Check list

1. There should be no paint on the pins **C7** and **D9**.
2. The main pin **D9** should be at right angles to the handle location plates **C2**.
3. The Formers should interchange easily; bushes **A5** should not protrude into the space for the Former and should be flush with the Side plates **A2**.
4. The bushes **A5** should be hardened, and tack welded to the location plates **C2**.
5. The adjusting screw should rotate freely and the slide should slide freely in the handle.
6. The welds which hold the Slider bars **B6** to the Slider side plates **B5** should be very strong as these take the full force of the bending load.
7. The Roller in the Slider assembly should be concentric. Spin it by hand to check this.
8. The Formers, whether wood or steel lined, should be a good fit to the radius of the pipe to be bent.
9. The Pipe guides should also be a good fit to the radius of pipe being bent. The guides should be straight.
10. The clamping Bolts **D6** should not be closer than 4mm to the smallest radius of the wooden former.

Introduction

This pipe-bending machine has been designed specifically to be constructed in workshops that have only a basic manufacturing capability, such as those that are to be found in developing countries.

Standard metric sizes of metal are specified in this booklet, but other sizes can be substituted according to availability, providing some consideration is given to the strength and durability which the components require.

The tools that are necessary to construct this machine are: welding equipment, a drilling machine, a lathe and general tools such as files, engineer's square, hacksaw, etc. The use of an angle grinder would make some of the filing jobs easier, but it is not essential. The lathe is only required to put a groove in the wooden formers around which the pipe is bent. If a lathe is not available, this process can be done by hand, using a wood saw, chisels and rasps; alternatively, the formers could be turned on a drilling machine.

The machine is a very useful addition to any manufacturing workshop, enabling new and better products to be made — such as school chairs and desks, wheel-chairs for the disabled, bed frames and agricultural tools. In many places, the facility to bend a pipe can do away with the need for a welded joint, and indeed the bend will be much stronger and quicker to make.

Glossary

Drill through	=	drill completely through the component
∅	=	diameter
M12	=	12mm Metric thread
Welding spatter	=	lumps of molten metal produced during electric arc welding
MS	=	mild steel
RHS	=	rectangular hollow section

Weld here =

Inside radius =

Outside radius =

I.D. = inside diameter

O.D. = outside diameter

O.D.

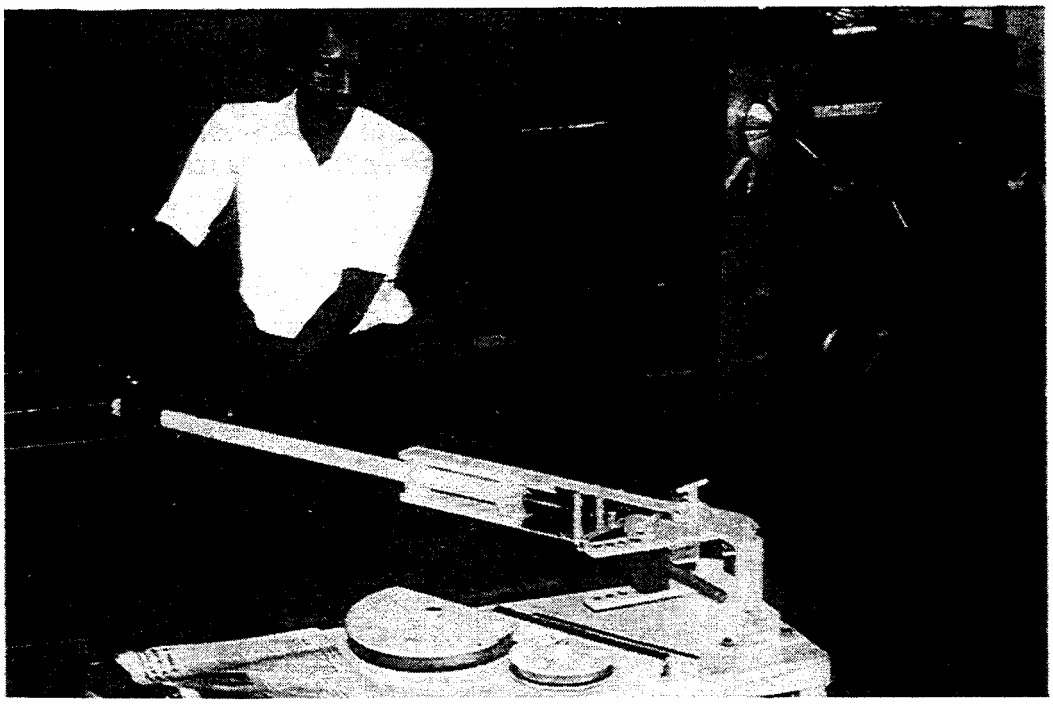
I.D.

Fig.1 = Figure 1

Contents

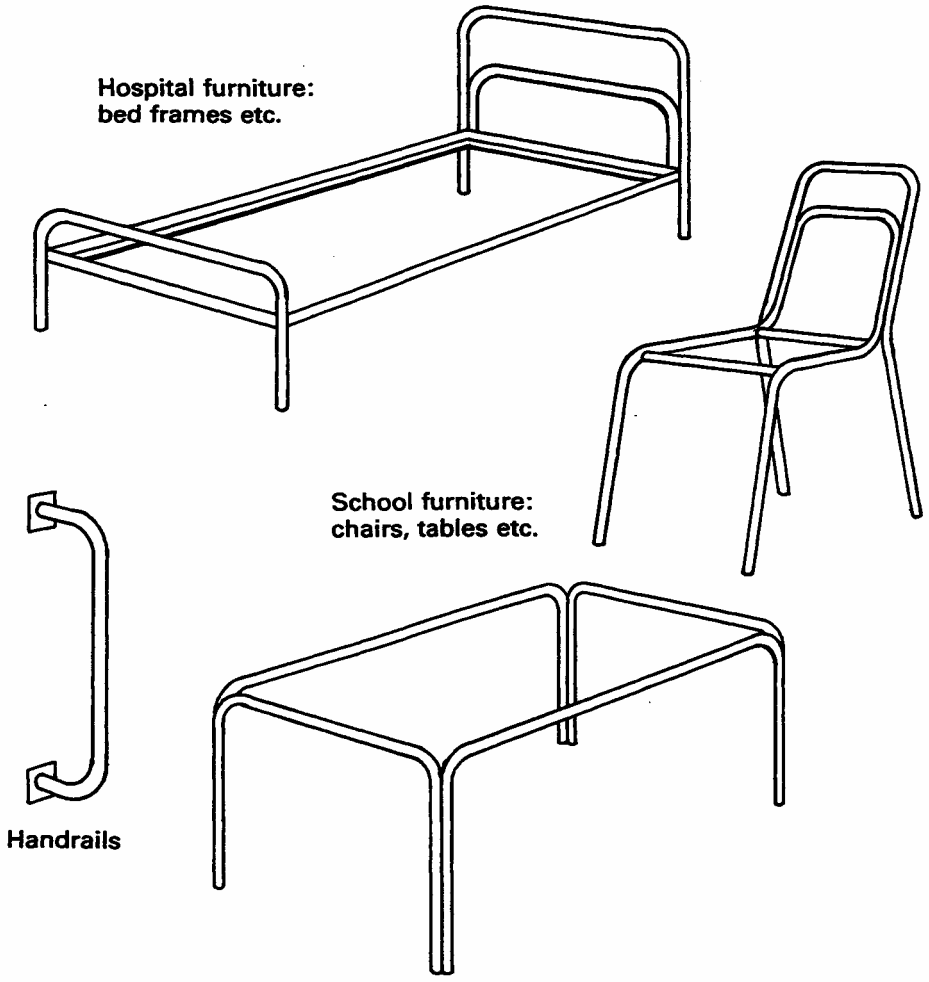
Important notice to Constructors

* The plans and instructions given in this manual **must** be read very carefully **at each step** of the construction process.
* The order in which parts are made and assembled which is described here is the easiest, and should be followed exactly.
* Particular care must be given to the relative positions of parts before they are welded.
* Where materials are not available in the sizes specified in the manual, give serious thought as to how substituting other material of a different size will affect the function of that part of the machine:
— Will the change weaken the finished machine?
— Will it make the machine less durable?
— Will this substitution alter other dimensions given elsewhere in the manual?
* Where flat bar or plate of the specified thickness is not available, consider whether you could weld two thinner pieces together around the edges and use this in its place.
* It is usually better to use a larger steel section than a smaller one.
* Components which slide together or rotate in one another should not be painted on those adjoining surfaces, and should be greased or oiled as the machine is assembled. Further oiling from time to time will also prolong the life of the machine.
* On page 2 of this manual is a Check list. Please read it both before you build the machine and after you have completed the machine. If all the points listed are O.K. you will be well pleased with your machine.



Uses of the Pipe-bending Machine

The largest size of pipe that can be bent in the pipe-bending machine is 25mm (1 inch) outside diameter. Using this size of pipe, the largest possible inside radius for the bend is 120mm.



