

Teaching Notes

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1. Marking out

General:

Accurate work depends on accurate marking out. The drawing to be marked out should be carefully studied. Critical dimensions should be checked against the blank first.

Learning outcomes:

At the end of the demonstration, the students will know how to:

1. Examine and study a working drawing
2. Select a datum to work from
3. Mark out the material correctly using the correct procedures

Equipment needed:

1. Files
2. Square
3. Rule
4. Scriber
5. Spring Dividers
6. Jenny Calipers
7. Combination set

Preparation:

Before marking out is started, a right angle should be formed between two leading edges. To cater for correct measuring angles.

Choice of datum:

Where: The datum may be a particular point on the component (i.e.) drill hole centre or a centre line.

When: Once the drawing is completely understood and two square edges have been prepared or selected.

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Why: This can lead to economic engineering and dictate future processes.

The choice of datum is important in the marking out process, as it can reduce manual labour and waste. The diagrams below illustrate this.

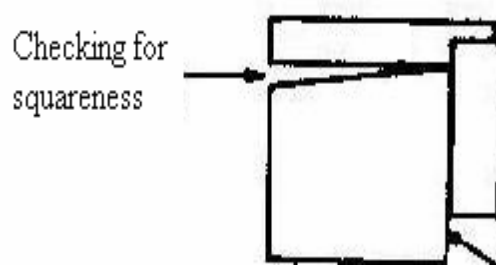
The edge choice of datum incorporates some thought and time however the workload is reduced considerably and the waste is more economic.

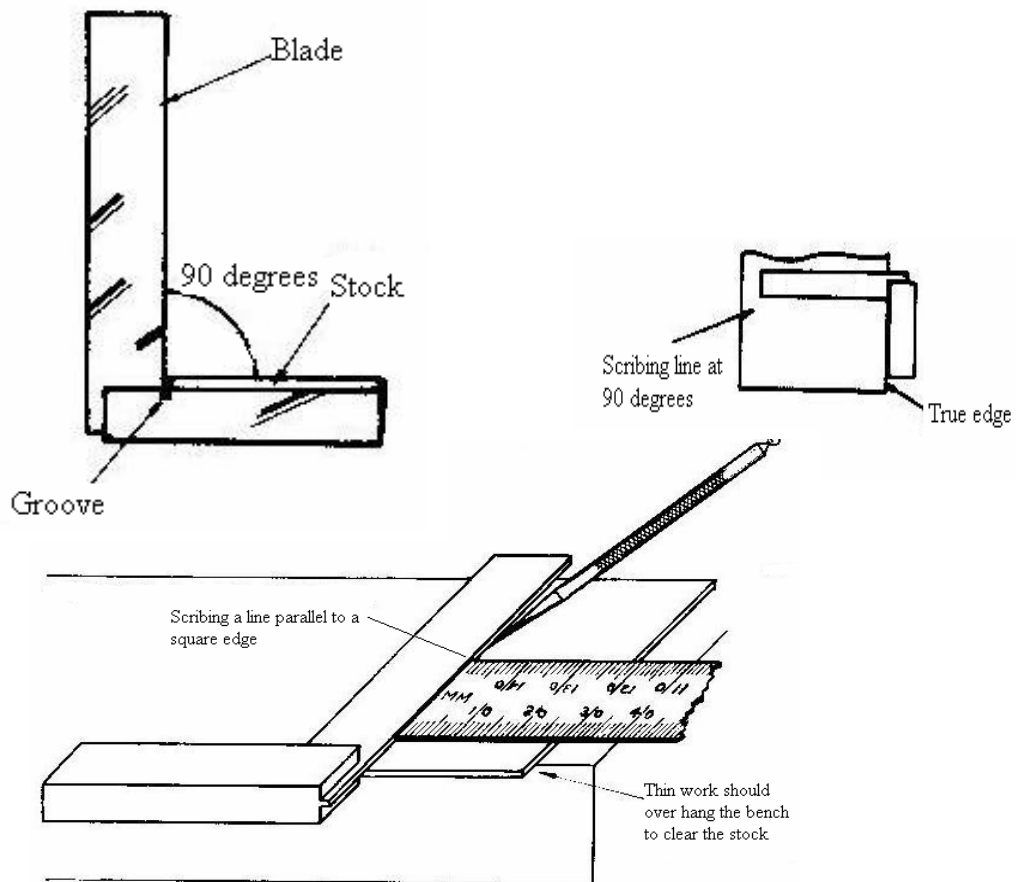
Depending on the components symmetry a centre line may prove to be more suitable as shown below.

Equipment:

1.1 Try square

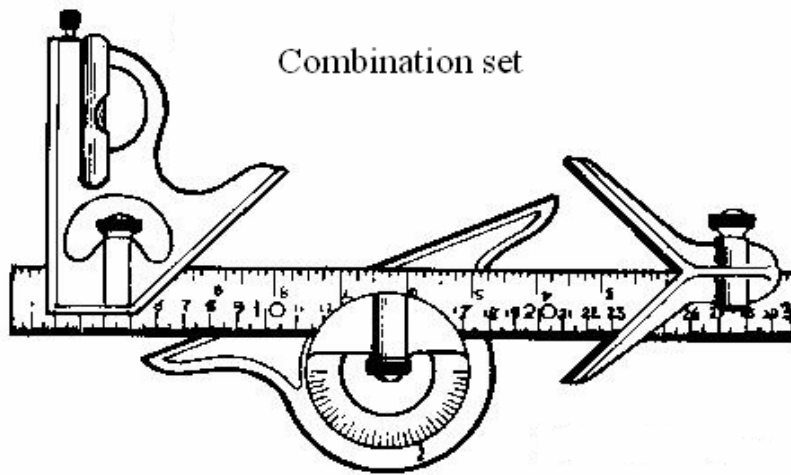
- Shown below and consists of a stock and a blade.
- The blade is securely riveted into the stock at 90°.
- Used for testing the accuracy of two surfaces at right angles to each other
- Scribing true lines to a surface.
- The stock is made from case hardened steel and the blade is hardened, tempered and ground to high accuracy.
- Groove is cut into the stock below the blade to accommodate burrs.
- Both the inside and the out side of the square can be used.
- The blade may also be used as a straight edge. As an inaccurate square is useless care must be taken not to damage it.
- The size is given by the inside length of the blade, commonly at 100mm. A square may be tested for accuracy by holding the stock against a straight (true) edge and scribing a line along the blade and then reversing the square and drawing another line. These lines must coincide for the square to be accurate.



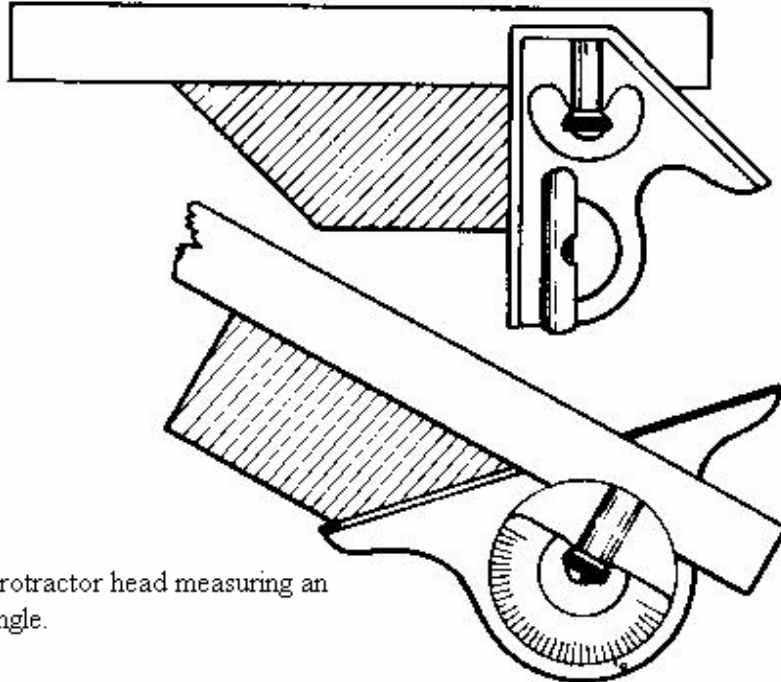


1.2 Combination set

- The combination set consists of a rule and three different heads that can be attached to it.
- Square head, which allows it to be used for marking out and testing right angles and 45° angles and can also be used as a depth gauge.
- Protractor head can be used to test and mark out any angle.
- Centre head is used to locate the centre of round bars.

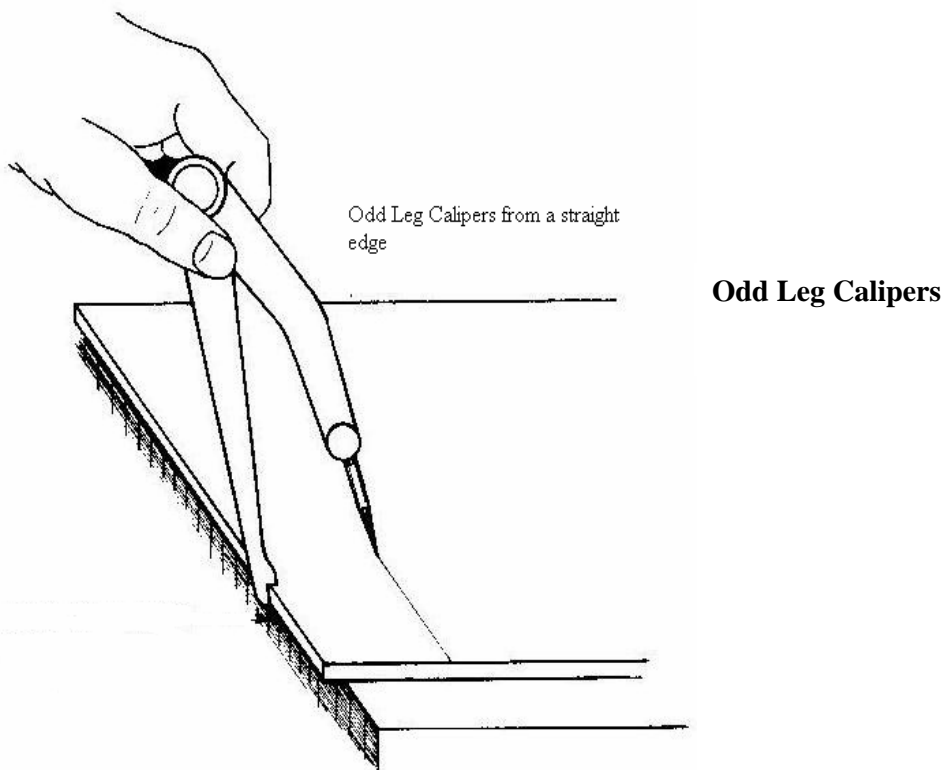
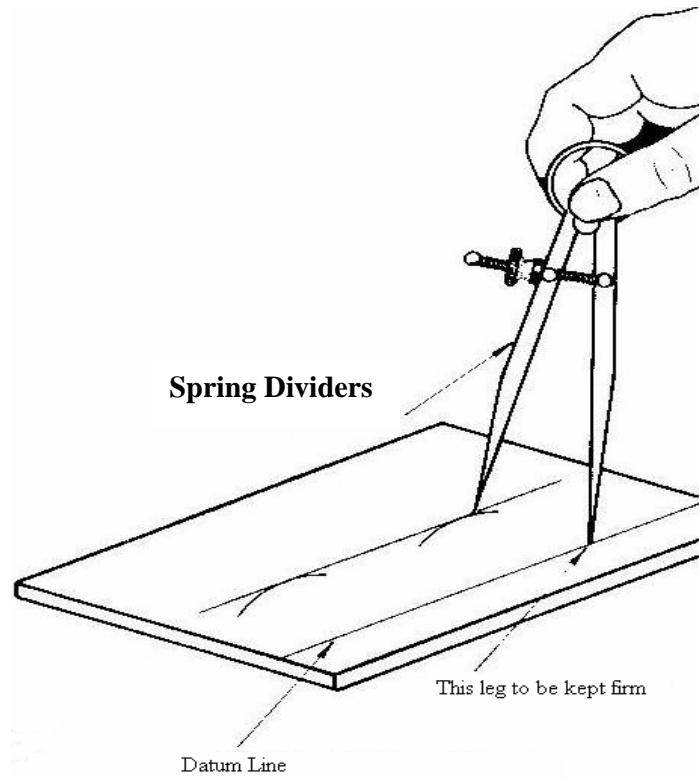


