safe rule is to never use any remover in a badly ventilated area or an area where its vapors could be ignited by an open flame such as the pilot burner of a hot water tank or furnace.

Many of the day or gel-like removers have a wax or paraffin in it to give them the body, which makes them so desirable to use on vertical surfaces. The paint or varnish remover that you should get will be based on methylene chloride, methyl ethyl ketone, or one of the other chemicals that has both a low toxicity and a low flammability quotient. To be on the safe side, use these outdoors if possible, or in a well-ventilated room away from an open flame.

BLEACHES AND FILLERS

When stripping, the method of stripping and the type of remover you have chosen, you may need oxalic acid to bleach certain spots which the remover has turned gray. Or, a stain or paint from an earlier finish that has penetrated too deeply. Another bleaching agent is ammonia, so all are a number of powdered household cleaners such as Gold Dust and Ajax, and liquids such as Clorox or Purex.

To neutralize, use vinegar as a neutralizing agent following the use of bleach. One or more of the above you may need to try, depending on the success of your stripping work and type of job that you're doing.

If the woods that you're working with have an open grain, you need to get a filler. Most wood such as oak, soft Mahogany, ash, Chestnut, and Hickory will require a filler. Some of the other open-pored woods are Elm and Sycamore, which are seldom used today in furniture making. When you get these fillers, use a thick filler for all of the above woods. Then fillers should be used on soft straight-grain Maple, Walnut, Beech, and a very fine-grain Mahogany's. On very close-grain woods like curled-grain maple, Birch, Cherry, and Gum you do not need to use a filler. Fillers come in various colors to match the tone of all the different furniture woods, and the colors can be adjusted with pigments if you like.

STAINING THE WOOD

If you plan to use staining, they have several functions. They will highlight imperfections in wood, bring out the grain beauty, and produce an exact color that will match other pieces of furniture or contrast with them. When you buy a stain, all of them are made by dissolving a coloring agent, powder, paste, or

GUNSMITHING AND TOOL MAKING BIBLE

liquid in some type of carrier or base that allows the hue of the staining to be adjusted from light to dark. Paste and liquid pigments are usually suspended in an oil or grease base, and in most cases must be thinned in a compatible carrier. Carriers can be thinned varnish or pure turpentine, or mineral spirits. Powder staining can be dissolved in either oil or a water base carrier. They can also be mixed in alcohol, lacquer, or water, and also in turpentine or mineral spirits.

If you want to use powder stains they are very handy if you want to deepen or darken any ready mix stains. The stains may have either an oil, lacquer, alkali resin, latex, or water base. Alcohol stains or water base stains will penetrate quite deeply into raw wood. Oil or alkali, or resin base stains tend to sink into the wood surfaces only very shallow. The alcohol or water base stains are usually labeled as "penetrating stains" so the user will know its characteristics. You must work carefully and swiftly with the stains to avoid overlap which results in a streak finish. Spirit stains, which are alcohol or water base, will strike in deeply and very quickly, and this will make brush application very tricky. Probably, you can do a better job if you wipe the stains on with a cloth instead of rushing them on.

The type of staining to use will depend on the kind of finish that you're trying to achieve if you want a very slick appearance of a lacquer finish, it would be best to use a water base staining to prevent the lacquer from dissolving the stain and causing it to bleed into the finish. When you apply lacquer over any type other than a water base staining it will absorb some of the color that is released by the bleeding, therefore your finish will not be perfect.