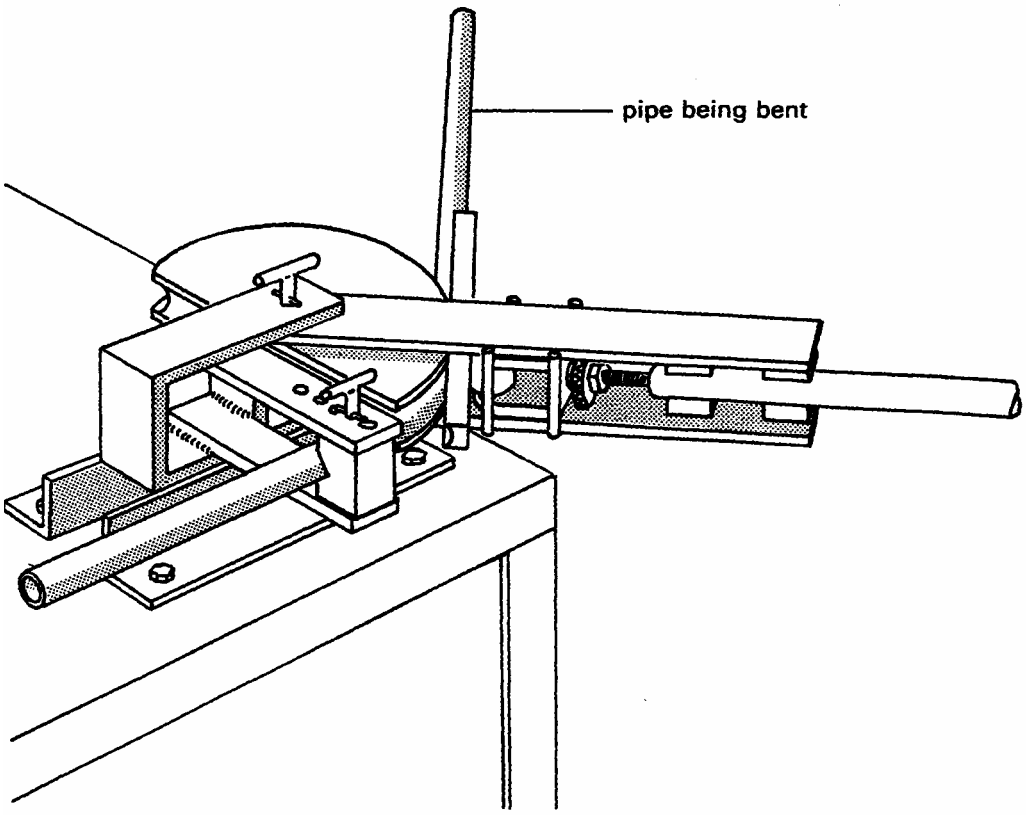


Figure 1 Complete pipe-bending machine

Main Assemblies

A — Handle assembly
B — Slider assembly
C — Bracket assembly
D — Former assembly

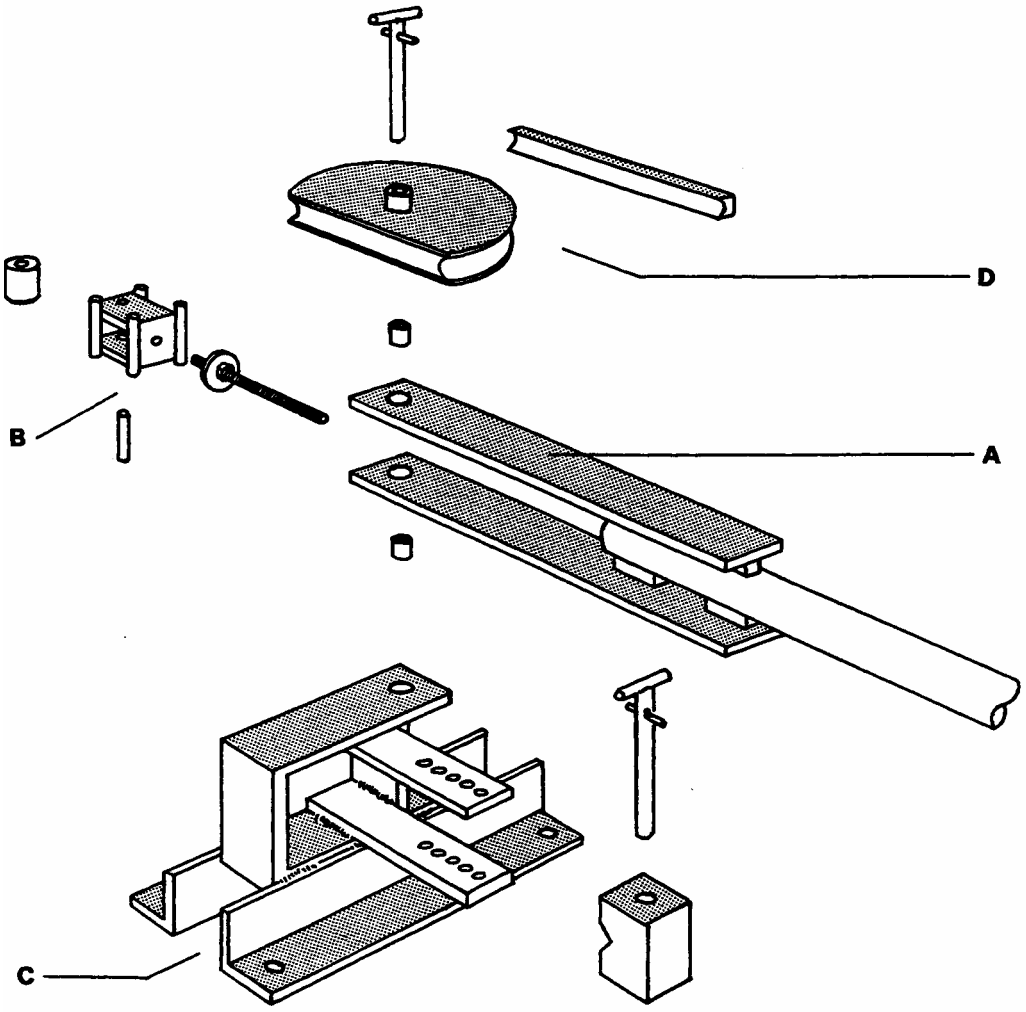


Figure 2

The pipe to be bent is located against a notch in a block in the Bracket assembly **C**. The Slider assembly **B** is adjusted so that the pipe to be bent is held closely against the semicircular Former. The Handle **A** is then pulled round to bend the pipe around the Former.

Construction

HANDLE ASSEMBLY — A PARTS

Part	Name	Quantity	Dimensions (mm)
A1	Handle	1	850 × Ø34 MS pipe (25 nominal bore)
A2	Side plates	2	550 × 40 × 12 MS flat
A3	Spacer	4	13 × 40 × 12 MS flat
A4	Nuts	2	M16 Nut
A5	Handle restraint bushes	2	30 × Ø19 MS pipe (or Ø25 turned)
A6	Washer	2	Ø19 (or Ø25 I.D. for larger bushes A5)

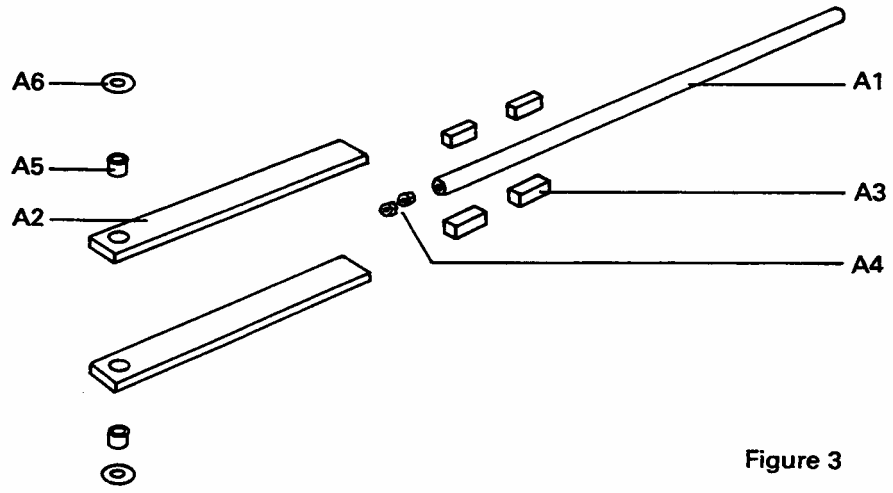
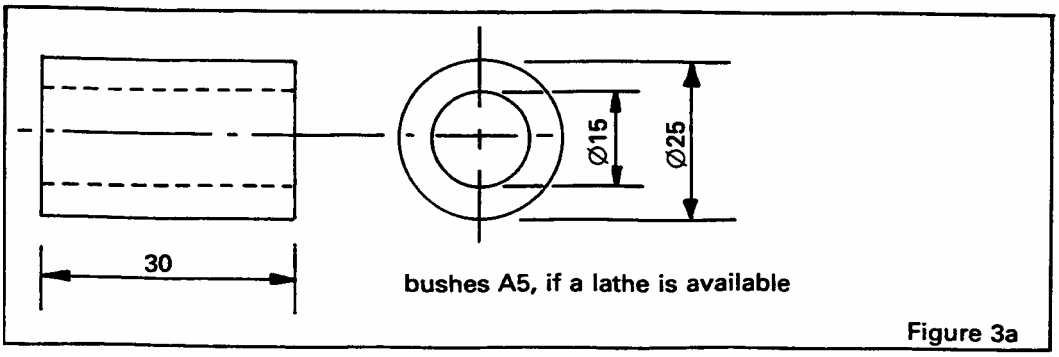


Figure 3

Bushes **A5** are the main pivots for the bending machine, and take a lot of wear. If a lathe is available they should be turned to the larger diameter (25mm) as in Figure 3a. This gives a larger bearing surface for the pivot. The holes in **A2** and **C2** will have to be drilled 25mm dia. to receive the bushes.



bushes A5, if a lathe is available

Figure 3a

Bushes **A5** will last much longer if they are case-hardened as follows:

Case hardening

This is a process of hardening the outer skin of the steel bushes to a depth of approximately 0.5mm, by introducing carbon into the surface of the steel. This is achieved by placing the bushes into a steel pipe which is then packed with carbon (or one of the compounds listed below). The pipe is heated to red heat in a fire and kept at this temperature for four hours. The bushes are then removed from the steel pipe, re-heated to red heat and quenched in water, or better still, urine.

A suitable steel pipe for this process is illustrated in Figure 4.

