Fundamentals
M7
MAINTENANCE PRACTICES

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M7.3
Tools

EASA Part-66
CAT B1

Training Manual

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M7 MAINTENANCE PRACTICES

M7.3 TOOLS

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COMMON HAND TOOL TYPES AND POWER TOOLS

Punch

Introduction

Punches concentrate the force from a hammer blow to the immediate area of the punch tip.

Punches are generally composed of steel, but can also be made of copper or bronze (to minimize damage to the object being drifted out).

Safety

Eye protection should always be worn when a punch is used. Over a period of time, the end of a punch (particularly the softer metals) will become burred over from repeated hammer blows. This burr can eventually split and small chips fly off; potentially a safety hazard.

The punch end should be ground back to its original shape. Use a hand-file for the softer materials.

Center Punch

A center punch's tip is ground to an angle of approximately 60 degrees and is used to make indentations in metal, so called punch-marks. This helps to prevent 'wander' when starting to drill a hole. Care should be taken not to distort the surrounding material by using too aggressive a blow. When working with thin metal sheets the danger of deformation has to be considered.

Automatic Center Punch

An automatic center punch incorporates an adjustable spring-loaded trip mechanism, negating the requirement for a hammer.

Drift (Taper) Punch

This is used to start when driving out a bolt or pin. Once the taper almost fills the bolt-hole, the job should be finished with a pin punch to prevent damage of the hole.

Pin Punch

Pin punches have a parallel shank and are available in different diameters.

The matching size punch is selected for the diameter of rivet being punched out. During this operation, the structure should be supported (normally with a riveting block) on the opposite face to prevent damage and minimize 'bounce-back'.

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Automatic Center Punch

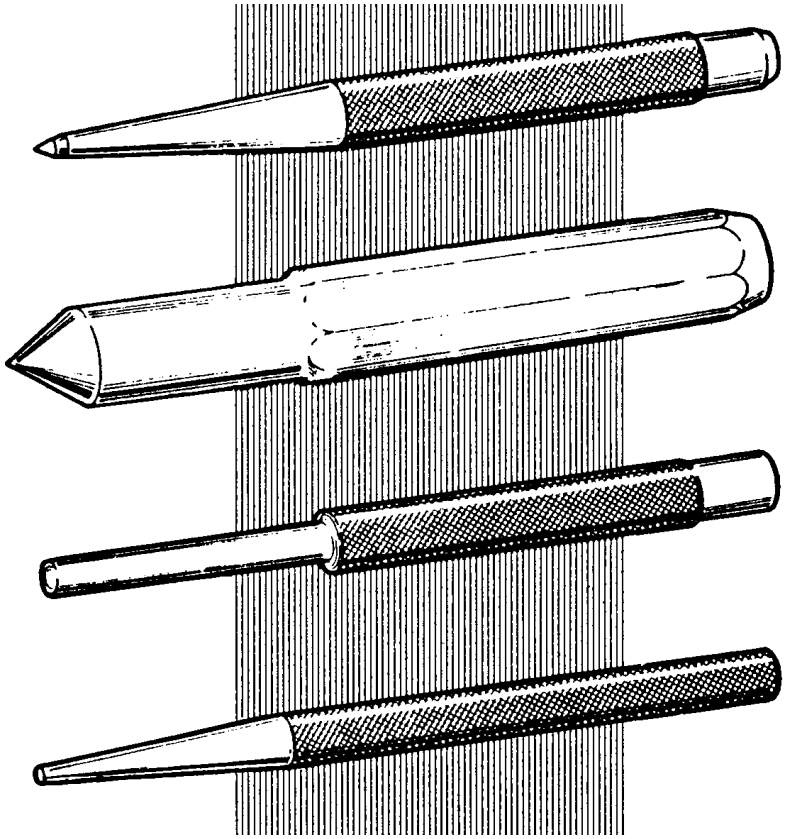




Figure 1 Punches

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Sawing

Introduction

Sawing is mostly used for separating material but also for producing grooves and notches.

A saw blade has many teeth. Their cutting edges are ground. When sawing, at any time more than one tooth must be in contact with the work piece. The teeth remove small chips of the material.

The ground side of the teeth must point in the cutting direction.

The blade fitted in the junior hacksaw has the teeth facing towards the handle; the cutting direction is towards the operator. This is because the saw frame is instable and springy.

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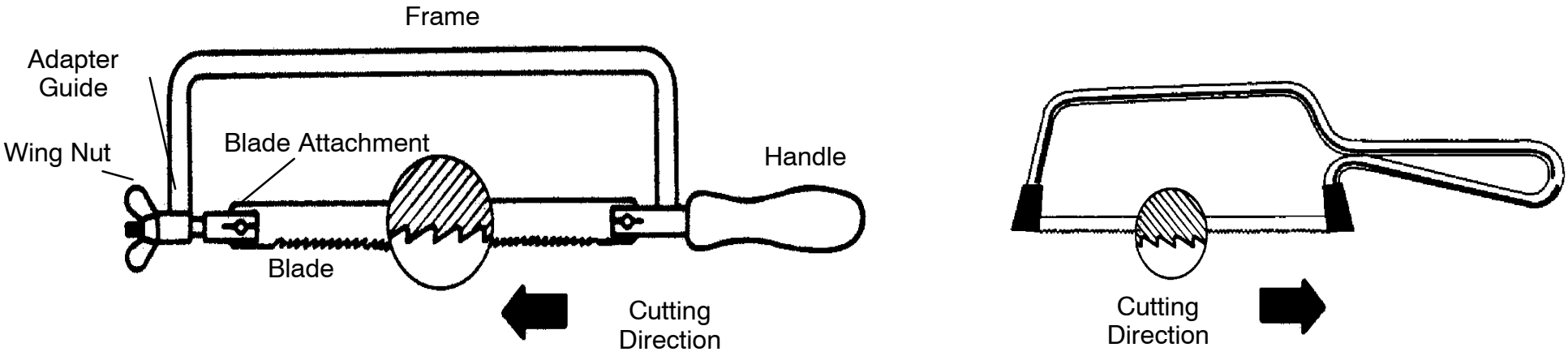


Figure 2 Saws

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SAW BLADE

Pitch

The pitch is the space from one tooth to the next.

Saw blades are rated depending on the number of teeth per one inch of blade length:

- **Coarse:** for soft materials
- **Medium:** for normal materials
- **Fine:** for hard materials

Clearance

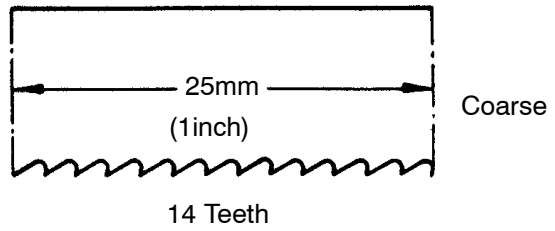
To prevent the saw blade from binding as it cuts into the material, the slot it creates must be greater than the blade thickness.

The saw blade, therefore, must cut the required clearance. This is accomplished by either of the following:

- The teeth are set or
- The blade is waved.

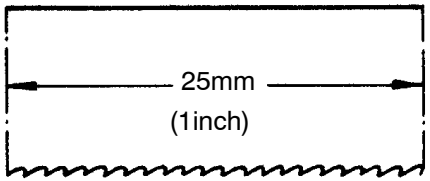
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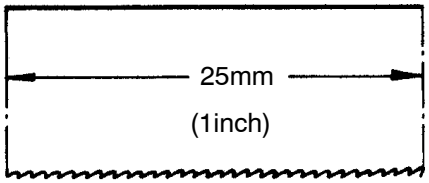
Coarse

14 Teeth



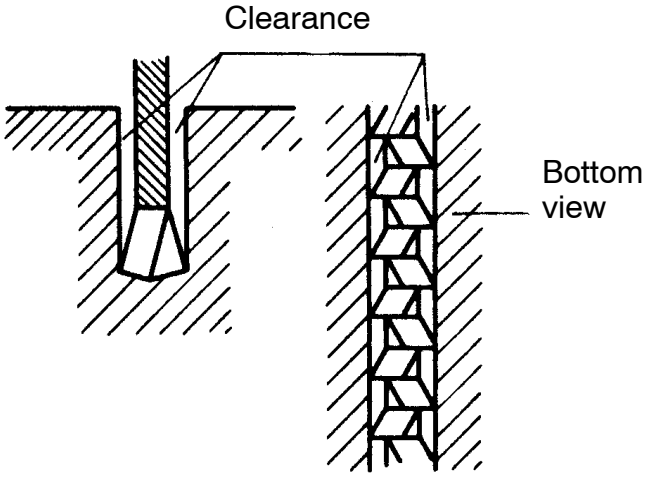
Medium

22 Teeth

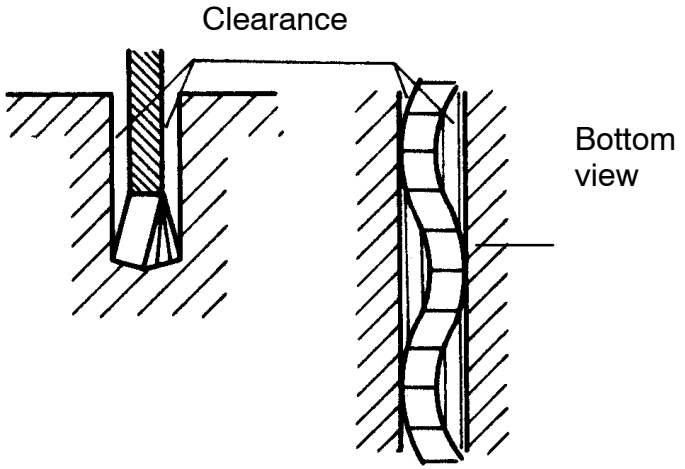


Fine

32 Teeth



Teeth are set



Waved blade

Figure 3 Saw Blade

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SAWING WITH THE HACKSAW

General

Cutting is achieved mostly by arm movement. Moving the body assists the process.

To produce a good cut, start the cut by holding the saw at an angle.

The sawing movement is done with:

- Forward stroke under pressure.
- Return stroke without pressure.

Exception: Coping saw, here proceed the other way around.

To work efficiently the whole blade length has to be used. The sawing should be done with constant movements and constant pressure.

Just before the component is cut through, the pressure should be lowered.

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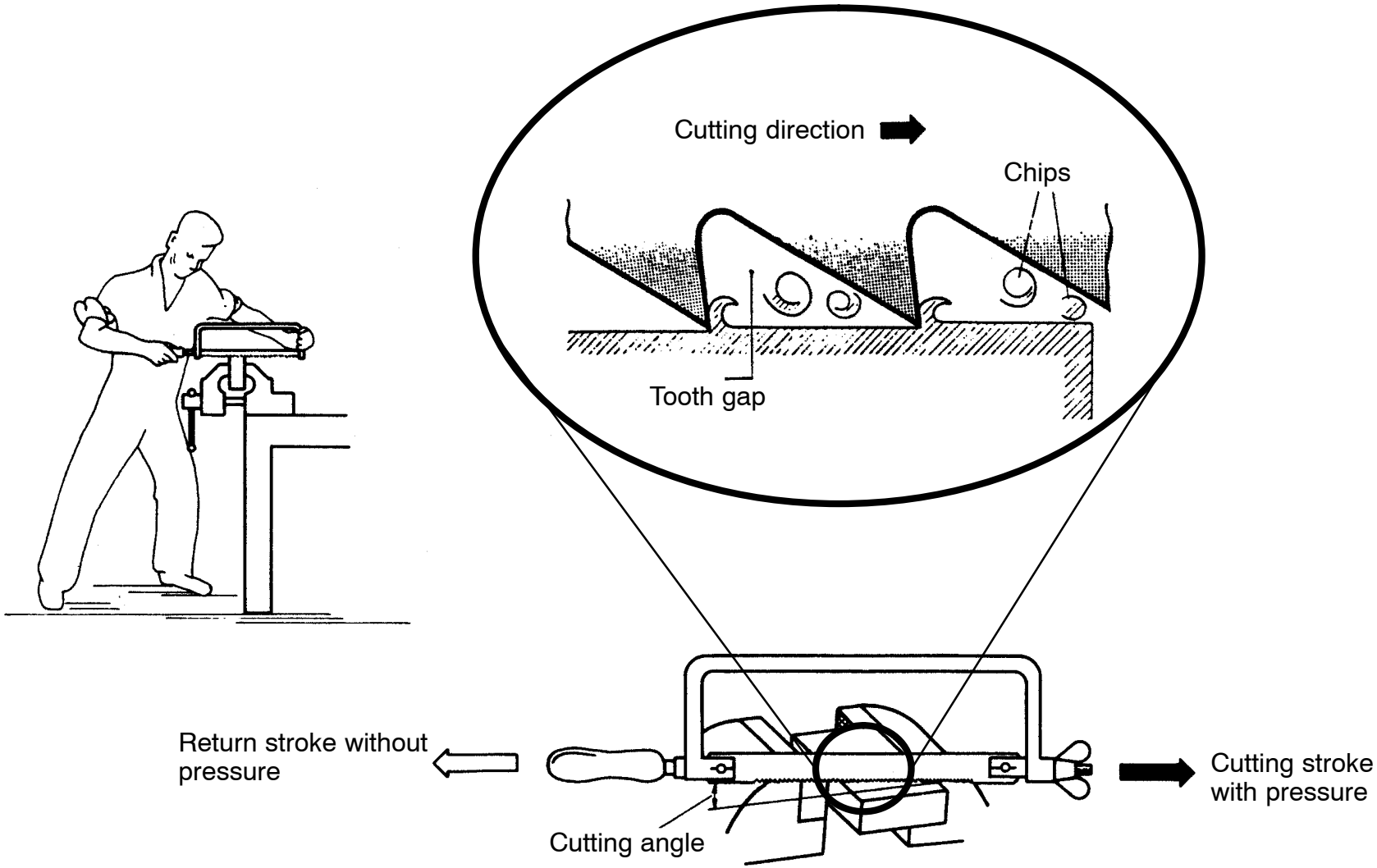


Figure 4 Sawing with a Hacksaw

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Files

Introduction

Filing is a process which removes material from metal or wood, etc.

Filing can be:

- A rough process to alter the size and shape of a part by removing a considerable amount of material.
- A finishing process to smooth a surface without removing much material.

File shapes

The selection of the file shape depends on the size and shape of the surface to be worked.

Flat files

Flat files are used for flat or convex surfaces.

Triangular files

Triangular files have a cross-section that is an equilateral triangle. These files are limited to internal angles greater than 60° .

Square files

Square files are used for filing keyways and for enlarging square or rectangular holes.

Round files

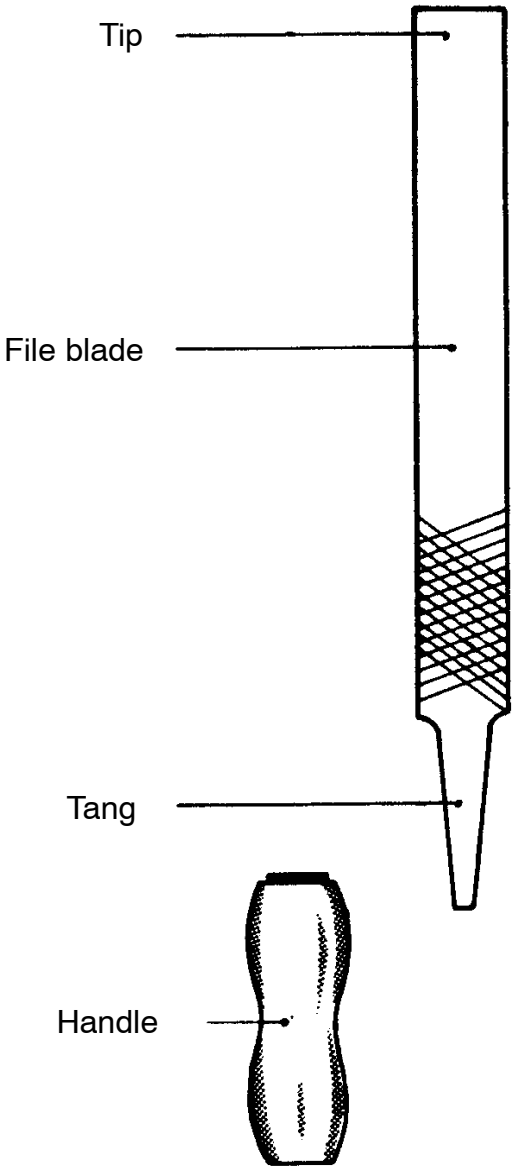
Round files are used to file small inner radii.

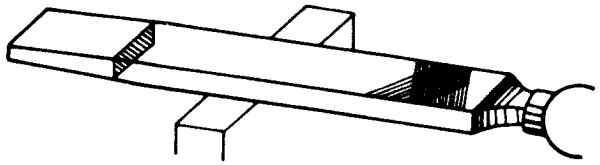
Half-round files

Half-round files have a flat side and a side with a radius. Half-round files are used to file medium and large inner radii.

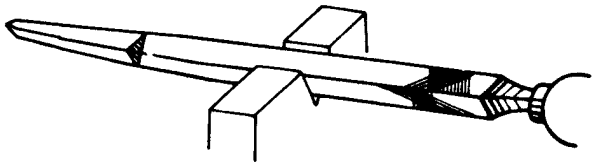
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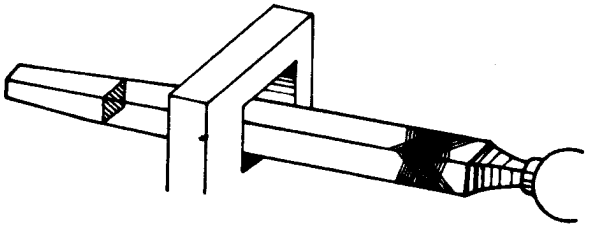




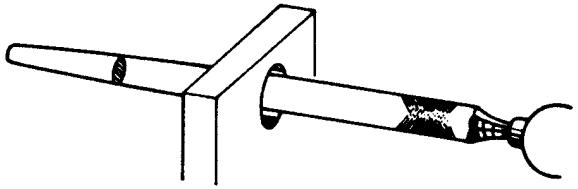
Flat



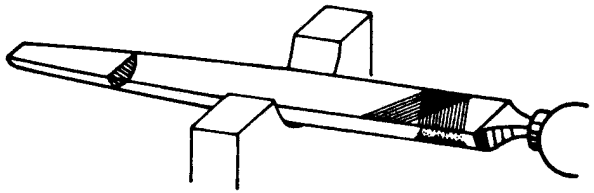
Triangular



Square



Round



Half-Round

Figure 5 Files

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FILE CUTS AND FILE GRADES

File Cuts General

File cuts are divided (with reference to the character of the teeth) into single-cut, double-cut, rasp-cut and curved-tooth.

Single-Cut

Single-cut files are generally used to produce a smooth surface or to file a keen edge and for use on soft metals like lead, zinc or aluminium.

Double-Cut

Double-cut files are used for fast metal removal and where a rough finish is permissible.

Rasp-Cut

A rasp-cut file produces an extremely rough cut and is used on very soft materials, e. g. wood.

Curved-Tooth

A curved-tooth file has a curved form single-cut (often called a 'Dreadnought') and is used to produce a very smooth finish on soft metals such as aluminum.

Grade of cut

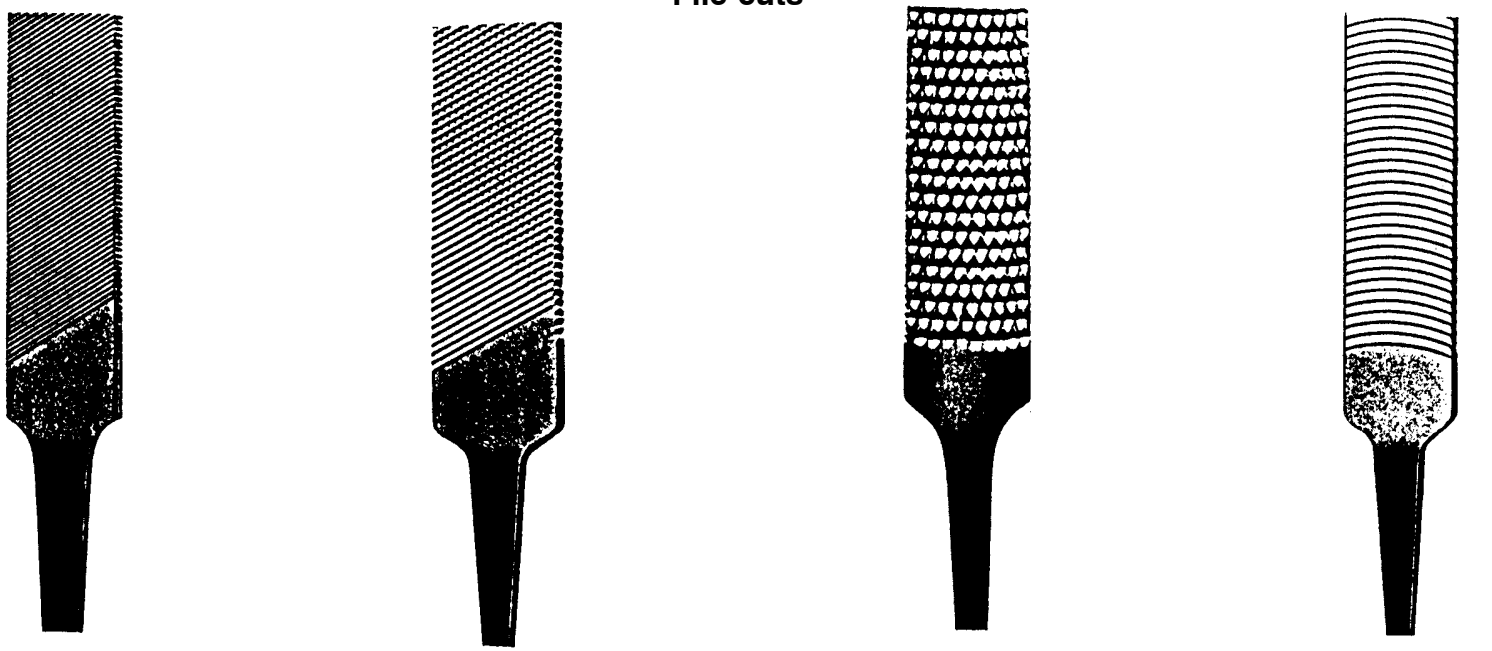
The grade of cut of a file determines the obtained surface finish. The files a classified in grades, which correspond to the intended surface finish:

- Smooth
- Second cut *(not to be confused with Double-Cut)*
- Bastard
- Rough

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File cuts



File Grades



Figure 6 File Cuts and File Grades

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PROPER WORKING POSITION WHEN FILING

Workbench

A well adjusted workbench is important for a proper working position. The upper side of the bench vice should be 5–8 cm (2–3 inch) below your elbow (see picture).

Holding the file

For right-hander:

- Hold the handle with your right hand so that the end of the handle presses against the palm.
- With the palm, or fingertips, of your left hand press down on the file tip.

Left handed persons should hold the handle in their left hand and press on the file blade with the right hand.

Safety

Before using the file ensure that the handle is fixed well at the tang. If necessary the handle has to be fixed.

Always ensure a file in use has a handle fitted - the tang can puncture your hand!

