

Trade of Sheet Metalwork

Module 1:	Sheetmetal Fundamentals
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Unit 10:	Cylindrical Work
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	Phase 2
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Document Release History

Date	Version	Comments
07/07/06	First draft	
04/03/14	2.0	SOLAS transfer

Module 1 – Sheetmetal Fundamentals

Unit 10 – Cylindrical Work

Duration – 14 Hours

Learning Outcome:

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

- Construct a cylinder with a hand grooved joint, flange, and swage
- Demonstrate use and care of a bending rolls and universal combination rotary machine (swaging machine)
- Stretch an edge on a cylinder
- State the fundamentals of stretching

Key Learning Points:

Rk	Use and care of tools/machinery and equipment especially bending rolls and swaging machine (manual/power).
Rk P	Use of cylindrical forms in sheet metal work.
Rk Sk	Breaking grain of metal.
Rk Sk	Pre-forming cylinder.
Sk	Effects of stretching/shrinking on metals.
Rk	Appearance/strengthening effects of swaging.
Rk	Metals - non-ferrous metals and alloys.
M	Calculations of circumferences/stepping of method (12 divisions) and calculating difference in blank length and finished dia.
Sc	Forces/vector diagrams. Parallelogram of forces law bows notation.

Training Resources:

- Toolkit
- 0.8mm mild steel
- Tools and machinery/equipment
- Safety equipment and protective clothing

Exercise:

Construct exercise to tolerance shown – Figure 1.

Key Learning Points Code:

M = Maths **D** = Drawing **RK** = Related Knowledge **Sc** = Science
P = Personal Skills **Sk** = Skill **H** = Hazards

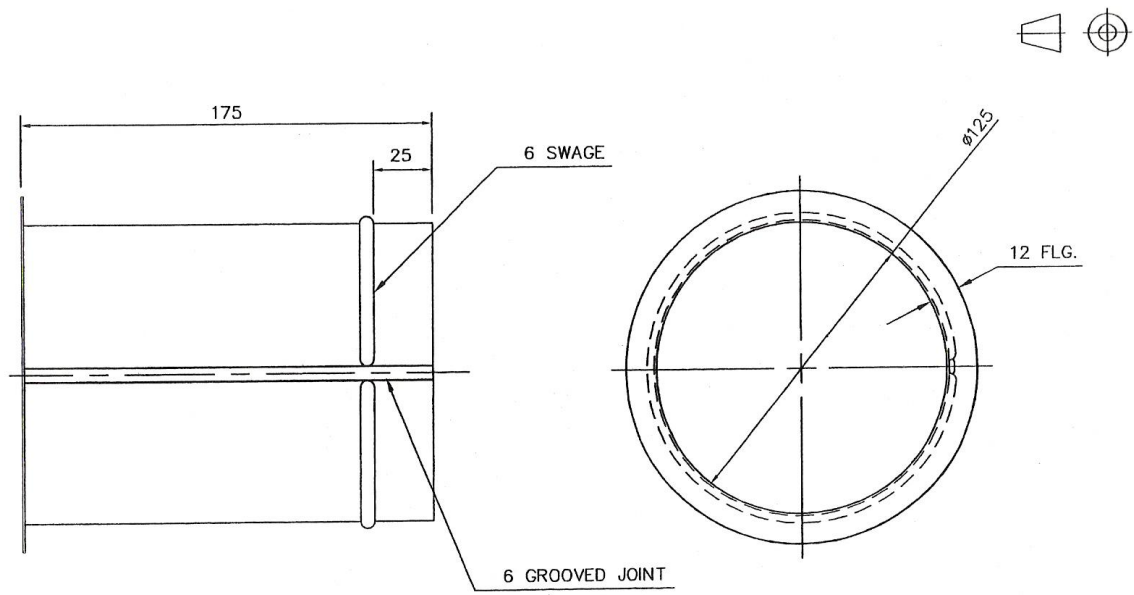


Figure 1 - Stretching

Bending Rolls

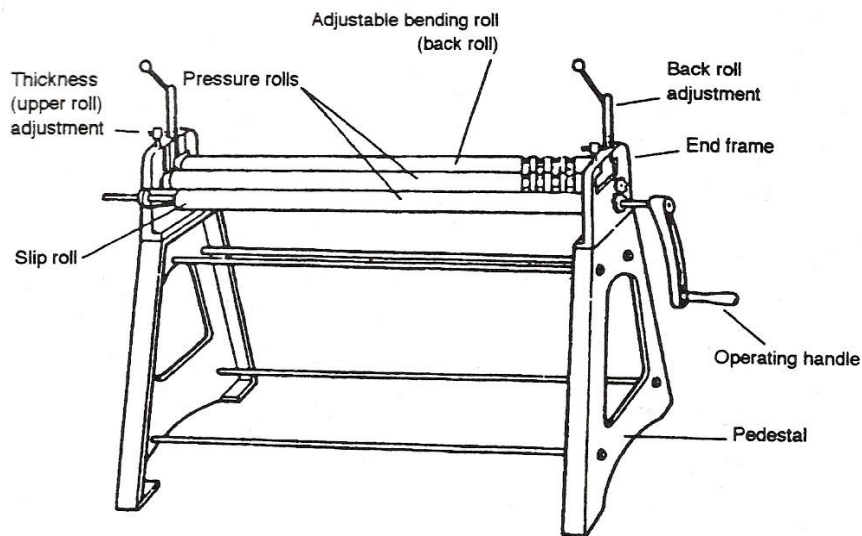


Figure 2 – Sheetmetal Bending Rolls

Machines used to bend sheet metal or plate into round or part round forms with either parallel or conical sides are called 'Bending Rolls'.

Bending rolls for sheet metal are made in various sizes from the bench type for tin plate work to the larger pedestal types which are suitable for general sheet-metal work. The basic type of rolls used in sheet-metal work is known as the 'Pinch-type Rollers'. These machines have two front rollers which lightly grip (Pinch) and draw the sheet through, and a 'free roller' at the rear to 'set' the metal to the desired radius.

There are two kinds of pinch-type rollers:

- a) Roll-up type: These machines have adjustment in an upward direction on the back roller. This type will roll any size of curvature above the size of the top roll.
- b) Roll-down type: These machines have adjustment in a downward direction on the back roller. This type will not roll more curvature than will pass beneath the pedestal frame of the machine.

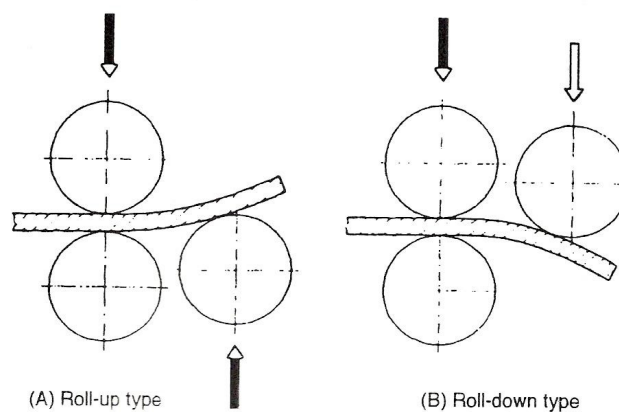


Figure 3 - Pinch-Type Rollers

The minimum diameter which can be rolled on a rolling machine is in the order of $1\frac{1}{2}$ to 2 times the diameter of the roll on which it is being rolled. Most machines roll the metal in an upward direction because this does not restrict the size of the cylinder or curve to be rolled. The identification of either kind of pinch-type rollers can easily be determined by visual inspection, as follows: Where pinch-type rollers have wiring or beading grooves, if these grooves are in the top and back rolls, the machine is designed to roll down. When the grooves are in the bottom and back rolls, then the machine is designed to roll up.

