Trade of Metal Fabrication

Module 1:	Basic Fabrication
Unit 14:	Light Gauge Metal Working
	Phase 2

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Document Release History

Date	Version	Comments
30/08/06	First draft	
13/12/13	SOLAS transfer	

Module 1 – Basic Fabrication

Unit 14 – Light Gauge Metal Working

Duration – 5 Hours

Learning Outcome:

By the end of this unit each apprentice will be able to:

- Identify sheet sizes and use sheet gauge
- Read and use a vernier calipers, height gauge and micrometer
- Identify and state the uses of a reciprocating machine (nibbler)
- Describe the various tools and stakes used in sheetmetal work
- State the application and purposes of wired edges
- Describe box and pan folding machine
- Describe the principles of stiffening

Key Learning Points:

Rk	Introduction to sheet metal work.
Rk	Vernier calipers, height gauge, micrometers.
Rk H	Reciprocating (nibbler) machines.
Rk	Lockforming and self-securing joints.
Rk	Tools and stakes.
Rk	Wired edges.
Rk	Folding machines.
Rk	Stiffening.
P	Communication - Quality awareness.

Training Resources:

Classroom and lecture facilities.

Handouts, notes and texts.

Key Learning Points Code:

M = Maths D= Drawing RK = Related Knowledge Sc = Science

P = Personal Skills Sk = Skill H = Hazards

Angle Section Work / Nibbling Machine

Apart from constructional steelwork, angle sections in particular, and rolled sections in general, are often used in conjunction with sheet metal in various fabrications. In this section some of the operations involved in angle section work will be described, and these may be applied to 'Tee', channel and similar sections.

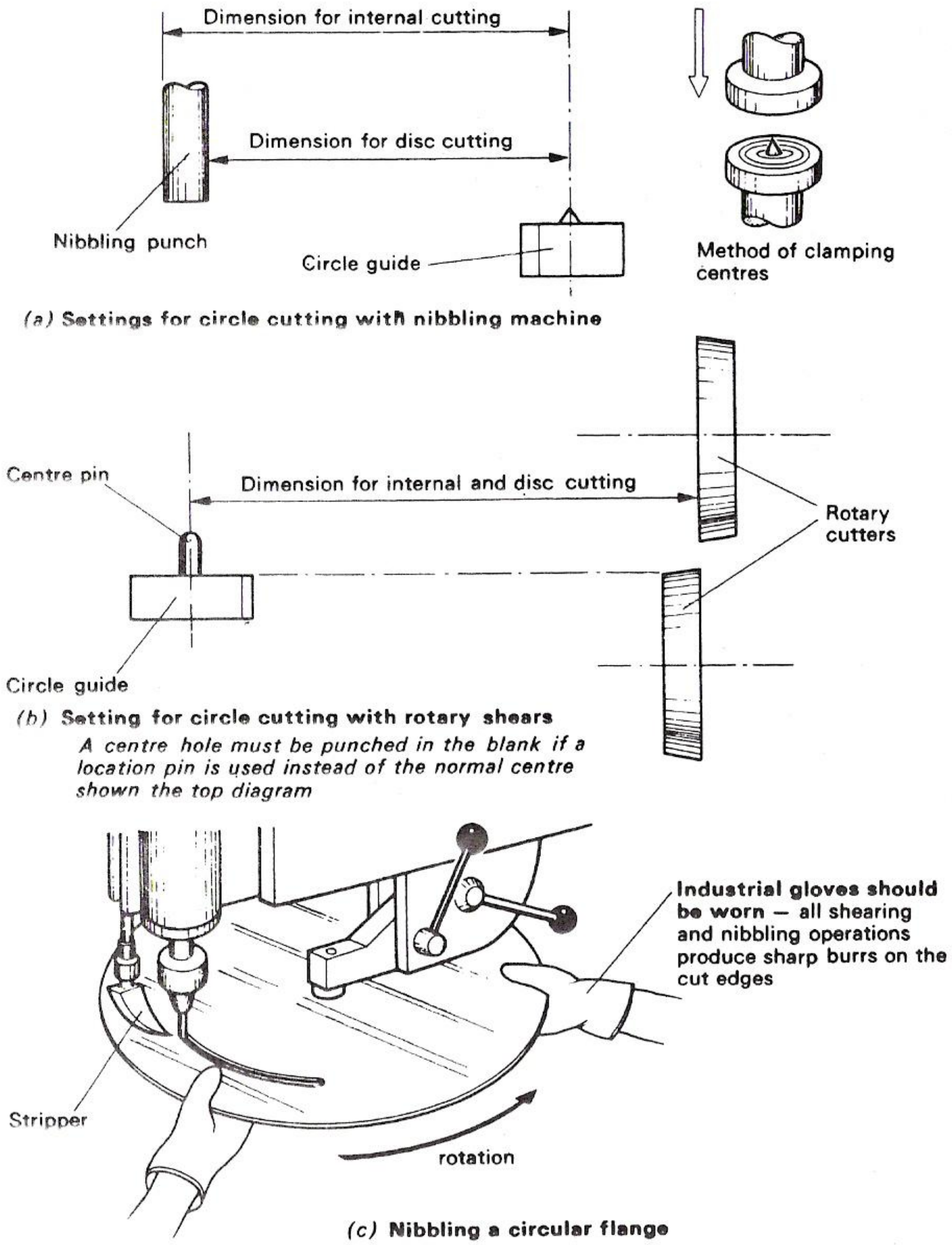
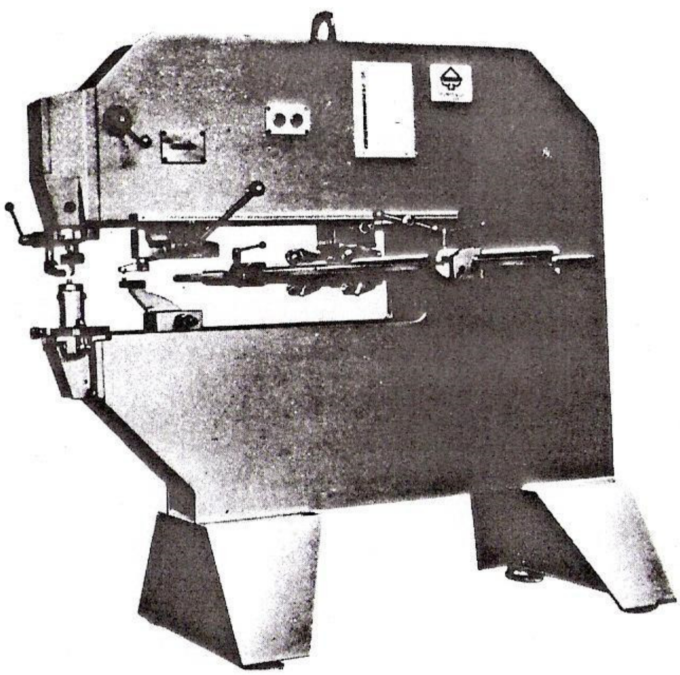