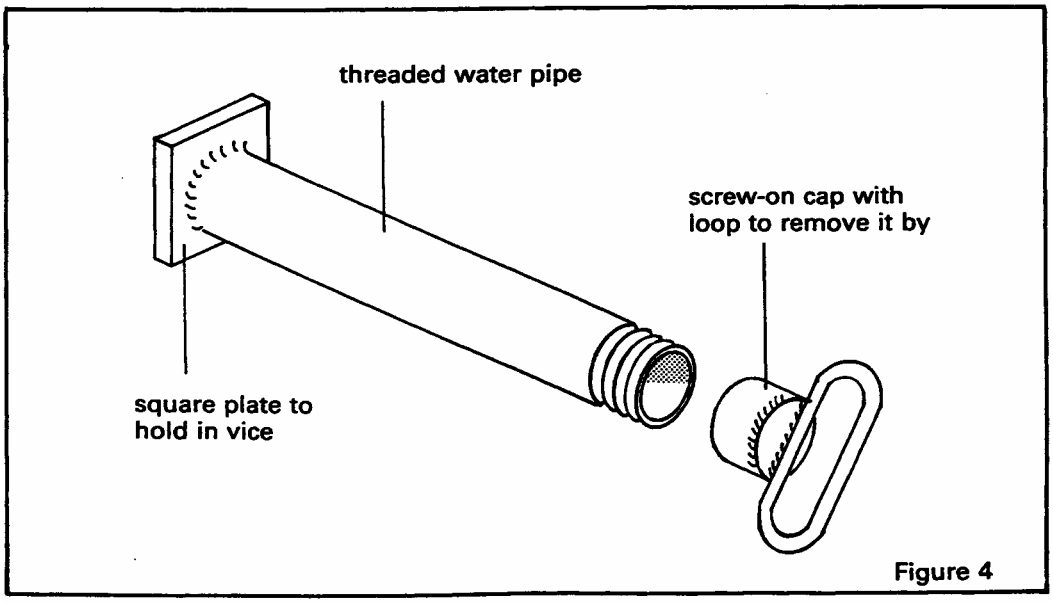


Figure 4

Carbon for this process must be a finely ground powder and must be packed tightly around the bushes. Suitable carbon can be made from bones, horn or hoove clippings, leather or wood, using the following process: pack them in granulated form (e.g. sawdust) into the pipe illustrated above; heat the pipe in a fire to red heat for half an hour; remove the charred grains, and crush them to a fine powder.

Three alternative mixes of powders which work well together are as follows:

1. Wood charcoal 95%, soda ash 5%, or 2. Wood charcoal 90%, common salt 10%, or 3. Anthracite coal 90%, bone black 10%.

Testing for hardness

Once you have case-hardened the bushes, you can test for hardness by attempting to file the surface of the bush. A fine file applied with a light pressure is best. It should slide over the surface of the steel without really cutting into the metal. Compare it with an unhardened piece of mild steel.

The bushes **A5** are not required until assembly (page 26).

Run the two M16 nuts **A4** lightly on to a bolt and weld them together, protecting the threads from weld spatter. Insert the two nuts into the end of the Handle **A1** and weld in place (Fig. 5) making sure that a bolt screwed through the nuts is in line with the Handle.

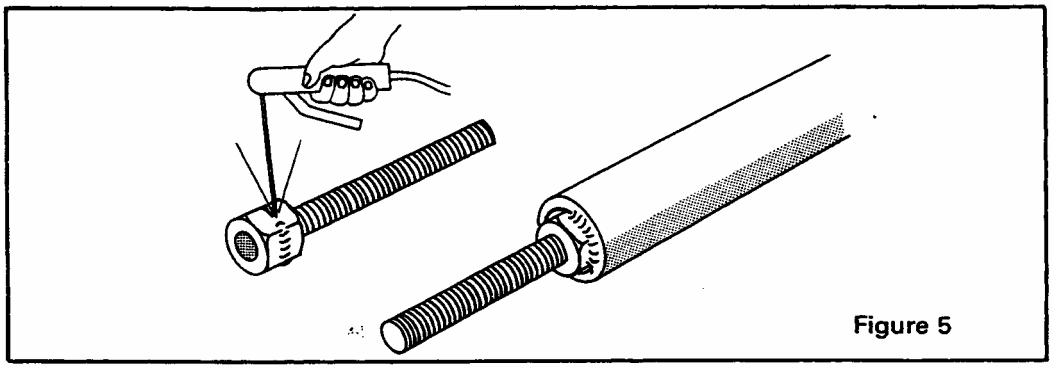


Figure 5

Mark out and drill the Side plates **A2** to suit the Handle restraint bushes **A5** (19mm dia. or 25mm if turned bushes are used). Clamp the handle **A1** to one side plate **A2** with two spacers **A3** in between. Tack weld (Fig. 6).

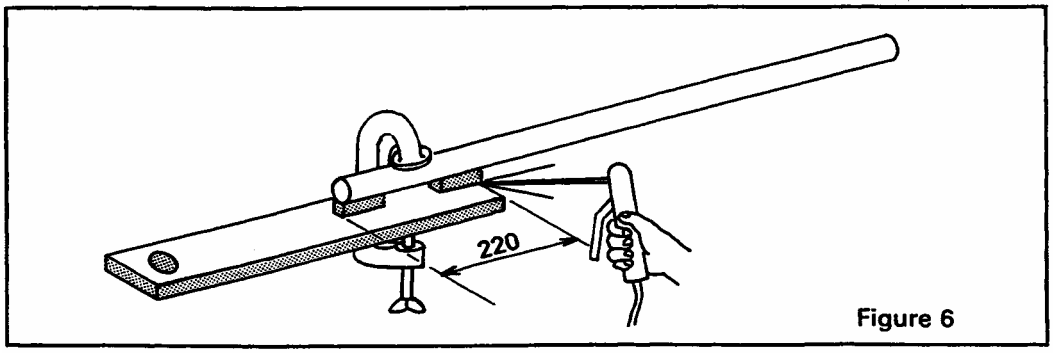


Figure 6

Clamp the second side plate **A2** to the Handle **A1** with the remaining spacers **A3** in between. Insert a long piece of Ø19 MS bar or pipe into the Bush holes to check the alignment (Fig. 7). Tack weld, as indicated, then check the dimensions and ensure that the Side plates are not twisted before welding fully.

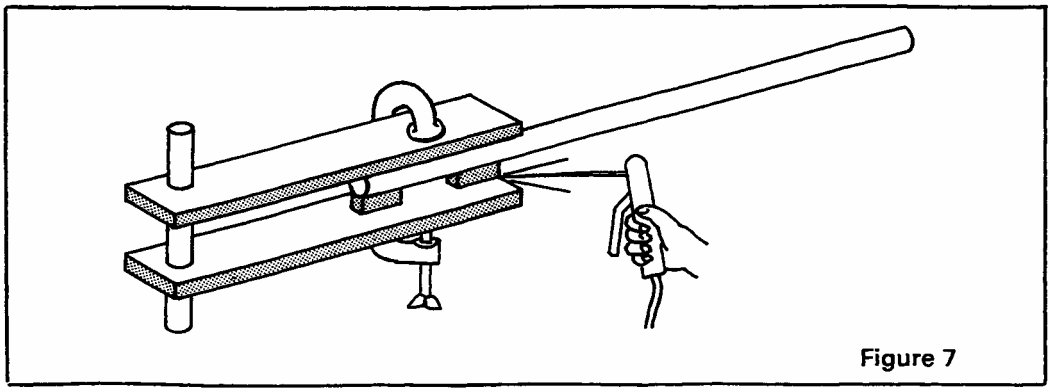


Figure 7

SLIDER ASSEMBLY — B
PARTS

Part	Name	Quantity	Dimensions (mm)
B1	Adjusting screw	1	200 × M16 studding
B2	Adjusting wheel	1	Ø52 × 5 MS plate
B3	Washers	2	M16 washer
B4	Slider top plate	1	38 × 40 × 10 MS flat
B5	Slider side plates	2	58 × 40 × 10 MS flat
B6	Slider bars	4	80 × Ø10 MS bar
B7	Roller	1	38 × Ø35 MS bar
B8	Roller pin	1	58 × Ø12 MS bar
B9	Nuts	3	M16 nut

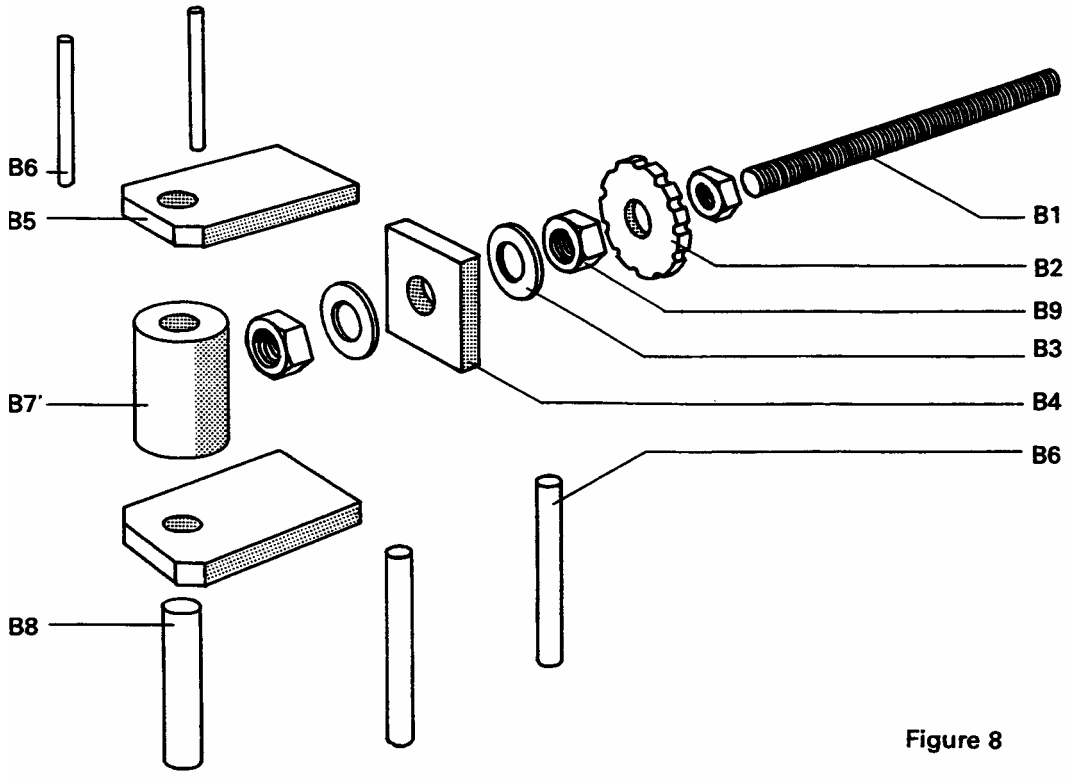


Figure 8

If a metal-turning lathe is available, cut, face ends, centre drill and drill (12mm dia.) Roller **B7**. Chamfer all corners. If a lathe is not available, file the ends as square as possible. Mark the centre accurately, centre punch and drill through using a 'V' block or drill vice (Fig. 9).