Breaking the Grain

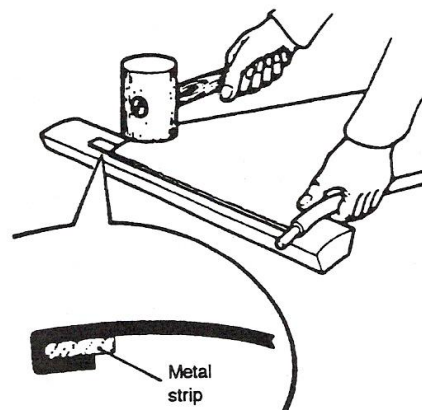
The first operation when working with light metal should be to 'break the grain' of the metal to prevent ridges forming on its surface. This consists of rolling the piece of metal backwards and forwards a few times in the rolls, reversing the bending each time. This process will ensure that the article to be formed by rolling will have a smooth surface free from kinks. If this 'breaking' operation is not carried out, a cylindrical or conical article develops ridges around the shaped body which, if not seen, may be more easily felt by passing the palm of the hand over the rolled surface.

It is good practice always to break the grain, especially on metals which have been 'cold reduced' before commencing forming operation by rolling.

Once the breaking operation is completed the pattern or blank should be rolled out flat in readiness for forming operations.

Preforming

When we roll metal into a cylindrical shape the edges may not curve the same as the rest of the cylinder. We may get two flat bits either side of the joint. To prevent this we perform the metal. This can be done by tapping the edge over a round bar with a mallet as shown in Figure 4.



Fit metal strips in groove folds to prevent closure.

The break press is used to preform heavier metal e.g. 3 mm steel.

Figure 4 - Preforming

Forming Machines

Forming Cylinders

The forming process is begun by inserting the work piece between the two front rolls as shown in Figure 5.

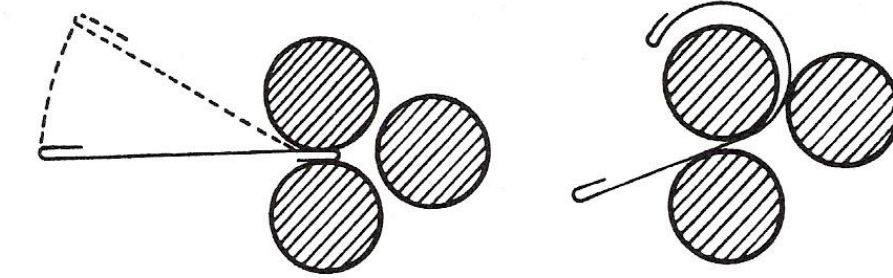


Figure 5 - Forming Cylinders

The front rolls are adjusted by turning the knuckled adjusting screw on the machine. The front rolls should be adjusted to allow just enough clearance between the rolls to avoid crushing the locks.

After the workpiece is inserted, it is tilted upwards as indicated by the diagram. This begins the curve and allows the workpiece to pass between the upper and rear roll.

For a large radius, the rear roller is lowered and for a small radius, the rear roll is raised. The rear roll is adjusted by the two adjusting screws located at the rear of the gear housing at either end of the machine.

The two types of bending rolls commonly used in the sheetmetal shop are the plain bending rolls and the slip bending rolls.

Plain Bending Rolls

The plain bending rolls consists of three rollers through which flat sheets of metal are fed through to be formed into cylindrical shapes. The two front rollers are either driven by a hand crank assembly or by an electric motor. Most shops mainly use the hand powered machine.

The rear or idler roll does the actual forming of the cylinder. It is adjustable up and down to roll the metal to the required diameter.

Slip Bending Rolls

The slip bending rolls works on the same principle as does the plain machine. The difference is that the upper roll on the slip machine can be swung away to facilitate removing the formed object.

On both machines the two front rolls operate as feeding and gripping rolls, while the rear roll gives the work its correct curvature. The front rolls are adjusted by adjusting screws at each end of the machine.

The rear roll is adjusted by two screws located at the rear of each housing.

The grooves in the front and rear rolls are used when forming objects with wired edges.

On the plain bending rolls, the workpiece can only be removed by passing all the way through the machine. On the slip bending rolls, the upper roll is released and swung away, allowing the piece to be slipped off the roll.

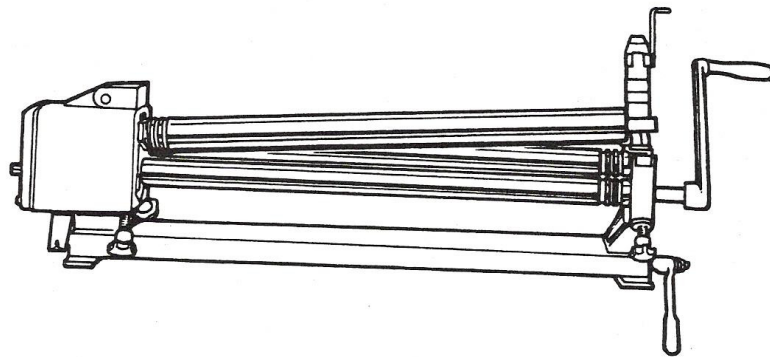


Figure 6 - Slip Bending Rolls

Forming Cylinder with Wired Edges

When forming pails, cans and other round objects with wired edges, the wire should extend past the metal slightly at one end. This is the end that should be inserted between the rolls.

The wire at the other end should be slightly shorter than the metal to form a pocket to receive the wire from the other end. A short piece of wire should be inserted to prevent the pocket being smashed. Continue to form the object to the required shape.

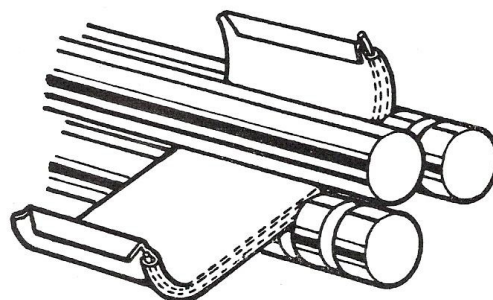


Figure 7 - Forming Cylinder with Wired Edges

Tinman's Jenny

This machine is used for turning edges on discs or forming fairly narrow flanges on cylindrical or conical shaped work. The machine is fitted with two rolls, a fine edged top, or pressure roll adjusted by a hand screw, and a recessed bottom or forming roll. An adjustable guide or gauge is fitted to control accurately the width of required flange.

The jenny is normally fitted to a cast iron bench socket but may also be mounted in a vice. When mounting, ensure machine is firmly fixed or held. Position so that the handle is at operator's right hand.

Hand operated jennies are generally limited to material lighter than 18 S.W.G.