I have found that varnish can be use over just about any type of stains, and the varnish stains combine two jobs into one by giving you a stain and the topcoat of varnish in one application. Many as the stains have a tung oil base and do an excellence one coat job. If you want the best finish you can get, you will probably have to use three coats. After sanding and wiping with a tack cloth, apply a sealed coat of thin varnish or shellac to keep the stains from penetrating too deeply. Use varnish and turpentine in equal parts, or alcohol and my shellac in equal parts. This type of sealer will dry immediately, and fill the tiniest wood pores that the seller may have missed. It will also give you a more even stained job. You could use a brush, then rub the sealer coat with felt and wipe with the tack cloth, apply staining, and then rubbed with felt. They end wipe with a tack cloth when the stain dries. Applying a coat of rubbed on Tung oil varnish will finish the job. After the Tung oil varnish dries give the work a final rubbing with felt and then wipe with a tack cloth. Use a thin coat of varnish to finish it off.

You can also brush the stains on, or rubbed it on, unless you're using a water base or alcohol base stains. Water base or alcohol base stains are not recommended for the home worker. Seldom, will you need to apply more than one coat of stain, and if you work both fast and carefully in applying that coat, all that will be needed before going to the finish coat is to rub down the surface with felt to get it a final polish. You can buy felt rubbing pads in most hardware stores, and always polish the work completely as that is what give you the best finish.

REFINISHING WOOD

There are basically three types of refinishing that you might do. You may want to completely refinish the wood items, which will begin by stripping the wood down to the bare wood. While this does is to prepare the wood so that you can put a new finish on it.

The second way of finishing wood is a partial refinishing. It stops short of stripping all the finish off of the wood, the generally you will need to remove old varnish or shellac. Then, buff the surface, but leave the old stain alone except for minor touch ups.

The third refinishing methods are when you try to blend a repaired or patch area to match the existing finish.

Complete refinishing is normally the easiest, especially for the newcomer that has done very little refinishing work. On complete refinishing call you need to do his stain, Barnes, or apply lacquer. You don't have the task of matching what somebody else has done.

In partial refinishing you'll find that plans can go wrong. You may end up taking off the stain or create patchy spots in it. If you are not careful you can also loosened glue joints. When doing a complete refinishing job this isn't a problem because you'll have bare wood to work with.

You will find that the most difficult of the three kinds of refinishing work is spot refinishing. Here, he must get an exact match and staining, and use the finishing materials that are either identical with these use in the piece when it was first finish. If you use materials that were like the original there will be no mismatch noticeable.

THE TOOLS YOU WILL NEED FOR REFINISHING

The refinishing tools, as well as good sandpaper, are very simple and you usually have these already. A scraper for flat surfaces, that is were used for crevices and corners as well. Many people make the mistake of using glass for scraping. The glass edges are never totally smooth unless the glass has been smooth on a special emery belt machine.

If you use a steel scraper, I get a good one. This is one of the best investments that you can spend your dollar on.

STRIPPING

If you use a big scraper with jagged edges this can make a lot of work for you. You can find very useful and suitable scrapers by going to a variety store and selecting wood and kitchen utensils that would include a pot scraper that has a smooth tapered edge. Normally these scrapers will last through three or four refinishing jobs, and the most important is they won't scratch the surface the wood softened by paint and varnish removers. When getting into corners, Constantine has a handy little tool they call a "grooves

GUNSMITHING AND TOOL MAKING BIBLE

and cranny nooker", which will get into tight spots.

Along with this may have another scraper with interchangeable blades that has outside and inside curves, as well as different points to get into very fine carved areas. You can also make wood groove scrapers from different size dowels sawed and filed to the exact shape that you need. These work extremely well, but they take time to make up. You will find they are nice to use for the final cleanup, as they won't mar wood surfaces a deal that one of them skid or even use too much pressure.

SANDING AND SANDING BLOCKS

When you go to a hardware store there are many good sanding blocks made of metal or rubber. I have found it work as well using a scratch piece of 1 x 3 lumber. The sanding blocks are easy to use; especially the rubber was, as they will follow the curves of the wood. When you come to grooves and edges, and other odd spots A-Acto makes a set of different shapes sanders that are very easy to use. When you need new paper on these, you'll find that won't take long to do. When you finish out table legs or chair legs and any other contoured surfaces, the Merit Sand-O-Flex is a real-time and energy Saver.

