THE VACUUM

This is easily dealt with by means of adapting one of the many small pumps associated with milking machinery, refrigeration or air conditioning. Many of these pump designs have a built-in motor of their own, or the pump can be driven mechanically without electricity. I used a secondhand vacuum pump from a milking machine with great success, driving it by a separate motor. To monitor the vacuum, a vacuum gauge is needed, and this is shown mounted on the cover of the vacuum chamber in Fig. 7.4B, and by the side of it the take-off pipe leads to the pump. A barrel nipple of ½ in (13 mm) pipe is screwed in or welded to the lid of the chamber and the link with the pump is made with a length of heavy ½ in (13 mm) plastic tubing. Steel pipe all the way can also be used.

It is important to place the gauge and the take-off pipe at the top of the chamber, as one of the problems with vacuum pug mills is the bank-up of shredded clay in the vacuum chamber. This tendency is minimised by having the slotted breather plate to allow the vacuum access to the shredded clay, while limiting its freedom to pile up. Some clay will inevitably get past the slot, and periodic cleaning out is necessary.

The tendency for shredded clay to pile up is hindered somewhat by the 28° pitch of the blades, and greater traverse for the helix in the exit half of the pug, and the 25° angle and only a 3 in (75 mm) traverse for the helix in the first half. This differential serves to slow down the entry of clay into the vacuum chamber in relation to its discharge speed from the mouth.

SHREDDING THE CLAY

Shredding the clay is achieved by means of the angle iron frame shown in Fig. 7.14G. This frame is seen from the vacuum chamber side, and the stainless steel mesh is spot-welded to the far side. It is made in two halves, which come together leaving a hole in the centre the sides of which come close to, but do not touch, the shaft. In Fig. 7.4B it will be noticed that neither blade nor helix is visible in the open cavity for the screens when the shaft is in position.

Caution is advised when welding on the helices and blades that this bare piece of shaft is left in the correct place. In Figs 7.14F and G, four small shaded areas are shown. These represent two 3 in (75 mm) lengths of ⅝ in (16 mm) square-stock welded on the one half in G only, and their function is to facilitate the extraction of the two frames. They have to be taken out periodically to clean the screens and, of course, they have to be removed first if it is desired to remove the shaft from the machine. It will be appreciated that the clay approaches the screens under pressure and therefore every crevice is filled, and the screens become quite difficult to move. However, the area occupied by the pieces of square-stock remain more or less free of clay and with a rod one can reach in to touch them.

My practice was to have a piece of ½ in (13 mm) × ½ in (13 mm) square rod about 10 in (250 mm) long, push it in from the left top side, see Fig. 7.14G, tap it fairly hard with a 2 lb (1 kg) hammer, and then repeat the operation pushing the rod in at the bottom. A few repeats of this will cause the vertical angle iron frame to emerge, and then one can get a box opener tip behind the frame and lever the unit out.

When one side has been removed it is easy to do the same with the other half but this time hammering against the angle iron frame. The welding on of the 3 in (75 mm) pieces was done simply to have something to hammer against to get the first half out.

CUTTING-OFF TABLE

Fig. 7.15A illustrates a side view of a cutting-off table hanging on the two central bolts which hold the mouth cone to the pug mill. They are on the same level as the table but located much further apart than the width of the table, hence the tapered extensions to the table shown in Fig. 7.15B. The level obviously has to be a fraction lower than the bottom of the mouth cone, and much lower than the two bolts from which the table hangs (see Fig. 7.15C), hence the two little vertical pieces of angle iron coming down to a level which is, in fact, at least 1 in (25 mm) below the bottom of the table. The two tapering extensions are fixed to the ends of the two verticals with a single bolt on each side, which makes it possible for the table to hang out of the way in a vertical position when not in use. When in use it is supported by a moveable leg at the far end. The table is a bolted frame consisting of four lengths of 1¼ in (31 mm) angle iron, which is welded to the two tapering extensions.