Figure 1 - Circle Cutting on Shearing Machines

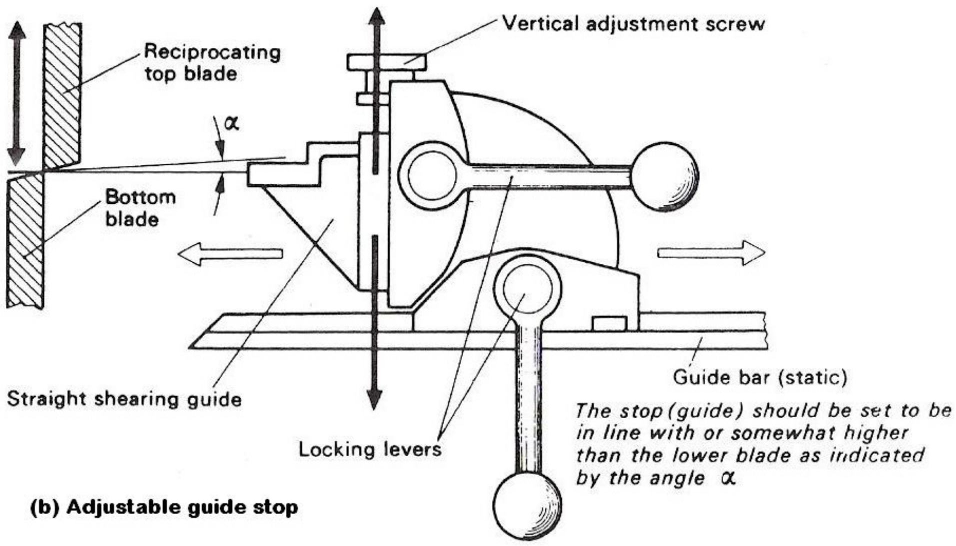
Cutting

The methods generally used for cutting angle sections are:

1. Shearing
2. Use of abrasive wheel machines
3. Cold sawing
4. Notching
5. Flame cutting.



(a) Typical curve, cutting-out and nibbling



(b) Adjustable guide stop

Figure 2 - Combination Shearing and Nibbling Machine

Methods of Wiring Cylinders and Cones

The two methods of producing a wired edge on curved surfaces are:

1. WIRING IN THE 'FLAT' BEFORE FORMING BY ROLLING;
2. WIRING THE EDGE AFTER FORMING BY ROLLING.

The method employed is optional, but the choice may be influenced by certain factors which will now be explained.

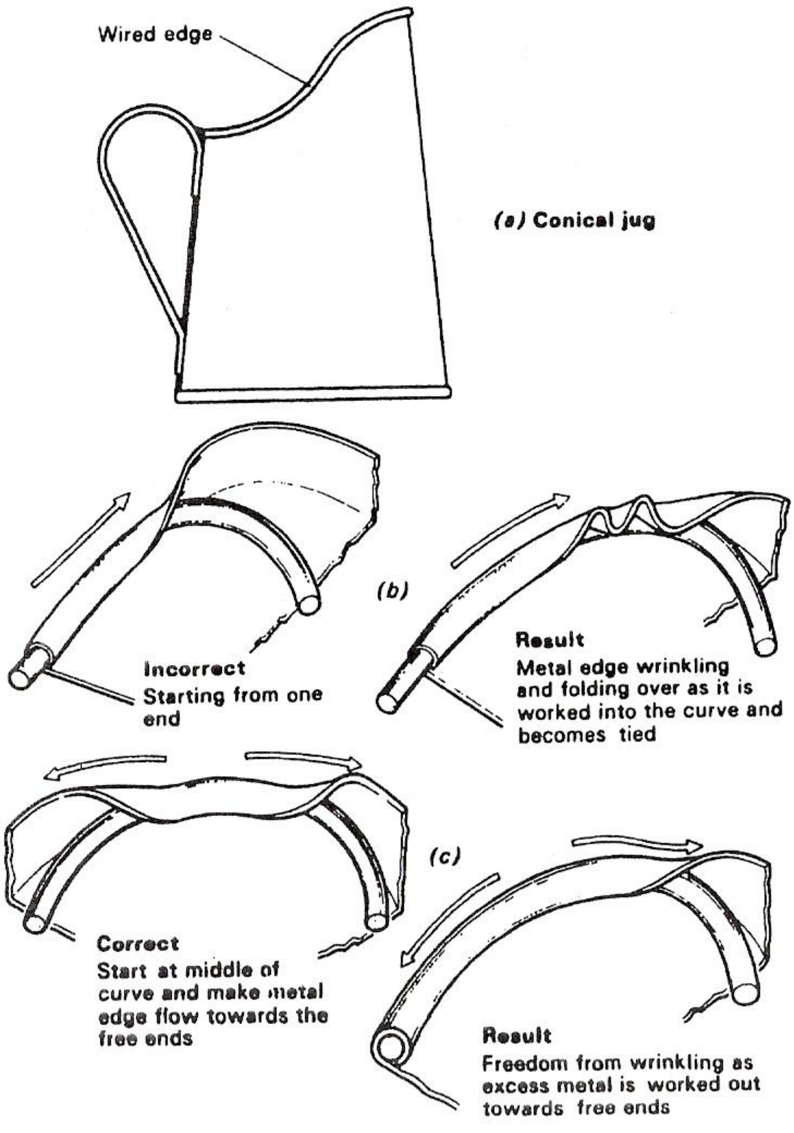


Figure 3 - Typical Faults when Wiring a Curved edge

Wiring before Rolling

On externally wired edges, the decision whether to wire in the 'flat' or wire after rolling will be influenced by the fact that when a cylinder is rolled after wiring, the inside diameter of the wired edge will be somewhat less than the required inside diameter of the cylinder. This is explained in Figure 4.

It should now be appreciated that wiring before rolling is unsuitable if the cylinder is to have a constant inside diameter.

The constriction in diameter caused by the wire can be minimised by light lubrication of the wire prior to wiring. This lubrication tends to assist the slight movement of the wire inside the bead during the rolling operation. Because the cylinder resists the constricting force of the wire, thus preventing it from attaining its smallest diameter, a gap results where the two ends of the wire should butt together. This unavoidable gap produces no real problem provided that the ends of the wire are slightly chamfered with a file to prevent them marking the bead when 'truing-up' with a mallet.

On internally wired edges, rolling after wiring produces the opposite effect to that obtained on externally wired edges of cylinders. The wired edge tends to become slightly larger in diameter than that of the cylinder. The process of internally wiring before rolling is used where it is not essential to maintain a constant outside diameter on cylindrical articles.