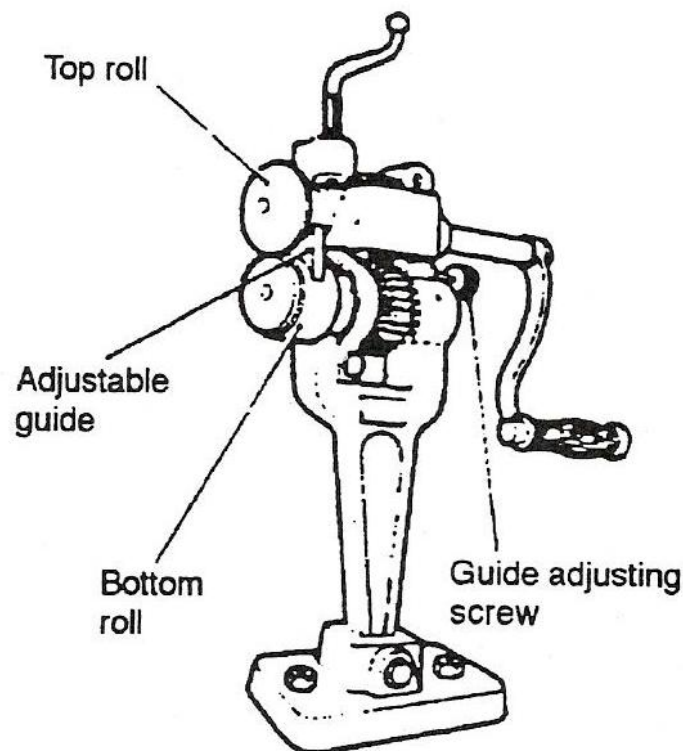
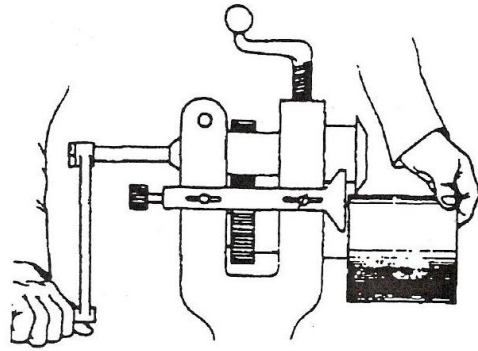


Figure 8 - Tinman's Jenny

Flanging a Cylinder

Ensure cylinder edge is smooth and burr free.
Support cylinder in machine and adjust top roll.
Turn handle slowly and smoothly maintaining
cylinder edge in contact with guide.

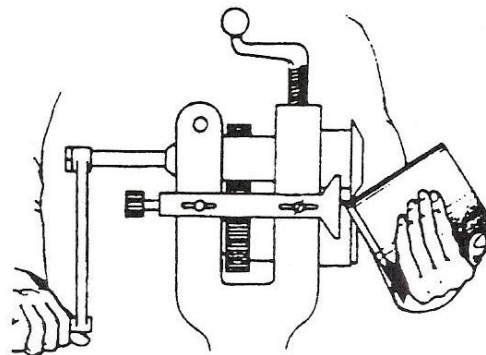
Tilt cylinder increase turning speed smoothly.
Change position of left hand when necessary and
continue applying upward pressure until flange is
at required angle.



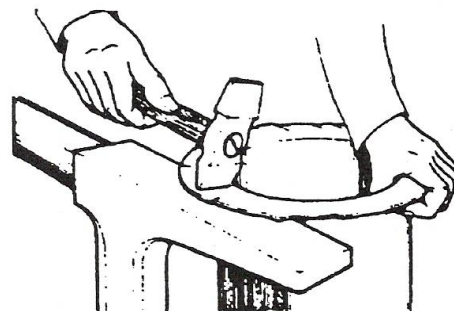
Note: When long cylinders are being flanged
assistance will be necessary. Assistant will raise
work to operator's instructions.

Wide flanges will need additional stretching using
a stretching hammer. The work should be
supported on a suitable stake.

Precaution: When using sharp edged rolls for
flanging operations, do not over-tighten the top
roll. If the top roll is too tight the metal will be
sheared. The top roll should be adjusted so as to
afford a light grip on the metal between the rolls.



The metal in the swaged bead is very highly
stressed. This produces a much greater
Strength/Thickness ratio than that of the sheet metal
with which it is formed. In general the maximum
thickness of sheet metal which may be swaged is
1.62 mm.



Flanging a Disc

Support disc in left hand, thumb on top, fingers supporting underneath.

Light pressure towards centre will maintain disc in contact with guide.

Safety: A small piece of metal folded as shown in Figure 9 should be used at all times to prevent injury to operator's hands. Make sure disc is deburred.

Position disc between rolls, edge against preset guide. Using top adjusting screw, lower top roll until metal is held firmly between rolls.

Maintain disc in contact with guide, turn handle clockwise with smooth steady action. Steadily tilt disc slowly upwards until required angle is obtained. Loosen top adjusting screw and remove disc.

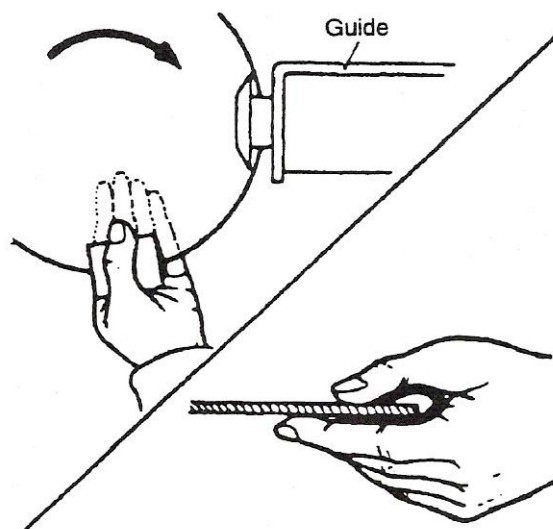


Figure 9 - Flanging a Disc 1

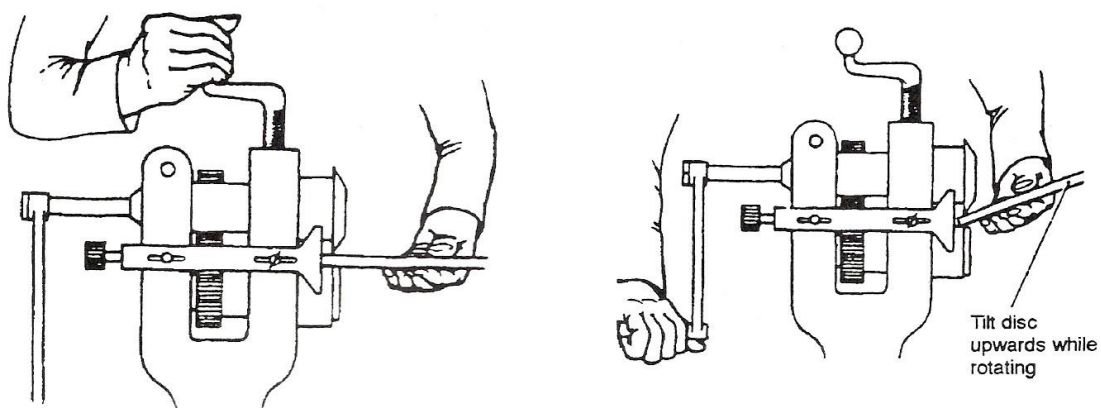


Figure 10 - Flanging a Disc 2

Forming Sheet Metal

The expression 'forming metal' usually means shaping or bending the material in three dimensions. This is much more difficult than simple bending in two dimensions, for some part of the metal must be Stretched or Shrunk. Consider a Flange to be put on a curved surface, for example a cylinder, as shown in Figure A. It will be apparent that the edge of the cylinder, after externally flanging, has a greater circumference than it has before the flange was thrown.

Now consider a Flange to be worked up around the edge of a flat metal disc, as shown in Figure B. Here it will be appreciated that the edge of the disc, after flanging, will have a smaller circumference than it had before flanging.

In case (A) the metal has been Stretched, whilst in case (B) the metal has been Shrunk or Compressed.

By way of contrast, the effects of increasing or decreasing the surface area of one flange of an angle strip are shown in Figure C. In practice, metal is not generally removed by the simple expedient of cutting 'Vee' slots. The surface area is reduced by compressing or shrinking the surplus metal. It is more difficult to produce an internally curved flange than an externally curved one, as it is much easier to stretch metal than to shrink it.