Note that the two cross-members of the frame are arranged with their top horizontal faces away from the pug. Arranged thus, the cross-member at the end offers a place for the supporting leg, which prevents it from touching the travelling cloth sleeve on the rollers. The flat face, at the end near the cone, is needed so that the cutting wire frame, shown in Fig. 7.15D, can pivot on a bolt attached to it. The cloth sleeve is just like a roller towel wrapped round fifteen rollers. It does not have to fit at all exactly as surplus length can hang below and causes no trouble. The sleeve should be made of close textured cotton, preferably with the dressing well washed out of it and given a hem all round both edges. This kind of cutting-off table was once used for receiving extruded drainpipes.

Fig. 7.14 Blade angles and vacuum chamber details

A Two aspects of a blade, and the direction of rotation showing how the cutting edge of the blade is bevelled

B The composite version of the unit j in Fig. 7.2A and sectional view of the lid s; the frame made up from the four pieces of angle iron r with a rubber seal between it and the lid. The breather plate seen in C is also shown in section

C The breather plate in perspective

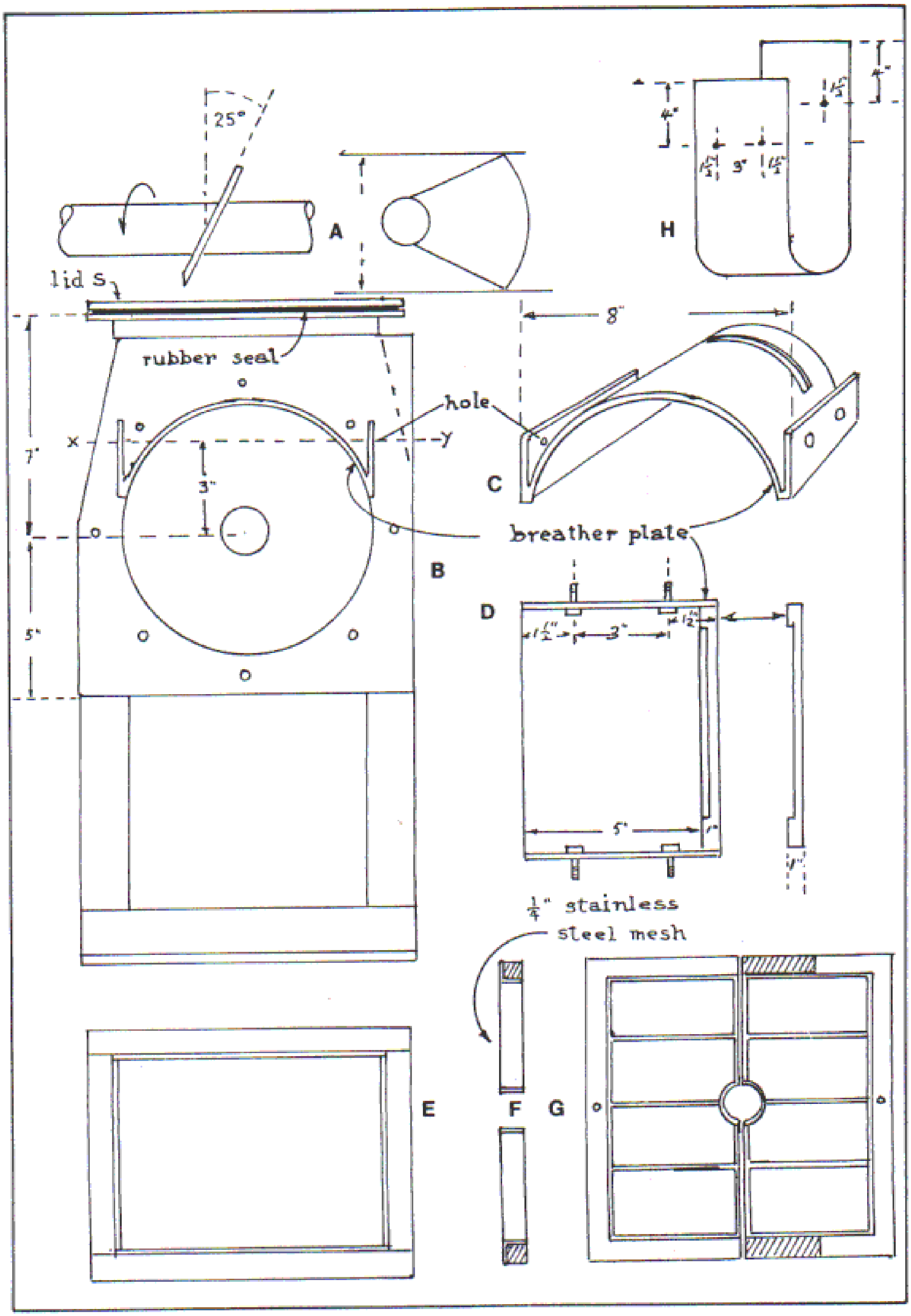
D The breather plate in plan

E The rim of the vacuum chamber made up from the four pieces of angle iron marked r in Fig. 7.2A

F A sectional view of the shredding screen

G The pair of shredding screens viewed from the discharge side

H Details of unit i in Fig. 7.2A



25°
A
H
lid s
rubber seal
hole
x
y
C
breather plate
B
D
¼" stainless
steel mesh
E
F
G

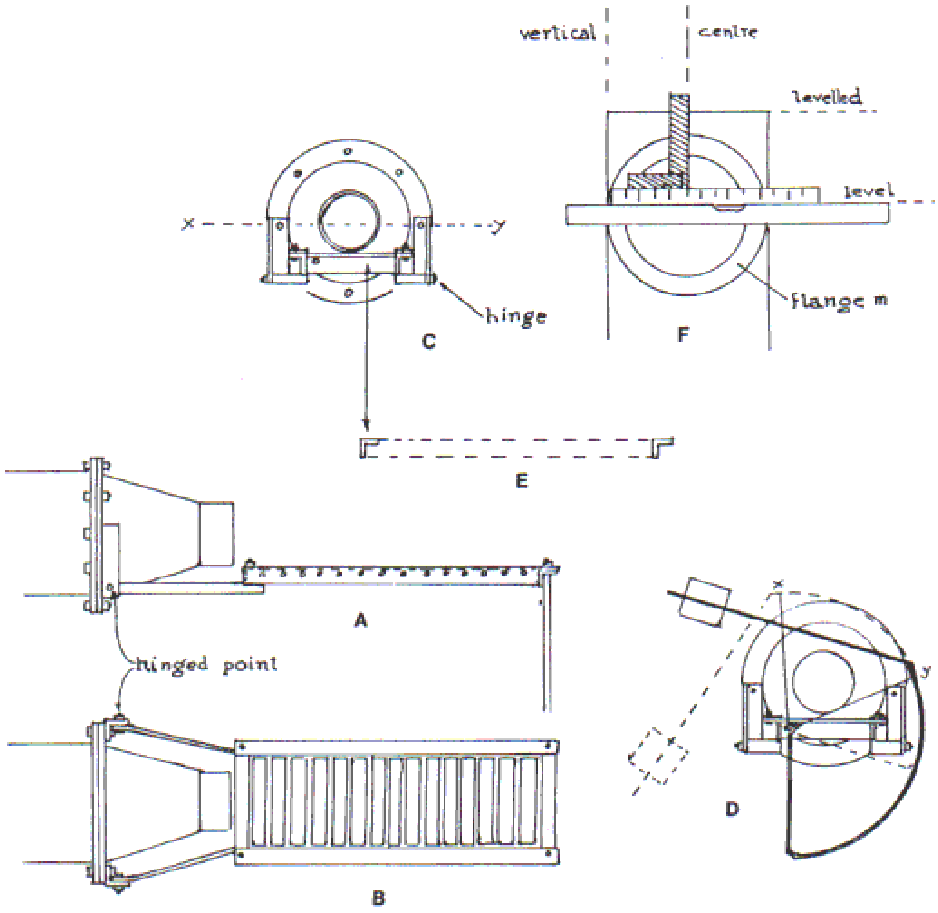


Fig. 7.15 A cutting-off table

A *A side elevation of the mouth of the pug mill and the cutting-off table. The hinge permits the table to hang vertically when a moveable leg is removed*