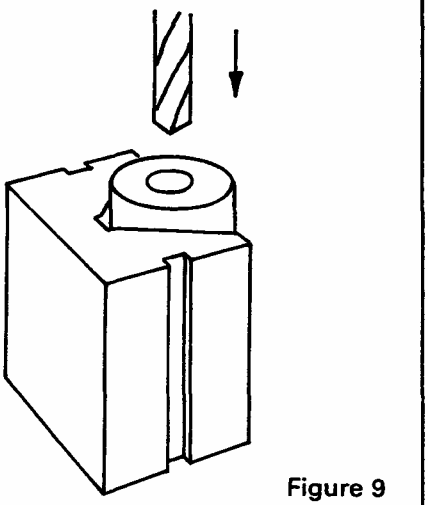


Figure 9

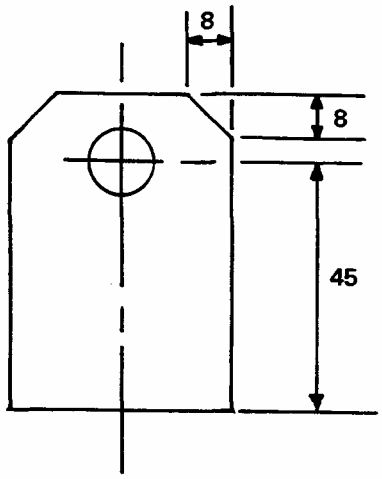


Figure 10

Mark out the Slider top and Side plates **B4** and **B5** on a length of flat bar, allowing for the width of the saw cuts. Centre punch and drill holes (**B4** 16mm, **B5** 12mm, Fig. 10). Countersink the outside of the holes on parts **B5**. Cut, position, clamp and weld these parts (Fig. 11a), inserting the Roller and Pin to assist in alignment. Position the Slider bars **B6** as shown in Fig. 11b and weld as indicated. Check that the assembly slides freely in between the Side plates **A2**. File the slider bars as necessary.

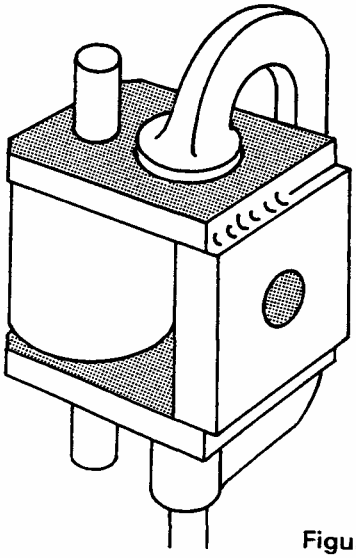


Figure 11a

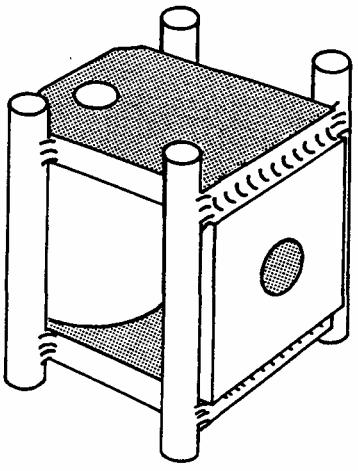


Figure 11b

Cut and drill the Adjusting wheel **B2**. This could be 'knurled' (i.e. have a gripping surface put on it) if the tools are available. Otherwise, round or 'V' shaped grooves can be filed into its surface (Fig. 12).

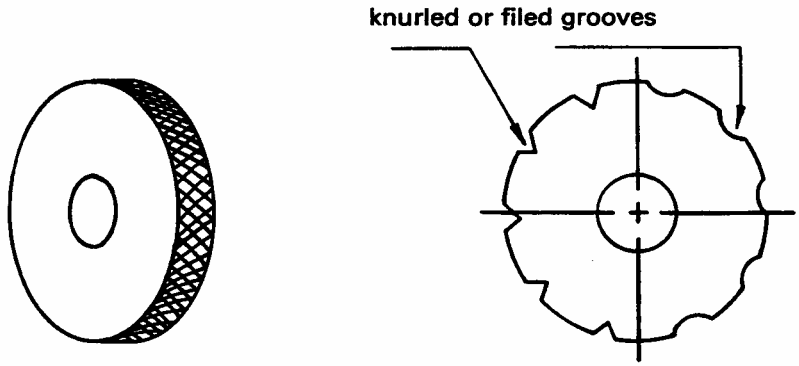


Figure 12

Position two M16 nuts **B9** and the Adjusting wheel **B2** on the Adjusting screw **B1** as shown in Fig. 13 and weld as indicated. Protect the threads from welding spatter.

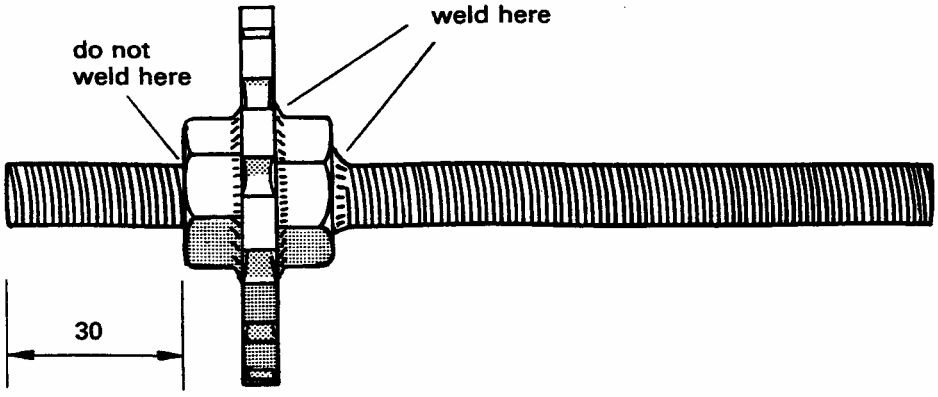


Figure 13

With a washer **B3** on each side of the Slider top plate **B4**, place the Adjusting screw **B1** through the hole and fit another M16 washer and nut. Leaving this nut slack, weld it to the end of the screw (Fig. 14).

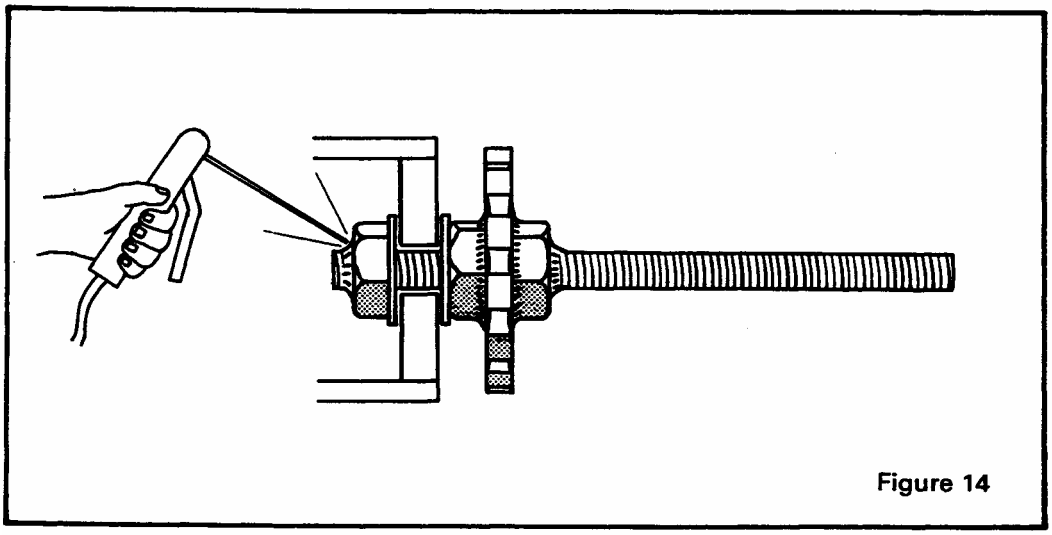


Figure 14

Cut the Roller pin **B8** to length. Chamfer the ends. Pass the pin through the Side plates **B5** and the Roller **B7**. Tack weld the pin to the sides as indicated (Fig. 15). This weld prevents the pin from rotating and ensures that the wear is taken on the largest surface. Grind the welds flat.

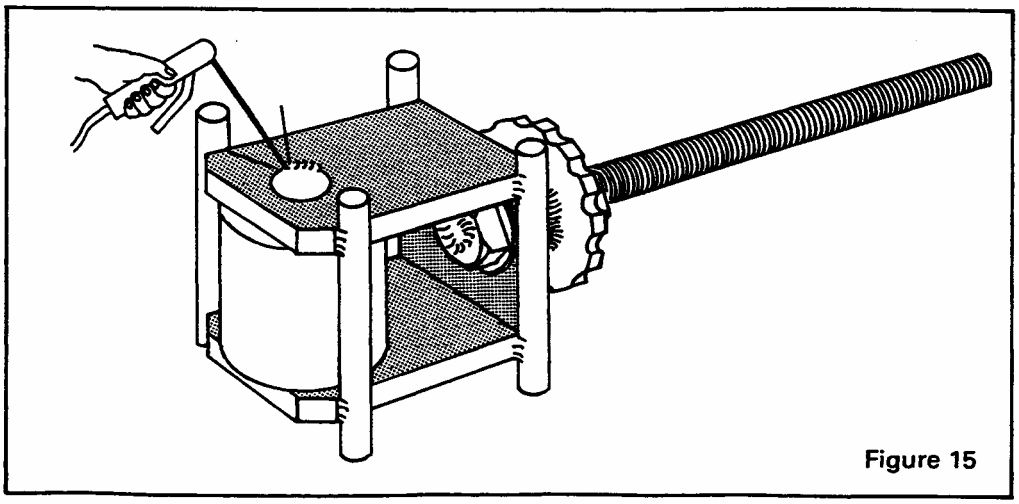


Figure 15

This assembly can now be slid in between the Handle side plates **A2**, and the screw **B1** can be screwed into the nuts previously welded into the Handle.

