FUNDAMENTALS OF MACHINE SHOP PRACTICE

STIERI

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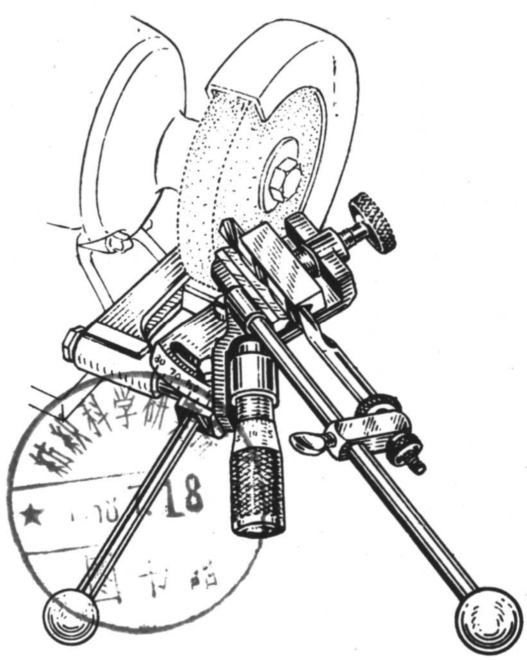
by
EMANUELE STIERI



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Foreword

Machine shop is considered a basic shop in the field of industry. The tools of industry and progress in manufacturing and production depend upon machine tools. A skillful mechanic in any field needs to acquire an understanding of machine shop processes, and especially of concepts of accuracy and required tolerances.

This book has been prepared to serve not only beginners entering machine shop work but all the machine tool trades. The hand tools, the measuring devices, and the fundamental machines of the machine shop are found in most other machine tool processes. The lathe, drill press, and grinders are common equipment in most production and maintenance shops.

The author has skillfully and artistically combined illustrations and written instruction so as to present in psychological sequence materials of value for beginners in machine shop practices and also for those engaged in numerous other machine tool trades. The author has recognized that demonstrators of shop subjects need instructional materials pertaining to fundamentals rather than step-by-step procedures for the completion of specific projects. The result is a richly illustrated text presenting needed instructions for the beginner to make progress on real jobs or selected projects.

The acquisition of skill in the use of hand tools and the operation of machines have been stressed with the inclusion of science and mathematics. This combination determines to a great extent the level of attainment of a machine tools operator. The combination of meaningful tool practices, science, and mathematics, presented on beginning level, is an outstanding contribution to the practical arts field.

CLAUDE H. EWING, PH.D.
Professor of Education
Teacher Trainer in Trade
and Industrial Education
University of Hawaii

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Contents

Chapter **1**

Machinist's Hand and Bench Tools

Hand and bench tools are employed in many and varied hand operations of machine shop work. The term "bench work" refers to such machine shop processes as laying out, assembling, filing, cutting, chipping, and others. The term "floor work" is applied to procedures incidental to the larger units which are assembled on the floor of the machine shop. Excellent indications of the ability of the machinist are his selection, use, care, and maintenance of tools. He should understand the importance and value of good tools, and realize that inferior tools make a high standard of work more difficult.

Hammers

The types of hammers used in the machine shop are the machinist's or ball peen, the straight peen, and the cross peen. The essential parts of a machinist's or ball peen hammer are shown in Fig. 1. The peen is available in three common shapes; the ball peen for riveting, and the straight and cross peen types for swaging.

Hammers are made of hardened and tempered steel with wooden handles, and are available in varying weights or sizes ranging from 6 ozs. to 2½ lbs.

Hammers with heads made of rawhide, lead, copper, babbitt, or plastic are called soft hammers or mallets (Fig. 2). They are used to drive mandrels, seat work in a machine vise, or for any procedure where a steel hammer might mar or injure the work. Other types of hammers and mallets are shown in Figs. 3, 4, and 5.

USING THE HAMMER. When using a hammer, grasp the end of the handle firmly. When striking a blow with the hammer use the elbow as a pivot point, not the wrist. If the forearm is used as an extension of the handle, the blow is more effective because the radius of the swing is longer (Fig. 6).

Wherever possible, strike the work with the full face of the hammer parallel to the work. This spreads the force of the blow over a greater area and avoids damaging the edge of the hammer face. This method will also prevent unnecessary denting or marking of the stock.

TIGHTENING AND REPLACING HAMMER HANDLES. To avoid serious injury hammer handles should be securely fastened in the eye or the hole of the hammerhead. Loose hammerheads should be tightened or the handles replaced.

Tightening Handles. If the wedge comes loose, remove it and install a larger wedge. If the wedge remains tight in the handle, but the handle loosens, drive a thin hardwood or iron wedge into the handle beside the original wedge. A loose handle can be temporarily repaired by soaking it in water. If you are unable to tighten the handle, replace it.

Replacing Handles. Remove the old handle from the head. If the handle is tight, saw off the old handle next to the neck of the hammerhead as shown at *A*, in Fig. 7. Do not saw the handle off so close to the head that the saw teeth will touch the head while sawing, thus damaging the set of the saw. A hacksaw may also be used.

Drill a hole in the old handle (*B*, Fig. 7).