B *The table in plan*

C *A front view of the mouth of the pug with the cutting-off table fixed to two of its bolts, and showing the cross-member from which the frame and cutting wire pivots back and forth*

D *The cutting wire in the y position is clear of the clay column on the right. When the wire is at the left in the x position, the frame and weight assume the position shown by the dotted lines. The weight must be such that it balances the weight of the frame, more or less, so that the wire stays whichever side it happens to be*

E *The angle irons of the cross-member are oriented away from the pug. This allows the wire to pass between the table and the pug*

F *Making the scratched line for the centre hole on flange m*

The main function of the cutting-off table is to facilitate the subsequent cutting of the clay column into standard lengths, which eliminates the weighing of lumps of uniform size for throwing. This is very much faster and quite proof against the inclusion of air pockets, so prone to happen in the weighing out process. The single cutting-off wire at the mouth of the pug severs long pieces of the column, which are then cut to size on a separate and adjustable cutting frame located on a bench close by.

Fig. 7.15D shows how the single cutting-off wire is attached to the table at the mouth cone end. The pivoting point is placed at one side, so that the wire can pass clear of the clay column and be held there by reason of the counterweight above. This position is fixed because the loop which carries the wire will act as a stop when it touches the tapered extension in either position. The loop frame is made of a length of ⅜ in (9 mm) rod about 30 in (750 mm) long, and the weight can be any weight that will keep the wire on the left-hand side until pushed across.

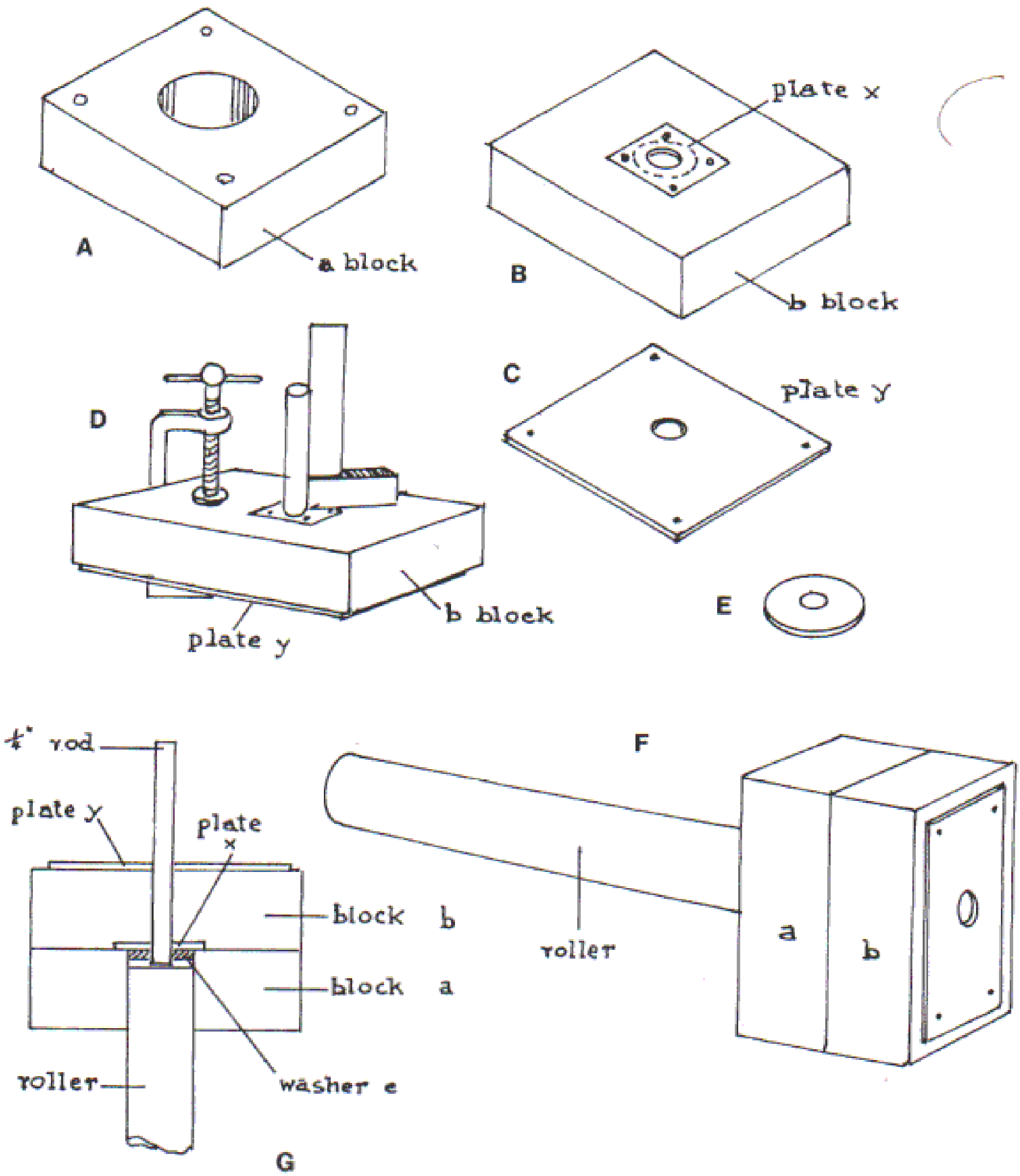
The rollers can be made of broom handle or dowelling from 1 in (25 mm) to 1¼ in (31 mm). The tricky part is getting the axle pins of say ¼ in (6 mm) steel rod and about 1¼ in (31 mm) long centred properly at each end of the roller. This would be a simple matter given a lathe, but we assume here that there is none available.