BRACKET ASSEMBLY — C
PARTS

Part	Name	Quantity	Dimensions (mm)
C1	Base angles	2	290 × 50 × 50 MS angle
C2	Handle location plates	2	195 × 40 × 12 MS flat
C3	Uprights	2	85 × 40 × 12 MS flat
C4	Angle ties	2	40 × 25 × 5 MS flat
C5	Pipe support plates	2	220 × 40 × 10 MS flat
C6	Pipe support	1	63 × 40 × 40 wood
C7	Support pin	1	115 × Ø12 MS bar
C8	Stop	1	20 × Ø5 MS bar
C9	Lifting bar	1	65 × Ø8 MS bar

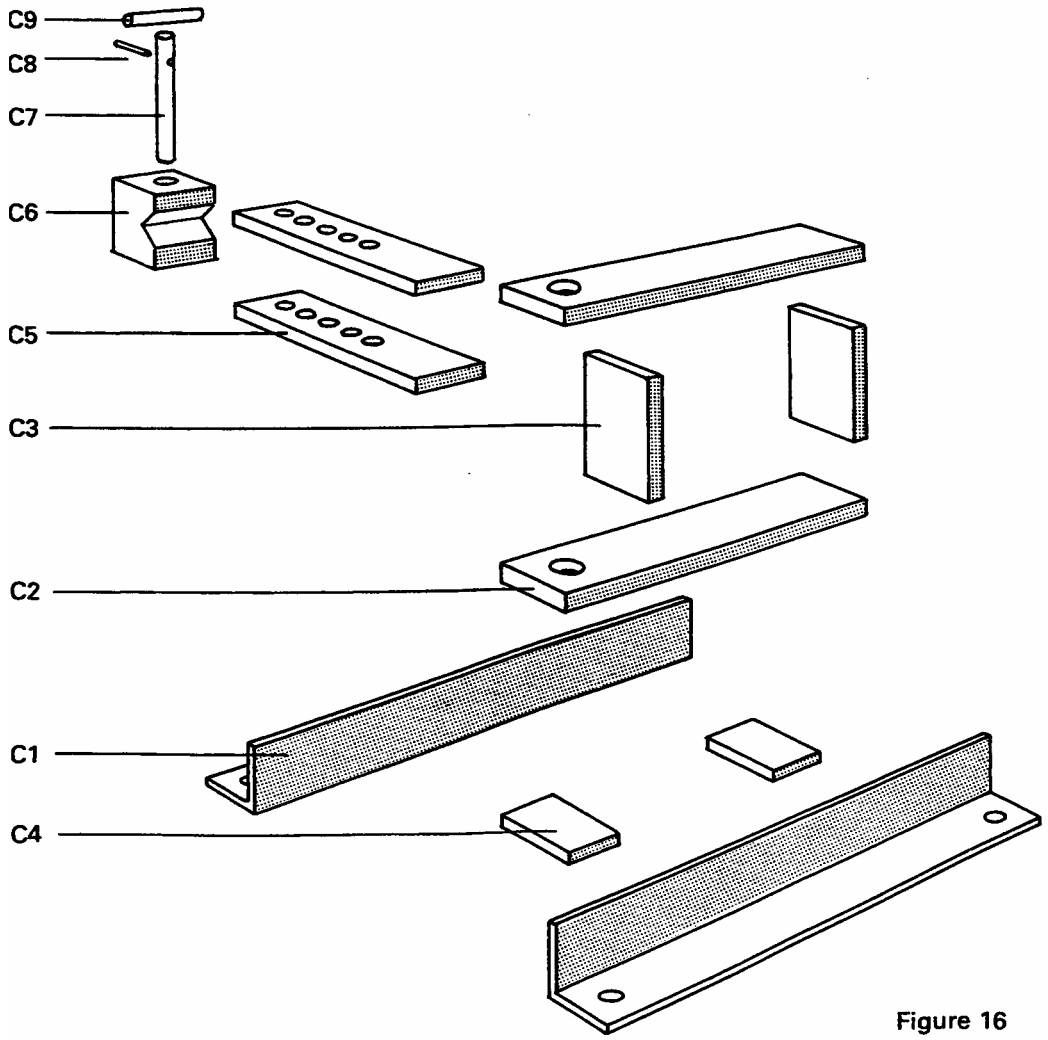


Figure 16

The two Base angles **C1** must be drilled (12mm dia.) to accommodate the bolting of the machine to a rigid bench with M12 nuts and bolts (Fig. 17a). Drill and countersink the Location plates **C2** (Fig. 17b).

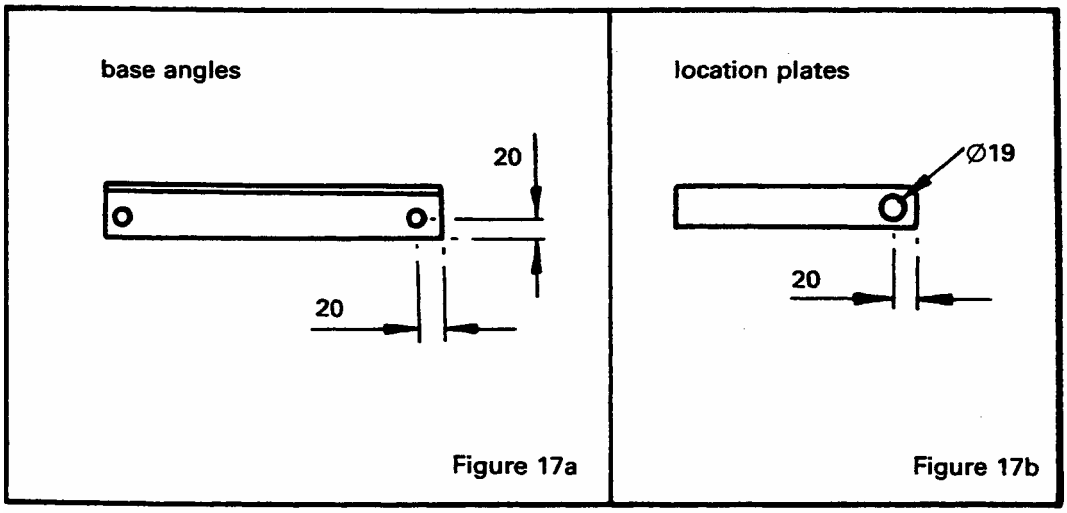


Figure 17a

Figure 17b

Using a 19mm (¾ inch) dia. pipe or bar, line up the Location plates **C2** and clamp these together with the Uprights **C3** (Fig. 18). Check for right angles. Weld as indicated.

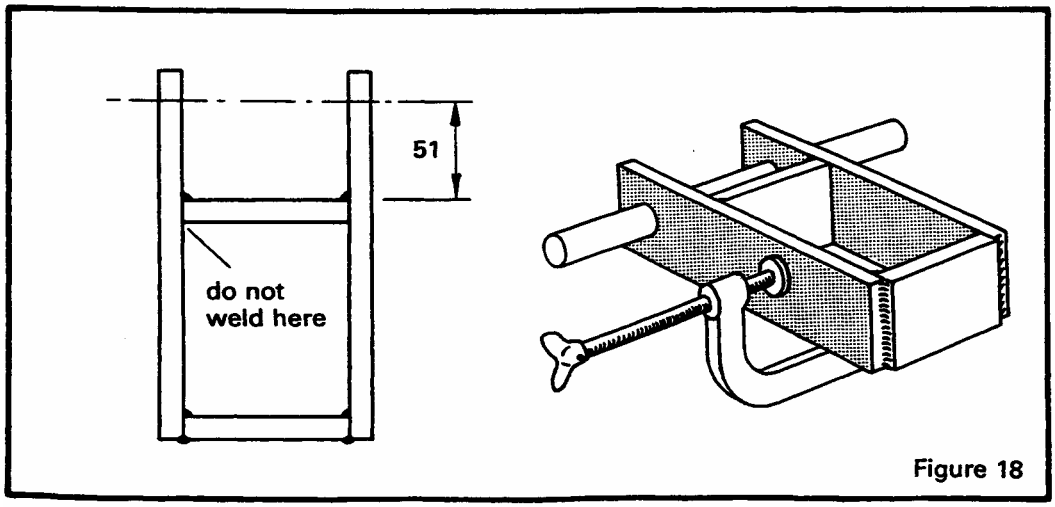


Figure 18

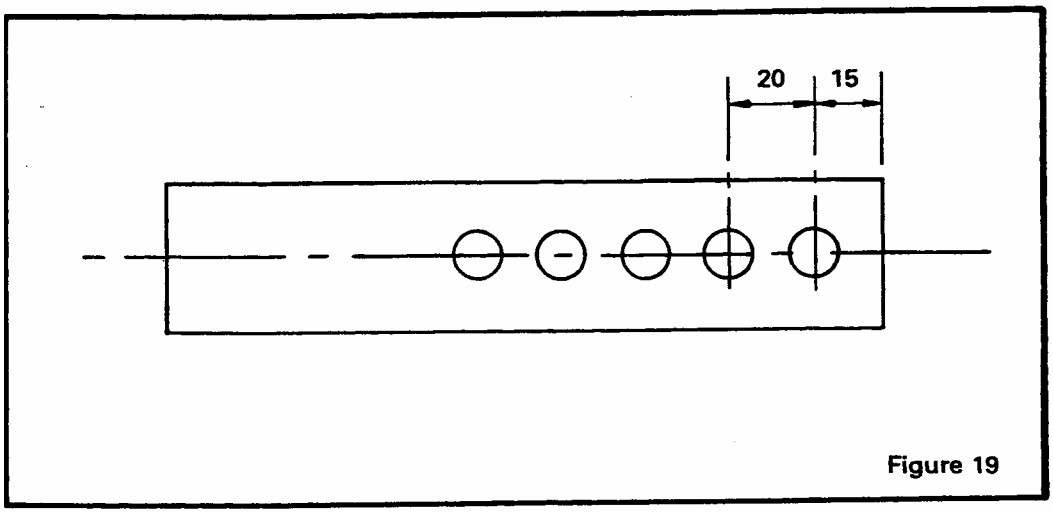


Figure 19

Drill the Pipe support plates **C5** (12mm dia.) in the five positions shown in Fig. 19 and weld the plates in place, as shown in Fig. 20. Clamp the Base angles **C1** to a flat surface with the fabricated Bracket assembly between (Fig. 20). Use some packing of approximately 45mm under the Bracket. Clamp and weld the assembly. Position the Angle ties **C4** and weld as shown in Fig. 21. Do not obstruct the lower pivot hole.