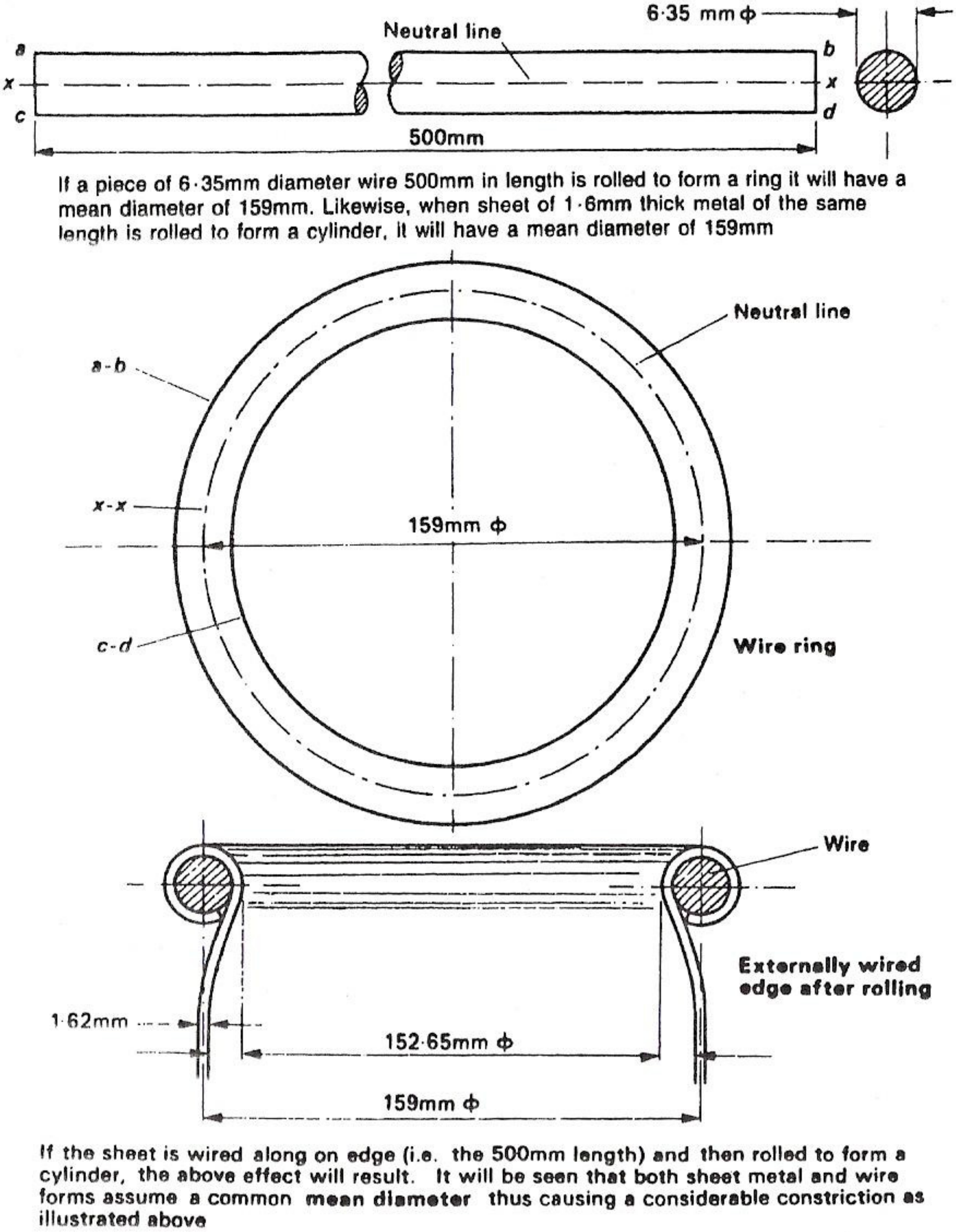


Figure 4 - The Effect of Wiring before Rolling

Wiring after Rolling

If a cylinder is required to have a constant diameter then the wiring operation must be carried out after the rolling operation.

Figure 5 illustrates the operation of rolling after wiring. SLIP ROLLS are used for rolling cylinders after wiring. The cylinder must be rolled over the slip roll. Care must be taken before inserting the metal in the rolls to ensure that:

(a) The wired edge rests in the correct groove in one of the 'pinch rolls';

(b) The machine is checked to determine whether it 'rolls up' or 'rolls down'.
The slip roll enables the cylinder to be withdrawn easily from the machine on completion of the rolling.

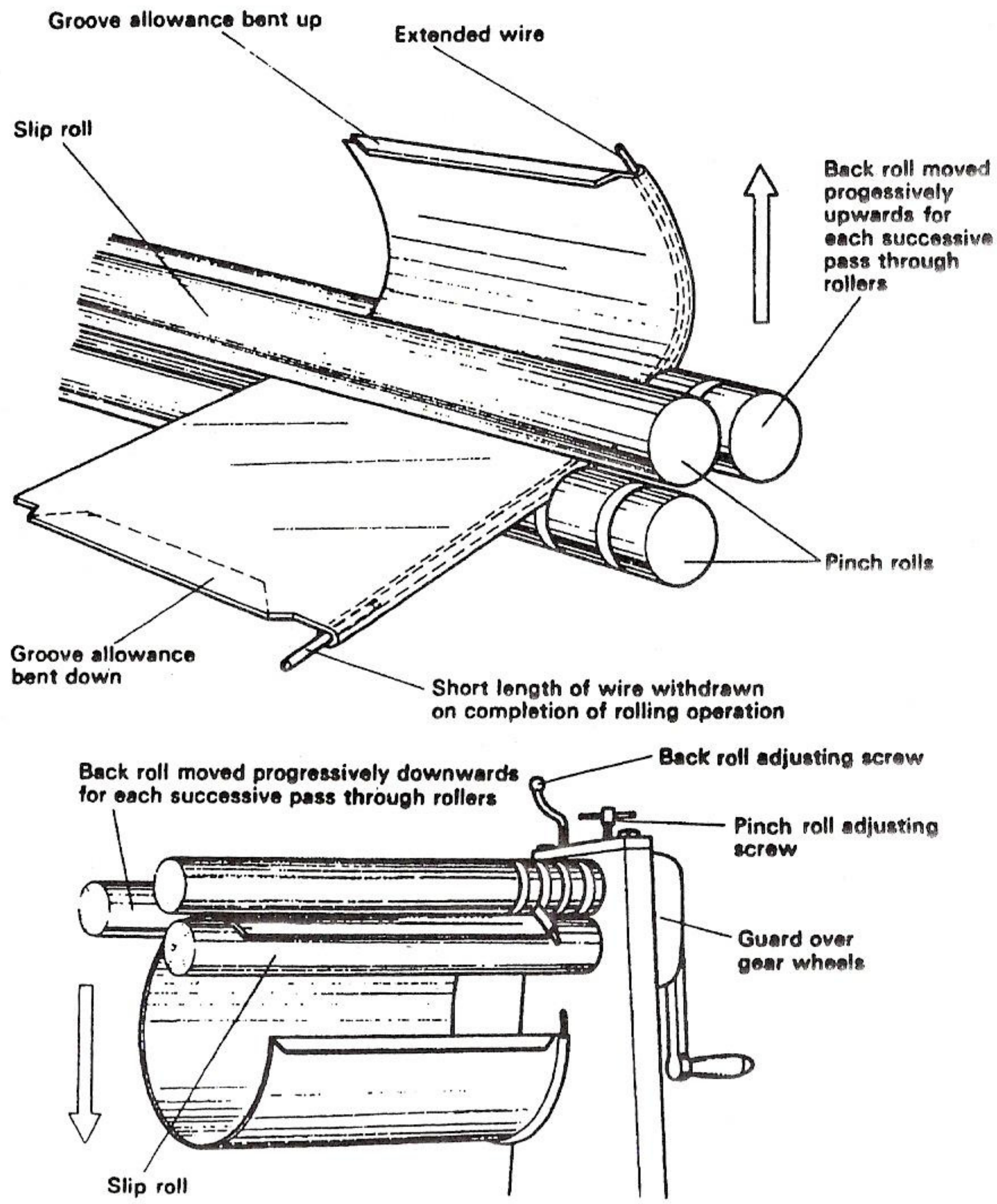


Figure 5 - Rolling after Wiring

Stiffening of Fabricated Material

Folding Edges

The width of the hem W (Figure 6) may vary between 5 and 10 mm, depending upon type and thickness of material and application, and allowances must be made for metal thickness.