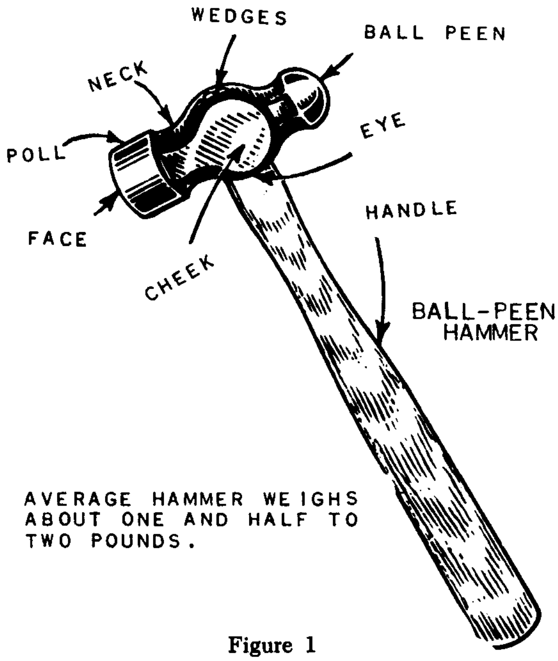


Figure 1

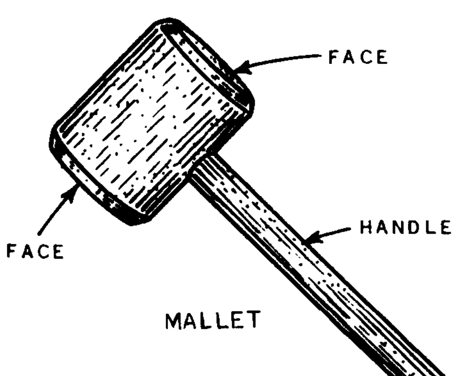


Figure 2

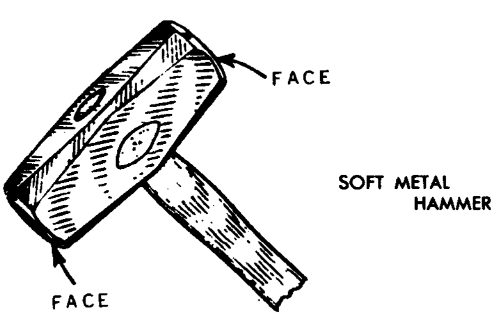


Figure 3

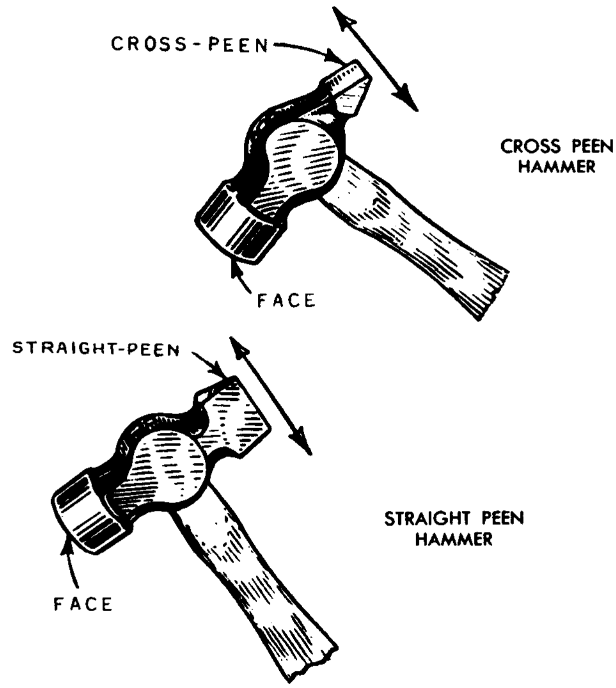


Figure 4

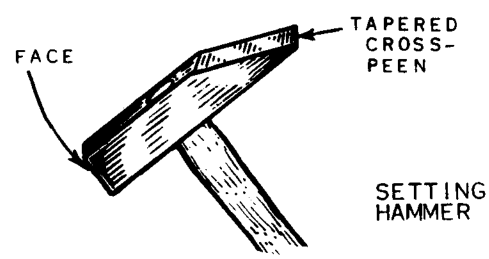


Figure 5

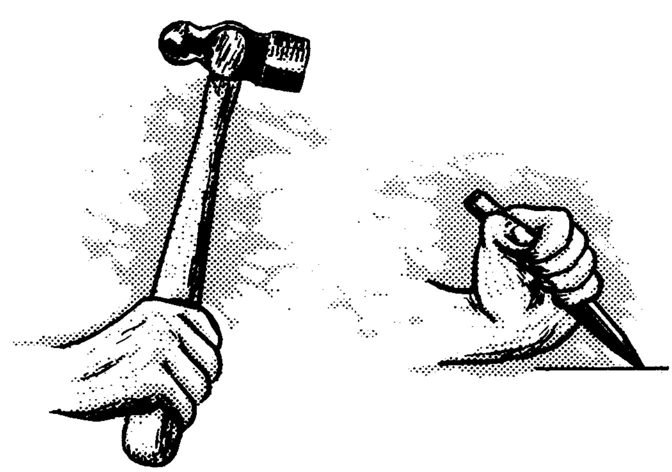


Figure 6

Drive the old handle from the head, secure the wedges, and shape the new handle to fit the head as shown at *C*, Fig. 7.

Insert the new handle in the head to determine the proper fit, and assemble for a tight fit by striking the end of the handle with a mallet to seat the head firmly on the handle (*D*, Fig. 7).

Check your results to determine if the handle fits properly.

Saw off the projecting portion of the handle close to the hammerhead as shown at *E*, Fig. 7, and cut slits for wedges. Avoid having the saw teeth touch the head during sawing.

Drive wedges into the handle. If wooden wedges are used, replace the old wedges or make new ones from straight-grain soft wood (*F*, Fig. 7).

File or grind the end of the handle even with the head. Use a wood rasp if wooden wedges are used.

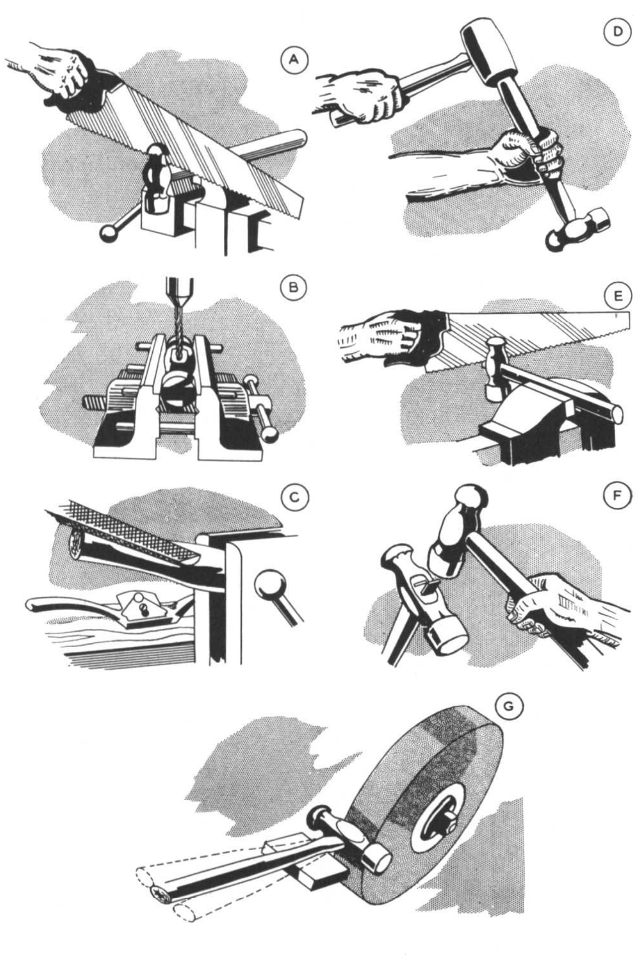


Figure 7

Grinding may be employed as shown at *G*, Fig. 7 if metal wedges are used.

Regrinding Hammer Faces. Incorrect or abusive use of hammer tools frequently results in uneven face wear. To reshape worn faces proceed as follows:

Determine whether the face should be flat or bell shaped by examining the unworn portion of the face or by comparing it with an unworn tool of the same type (*A*, Fig. 8).