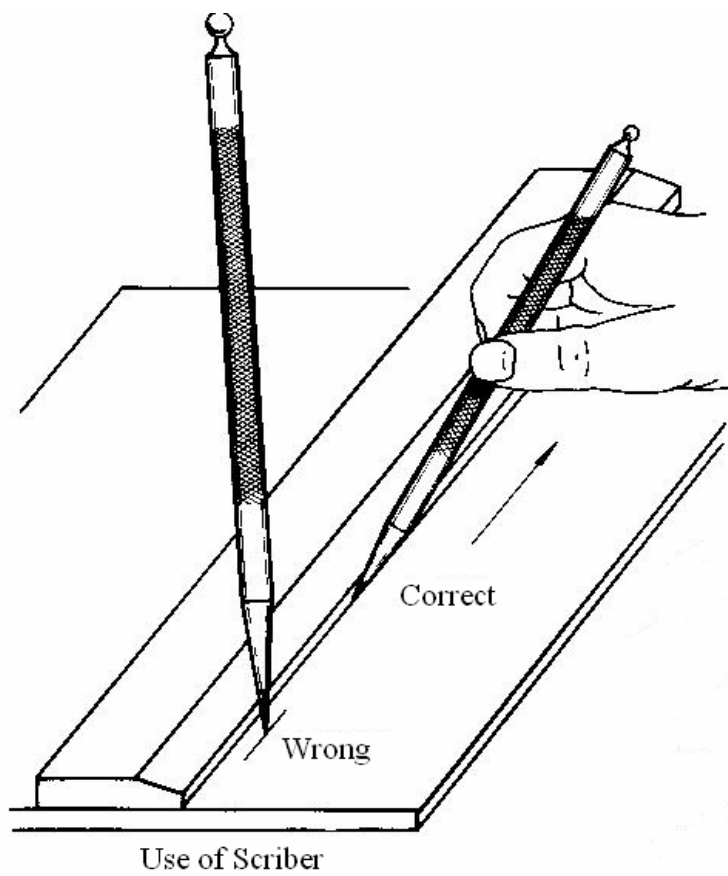
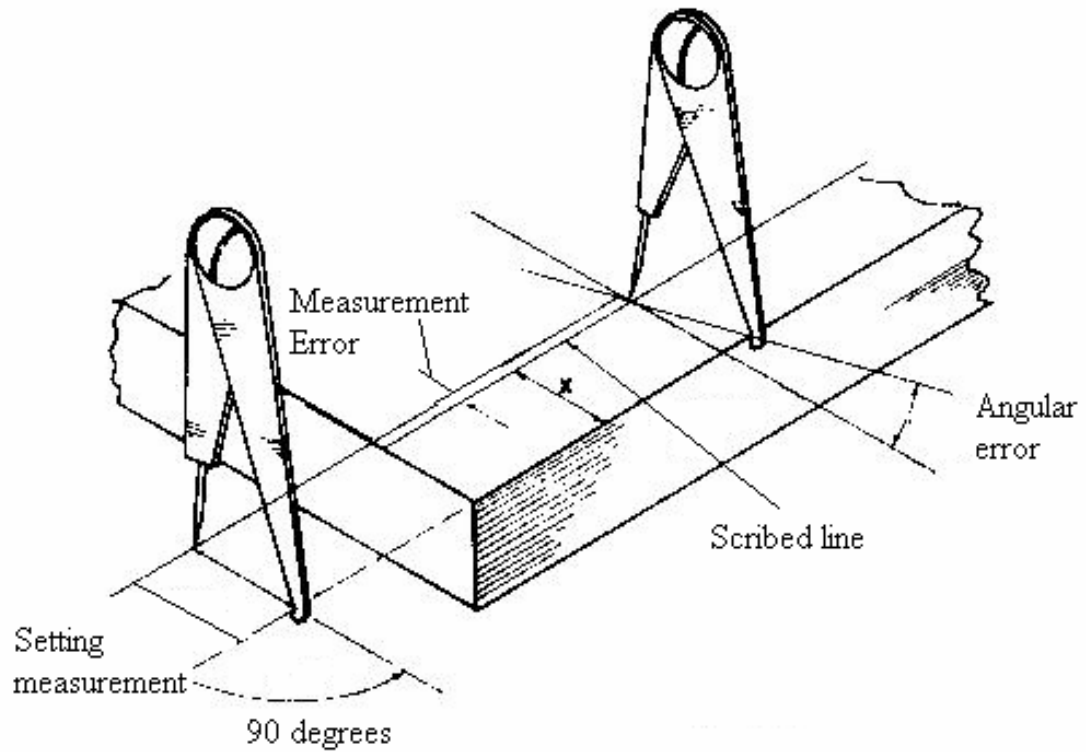
Using as a Try Square



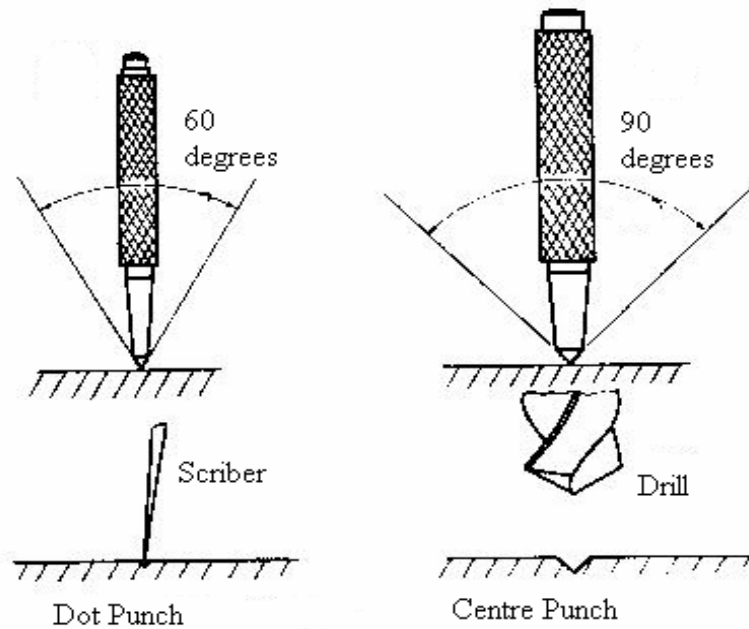
Protractor head measuring an angle.

1.3 Scribing lines and arcs





1.4 Punches



Centre punch

Made from high carbon steel,

Hardened and tempered.

Point angle is 90° used to mark the centre for drilling to ensure the drill starts in the correct place.

Prevents drill walking.

Dot punch

Similar to centre punch but of slimmer proportions

Point is ground to 60° .

Used to 'witness pop' when marking out lines and circles.

Method for marking out

Once the drawing is understood and a datum has being selected

Begin by scribing lines on the back of the component

Draw all critical lines, centre punch where necessary

Scribe arcs, angles and complete

Dot punch only if necessary

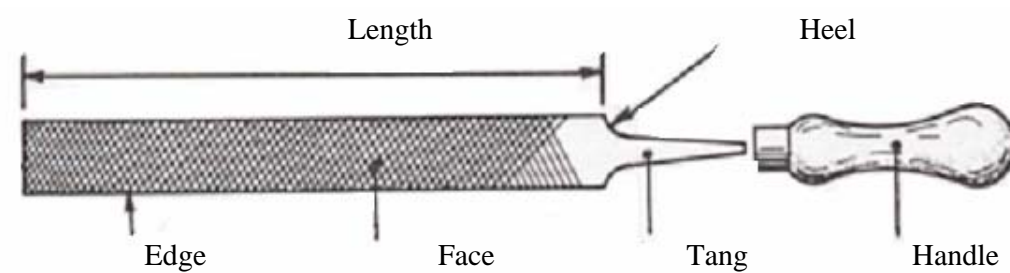
2. Filing

General:

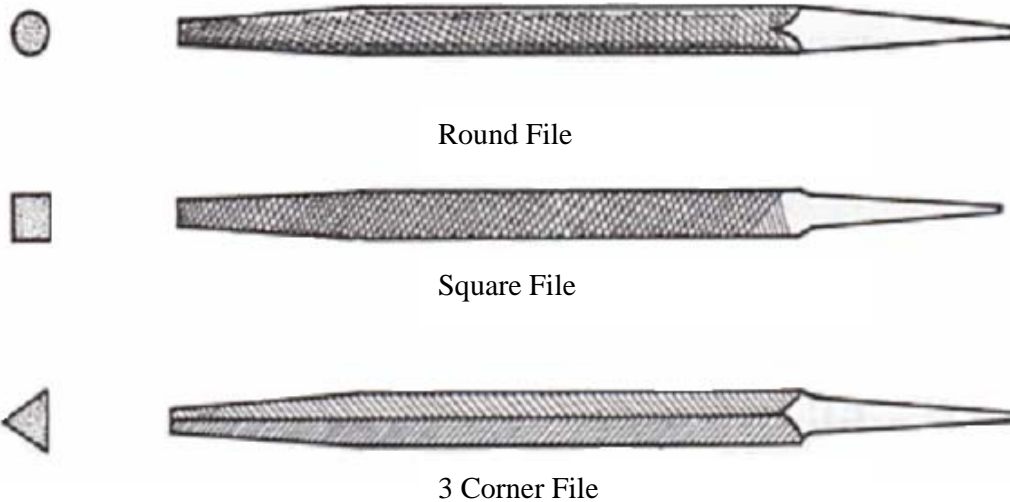
Filing is used to remove small amounts of material and can be used skilfully to high standards and tolerances.

2.1 Types and Terminology

The file is one of the workshop's basic bench tools.



Files come in a number of different shapes and sizes for different applications.



Files come in five different grades, referring to their coarseness. They are

Rough Smooth

Bastard

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Dead smooth

Second cut

The longer the file the coarser it is, i.e. a 250mm is coarser than a 150mm smooth file. There are two main forms of file teeth, single and double cut. Single cut teeth are produced by cuts in one direction and double cut teeth are produced by cuts in two directions, as shown below.

Learning outcomes:

At the end of the demonstration the students will know how to
Use and manipulate different types of file to suit specific tasks
Finish a component to a high degree of accuracy and finish using the correct files
Complete convex and concave surfaces using the correct technique.
Use and care for files in a safe and correct manner.

2.2 Filing technique:

Place the work low in the vice and parallel with the vice top.

Take up a comfortable position, not too close to the work nor too far from it, and with the weight of the body balanced evenly on both feet.

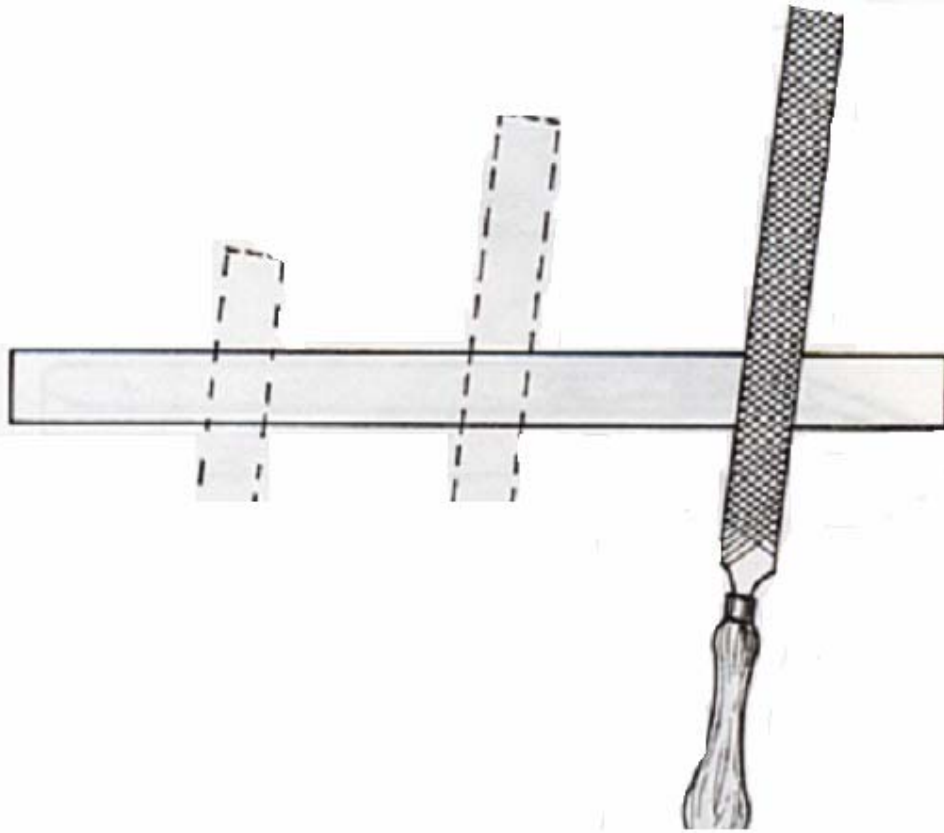
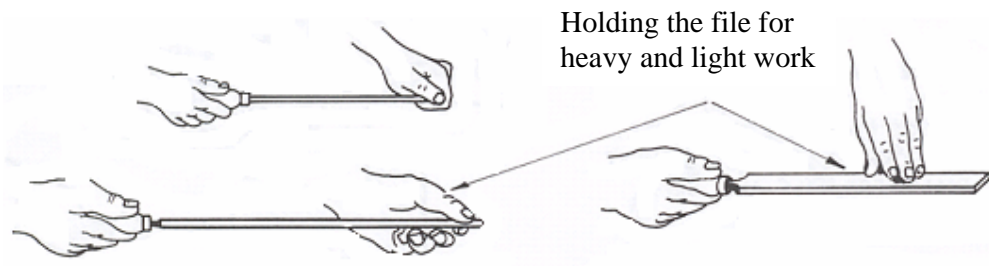
Keep the shoulder and elbow joints free and easy moving. The wrist, which is behind the file handle, must be kept rigid to maintain the file in the flat position.

Apply pressure on the forward stroke, easing the pressure and lifting very slightly on the return stroke, remembering that the file cuts on the forward stroke only.

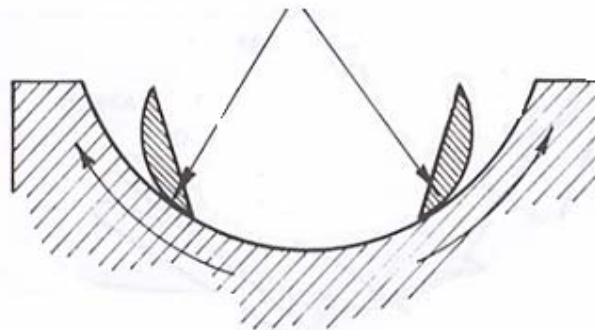
To produce a flat surface the file should be used diagonally across the work, changing direction frequently.

Use the full length of the file and cover a large part of the work with each stroke.

When filing a flat surface it should be checked regularly with the try square and the high points should be concentrated on.



File internal curves



2.3 Safety and care of the file:

New files should be 'broken in' on brass so as to even out prominent teeth making them level with others, as they would break off if used on steel.

Pinning is caused by soft metals clogging the file teeth reducing its effectiveness; these can be removed with a file card or the edge of a small sheet of copper. Initial pinning can be prevented by rubbing a little chalk over the file

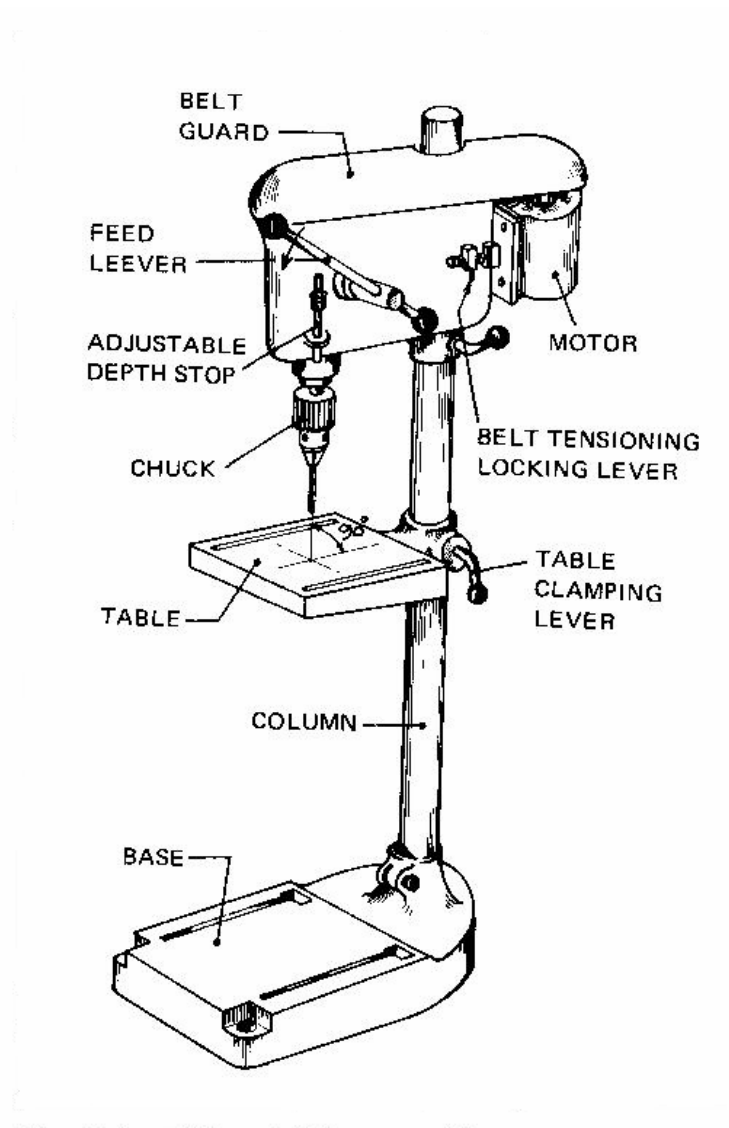
It is very important that the file handle is a tight fit and that it is not damaged. Any loose or damaged handles should be repaired/replaced immediately and a file should never be used with out a handle.