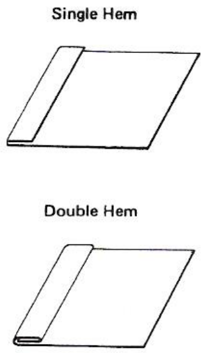


Figure 6 - Folding Edges

Jay preparations being milled on thick plate using an edge milling machine. Note the hydraulic clamps on the left, the protractor for setting the edge bevels. (*courtesy Hugh Smith (Glasgow) Ltd.)*

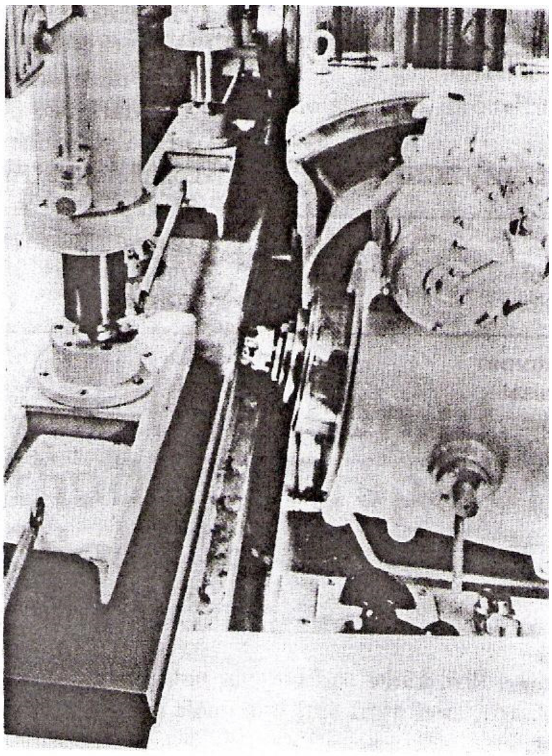


Figure 7 - Edge Milling Machine

Laying Out

Examples are given in Figure 8.

Example Calculation

For double hem: W = 6 mm

Allowance = 2 x W = 12 mm

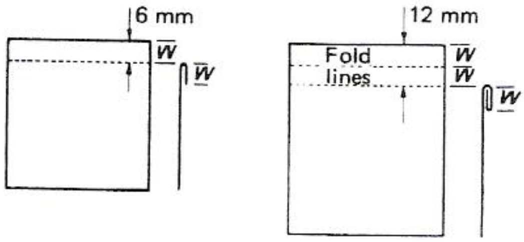


Figure 8 - Layout Out

Forming Analysis (Using a bar or a cramp folder)

1. Set folder for the correct width of the hem (allow for metal thickness on cramp folder).
2. Insert sheet and swing bending beam as far as it will go.
3. Remove sheet and place it with the bent edge facing upward on the bevelled part of the blade. Flatten the hem by bringing the beam down, or by malleting.
4. To form a Double Hem, repeat the above procedure.

Comparative Uses

The hem is used to eliminate sharp edges, increase strength and stiffness, and improve appearance. The hem is the simplest and quickest method of forming a safe edge.

Uses: Bins, trays, table tops, chutes, boxes and shelves.

Folding Machines

The main specifications of folding machines are as follows:

1. The maximum length and thickness to be bent. For example, the capacity of the machine may be 1.5 m times 1.62 mm. This means that the machine is capable of folding a sheet of metal 1.5 m wide and of 1.62 mm (16 s.w.g.) thickness.
2. The lift and shape of the clamping beam.
   The smallest width of bend is 8 to 10 times the metal thickness. The minimum inside corner radius of the bend is 1½ times the metal thickness.

The THREE MAIN STEPS in folding work are:

1. *Clamping*. In clamping, the amount of lift of the clamping beam is important. It should be sufficient to allow the fitting and use of special clamping blades, or to give adequate clearance for previous folds.
2. *Folding*. Care must be taken to see that the folding beam will clear the work, particularly when making second or third folds. Some folding machines are designed to fold radii above the minimum, either by the fitting of a radius bar or by adjustment of the folding beam.
3. *Removal of the work*. Care must be taken in folding to ensure that the work may be easily removed on completion of the final bend.
   The sequence of folding must be carefully studied. The lift of the clamping beam is important here. Some folding machines known as 'UNIVERSAL FOLDERS' have a swing beam. The work may be completely folded around this beam, which is then swung out to allow removal of the work.

Some of the above points are illustrated in Figure 9.

Figure 9(a) shows a section of a 'box and pan' folding machine.

It is fitted with a standard bed bar and fingers. The sheet metal is shown in position after completion of a right-angle bend, using a standard angle folding bar.

Figure 9(b) shows small radius bends being made. The folding beam is lowered, and the metal is clamped in the normal way.

When the folding beam is raised, the gap between the nose of the folding blade and the face of the folding bar allows a larger radius to be made.

Figure 9(c) shows small return bends being made on this machine by using a specially stepped bed bar. Such a bar is very useful for moulded work. The clamping beam lifts high enough to allow that part of the metal on the inside of the beam to be withdrawn over the bar. In this case the standard folding bar has been substituted by a narrow blade, giving smaller face width to the folding beam.

Figure 9(d) shows the use of radius fingers with the standard angle folding bar. This allows radius bends up to a maximum of 25 mm radius to be made.

The fingers may be positioned where required on the clamping beam to allow short lengths to be folded.