Grind the face to the original shape (*B*, Fig. 8). Frequently immerse the head in water to prevent burning. Do not remove more stock than necessary.

On mallet-type tools, grind an equal amount of material from both faces to preserve balance.

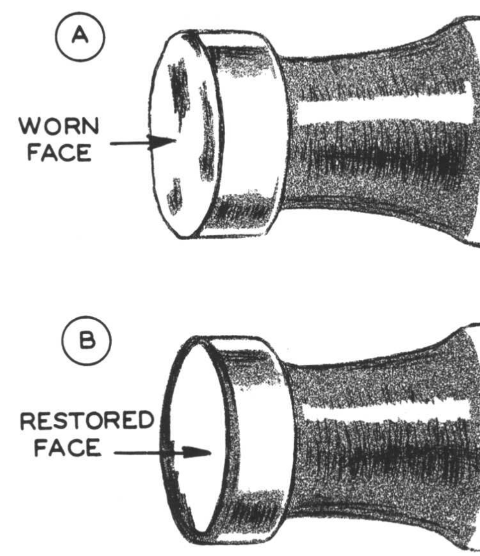


Figure 8

Cold Chisels

The five general types of cold chisels used in the machine shop are the flat, cape, roundnose, side, and diamond point (Fig. 9). Cold chisels are used to cut metal to required sizes and shapes, to chip the surface of metal to required thicknesses, to cut off rods and bars to desired lengths, to cut off rivetheads, and to split obstinate nuts that cannot be moved with a wrench. They are available in sizes ranging from 1/8 in. to 1 in.

FLAT AND CAPE CHISELS. The flat cold chisel is the type most commonly used and has a slightly rounded cutting edge formed by a double bevel. It is used for chipping a considerable amount of metal from large surfaces that cannot be filed or surface-machined (Fig. 9).

The cutting edge of a cape chisel has a double bevel similar to that of a flat chisel, but is narrower for cutting narrow grooves and square corners (Fig. 9). It is slightly wider than the shank so that there will be no binding in narrow grooves. Cape chisels range from 1/8 in. to 1/2 in. in width.

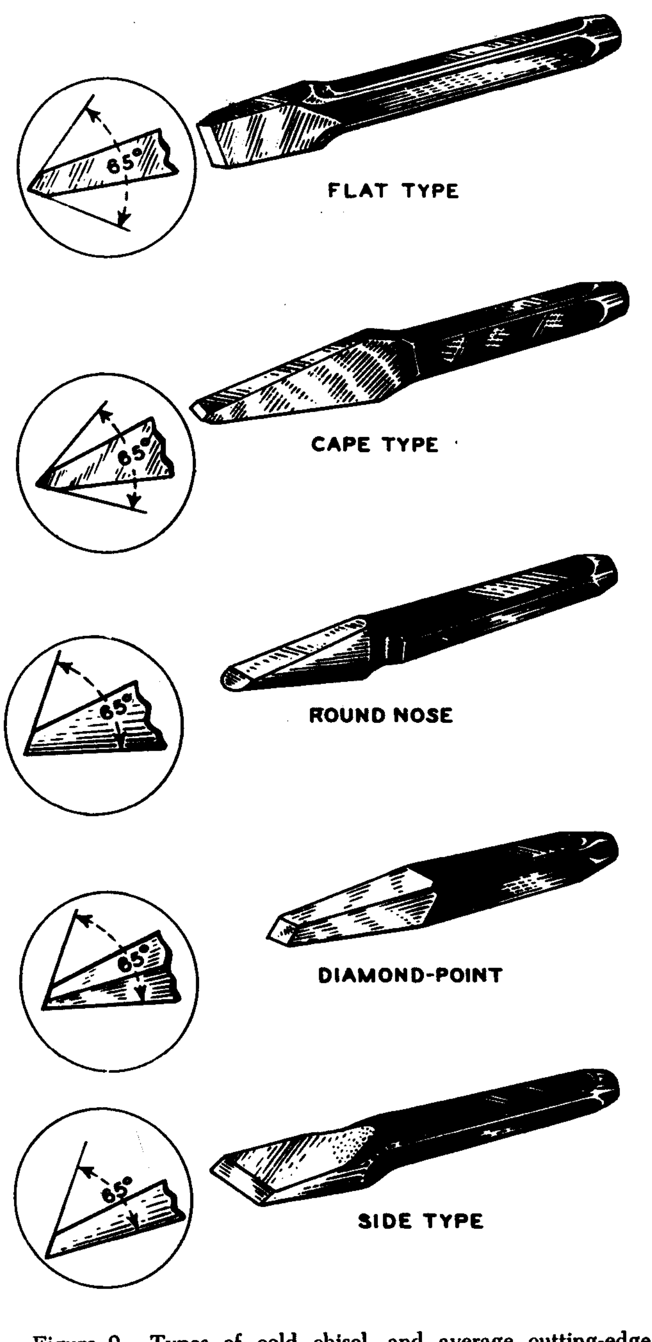


Figure 9. Types of cold chisel, and average cutting-edge angle of each.

Roundnose and Side Chisels. The cutting edge of a roundnose chisel is formed by a single bevel. It is used for cutting semicircular grooves and inside corners on metal (Fig. 9). The side chisel also has a cutting edge formed by a single bevel, similar to a carpenter's chisel. Side chisels are generally used for removing metal from keyways and slots (Fig. 9).

Diamond-Point Chisels. The diamond-point chisel has a tapered shank ground on an angle across diagonal corners, forming a diamond-shaped cutting edge. They are used for cutting V-shaped grooves, for squaring up the corners of slots, and for removing broken screws (Fig. 9).

CUTTING WITH A COLD CHISEL. A machinist's hammer is used to drive a cold chisel, and the size of the chisel determines the size of the hammer. The cold chisel is held loosely between the thumb and the first finger of the left hand (Fig. 10). The shank of the tool is held loosely with the remaining fingers. Holding the hammer in the right hand, strike sharp, quick blows with the flat face of the hammer and gradually increase the force of the blows as the work progresses.

CUTTING METAL HELD IN A VISE. When you are cutting metal held in a vise, mark the metal with a scriber to indicate the cutting line; then, using the scriber or a sharp-pointed tool, deepen the line. Clamp the metal in the vise with the scribed line visible above the jaws and parallel to the top edge of the vise. Hold the chisel at an angle to the metal so that the cutting edge shears it across the top of the vise jaw. Strike sharp, quick blows with the flat face of the hammer, and drive the chisel forward along the line to be cut. Always start a cut at the right-hand edge of the metal, and drive the chisel to the left toward the solid stationary jaw of the vise (Fig. 10).