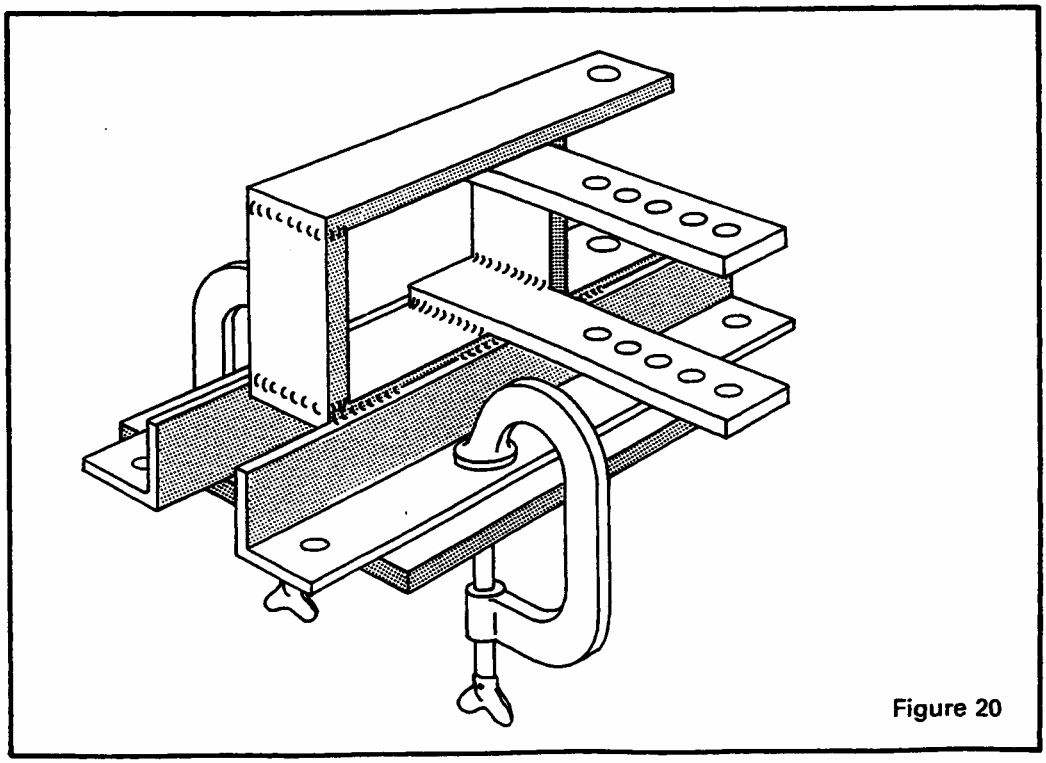


Figure 20

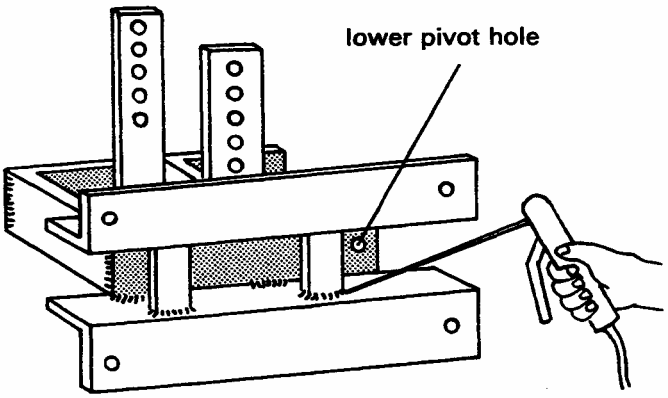


Figure 21

Cut and drill the wooden block Pipe support **C6** with the grain in the direction shown. Cut a 'V' centrally in one side (Fig. 22).

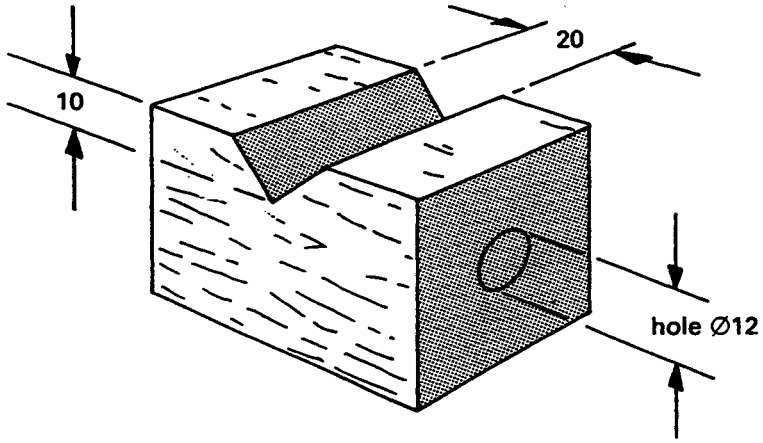


Figure 22

Drill the Support pin **C7**, insert the Stop **C8** and tack weld in place. Weld the Lifting bar **C9** on top of the pin (Fig. 23).

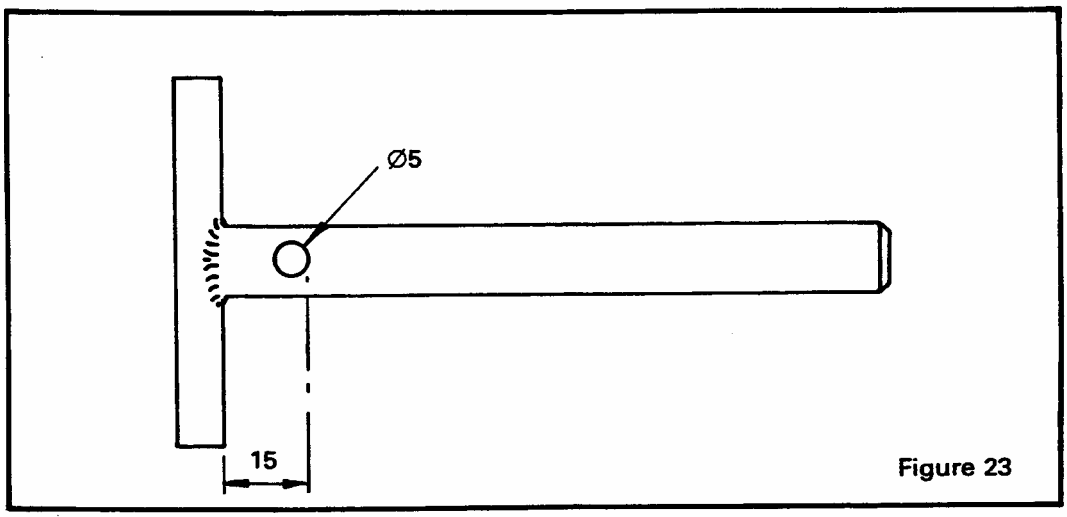


Figure 23

FORMER ASSEMBLY — D
PARTS

Part	Name	Quantity	Dimensions (mm)
D1	Side plates	2	[Ø190] × 5 MS plate
D2	Wooden former	1	[Ø180] × 20 hardwood
D3	Spacer	1	58 × Ø19 O.D., Ø15 I.D. MS pipe (conduit)
D4	Pipe guide	1	[220 × Ø19 I.D.] MS pipe or 20 × 20 × 5 angle iron
D5	Guide holder	1	[220 × 20] MS RHS (or angle iron & flat strip)
D6	Bolts	5	M8 bolts
D7	Nuts	5	M8 nuts
D8	Handle pivot pin	1	140 × Ø15 MS bar
D9	Stop	1	25 × Ø5 MS bar
D10	Lifting bar	1	65 × Ø8 MS bar

The above sizes marked [ ] are to bend 20mm dia. pipe to an inside radius of 90mm. Different sizes of formers and guides will be necessary for different diameters of pipe to be bent, and for the different radii to which you may require the pipe to be bent. See the Formers section on page 22 for a table of the dimensions of Formers for various sizes of pipe and bend radii.

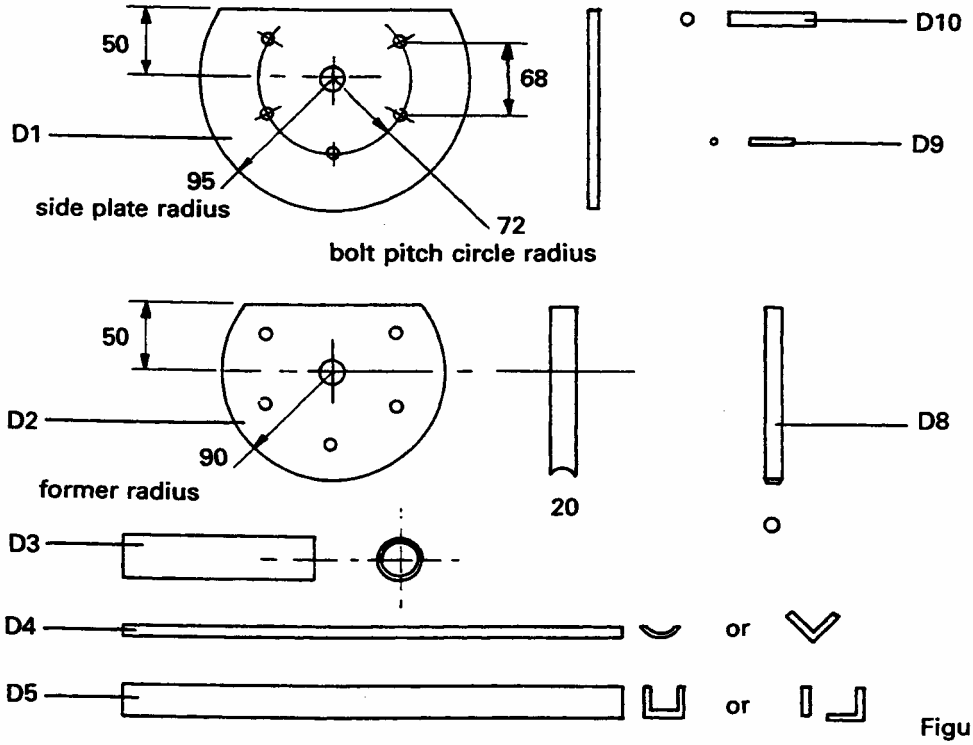


Figure 24

Cut out the Side plates **D1** from steel plate not less than 4mm thick. These must be strong enough to resist the considerable pressure exerted on them as the pipe is bent (the pipe tends to flatten and expand sideways). The function of the Side plates is to resist this expansion. Grind or file a slight angle on the inside faces of the Side plates for 5mm, as indicated in Fig. 25b. Drill the central hole and bolt holes as shown in Fig. 24. Cut out the wooden Former **D2**. This is best turned on a lathe and the groove made to match the sides of the pipe to be bent (Fig. 25a).