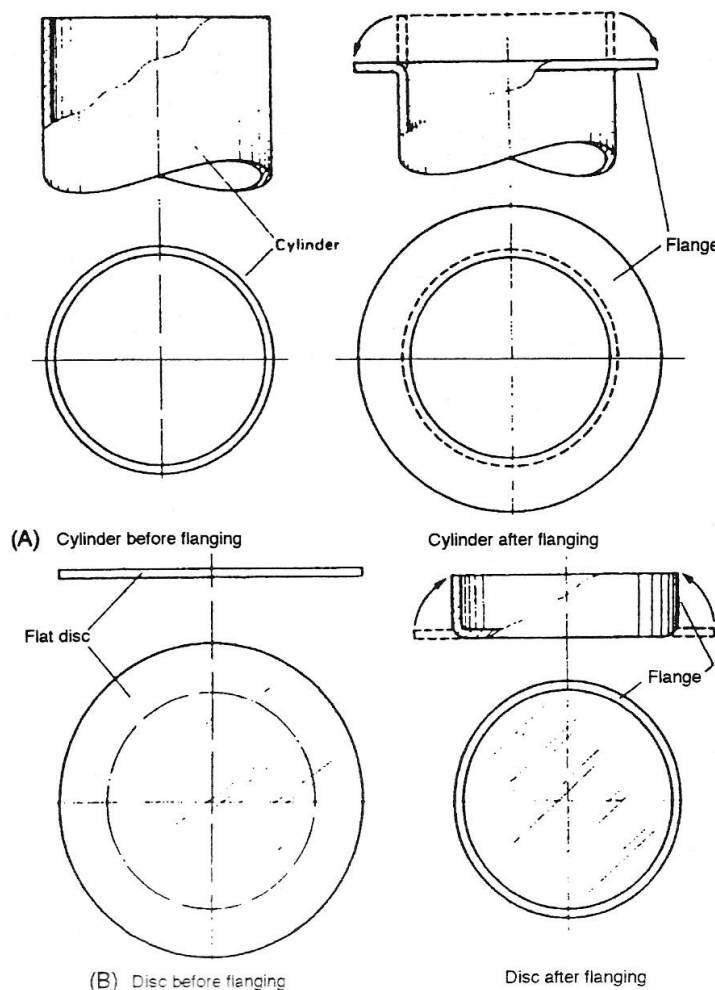


Figure 11 - Forming Sheet Metal A + B

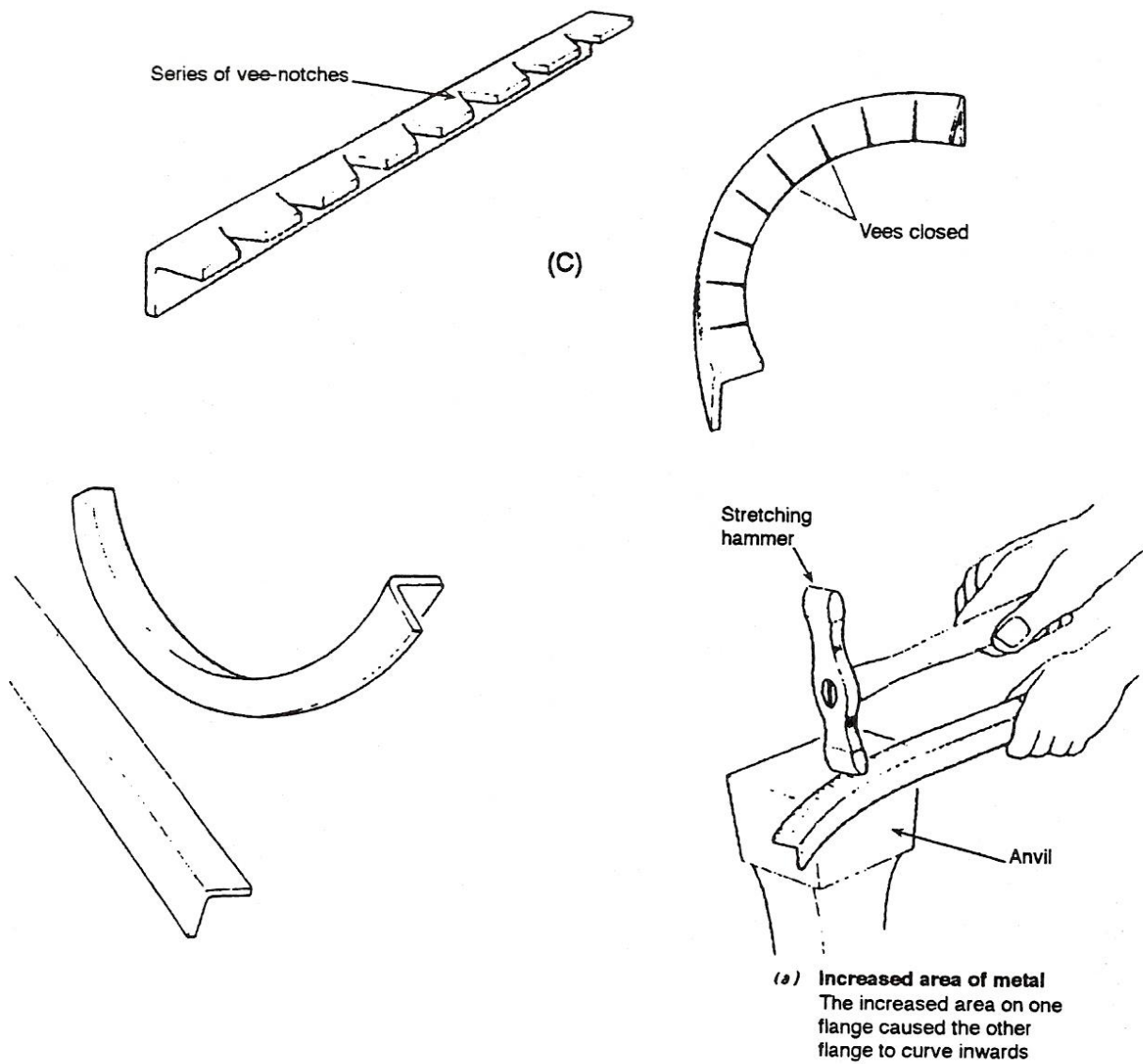


Figure 12 - Forming Sheet Metal C

Main Aspects of Forming Sheet Metal by Hand

It's necessary for the craftsman to possess a thorough basic knowledge of the properties of the materials which he has to use.

This enables him to understand, and forecast the behaviour of materials under applied forces, and be in control of the direction of their flow during a particular forming process.

Failure to understand these points will result in material, time, and effort being spent producing faulty shapes, stressed areas, splitting and other undesirable features.

The methods employed for shaping work by hand are similar for most materials, the main difference being concerned with such factors as:

- a) The Force with which the blow strikes the metal.
- b) The Direction in which the Force or blow is applied.

It should be appreciated that if, for example, a piece of aluminium and a piece of mild steel sheet of equivalent thicknesses are struck with blows of equal force, the aluminium - being softer and more malleable and ductile - will be deformed to a much greater extent than the mild steel.

Since the shaping of sheet metals by hand is essentially a Hammering Process, it is important to consider the types of blow which can be struck on sheet metal, and that each has its own field of application for particular purposes.

Universal Combination Rotary Machine

Crimping

Crimping is the process used to corrugate one end of a pipe to make it smaller so it will fit easily into the end of another pipe of the same dimension.

This method eliminates the need of making one end of the pattern for the pipe smaller than the other. Crimping can be used on light gauge metal only.