CUTTING METAL ON A METAL BLOCK OR ANVIL. To cut metal on a block or anvil, mark and deepen the cutting line on the metal. To get a clean-cut edge, lay the sheet on a block or anvil of soft iron or soft steel. The chisel is held vertically to the surface of the sheet. On plate or heavy metal, the cut deepens gradually, and it is necessary to go over the line several times before it is cut through. On thin metal, the cut is made almost immediately. To cut along a curved line, use a narrow chisel so that the shape of the cut will conform more closely to the curved line.

CUTTING RODS OR SMALL BARS. To cut a rod or a small bar, mark the metal to indicate the cutting point. Lay the rod or bar on a block of steel or iron.

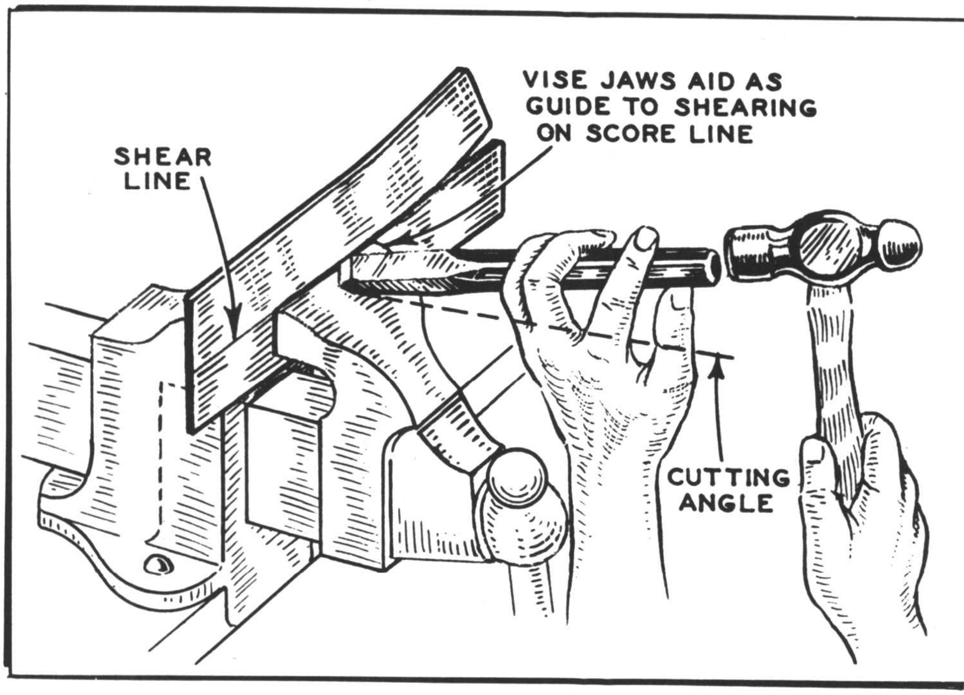


Figure 10. Cutting metal with a cold chisel.

Hold a flat chisel in a vertical position on the cutting point, and with a few taps of the hammer, cut a deep nick on opposite sides of the rod. Bend the rod slightly at the nicks; it will snap apart.

CUTTING SLOTS OR HOLES IN METAL. To cut a slot or hole in sheet metal, mark a line on the metal to indicate the hole and then deepen the line with a scriber. Drill a series of holes with a twist drill in the metal as close together as possible inside the scored line. Lay the metal on a steel plate and, with a chisel held at a slight angle, cut through the metal (Fig. 11).

CHIPPING LARGE SURFACES. Chipping is a metal-working operation used when a considerable amount of metal must be removed from large surfaces that cannot be either filed or surface-machined. When chipping metal, wear goggles as a precautionary measure against the flying chips. When the surface of the metal to be chipped is large, divide it into squares by cutting a series of grooves with a cape chisel. Space the grooves so that they are slightly closer together than the width of the flat chisel to be used. Drive the flat chisel toward the stationary jaw of the vise, holding it in the position shown in Fig. 12. The angle at which the chisel is held controls the depth of the cut. The maximum depth of the first

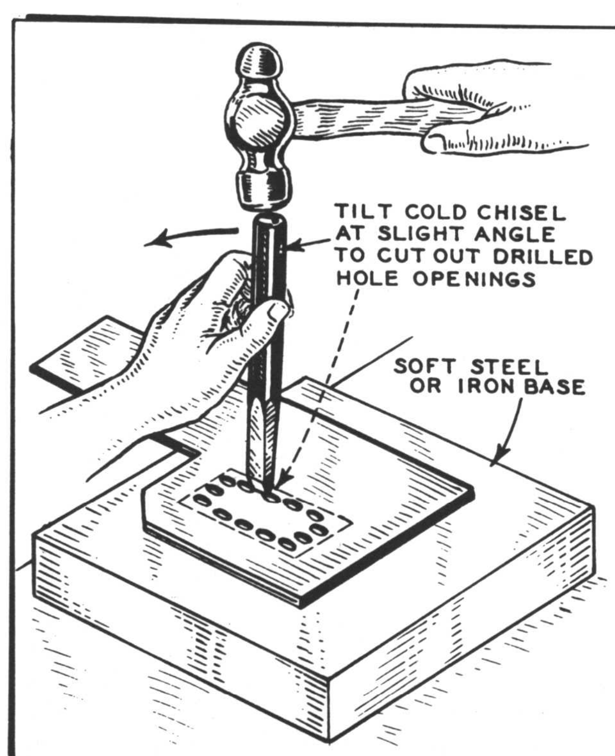


Figure 11. Cutting slots or holes in metal.