3. Drilling

General:

In the work shop drilling is the primary means of creating round holes in material.

The most common drilling machine used in the workshop is the pillar drill.



The main parts of the pillar drill are shown above, a gear driven machine is also available but both machines are basically the same.

- The chuck is held in the spindle with a Morse taper

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- For larger drills the chuck is removed and the drills are held directly in the spindle with Morse sleeve tapers.
- The spindle is raised and lowered with a rack and pinion system.
- The table can be raised and lowered or swung out of the way to accommodate larger work. Some tables can also be tilted at an angle to allow holes to be drilled into work at an angle.
- Spindle speed is adjustable for different size drills and different material's to suit required cutting speed.

Learning outcomes:

At the end of the demonstration students will know how to:

1. Operate a drilling machine safely
2. Remove the drill chuck and fit larger Morse taper drills
3. Select the correct spindle speed for the required drill size and material.
4. Change spindle speeds on both gear driven and belt driven machines.
5. Identify the parts of parallel and taper shank drill bits.

Equipment:

- Pillar drill
- Marked out material (with a selection of hole sizes)
- Cutting fluid

3.1 Cutting speeds:

These are given in metres pre minute for each particular material, the formula

$$N = \frac{1000 \times S}{\pi \times D}$$

Where N = Spindle speed in revs per minute.

S = Cutting speed in metres/ minute.

D = Diameter of drill in millimetres.

typical cutting speeds	
material	m/ min
Aluminium	70 – 100
Brass	35 – 70
Copper	35 – 45
Cast Iron	25 – 40
Mild Steel	30 – 40
Steel (medium carbon)	20 – 30
Steel (alloy: high tensile)	5 – 8
Thermosetting plastics	20 - 30

- Of the calculated spindle speed is not available the machine, always use the next lower speed, never use a higher speed.
- The values above are average values when using a coolant, experience may show that a lower speeds may be more suitable.

Safety is paramount and all safety precautions must be taken when operating a drill.

4. Cutting screw threads by hand

Where it is necessary to be able to take components apart easily and quickly, without damage screw fastening is used. For cutting external threads a 'die' is used, and for internal threads a ~tap' is used.

Learning outcomes:

At the end of the demonstration, the students will know how to:

1. Prepare material for tapping and threading.
2. Construct stocks and dies, and taps with tap wrench.
3. Tap and thread using the correct procedures.
4. Test the threads with nuts and bolts.

Equipment required:

1. Work piece with tapping size hole drilled (i.e.) 8.4mm for a 10mm thread
2. Tap wrench and taps (taper, second, plug) (Blind hole)
3. Square
4. 10mm diameter bar (taper started)
5. 10mm die nut
6. Die stock

7. Cutting fluid

4.1 Set up:

Have tapping material opposite side to that of threading. Various screw forms to be mentioned. Other processes of mass production (rolling for external and die design for internal) Tapping size hole is drilled smaller because of its minor diameter. Cutting fluids use.

4.2 Preparation of work:

Assemble the taper tap on the tap wrench; place the work with a tapping size hole parallel to the jaws of the vice.

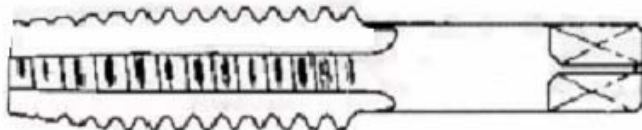
Place the die into the stock with the writing facing the retaining shoulder and the taper facing down. The bar should be placed in the vice perpendicular to the jaws with the filed chamfer.

4.3 Method: Tapping

- Start the tap by applying downward pressure.
- Continually test with square for accuracy.
- Once a thread grip is achieved, complete one half turn.
- Reverse direction $\frac{1}{4}$ turn to break 'swarf' and repeat.
- Test with bolt.



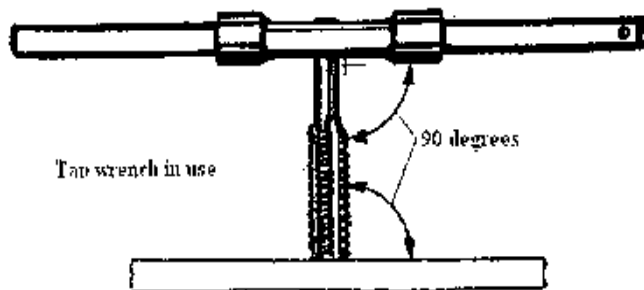
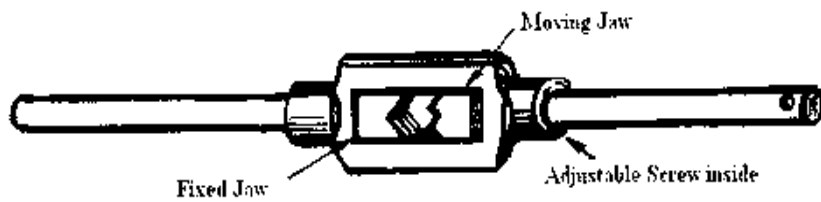
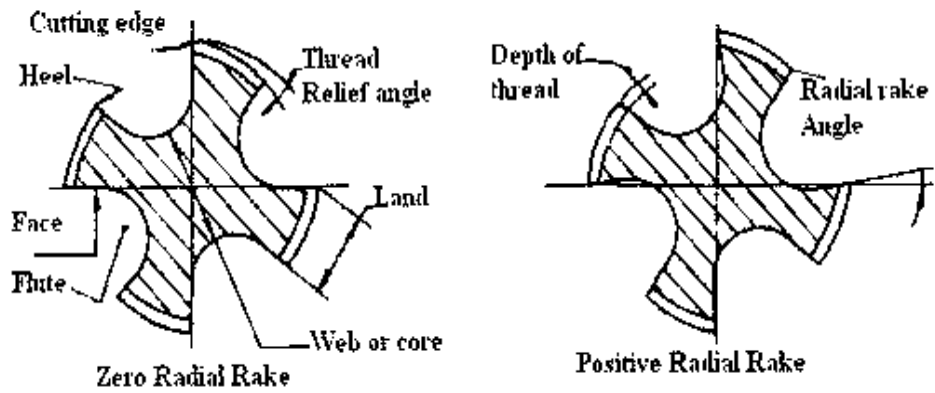
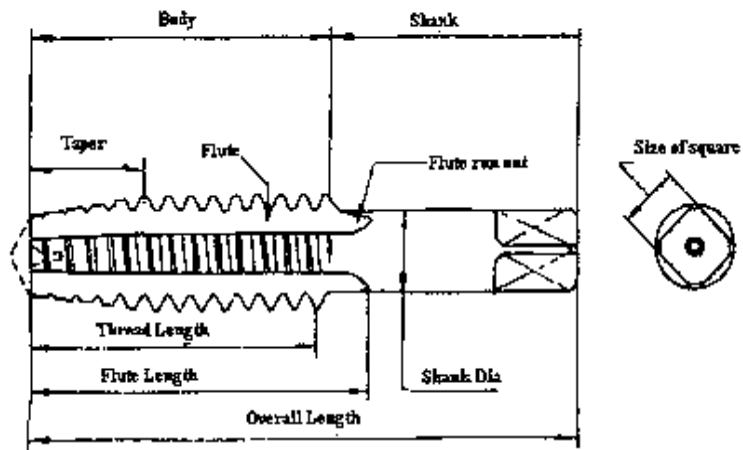
Taper Tap



Second Tap



Plug Tap



4.4 Threading:

Ensure the bar is the same diameter as the thread size (i.e.) 10mm die and 10mm bar

Complete chamfer with file

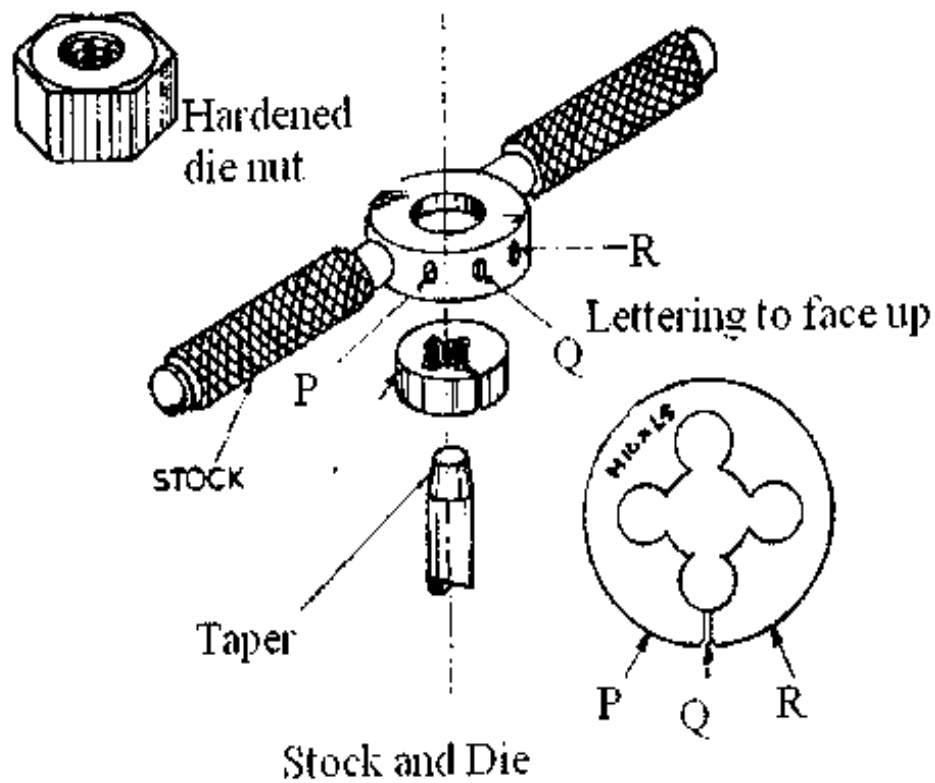
Turn die with taper down and the retaining shoulder acting as a stop for the dies

Apply downward pressure

Check that the die is running true with the square

Revert direction 1/4 turn to break 'swarf' and repeat this after 3/4 revolutions

Test with nut



Common faults

'Drunken' thread caused when the die is not square to the rod axis

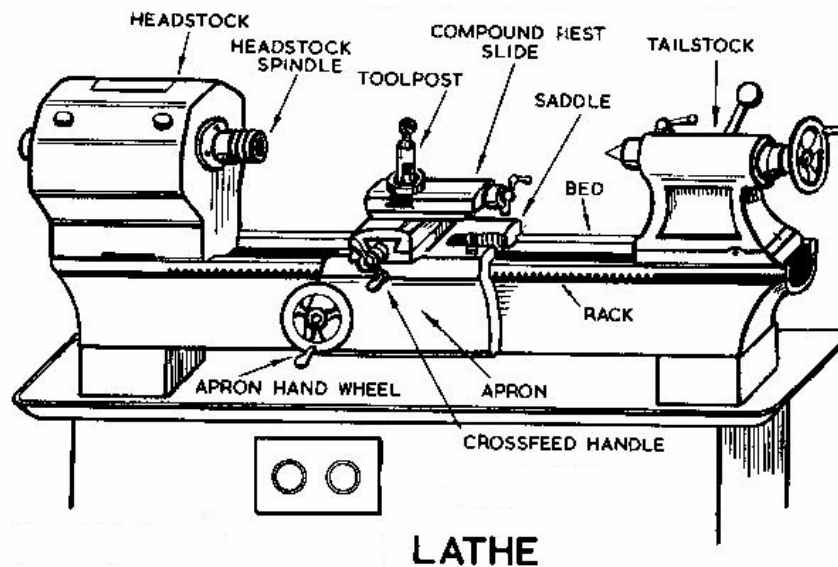
Broken threads caused by not clearing for swarf lubricant

Tap / Die jamming due to incorrect hole or bar diameter

5. Lathe Work

General: a machine for generating cylindrical forms in its most basic use, however it can be used for much more than this. The centre lathe is of concern here however there are various others, capstan and turret.

5.1 Parts of the lathe:



The Headstock is to turn the metal being worked. The headstock spindle is turned by means of a gearbox. The speeds can be altered from the levers from the side.

The Tailstock is used to support the end of the work opposite to the headstock. It also holds the chuck when drilling.

The Bed of the lathe is very accurately machined and tested for trueness.

The saddle is moved along the bed of the lathe by means of the apron hand wheel.

The apron is the front part of the saddle. Screw-cutting lathes have several control levers on the apron.

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The tool post is used to hold the tool that cuts the metal. There are several types of tool post.

The cross feed handle is used to feed the tool at right angles to the bed of the lathe. The tool is carried in the tool post along the cross slide.

The compound rest slide is mounted on top of the cross feed. It may be set at any angle for tapers.

The work is commonly held in the chuck. The three jaw/ self-centring chuck is used to hold round or hexagonal metal. The four-jaw/ independent jaw chuck is used to hold irregular material or for turning off centre.

The tool post carries the cutting tools; the most common is the four-way tool post. This is convenient as four tools can be set without having to change tools constantly. The height of tool can be checked from a rotating centre in the tailstock.

Cutting tools are broken into two fields solids tools and inserts.

Cutting speeds are selected through the formula $N = 1000S/\pi D$.