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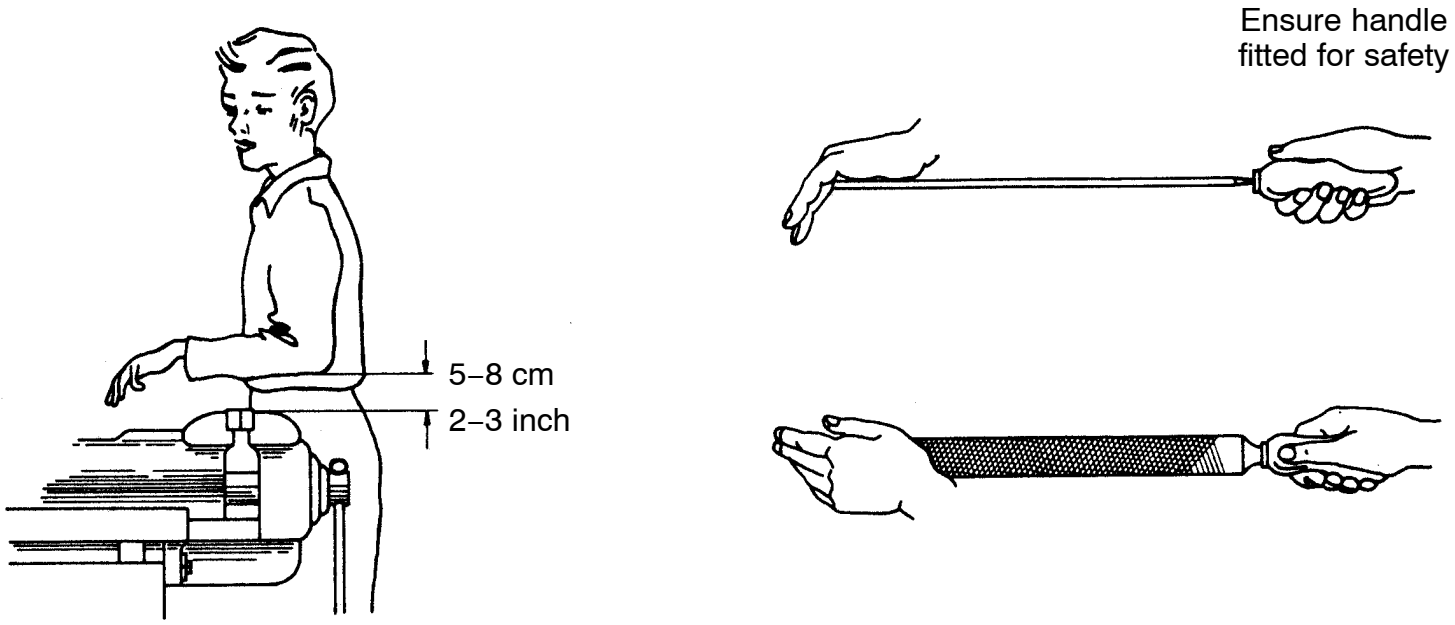


Figure 7 Working Position when Filing

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FILE TECHNIQUE

General

The file movement and so the load transmission is done with the arm muscles, but it can be supported with an evenly body movement.

Move the file in the direction of its longitudinal axis in order to avoid burrs in the work surface.

Pressing on the file

For right hander:

- With your right hand push the file along the longitudinal axis and press it down; with your left hand mostly guide it and only press it down slightly.
- Apply pressure on the forward stroke *only*.
- Return the file without pressure!

Left handed persons do the first point vice versa.

Soft Metals

However, when filing very soft metals (such as lead or aluminum), pressure should be applied on both forward *and* backward strokes. This has the effect of dislodging chips from between the file teeth, which would otherwise make work harder and could cause grooves on the work piece surface.

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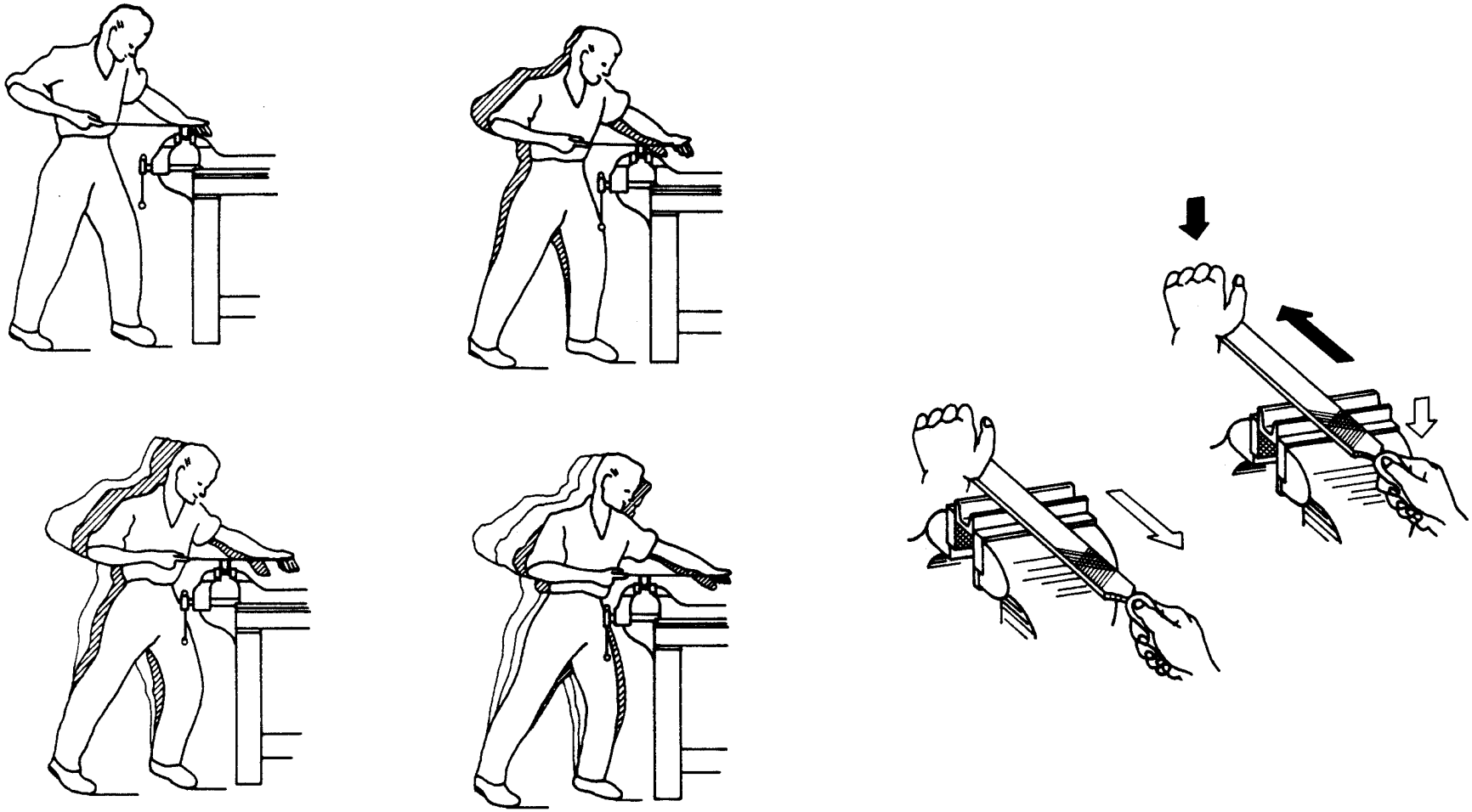


Figure 8 File Technique

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FILE TECHNIQUE (CONT.)

Filing of convex radii (outer radii)

In order to obtain a radius, flat surfaces are filed crosswise to the edge side by side until they approximately form a radius.

The file is moved in the longitudinal direction (90 degrees to the first step) over the surface and is at the same time guided in a luffing movement.

The position of the work in the vice has to be changed frequently in order to produce an accurate radius.

Filing of concave radii (inner radii)

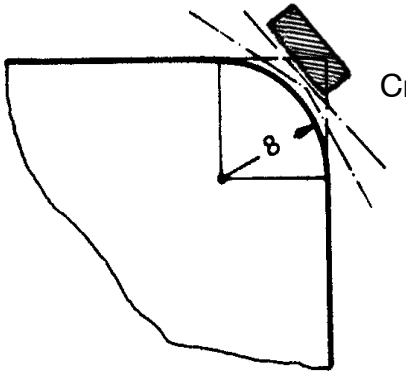
The radius of the round- or half-round-file must be smaller than the radius to be filed.

To produce an even radius it is necessary to advance the file sideways. To prevent burrs, do not feed sideways.

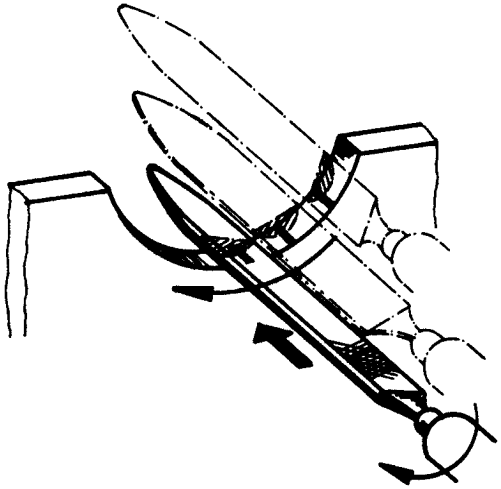
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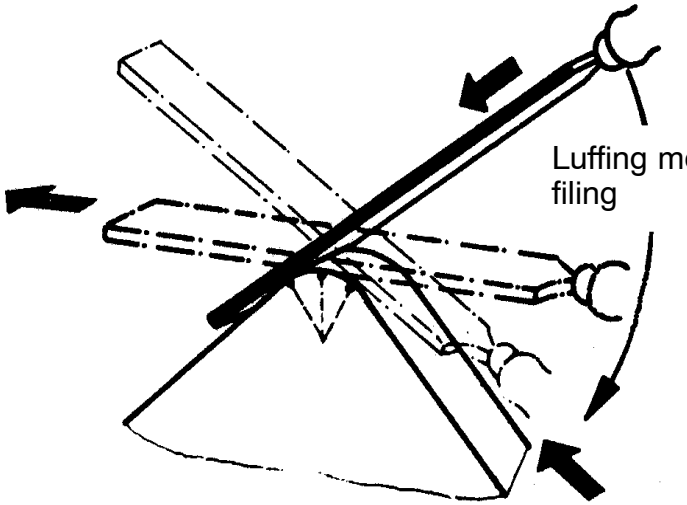
1. Step:



Create several flat surfaces



2. Step:



Luffing movement during filing

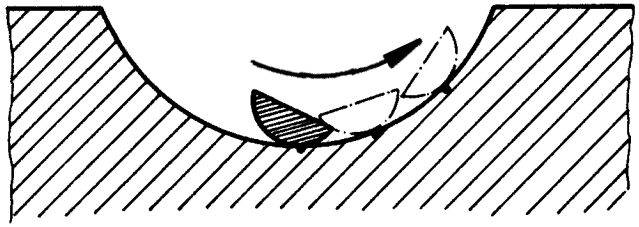


Figure 9 Filing of Radii

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DRAW FILING

For the final finish of raw edges, you can use the draw filing process. The draw filing is also used for breaking edges after machining like sawing or stamping of sheets or other parts

The file is hold crosswise to the edge of the work piece and moved crosswise to the normal feed motion.

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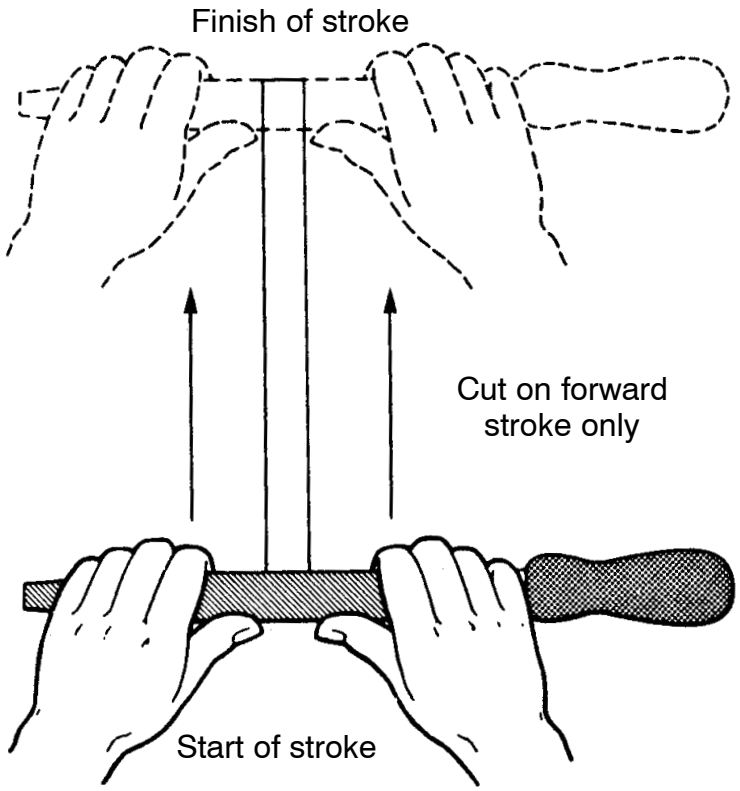


Figure 10 Draw Filing

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CLEANING DIRTY FILES

Files need to be cleaned frequently. A dirty file cannot produce a good finish and acts like a dull file.

You can clean a file with a file brush by brushing across the file in a direction parallel to the teeth.

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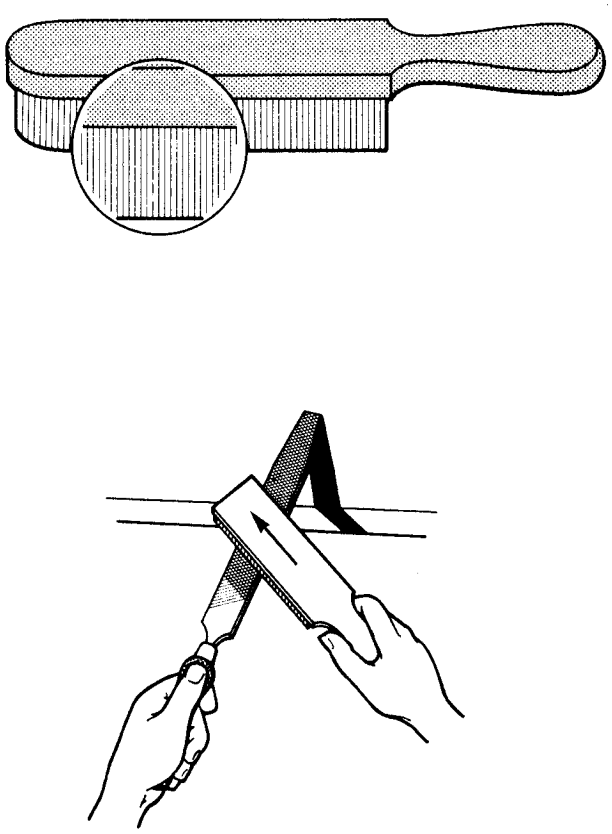


Figure 11 File Cleaning

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Drills

General

Technicians are often faced with the need to drill accurately-sized round holes in order to make attachments and join parts of an assembly. The tool usually used for drilling such holes is the spiral– or twist-drill.

The steel drill usually consists of a cylinder into which has been cut spiral grooves or flutes. One end is pointed and fitted with the cutting edge.

The other end can have different shapes and is used to fit in particular drill chucks of the drill machine.

Drills are made of chromium–vanadium–steel (CV) or high speed steel (HSS).

The CV drills cost less, but they will overheat and lose their hardness when they are used to drill very hard or tough material. For this reason, HSS drills are by far the most economical for use in aviation work.

For every application and material not only the drill, but also drill speeds, cutting agents and pressure for different materials have to be chosen adequately.

Shank

The shank of a drill is the part designed to fit into the drilling machine. It may be a plain cylinder in shape, which is designed for use in a drill chuck on a drill motor, pillar drill or hand drill.

The drill shank may also be tapered, the so called Morse taper, or pyramid–shaped. The tapered drill shank is usually used in pillar drills.

Body

The body of a drill is the part between the point and the shank. It includes the spiral flutes, the lands and the margin.

The body is slightly tapered, being fractionally larger in diameter at the tip than at the shank, thus causing it to bore a hole with clearance to prevent the drill from binding.

Cutting edge

The point of a drill includes the entire cone–shaped cutting end of the drill. The point includes the cutting edges, or lips, which are sharpened when the drill is ground.

Land

The land is the peripheral portion of the body between adjacent flutes.

Flutes

Helical grooves cut or formed in the body of the drill to provide cutting lips, to permit removal of chips and to allow cutting fluid to reach the cutting lips.

Twist drills have one to four spiral flutes. Drills with two flutes are used for most drilling. Those with three or four flutes are used principally to follow smaller drills or to enlarge holes with small tolerances.

Margin

The raised part of the bevel creates a gap between the bore wall and drill and prevents the seizure of the drill.

Extension drill

The extension drill has a long shank for reaching limited–access areas. The drill should not be used unless absolutely necessary.

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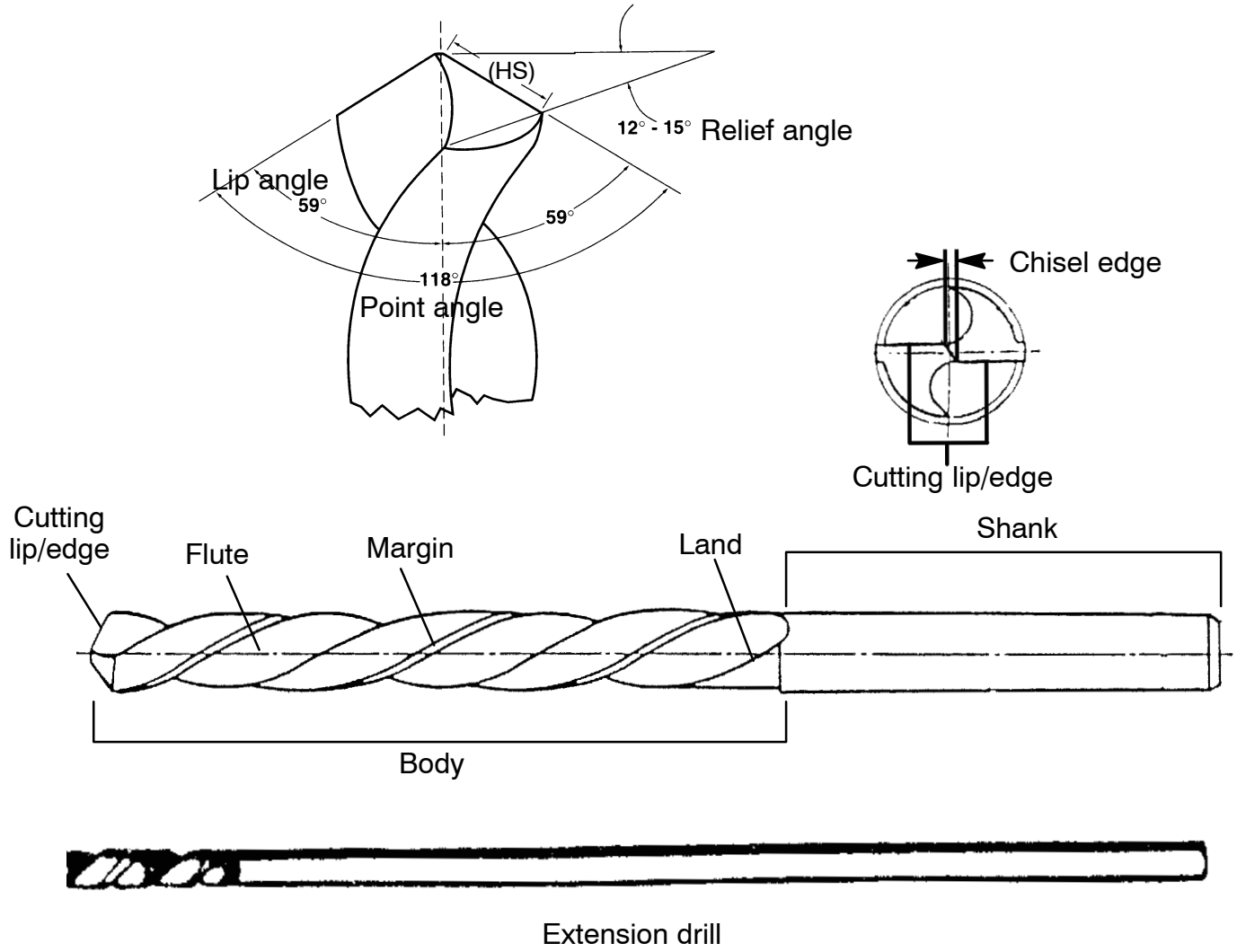


Figure 12 Drills

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DRILLS (CONT.)

Taper shank drills

Tapered shank drills have a taper called the Morse taper. The size of taper incorporated on any particular drill depends on the drill diameter. At the end of the taper shank of a drill is a tongue, called the tang, and when the taper shank is fitted into the socket or machine spindle this tang engages in a slot.

If the taper itself is in good condition, the frictional grip between it and the surface of the taper hole should be sufficient to drive the drill. But on older and often used drills sometimes the force exceeds the friction connection and is then transfused by the tang.

If the drill is jamming in such a case the tang can be twisted off or the whole work piece and fixture may be swept along!

That is why taper shanks should always be well maintained.

The extraction of the drill is done with a matching taper drift through applied into a groove in the machine spindle. With a soft blow or a lever force pressure is applied to the tang of the drill and so the drill can be extracted carefully from the machine spindle.

Machine Spindle

The number of the Morse taper hole in a machine spindle will depend on the size of the machine:

- Morse 1 for small machines
- Morse 4 for large machines.

When a drill has to be accommodated in a spindle with a larger taper than its shank, taper sockets must be used.

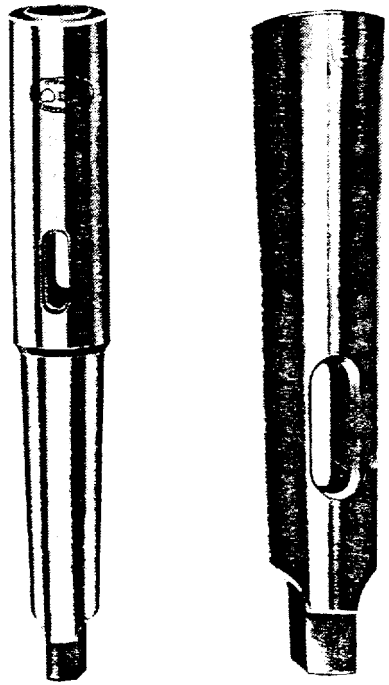
These should also be cared for, because if they become damaged, the drill fitted into them will no longer run true.

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Taper shank drill



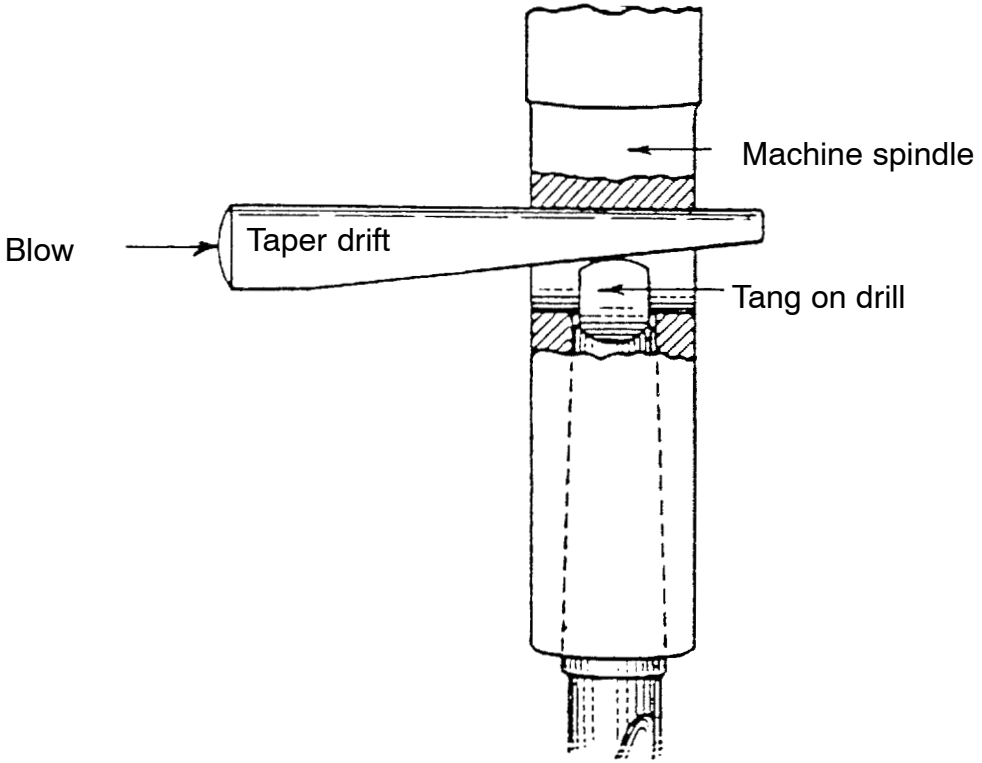


Figure 13 Taper Shank Drills

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DRILL GRINDING

Introduction

Do not use blunt drills or attempt to sharpen them yourself.

To create good holes blunt drills are not suited, they cause bad work results. Return them to the tool shop. The drills will be sent for re-sharpening.