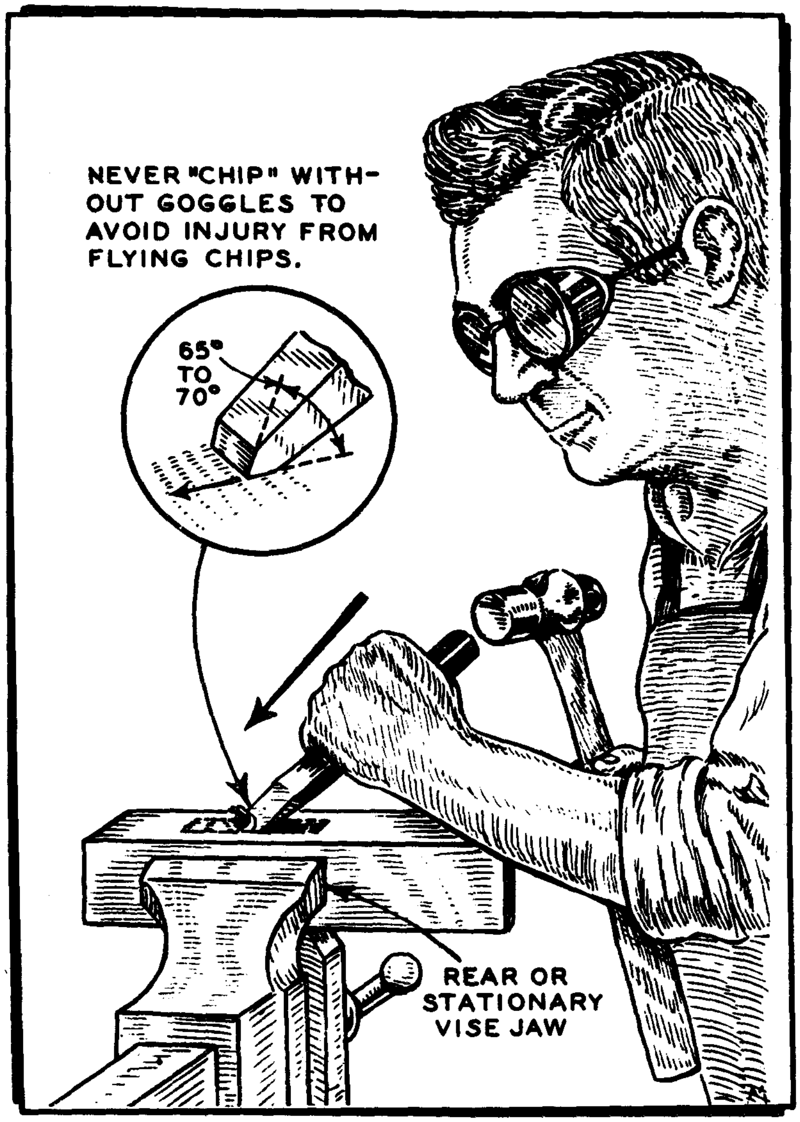


Figure 12. Always drive flat chisel toward the stationary jaw vise.

or roughing cut is usually $\frac{1}{16}$ inch. Finishing cuts should be $\frac{1}{32}$ in. deep or less. Hold the chisel loosely with the thumb and fingers of the left hand, and with the hammer in the right hand, strike one or two light blows to determine the amount of force required to make the cut. Gradually increase the strength of the blows and keep the cutting edge of the chisel against the chipped edge of the work. Chip from both sides toward the center of the material. Then file the surface of the metal straight and true. Chipping procedures for small rectangular areas are shown in Fig. 13.

Removing Broken Screws, Studs, and Frozen Nuts. To remove a broken screw or stud, first mark its exact center with a center punch. Then drill a hole with a small-sized twist drill into the full length of the screw or stud. Enlarge the hole by drilling it through again with a larger-sized drill until the screw or stud is a thin-walled, threaded sleeve. Insert a diamond-point chisel into the hole and drive it in lightly. Fit a wrench onto the shank of the chisel and turn it in a counterclockwise direction to back out the broken screw or stud. If the threads of a screw or stud are rusted, insert several drops of kerosene or thin oil after the hole is drilled. Allow some time for the oil to penetrate, and then remove the screw or stud (Figs. 14 and 15). To remove a frozen or rusted nut or one with rounded corners, apply some kerosene or thin oil and allow sufficient time for it to work into the threads. Split the nut with a sharp flat cold chisel and remove it.

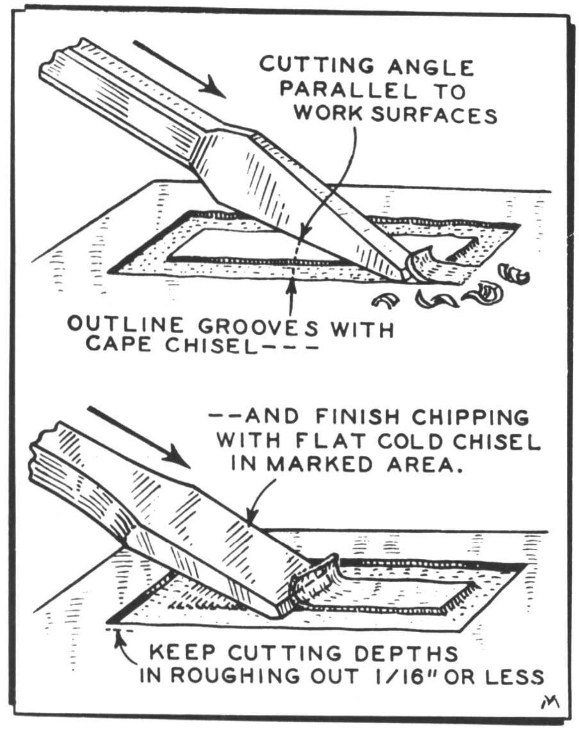


Figure 13. Procedures for chipping small rectangular areas.

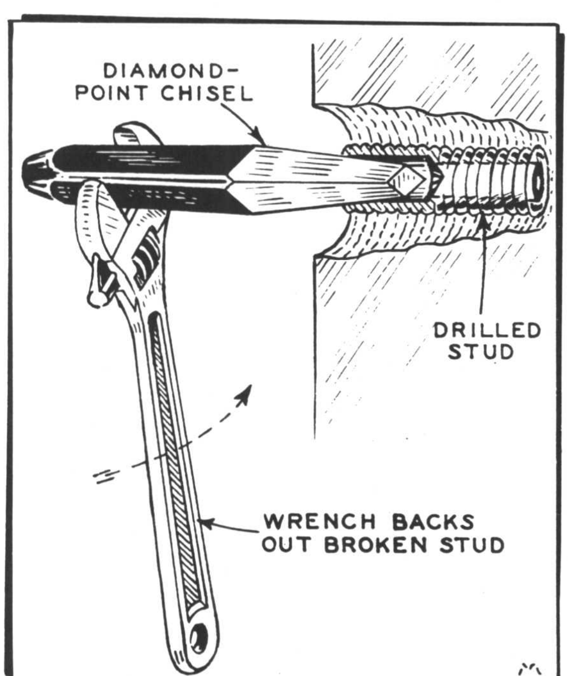


Figure 14. Removing broken stud with cold chisel.