Where S is the cutting speed in meters per minute. For mild steel the S is 25-30 , with aluminium between 120 and 300.

Learning Outcomes:

At the end of the demonstration, the students will know how to:

1. (Re)grind a cutting tool (HSS)
2. Prepare a lathe for work
3. Demonstrate the various processes in an outlined procedure safely.
4. Produce the exercise part to an acceptable standard.

Equipment:

1. Lathe (gearing set to correct speed).
2. Prepared cutting tool.
3. Parting off tool.

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4. Spanner to adjust the top slide.
5. Knurling tool.
6. Center drill and drill bit 5.1mm
7. 6mm tap set and wrench

5.2 Set up:

$N=1000S/\pi D=1000(27)/(3.14)(25)=343.9$ revs. Nearest machine setting is

Gather all equipment and test the tool height, angles and spindle speed.

5.3 Facing off:

It is common to face off the front of the bar first to select a working datum.

1. The tool should be clear of the work before starting the lathe
2. A slow in-feed in the direction of the chuck until contact is made
3. Then in-feed parallel to the chuck with the top slide.
4. Continue this process until a satisfactory finish is achieved

Turning down/ Parallel turning:

This is achieved by using the carriage moving parallel to the bed.

1. The tool is moved in towards the work by the cross slide.
2. The cutting is produced when the carriage moves in towards the work.
3. This is done until the desired diameter is achieved.

Procedure:

1. Start the chuck with the correct speed selected.
2. Touch the tool off the work and set the top slide to 0 zero.
3. Measure the work using a Vernier or Micrometer.
4. Calculate how much needs to be removed.
5. Remove in measured amounts leaving no greater than 0.2mm for the final cut.
6. Automatic feed should be encouraged to gain a consistent finish.

5.4 Parting off/undercutting:

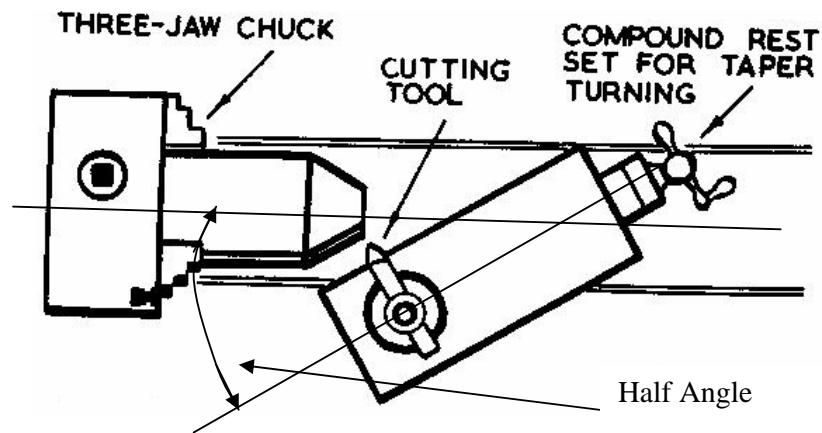
Good stiff solid Machine required.

A parting off tool must be fitted (ensure to set top slide at 90°)

1. When parting off it is recommended that the speed be decreased
2. Two in-feed cuts of the tool side by side should be made to cater for better tool wear and operation.

5.5 Taper turning:

This is achieved through setting the compound slide at a known angle. The top slide is used to create the taper. It can be defined as a consistent change in diameter per unit length. Some cutting tools may have predefined angles all ready ground.

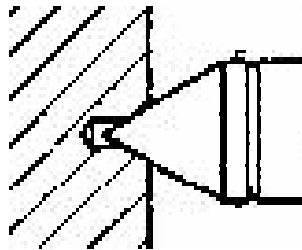


The top slide needs to be set at half the required angle. This is due to the case that both sides of the work are being machined at the same angle. For example if a 90° center punch head needs to be formed the top angle would be set to 45°. One common error in taper turning is the incorrect selection of datum.

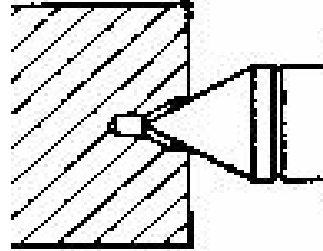
To cater for a consistent surface finish the cutting tool needs to be moving at a constant speed this cannot be maintained with one hand therefore a hand over hand technique is used.

5.6 Center drilling:

This center drill or slocombe center is used to accommodate for rotating centers. The countersink and dead/live center angles are equal. The diagram below depicts a correctly drilled center hole and an incorrectly drilled center hole.



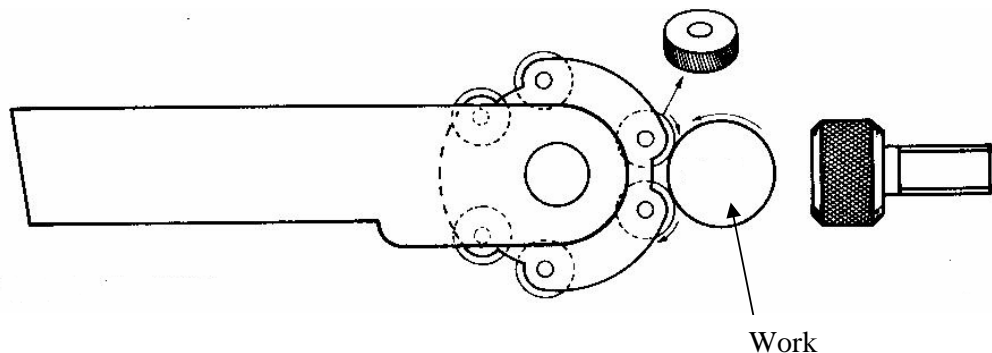
Hole drilled correctly



Hole drilled too far

5.7 Knurling Tool:

This operation should incorporate the use of automatic feed to create a consistent surface. The process should use the slowest speed possible on the lathe with the tool working from right to left. Knurling is a forming process. There are three different grade finishes with two patterns straight and diamond.



5.8 Drilling:

Parallel-shank drills are held in the chuck. This has a Morse taper shank that is inserted into the tailstock spindle. Before drilling, the end of the work should be centre drilled, as when turning between centres. When drilling small diameter holes, care must be taken to avoid excessive pressure on the drill, as this will deflect the drill point, causing breakage. Even if the drill does not break,

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6. Sheet Metal Work

General:

Sheet metal work is a highly skilled craft involving various techniques. The metals used are tinfoil, terneplate, and plain or galvanised sheet iron. Coating sheets of low carbon steel with a skin of tin produces tinfoil. Terneplate is produced similarly with an alloy of tin and lead. Consequently this cannot be used in the food industry due to the use of lead. Sheet iron of a very low carbon content is dipped into molten zinc, which forms an alloy with the steel, providing a protective coating.

Learning objectives:

At the end of this pupils will be able to

1. Recognise tools for sheet metal work.
2. Correctly demonstrate the formation sequence of individual joints.
3. Understand the logic behind the different joints.
4. Take safety considerations into account.

Procedure:

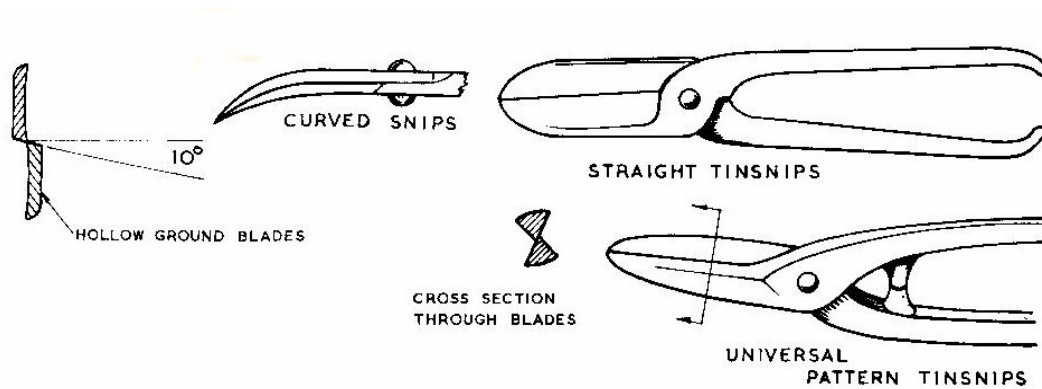
6.2 Marking out:

Marking out of tin plate can be done in pencil, hence preventing the protective layer from being removed, a scriber can be used to mark cutting lines. Care must be taken to cut the material accurately on the first attempt as it is difficult to re-cut the sheet.

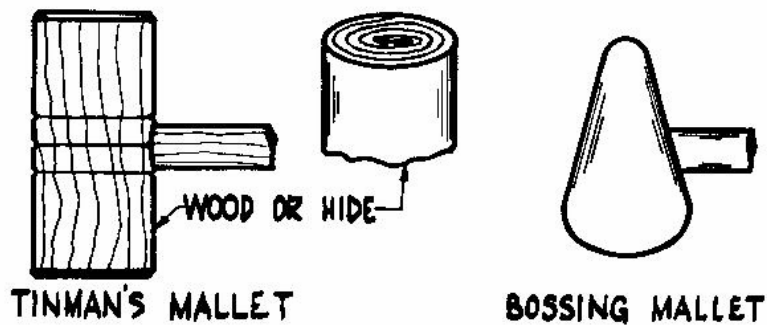
Tools used in sheet metalworking:

6.1 Tinman's snips/ shears:

The shears are used to cut the sheet metal to the outlined development. When using the snips the cut metal on the left should be raised and the cut metal on the right should be lowered. When cutting it is important not to close the snips completely as this leaves a small kink in the metal.

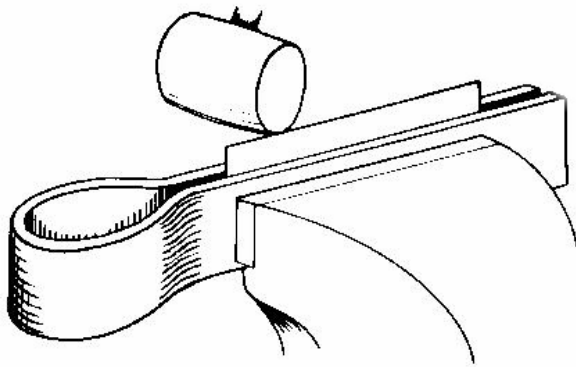


To avoid denting the metal with wooden (boxwood) or hide (leather) heads are used for some operations. The bossing mallet is used for working round curved surfaces. The handles are cane, ash or hickory and are wedged into place.



6.3 Forming tools

Folding bars: used to bend sheet metal for various processes. The metal to be bent is levelled with the inside edge and then the vice is tightened. The bend can be made with the hands or a mallet. It is important to protect the outside of the bars as these can be used for bending also.



The extinguisher stake is used for cones with a steep angle. The bick iron is used for working on small diameters and used for forming rings. The tail of the stake may be used on small flat surfaces. The creasing iron is chiefly for working hollow grooves and bends in sheet metal and for finishing a wired edge. The stakes are made from wrought iron faced with steel.

6.4 Joints used in sheet metal work:

Lap joints a very simple form of joint relying entirely on solder for its strength.

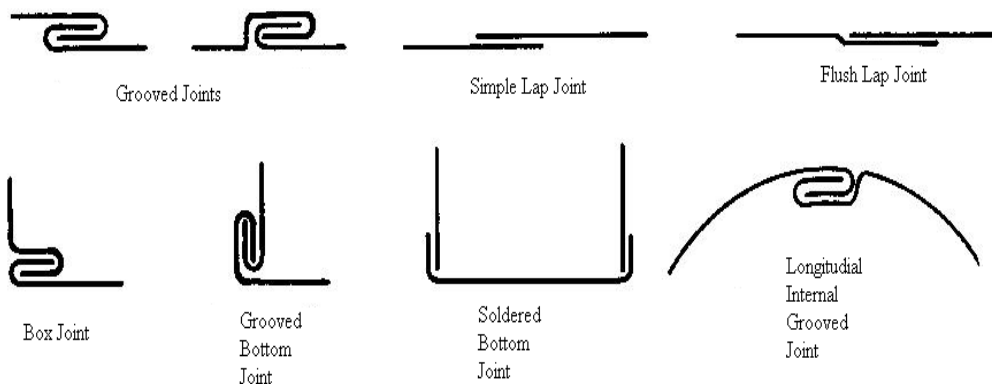
Flush/creased lap joint also relies on solder but shows a flush face on one side.

Grooved seam produces a strong stiff joint that is finished by solder.

Box joint is a strong joint for box corners, which leaves both faces flush, neat appearance.

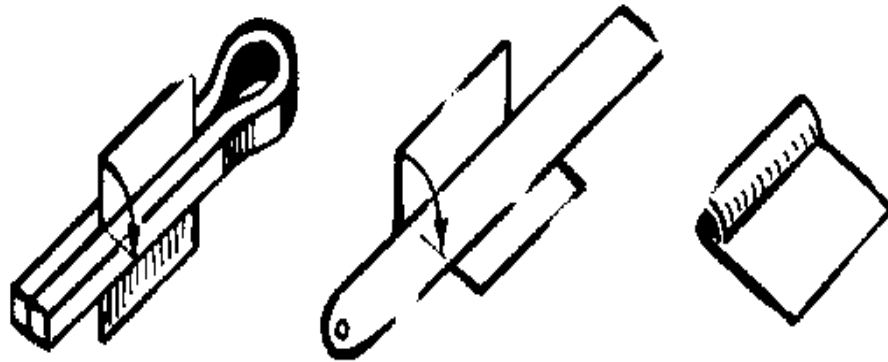
Bottom joint/circular lapped seam, used for the bottom of cylindrical vessels, known also as a 'snuffed bottom' requiring solder to complete it.

Grooved bottom joint/knocked up joint. Good strength and watertight capabilities.



6.5 The safe edge:

Tin plate is a very thin material and leaves sharp edges. Therefore articles made will need to cater for this by producing a safe edge. In planning this work allow for 6mm to form the safe edge. As the edge is to be folded to come on the outside of the article, this line will be made on the outside of the blank. The metal is then placed in the folding bars and bent in towards the line at 90°. Once this is done the sheet is taken out of the folding bars and placed on a flat surface where the safe edge is formed. Using a thin plate and mallet. It is important to carry out the edge treatments before the article is bent into shape.