Fig. 7.16 explains, in six sketches, a very simple way to make a jig that will enable one to drill holes accurately in the end centre of a wooden cylinder — the roller. Fig. 7.16A shows a block of wood with a central hole drilled to fit the roller tightly. For this the adjustable wood drill shown in Part II, chapter 17, Fig. 17.1. should be used. The size of the block is unimportant; only the thickness matters, and that should be at least 1 in (25 mm) thick, but 1¼ in (31 mm) or 1½ in (38 mm) would be better. It must be very carefully marked, preferably from both sides, and the hole should be drilled from both sides to ensure a perfectly vertical entry. It need only be perfectly vertical in relation to one face, and that should be checked with a square while a roller is forced in the hole. Error can be corrected by planing the block. If not successful, the hole can be drilled again or another block used. The face used in checking for verticality is the one that must be made to contact the block, shown in Fig. 7.16B, when they are joined together later. Block *a* also has four holes in the corners, which will be used to join it to block *b*.

Fig. 7.16B shows this second block, which is roughly the same size as the first. It has a hole about ½ in (13 mm) in diameter drilled through its centre, indicated by the dotted ellipse. Exact verticality of this hole is not important. It is covered by plate *x* made of an oddment of steel in $\frac{1}{16}$ in (1.5 mm) or ⅛ in (3 mm) plate and has a ¼ in (6 mm) central hole (the size of the intended axle pins). The block has a shallow recess chiselled out to take plate *x* which must not protrude above the face of the block. The plate is nailed in the recess as indicated by the four dots. Note that the plate is much larger than the ½ in (13 mm) hole which was drilled through the wood.

Fig. 7.16C shows a steel plate *y*, roughly the same size as block *a*. Exactness is not important. It must be flat, have a ¼ in (6 mm) central hole and four nail holes in the corners. Its thickness is the same as plate *x* but not less than $\frac{1}{16}$ in (1.5 mm); thicker is better. At this point a perfectly straight ¼ in (6 mm) rod or bolt is pushed through the hole in plate *y*, and up through plate *x*, which is already fixed in block *b* (see Fig. 7.16D). Plate *y* is jiggled around inside the ½ in (13 mm) hole in the block of wood until the ¼ in (6 mm) rod sticking out of the top is perfectly vertical. This is done by checking with a square as shown in Fig. 7.16D and the ½ in (13 mm) hole in the wood permits the necessary adjustment to plate *y* for this. When verticality is perfect the plate is clipped to the underside of block *b* with a G-clamp as shown in Fig. 7.16D (two clamps would be better), and plate *y* is nailed to block *b*.