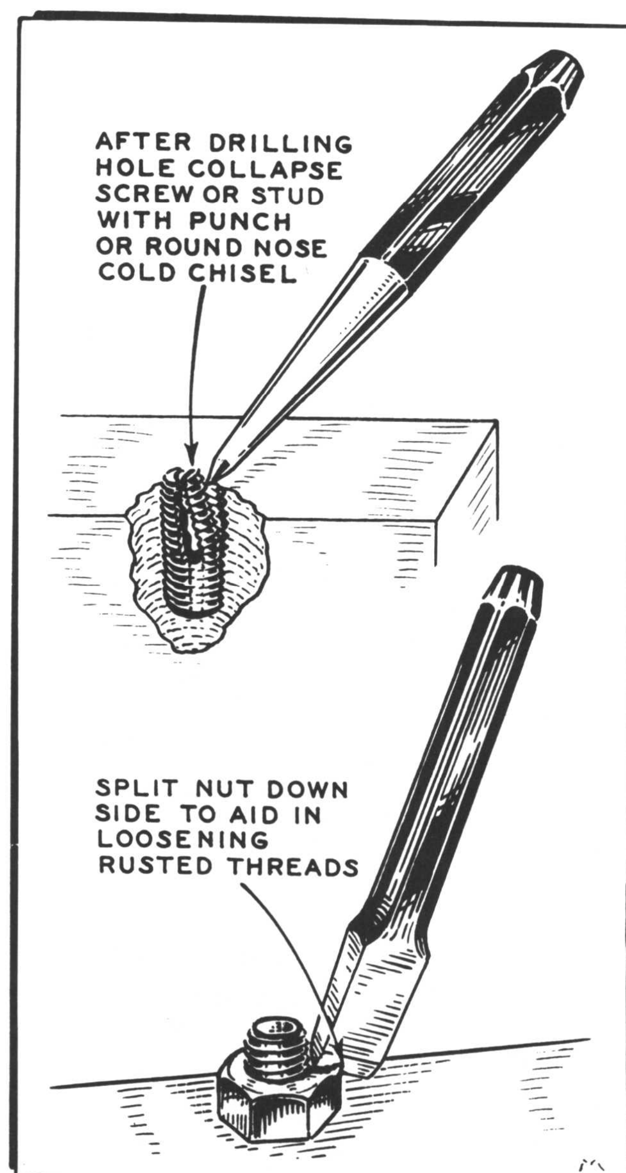


Figure 15. Removing broken or rusted screws and nuts with cold chisel.

Maintenance of Machinist's Chisels

The cutting angle of a chisel is determined according to the hardness and toughness of the materials being cut. An included cutting edge angle of 65 degrees works well for most work. When chisels used on hard or tough metal require greater strength to back up the cutting edge, an angle up to 90 degrees may be used for this purpose (Fig. 16). The cutting angle can be decreased somewhat from 65 degrees for cutting softer metals.

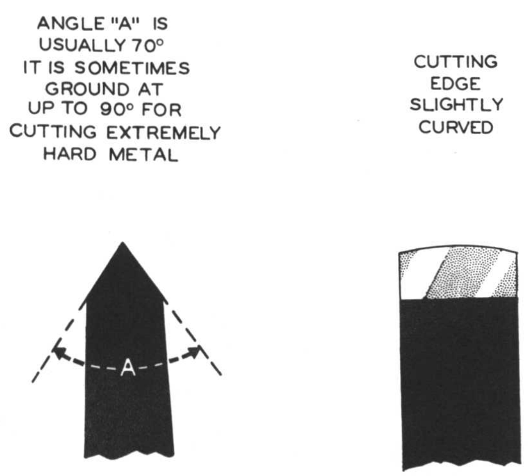


Figure 16

GRINDING. Set the grinding tool rest to secure the desired bevel angle. Move the chisel head from side to side a little during grinding to curve the cutting edge slightly. Turn the chisel over to grind the other bevel. Keep the bevels the same size or the cutting edge will not be centered. Dip the chisel frequently in water to preserve temper.

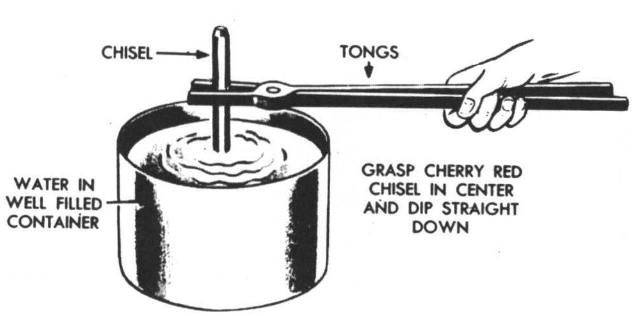


Figure 17

HARDENING AND TEMPERING MACHINIST'S CHISELS. Heat the whole chisel to a cherry red in a gas furnace or charcoal fire. Grasp the chisel in the center with tongs (Fig. 17). Dip the cutting end in clear, cold water to a depth of about 1¼ inches. Turn the chisel over and dip the head end about 1 inch. Quickly polish the hardened ends with a piece of emery cloth. Watch the color return from the heated center section of the chisel to the ends. Redip the cutting end every time the end becomes purple. Redip the head end every time it becomes blue. When red disappears from the chisel, dip the whole tool.

Wrenches

The wrench is a tool used to tighten boltheads, nuts, and studs. Most wrenches are designed to fit hex-heads and hex-nuts. The size of a wrench is determined by the size of the opening between its jaws.

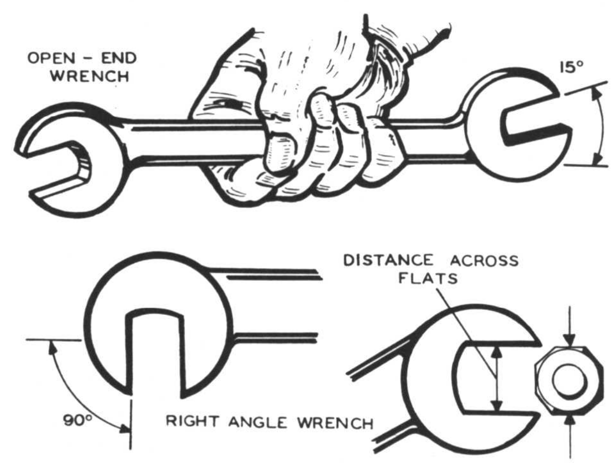


Figure 18. Monkey wrench, and proper position for its use.

Open-End Wrenches. Solid, nonadjustable, wrenches with openings in one or both ends are called open-end wrenches (Fig. 18). They are available in sets of 6 to 10 inches, with openings ranging from 5⁄16 to 1 inch. Open-end wrenches may have their jaws parallel to the handle or at angles anywhere up to 90 degrees. Their handles are usually straight, but they may be curved. Those with curved handles are called S-wrenches. Other open-end wrenches have offset handles to reach nuts sunk below the surface.

When using open-end wrenches be sure that the wrench jaws fit the nut or bolt head. When it is necessary to pull hard on the wrench, as in loosening a tight nut, make sure the wrench is seated squarely on the flats of the nut. Pull on the wrench whenever possible. If it is impossible to pull the wrench, push it with the open palm of the hand. To tighten a nut, turn it until the wrench has a firm, solid "feel." This will turn the nut to its proper tightness without stripping the threads or twisting off the bolt.