Only machine grinding is sufficiently accurate to produce sharpened drills that will cut holes to the correct size. A hand–sharpened drill usually has the point off–center and will cut oversize holes.

Point- and Relief Angles

Only exactly grinded sharp drills create good holes with an acceptable quality. Especially the symmetry of the cutting lips and the size of the cutting angle are very important.

The point of a general–purpose drill is cone shaped and has a point angle of 118°. This type of point is sufficient for most of the drilling jobs.

For very hard or tough metals, a greater angle at the point is often used. The point angle may be as great as 140° in this case.

For soft metals or fiber, the included angle should be 130°.

The point is ground with a lip relief angle ranging from about 12–15° for drills used in normal hard materials. For very soft materials, this angle is usually increased to somewhere around 18–20°.

Grinding of Drills

In grinding the drill point, it is important to see that the desired point angle and the proper lip–relief angle are obtained.

Further, it is essential that the lengths of the lips be made equal.

Where they are unequal, the drilled hole will be oversize and possible out-of-round.

If the cutting lips are ground with different cutting angles, the drill will bind on one side and may break. Otherwise, it will produce an oversize hole.

Drill Grinding Sequence

1. Adjust the grinder tool rest to a convenient height for resting the back of the hand whilst grinding.
2. Hold the drill between the thumb and index finger of the right or left hand. Grasp the body of the drill near the shank with the other hand.
3. Place the hand on the tool rest with the center line of the drill making a 59° angle with the cutting face of the grinding wheel. Lower the shank end of the drill slightly.
4. Slowly place the cutting edge of the drill against the grinding wheel. Gradually lower the shank of the drill as you twist the drill in a clockwise direction. Maintain pressure against the grinding surface only until you reach the heel of the drill.
5. Check the results of grinding with a gauge to determine whether or not the lips are the same length and at a 59° angle.

Point Thinning

The metal at the center of a drill (the web) tapers and gets thicker towards the shank. This causes the center of a drill point to get thicker as its length is reduced by grinding. To prevent this thick edge from reducing the efficiency of the drill it should be ground thinner.

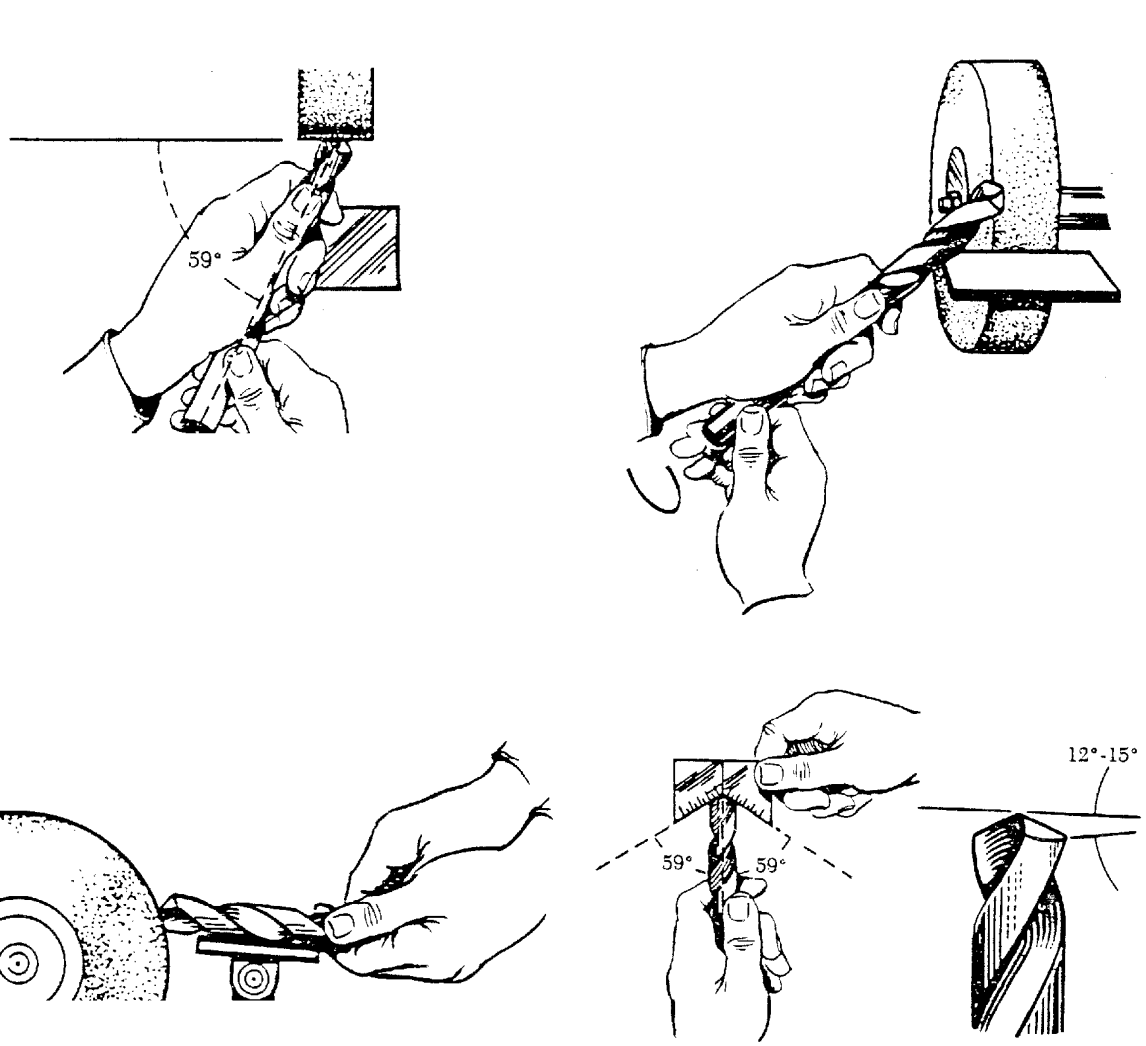
The point thinning of a drill will usually keep the drill in a proper position when starting the hole.

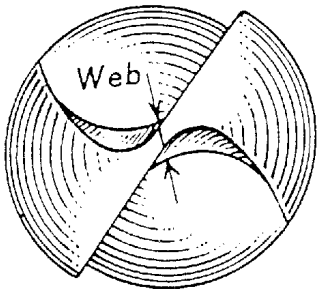
Problems with falsely ground drills

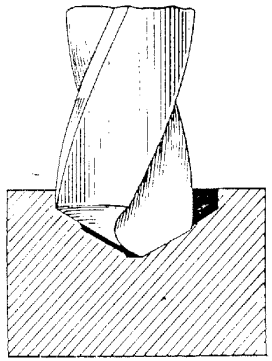
- **Lips of different lengths**: Drill moves off starting position („so called wandering“) and oversize holes are possible.
- **Cutting lips with different angles:** Hole will be enlarged, rough hole surface.

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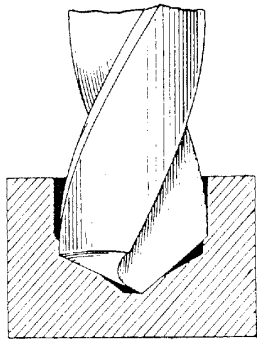
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Lips of Different Lengths



Lips at Different Angles

Figure 14 Drill Grinding

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Drill Machines

Pillar Drill

A pillar drill is a bench−mounted or floor-mounted machine.

The pillar drill is driven by an electric motor through a speed−changing mechanism; either a belt transmission or a gear transmission.

This is an important feature because the speed of rotation of the drill bit should vary in accordance with the type of material being drilled and the size of the hole being drilled.

The pillar drill spindle is either fitted with a standard chuck or provision is made for the insertion of drill bits with tapered shanks (Morse taper).

Most pillar drills are designed to insert small drills into the drill chuck.

Larger drills with taper shanks are inserted directly into the hole in the spindle as a replacement for the drill chuck.

When used correctly, the pillar drill makes it possible to do precision drill work. There should be no play in the spindle, spindle bearing or chuck and all should be in perfect alignment.

The work being drilled must be securely clamped to the pillar drill table so it cannot move during the operation.

The operator of a pillar drill should make certain that the machine speed is adjusted correctly for the work being performed.

Also the point angle has to be chosen most suitable for the material of the work piece and the correct drilling pressure has to be applied with the feed lever.

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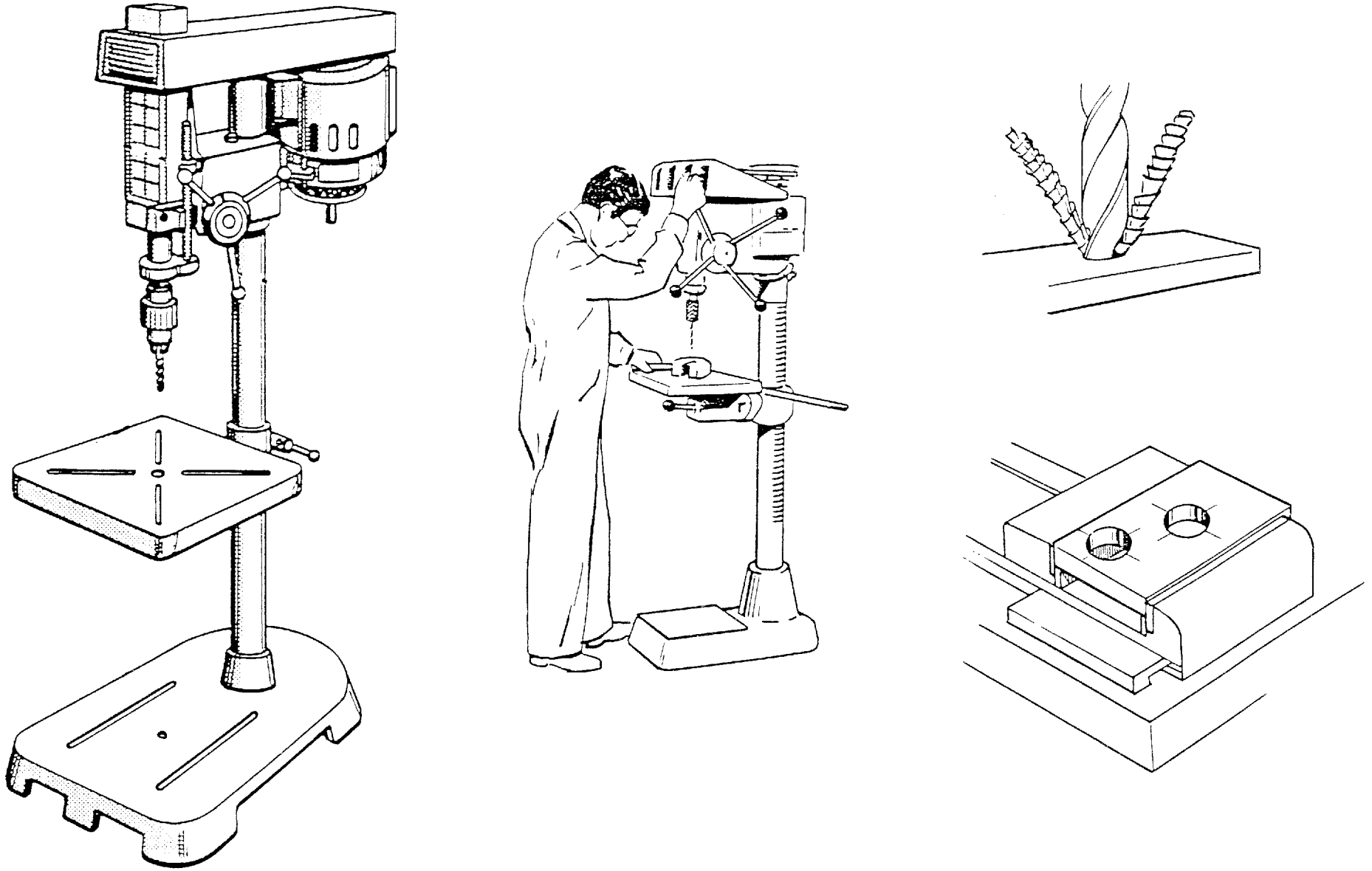


Figure 15 Pillar Drill

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DRILL MACHINES (CONT.)

Hand Held Drill Motor General

The most commonly-used hand held drill motor for drilling aircraft sheet metal is the pneumatic or air drill.

The main advantage of an air drill over an electric drill is safety. Sparking in the motor of an electric drill can ignite fuel or oil vapor.

It is also far less hazardous to have air hoses in the crowded aircraft structure than to have electrical cables.

Another advantage is the control offered by air drills. By varying trigger pressure we can make them run slow, intermediate or high speed and there is always adequate torque.

Air drill motors are equipped with quick-change chucks or keyed chucks.

Hand Held Drill Motors with a Straight-grip or a Pistol-grip

The pistol-grip or straight drills are the most often-used drill motors. These tools are ordered by drill power and speed.

Because of their compact dimensions these drill motors can well be applied in difficult environment, like e. g. limited space.

Angle Drill Motors

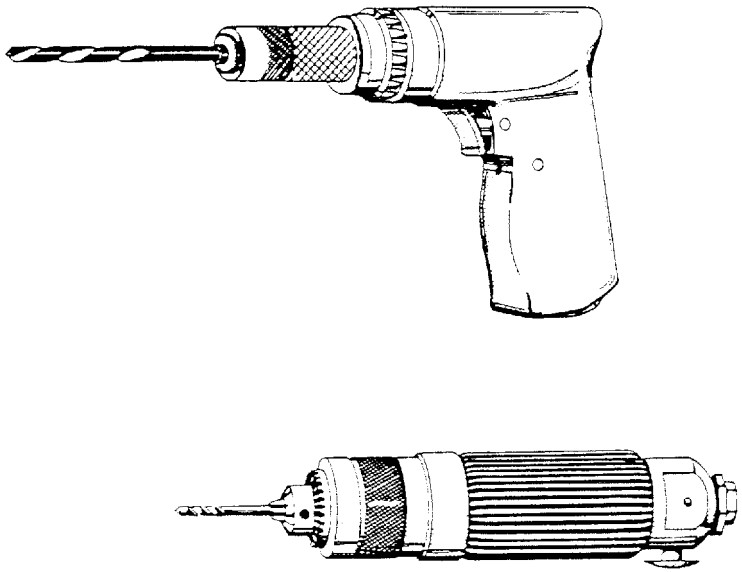
Angle drill motors are used in environments, in which a straight-grip or a pistol-grip drill motor can not be used due to limited space and access or due to the work piece geometry.

They are especially often needed when working at the aircraft structure and aircraft components.

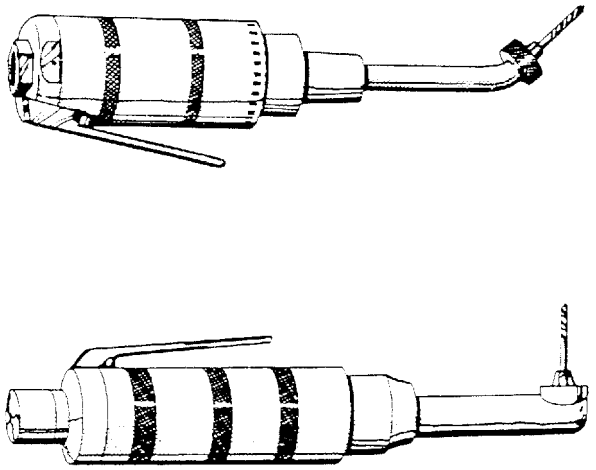
Angle drill motors are available with various cranks, e. g. 90°, 30°, etc.

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Hand Held Drill Motor with Pistol- and Straight-Grip



Angle Drill Motor

Figure 16 Hand Drills

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DRILL MACHINES (CONT.)

Flat Offset Drilling Head

Another tool designed for use in close quarters is the flat offset drilling head or „pork chop”.

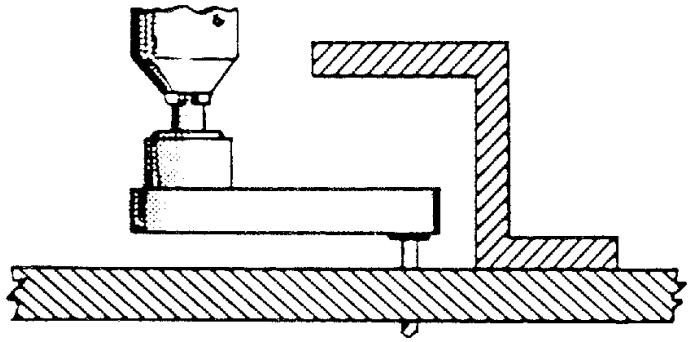
This tool allows the work application in limited space areas through an ancillary transmission. Because of the ancillary transmission an offset is assured and through the very flat height of the transmission an entry into tight interstices is possible.

Flexible Snake Drill

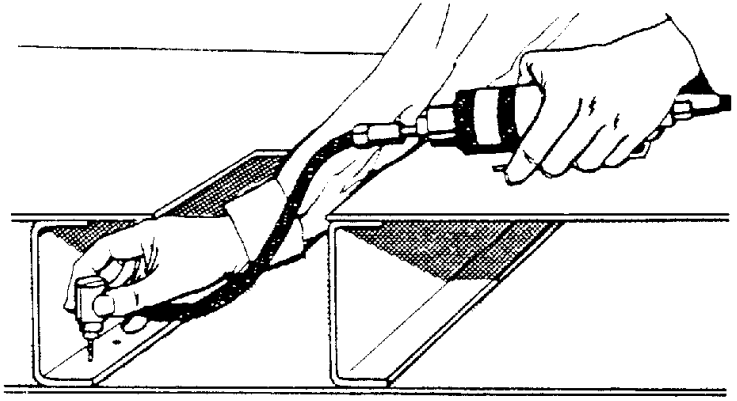
The flexible snake drill is used only in limited−access areas where an angle drill motor cannot be held perpendicular to the surface. The drill motor should be held in one hand, the snake drill steadied with the other.

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Flat Offset Drilling Head



Flexible Snake Drill

Figure 17 Special Hand Held Drill Motors

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DRILL MACHINES (CONT.)

Hand Drill

The hand drill is a simple drilling device, in which a drill is turned with manual power through a transmission.

Since the revolution speed is very low, the hand drill is only suited for drilling, countersinking or chamfering of small holes in materials with low strength.

The hand drill consists out of a drill chuck, a grip, an operating handle, a pad and a transmission.

Hand Drill Handling

- Position for vertical drilling:

  One hand is used for rotating the operating handle and the other for pressing the drill down.
- Position for horizontal drilling:

  One hand is used for rotating the operating handle, the other holds the grip and pressure is exerted with the chest.

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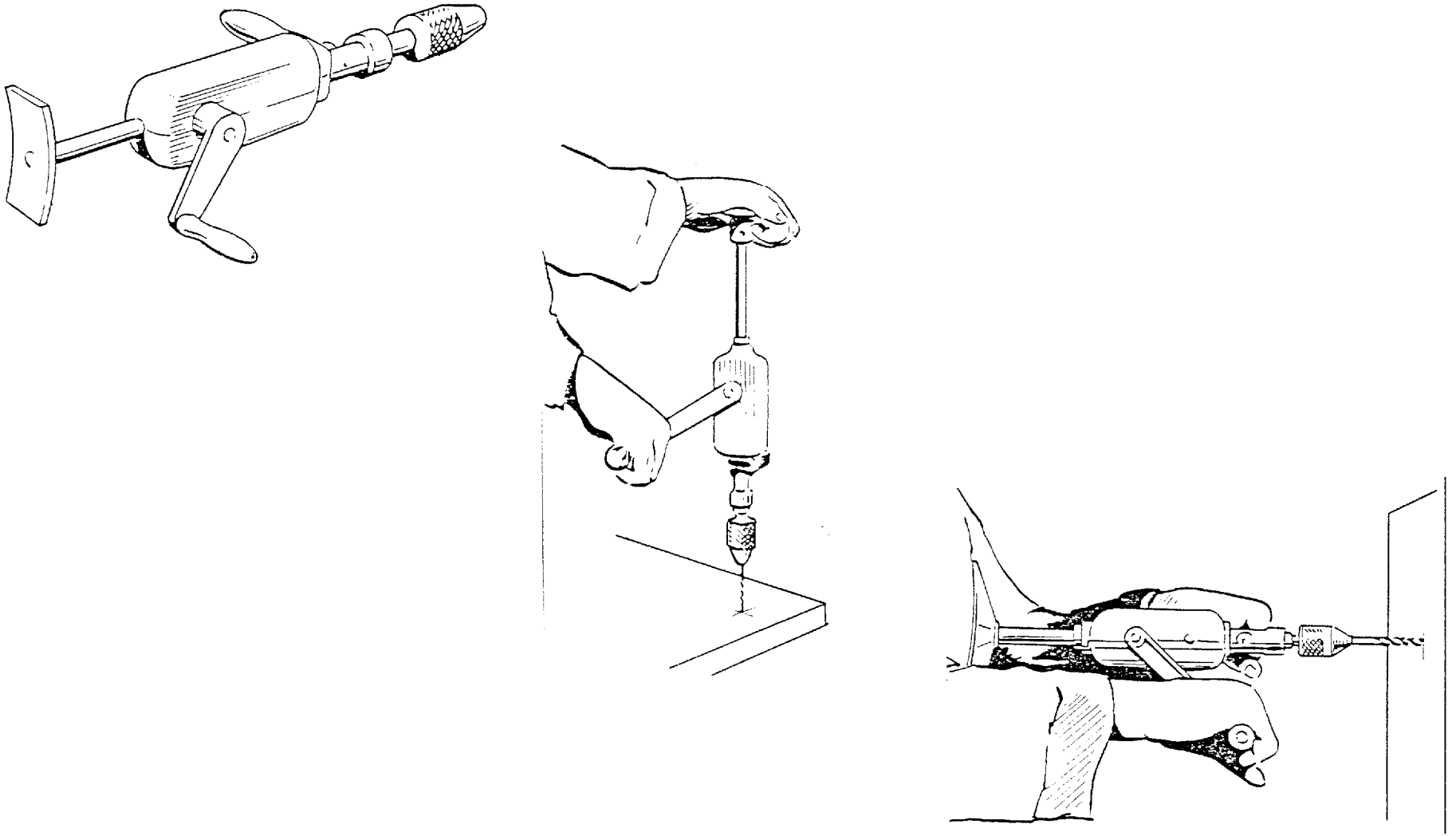


Figure 18 Hand Drill

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THE CHUCK OF A DRILL MACHINE

Using the Keyed Chuck

The chuck of a drill machine is a tool which tightens the drill, countersinking bit, reamer, etc.

Before usage of these chucks the following points have to be kept in mind:

- The chuck key must match to the keyed drill chuck, which means it must have the correct size.
- The key should mesh easily but firmly with the teeth of the chuck.
- The key should be used with adequate pressure, to prevent it slipping.
- Turn the key counter–clockwise until the tool slips easily into the chuck jaws.
- Turn the key clockwise and tighten the tool securely in the jaws, using at least two different keyholes, to ensure a correct fit.
- Check the tightness of the tool. If necessary, tighten further, using the third keyhole.

Safety Precautions

Do not tighten the chuck by holding it in your hands with the motor running. This practice can cause injury and can also damage the chuck or the drill.

Do not start the motor with the key in the chuck; the key can cause injury**.**

The power or air supply should be disconnected whilst working with the chuck.