Fig. 7.16E shows a washer which can be made of hardboard or metal (metal is better because the washer must be accurate). It has a ¼ in (6 mm) central hole and its outside diameter must fit nicely inside block *a*, i.e., the same diameter as the



rollers. To cut such a washer the internal hole and the external diameter must be marked on the plate (or hardboard) with a pair of steel dividers using the same centre mark made with a sharp centre punch. Then the centre mark can be accentuated with the punch and a ¼ in (6 mm) hole drilled. The outside diameter must be cut with a hacksaw and then filed exactly to size. Finally, this washer is dropped over the ¼ in (6 mm) rod shown sticking up in Fig. 7.16D, and placed to rest on plate *x*. Then block *a* is lowered onto it so that the washer enters the block, which makes firm contact with the block beneath it. These are then clamped together, perhaps using two clamps, and the upper block is screwed to the lower one. Remove the washer by turning the blocks upside down or loosening the screws, and the jig is now ready to use. This is seen in Figs 7.16F and G with a roller inserted into block *a*. The roller is now ready to receive a ¼ in (6 mm) hole drilled via the holes in plates *x* and *y*, which are now in alignment with the axis of the roller. A steel drill bit should be used (not a wood drill) and the jig should be held in a vice. The ¼ in (6 mm) axle pins can then be glued into the holes.

Cutting-off frame: Fig. 7.17A shows the cutting frame used in conjunction with the cutting-off table. It is provided with seven high tensile steel wires (piano wire) which yield six units per cut. Two columns of clay placed side by side can be cut in one stroke. The wires are attached to shaft collars which slide along two ¾ in (19 mm) rods. Each collar has a shallow saw cut in it leading to the setscrew which ensures that the wire remains in the correct setting. Extended setscrews are needed so that the wire is looped round them and at the same time they have to be provided with a wing nut head for easy setting.

Fig. 7.16 A jig for drilling ¼ in (6 mm) holes for axle pins in the rollers

A *The hole in block a is carefully cut at right angles to the two faces of the block. This hole is the same diameter as the rollers*

B *Plate x has a ¼ in (6 mm) central hole and is sunk into the face of the block with its upper face flush with the block. Under the plate a hole about ¾ in (19 mm) in diameter is drilled right through the block and the dotted ellipse indicates this*