Don't use drill-operated sanders that you use tiny metal fingers. The tiny metal fingers will cut grooves into the wood surface. The Sand-O-Flex is available in two sizes, which is standard and small models. It uses thin strips of sandpaper, and also has brushes to keep your work area clean. You'll find it will do a good job on any irregular surface, and even small carvings and decorations.

BRUSHES

When you buy, brushes by the best that you can get. I have found that many skilled refinishers use only brushes, which are two-inch varnish brush that they keep scrupulously clean. Many other wood finishers prefer to keep a brush for staining, and another for varnishing or shall lacking. They follow clean procedures very rigidly to keep their brushes in good order. Always by the best quality brush you can get, and one with a chisel tip of natural black bristles set in rubber. You need to keep it clean by washing it with mineral spirits or turpentine after you finish each job.

Always keep the brushes in a close container, suspended, and wash it well just before you use it as well as after the job that you are doing is completed.

A good tack cloth is also a necessary tie them that will last as long as the brush. Tack cloths are used to clean raw wood surfaces before staining. You use a tack cloth on stained surfaces before varnishing, and a partly finish surface between varnish coats. Most hardware stores have tack cloths or you can even make your own. If you want to make your own, start with an 18 to 20 inch square of cotton or wool cloths. Do not use synthetics! The cotton or wool cloths should have been washed enough times to take out all the lint and loose fuzz.

Now, moistened the cloths with turpentine, and in a container add a few drops of clear varnish on it. You want to put enough on it to make the fabric very slightly sticky.

Then, squeeze the cloths and wring out excessive liquid. Get an old fruit jar or other plastic container that

GUNSMITHING AND TOOL MAKING BIBLE

has tight covers and store it in there.

1. Use water or NGR stains. If you find it necessary to use a pigmented wiping stain, give it at least forty-eight hours to dry. Otherwise, the lacquer thinners may act in the manner of paint and varnish removers.
2. Give any standard paste filler forty-eight hours to set up hard, for the same reason.
3. A safeguard is the use of thinned shellac as a sealer after stains or filler or both.
4. Use a lacquer type sander sealer filler unless the wood is of such open grain that paste fillers are required.
5. Let everything dry thoroughly, before lacquering, especially any oil resin or petroleum derivative materials.
6. When you plan to use lacquer over rosewood or dark mahogany, use a thin shellac wash coat as a sealer and do not sand it. The shellac will seal the pigment, keeping it from bleeding, and you might cut through it if you sand, thus breaking the seal.

Lacquer rubs and buffs to a higher polish than you can get with varnish, which is one reason it is so often used for small, elegant projects that look best with a high finish.

The good rubbing quality also accounts for speedy drying for the popularity of lacquer on most commercial furniture.

Whenever you want to keep the maximum natural wood color that is, without any of the darkening oil finishes produce don't forget that lacquer itself is the whitest and the least darkening of all. On top of that is the magical effect of lacquer lighteners, which leave the wood almost identical in color to its raw hue.

If the wood has an open grain, apply wood filler especially made for stocks and to go under lacquer. It is important that the correct type of filler be used. One made for varnish will be dissolved by lacquer. After filler is applied, repolish stock with very fine grit sandpaper.

In applying filler, rub it in both with and across the grain. Let it dry partially and continue rubbing until it takes on a light sheen. Apply more filler if necessary, to be certain all wood pores and cracks are filled. Wipe off excess only across the grain. If you wipe with the grain, you will remove the filler. Let dry thoroughly.

Apply a thin coating of lacquer especially made for gun stocks. A spray can or a paintbrush may be used. After drying, polish with #400 fine grit paper. Apply another coat of lacquer.

Some workers prefer three or more coats, sanding in between.

GUNSMITHING AND TOOL MAKING BIBLE

Use your own judgment about the number of coats. Too many or too thick applications are likely to crack and peel, so be certain the coats are thin and well polished in between.