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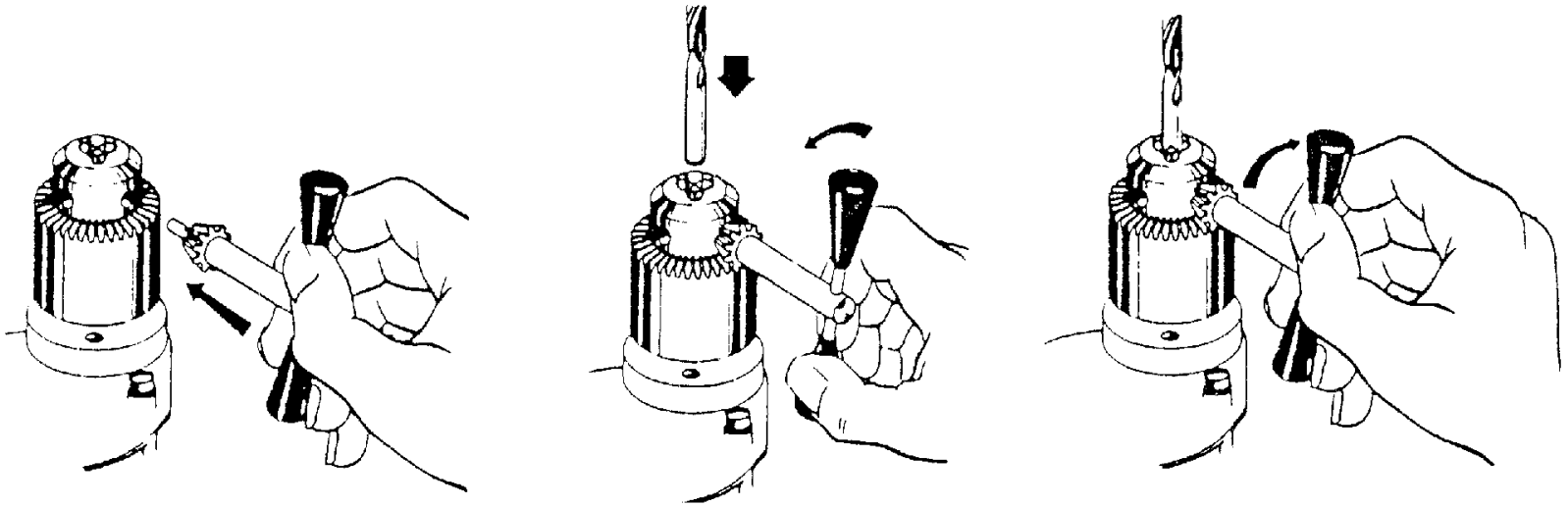


Figure 19 Keyed Chuck with Key

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DRILLING WORK SEQUENCE

Using the Drill:

1. Hold the drill motor as shown. Notice that the thumb and forefinger of one hand are used to steady the motor. This method can be used only with a short drill.
2. Put the drill point on the spot to be drilled.
3. Keep the drill perpendicular to the surface being drilled. If necessary use a drill guide.
4. When drilling thick material (two or three times drill diameter or more), withdraw the drill from the hole periodically to prevent chips from packing in the drill flutes. Tightly-packed chips can cause an oversized, scarred hole.
5. Use just enough pressure to allow the drill to cut its way through the metal. Never force the drill; this can cause drill breakage, separation of parts or oversize or out−of−round holes.
6. Ease the pressure just as the drill point breaks through the material, drill the rest of the hole with this reduced pressure.
7. When drilling through the whole profile the drill should not poke out of the hole too much to prevent damage on adjacent structure or injury of persons. As an aid you can use a drill-stop.
8. The withdrawing of the drill from the hole is done with the motor running. Here the RPM can be reduced. The rotation of the drill prevents vertical grooves!
9. Keep the motor running until the drill is withdrawn from the hole completely.

Hints:

- For soft metals use a drill with a quick twist to its flutes, and vice versa for hard metals.
- For drilling use suitable cutting- and cooling compound or fluid.
- If the hole surface is rough, the cutting speed or feed is too high. Another cause could be a damaged minor cutting edges or a damaged land of the drill.
- For holes larger than 3.2mm, it is necessary to initially drill a pilot hole and enlarge it to the required hole size.
- Parts that will be assembled together also have to be drilled together.
- If two or more sheets are drilled together a good temporary fastening is necessary to prevent turning.

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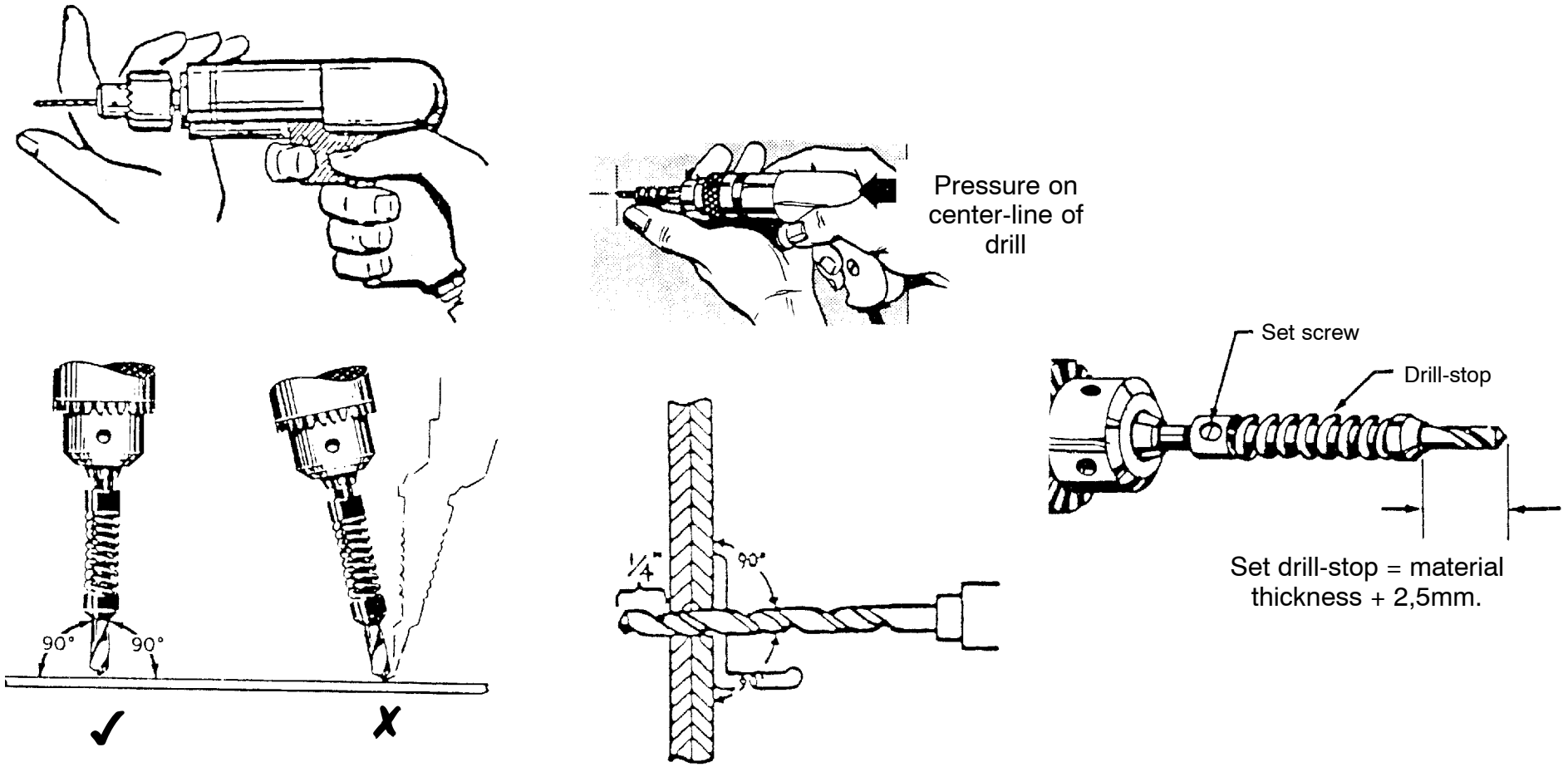


Figure 20 Drilling Work Sequence

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DRILLING SAFETY PRECAUTIONS

Safety Precautions and Guidelines for Drilling

The following safety precautions and guidelines have to be followed in every case, to prevent personal injuries and also possible structural damages or to minimize them.

- When drilling, safety glasses, goggles or face shields must be used to protect the eyes.
- Do not wear gloves when drilling. Do not wear clothes which can be entangled with the spindle.
- Remove the chuck key before starting the drill motor. Serious injury may otherwise result.
- When drilling through structure, give warning to anyone who may be on the opposite side.
- Use drill stops. They will protect aircraft skin material and understructure, as well as personnel.
- Use extreme care when drilling with extended drills.
- Limit drill speed to a maximum of 6000 RPM for all drills longer than three inches (5 cm).
- Use only a sharp drill with the correct point angle.
- Never use a drill that is bent.
- Select a drill motor suited to job requirement: size, speed, range and configuration.
- Use the shortest drill practicable.
- If you drill magnesium or titanium alloys, ensure that there is a fire extinguisher next to you.
- Prevent your hair becoming entangled with the spindle of the boring machine.

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WORK CLAMPING

General

The necessity for clamping cannot be understated because unclamped or insecurely clamped work is not only a cause of inaccurate work and broken drills, but also a danger to the operator.

The chief danger in drilling occurs just as the drill point breaks through at the underside of the part being drilled.

When feeding the drill, pressure should be eased off when the point is felt to be breaking through.

Special care is necessary when drilling thin plate, as the drill point often breaks through before the drill has cut its full diameter.

Pillar Drill Clamping

To secure work when using the pillar drill a vice, clamps and dogs are often used.

Vice

Most work will be secured by using a vice. The main use of the vice is to hold the work during drilling, reaming etc. in the correct position. By holding the handle of the vice, the vice and so the work piece is saved against turning.

Care should be taken to ensure that when the drill passes through the work it does not drill into the bottom of the vice.

Clamps and Dogs

The tables of most pillar drills are provide with either T-slots to accommodate bolt heads or long slots running through to enable bolts and clamps/dogs to be used.

Clamps and dogs are used if the part can not be clamped by a vice due to the part's dimensions.

Hand Drill Clamping

When using a hand drill motor, the work to be drilled must be properly secured so it cannot move.

It should never be held by hand because, in the event of a broken drill, the broken end may pierce the hand or a finger, causing a painful injury.

Angle vices, pin vices, hand vices etc. are to be used to hold the work to be drilled in position.

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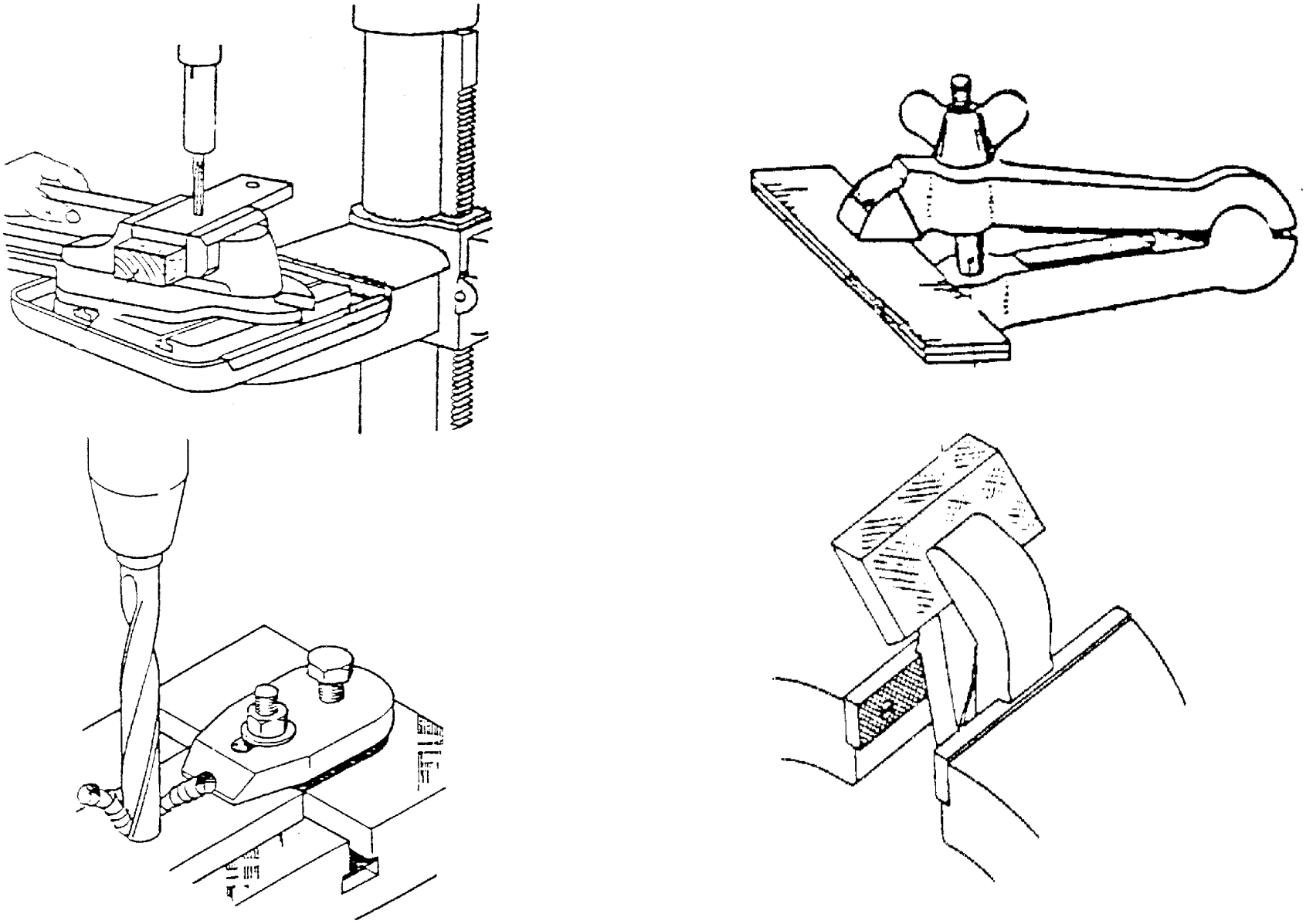


Figure 21 Work Clamping

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DRILLING AIDS

Drill Stop

The drill stop is used as a block and is available in the most common drill diameters. The drill stop locks onto the drill with a set screw.

The drill stop has the following functions:

- Limit the hole depth
- Prevent the danger of break through
- Eliminates surfaces marks
- Prevent drill breakage

Drill Guide

The hand-held drill guide keeps the drill 90° to the skin surfaces.

The guide assembly consists of a plastic housing and special screw in type hardened steel bushing.

The drill guide is available in the common drill diameters.

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Figure 22 Drill Stop and Drill Guide

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DRILL AIDS (CONT.)

Nut Plate Drill Jig

The nut plate drill jig is designed for accurate drilling of rivet holes for nut plates (sometimes called 'anchor-nuts'). There are a lot of different drill jigs available.

Drill Jig Handling

1. Align the pilot with the pilot hole, adjust the jig and drill the first hole.
2. Turn the Jig 180 degrees and align the pilot with the pilot hole, pilot-pin the hole drilled in the first operation and then drill the second hole.

Hole Finder

When replacing an old skin with a new one, if there are no pilot holes drilled in the new skin it is quite difficult to precisely locate the holes in the structure. For this procedure, a hole finder (sometimes called a 'back-marker') may be used.

The hole finder consists out of two metal stripes lying upon another and is slipped sideways over the new skin.

A short pin in the lower metal stripe is used as a thorn and is inserted into the hole in the structure.

A bushing in the top side guides the drill in making a hole in the new skin that will align with the one in the structure.

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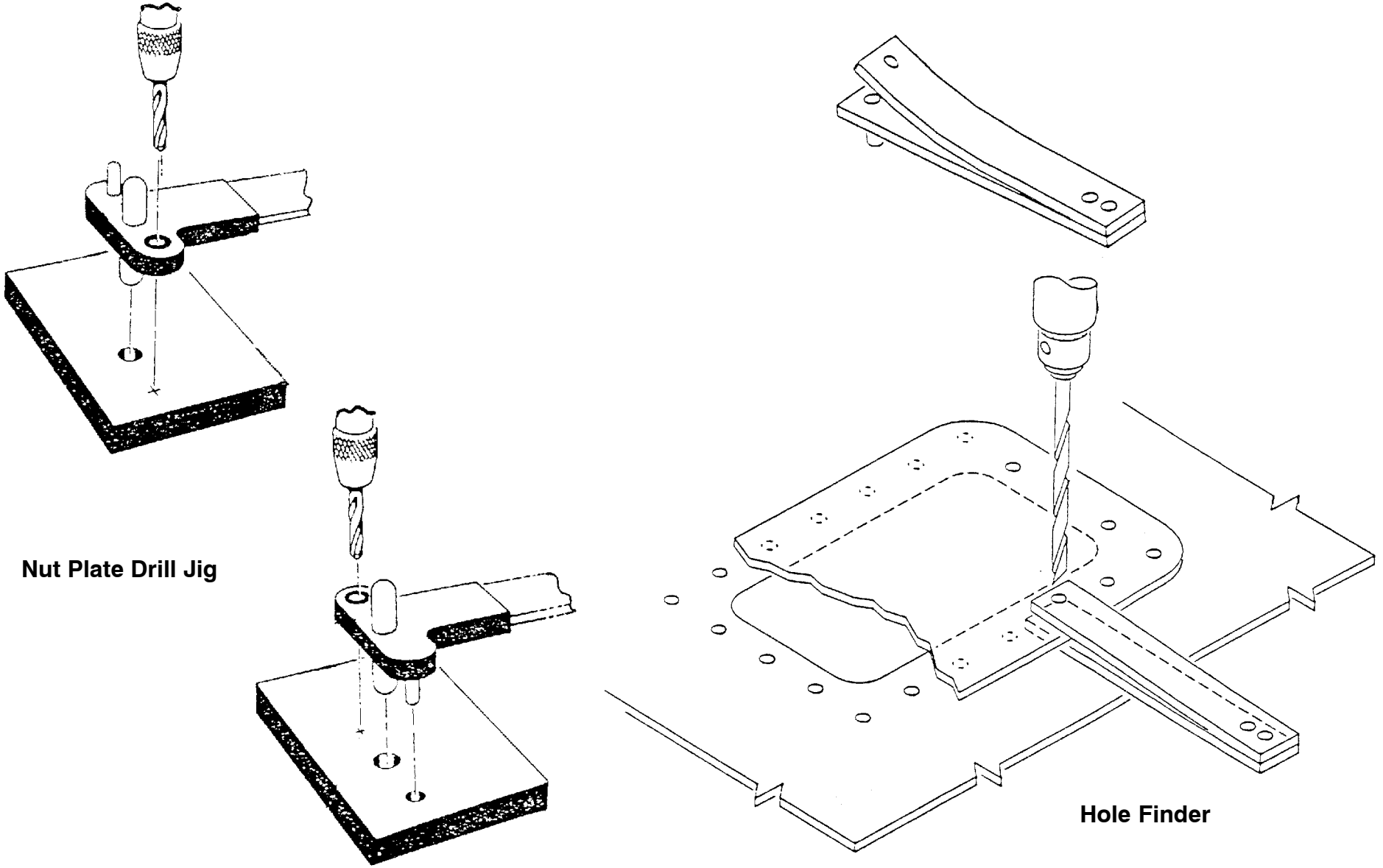


Figure 23 Nut Plate Drill Jig and Hole Finder

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DRILLING SIZES

General

Twist drills used in aircraft sheet metal are given in Millimeters, Inches or number drill sizes.

The diagram shows a twist–drill size chart that lists sizes from 1/16 inch (1,588mm) up to 5/16 inch (7,938mm).

The diagram shows all three alternatives for the denomination. It has to be noticed that there is not a gauge value, letter value or a fraction (Inch) for every mm diameter.

There are, of course, drill sizes smaller and larger than those listed, but they fall outside of the general use of the aircraft mechanic.

Classification Number

When drills are denominated with a classification number or letter the diameter can not directly be read, but can be determined from a diagram.

A No. 80 drill is much smaller than the No. 1 drill.

Classification Letter

In addition to the number drills, there are letter drills from A to Z, with A being the smallest.

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DECIMAL EQUIVALENTS

Frac.	mm	Gauge	Inch	Frac.	mm	Gauge	Inch
1/16	1.588		.0625		2.705	36	.1065
	1.60		.0630		2.75		.1083
	1.613	52	.0635	7/64	2.778		.1094
	1.65		.0650		2.794	35	.1100
	1.70		.0669		2.80		.1102
	1.702	51	.0670		2.819	34	.1110
	1.75		.0689		2.85		.1122
	1.778	50	.0700		2.870	33	.1130
	1.80		.0709		2.90		.1142
	1.85		.0728		2.946	32	.1160
	1.854	49	.0730		2.95		.1161
	1.90		.0748		3.00		.1181
	1.930	48	.0760		3.048	31	.1200
	1.95		.0768		3.10		.1220
5/64	1.984		.0781	1/8	3.175		.1250
	1.994	47	.0785		3.20		.1260
	2.00		.0787		3.25		.1280
	2.05		.0807		3.264	30	.1285
	2.057	46	.0810		3.30		.1299
	2.083	45	.0820		3.40		.1339
	2.10		.0827		3.454	29	.1360
	2.15		.0846		3.50		.1378
	2.184	44	.0860		3.569	28	.1405
	2.20		.0866	9/64	3.572		.1406
	2.25		.0886		3.60		.1417
	2.261	43	.0890		3.658	27	.1440
	2.30		.0906		3.70		.1457
	2.35		.0925		3.734	26	.1470
	2.375	42	.0935		3.75		.1476
3/32	2.381		.0938		3.797	25	.1495
	2.40		.0945		3.80		.1496
	2.438	41	.0960		3.861	24	.1520
	2.45		.0965		3.90		.1535
	2.489	40	.0980		3.912	23	.1540
	2.50		.0984	5/32	3.969		.1562
	2.527	39	.0995		3.988	22	.1570
	2.55		.1004		4.00		.1575
	2.578	38	.1015		4.039	21	.1590
	2.60		.1024		4.089	20	.1610
	2.642	37	.1040		4.10		.1614
	2.65		.1043		4.20		.1654
	2.70		.1063		4.216	19	.1660

DECIMAL EQUIVALENTS

Frac.	mm	Gauge	Inch	Frac.	mm	Letter	Inch
	4.25		.1673	15/64	5.953		.2344
	4.30		.1693		6.00		.2362
	4.305	18	.1695		6.045	B	.2380
11/64	4.366		.1719		6.10		.2402
	4.394	17	.1730		6.147	C	.2420
	4.40		.1732		6.20		.2441
	4.496	16	.1770		6.248	D	.2460
	4.50		.1772		6.25		.2461
	4.572	15	.1800		6.30		.2480
	4.60		.1811	1/4	6.350	E	.2500
	4.623	14	.1820		6.40		.2520
	4.70	13	.1850		6.50		.2559
	4.75		.1870		6.528	F	.2570
3/16	4.762		.1875		6.60		.2598
	4.80	12	.1890		6.629	G	.2610
	4.851	11	.1910		6.70		.2638
	4.90		.1929	17/64	6.747		.2656
	4.915	10	.1935		6.75		.2657
	4.978	9	.1960		6.756	H	.2660
	5.00		.1969		6.80		.2677
	5.055	8	.1990		6.90		.2717
	5.10		.2008		6.909	I	.2720
	5.105	7	.2010		7.00		.2756
13/64	5.159		.2031		7.036	J	.2770
	5.182	6	.2040		7.10		.2795
	5.20		.2047		7.137	K	.2810
	5.220	5	.2055	9/32	7.144		.2812
	5.25		.2067		7.20		.2835
	5.30		.2087		7.25		.2854
	5.309	4	.2090		7.30		.2874
	5.40		.2126		7.366	L	.2900
	5.410	3	.2130		7.40		.2913
	5.50		.2165		7.493	M	.2950
7/32	5.556		.2188		7.50		.2953
	5.60		.2205	19/64	7.541		.2969
	5.613	2	.2210		7.60		.2992
	5.70		.2244		7.671	N	.3020
	5.75		.2264		7.70		.3031
	5.791	1	.2280		7.75		.3051
	5.80		.2283		7.80		.3071
	5.90		.2323		7.90		.3110
	5.944	A	.2340	5/16	7.938		.3125

Figure 24 Drill Size Chart

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Drill Gauge

The size of a drill is stamped on its shank. If the size cannot be read, it can be determined by using a drill gauge. Drill gauges consist out of a hardened metal plate with holes in different sizes.

Drill Gauges for the metric system are furnished with different hole sizes in steps of 0.1mm.

Fractional drills are furnished in sizes from 1/16 to 1 inch in diameter, graduated in sixty–fourths of an inch.

Handling of a Drill Gauge

To gauge a drill, insert the point into a hole in the drill gauge (remember the shank is fractionally smaller than the point). If the drill slips easily into the hole, insert it into the next smaller hole. When the correct size has been determined, the drill will rub lightly in the hole.