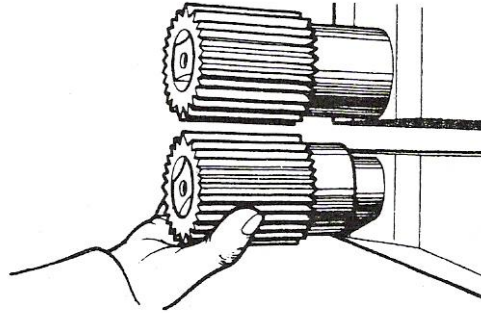


Figure 13 – Crimping 1

Crimping can be used when turning large flanges on collars since it aids in stretching the metal.

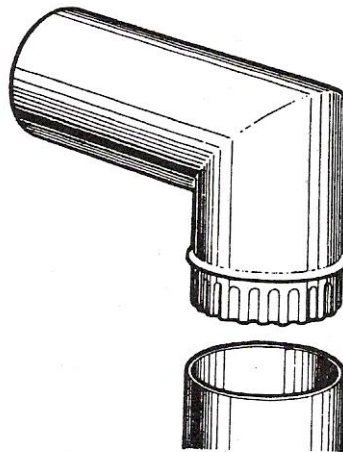


Figure 14 - Crimping 2

Swaging Machine

Swages are formed on cylindrical objects to serve as stiffeners, reinforcement or ornamentation. The swaging machine is a rotary machine equipped with special swaging rolls. The standard shapes of swage are the single, ogee and triple swage.

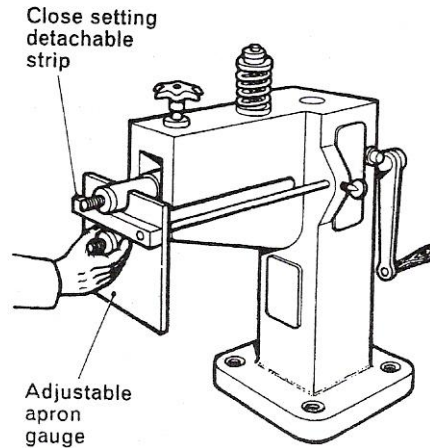


Figure 15 - Swaging Machine

Before operating the machine, if it is powered you must familiarise yourself with the starting and stopping procedure. Use of different rolls permit the universal rotary machine to combine the functions of swaging, jennying, wiring, crimping and joggling. The machine may be either hand or power operated.

Fitting Swaging Rolls

Check swage width. Select appropriate size rolls and check that they are free from damage or blemishes.

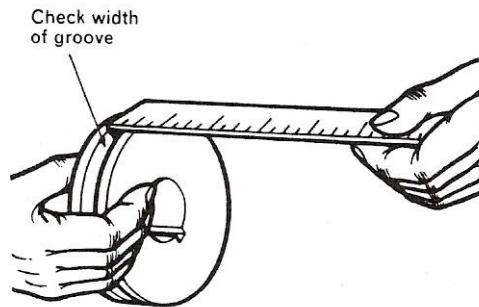


Figure 16 - Checking Swage Width

Note: One shaft has a left hand thread, and the securing nut must be unscrewed in the appropriate direction.

Remove rolls from machine by unscrewing nut anticlockwise. Remove nut and pull rolls clear of shaft.

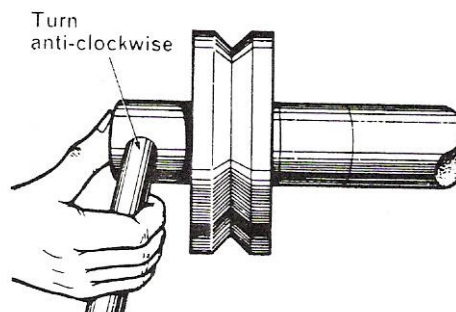


Figure 17 - Remove Rolls from Machine

Use the apron gauge when cylindrical work is being swaged, joggled or crimped, close to edge of work.

Fit gauge into locating holes on machine frame.

Slide gauge clear of shaft ends.

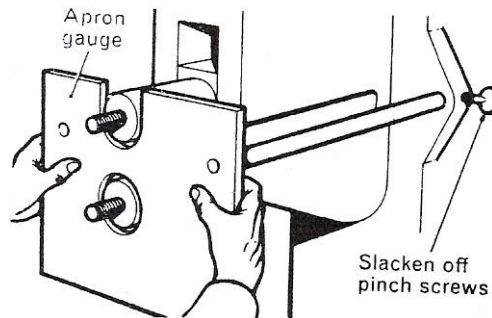


Figure 18 - Using the Apron Gauge

Push swaging rolls on to correct shafts, using spacing collars if necessary. Fit grooved rolls on top shaft for external swage, or a bottom for internal swage.

Ensure rolls engage correctly on keys and shafts.

Fit nuts noting thread type of direction, then tighten up.

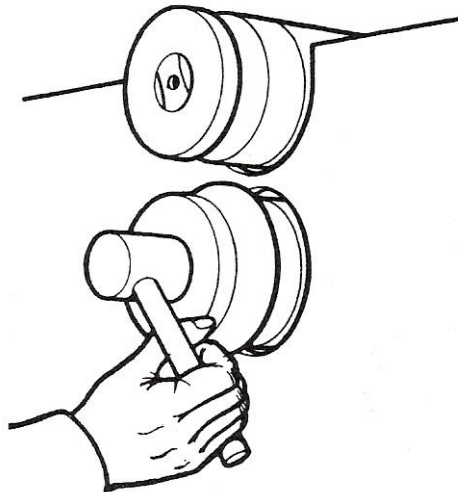


Figure 19 - Fitting Swaging Rolls

Setting Rolls in Correct Alignment

Loosen locking ring at handle end of shaft.

Fit spanner to screwed bush and adjust bush by turning until alignment is approximately correct.

Screw down top rolls adjusting screw until top and bottom rolls engage.

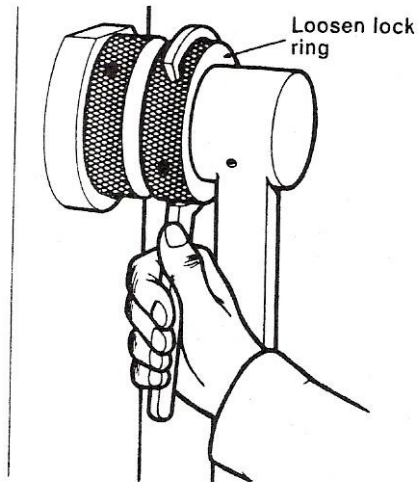


Figure 20 - Setting Rolls in Correct Alignment 1

Continue adjusting screwed bush until clearance between rolls is even.

Tighten nut holding bush to prevent it moving.

Set gauge to dimension required, checking dimension from gauge to inside edge of groove or roll.

Tighten pinch screws.

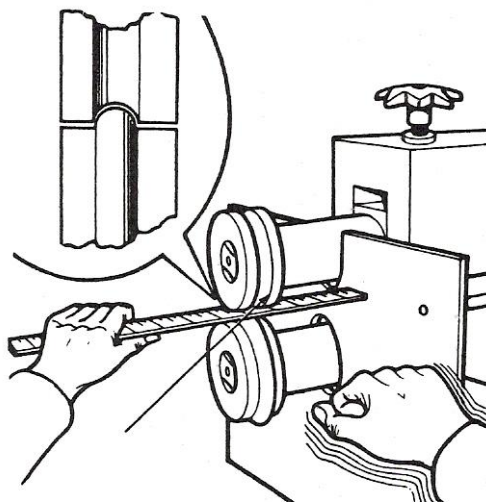


Figure 21 - Setting Rolls in Correct Alignment 2

Swaging

Open rolls by loosening top roll adjusting screw.

Position work between rolls and set against gauge.

Tighten adjusting screw until lower roll just marks material.