TIPS ON USING LACQUER

Since most people have had much more experience with varnish than with lacquer, the best way to explain the tricks of lacquer application is to contrast them with varnish.

1. Instead of laying the material on, then smoothing it, you should try to flow lacquer on in a good wet coat without too much brush back. Move fast, using long strokes. Keep a wet edge by working in small areas. Usually a relatively long and narrow area is easiest to handle. To keep the action fast, use a wider brush than you might like for varnish. Never apply lacquer with a tiny brush unless the project itself is tiny. Width rather than fullness is the mark of a good lacquer brush, which need not have bristles as long as are considered best for varnish.

2. Instead of using lacquer as thick as you can brush it comfortably, as you do with varnish, keep it thin enough to flow out well. This may mean some thinner, even in a material such as Satin lac, which is canned at a brushable consistency as it is. Be sure to buy a good thinner. There are many chemicals that will reduce the consistency of lacquer, but not all of them produce good results. Thin all coats, if necessary.

3. Sanding between coats is not necessary with lacquer to provide adhesion. Each coat tends to soften the preceding one minutely, bonding to it. Thus, scarifying for mechanical bond, as with varnish, doesn't help. However, you may want to scuff sand enough to knock off high spots and the few dust specks you'll you will be bound to get, even with lacquer.

If you are working toward a high rubbed finish, you will always sand to plane the surface, if application is rough. Do not use water on between coat sanding with lacquer. Be sure to give lacquer at least four hours to dry before sanding and re coating. Give the final coat overnight, before you do the last stages of rubbing with pumice.

When using lacquer, you may encounter any one of several difficulties, which can be handled if you know how.

THE PENETRATING RESIN FINISHES

These are manufactured by dozens of paint companies and sold at every paint store, have gained a place among the most popular clear finishes. There is a remarkable list of reasons why: They are by far the easiest of all finishes to apply.

They are among the most durable, so tough that they rank at the top in floor finishes. They have arrived

GUNSMITHING AND TOOL MAKING BIBLE

with top designers in modern furniture; among them the more natural a wood can look the better.

They give the wood a fire and color unlike that produced by any other finish. Wood hues are intensified made more vivid, and there is no obscuring of the grain or wood texture. They are so foolproof and quick to use that they rank well at the top as finishes for large area surfaces such as wood paneling.

Penetrating resin finishes are like varnish, but instead of lying on the surface, they sink in. The resins harden between the fibers of the wood, in the air cells and other voids. When they are dry, the wood itself is measurably harder, and it is impervious to all ordinary damage. In a sense they impregnate the wood with a plastic like substance that turns the wood into plastic. However, there is no look of plastic.

WHERE TO USE PENETRATING FINISHES

Some penetrating resin finishes are intended primarily for floors, and these particularly rugged brands are superior for furniture, too. Penetrating resin finishes are not meant for outdoor use, but work fine for gun stocks.

HOW TO APPLY A PENETRATING FINISH

Flow penetrating resin on the wood thickly. Don't worry about fancy brush work. Many finishers don't even use a brush. They mop the material on with rags or pour it on, then spread it. You can even use your hands, if you want, rubbing the finish in as you spread it. Some experts use a pad of very fine steel wool to spread the puddles of finish and work it into the wood. This is one of the best techniques of all.

Keep the surface wet for about half an hour. Read the label, because some manufacturers ask for a full hour of penetration. If you see dull spots appear, indicating that all the material has soaked in, apply more to keep the surface wet.

After the wood has soaked up all the liquid it will take, use plenty of rags to wipe all the surface liquid off. Wipe it clean.

Do not leave a trace of the finish on the surface, for if you do, it will dry to an unpleasant sort of sheen. Should this happen and you catch it the next day, you can usually cut the dried material by brushing on more finish, then wiping it in a few minutes.