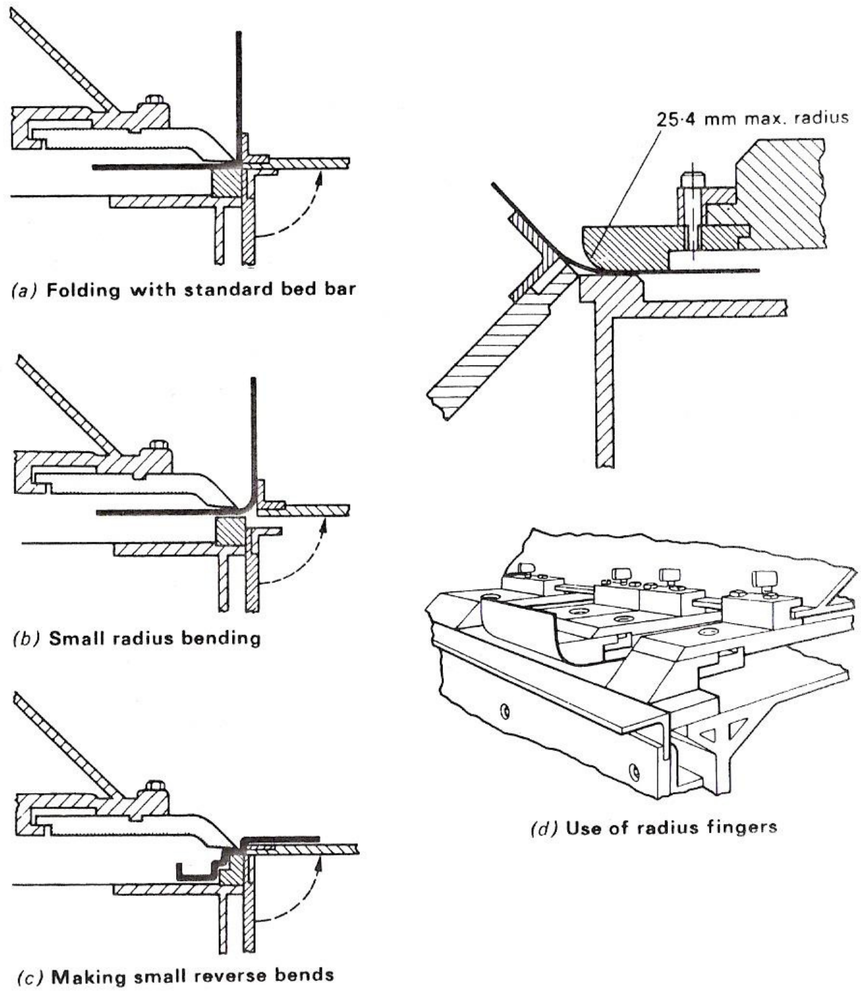


Figure 9 - The Use of Folding Machines

By fitting a special narrow bar to the folding beam, it is possible to form reverse bends narrower than the face of the standard angle bar. This is shown in Figure 10. This, of course, reduces the maximum gauge of sheet metal which would be normally folded with the standard blade.

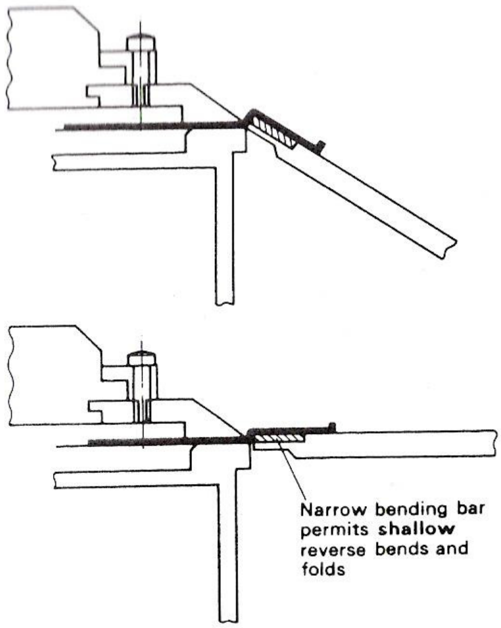


Figure 10 - Use of a Narrow Bending Bar

The variety of bends and combinations of bends that can be made on the folding machine are shown in Figure 11.

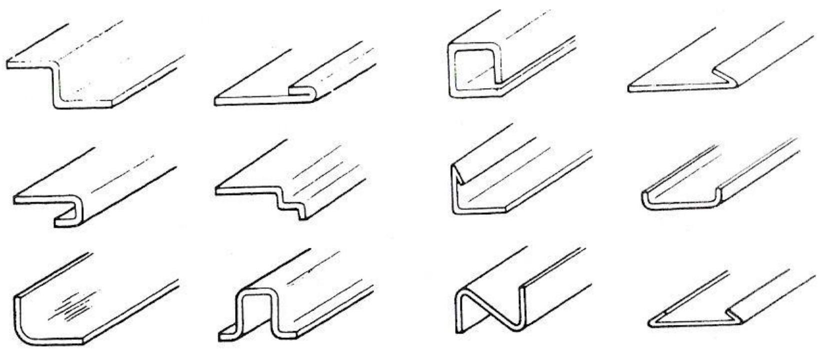


Figure 11 - Examples of Work Produced on a Folding Machine

Some folding machines have provision for inserting a round mandrel in trunnion arms on the machine. Such is the case with UNIVERSAL SWING-BEAM FOLDERS, as shown in Figure 12.

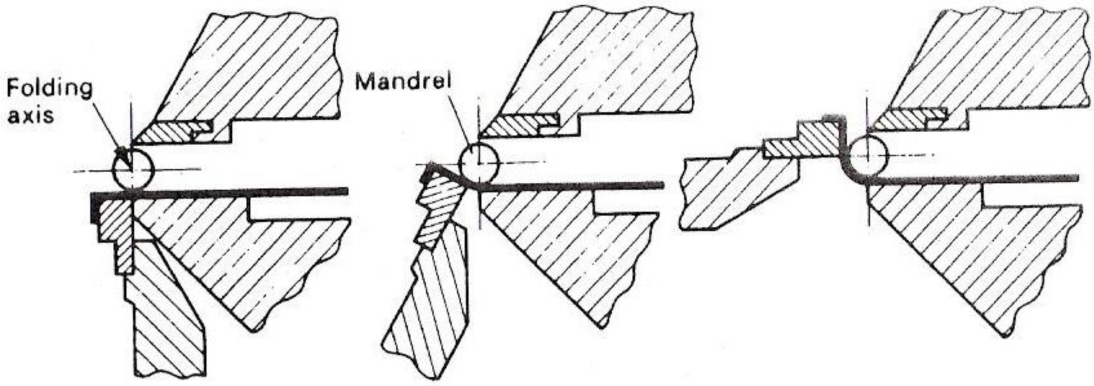


Figure 12 - Use of a Mandrel in a Folding Machine

The amount of lift in the clamping beam is very important. It governs the maximum size of the mandrel used. A machine with a clamping beam lift of between 175 and 200 mm will allow a mandrel of 152 mm diameter to be used.

Self-Secured Joints in Light Gauge Fabrication

Paned-down

The joint is illustrated in Figure 13. Laying-out examples are given in Figure 14, Figure 15 and Figure 16.

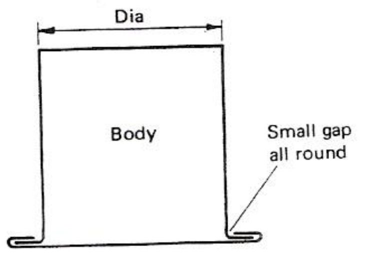


Figure 13 - Paned-Down Joint

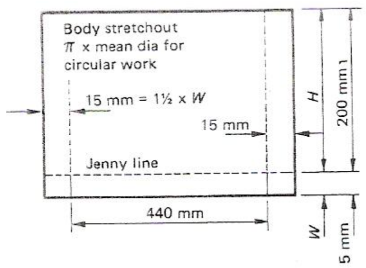


Figure 14 - Laying Out 1

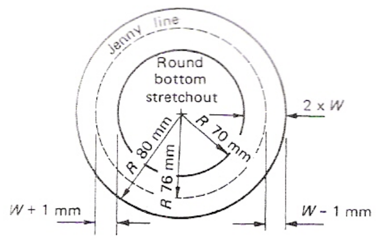


Figure 15 - Laying Out 2

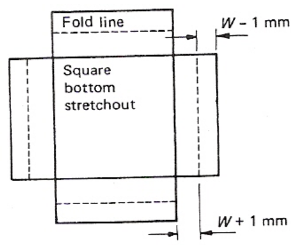


Figure 16 - Laying Out 3

Note: The small gap (approximately 1mm) is left to prevent distortion during forming.