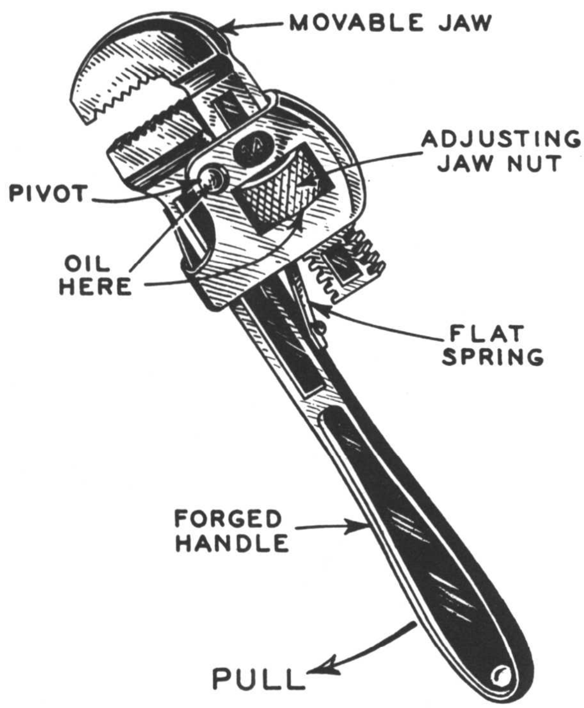


Figure 19. Adjustable end wrench.

Adjustable Wrenches. Adjustable open-end wrenches (Fig. 19) have one jaw fixed, and the other jaw is moved along a slide by a screw adjustment. When using the adjustable open-end wrench, be sure to pull on the side of the handle attached to the fixed jaw. Other adjustable open-end wrenches (Fig. 20) operate on the same principle and are used in the same manner.

Figure 20

Monkey Wrenches. Monkey wrenches are usually used on large, square nuts, but are too bulky for most small jobs. The jaws make an angle of 90 degrees with the handle, and should point in the direction of the pull as shown in Fig. 21.

Box-End Wrenches. Box-end wrenches completely surround the nut or bolthead. Some of these wrenches have six inside faces, but most have 12 notches as shown in Fig. 22. They are known as either "12-point" or as "double-hex" box wrenches, and they

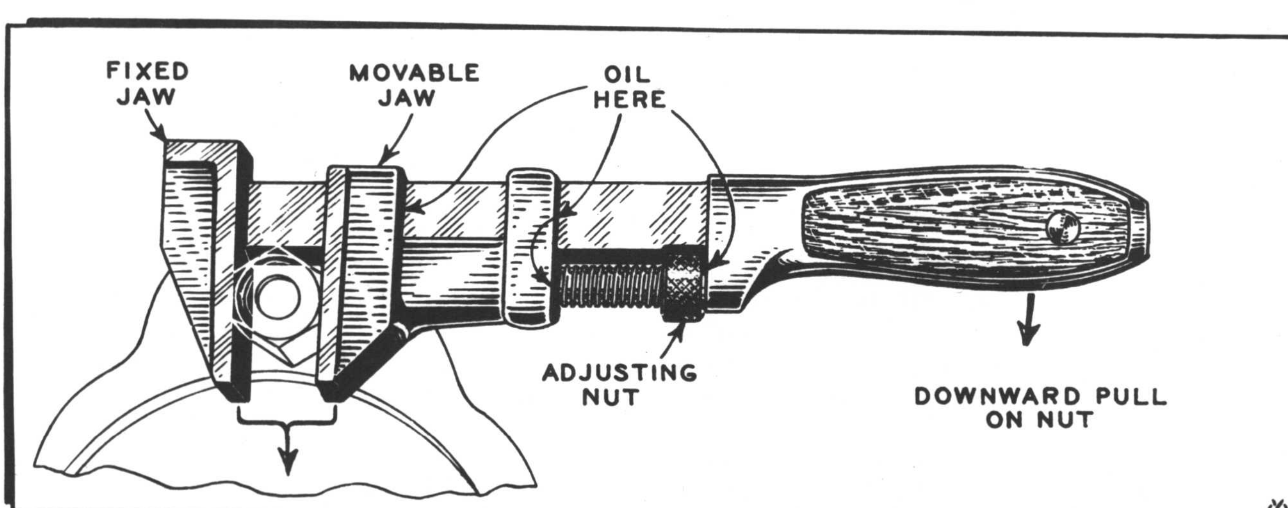


Figure 21

can be used with a minimum swing of 15 degrees. The sides of the "box" opening are thin so that this wrench is suitable for turning nuts which are hard to get at with an open-end wrench.

The *offset wrench* is shown in Fig. 23.

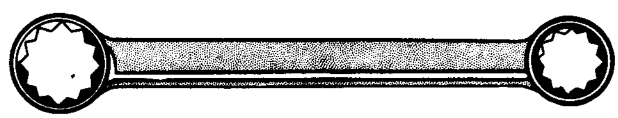


Figure 22. Box end wrenches.

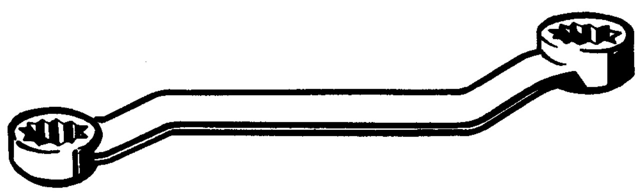


Figure 23. Offset wrench.

Combination Wrench. A combination wrench, which has a box wrench on one end and an open-end wrench on the other (Fig. 24), is used when a tight nut is broken loose. The box end can be used for breaking nuts loose or for snugging them down, and the open end for faster turning.

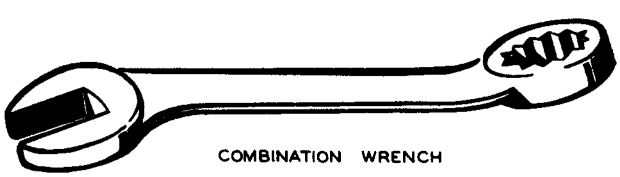


Figure 24

For heavy-duty work, there are long-handled, single, box-end wrenches. They are made only in the larger sizes and all necessary pressure can be safely exerted.

One-piece socket wrenches are made with six inside faces for hex-nuts, or with four inside faces for square nuts. They are one-piece, heavy-duty wrenches and generally are made in the larger sizes. The offset and the straight T-handle types are shown in Fig. 25.

Socket sets contain an assortment of individual sockets made to fit different handles. There are several types of handles, such as the T-handle, ratchet handle, screwdriver-grip handle, and a "speed" handle. The "speed" handle resembles a carpenter's brace. These handles and sockets can be assembled in combinations that will do almost any job quickly and easily (Fig. 26). The sockets have 12-point openings and thin walls (Fig. 27). To use the socket wrench, select a sockethead that fits the nut. Put the sockethead on a suitable handle and then place it over the nut. The sockethead is held on the handle lug by a small friction catch that engages when the sockethead and the handle are forced together.