6.6 The wired edge:

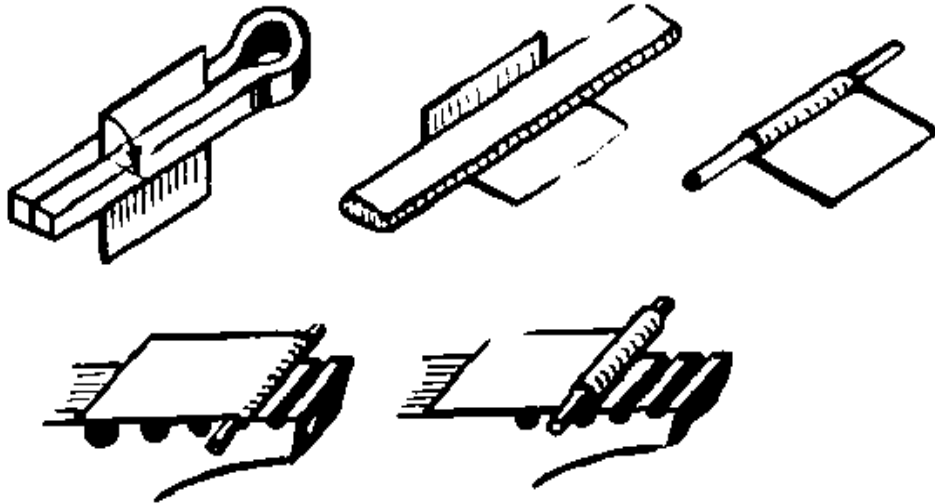
Wiring allowance is 2.5mm the wire diameter. The sheet metal is placed in the folding bars up the required height and is bent at 90°, this bend is not sharp so a mallet should not be used. A strip of material the thickness of the wire diameter with its edges filed off is placed at the bend and a mallet is used to bend the material over this. The strip of material may be taken out and the wire placed instead. The wired edge may now be turned over and placed in the crease. If the wired edge is now tapped quite hard with the mallet, and moved across the stake the metal will be closed right in on to the wire.

Description of operations

1. Mark the material 2.5*
2. Grip the material in the vice/bending bars and bend at 90°

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3. Further bend the material using the bending bar to produce a uniform radius.
4. Place the wire in position and tuck the edge of the lap round it to a close fit using a penning hammer lightly.
5. Place the work in a suitable creasing iron and finish with a hide mallet.



6.7 Folded seam:

Description of operations:

Mark out both pieces with pencil and cut to size.

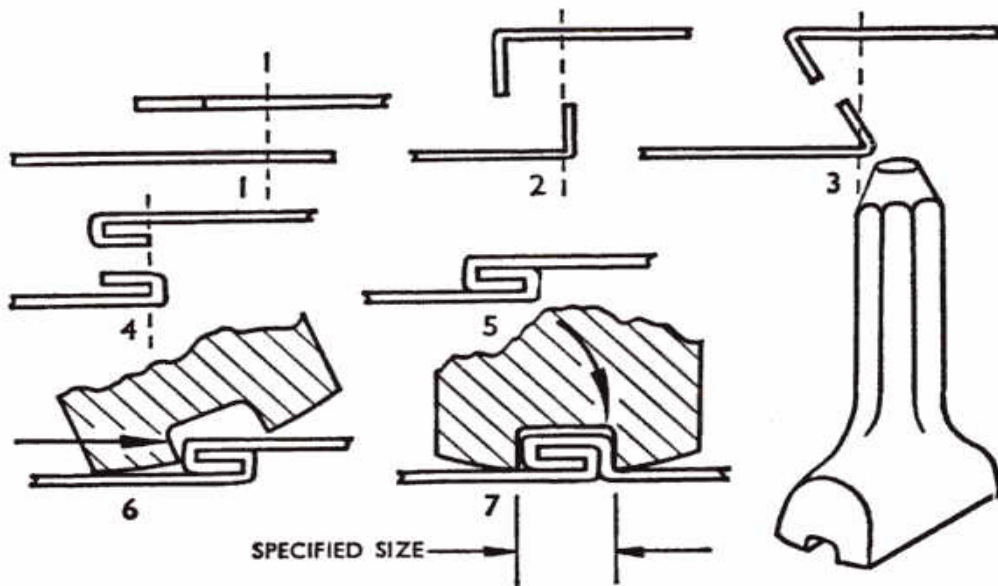
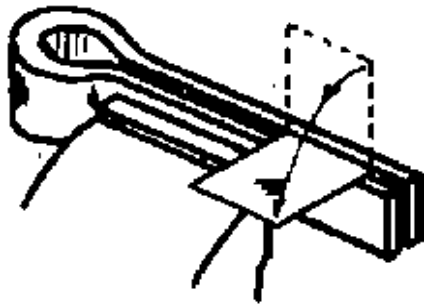
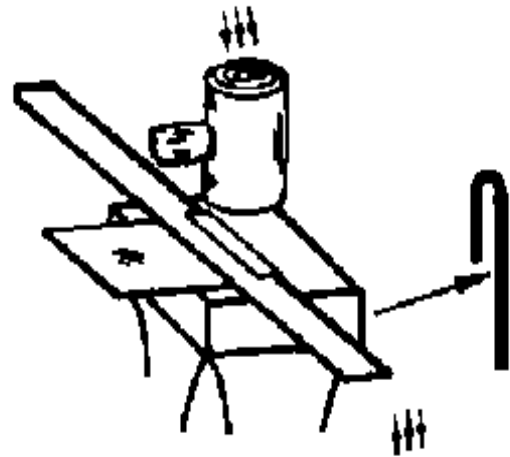
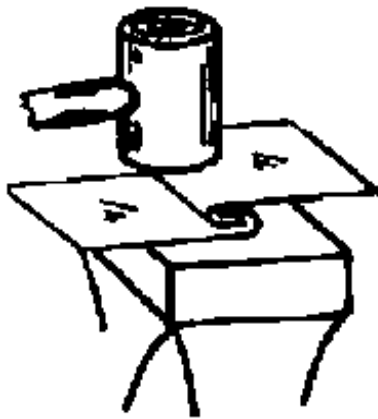
Grip lap portion between folding bars, press over with fingers to form right-angled bend repeat on second piece.

Using the hide mallet, gently tap laps over to make hooks.

Using a strip of the same material fold laps over it to complete the hooks.

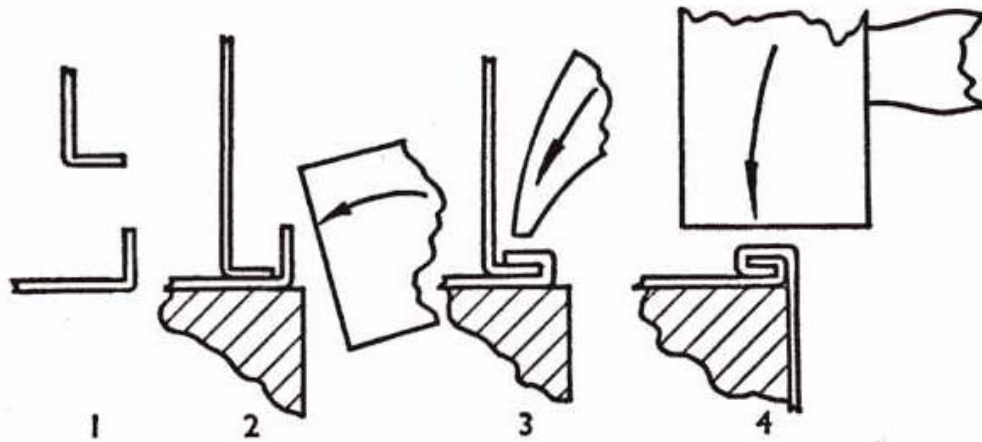
Remove strip and fit the laps together and tightly close them with the mallet.

Placing a groover over the seam and progressing gradually until both plates are in line can produce a grooved seam.



Making a Grooved joint

GROOVING TOOL



Making a knocked up joint

6.8 Safety:

Ensure that all equipment is well maintained.

Sweep down the workbench regularly to ensure that all off cuts are cleaned off.

Clean file the edges to prevent dangerous burrs.

Do not cut wire using the snips.

7. Cutting Tool Grinding

General:

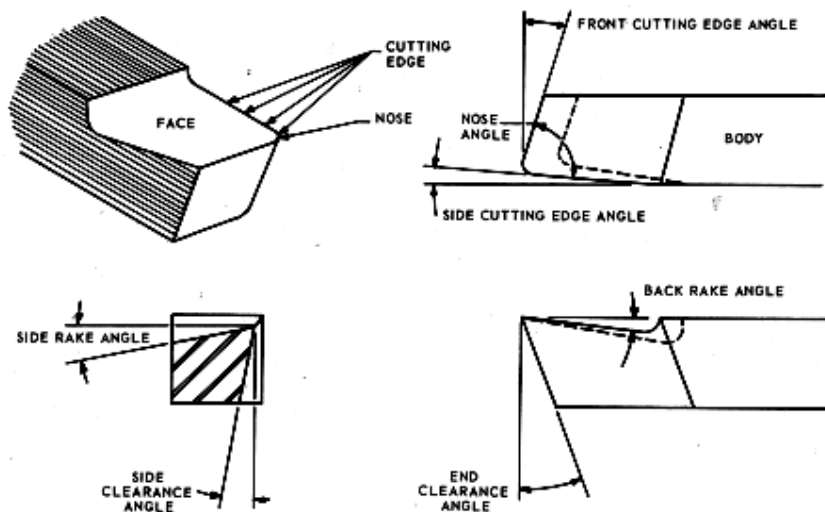
A lathe tool tears the metal off rather than cutting it. The swarf or metal chip in contact with the top face of the tool is directed away from the actual cutting edge. As the work rotates it is continually approaching the top face of the tool. The pressure on the chip causes it to fracture. This leaves a rough surface that is smoothed out by the tool edge. No metal cutting tool will operate efficiently unless certain clearance angles are provided on its cutting end. If these are not used the tool will merely rub on the work. The clearance and rake angles are different for the various metals. High-speed steel can retain hardness up to 600°C.

Learning objectives:

At the end of the lesson pupils will be able to:

1. Grind a lathe cutting tool
2. Describe and explain the cutting angles and geometries
3. Critique their cutting tool form use.
4. Compose a report outlining the procedure taken to grind a cutting tool.

7.1 Tool geometry (angles):



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The point/wedge angle is $90^\circ - (\text{rake} + \text{clearance})$. The type of tool for a particular operation is determined largely by the nature of the (1) operation (2) material to be machined) (3) finish required. The clearance angle should be kept as low as possible to prevent weakening of the tool. The top and side rake result in the compound rake referred to as the true rake. Top rake angles are below for various metals.

Aluminium 30° Brass $0-5^\circ$ Mild Steel $12-20^\circ$ Cast Iron $10-12^\circ$

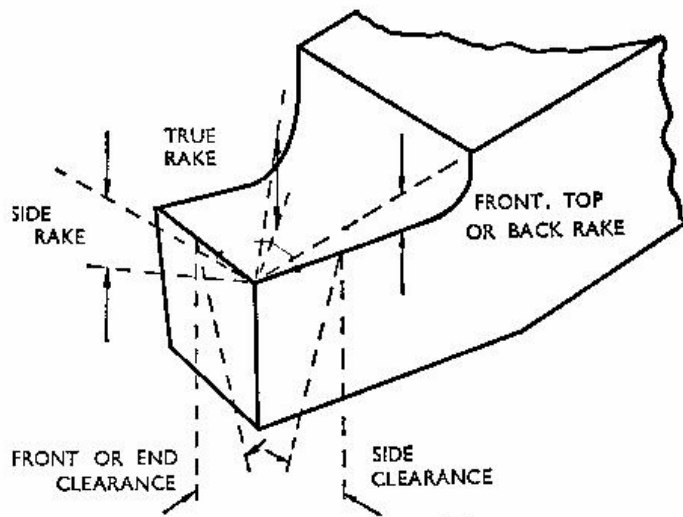
With a clearance of $6-10^\circ$. High Speed Steel (HSS) is commonly found in square section at 6mm or 12mm sides. This is an alloy of Tungsten (18%) Chromium (4%) Vanadium (1%) and Carbon (0.8%).

Tungsten: improve red hardness, retention of hardness and high temperature strength of the matrix, form special carbides of great hardness.

Chromium: promotes depth hardening, produces readily soluble carbides.

Vanadium: forms special carbides of supreme hardness, increases high temperature wear resistance, retention of hardness and high temperature strength of the matrix.

Carbon: forms carbides, increases wear resistance, and are responsible for the basic matrix hardness.

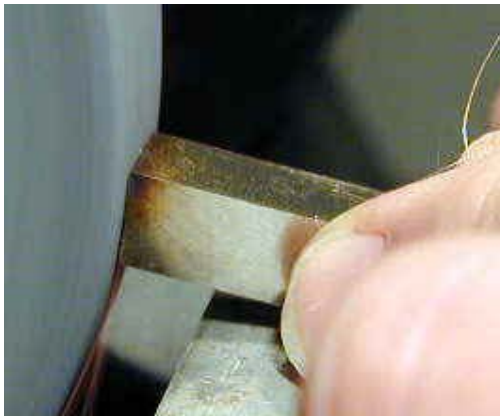


7.2 Grinding of cutting tool:

Grinding is the removal of metal by abrasive grit wheels. These provide several cutting edges. The ideal state is that once the grit loses its edge it will wear exposing another edge. This will continue for a short period then they will have to be dressed.

The wheel can be dressed using the Huntington pattern wheel dresser. There are various types of wheels, different grit and bond grade.

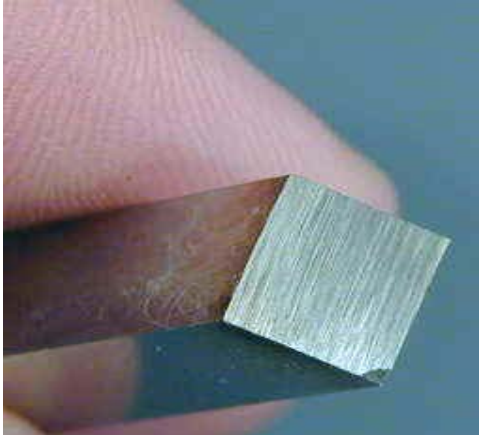
Grinding wheels are clamped between two dished flanges with paper washers used to protect the surface.



The end of the tool blank is machined first creating the front clearance and angle to create a side clearance of about 10-15°.

This picture is a plan view of the operation. You may notice the discolouration on the top of the cutting tool. This is due to a rise in temperature at the tip of the cutting tool. Temperatures in excess of 600°C may harm the tool therefore it is important to cool the tool in water constantly.





This picture displays the cutting tool after both the front and side clearance have been ground. You may notice the cutting tool reflects the geometry of the wheel.

The left side rake angle is produced in a similar fashion at 10° to the wheel. The cutting edge should not be touched.