The penetrating finish continues to soak in and permeate the pores and spaces in the wood after you wipe it. For that reason, a second application is usually a good idea, especially if the wood is porous. Do not wait until the first coat has dried and hardened completely.

Three hours or so is long enough to wait. Brush or swab on the second coat. Keep it wet for half an hour or longer and wipe it all off Again.

When this well wiped application is dry, the job is done. You can wax the wood if you want to, but this tends to clog the pores and steal some of the natural, textural beauty of the finish.

THE COLORS OF PENETRATING FINISHES

The natural look of the penetrating finishes is at its best on open pored woods such as oak, walnut, mahogany, pecan, chestnut, etc. It leaves their texture unfilled, and makes them look like wood. Maple, birch, cherry, and other close grained woods take the finish, of course, but are not so spectacular as the coarser textured species.

Darker colored walnut reaches its usual dark brown color. Rosewood's browns go almost black.

This degree of darkening is considered ideal for each species.

Stain is not usually required. If you want a penetrating finish that is lighter in color, use a wood bleach to lighten the natural color a shade or two. Of course, no filler is used with a penetrating resin finish.

Although the color given woods by a penetrating resin finish alone is usually appreciated by most people in the darker woods, you may want to stain some of the lighter species. If you use a pigmented wiping stain, then follow it with a penetrating finish. The finish will not change the color of the stained wood, other than to intensify it slightly. The reason for this is that most pigmented wiping stains are mixed in a vehicle that is much like a penetrating finish.

If you use water or a non-grain raising stain, however, you must expect a considerable intensification of the color, a shift in hue toward the reds, and some darkening.

HOW TO BUY PENETRATING FINISHES

There are two kinds, one is formulated on the phenolic resins, the other on alkyds. The phenolics tend to penetrate deeper. Look for the word penetrating and the word resin. Look for instructions that tell you to brush it on and wipe it off. Every major paint manufacturer has a penetrating resin finish.

There are materials that are similar in application based on oils, not resins. In situations where protection is not important, they can be used, although they offer no advantages in service or application ease.

It is practically impervious to water and will stand much use, and even abuse, without cracking or peeling. It comes in either a high gloss or a soft or satin finish. It may be used as a wood sealer, and/or as a filler, or for the final finish as well.

No wood filler is required, since it is its own filler if several coats are applied, with excess rubbed and polished off between coats.

If the resin finish is to be used as a wood filler as well as a sealer, apply as above instructions. If you allow the resin to dry, it is so hard that subsequent coats will not stick to it. If you are using a final finish of something other than resin, allow the filler coat to dry a full 24 hours before polishing it back down to the

GUNSMITHING AND TOOL MAKING BIBLE

base wood with steel wool. This should leave every wood pore filled completely so the regular, final finish can be applied.

APPLYING AN OIL FINISH TO THE STOCK

An oil finish is considered by many gun owners to be the most handsome of all, especially if the wood of the stock is especially fine. The reason an oil finish is not usually applied by commercial gun makers is that it is a time consuming process. However, the individual gun owner will get much pleasure out of refinishing his stock, and have a beautiful product as a result. While time consuming, the process is quite simple. The following suggestions should prove helpful.

Use a regular gun stock oil or Tung Oil rather than boiled linseed oil.

Linseed Oil, Trueoil, Tung Oil, and Genuine Oil are three of the better known brands. They are much easier and faster to use than linseed oil, and leave a handsome finish.

See Sanding stocks at the start of this article.

When the stock has been filled with oil, hang it outdoors in the sun and wind and let it dry completely. Apply a second and third heavy coat of oil, drying completely outdoors between coats. Allow the third coat to dry for a full twelve hours at least.

FINISHING THE STOCK

STEEL WOOL AND OIL - The steel wool pad is soaked with any light oil like machine or crude oil, and then used to rub the surface in the same manner as in the dry rubbing method. The surface must be dried clean of oil and grime after the rubbing operation has been completed. No other polishing device is necessary since the oil remaining on the surface serves as the polishing agent,

The width of the scratch produced by the abrasive determines the amount of luster resulting on the surface. Thus, if a series of very wide scratches is made on the surface, a very dull appearance will result, and if a series of very fine scratches is made, a gloss surface will result. No scratch at all should produce a mirror like surface.