The *ratchet handle* permits the wrench to be backed up without removing it from the nut, and can be used to turn the nut in either direction. If

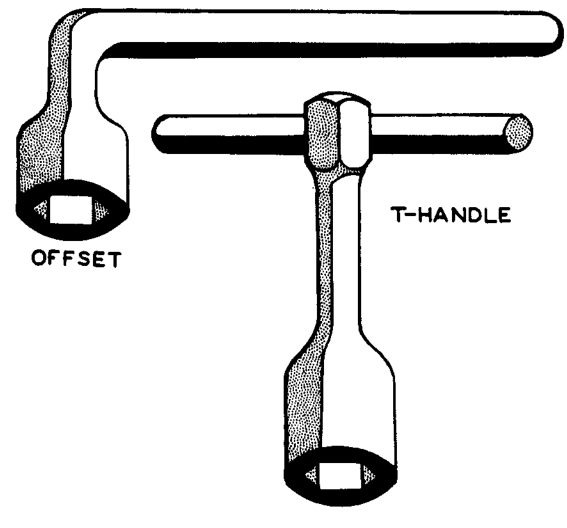
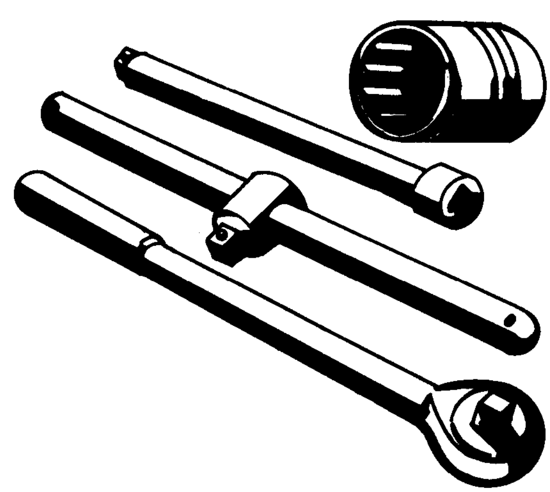


Figure 25



SOCKET HEAD AND HANDLES

Figure 26

such a handle has a *fixed* lug, it will have a "gear-shift" to change the direction. If the lug is *removable,* the working direction can be changed by inserting the lug on the opposite side of the handle.

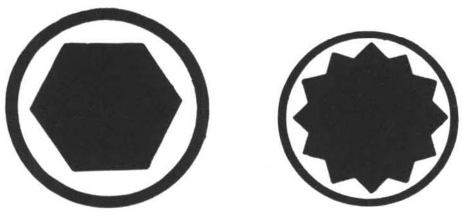


Figure 27

Elaborate socket-wrench sets contain extension bars, T-handles, L-handles, speed handles or "spinners," and universal joints. Special deep sockets can be obtained for removing or tightening spark plugs and for use where the nut is a long way down on the bolt.

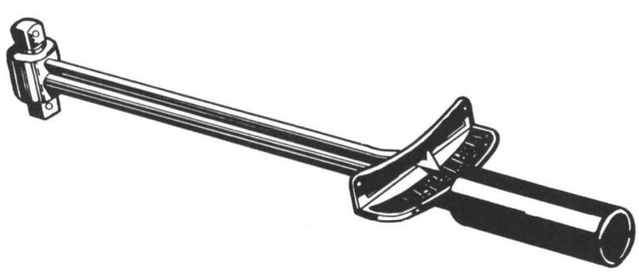


Figure 28

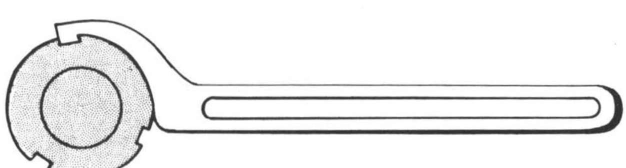


Figure 29

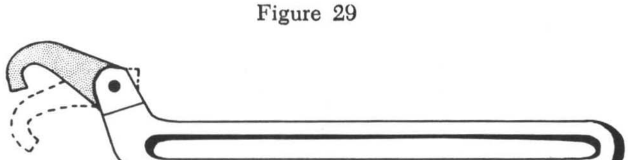


Figure 30

Another accessory for the socket-wrench set is the *torque wrench* shown in Fig. 28. The torque wrench indicates on a scale or dial how great a twist is being exerted, and is used for the final tightening of nuts and studs to prevent twisting them in two or stripping the threads, yet tightening them to the proper degree.

Spanner Wrenches. Spanner wrenches are designed for special purposes. The *hook spanner* (Fig. 29) works on a round nut which has a series of notches cut in its outer surface. The hook or lug is placed in one of these notches and the handle turned to loosen or tighten the nut. The *adjustable spanner* (Fig. 30) is designed to fit nuts of various diameters. *Pin spanners* have a pin (Fig. 31) that fits a round hole in the edge of the nut. *Face-pin spanners* have round pins instead of lugs (Fig. 32).

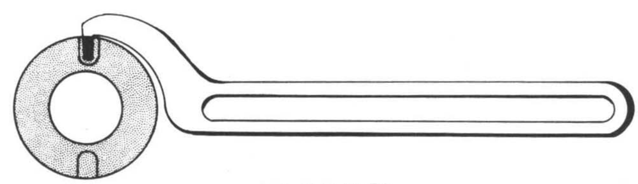


Figure 31

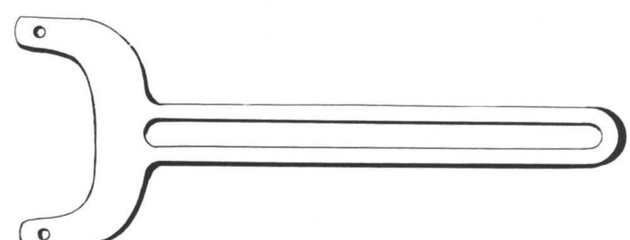


Figure 32

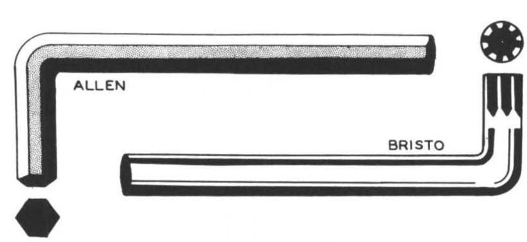


Figure 33

Special Wrenches. Figure 33 shows the *Allen*-type wrench. Its six-sided shaft fits into the hollow hex-shaped recess of setscrews and capscrews. This wrench comes in sizes from 1/8 to 3/4 in., and the