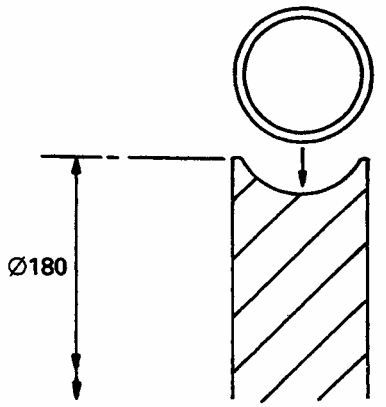


Figure 25a

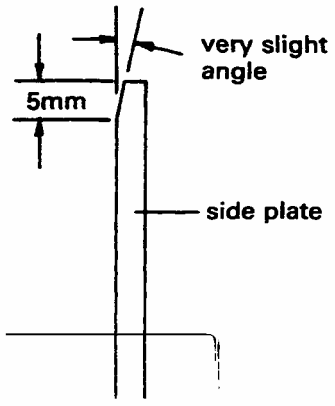


Figure 25b

If a lathe is not available, a drilling machine can be used. First cut the Former out roughly and drill the central hole. Mount this on a bolt with two washers and a nut. Mount the bolt in the drill chuck, improvise a tool rest and cut the groove with a chisel (Fig. 26).

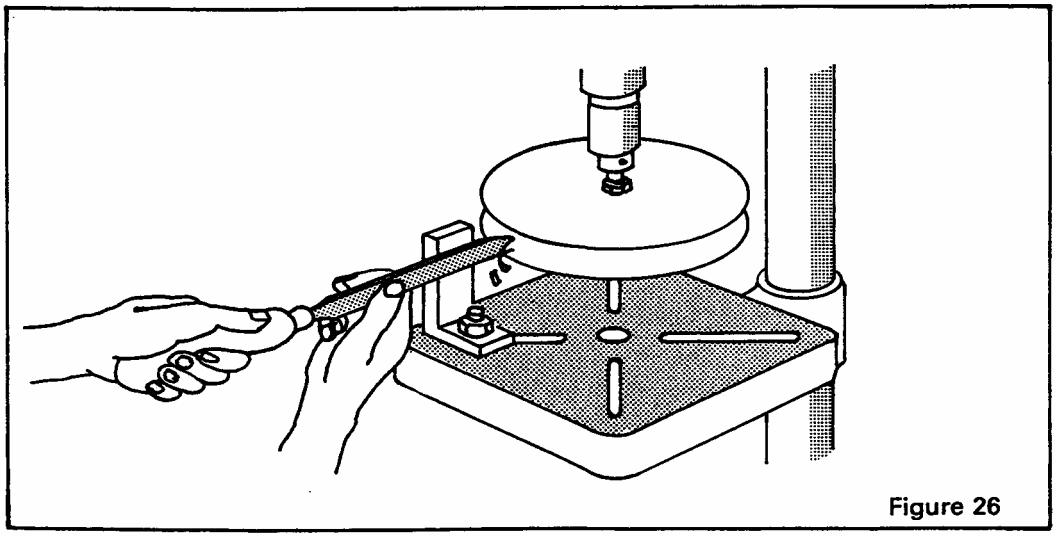


Figure 26

Clamp one Side plate to the wooden Former. Line up the centre holes. Drill through the bolt holes. Bolt on both Side plates using the M8 bolts **D6** and nuts **D7**. Spacer **D3** should be pushed through the Former with an equal amount protruding on each side. Tack weld **D3** to one Side plate (**D1**) only (Fig. 27).

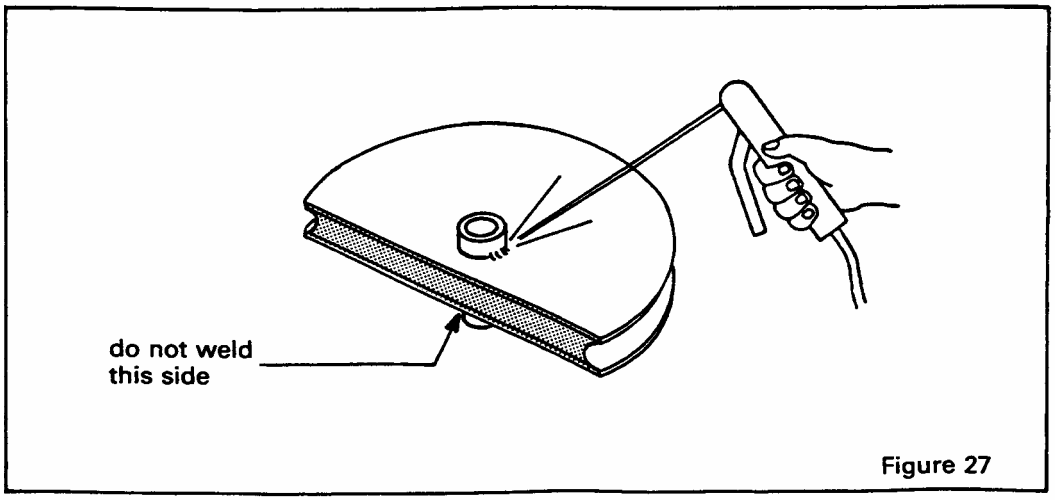


Figure 27

FORMERS

The following table gives dimensions for four common sizes of pipe. The radii of formers given are the smallest possible for each pipe size, for thin (1.5mm) walled pipe.

Pipe outside diameter, mm	Former radius (before being grooved), mm	Side plate radius, mm	Bolt pitch circle radius, mm
12.5	65	70	52
20	90	95	72
25	115	120	94

(See Fig. 24).

Thicker walled pipe can be bent to a slightly smaller radius. Formers of larger radius could be made for any size of pipe as required. Corresponding side plates would also need to be made large enough to fully include the diameter of the pipe. The centres of the holes for bolts **D6** should be 8mm in from the smallest radius of the wooden former.

A MORE DURABLE FORMER

If suitable hardwood is not available, or a more durable steel-lined former is required, proceed as follows: make the wooden former thicker by 3mm and turn it down an extra 1.5mm on the radius. Take a piece of steel pipe (1.5mm wall thickness) of the same length as the working circumference of the former, and approximately 3mm larger in diameter than the size of pipe required to be bent. Cut this pipe lengthways just slightly to one side of centre (Fig. 28a). Place the larger piece against a piece of pipe of the same size as the pipe to be bent and, trapping the cut piece against the wooden former, bend both pieces at the same time (Fig. 28b).

Remove the bent 'whole' pipe, leaving the cut piece in the former. Tack weld the cut piece to the side plates. Weld completely along both edges and grind the welds smooth (Figs. 29a and 29b).

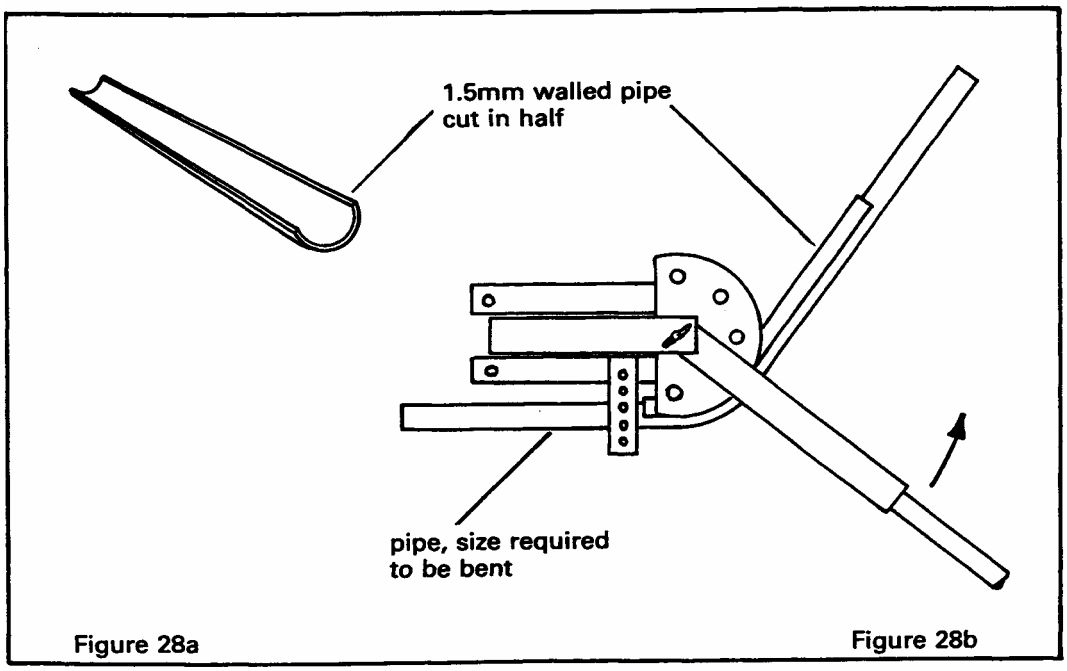
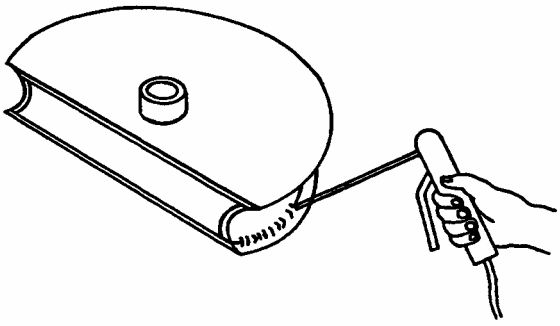


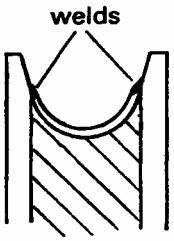
Figure 28a

Figure 28b



welding in the cut
pipe steel liner

Figure 29a



cross-section of
former showing pipe
liner welded in place

Figure 29b

The Pipe guide **D4** is made from a piece of pipe with an inside diameter of the same dimension as the outside diameter of the pipe to be bent. The pipe from which the Pipe guide will be made is cut to one side of its centreline and the smaller piece is used (Fig. 30). The Guide holder **D5** is made by removing one side of a square hollow section with a hacksaw or by welding a piece of angle iron to a piece of flat strip. Place the Pipe guide **D4** into the Guide holder **D5**. Tack weld and then complete the welds full length (Fig. 30). Note that the complete guide and Holder **must** fit between the Side plates, so it should be no wider than the pipe to be bent. Grind off any surplus weld and the edges of **D4**.