RUBBING TIPS AND SHORTCUTS

The fastest and easiest method of sanding the finish smooth is with No. 400 waterproof paper, such as Wet or Dry.

It is also the cheapest, despite the higher cost of the paper, since it doesn't clog when it is used with water, and it wears a long time.

GUNSMITHING AND TOOL MAKING BIBLE

The best sort of a block to use with wet sandpaper is rubber. Paint stores sell rubber blocks that are a nuisance to use. However, you can cut them down so they are a plain block of rubber, and they work well. Another way to get a rubber-sanding block is to use contact cement to fasten a piece of inner tube to a wooden block.

Sprinkle water on the surface and sand. Keep a piece of paper in saucer of water, so the backing will soften, and rotate the paper as its edges and backing dry. Many workers prefer to dip the paper in the saucer of water, letting it drain, thus washing the accumulation of varnish powder off the paper.

Now and then you hear recommendations to use soapy water, but this does no good, and actually slows the job down. Plain water gives you the fastest and cleanest cut.

Depending on how fine waterproof sandpaper you can buy, you may be able to do an entire rubbed finish without using pumice or rotten stone. The equivalent to rotten stone is crocus cloth.

CARVINGS.

Most finishers don't try to rub carved and coped surfaces as carefully as they do flat or mildly curved surfaces. For one thing, such a high finish is not necessary, because carved surfaces carry their own decorative weight.

Wet sandpaper, in fact any sandpaper is useless on carvings, although it can be used on some simple moldings. Try steel wool for early coats.

Then, toward the end of the finishing, use a small scrub brush to apply pumice and oil. Take special pains to clean the pumice out of small cracks and crevices. Any that you leave will dry white and give the carvings a scurvy look.

FINISHING THE OILED STOCK

Polish the stock with steel wool, rubbing until all the oil is removed and you are down to the bare wood again. The pores of the wood, however, remain completely filled with the surface smooth. If there are thin spots in the skin, repeat one or two more coats and cut the finish back to the wood again. Never start the final finish until all the pores is filled.

Apply the final coat very lightly, using the fingertips, rubbing in and smoothing as you go along. To get a fine finish, smooth out each drop of oil over as broad a surface as possible. Rub each drop in completely until it starts to pull as you rub your finger over it. Cover each area of the stock turn, going on to the next without going back over a section already done. Make certain all the stock is covered completely.

Allow this coat to dry in the sun and wind. Apply a thin second coat as you did the first, and hang the stock up to dry again. Repeat this process until the stock takes on a sheen. Usually about five coats are

GUNSMITHING AND TOOL MAKING BIBLE

required to get a good finish.

You might have to apply more coats on more porous woods.

If you prefer a high gloss, wipe the stock clean with a special stock rubbing compound, and apply one final coat of stock oil.

If you prefer a rubbed finish, rub the entire stock very lightly with pumice, rubbing just enough to remove some of the gloss but leaving a satin glow look to the finish.

Whether you prefer the high gloss or rubbed look, the final step is to wax the stock completely with good quality paste wax, rubbing until hard. I find that a good paste floor wax is hard to beat. Finish off by wiping with a soft flannel cloth.

Safety First.