C *Plate y also has a ¼ in (6 mm) central hole and four screw holes*

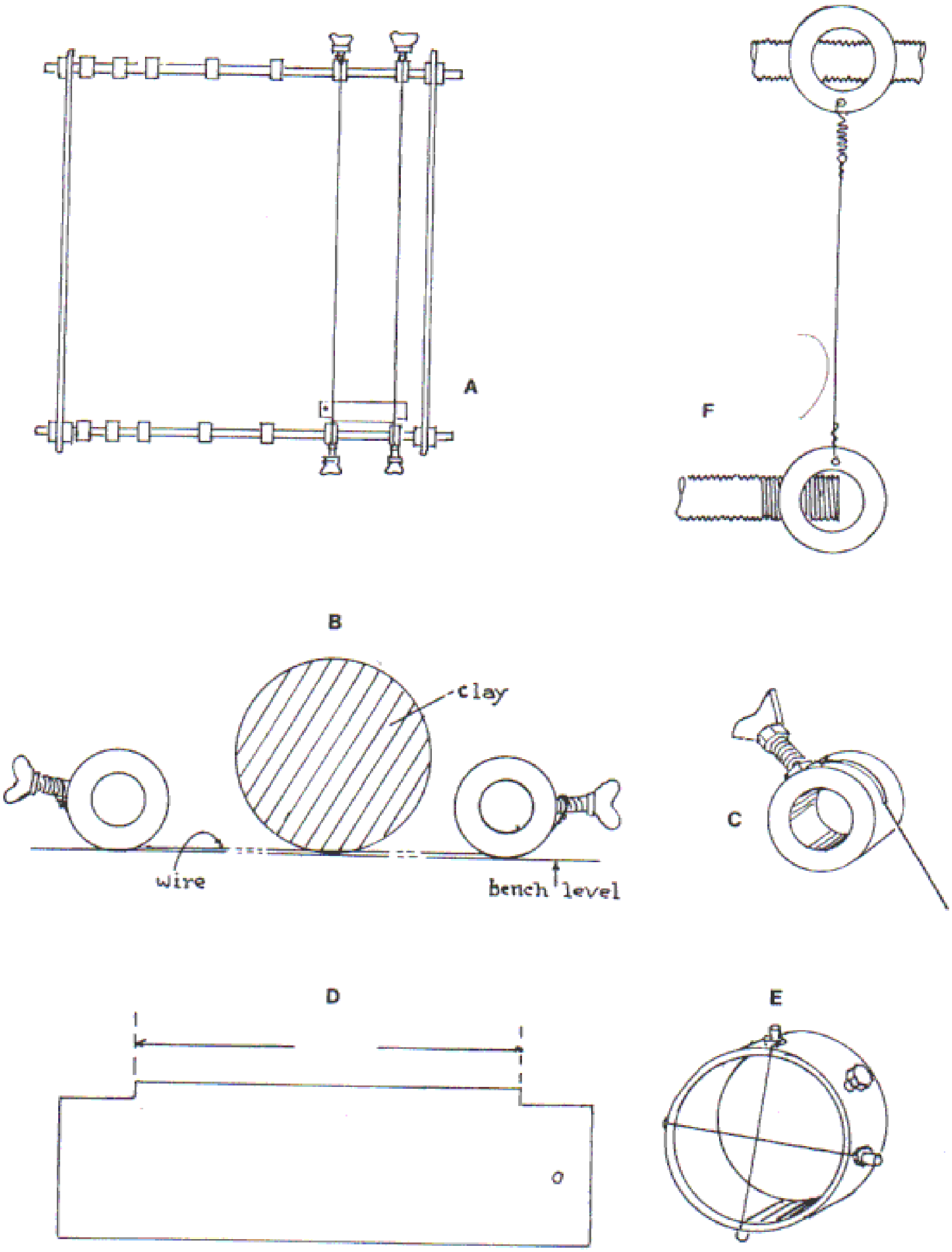
D *Positioning plate y under block b*

E *A washer cut with outside diameter the same as the rollers and a ¼ in (6 mm) hole in its centre*

F *Block a is screwed to block b while the washer is inside block a with the ¼ in (6 mm) rod just entered in its central hole. A roller is pushed in to hold it there, and that gives the correct alignment for drilling the axle holes in the rollers*

G *A repeat of F seen in section. The washer is no longer needed and the axle pin holes are drilled by introducing the ¼ in (6 mm) drill bit exactly in the way the ¼ in (6 mm) rod is shown in this figure*

These heads can be made by welding a short piece of metal on the top of an ordinary bolt. The $\frac{3}{4}$ in (19 mm) rods are 25 in (625 mm) long and threaded at both ends. They are held apart by two 24 in (600 mm) lengths of $1\frac{1}{4}$ in (31 mm) × $\frac{3}{16}$ in (5 mm) flat-stock, drilled with holes 22 in (550 mm) centre to centre. The two rods have two nuts at each end, and these are tightened against each other on either side



of the pieces of flat-stock. This provides a rigid frame, the collars of course being threaded onto the rods first, as shown in Fig. 7.17A. Figs 7.17B and C show how the wires are let into the sides of the collars. Note that the setscrews in Fig. 7.17B are angled slightly above the horizontal which is necessary for two reasons. First, when in use, the frame is placed on a bench with the wire side down, resting on the collars with the wires almost touching the bench, and in this position the setscrews are out of the way. Second, when setting the wires, the setscrews function as levers to put tension on the wires, as well as a means of fixing them. Also, when in a more or less horizontal position, the wire must remain in the groove provided, and angled setscrews ensure this.

Fig. 7.17F shows an alternative design which was suggested to me by a potter in Australia. I have not tried it but it seems an excellent idea. Instead of the ¾ in (19 mm) rods and collars, threaded rods and washers are used. The hole in the washer is such that it can be moved along the rod at will, but when released a powerful little tension spring linked into the cutting wires holds the washers in whichever groove of the threaded rod they are placed. The spring, of course, must be under considerable tension when the wire is fixed to the second washer. It will be seen that the wire and the spring are attached by small holes drilled in the rim of the washer. This system would speed up the setting of the spacings between the wires.