Turn handle keeping work pressed against gauge.

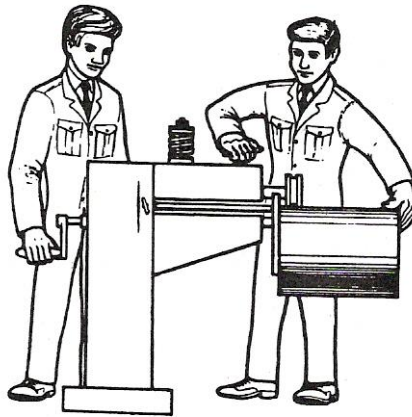


Figure 22 - Swaging 1

Tighten adjusting screw slightly at each revolution until satisfactory depth of swage is obtained.

Note: Assistance may be required for large work. Assistant must keep clear of control and must obey operator's instructions.

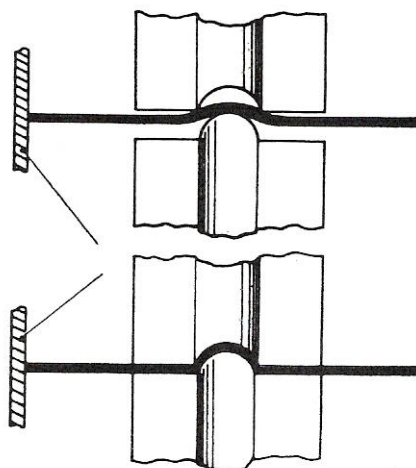


Figure 23 - Swaging 2

Swaging cylindrical work with fully grooved joints.

Set swage rolls and gauge position work joint close to roll and tighten adjusting screw.

Turn handle, keeping work close to gauge.

Stop rotation when joint is reached. Slacken off adjusting screw to allow joint to pass between rolls.

Re-position work on other side of joint and continue operations until satisfactory swage is obtained.

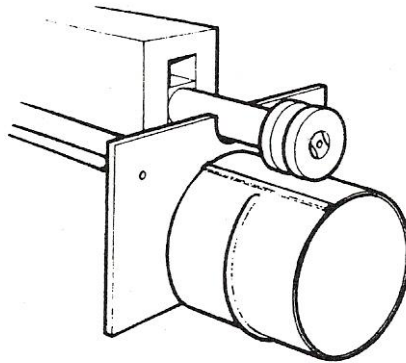


Figure 24 - Swaging 3

Use of Narrow Gauge

Use narrow gauge when required line of swage is too far from edge of work to permit use of apron gauge. Fit and adjust as for apron gauge.

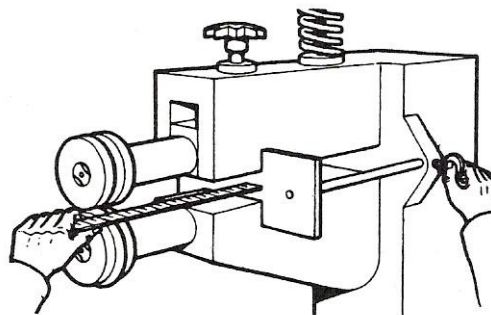


Figure 25 - Use of Narrow Gauge

Swaging Slip Joint in Ducting

Swaging is often employed to form a seating from slip joints in round ducts. It is usual in this case to notch the groove allowance to form a lap joint on the slip area.

Mark sheet and notch before folding.

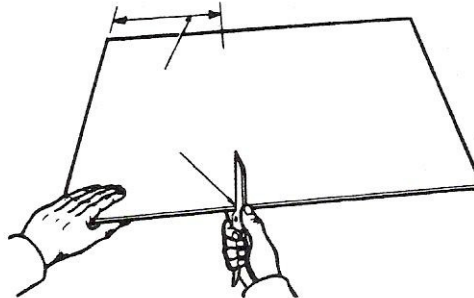


Figure 26 - Swaging Slip Joint in Ducting

Flatten notched portion after folding.

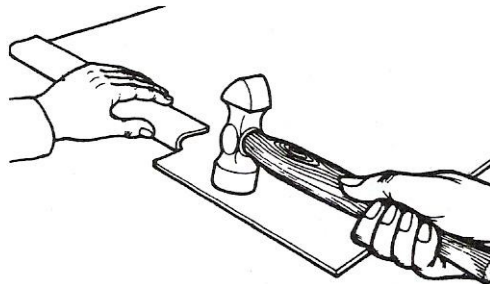


Figure 27 - Flatten Notched Portion

Secure cap with spot welder or small rivets hammered flat after forming and joining.

This operation is also necessary when grooved pipes are to be joggled or crimped.

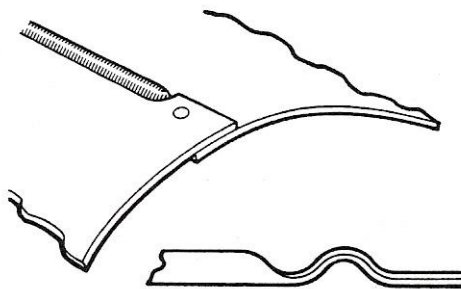


Figure 28 - Secure Cap

Swaging Square or Rectangular Work

Swaging is often used to stiffen rectangular sections, or to locate internal plates. An example is shown in Figure 29 of a fuel tank with two internal baffles.

Fit swage rolls in correct position. Internal swage is required; therefore grooved roll is on bottom shaft. Adjust narrow gauge to required position.

Form baffle swages first.

Note: Swage cannot be produced to corner. Re-set gauge to form tank ends and swages.

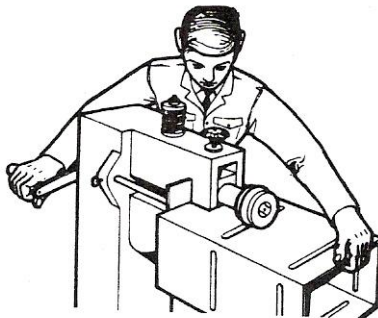


Figure 29 - Swaging Square or Rectangular Work

Swaging Flat Panels for Stiffening Purposes

Used to stiffen flat panels, swaging may also be used to remove any slackness present in the centre of a flat plate.

When rounded corners are required for appearance, swage a piece of scrap material to find the minimum radius that the machine will form.

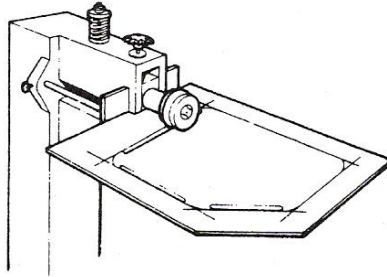


Figure 30 - Swaging Flat Panels for Stiffening Purposes 1

Mark off plate to required swage line.

Mark corner radii using dividers. Check rolls and form straight swages first.

Push gauge clear of rolls to allow free movement of plate when forming radii.

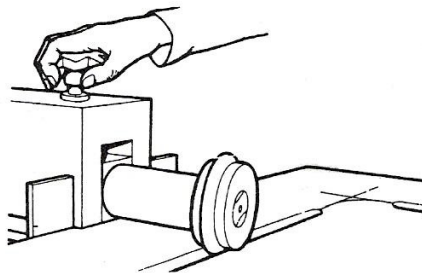


Figure 31 - Swaging Flat Panels for Stiffening Purposes 2

Loosen adjusting screw and reposition work at start of radius.

Increase adjusting screw pressure slightly, carry out this procedure until satisfactory swage is obtained.