Example Calculation

Mean diameter	D = 440mm	
Allowance width	W = 5 mm	
Height	H = 200 mm	
Round Bottom:		
Overall dia. of bottom		= D + 4 W
		= 140+20mm
		= 160 mm or 80 mm radius

Comparative Uses

This joint is the simplest form of self-secured joint and may be used for bottoms on circular, square and rectangular work or for joining a cone to a cylinder, or blanking off the ends of ductwork.

It is not a particularly strong joint and should be avoided if there is the possibility of rough usage. It is seldom used on material thicker than 1.5 mm.

Knocked-up Seam

The joint is given in Figure 17, Pattern layout and calculation as for paned-down joint,

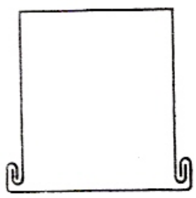


Figure 17 - Knocked-up Seam

Forming Analysis

1. After forming the paned-down joint, place the container over a suitable stake with the inside edge firmly against the end of the stake and with a mallet, bend the seam over gradually to approximately 45° (Figure 18),
   Form the bend by gradually turning the container constantly,
2. When the seam has been completely flattened, tighten the joint with a light hammer (Figure 19), remove the container from the stake or bar, and rest the edge on a flat stake. Now tap the bottom lightly to square and straighten the seam (Figure 20).

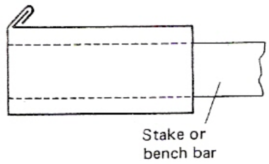


Figure 18 - Forming Analysis 1

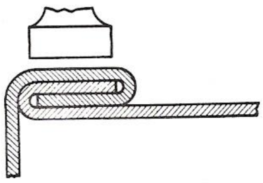


Figure 19 - Forming Analysis 2

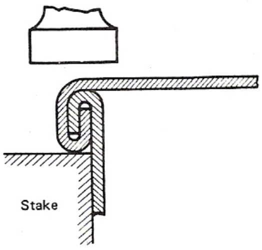


Figure 20 - Forming Analysis 3

Comparative Uses

This joint is much stronger than the paned-down joint and is also used for fitting bottoms on to round, square or rectangular containers, when access may be gained to support the knocking-up operation. It is the most common self-secured joint.

Circular body stretchout = πD + joint allowance (see grooved joint)

$$= \frac{22}{7} \times \frac{140}{1} + J.A.$$

= 440mm + J.A.

Body height = H + W

= 200 + 5 mm = 205 mm

Forming Analysis

3. Mark out one parallel line from the edge of the body stretchout (Figure 14) and two parallel lines from the edge of the round bottom to dimensions shown in Figure 15, and cut out.
4. Form a flange of the correct width on the bottom piece on the jenny, keeping the edge firm against the guide. Next, jenny the edge up on the body using the same guide setting.
5. Insert the body of the container in the bottom piece, making sure it is a loose fit, as in Figure 21. Then using a paning-down hammer, after pinching the container at four diametrically opposite places, close down the flange gradually to prevent buckles and wrinkles forming. Ensure that the work is on a flat surface and turned constantly. The final paning down is done using the peen end of the hammer, or by inverting over a hatchet stake and closing (Figure 22). Care should be taken not to mark the body.

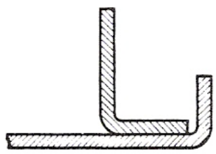


Figure 21 - Forming Analysis 4

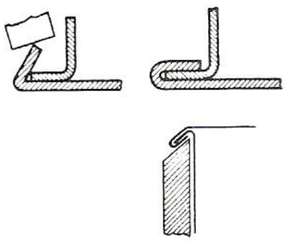


Figure 22 - Forming Analysis 5

Tinman's Heads and Stakes

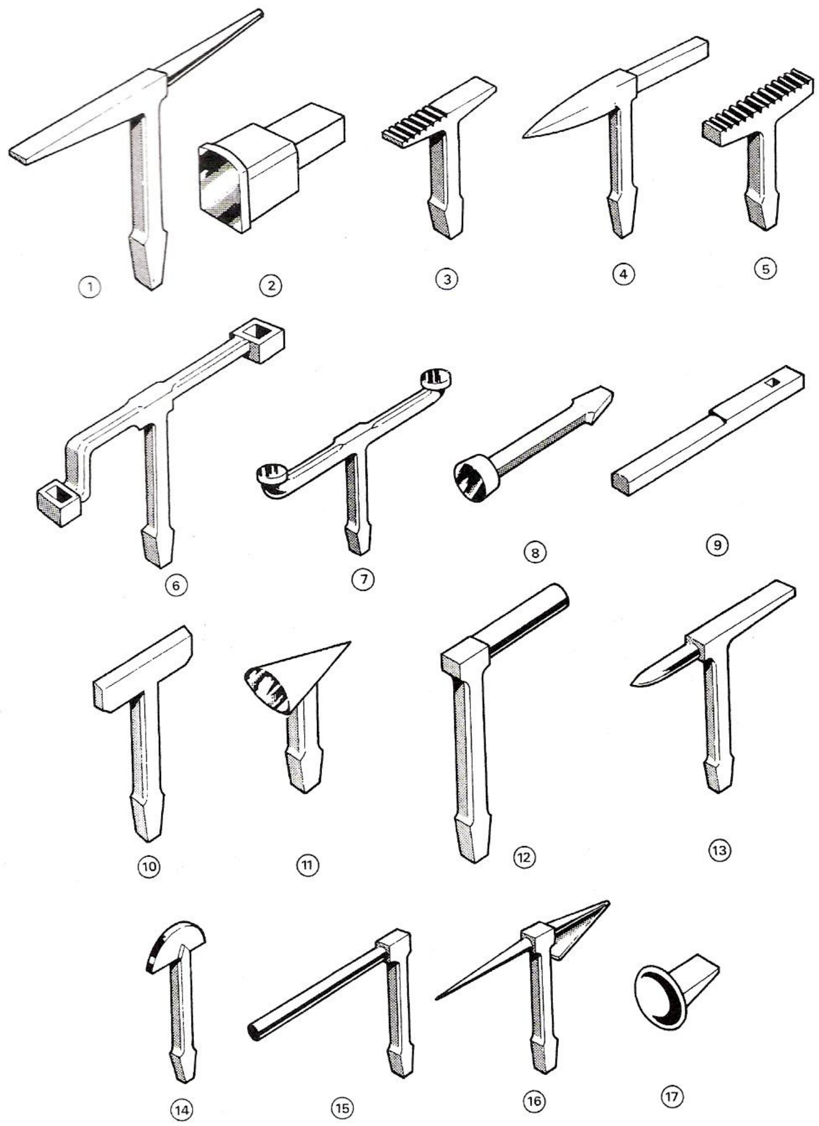


Figure 23 - Tinman's Heads and Stakes

A selection of the more commonly used heads and takes. Stakes are manufactured from steel forgings, heads from cast steel or cast iron.