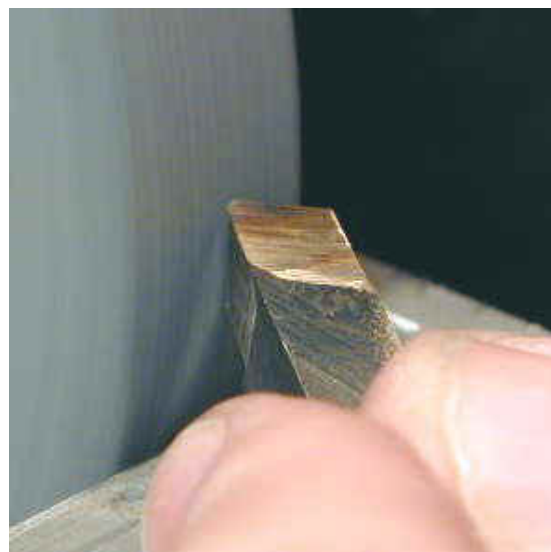
Make sure not to grind an angle greater than 10° . This will reduce the strength of the cutting tool and lead to poor tool life.



Grind the top surface to form the top rake. Be careful during this operation not to grind down the cutting edge or you will end up with a tool whose tip is below the centre line of the lathe. If this happens, the tool will leave a little nub at the centre of the work piece when you make a facing cut. The usual remedy is to use a thin piece of shim stock under the tool to bring it back up to the centre line.

Once the angles have been produced and perfected to a reasonable standard. It is common practice to radii the tool cutting point. This is carried out for two reasons

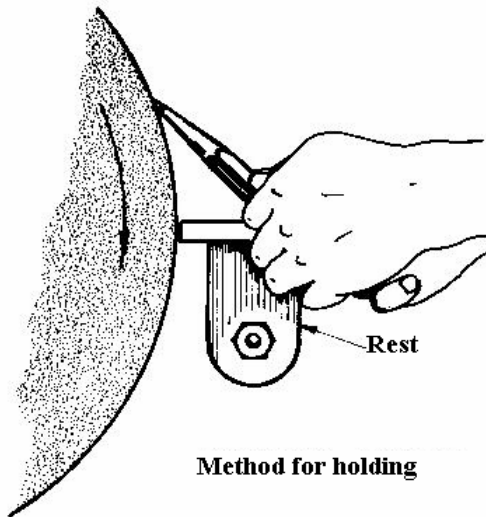
- (a) the point surface has increased creating a stronger tool point.
- (b) the surface finish will be improved as a sharp cutter will leave the surface rough. A grinding stone/block may produce this.



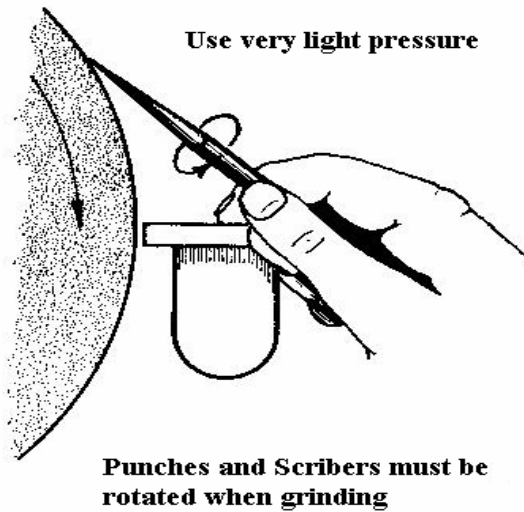
7.3 Tool Height:

To test tool height a facing off sequence will indicate that the tool may be too high or low. The most common method of testing is to insert a centre or drill into the tailstock or chuck. Then alignment of height will become clear by orientating the cutting tool up to this centreline height.

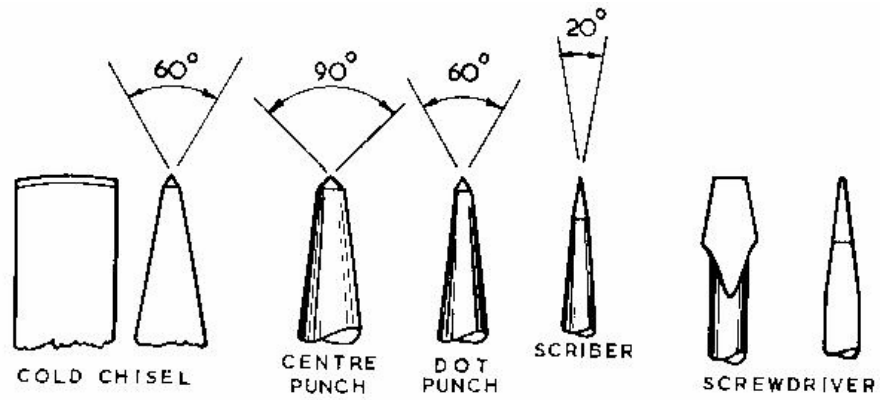
Tool height can have various effects on cutting tool and surface finish.



Grinding a Centre punch

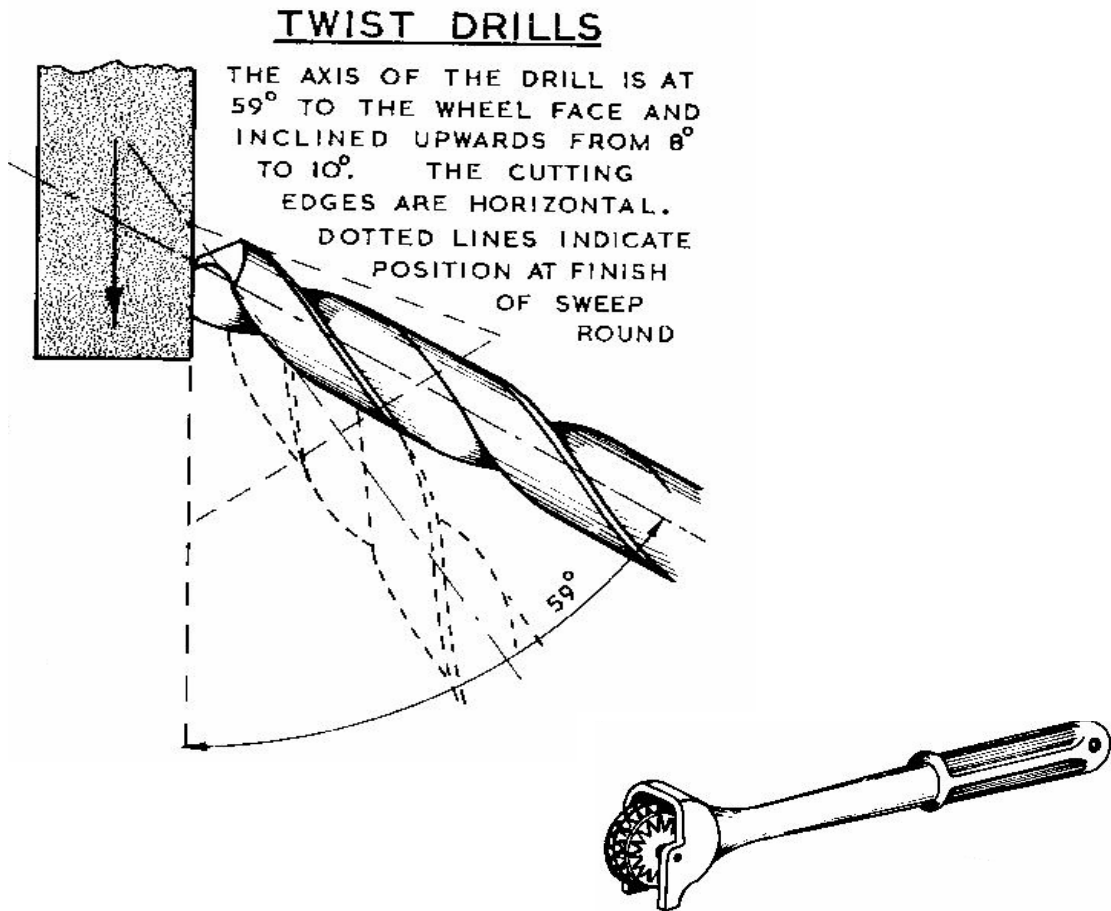


Grinding a scriber



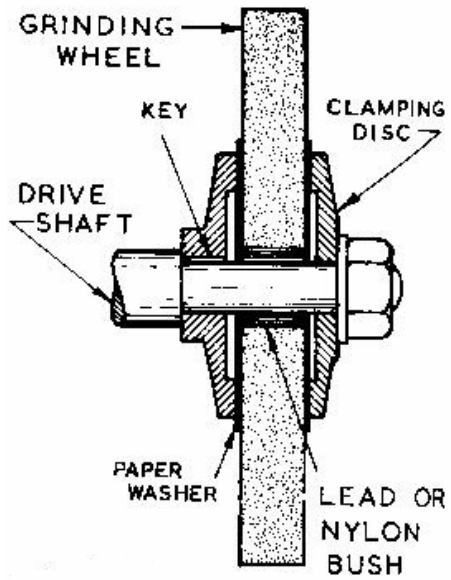
Various tools with angles ground

Method of grinding a drill:



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Dressing tool used to dress the grind wheel. Named the Huntington wheel dresser. Is composed of a series of alternate star wheels and washers.



Cross section of the wheel fitted to the grinding wheel.

8. Soft Soldering

General:

Soft soldering is a permanent joining process and is different from welding in that the filler metal (solder) and the parent metals (typically copper, brass or mild steel) are different.

The parent metal does not melt like in welding. Instead the solder forms an amalgam (an alloy or solid solution) in the parent metal at either side of the joint.

Temperatures are around 183°C for Tinman's solder (70/30 lead/tin) but will be higher (200C) for lead free varieties.

In these respects they are similar to

Brazing which uses Brass as a filler metal (800C) and
Silver Soldering (Ag Cu and Sn) (600C)



Green Flame indicates correct

Soldered joints are primarily used for sealing and do not have a high mechanical strength.

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Solder can only flow where bare metal contact occurs – hence need for a flux to remove oxides and keep air away from hot metal when soldering to prevent re-oxidization

Two types of flux - Active

- Passive

Active Fluxes remove present oxides from the surfaces and prevent further oxidation during soldering, they are corrosive and when used the joint must be washed afterwards to prevent further oxidation. (Zinc Chloride)

Passive fluxes are otherwise known as protective fluxes and just prevent oxidation during the soldering. (Resin based)

Learning Outcomes:

At the end of the demonstration, the students will know how to:

1. Prepare and heat the soldering bit to the correct temperature
2. Correctly prepare and flux the parts to be soldered
3. Execute a Tee fillet joint using a hatchet bit
4. Execute a sweated lap joint using the blowtorch as a heat source
5. Tin an area to a predefined boundary

Equipment:

1. Hatchet Bits 2 Off stored in box and marked for demo
2. 20 off 1.5mm copper cut to 60x40mm on guillotine
3. Tin Baker's soldering fluid and glass vessel for pouring into
4. Artist's paintbrush, Scriber, 1200 grit emery paper
5. Soldering oven
6. Stick of Tinman's solder

Set up:

Light soldering oven and adjust flame

Clean up bit with file if required to look like



Heat until blue/green flame. Dip in flux (Use safety glasses)

Apply solder until tinned



- Mention Active and passive fluxes
- Mention composition and properties of Tinman's solder
- Mention Lead-free solders to become commonplace in future
- Safety hazard with $ZnCl_2$

Preparation:

Make sure joints are good fit – Solder flows by capillary action – the smaller the gap the better.

Emery first, Apply Flux using brush to limits of tinned area (solder flow will follow flux)

Scribe line if necessary to define edge of fluxed area

Safety – Keep corrosive flux away from skin.

Method:

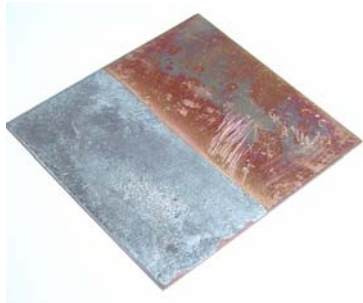
8.1 Tinning:

Ensure bit is at correct temperature

Apply solder to bit – ensure correct amount

Place bit in contact with work until solder starts to flow

Slowly tease solder across work until required area is tinned.



8.2 Tee Joint:

Prepare joint as described

Heat, flux and apply solder to bit.

Hold pieces in position with pliers

Use safety glasses.

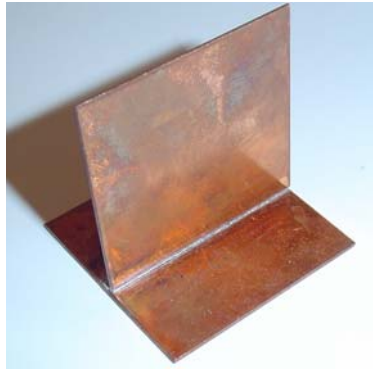
Place bit in angle of joint ensuring contact with both pieces.

DO NOT MOVE until the solder can be seen to run and form a meniscus with between the bit and work piece

Slowly move bit along the joint maintaining the solder run.

Hold Joint in place when finished for a few seconds until solid.

8.3 Characteristics of a good Soldered Joint:



Penetration - Can be determined by breaking piece

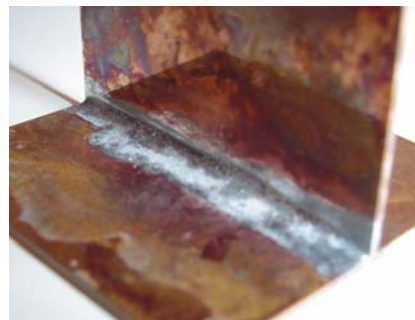
No excess solder



Common Faults

Too Cold

Not adequately fluxed



Too much solder etc. etc.

Safety points:

1. Goggles
2. Care of Flux (ACID)
3. Heat precautions (Lead)

9. Metal Forming (Hot Forming)

General:

Forging is the working of metal, which has been heated to a soft and plastic state. Forge work involves bending, shaping, joining and various other formation works. Drawing a chalk line usually suffices or marking out. Accuracy is not essential in this work, aesthetics is.

Learning objectives:

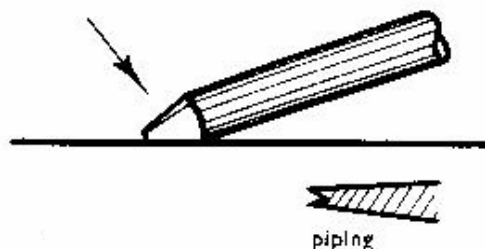
At the end of the lesson pupils will be able to:

5. Name and explain the design theory behind the tools.
6. Correctly demonstrate the individual processes.
7. Practice and prepare actual processes.
8. Assess/defend there own work for errors.
9. Analyse the process before commencement
10. Take safety considerations into account.