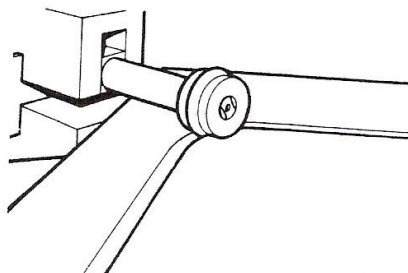


Figure 32 - Swaging Flat Panels for Stiffening Purposes 3

Alternate method of swaging flat panels.

Swages may be formed to provide angled corners instead of rounded corners.

Mark of plate to required line of swage.

Check correct rolls are fitted. Set gauge.

Form swage. Stop machine when marked line or previous swage is reached.

Note: How swages meet each other.

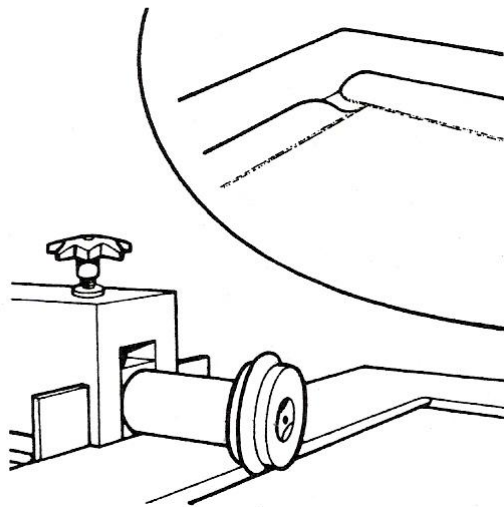


Figure 33 - Swaging Flat Panels for Stiffening Purposes 4

Remove work from machine. Select suitable flat top stake. Obtain cross pein hammer.

Support work on edge of stake, swage just clear of edge. Using hammer, tap corner to shape avoiding over stretching. Corners should blend smoothly.

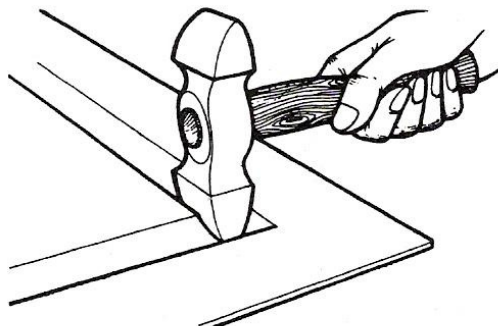


Figure 34 - Swaging Flat Panels for Stiffening Purposes 5

Jogging

Use jogging wheels to increase or decrease diameters of pipe. Fit selected wheels to machine. Wheels fitted as shown in Figure 35 will reduce diameter. Adjust lower roll to align wheels. Allow for material thickness between rolls.

Set gauge to size required. Position pipe against guide. Form joggle in stages, tighten rolls at each revolution.

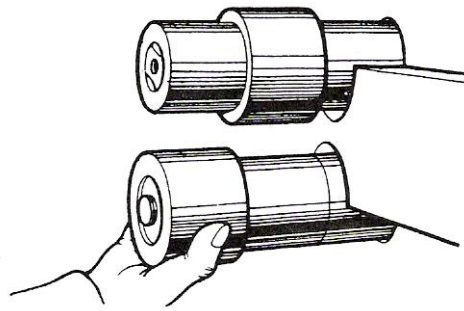


Figure 35 - Jogging

Types of Blow Used on Sheet Metal

1. **A solid blow:** Where the metal is struck solidly over a solid steel head or anvil, a solid blow will stretch the metal.
2. **An elastic blow:** Where either the head or the tool (or both) are made of a resilient material such as wood. An elastic blow will form sheet metal without unduly stretching it, and can be used to advantage to thicken the metal when shrinking it.
3. **A floating blow:** Where the head or the anvil is not directly under the hammer. The floating blow is one which is used to control the direction in which the metal is required to flow during the forming process. It is delivered while the metal is held over a suitable head or stake, hitting it 'off the solid', thus forming an indentation at the point of impact.

Calculation of Circumference

The formula for obtaining the circumference of a circle is:

$$2\pi R \text{ or } \pi D \qquad \pi = 3.142$$

Example to get the circumference of a circle with a 50 mm radius.

$$\begin{aligned} 2\pi R &= 2 \times 3.142 \times 50 &&= 314.2 \\ \pi D &= 3.142 \times 100 \text{ (diameter)} &&= 314.2 \end{aligned}$$

When marking out a pattern most craftsmen divide the plan of the pipe into 12 equal spaces. The radius of the pipe is used to do this; one of the divisions is then taken and stepped out 12 times to obtain the circumference of the pipe. This way is not the most accurate as dividing the pipe's plan does not always give 12 equal divisions in practice. If there is an error of even .5 mm in the division you take the accumulative error is

$$.5 \text{ mm} \times 12 = 6.0 \text{ mm.}$$

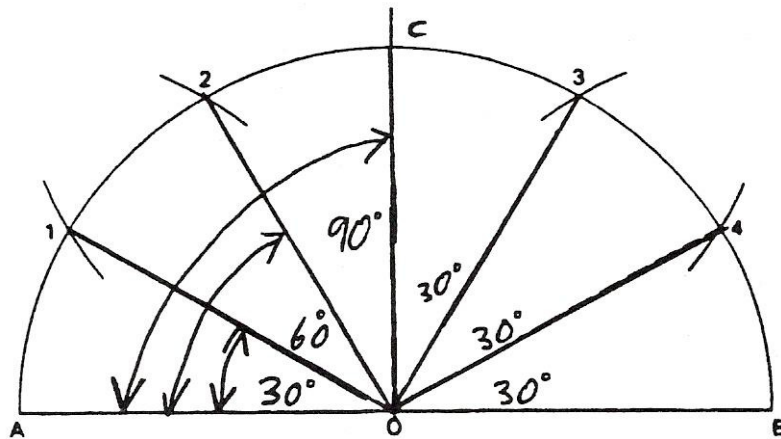


Figure 36 - To Divide a Semi-Circle into Equal Parts

Put the dividers at A and mark off point 2.

Put the dividers at B and mark off point 3.

Put the dividers at C and mark off points 4, 2.

A more accurate way is to divide the circumference, e.g. $314 \cdot 2$ by 12.

The answer is 26.18.

We then step out 26.18 12 divisions and make sure we get 314.2 for our circumference.

Composition of Forces: Parallelogram Law

Parallelogram Law of Vectors: If two vectors are represented by the two adjacent sides; ab and ad of a parallelogram $abcd$, then the diagonal ac represents their resultant.

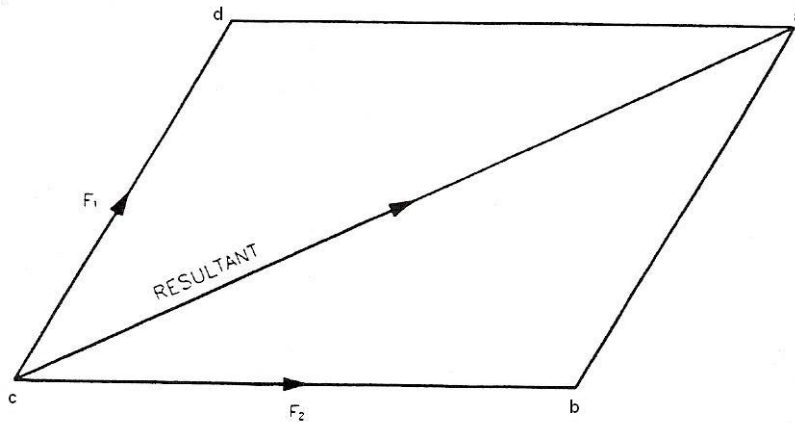
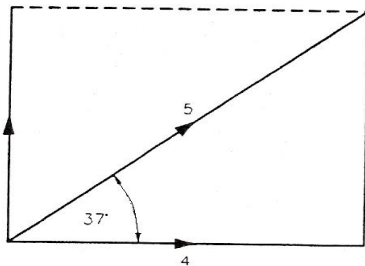


Figure 37 - Parallelogram Law

Example:

Find the resultant of a force of 3 units due north and a force of 4 units due east.