GUNSMITHING AND TOOL MAKING BIBLE

ADDRESSES

Chapman Mfg. Co.
PO Box 250 Rt. 17 at Sawmill Rd.
Durham,Ct.,06422

Chicago Wheel & Mfg.
1101 W Monroe St.
Chicago,Ill.,60607

Chopie Mfg.
200 Copeland Av.
LaCrosse,Wi.,54603

Classic Arms Corp.
PO Box 8
Palo Alto,Ca.,94302

Clymer Mfg.
1645 W Hamlin Rd.
Rochester Hills,Mi.,48063

Danjon Manufacturing Corp.
1075 S. Main St.
Cheshire, Conn. 06410

Dem-Bart Hand Checkers
6807 Hiway # 2
Snohomish,Wa.,98290

Dremel Mfg.
4915-21st St.
Racine,Wi.,53406

E F Houghton Co.
303 W Lehigh Ave.
Philadelphia,Pa.,19133

Electro Glo Co.
621 S Kolmar Ave.
Chicago, Ill.60624

Emco-Lux
2050 Fairwood Av.
PO Box 07861,
Columbus,Oh.,43207

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Forster Products
82 E Lanark Av.
Lanark,Il.,61046

G R S Corp
PO Box748, 900 Overland St.
Emporia,Ks.,66801

Heatbath Corp
Springfield
Mass.,01101

Henriksen Tool Co.
PO Box 668
Phoenix,Or.,97535

International Nickel Co.
1 New York Plaza
New York, NY 10004

JGS Tool Mfg.
1141 S. Summer Rd.
Coos Bay,Or.,97420

Jeffredo Gunsight
1629 Via Monserate
Fallbrook,Ca.,92028

Kasenit Co.
PO Box 726
Mahwah,NJ.,07430

Ken Jantz Supply
222 E Main
Davis,Ok.,73030

Lea Mfg.
237 E Aurora St.
Waterbury,Ct.,06720

LS Starrett
121 Crescent St
Athol,Ma.,01331

Mcinty Tools
PO Box 491/State Rd. # 1144

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Troy,NC.,27371

Michaels Of Oregon
PO Box 13010
Portland,Or.,97213

Norton Co.
6120 Howe St
Troy,NY.,12181

Norton Chemical
130 East Ave.
Tallmage,Oh.,44309

Olympic Arms
624 Old Pacific Hwy SE
Olympia,Wa.,98503

Palmgren Steel Producs
8383 South Chicago Ave.
Chicago,Il.,60617

Roto Carve
6509 Indian Hills Rd.
Minneapolis,MN.,55435

Sandoz Inc.
Route 10
Hanover, NJ 07936

Sanford ProcessCorp.
61 North Ave.
Natick,Mass.,01760

Schaffner Mfg Co.
Emsworth
Pittsburg,Pa.,15202

Scionics Corp
8910 Winnetka Ave.
Northridge,Ca.,91324

Sanfax Metal Processig
5001 Peach Tree Industrial Rd.
Alanta,Ga.,30341

GUNSMITHING AND TOOL MAKING BIBLE

Terry K Kopp
Highway 13 South
Lexington,Mo.,64067

Texas Platers Supply
2453 W Five Mile Parkway
Dallas,Tx.,75233

The Carborundum Co.
Buffalo Av. at Portage Rd.
Nigara Falls,NY,14302

Timmey Mfg.
3106 W Thomas Rd.
Phoenix,Az.,85017

Tools and supplies

Wholesale Tool1
1212 Adamo Drive
Tampa,Fla. 33619

United Mineral/Chemical
129 Hudson St.
New York,NY,10013

W.E. Brownell Checkers
3356 Moraga Place
San Diego,Ca.,92117

Williams Gun Sight
7389 Lapeer Rd.
Davison,Mi.,48423

Wholesale Tool
9909 E. 55th. Place
Tulsa, Ok. 74146

Wholesale Tool
8758 Clay Road, Bldg. 410
Houston, Texas 77080

Wholesale Tool
1234 Washington St. Box 481
Stoughton, Mass. 02072

GUNSMITHING AND TOOL MAKING BIBLE

Wholesale Tool
4200 Barringer Drive,
Box 240965
Charlotte, NC 28210

These are the main suppliers that I used. A complete list can be found in the Gun Digest, in the back of the book under suppliers.