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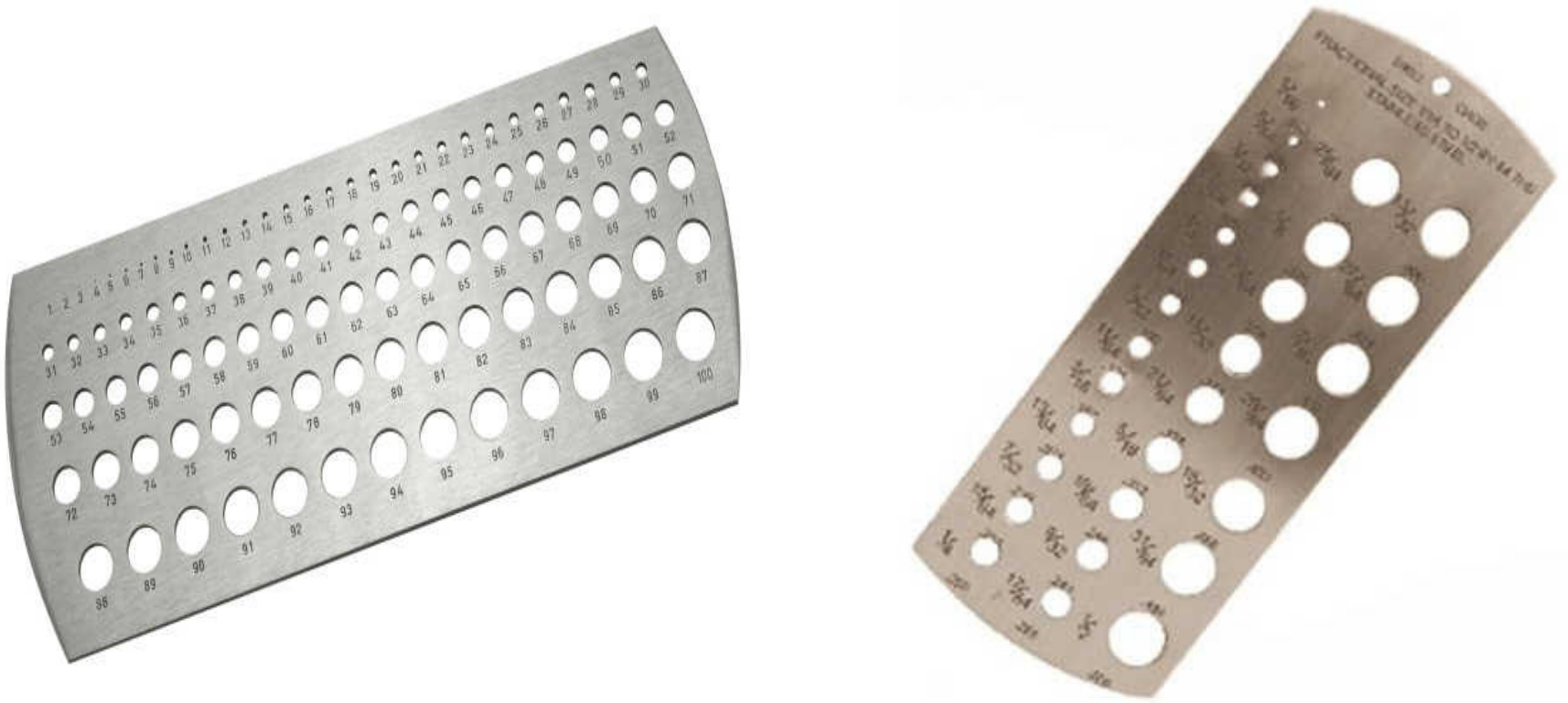


Figure 25 Drill Gauge

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DRILL SPEEDS

Introduction

Drill speeds are an important factor in getting good results. Drill speed determines the rate at which the outer cutting edge of the drill is moving across the material being out.

Cutting Speed

The cutting speed, which is the circumferential speed of the drill, is given in ft/min (feet per minute) or m/min (meter per minute).

Revolutions per Minute

Often, only the cutting speed of the different materials is given. To find the right drilling speed its necessary to convert the cutting speed to RPM depending on the diameter of the drill.

Conversion Cutting speed/RPM:

$$RPM = \frac{(Cutting\ speed\ in\ ft/min\ or\ m/min)}{(\pi \times diameter\ in\ ft\ or\ m)}$$

When harder materials are drilled, slower speeds are required, when softer materials are drilled, higher speeds are required.

The following table (A340–600 SRM) is an example for recommended drill speeds in different materials.

Influencing Factors on the Hole Quality

Revolutions per minute (RPM), cutting speed, feeds and maybe drilling agents are values to improve tool life, hole tolerance, and hole finish.

Hints

Despite all these facts for practical purposes:

- Use the correctly-ground drill and appropriate lubricant.
- Start drilling slowly and increase the revolution until swarf starts to appear.

LUBRICANTS AND COOLANTS

General

Lubricants and coolants are recommended for drilling, reaming and countersinking (unless prohibited by the engineering drawing).

It is used to improve tool life, hole tolerance and hole finish.

Cetyl Alcohol

Cetyl alcohol is a non–toxic lubricant from the fatty alcohol chemical family. It is suitable for many production operations and is manufactured in solid, paste, and liquid forms.

It is approved for use with aluminum, steel or titanium materials.

It is also sealant- and paint compatible, and is non–corrosive. Disassembly for cleaning is not required in sealant or paint areas.

These lubricants have the following characteristics:

- non–toxic, non–polluting and non-irritating under normal conditions
- excellent lubricating properties under extreme pressure
- removed by solvent wiping or washing with warm water and mild detergent
- compatible with most lubricant application systems

ATTENTION: Remaining lubricant residue must be removed from all surfaces within 48 hours after use, to prevent negative long-time effects.

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A340-500/600

STRUCTURAL REPAIR MANUAL

MATERIAL	PERMISSIBLE R.P.M. RANGE (given range divided by drill diameter)	
Aluminum / Al. Alloy	765 to 1145 drill DIA in inches	19450 to 29100 drill DIA in mm
Steel	190 to 305 drill DIA in inches	4850 to 7750 drill DIA in mm
Stainless Steel	115 to 155 drill DIA in inches	2950 to 3950 drill DIA in mm
Titanium Alloy	75 to 230 drill DIA in inches	1950 to 5850 drill DIA in mm
Titanium	190 to 380 drill DIA in inches	4850 to 9650 drill DIA in mm

Drill Speed Range

Example of Application:

When drilling a 6.35 mm (0.2500 in.) hole in aluminum alloy use a drill speed in the range of 3060 to 4580 rpm for example 19450 to 29100 divided by 6.35 mm (0.25 in.) (765 to 1145 divided by 0.25 in. (6.35 mm).

51-44-11

Figure 26 Drill Speed

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Deburring

General

When holes are drilled through two sheets of material, small burrs are formed around the edges of the holes and chips can be pushed between the two sheets. It is therefore essential to remove the burrs and chips.

Removal of burrs from drilled holes may be accomplished with a manufactured deburring tool or a countersinking tool (using a very light cut).

Care must be taken to remove only the rough edges and chips from the hole.

When two or more sheets are drilled at the same time, it is necessary to remove chips from between the sheets.

WARNING: IN AVIATION A LARGE TWIST-DRILL IS NOT PERMITTED FOR DEBURRING!

Special Deburring Tool

This tool is designed to deburr holes on the back side which you could not reach with standard deburring tools, due to limited access.

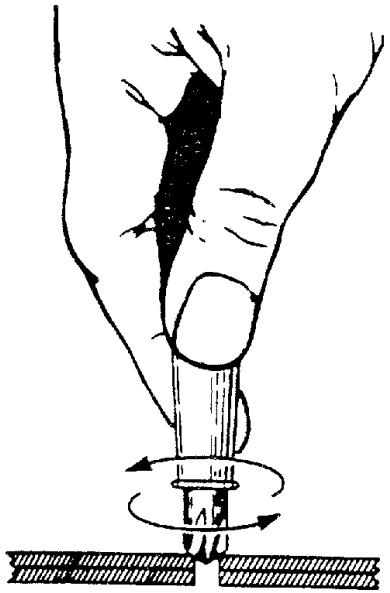
This tool is chucked in a drill motor. The retractable blade is held in place by spring pressure. To use, push the tool through the hole and remove burrs from the back side.

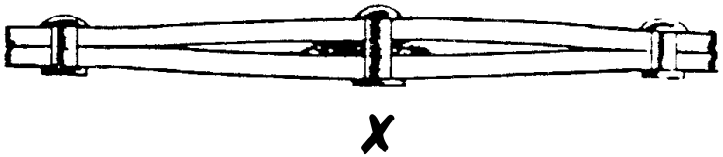
After drawing the tool back through the hole and the burrs can be removed from the entry side.

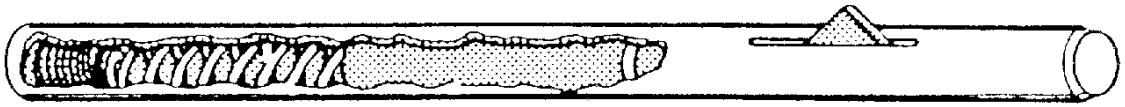
This deburring tool comes in common hole sizes from 1/8Inch (3,2mm) to 3/8Inch (9,6mm).

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Special Deburring Tool

Figure 27 Deburring

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Reaming

Introduction

The quality of a hole has, besides the chosen fit, an important influence on the lifetime of a fastener connection.

Under certain flight conditions, the maximum design strength of every fastener is required. Proper hole fill is essential in attaining maximum design strength.

So these holes must have a high surface quality and dimension accuracy. Through reaming this high surface quality requirements of a hole can be fulfilled.

When a fastener does not fill the hole, it is the weak link.

Care and good workmanship are essential in reaming high quality holes.

Basics

Reaming is a finishing operation that provides closer control of hole sizes and better finish than drilling alone.

For this a reamer is used, which is similar to a drill, but has additional cutting edges on the girth. These cutting edges can be straight or spiral fluted.

In normal practice, a hole that is to be reamed is drilled 1/64 inch (0,3–0,4 mm) under the finished hole size. After that reaming produces the desired hole size. For this there are reamers in different types and dimensions available.

Before using a reamer on a production part, try it out on scrap material of the same alloy and thickness in a drilled hole of the same size as the one to be reamed.

Verify that the reamer will cut to the required tolerance or continue testing until the right combination of reamer size, speed and feed is found.

A reamer will generally produce a hole that is from 0.0001 to 0.002 inch (0,0025 - 0,050mm) larger in diameter than the exact size of the reamer.

Reamer blades are hardened to the point of being brittle and must be handled carefully to avoid chipping them.

When reaming a hole, rotate the reamer in the cutting direction only.

Turn and feed the reamer steadily and evenly to prevent chattering, or marking and scoring of the hole walls.

Reamers are available in any standard size.

Reamers are divided into straight-fluted and spiral-fluted reamers. The straight–fluted reamer is less expensive than the spiral–fluted reamer, but the spiral type has a less tendency to chatter.

Both types are tapered for a short distance towards the end to aid in starting.

Many factors affect the finished size of a reamed hole. The following are the most common:

- Hardness of material being reamed.
- Amount of material being removed by the reamer.
- Speed of reamer.
- Rate of feed (pressure).
- Sharpness of reamer.
- Amount and type of lubrication.
- Removing reamer from hole.

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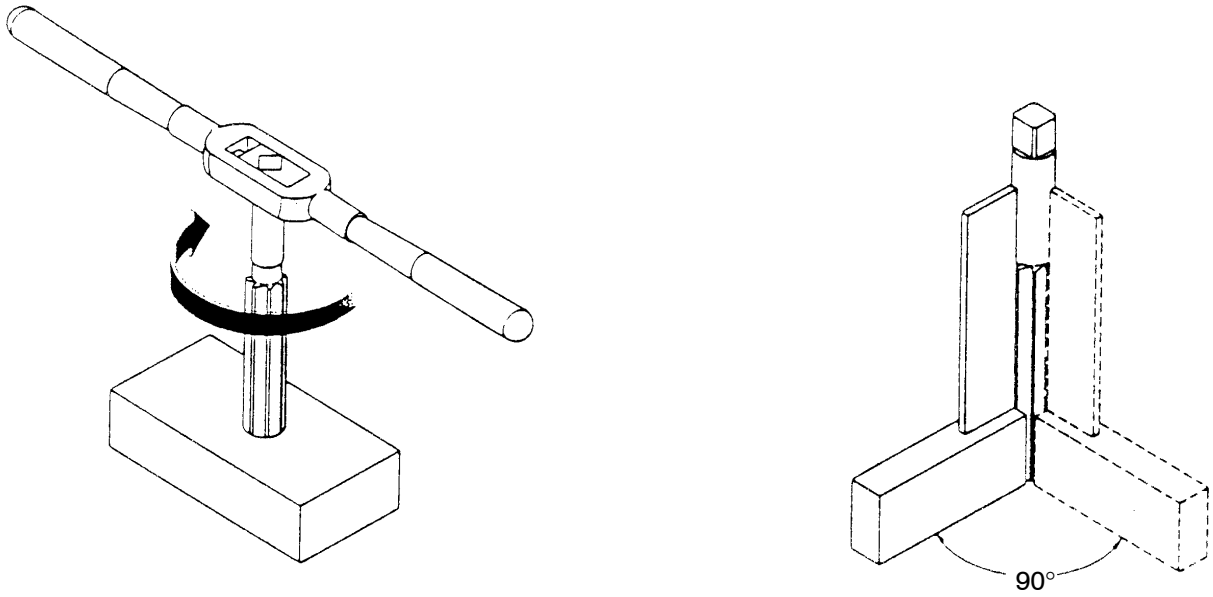


Figure 28 Reaming

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REAMER DESCRIPTION

Shaft

Shafts of reamers can take different shapes and forms. There is never a characteristic shape for either a hand– or a machine–reamer. The type of driving mechanism determines the shape of the shaft.

Hand reamers mostly have a cylindrical shaft with a square end (for a tap wrench).

Shafts of machine–reamers are cylindrical or Morse tapered.

Chucking grooves

Chucking grooves are the spaces between the single teeth; all chips are collected and transported in these spaces.

The course of the chucking grooves affects the direction of the removal of chips. There are straight–fluted and spiral–fluted reamers.

Straight–fluted reamers have no precise affect on the direction of the removal of chips. They have a low abrasion and are the most used type.

Spiral–fluted reamers, on the other hand, lead the removed chips in a definite direction.

Left–hand twist – Right–hand twist

Right–hand twist affects the direction of the removal of chips like a normal twist drill.

The Left–hand twist moves the chips into the advance direction. The chips cannot have an adverse effect on the reamed part of the holes drilling. Therefore left–hand twist–fluted reamers are only suitable for transmission drills.

They have the advantage that they do not tend to pull themselves into the hole.

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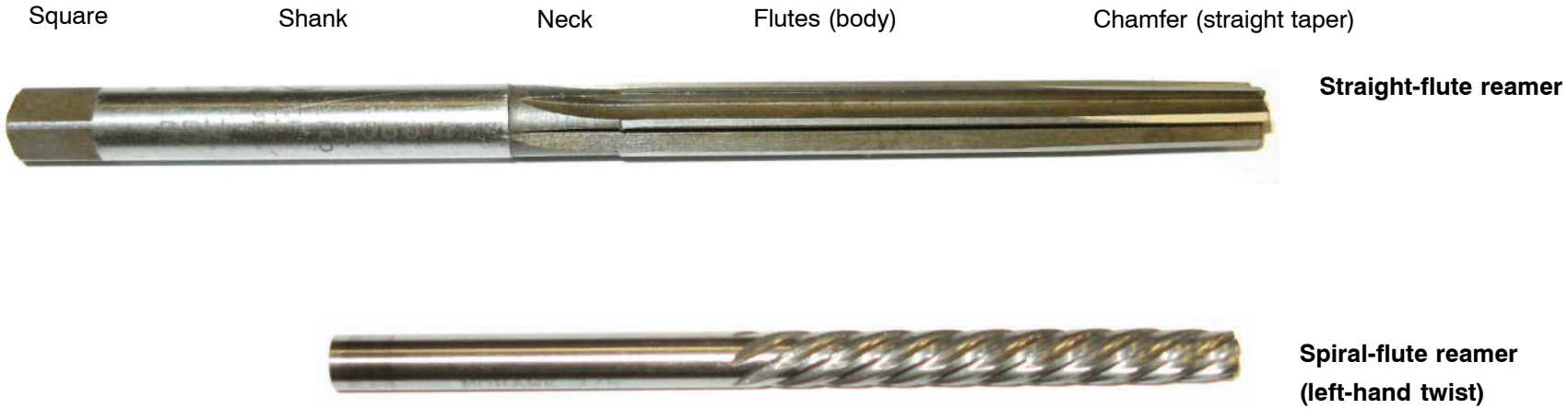


Figure 29 Reamer

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REAMER DESCRIPTION (CONT.)

Spacing

Vibration of the tool or work whilst cutting often leads to undesirable chatter marks.

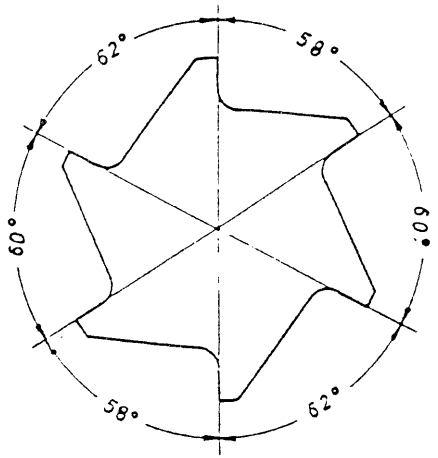
Modern reamers are made with an uneven spacing; in that way the effect of periodical vibration is reduced.

Remove the reamer from a hole by rotating it in the cutting direction (working direction). Otherwise, due to the wedge effect of the chips at positions A and B, the hole surface and/or the cutting edges will be damaged.

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Spacing and diametral pitch are designed in such a way that two cutting edges are facing one another (measurability)



Correct direction of rotation of reamers (working direction)

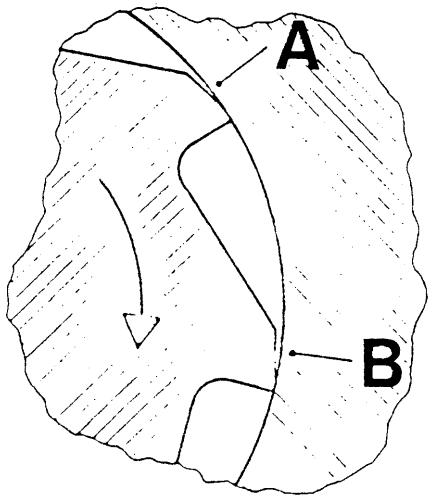


Figure 30 Spacing of Cutting Edges

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TYPES OF REAMERS

General

There are two basic types of reamers; the hand– and the machine–reamer.

Machine Reamer

The machine reamer is designed with a large cutting angle, short major cutting edges (short first cut) and short overall cutting edges.

Due to the short first cut the machine reamer, in principle, can only be used if the work piece and the reamer have no axial play during the reaming process. So you cannot use a hand drill.

The advantages of a machine reamer are a much higher cutting capacity and the possibility of reaming dead center holes almost to the bottom of the hole.

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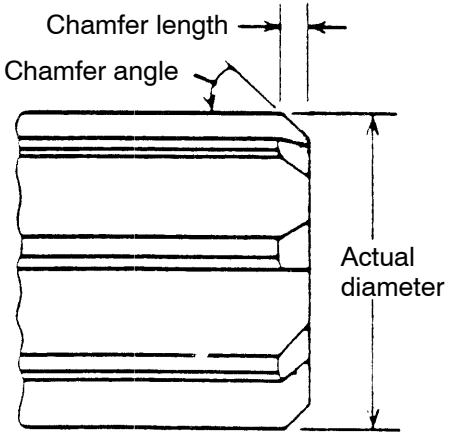






Figure 31 Machine Reamer

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TYPES OF REAMERS (CONT.)

Hand Reamer

The hand−reamer is designed with a small cutting angle, large major cutting edges (large first cut) and large overall cutting edges.

The hand−reamer will be guided into the hole through the long first cut and the long major cutting edges.

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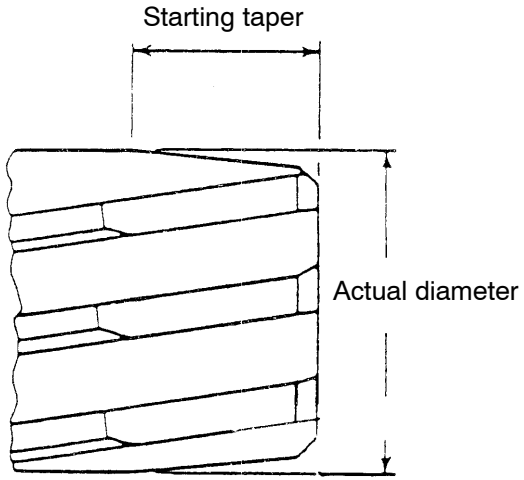




Figure 32 Hand Reamer

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TYPES OF REAMERS (CONT.)

Pilot Reamer

The pilot reamer has a cylindrical beginning and is guided into the hole through a matching bushing.

This assures that the reamer is automatically arranged centrically and in the right angle to the existent hole.

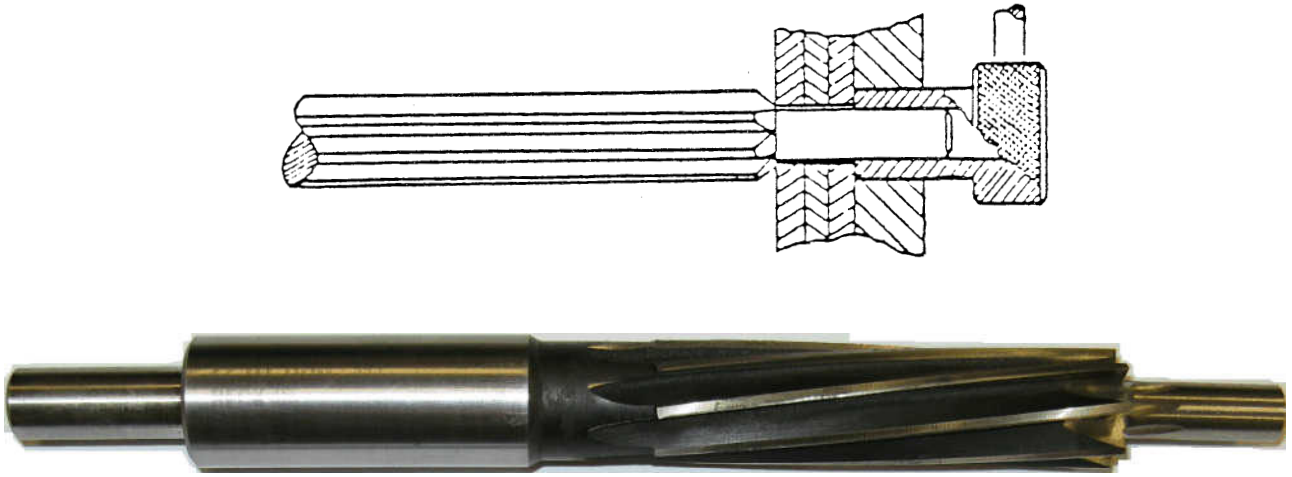
Pilot Chuck Reamer

This reamer is used very often. It is guided very well by the first section, whose diameter is matching with the pilot hole, and assures through the default reamer step diameter a superior finish.

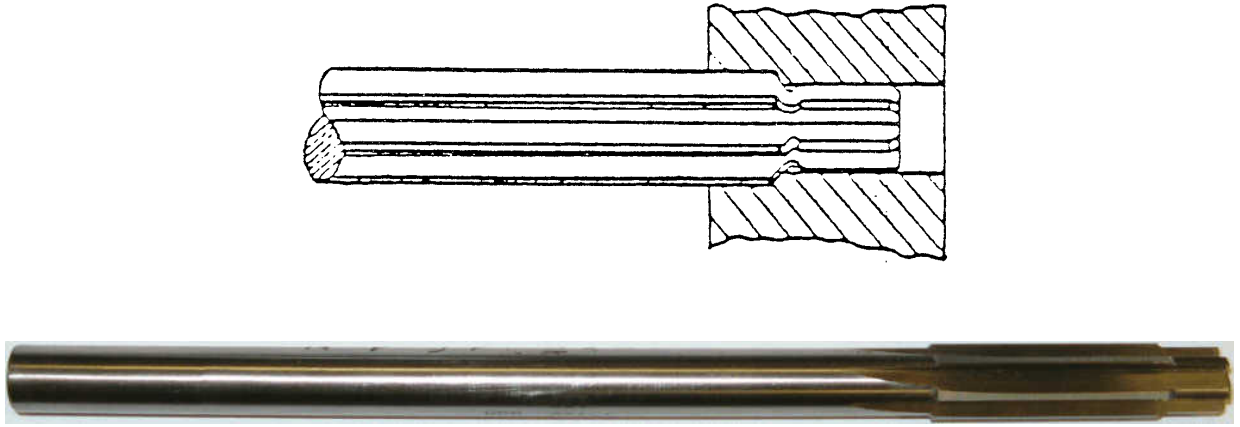
Also at this reamer a centrically an right angled reaming is guaranteed by the guidance which is given by the first section of the reamer.