Processes and procedures:

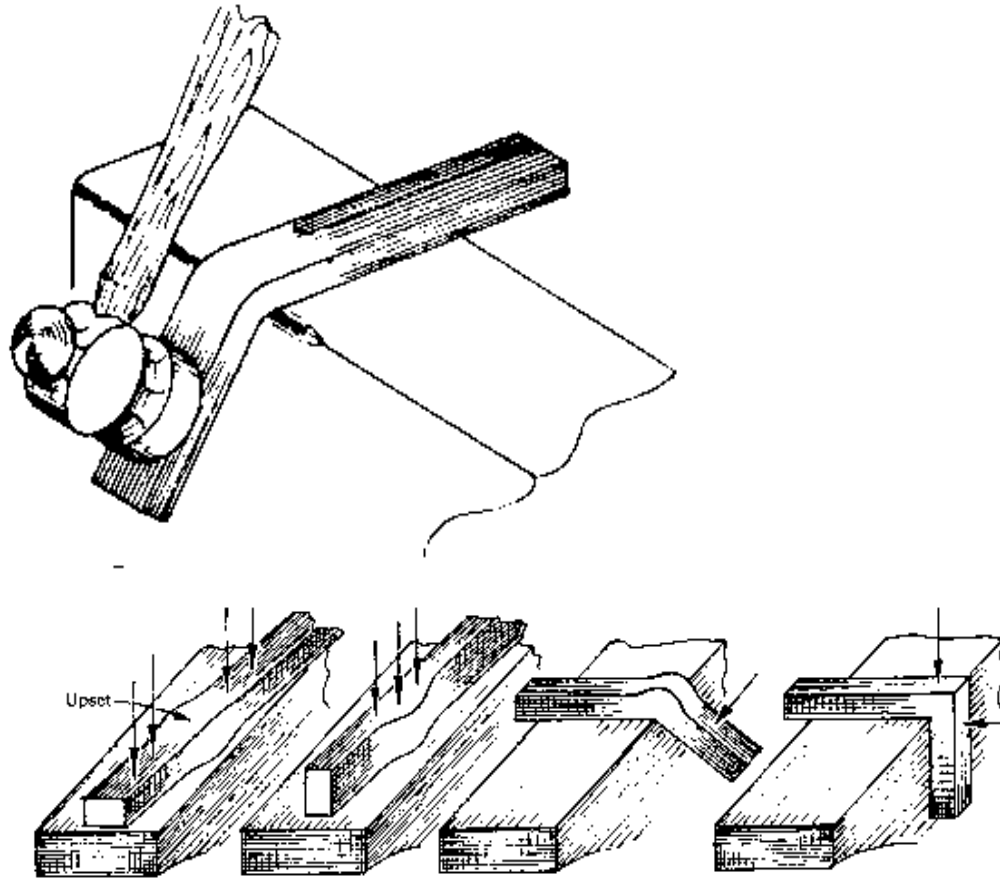
9.1 Drawing down:

The making thinner at one end of a piece of metal. This usually involves forming a point. Material is not taken away but is hammered into shape. The metal to be formed is brought to a bright red colour and hammered on the anvil. The working of cold metal will only split it. A common error in drawing down is that piping may occur, this is when a hollow in the centre of the metal. To prevent this a short blunt taper should be started and hammer towards the thongs.



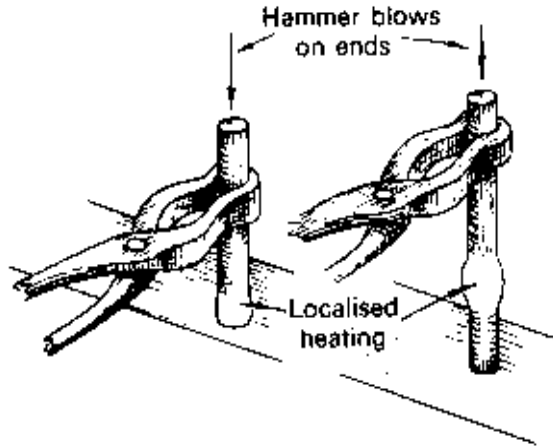
9.2 Bending:

Metal is bent by placing it in the vice or across the anvil, striking it with a hammer below the bend mark to prevent thinning. If a square outer corner is required the metal is first jumped/upsetting up at the corner.



9.3 Upsetting:

This consists of increasing the size of the cross section by reducing the length. The direct opposite to drawing down. Heating is localised and is also used for bolt-heads, welds and bends.

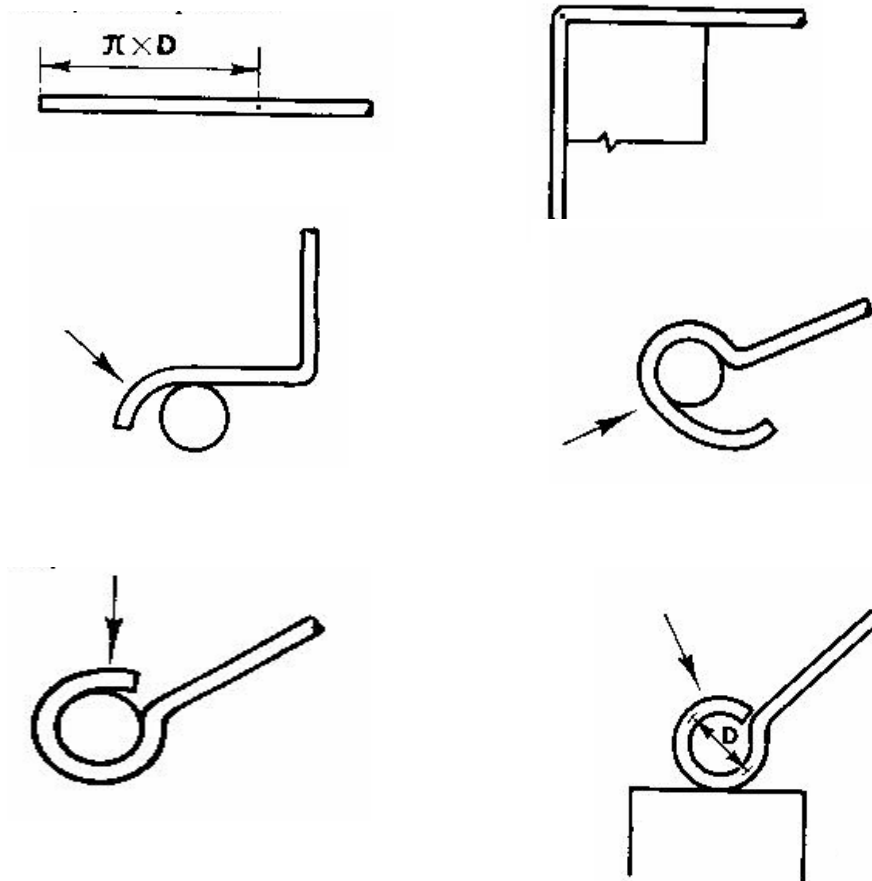


9.4 Forming an Eye:

The required corner point is lightly centre punched. The length is calculated by simple math. $\pi \times D$

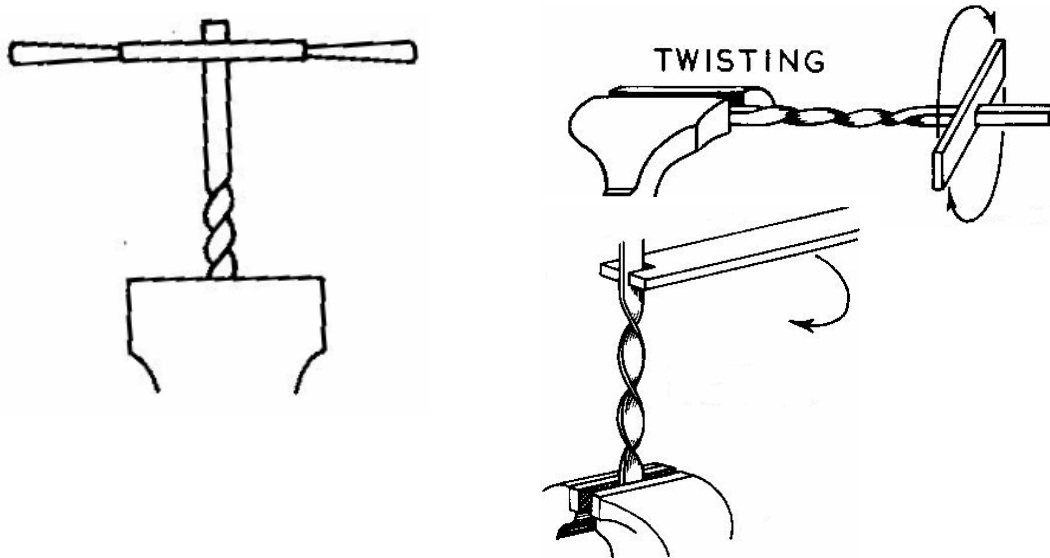
The bar is bent to a right angle in the vice, or over the anvil.

The bend is usually worked over the anvil bick if hot formed, or gripped in the vice if cold formed. Finally the eye is closed.



9.5 Twisting metal:

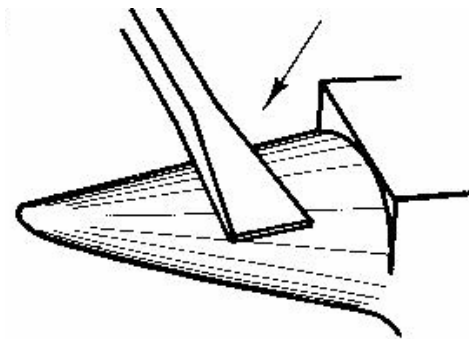
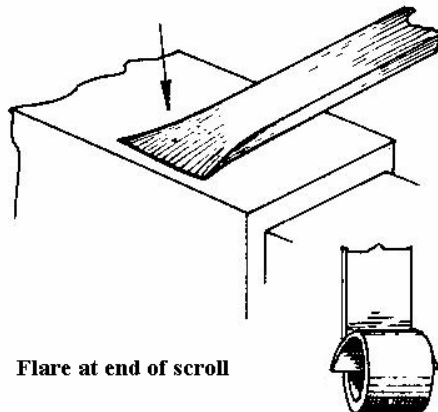
When the metal is at forging temperature ornamental twists can be made. An equal pressure must maintain, at a uniform rate of rotation. The most difficult part of the operation is producing a spiral with a consistent angle a given pitch.



9.6 Scrolling and Flaring

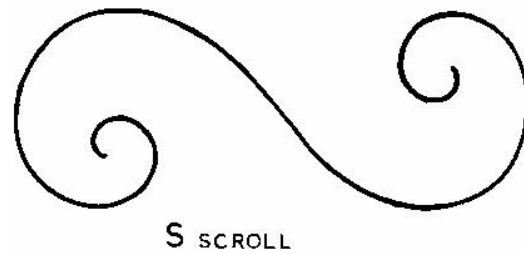
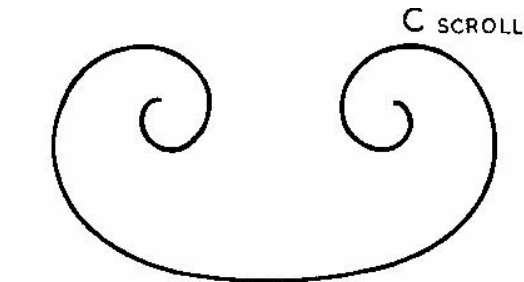
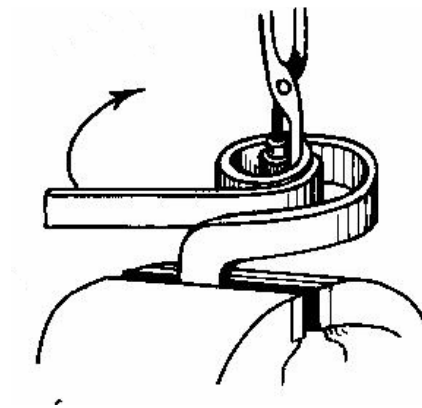
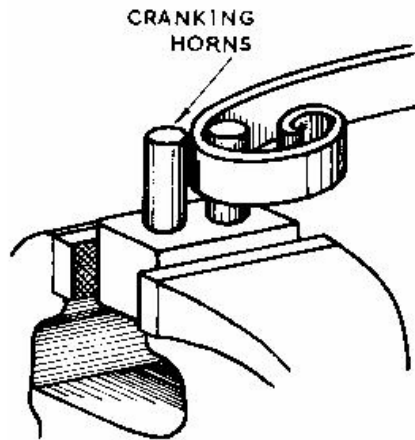
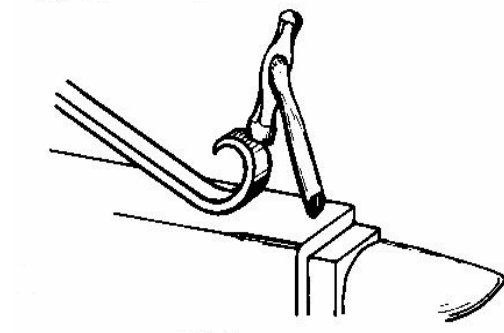
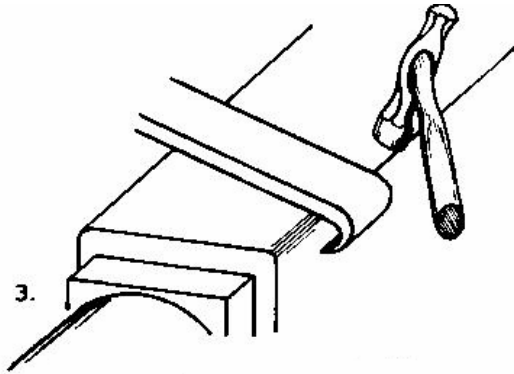
Flaring is used at the end of scrolls to create decorative work. The metal is drawn down on two faces only with the other two faces being struck only enough to control the extent and the form of the flaring.