1. **By drawing**

Answer: A force of 5 units 37° north of east.

2. **By calculation – (Pythagoras)**

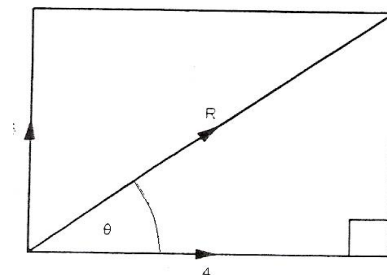
$$R^2 = 3^2 + 4^2$$

$$R^2 = 25$$

$$R = 5$$

$$\tan \theta = \frac{3}{4} = 0.75$$

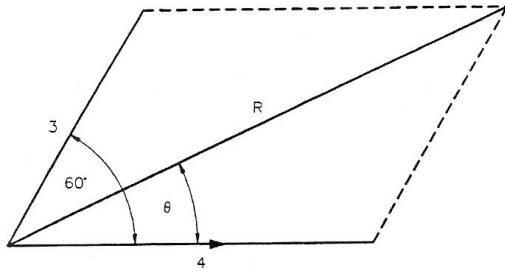
$$\theta = 36^\circ 52'$$



Answer: A force of 5 units at an angle of $36^\circ 52'$.

If the vectors are not perpendicular the calculations are somewhat more complicated.

Find the resultant force of 4 units due east and a force of 3 units 60° north of east.

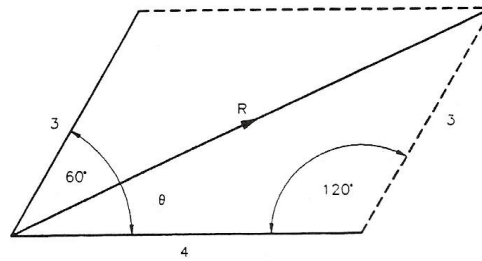


1. **By drawing**

Answer: A force of 6 units 25° north of east.

2. **By calculation**

By the cosine rule
 $R^2 = 3^2 + 4^2 - 2 \times 3 \times 4 \cos 120^\circ$
 $R^2 = 9 + 16 - 24 (-\frac{1}{2})$
 $R^2 = 25 + 12$
 $R^2 = 37$
 $R = \sqrt{37} = 6.082$



By the sine rule:

$$\frac{\sin \theta}{3} = \frac{\sin 120^\circ}{6.082}$$

$$\sin \theta = \frac{3 \sin 120^\circ}{6.082}$$

$$= \frac{3(0.8660)}{6.082}$$

$$= 0.4272$$

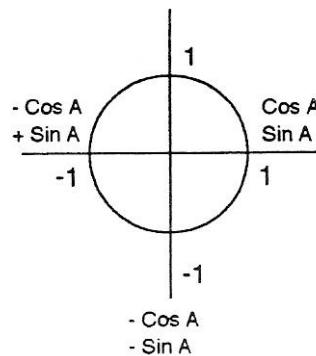
$$\theta = 25^\circ 15'$$

Cosine Rule $= A^2 = B^2 + C^2 - 2BC \cos A$

Sine Rule $= \frac{A}{\sin A} = \frac{B}{\sin B} = \frac{C}{\sin C}$

1. $\tan = \frac{Opp}{Adj}$
2. $\sin = \frac{Opp}{Hyp}$
3. $\cosine = \frac{Adj}{Hyp}$

Answer: 6.082 units at an angle of 25° 15'.



Self Assessment

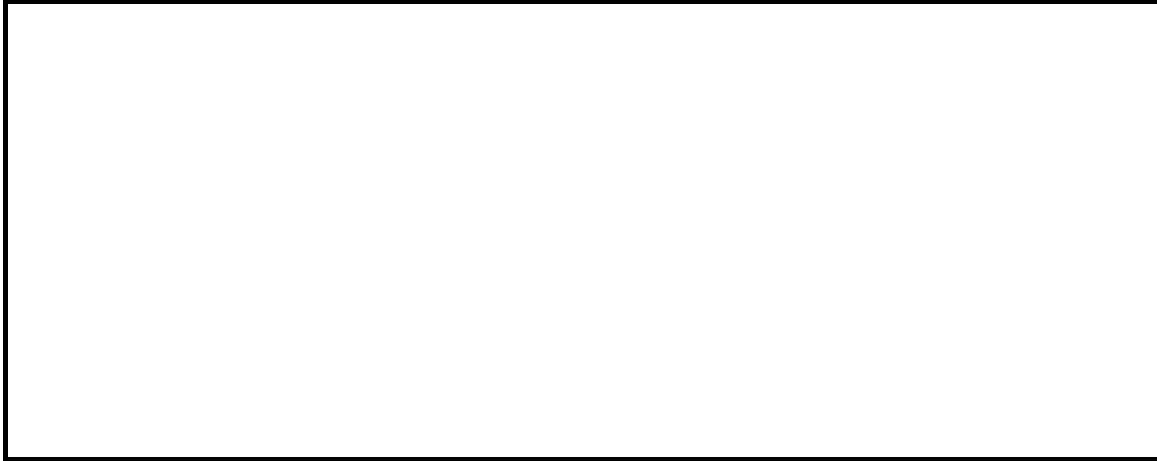
Questions on Background Notes – Module 1. Unit 10

1. What is the formula for wiring?

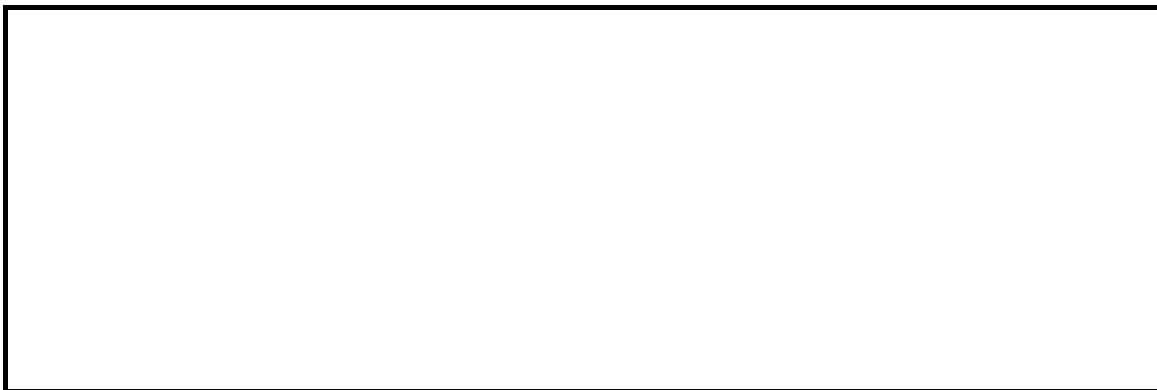
2. Name another way of obtaining the correct wiring allowance.

3. What is the melting point of tin?

4. How would you make a joint leak proof if made from tin?



5. Would you use a scribe when marking out a tinsplate job?



Answers to Questions 1-5. Module 1. Unit 10

1.

Diameter of Wire x 2½ - 1 Material Thickness

This formula is not 100% accurate so care is needed to establish a good neat job.

2.

Trial and Error

3.

Tin melts at 232C°

4.

We soft solder any joints on the job.

5.

No, this would remove the tin surface and expose the new metal underneath which is mild steel, the steel would rust over time.

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