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Pilot Reamer



Pilot Chuck Reamer

Figure 33 Pilot and Pilot Chuck Reamer

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TYPES OF REAMERS (CONT.)

Expansion Hand Reamer

This reamer is used when the hole must be cut a few thousandth of an inch for fitting purposes. Slots are cut into the hollow center of the tool and the center opening is machined on a slight taper.

The reamer is expanded by tightening a taper screw into this opening.

The amount of expansion is limited and the reamer could be damaged if over-expanded. It is not recommended that the expansion reamer be used in place of a solid reamer because of the danger of producing oversize holes.

Taper Reamer

This reamer is used to finish a taper hole (for example for a taper shank bolt) accurately and with a smooth finish.

Because of the long cutting edges, taper reamers are somewhat difficult to operate.

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Expansion Hand Reamer



Taper Reamer

Figure 34 Expansion Hand Reamer and Taper Reamer

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TYPES OF REAMERS (CONT.)

Adjustable Hand–Reamer

This reamer is threaded its entire length and fitted with tapered slots to receive the adjustable blades. The blades are tapered along one edge to correspond with the taper slots in the reamer body so that, when they are in position, the cutting edges of the blade are parallel.

The diameter of the reamer is set by loosening one adjusting nut and tightening the other. The blade can be moved in either direction.

This type of reamer is manufactured in different sizes ranging and each reamer has sufficient adjustment to increase the diameter to the size of the next larger reamer.

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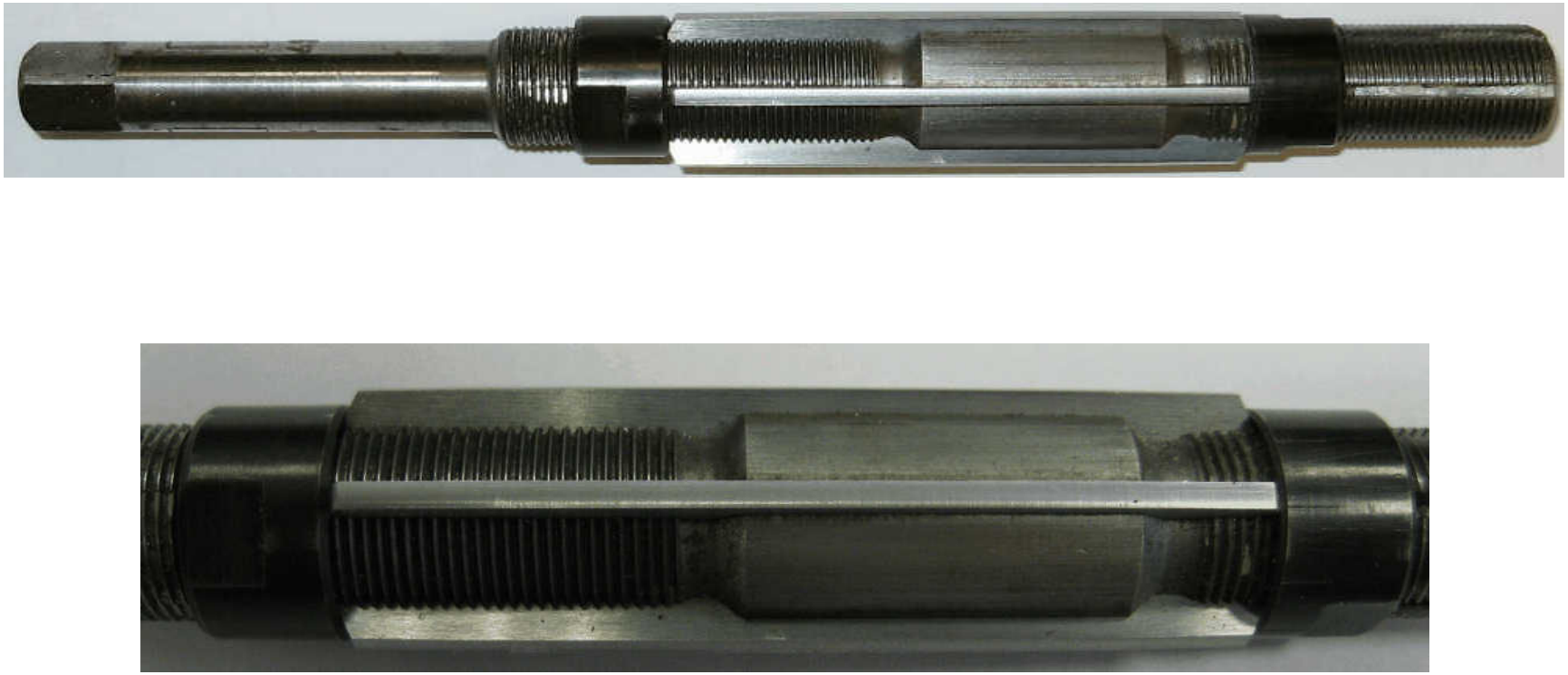


Figure 35 Adjustable Hand Reamer

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REAMING AND CUTTING SPEED

Reaming speeds

The reaming speed depends on the material and the diameter of the reamer.

The recommended speeds are given in RPM (Revolutions per Minute) or 1/min. The reaming speed is less than the drilling speed.

Cutting Speed when Reaming

The cutting speed, which is the circumferential speed of the reamer, is given in ft/min (feet per minute) or m/min (meter per minute).

Often, only the cutting speed of the different materials is given. To find the right reaming speed its necessary to convert the cutting speed to RPM depending on the diameter of the reamer.

Conversion Cutting speed / RPM:

$$RPM = \frac{(Cutting\ \ speed\ \ in\ \ ft/min\ \ or\ \ m/min)}{(\pi \times diameter\ \ in\ \ ft\ \ or\ \ m)}$$

REAMING ADVICE

General

- Before using a reamer on a production part, try it out on scrap material of the same alloy and thickness in a drilled hole of the same size as the one to be reamed.

  Verify that the reamer will cut to the required tolerance. The reamed hole can be checked with a plug gauge.
- Do not try to straighten the drilled hole by applying side pressure; you will probably cut oversize.
- Stop reamer rotation as soon as the reamer's major diameter breaks through.
- When removing the reamer from the hole rotate it in the direction of the cut.
- Chatter corrections may be made by changing the speed, the feed or using a reamer with a pilot.
- Oversize holes can be caused by inadequate work support, worn guide bushings, loose spindle bearings or a damaged reamer shank.
- Check the reamer if it gradually starts cutting holes which are not in the given tolerance marked on the reamer; it may be caused by built–up edges on the reamer cutting surfaces
- Reamers should be stored so that they do not get in contact with another reamer to avoid burrs on the tools.
- Every reamer or reamer set has to be checked if it has the right size before usage. The size which is marked on the shaft must be compared with the size that is given by the work order or the manufacturers guide.

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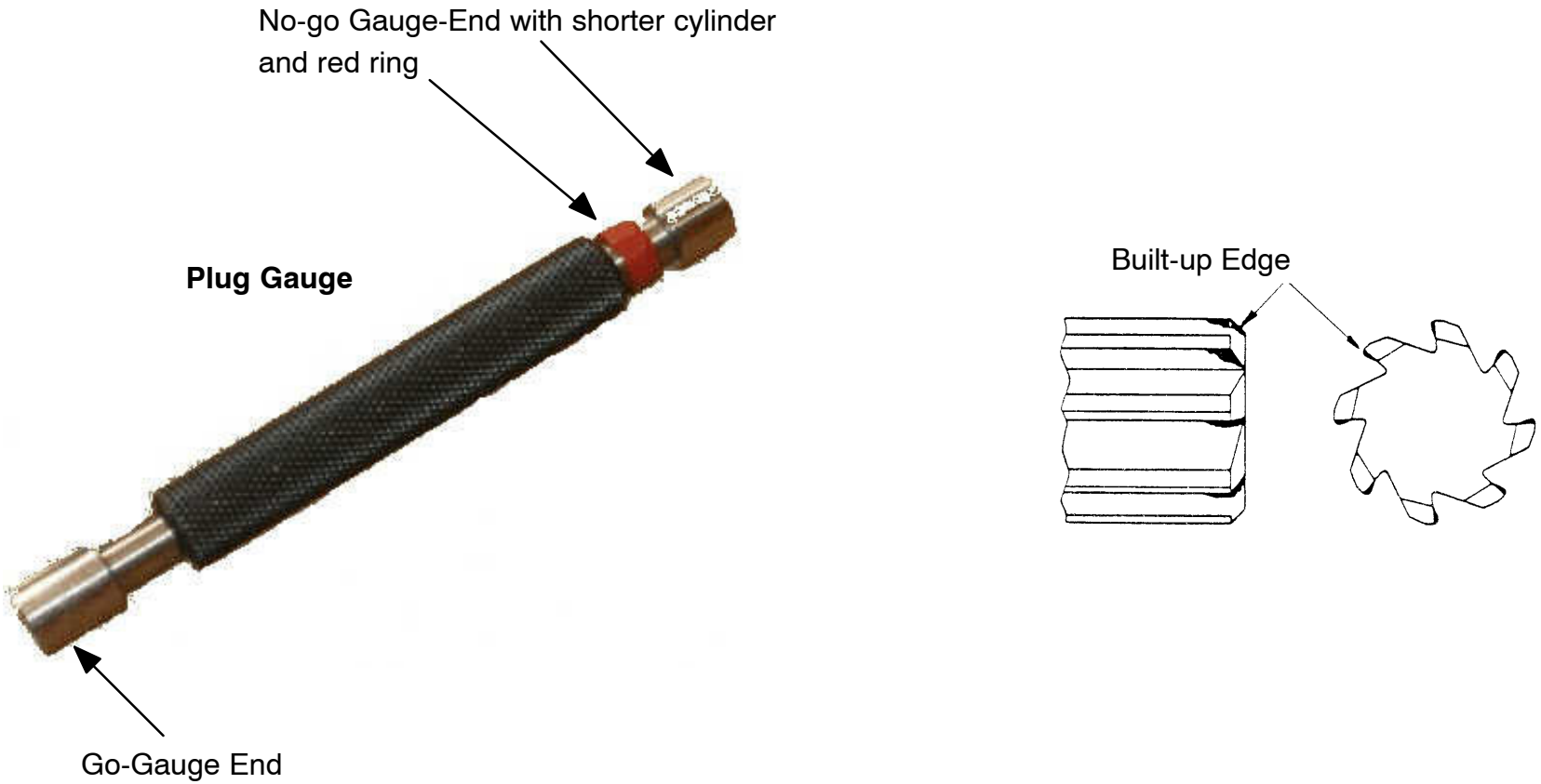


Figure 36 Reaming Advice

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Countersinking

Introduction

The installation of countersunk fasteners, like rivets, bolts and pins is necessary to create a aerodynamically clean surface (e. g. fuselage skin) or a smooth surface (e. g. seat rails).

To provide this a conical cut-out or depression is made into the component. The creation of the countersunk is mostly done via cutting. If the sheets are very thin the depression is made via dimpling with a special tool.

Minimum Sheet Thickness

When countersinking, there has to be paid attention to comply the minimum sheet thickness of the faster being installed (see table), to avoid a countersinking through the whole sheet. Countersinking through the sheet, also called „Knife Edge“, is a potential crack source.

Countersinking Tool

There are several different countersinking tools available to make a countersunk. There are one or multi cutting-edge, with or without a Pilot-Pin and with different cutting angles. The most commonly used countersinks for a normal fastener is 100°.

For special fasteners there are countersinking tools with 82° and 120°. To create countersunk for so called NACA-rivets a special countersinking tool is necessary.

The cutting angle of the chosen countersinking tool must always match with the fastener which has to be installed.

Countersinking tools are usually used with hand or a pillar drill.

So called „hand countersinking tools“ are used to create countersinks manually.

ATTENTION: For joining sheet metal almost only 100° fastener heads are used.

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A340-500/600
STRUCTURAL REPAIR MANUAL

FASTENER NOMINAL DIAMETER		MINIMUM PART THICKNESS FOR COUNTERSINKING <1>							
		APPLICABLE FASTENER TYPE							
		STANDARD SOLID AND BLIND RIVETS		SHEAR HEAD SOLID RIVETS, HI-LOK, HI-LITE AND LOCKBOLT		SPECIAL SHEAR HEAD HI-LOK, HI-LITE AND LOCKBOLT		TENSION HEAD HI-LOK, BOLTS, BLIND BOLTS AND LOCKBOLT	
mm	in.	mm	in.	mm	in.	mm	in.	mm	in.
3.2	1/8	1.295	0.051	0.940	0.037	-	-	-	-
4.0	5/32	1.600	0.063	1.245	0.049	1.448	0.057	1.981	0.078
4.8	3/16	2.000	0.078	1.397	0.055	1.626	0.064	2.286	0.090
6.4	1/4	2.591	0.102	1.753	0.069	2.083	0.082	2.972	0.117
8.0	5/16	-	-	2.235	0.088	2.845	0.112	3.973	0.155
9.6	3/8	-	-	2.489	0.098	3.302	0.130	4.623	0.182
11.2	7/16	-	-	2.972	0.117	3.708	0.146	5.309	0.209
12.7	1/2	-	-	3.226	0.127	4.115	0.162	5.994	0.236
14.3	9/16	-	-	-	-	4.394	0.173	6.680	0.263
15.9	5/8	-	-	-	-	4.928	0.194	7.417	0.292

Minimum Part Thickness for 100° Countersinking

Table 1

<1> Only measure the single thickness of the material/part that is to be countersunk.

WARNING: MINIMUM THICKNESS GIVEN IN TABLE 1 ASSUMES THAT FASTENERS ARE TO BE FLUSH.

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Figure 37 Minimum Sheet Thickness

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COUNTERSINKING TOOLS

Standard Countersinking Tool

A standard countersinking tool has one, three or eight cutting edges.

The most common is the three cutting edge countersinking tool. It is available in different cutting angles and diameters and can be used with every drill.

If a standard countersinking tool is used manually, it is difficult to create a uniform depth of the countersunk.

Standard Countersink Tool with Pilot

Countersinking tools with a pilot pin, which guides the countersinking tool into the hole and therefore creates a axial orientation.

Microstop Countersinking Tool

The Microstop countersinking tool is used, if a large amount of holes have to be countersunk with high quality and uniform depth.

The Microstop countersinking toll is adjustable in his countersinking depth.

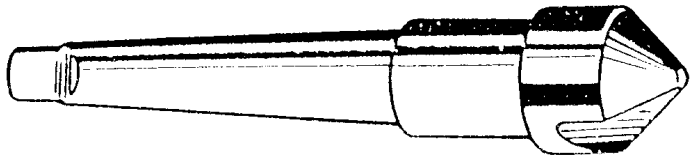
The countersinking tool of the microstop countersink has a pilot pin and is exchangeable and available with different cutting angles. The pilot pin guides the countersinking tool in the hole and gives axial orientation. The pilot pin has to be chosen matching to the hole size.

To create the hole and the countersunk in a single action there are microstop countersink tools available with a drill head in place of the pilot pin.

ATTENTION: A proper and perpendicular drill hole is the prerequisite for a high quality countersink!

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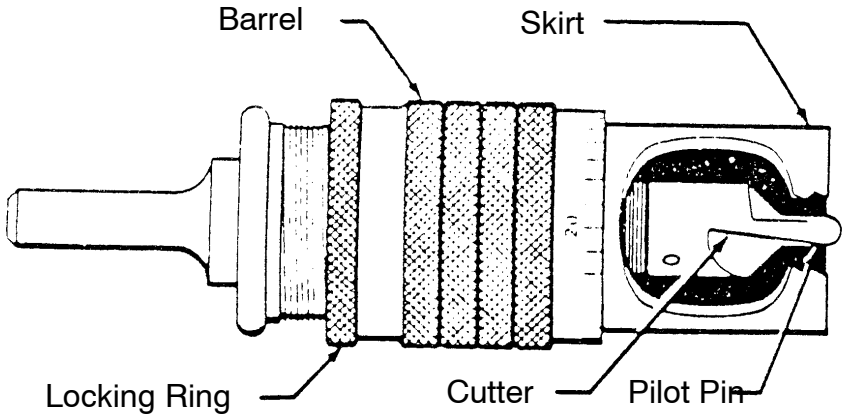
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Standard Countersinking Tool



Countersinking Tool with Pilot Pin



Microstop Countersinking Tool

Figure 38 Countersinking Tools

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WORKING WITH A MICROSTOP COUNTERSINKING TOOL

Assembly of the Microstop

The shaft of the microstop countersink tool rotates on a bearing inside an adjustable locking sleeve and foot piece assembly. The foot piece (or ”stop” as it is often called) screws onto the shaft bearing, enabling depth adjustments to be made.

Markings, indicating depth differentials in 0.001–inch increments, surround the beveled circumference of the locking sleeve to aid in depth adjustments.

The pilot pin guides the spinning cutter as it cuts into the material. The pilot pin has therefore to be chosen matching to the hole diameter. A pilot pin, which is too small, can only insufficiently guide the countersinking tool in the hole and creates a bad countersunk.

Adjustment of the Countersinking Depth

Adjustment is made by loosing the locking ring, pulling the barrel back and turning the stop to adjust the cut to the desired depth. The sleeve is then dropped back into its original position to affect a lock.

ATTENTION: Make sure that the locking splines intermesh; only then is the adjustment securely locked. In general, adjustment of the microstop will be made on scrap material.

The proper depth of the countersink is determined by driving a test rivet in a scrap piece of metal.

The depth adjustment of the microstop countersink tool is gradually changed, until the rivet is inside the tolerance of the manufacturer given in the SRM.

Once the correct countersink adjustment has been established in this manner, the tool can be used for countersinking all holes of the component in a constant high precision. Periodically check countersink depth throughout the countersinking operation if many holes are countersunk one after another.

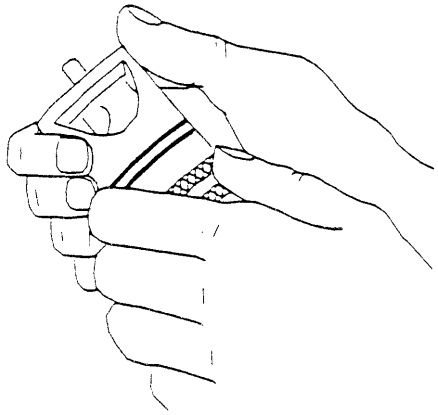
Advices for Using the Microstop Countersinking Tool

- When countersinking concave or convex surfaces, the cutter will not cut the same depth as set up on a flat piece of material.
- Most of the countersinking tools have a nylon face fitted to protect the surface of the work piece.

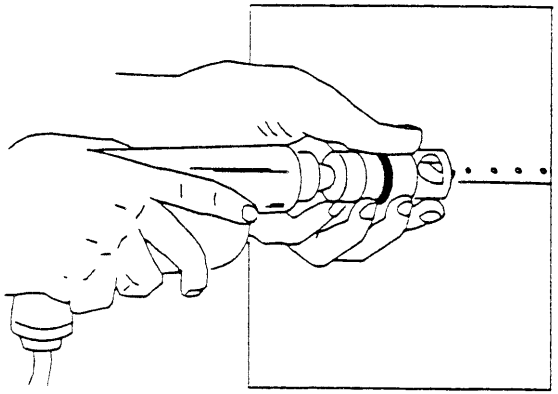
  Sometimes chips will become embedded in this face during the countersinking operation. It is vital that the skirt is prevented from rotating to stop these chips becoming ground into the work piece.
- Take care that all exchangeable parts of the microstop, like countersinking tool and nylon face, are fixed properly. Otherwise an unconstant cutting depth will result!

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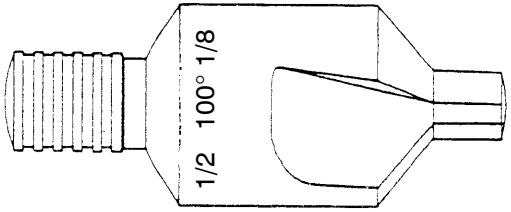
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Adjustment of the Microstop Countersinking Tool



Holding the Microstop Countersinking Tool Skirt



Exchangeable Countersinking Cutter

Figure 39 Working with the Microstop Countersinking Tool

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COUNTERSINKING TOOLS (CONT.)

Back Countersinking Tool

The back countersinking tool is used to countersink inaccessible holes.

A rod which is clamped in the drilling machine is inserted into the hole from the backside of the component and the back countersinking tool is connected on the side which has to be countersunk with the rod.

The rod must be slightly smaller than the hole.

The work sequence can be listed as follows:

1. Install the rod in a drilling motor.
2. Insert the rod through the hole.
3. Attach the cutter on the backside of the part to the rod end.
4. Start drilling motor and pull back the motor.
5. Check the countersinking depth from time to time, until the desired depth is created.

Since no axial guidance is given in this procedure due to the small diameter of the rod, the right orientation of the countersinking tool has to be checked!

Spot facing

Spot facing is a operation to create a flat area for e. g. a fastener head, a locking ring or a nut. This method is also used to create a flat surface on e. g. an uneven component surface.

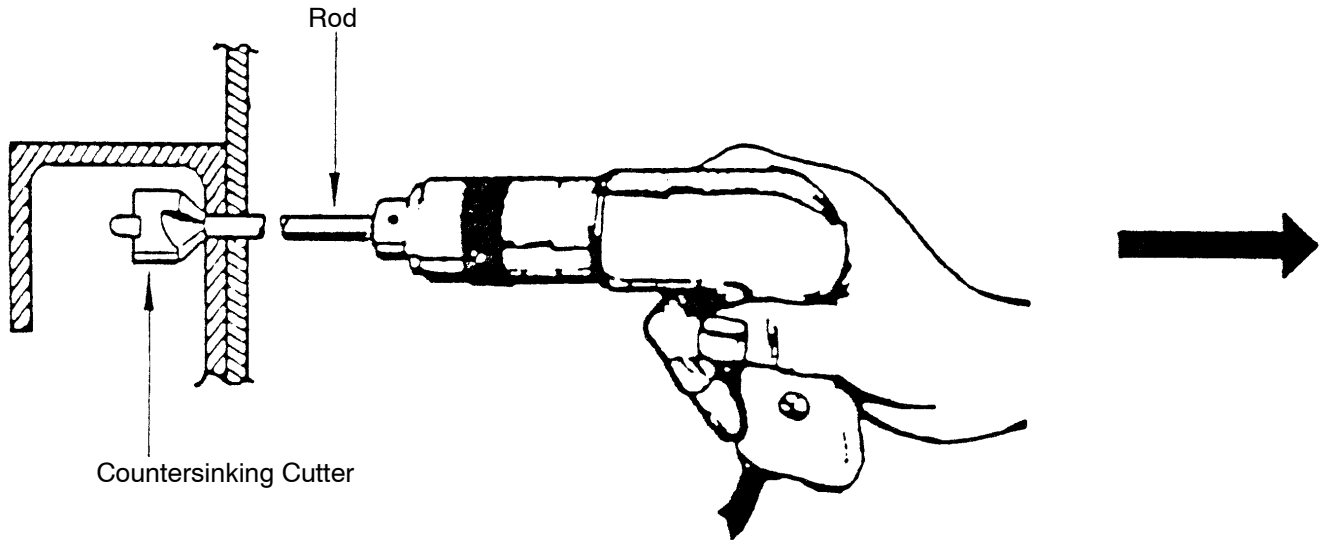
This operation should be done in a pillar drill whenever possible.

Spot facer have a pilot pin, which assures guidance inside the hole.