1. Bick Iron
2. Anvil Stake
3. Creasing Iron
4. Combined Funnel and Side Stake
5. Grooving Stake
6. Horse
7. Saucepan Belly Stake
8. Round Bottom or Canister Stake
9. Tinman's Mandrel
10. Hatchet Stake
11. Funnel Stake
12. Side Stake
13. Extinguisher Stake
14. Half-Moon Stake
15. Pipe Stake
16. Blow Horn Stake
17. Oval Horse Stake

Introduction to Micrometers

Micrometers are measuring instruments that enable accurate measurements to be taken.

Outside micrometers are used to measure:

- Outside diameter.
- Thickness of material.
- Lengths of parts.

Micrometers are available in various sized frames. All sizes however have a measuring range limited to the length of the thread on the spindle.

The range is 0 to 25, or 0 to 1".

The- principal parts of a micrometer are:

- Frame
- Anvils
- Spindle and thread
- Sleeve or barrel
- Thimble

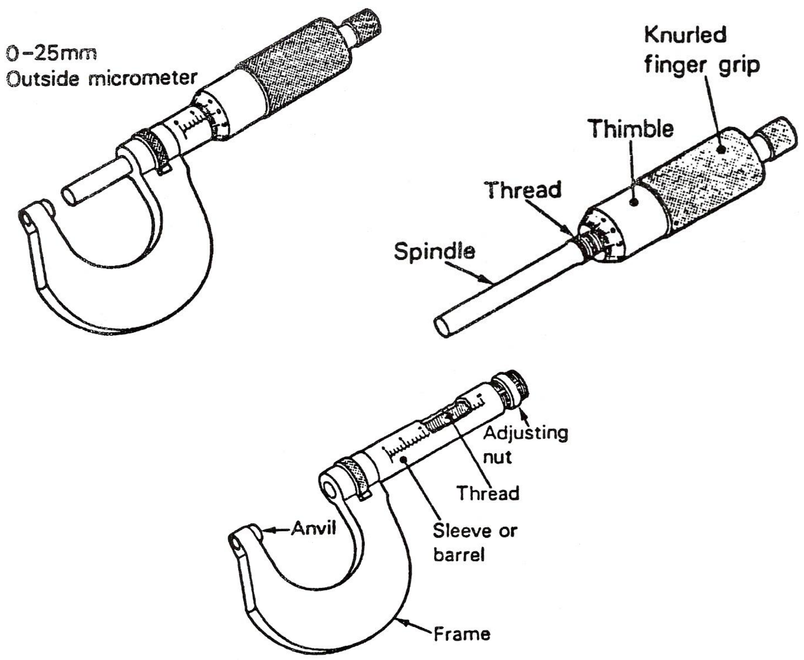


Figure 24 – Outside Micrometer

A knurled collar or a small lever on the frame can be used to lock the spindle in the barrel.

After the anvils have been set against the work being measured, tighten the spindle lock.

This prevents any movement of the spindle while you are reading the micrometer scale.

Remember to loosen the clamp before attempting to take any further readings.

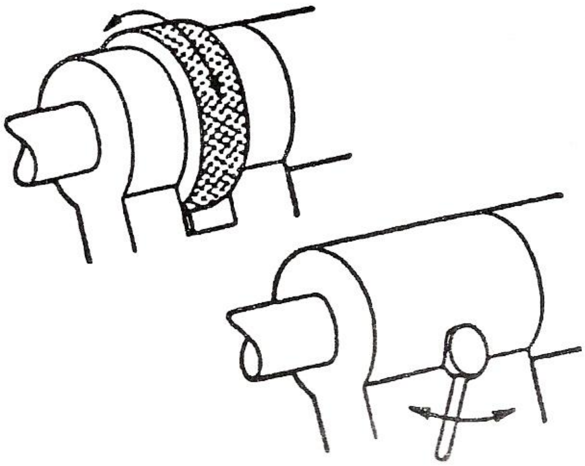
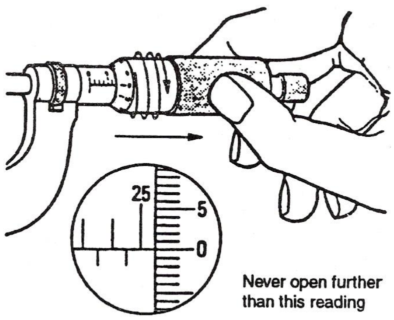


Figure 25 - Spindle Locks

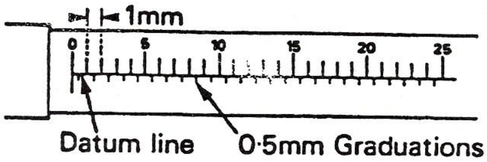
Principle of a Metric Micrometer

The principle of a micrometer that reads to .01 of a millimetre is explained as follows:

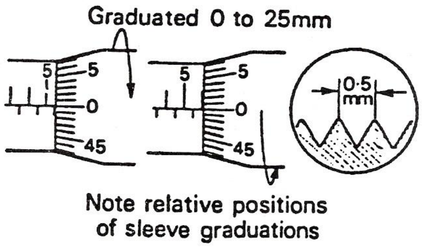
- Hold a 0·25 mm outside micrometer by the frame, between thumb and first finger of your left hand. Keep the graduations on the sleeve towards you.



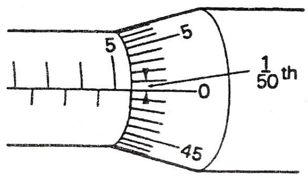
- Loosen the spindle lock.
- Use the finger and thumb of your right hand on the knurled part of the thimble to screw it anticlockwise. This uncovers the graduations on the sleeve.



- Look at the gap between the anvils. It is equal to the uncovered length of the datum line.
- Look at the datum line on the sleeve. It is graduated into millimetres and half millimetres, from zero up to 25 mm and each fifth millimetre is numbered.
- Turn the thimble until zero is level with the datum line. Note the position of the graduation on the sleeve.



- Turn the thimble one complete turn. The thimble will move along one graduation of the sleeve scale. This is because the pitch of the thread on the spindle is half a millimetre. Two turns of the thimble moves the spindle one millimetre.
- Look at the graduations around the thimble. There are 50 graduations and each fifth graduation is numbered.



- Now wipe the face of the anvils with a piece of clean cloth.
- Screw the thimble inwards towards the frame until the anvils are touching.
- Close the anvils gently, never apply force. Allow your fingers to slip on the knurled part of the thimble.

Vernier Calipers

The vernier caliper consists of a fixed jaw and a frame or beam along which is engraved an accurately graduated scale.

A sliding jaw fitted with a vernier scale can be moved along the frame. Use the clamping screws to fix it close to the required setting.

Then the sliding jaw may be finely adjusted along the frame by means of a knurled thumb screw. Vernier calipers often have provision for taking internal measurements.

When you have finished using the vernier, it must be wiped clean, oiled with a suitable protective oil and stored in a protective box.