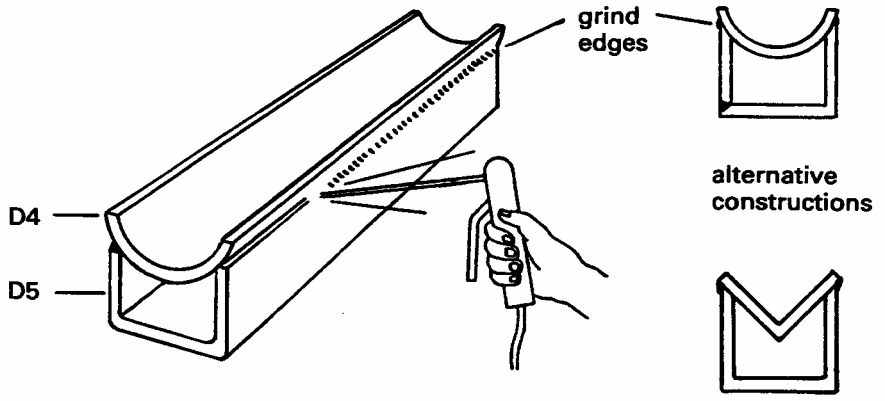


Figure 30

Assembly

The Handle assembly — **A** (now containing the Slider assembly — **B**), and the Bracket assembly — **C** are joined by the Handle restraint bushes **A5**. Rest the Handle in position and press one bush into the top holes and one bush into the bottom holes, with a washer **A6** in between each of the two moving surfaces.

The bushes **A5** should be flush with the inside faces of the Side plates **A2** and should protrude from the outer faces of Handle location plates **C2**. Tack weld the bushes to the Handle location plates (Fig. 31).

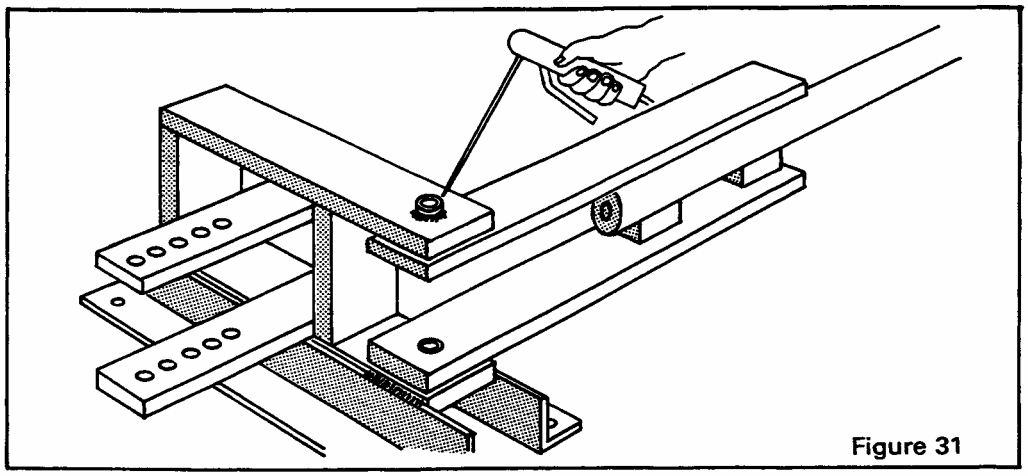


Figure 31

Cut and drill the Pivot pin **D8**. Chamfer the ends. Insert the Stop **D9** and tack weld in place. Weld on the Lifting bar **D10** (Fig. 23).

Mounting

Bolt the pipe bender securely to the top of a strong bench or stand. Figure 32 shows a suggested arrangement for mounting to a bench, which should preferably be in the middle of the workshop and bolted to the floor.

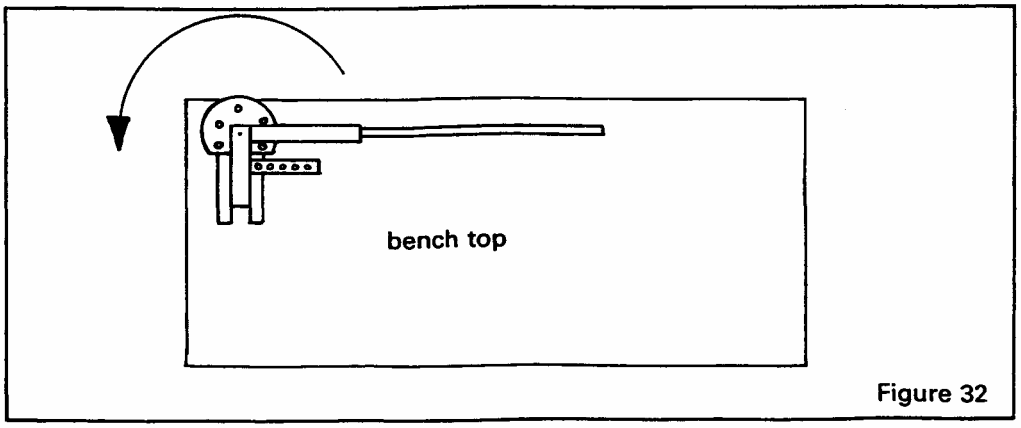


Figure 32

Operation

Select the appropriate Former/Guide combination for the pipe that is going to be bent. Locate the Former between the Handle side plates and pass the Pivot pin through to locate it. Position the wooden Pipe support with its pin, and with the Handle in the position shown, pass the pipe to be bent through the Handle and the Pipe support (Fig. 33).

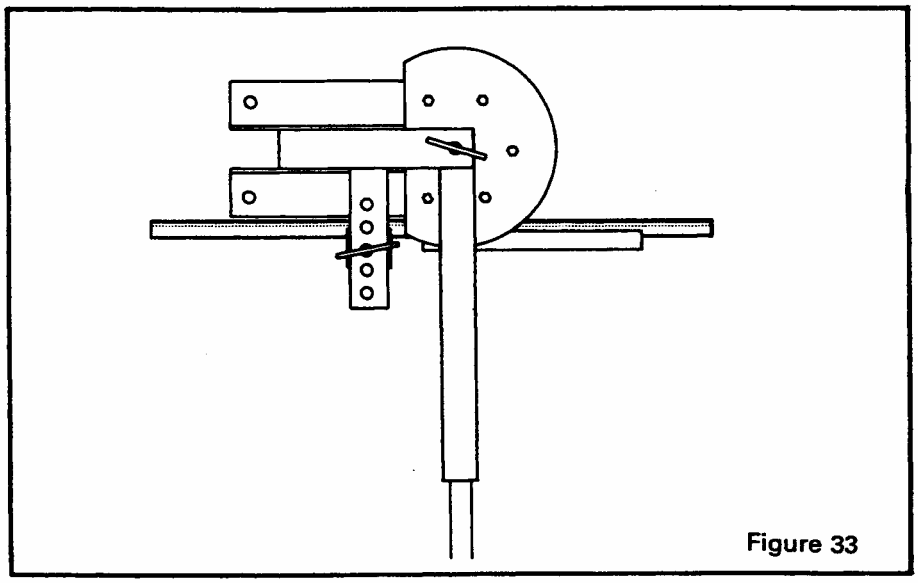


Figure 33

Position the Pipe guide with most of it along that part of the pipe where the bend will be. Screw out the Adjusting wheel until the Roller makes contact with the Guide, and the pipe is in contact with the wood Former. Pull the Handle round until the required amount of bend is achieved (Fig. 34). The pipe will expand slightly in width and may need to be knocked free of the former with a hammer.

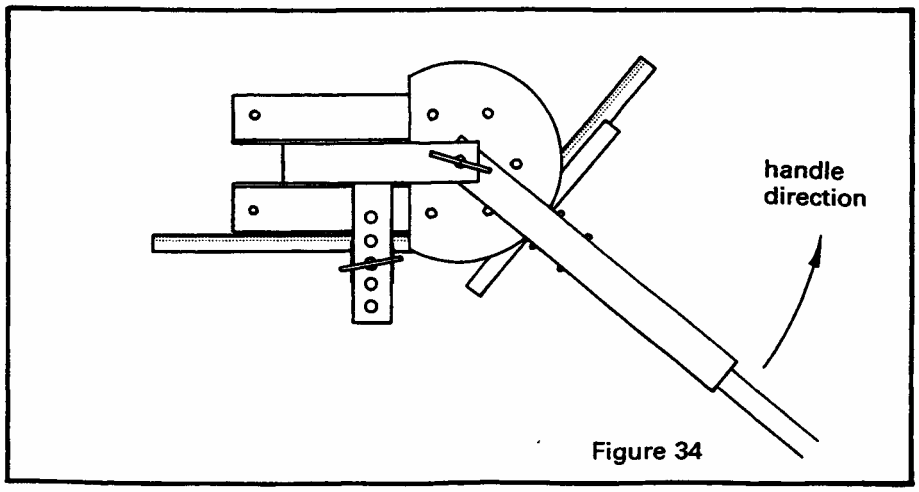


Figure 34