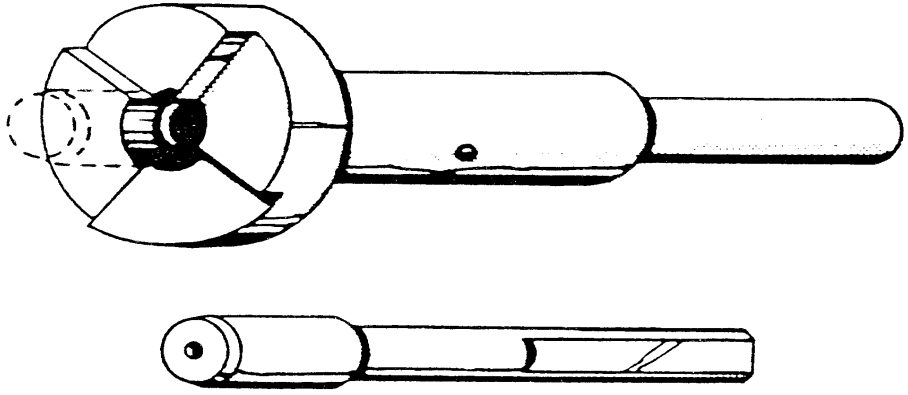
The plot pin has to be chosen matching to the hole diameter. If the pilot pin is too small, guidance will not be sufficient. This would cause chatter marks on the surface.

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Back Countersinking Tool



Spotfacer

Figure 40 Back Countersinking Tool/Spotfacer

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Thread Cutting Tools

Stock

The stock is the tool used to hold and turn a threading die when producing external threads by hand.

Die

Dies have three or more flutes to form cutting edges on the internal threads and cavities for removal of chips.

They have chamfers ground on the first few threads of the leading end of the die to facilitate easy starting.

Dies are available for right- and left-hand threads and all different thread types.

Tap Wrench

Tap wrenches are tools used to hold and turn a tap when cutting internal threads by hand. Tap wrenches have adjustable jaws to grip the hand tap.

Hand Taps

Hand taps have three or more flutes to form cutting faces on the external threads and channels for removal chips. Hand taps have chamfers ground on the leading threads of the tap to enable easy starting. The end of the shank is squared to allow it to be gripped firmly in the tap wrench.

Hand taps are available for right- and left-hand threads and all different thread types.

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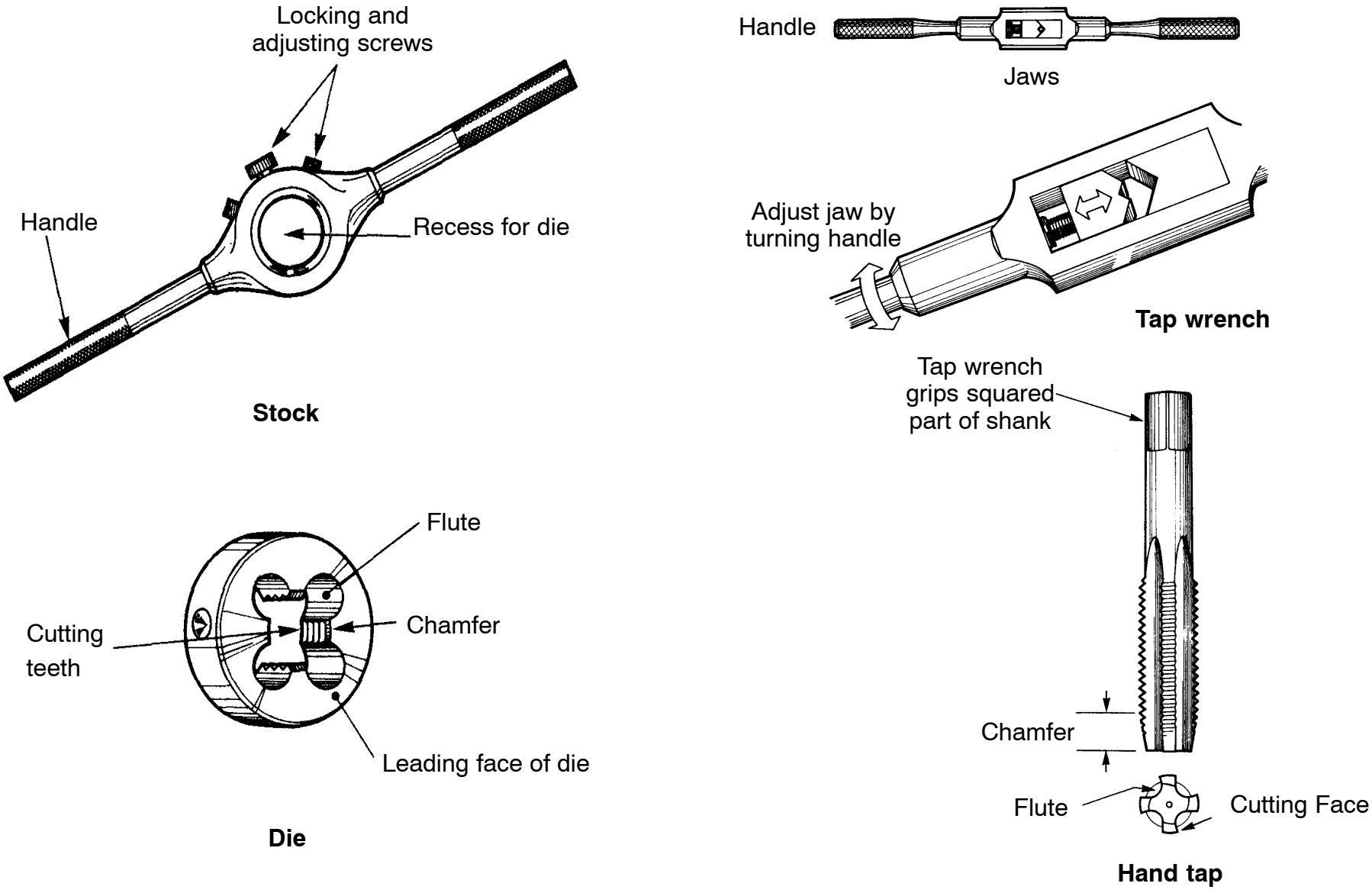


Figure 41 Thread Cutting Tools

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THREAD CUTTING TOOLS (CONT.)

Hand-Tap Sets

Each regular hand tap set consists of a taper, an intermediate and a bottoming tap. Each tap in a set has identical length and thread measurements and only the tapered lead is different.

The differences of the taps are:

- The taper tap has a long chamfer.
- The intermediate tap has a short chamfer.
- The bottoming tap has a continuous thread.

Beneath the different chamfers the hand taps can also be identified by different numbers of grooves on the shank.

Machine tap

The machine tap cut the thread in one go. In general machine taps are longer then hand taps and they have a long chamfer.

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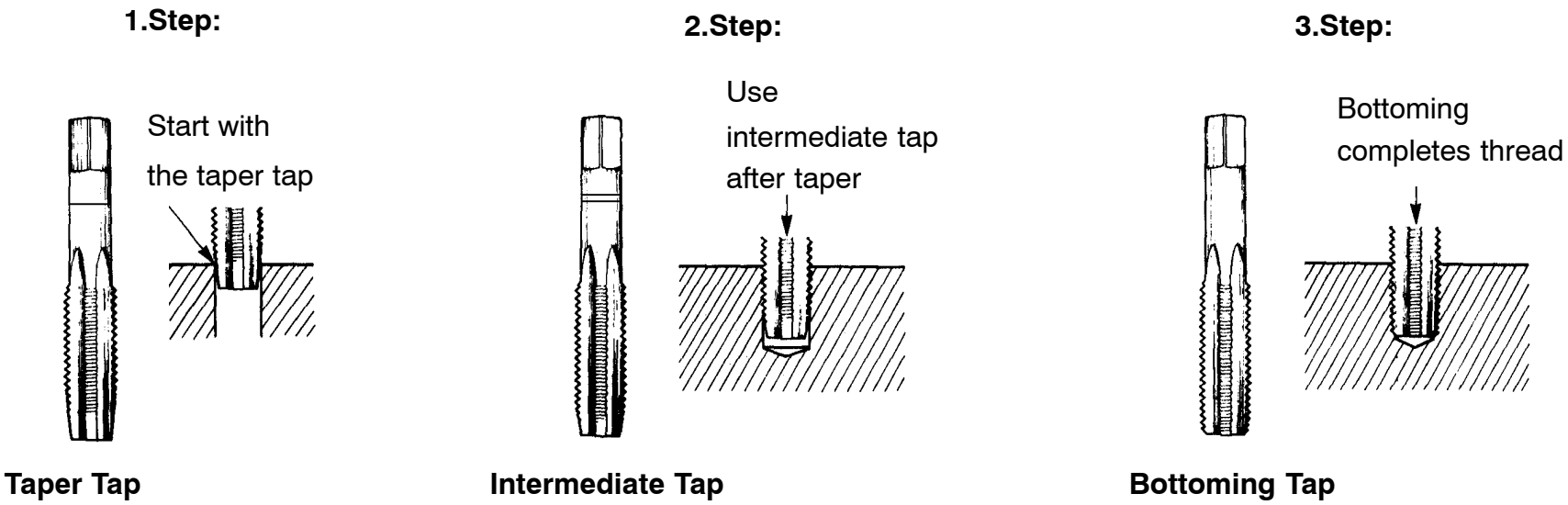


Figure 42 Types of Hand Taps

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TAPPING

Pre-Drilling before Tapping

The size (hole diameter) and the condition (surface quality) of a hole, in which a thread has to be cut, are very important for a optimal thread quality.

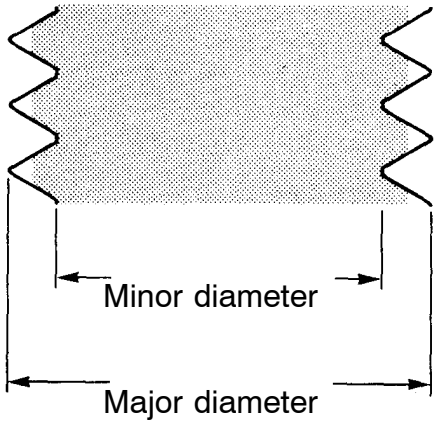
Theoretically, a tap would produce a 100% thread in an accurate hole of the same diameter as the minor diameter of its thread.

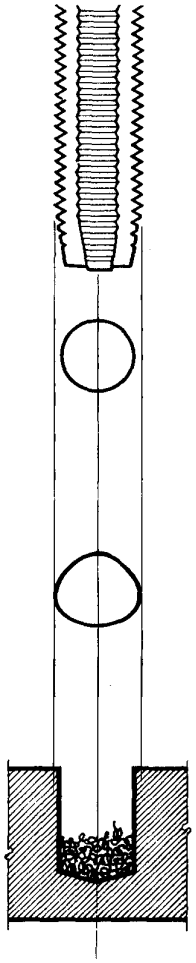
Calculations based on a different standard formula for each thread may be used.

Engineering handbooks and manufacturers give tables of tapping drill recommendations.

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Drill hole too small

May cause the breakage of the thread or the tap.

Drill hole not round

May cause the breakage of the tap.

Drilling swarf left in bottom of blind hole

May cause tap to jam on packed swarf and break.

Figure 43 Pre-Drilling before Tapping

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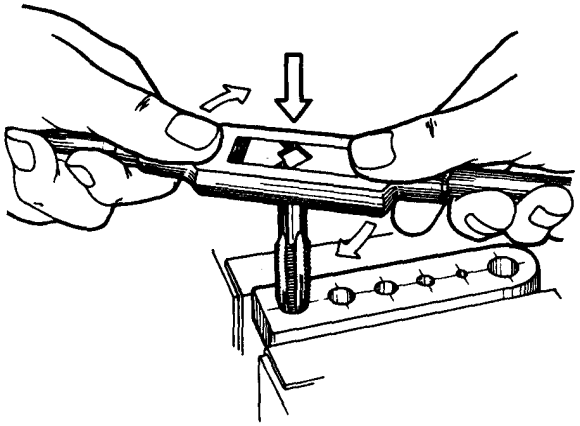
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TAPPING PROCEDURE

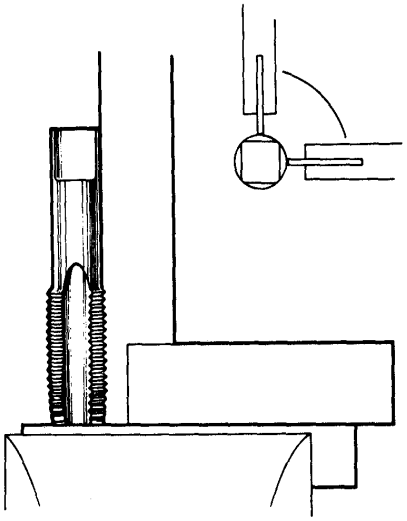
1. Check the size of thread required and selects the correct taps.
2. Determine the correct size of tapping drill. Drill the tapping hole carefully and deburr the edges.
3. Fit the taper tap in a matching size bar-type tap wrench.
4. Apply a suitable cutting fluid.
5. Hold the tap wrench with both hands close to the center. Place the end of the tap in the hole. Sight up, that the tap is perpendicular to the surface of the work.
6. Apply steady downward pressure and begin turning the handles clockwise in a horizontal plane for two turns.
7. Release and remove the tap-wrench and place a small tri-square on the work to check that the tap is vertical to the work surface. Test again in a second position about 90° from the first. If the tap is not square to the surface, note the correction required.
8. Refit and tighten the tap-wrench.
9. Hold the tap wrench as before and begin turning. To correct a tap that is out of square, apply slight side pressure in the direction required as the wrench is turned.
10. Complete two turns and check as before that the tap is square. The tap must be square within the first few turns. Out of squareness cannot be corrected after this.
11. Hold the tap-wrench at the end of the handles with the fingers to allow sensitive feel of the torque applied to the tap.
12. Turn the wrench with constant pressure applied evenly with both hands. No downward pressure is required once the tap begins to feed itself into the hole.
13. As you turn the wrench try to feel the degree of resistance being offered to the tap. If you feel it is increasing, reverse the wrench a quarter turn. This will break off metal build-up.
14. If the flutes are clogged, reverse the tap carefully and remove it from the hole. Use a brush to remove the chips from the tap and the hole and continue the tapping process.
15. Continue turning the tap until at least half the tap extends below the lower surface of the material.
16. To complete the hand-tapping, the intermediate and the bottoming tap have to be used in the same way as described for the taper tap.
17. Clean the tools after tapping.

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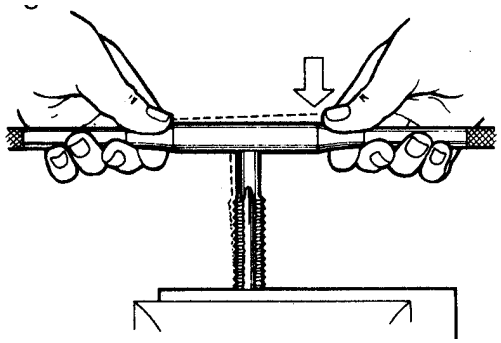
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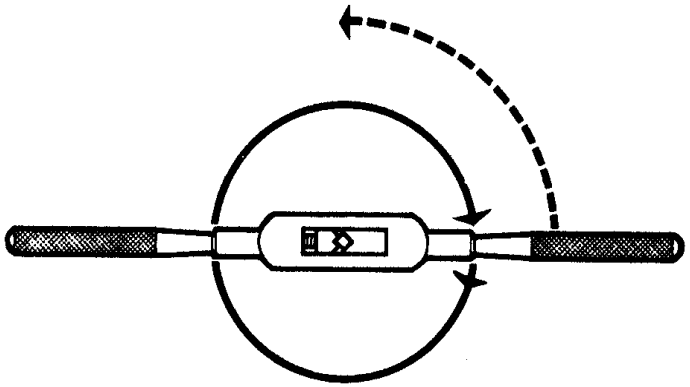
Start tapping



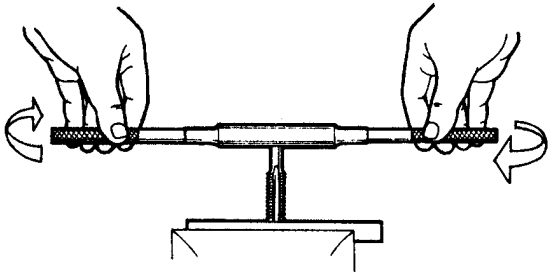
Check tap is perpendicular to surface



If necessary adjust tap.



Quater reverse when necessary to break metal built up



Complete tapping by constant turning

Figure 44 Tapping Sequence

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Abrasive Wheels

Introduction

The abrasive wheel is made of abrasive materials bonded together.

Most wheels are made from silicon carbide (carborundum), but aluminum oxide abrasives are occasionally used for fine grinding.

Safety

An off-hand grinding machine is potentially very dangerous, so approximately 3/4 of the circumference of the wheel is encased in the wheel guard.

Additionally, there is a transparent screen covering as much of the exposed part of the wheel as is practical.

Despite this screen, always protect your eyes with goggles as well.

The tool rest should be adjusted to give the smallest possible clearance between it and the wheel.

WARNING: NEVER USE THE SIDE OF AN ABRASIVE WHEEL; A GROOVE CAN FORM OVER TIME, CREATING A WEAK POINT THAT HAS, IN THE PAST, LED TO WHEELS EXPLODING.

Over a period of time, the surface of the wheel will become grooved and pitted and embedded with metal. A specially-trained operative will dress the wheel using a diamond-tipped tool.

Description

The off-hand grinding machine which is normally used in the industry is basically an electric motor with grinding wheels mounted onto the spindle (normally one on either side).

It is common practice to have different grade wheels; one for rough finishes and the other for finer grinding.

Grinding machines can be either bench- or floor-mounted.

Floor-mounted (or pedestal) grinding machines can be equipped with a foot switch and often have a tank mounted on the front containing some sort of quenching fluid (usually water).

Excessive grinding without periodic cooling can degrade the tool quality.

Grinding a Center Punch

- Hold the punch in one hand and position the fingers of the other hand towards the head of the punch so that it can be rotated during the grinding operation.
- With the first hand steadied against the tool-rest, adjust the angle of the punch so that it is approximately 60° to the face of the wheel.
- As you touch the point of the punch on the wheel, maintain a light, even pressure and rotate the punch.
- Quench the punch frequently to prevent over-heating and subsequent softening of the metal.

WARNING: THE POINT OF A PUNCH SHOULD ALWAYS BE GROUND WITH THE GRINDING LINES PARALLEL TO THE AXIS.

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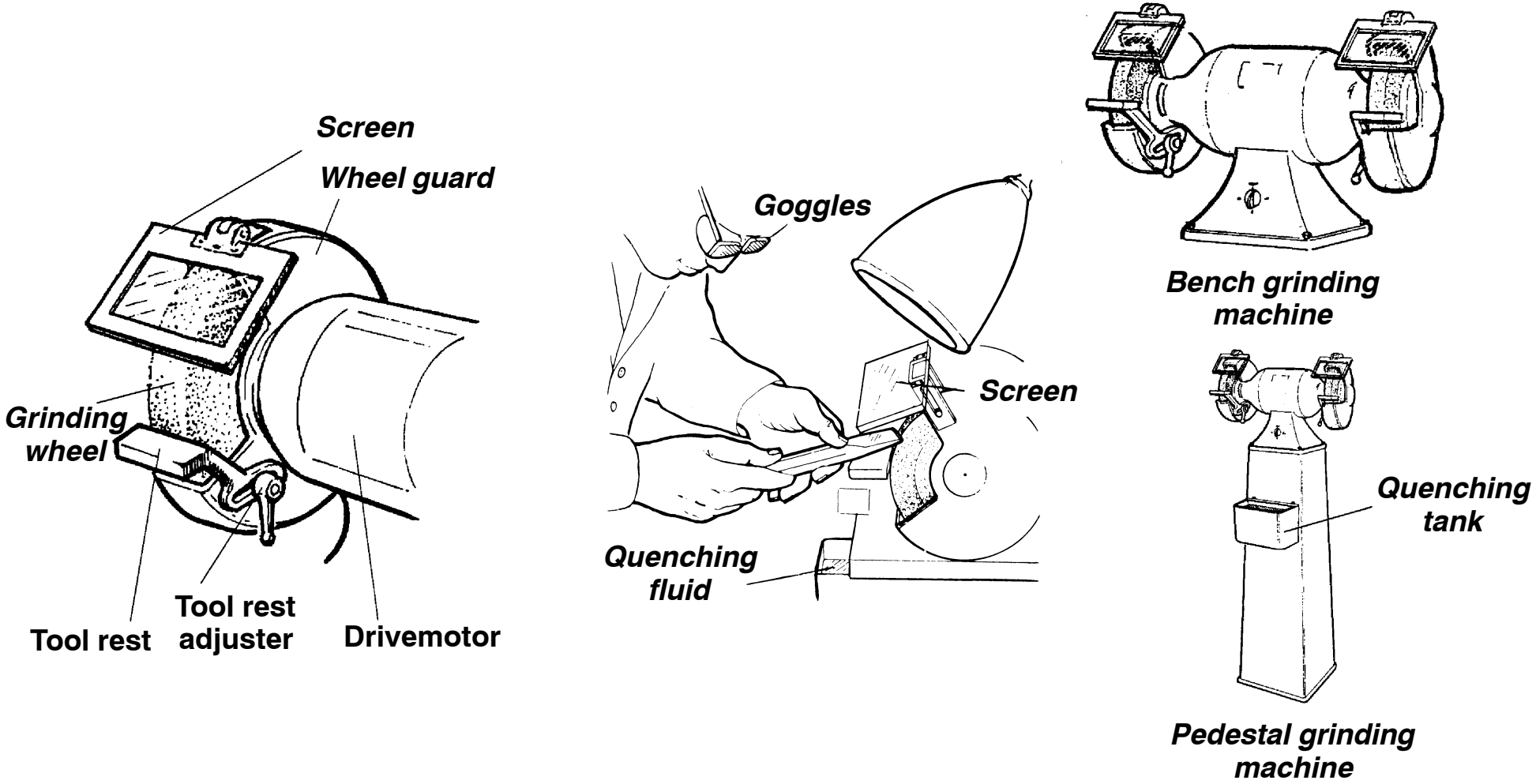


Figure 45 Off-Hand Grinding Machine

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OPERATION AND USE OF PRECISION MEASURING TOOLS

Vernier Caliper

General

Vernier calipers/sliding gauges are used widely in the metal industry because of their flexible measuring and simple construction. They can make inside or outside as well as depth measurements

The measurements are very accurate.

In comparison to micrometers measurements can be done faster and in a wider measurement range.

Assembly and Operation of a Vernier Caliper

The vernier caliper consists of a bar and two measuring jaws. One jaw is fixed to the bar, the other one slide on the bar.

The bar of a vernier caliper at which also the fixed jaw is installed, is equipped with an engraved scale.

The scale of a metric vernier caliper is graduated in mm.

There is the vernier scale on the movable slide. This scale is divided in 10, 20, or 50 equal spacing, known as 1/10, 1/20 or 1/50 vernier.

For a measurement open the slide of the vernier caliper so that the part, which has to be measured fits into the space between the jaws and touches the fixed jaw.

After that, the slide is moved with the thumb to the left until also the second jaw touches the part surface.

The value can be read on the main and the vernier scale.

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1 Internal measuring jaws
2 Clamp screw
3 Slider
4 Depth bar
5 Main beam
6 Reference surface
7 Main scale
8 Vernier scale
9 External measuring jaws
10 Step measuring face

Figure 46 Vernier Calliper

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VERNIER CALIPER (CONT.)

Reading of the Value

The last number on the main scale in front of the zero of the vernier scale represents the value before the decimal point.

The value at which the graduation line of the vernier scale and the graduation line of the main scale are matching represents the value after the decimal point.

Often the main scale is engraved with the metric system in the lower part and the imperial system in the upper part.

In the metric system one graduation line of the main represents 1mm.

In the imperial system the value is 1/16 inch. Depending on the graduation of the vernier scale in the particular system a certain accuracy of the measurement can be reached.

Graduation of the Vernier Scale

1/10 mm Vernier Scale

The distance from 0 to 1 on the main scale is 10mm.

The 10 divisions on the sliding vernier scale are equal to 9mm on the main scale.

The length of the bottom division is 9mm divided by 10 = 0.9mm.

Since the top division is 1mm, the difference is 1mm – 0.9mm = 0.1mm. This difference represents the accuracy to which readings may be taken.

1/20 mm Vernier Scale

The most often used vernier caliper is the caliper with the 1/20 vernier and an accuracy reading of 0.05mm.

1/50 mm Vernier Scale

The accuracy reading is 0.02mm.