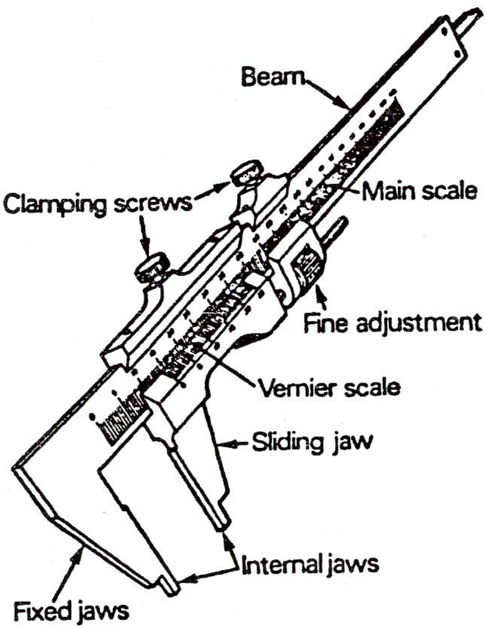


Figure 26 - Vernier Calipers

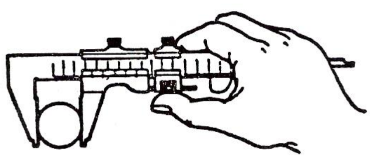


Figure 27 - Measuring an Outside Diameter

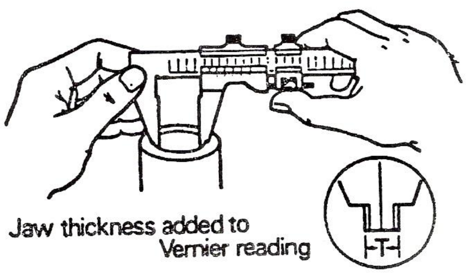
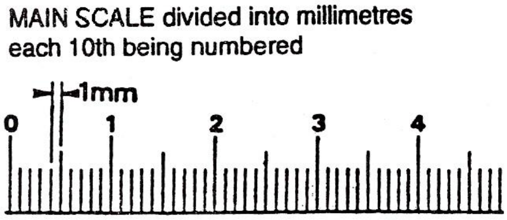


Figure 28 - Measuring an Internal Diameter

The Principle of a Metric Vernier

The principle of a metric vernier to read to .02 of a millimetre is explained as follows:



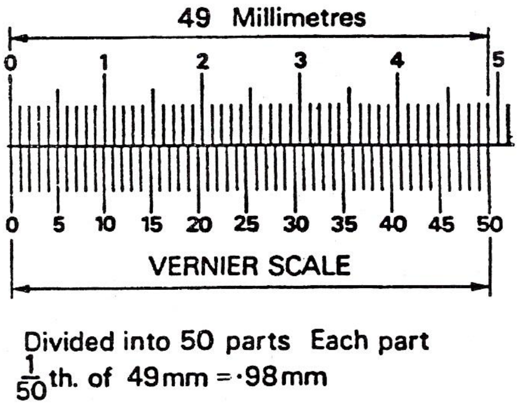
The main scale is graduated into millimetres, with each tenth millimetre being numbered.

The vernier scale is made 49 millimetres long and divided into 50 equal parts.

The length of each division is therefore one fiftieth of the total length of 49 millimetres.

1/50 of 49 mm

= .98 of a millimetre.

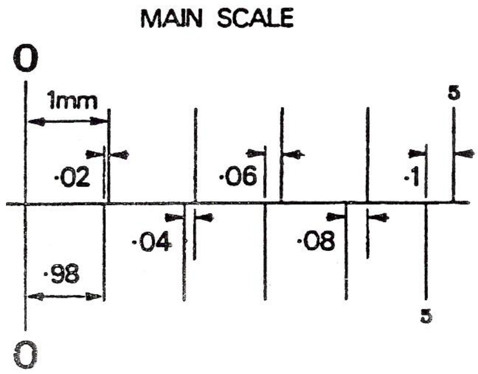


The main scale divisions are one millimetre long. The vernier scale divisions are .98 of a millimetre long. This means that the vernier scale divisions are .02 of a millimetre shorter than the main scale divisions.

From the sketch, note that each vernier division is progressively displaced by .02 of a millimetre from its corresponding main scale division.

1 mm - .98 m = .02 mm.

From the sketch, note that each vernier division is progressively displaced by .02 of a millimetre from its corresponding main scale division.



Vernier Height Gauge

The vernier height gauge is a development of the vernier caliper.

The graduated frame is held in the vertical position in an accurately ground base.

The gauge is read in exactly the same way as the vernier calipers, except that the readings are taken from the moveable jaw to the base.

The height gauge is usually used on a surface plate or marking out table. It is designed for accurate marking out or checking heights.

Several attachments are available which may be clamped to the measuring bar of the height gauge.

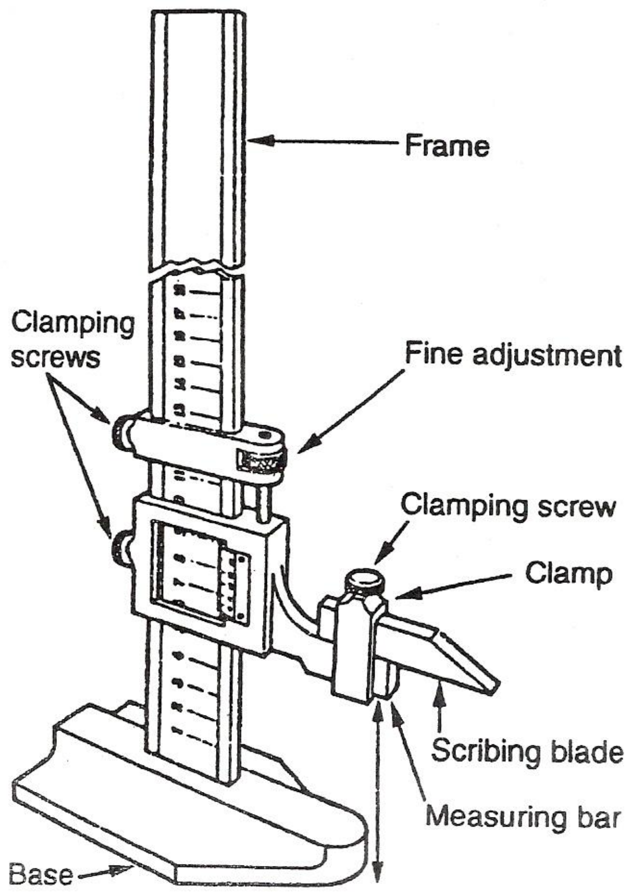


Figure 29 - Vernier Height Gauge

Self Assessment

Questions on Background Notes – Module 1.Unit 14

1. In you own words, what type of work would relate to a Nibbling Machine, putting a 'Hem' on material and having a Self - Secured Joint.

2. Give one example of the uses of a Micrometer.

3. What is the difference between a Vernier Calipers and a Vernier Height Gauge?

Answers to Questions 1-3. Module 1.Unit 14

1.

Light Gauge Fabrication Work.

2.

Measuring the outside Diameter of a Shaft.

3.

Vernier Calipers:

A Vernier Calipers is a hand held measuring tool with a sliding jaw.

Vernier Height Gauge:

A Vernier Height Gauge is on a fixed frame and is held in the vertical position in an accurately base fixture, normally used on a smooth marking out table.

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