Setting the wire spaces on the cutting frame is a matter of fixing the first wire parallel with the frame. Hold the template shown in Fig. 7.17D against the wire with a shoulder touching it, then move the second wire along until it touches the other shoulder, and fix it also. This is done with the template in the position shown in Fig. 7.17A, i.e., close to the two collars at the bottom of the frame and is then repeated with the template held between the two wires close to the two

Fig. 7.17 A cutting frame used instead of scales in preparing balls of clay for throwing

A *Plan of frame with one spacing template in place between two wires. The full quota is seven wires*

B *When in use, the wires are in contact with the bench top and the rolls of clay (two or three at a time) are laid on the wires. Then the frame is lifted*

C *A close-up of a wire let into a collar. When fixing the wire, the wing bolt is levered downwards as it is tightened*

D *A specimen spacing template. Dotted lines represent wires*

E *A short length of pipe with a setscrew to fix it to the mouth of a pug mill, and four screws welded on to attach the wires. Shallow hacksaw cuts position the wires for a quarter or a half division of the clay column. For larger lumps the unit is removed*

F *An alternative construction of the frame in A using threaded rods and washers in place of smooth rods and collars. Quicker setting of the spaces is possible with this* collars at the top. With the two shoulders on the template set 4¼ in (106 mm) apart the clay lumps (with a 4 in [100 mm] mouth cone) will be about 4 lbs (2 kg).

If the accessory shown in Fig. 7.17E is attached to the mouth of the pug mill, the column will be quartered and the lumps will weigh about 1 lb (500 g). Similarly, the same accessory can be provided with a single wire which will yield 2 lb (1 kg) lumps. This accessory is simply a ring which fits over the outside of the mouth of the pug mill and is held there with a setscrew positioned in a threaded hole in the ring. Where the wires cross the thickness of the ring they should be given a deep groove with a hacksaw blade so that they do not move out of the proper position even if the wires get a bit slack.

THE VERTICAL PUG MILL OR WAD MACHINE

The earliest pug mills were powered by a horse harnessed to a pole attached to the top of the blade shaft. The horse walked round and round and the pole passed over the heads of the people in the middle who were feeding the machine and removing the clay as it oozed out at the side at the bottom. At that stage of development such a unit would have had a rock, or a block of wood with a hole in it, placed in the bottom centre to function as a footstep bearing. This is what dictated the side delivery which remained a feature of pug mills for a very long time, especially in the pottery trade, and some are still with us. It was an unavoidable feature of the early horse-pug, but it was continued even after the machine had been laid on its side and powered by other means. This is surprising because the side delivery greatly reduced the efficiency and increased the amount of power needed to drive it.

Only when the desire for continuous extrusion of a clay column for pipe or brick making arose was an end bearing and side delivery seen to be unnecessary and expendable. The small vertical pug mill or wad machine was an obvious example of this. In the days when saggars were the accepted form of shelving in kilns it was necessary to use great quantities of spaghetti-like strips of clay placed between the saggars to ensure a perfect distribution of weight. These strips were called wads, and the wad machine was located near the kiln. The extruded wads dangled from the bottom of the machine, which was bolted to a wall or pillar several feet from the ground. This is the type of simple pug mill discussed below.

Although it has certain disadvantages, mentioned in the introduction to this chapter, one advantage is that it is small and, being attached to a wall, takes up very little floor space. From the point of view of anyone wanting to build a pug mill, its main advantage lies in the simple way in which two sets of reduction gears or pulleys can be arranged on either side of the supporting brackets. The fact that these gears or pulleys just hang over the edge means that a great range of sizes can be accommodated without any need to alter the structure. With the vertical delivery it is necessary to use a pair of bevel gears to make the transition from a horizontal drive to the vertical blade shaft, but this is the only place where spur wheels must be used. The rest can all be done with V-belts, but if a pair of 3:1, or 4:1 gears are available, these could be used as well.

A non-de-airing pug mill is quicker and much easier to build. No vacuum or