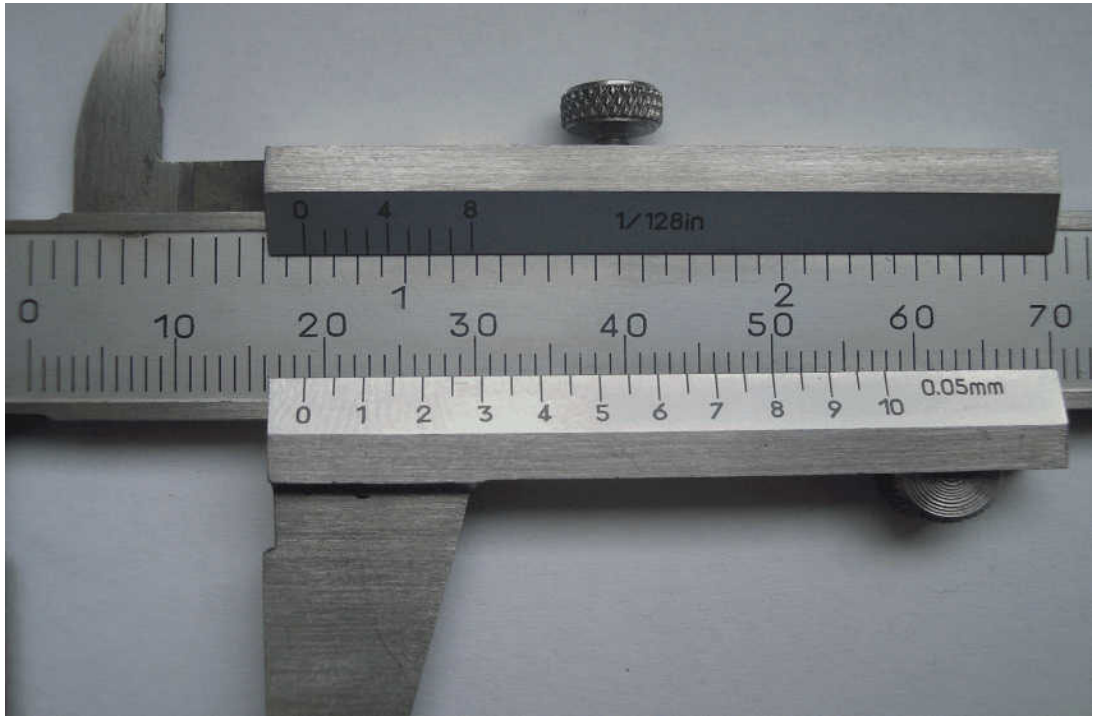
1/128 Inch Vernier Scale

This graduation is very common in the imperial system. One graduation line on the main scale corresponds to 1/16 inch, so every second graduation line is 1/8 inch. On the main scale whole, 1/16 and 1/32 inch can be read, which sum is before the decimal point.

The graduation line on the vernier scale which matches with the main scale, gives the value behind the decimal point in 1/128 inch.

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Metric with 1/20 mm vernier scale

Value on the main scale before the zero of the vernier scale 18	= 18mm
Graduation line of the main scale matches with the graduation line of the vernier scale at 7	= 0,7mm
Measurement:	= **18,7mm**

Imperial with 1/128 inch vernier scale

Value on the main scale before the zero of the vernier scale 11 (11/16 new denom.: 88/128)	= 88/128 inch
Grad. line of the main scale matches with the graduation line of the vernier scale at (6/128)	= 6/128 inch
Measurement:	= **94/128 inch**

Figure 47 Example of Measurements with a Vernier Caliper

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VERNIER CALIPER (CONT.)

Vernier Caliper Handling

The vernier caliper is made in various sizes. The most common vernier caliper has a size of 150mm. This vernier caliper is also known as „Pocket caliper“.

Inside Measurement

To measure openings, e. g. drill holes, the cross jaws are set to a smaller size than the dimension that has to be measured.

Guide the cross jaws inside the hole and move the fixed jaw to the hole surface.

Then the movable cross jaw is moved via the slide to the other hole surface.

The Measured value can be read on the main and the vernier scale.

Outside Measurement

For a measurement open the slide of the vernier caliper so that the part, which has to be measured fits into the space between the jaws and touches the fixed jaw.

After that the slide is moved to the left until also the second jaw touches the part surface.

The value can be read on the main and the vernier scale.

Depth measurement

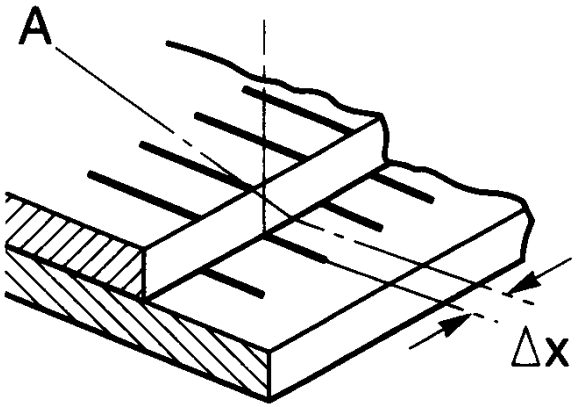
During a depth measurement the end of the main beam has to be pushed firmly onto the surface of the part, which has to be measured.

Now the slide is moved and the depth bar is extended until it touches the surface of the depression.

The value can be read on the scales.

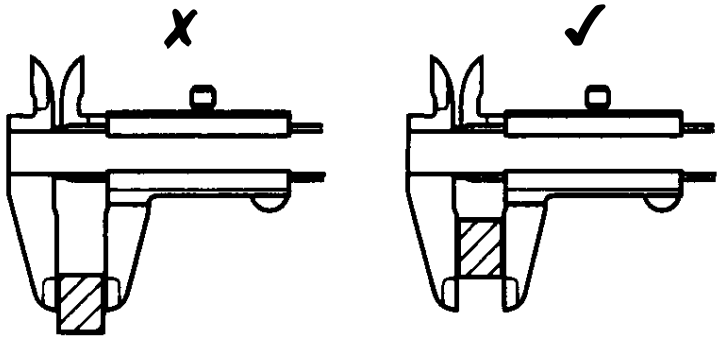
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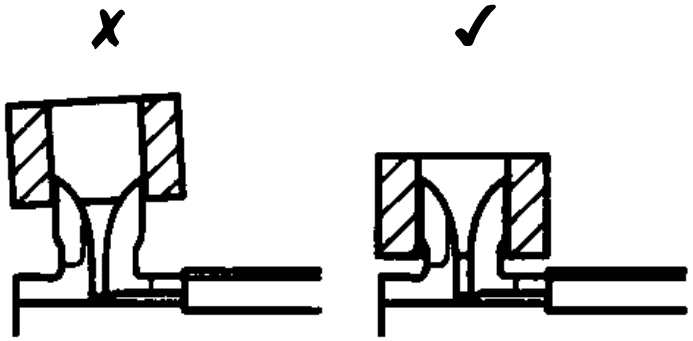
Parallax Error

When taking the reading, ensure you view the scale perpendicular to the measured point. When viewed obliquely (direction A) parallax error occurs, resulting in inaccurate reading.



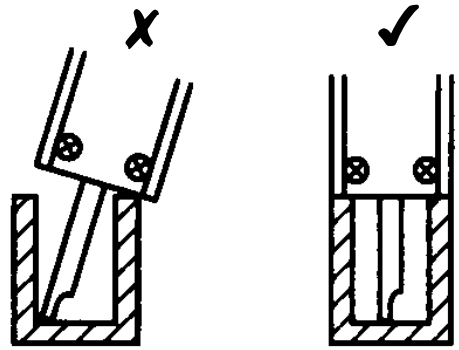
Outside Measurement

Place the work piece as deep as possible into the jaws. The jaws should touch the surface of the object. Do not use to much pressure when measuring, this can produce inaccurate measuring.



Inside Measurement

Insert jaws as deep as possible into the the work piece. Read the largest value (inside diameter).



Depth Measurement

Hold the calliper perpendicular to the surface.

Figure 48 Vernier Calliper Measuring Precautions

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Micrometer

General

Micrometers are used, if an accuracy is demanded, which can not be reached with a vernier caliper.

They are very common in the metal industry and are used for accurate measurements up to the second decimal place. So they are used in the hundredth millimeter interval.

Assembly and Function of a Micrometer

The micrometer consists out of a fixed and a movable surface, which can be adjusted by a fine thread. They are connected through a semi-circular frame.

The work piece has to be located between the two surfaces and the thread is tightened through a screw head, until both surfaces touch the work piece.

On the first scale, which is located on the barrel, the size of the part in whole pitches of the thread (commonly one or a half millimeter) can be read.

A second scale on the thimble is made for reading the part of the size, which can only be expressed in fractions of the pitch. Often it is possible to read on this scale a hundredth of a millimeter or a thousandth of an inch.

The distance between both measuring surfaces, which is standardized to 25 mm or 1 inch, is measured.

Micrometers are often offered as sets. All micrometers have a 25 mm wide scale, but with different overall openings: 0–25; 25–50 and so on. The most common sizes end with 100 mm.

Calibration

Micrometers have to be calibrated periodically within the predetermined calibration dates, or if the accuracy starts to fade, it has to be calibrated immediately.

The zero-point has to be adjusted with the set screw of the thimble with the help of a supported tool.

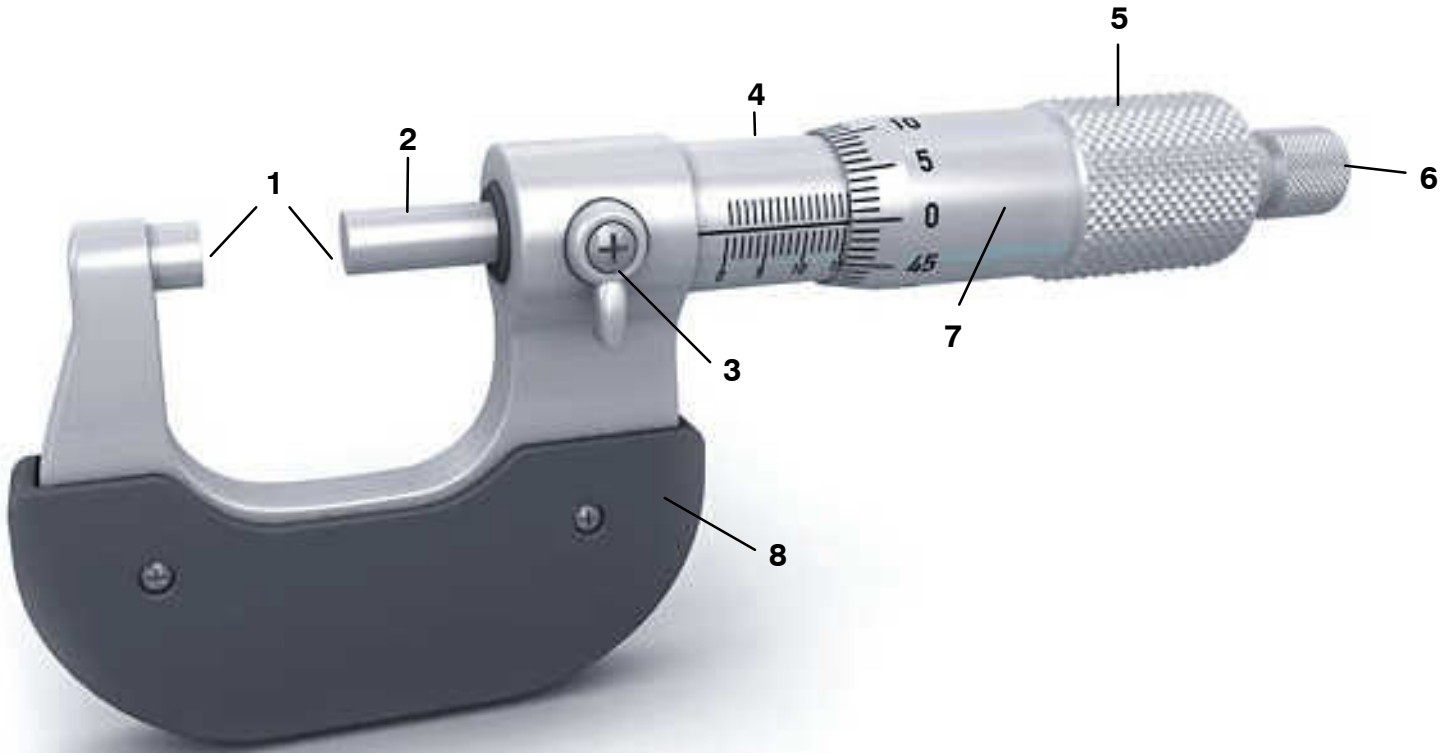
The tool is inserted between the anvil and spindle and the spindle then closed gently.

The tool is then adjusted by means of a wrench (supplied with the micrometer) so that the zero mark on the thimble exactly coincides with the sleeve datum line.

Calibration/adjustment is normally carried out by a specialist in a temperature/humidity controlled environment.

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1. Anvils
2. Spindle
3. Locknut
4. Sleeve
5. Thimble adjusting nut
6. Ratchet stop
7. Thimble
8. Frame with insulating plate

Figure 49 Micrometer

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MICROMETER (CONT.)

Micrometer Readings - Metric

The screw in the metric micrometer has a pitch of 0.5mm, so that the jaws open 0.5mm for each revolution of the thimble.

The unit on the **barrel** is millimeter and the graduation is 0.5mm per graduation line.

There are 50 graduation lines on the **thimble**. Every line represents 0.01 mm.

When reading the scale, the visible full or half millimeter of the barrel and the hundredth of millimeter of the thimble, have to be summed.

Reading Example:

The thimble is opened with 10 full revolutions = 5.00mm.

Additionally one half millimeter graduation line is visible = 0.50mm.

37 graduation lines on the thimble have passed the datum line = 0.37mm.

Reading = 5.87mm.

Micrometer Readings - Imperial

The screw in the metric micrometer has a pitch of 0.025 in, so that the jaws open 0.025 in (1/40 in) for each revolution of the thimble.

The unit of the **barrel** is 0.1 inch and the graduation is 0.025 inch per graduation line.

There are 25 graduation lines on the **thimble**. Every line represents 0.001 inch.

When reading the scale the visible tenth or hundredth inch of the barrel scale have to be summed with the thousandth inch of the thimble.

Reading Example:

The thimble has moved out 2 complete turns = 0.200 inch.

2 additional 0.025 Inch divisions are visible = 0.050 inch.

21 thimble lines have passed the datum line = 0.021 inch.

Reading = 0,271 inch

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Metric Micrometer

Highest visible number **top** on barrel 5	= 5mm
Lines **bottom** visible 1 (1x0,50)	= 0,50mm
Thimble lines which have passed the datum line 37	= 0,37mm
Reading:	= **5,87mm**



Imperial Micrometer

Highest visible number **bottom** on barrel 2	= 0.200 inch
Lines **top** visible 2 (2x0,025)	= 0.050 inch
Thimble lines which have passed the datum line 21	= 0.021 inch
Reading:	= **0,271 Inch**

Figure 50 Reading Examples of a Micrometer

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MICROMETER (CONT.)

Micrometer handling

- Set the micrometer to an oversize dimension
- Set the frame anvil straight to the work
- Clamp the spindle against the subject using the ratchet stop

ATTENTION: Use only the ratchet stop, otherwise the measurement will be inaccurate due to over tightening.

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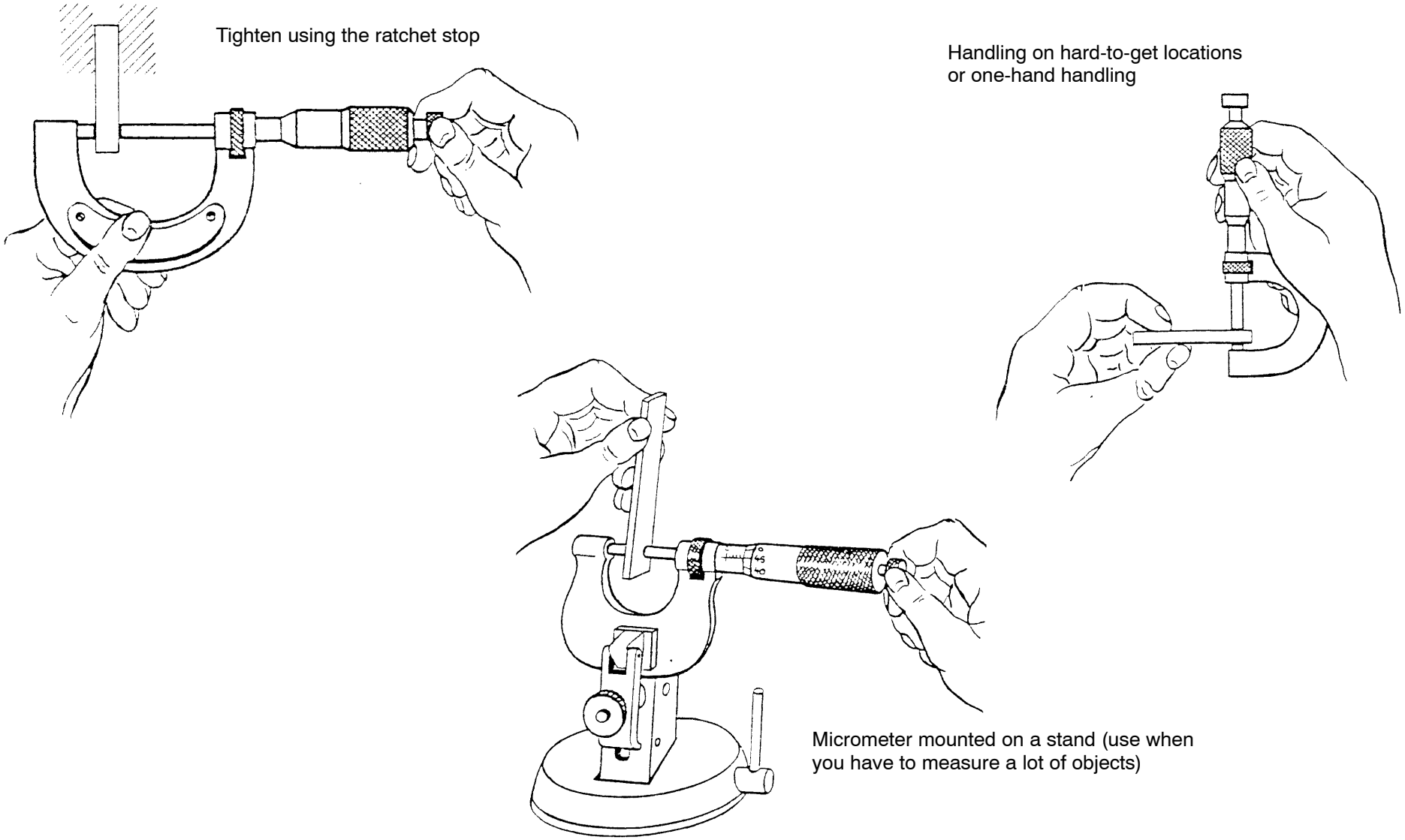


Figure 51 Micrometer Handling

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Dial Indicator

General

The dial indicator is a high-precision measurement tool with an accuracy of 0.01 mm. It is especially used in the mechanical engineering section for comparison, smoothness or roundness measuring.

A special type of dial indicator is an excellent tool to measure material removed after corrosion or lightning-strike repairs.

Description

One revolution of the large hand corresponds to 1mm.

The second smaller hand of the rotation tachometer counts the revolutions of the large hand.

Measuring range is normally 10mm.

The indicator can be set to zero by revolving the rotary scale.

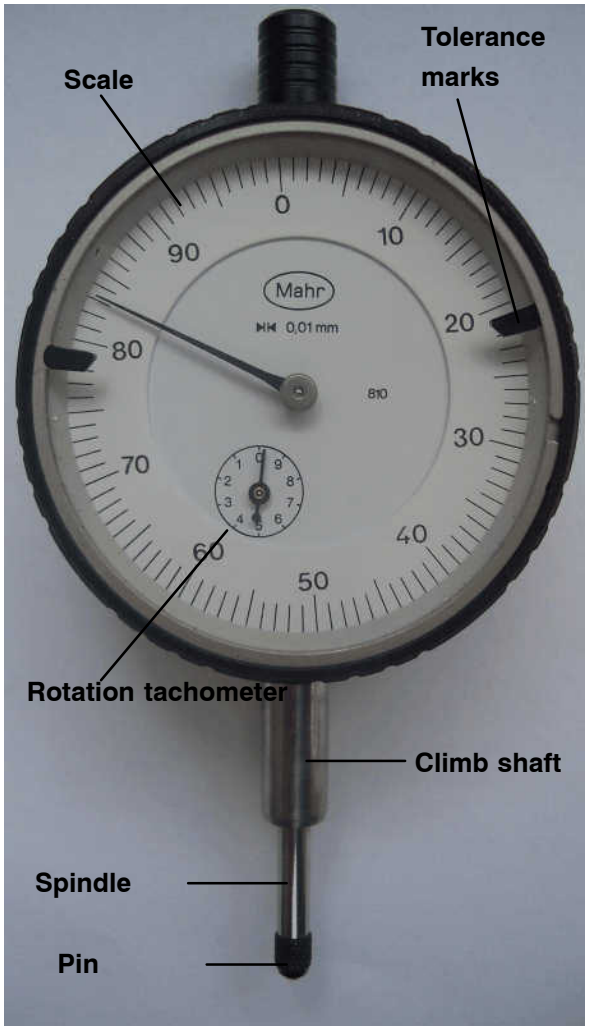
Work Sequence when Measuring the Depth of a Machined Area

- Clean up damaged area.
- Put the dial indicator with the measuring stand on a flat surface and rotate the rotary scale mark to zero.
- Carry out the inspection at different points in the inspection area until you find the maximum depth of removed material.

ATTENTION: This procedure measures the depth of the material removed. The thickness of the material remaining must be found out by calculation.

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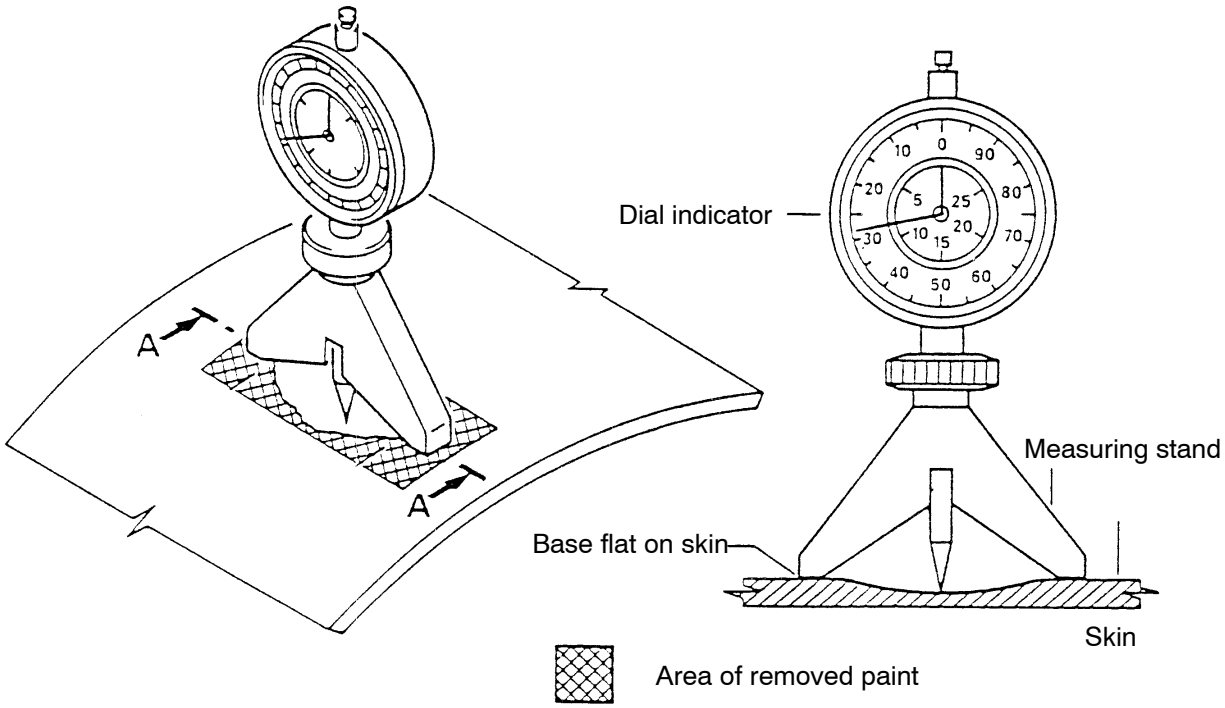


Figure 52 Dial Indicator

FOR TRAINING PURPOSES ONLY!

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