Flaring by hammering

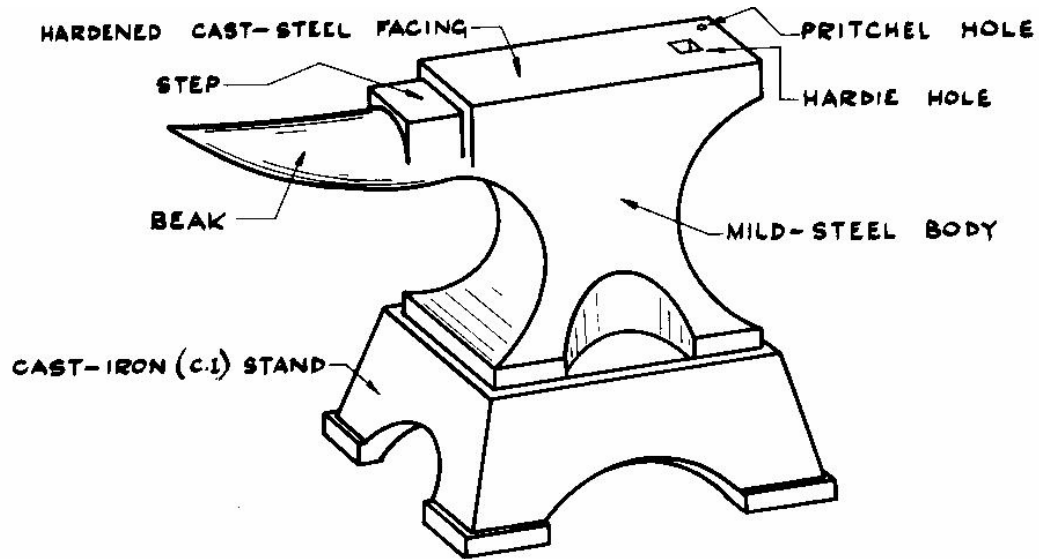


9.7 Scrolling

Initially started on the anvil and on the anvil face. Once the scroll is established either a bending jig such as a cranking horns or a scroll iron.



9.8 The anvil



The 'London Pattern' anvil is used most popular. The body is of wrought iron with a hardened steel top. Others may be cast iron with the surface chilled. The height should be touching the fingertips when the hand is a rest. The anvil is usually supplied with a sage block that is used for swaging.

On Going Process Sheets

General Aim:

To further develop pupils craft skills in the different processes.

Objectives:

Pupils will be able to

1. Describe the process in detail
2. List the preparation and the procedure
3. Apply the procedure to the project
4. Develop safety skills and an awareness of accuracy

General Aim: To promote and develop pupil's awareness of accuracy and process procedures in the workshop.

Objectives: Pupils will be able to:

1. Demonstrate the particular skill correctly and safely.
2. Formulate methods/techniques custom to themselves.
3. Make components to a desired standard.

Processes

Hack sawing

Filing

Marking out

Lathe work

Taper turning

Treading and tapping

Drilling

Bending

Marking out

1. Basic principles:
 - (a) Drawing to work off
 - (b) Marking out compound
 - (c) Axis of symmetry, dot punch, datum line
 - (d) Scribe lines only where necessary

2. Preparation
 - (a) Good lighting
 - (b) Check equipment
 - (c) Dot punch centres for drill holes

3. Safety
 - (a) Marking out equipment held correctly at all times
 - (b) Safe storage of equipment
 - (c) Select correct procedure of marking
 - (d) Use tools for the purpose that they were designed for

4. Application to project

Every part in the project will need to be marked at some stage, as there is a lot of work in the individual pieces. The marking equipment is an individual section of the on going processes.

(Marking out) Spring Dividers

1. Basic principles
 - (a) Based on spring to tension
 - (b) Same purpose as compass
 - (c) Made from cast steel

2. Use of the spring dividers
 - (a) Adjusting nut on screw thread
 - (b) One leg on the dot punch mark
 - (c) Drawing circles turn both work and dividers.

3. Care of spring dividers
 - (a) Do not damage points
 - (b) Oil them occasionally
 - (c) Avoid screw wear by pressing the legs together for rough adjustment.

4. Application to the project

The spring dividers are used to scribe circular and straight lines from a centreline or a dot punch. For example the seat in the project the dot punch should be kept to the back of the chair.

(Marking out) The scriber

1. Basic principles:
 - (a) Cast steel hardened and ground
 - (b) Used mark metal surfaces
 - (c) Angle point 30 degrees

2. Use of the scriber
 - (a) Used for marking only not a tommy bar
 - (b) Hold on knurled surface
 - (c) Point against the rule

3. Care of the scriber
 - (a) Hold in hand like pen
 - (b) Do not carry in pocket
 - (c) Draw line once only
 - (d) Two hands on job

4. Applications to the project

The scriber is on both plastic and metal, however it is better practice to use a pen on the plastic, as it will not scratch the surface. The scribes should be held in a wooden base to prevent any of them from blunting at the ends.

(Marking out) Engineers try square

1. Basic principles
 - (a) Stock is riveted to blade
 - (b) Case hardened steel
 - (c) Groove to accommodate burrs

2. Use of the try square
 - (a) Use both inside and outside
 - (b) Used as straight edge
 - (c) Do not play with or drop

3. Care of the try square
 - (a) Test inspection grade
 - (b) Handle with care
 - (c) Test square using square line

4. Applications to the project.

The square is used quite regularly for both marking and inspecting. The square can show the inaccuracies quite easily and shows what part needs to be filed more. When bending sheet metal the square can be used as a rough guide to how much it has being bent.

(Marking out) The rule

1. Basic principles
 - (a) Made from spring or stainless steel.
 - (b) Hardened or flexible
 - (c) Length of rule 300mm or 150mm

2. Use of rule
 - (a) Hold parallel
 - (b) Line up eye with graduations
 - (c) Place rule graduations as near as possible to the line.

3. Care of the rule
 - (a) Use for measurement only
 - (b) Protect edges from damage
 - (c) Bottom kept at 90 degrees not a de-burring tool
 - (d) Protect from rust
 - (e) Hang up from hole

4. Applications to project

The rule is the most basic measuring instrument in the engineering room. It will be used for all measuring, however the vernier and the micrometer will be used when working on the lathe. The rule may be used to draw straight lines and take measurements from.

Hammer

1. Basic principles
 - (a) $\frac{3}{4}$ lb used for marking out
 - (b) Metal head
 - (c) Hickory or ash handle

2. Use of the hammer
 - (a) Marking out
 - (b) Riveting
 - (c) Clinching

3. Care of the hammer
 - (a) Do not hammer objects harder than the hammer
 - (b) Do not use hammers with loose heads
 - (c) Hammer, holding the end of the shaft/handle

- 4.

The ball pein hammer is used for the marking purposes of striking the centre punch. The flat end of the hammer may be used when bending in the vice. Hammers can come in three common formats cross pein and straight pein.

(Marking out) centre and dot punch

1. Basic principles
 - (a) Enable mark to be seen better
 - (b) Light hit with hammer
 - (c) Point at 60 –90 degrees

2. Use of the punches
 - (a) Use centre punch to mark centre of hole to be drilled
 - (b) Hold the tool where the knurl is positioned
 - (c) Hit the tool only once

3. Care of punches
 - (a) Taper top and leave soft to prevent mushroom head
 - (b) Harden point
 - (c) Store in wooded base to keep sharp

4. Applications to the project

Centre punching is widely used to mark the centre point. Care must be taken not to distort the metal after hitting it. The material should be well supported under a solid metal base. It is important to mark the centre of the hole on the acrylic base, but it must not be centre punched, as it would damage the material.

Threading and tapping

1. Basic principles

- (a) 3 pointed cutting tool
- (b) Thread forming externally and internally
- (c) Temporary joining fixture
- (d) Two types

2. Preparation

Tapping

- (a) Drill hole correct size
- (b) Use taper tap to begin with
- (c) Align tap at 90 degrees to piece

Threading

- (a) File chamfer on edge
- (b) Correct diameter bar in use
- (c) Hold at 90 degrees

3. Safety

- (a) Tap in bench vice
- (b) Do not thread on lathe
- (c) Reverse taps and dies and prevents spin offs.

4. Application to the project

There are quite a number of parts that need tapped and threaded, the same process should follow for all pieces, but extreme care should be taken when tapping brass as it is difficult to get a start on.

Hack sawing

1. Basic Principles
 - (a) Large material removal
 - (b) Cut one direction
 - (c) Saws down into material

2. Preparation
 - (a) Correct blade type
 - (b) Holding of material to be cut
 - (c) Correct height and direction

3. Safety
 - (a) Two hands on the saw
 - (b) Material well supported
 - (c) Use full length of the blade

4. Application to project

The base will need to be hack sawed in four different cuts. Also the axels will need to be sawed. Pupils under my supervision to cut the wheels, as parting off may be quite dangerous, may use the power hacksaw. The material used for cutting should be treated correctly. Cut waste side of the line down in a vertical motion.

Filing

1. Basic principles
 - (a) Simple material removal
 - (b) Cross and draw filing
 - (c) Single or double cutters

2. Preparation
 - (a) File card to clean file
 - (b) New files broken in
 - (c) Care of files

3. Safety
 - (a) Two hands on the file
 - (b) Correct vice clamps
 - (c) Stance to prevent back ache

4. Application to the project

All the pieces need to be filed except from the lathe parts. Both cross and draw filing will need to occur to finish the pieces to an accurate and neat finish. Filing will be used to square up pieces and then the marking processes may occur. Files with a safe edge will be needed for parts 1, 2, 3, this is to prevent cutting into the main work.

When filing sheet metal keep the work as low as possible in the vice to prevent noise.

Drilling

1. Basic principles

- (a) Material, removal using a cylindrical machine tool.
- (b) Work held in vice, tool moves
- (c) Tool geometry two cutters

2. Preparation

- (a) Work held correctly
- (b) Correct drill speed
- (c) Drill correctly ground

3.Safety

- (a) Eye protection
- (b) No loose clothing
- (c) Work and drill holding

5. Application to the project

Most pieces need to be drilled and the pillar drill will be used to drill these. Correct size holes for tapping will need to be catered for. The tapping size is on the back of most engineering rules. Perspex will not be centred punched so drill walking may occur. Accuracy is essential here as precision is necessary to complete the project.

Lathe Work

1. Basic principles

- (a) Material rotates on centre line
- (b) Tool is moved against work piece
- (c) Drill cylindrical material dead centre

2. Preparation

- (a) Select nearest correct speed
- (b) Tool held and supported correctly
- (c) Select on correct procedure

3. Safety

- (a) Eye protection
- (b) No loose clothing
- (c) Material and tool held tightly

4. Application to the project

The wheels on this project need to be turned, drilled and tapered. The same drill speed will be used on each of the parts as not to confuse pupils. The steering shank made from brass will need to be machined very accurately as the steering will work off this.

(Lathe Work) Taper Turning

1. Basic principles
 - (a) Change in diameter per unit length
 - (b) Top (compound) slide
 - (c) Producing an angle on top
 - (d) Same geometry type cutter used

2. Preparation
 - (a) Cutting tool needs to be sharp
 - (b) Selection of compound angle
 - (c) Select speed (about 500 revs)

3. Safety
 - (a) Correct clothing
 - (b) Work held correctly
 - (c) Move back cutting tool before turning on.

4. Application to the project

The wheels for the buggy need to be tapered at 45 degrees. Therefore it is important to carry out this delicate process correctly using the correct procedure. The facing and tapering should happen before the wheel is cut from the bar. As this prevents waviness in the taper. The slide can be swivelled either side so it is important to select the correct side.

Bending

1. Basic principles

- (a) Folding material
- (b) Ability to make three dimensional
- (c) Developments and enclosed objects
- (d) Using folding bars

2. Preparation

- (a) Line drawn on object
- (b) Instrument to level material (hammer)
- (c) Clamping device to hold folding bar and material.

3. Care and Safety

- (a) Important to fold towards you
- (b) Bend all the piece together
- (c) Prevent over hitting only hit near the edge of the former

5. Application to the project

A lot of the parts require very tough bending techniques to form the individual parts. The parts involve bending of the pieces less than 90 degrees so they do not want to over bend the material. All other processes should be carried out before the bending process is preformed.

The ring end on the folding bars is essential to open the front of the legs. On some bars one leg is longer than the other to facilitate the insertion of material.

Shearing

1. Basic Principles

- (a) Cutting sheet metal
- (b) Shearing method of metal removal
- (c) Types, curved, straight

2. Preparation

- (a) Sheet metal marked
- (b) Cut as close to line as possible
- (c) Avoid cutting wire and closing the snips

3. Safety

- (a) Avoid using both hands to close the shears
- (b) No cutting material above 2mm
- (c) Hold one leg in vice to work easy

5. Application to the project

The spoiler at the rear of the project is made from sheet metal also is the seat so pupils will need to be able to perform these easy tasks. Shearing produces the cutting action, as the forces are low due to the sheet metal thickness.

Riveting

1. Basic principles

- (a) Permanent means of fastening
- (b) Fixed or movable joints
- (c) Made from malleable metal (brass)
- (d) Different types counter sunk, pan head

2. Preparation

- (a) Correct sized hole drilled
- (b) Holes align up correctly
- (c) 1.5 diameter left for snap head
- (d) Set the rivet before forming the head

3. Aspects to watch out for

- (a) Place rivet in hole and then measure up 1.5 times the diameter
- (b) Drill on hole and rivet and then drill all other holes
- (c) The ball pin head should be checked
- (d) Better to be looking at the rivet head than looking for it.

4. Safety note

- (a) Hold bottom dolly in the vice tightly.

Forming

1. Basic principles

- (a) Cold forming of material
- (b) Forming using forms
- (c) Shaping of metal

2. Preparation

- (a) Correct size form
- (b) Material ability to bend
- (c) Holding former and material

3. Safety

- (a) Do not use brittle material
- (b) When forming place cloth over piece
- (c) Use both hands and hammer when forming

4. Aspects to watch out for

- (a) Allow for inaccuracies
- (b) Bend/Form the material using the longest material to act as a lever.
- (c) Consider other methods all the time

5. Applications to the project

Forming is carried out on the roll cage and if pupils use mechanisms for the steering they will need to carry out some forming.

Hammering

1. Basic Principles

- (a) Hollowing object
- (b) Ductile material to take shape
- (c) Using hollowing hammer/ Mallet

2. Preparation

- (a) Sand bag for support
- (b) Chiselled out wooden base
- (c) Hammer good enough, light, ball pien.

3. Safety

- (a) Draw concentric lines on artefact
- (b) Support hollow objects on solid base
- (c) Ensure that metal head is correctly fixed
- (d) Avoid over hitting in one spot
- (e) Remember to anneal.

4. Application to process

Hammering and hollowing are usually seen on decorative metal objects that does not mean that they can not be incorporated in to this project, however due to time implications pupils will be guided on a one to one basis if they need to carry out this process,