

# Light vertical MILLING MACHINE

Continued from June 15

by Edgar T. Westbury

## Now for the FEED GEAR

THE assembly of the quill feed gear is shown in side and rear elevations, sectioned on the centre line of the wormshaft bracket and pinion housing. Taking the main or coarse feed first, the pinion shaft is carried in a flanged bush at one end and a light steady bush at the other. The bushes are both turned to fit the bore of the housing. In normal circumstances they are bored concentrically, but sometimes eccentric bores may be required to adjust the meshing of the pinion with the rack, as will be explained later.

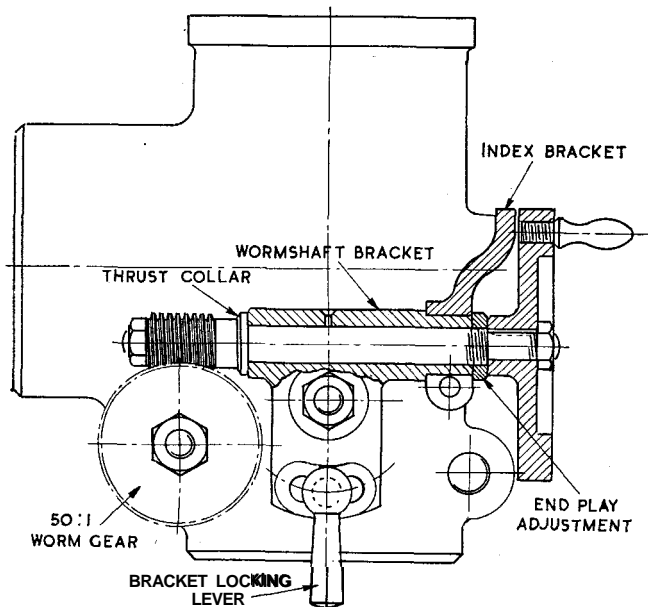
I regret that the centre location of the main feed shaft was incorrectly dimensioned on the detail drawing of the housing, especially as it is important that the bore in which the bearings of the pinion are fitted should be correctly located to set the pinion in proper mesh with the rack cut on the quill. But the error in the dimension is so obvious that no constructor will have been misled. The correct centre distance is given here in the scrap section showing the rack and pinion in engagement.

The pinion, which has a blank diameter of  $7/8$  in., may be made in bronze or cast iron. It has 20 teeth,  $1/8$ -in. circumferential pitch, with a tooth depth of 0.075 in. I have departed from diametral pitch standard, to simplify the pitch measurement of the rack, and to facilitate indexing on the worm-gearred fine feed control. Thus, one complete turn of the pinion represents  $2 \frac{1}{2}$  in. vertical travel on the quill; with the line feed shaft geared to 50:1 reduction, one complete turn of the worm gives  $2,500/50$ , or 50 thousandths of an inch movement. The wormshaft handwheel, graduated

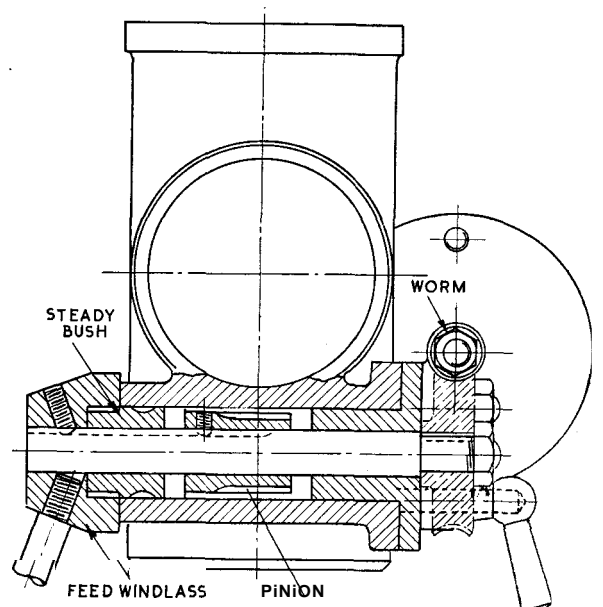
in 50 divisions, will therefore measure  $1/1,000$  in. increments.

The teeth of the pinion are not cut to the full length of the blank, but are run out about  $3/8$  from the end, the object being to leave sufficient thickness of metal for the tapped hole which takes the grub screw. There is no advantage in making the pinion teeth any longer, as they mesh with convex rack teeth and the area of contact is therefore very limited. The distance between the bushes of the pinion shaft allows the pinion to be adjusted endwise, so that if any wear of the teeth takes place it can be shifted to a fresh position. By cutting the teeth slightly on the taper you could also compensate any error in meshing, or take up backlash caused by wear.

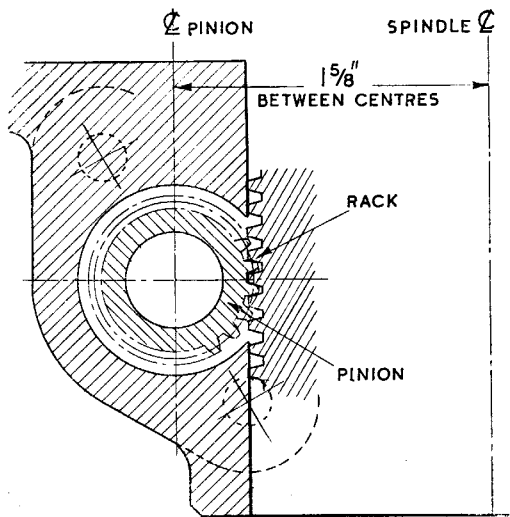
If you happen to have a pinion of the correct pitch and approximate dimensions, you may be able to adapt it for this purpose, though some alteration may be needed to the shaft centre position. The best way would be to fit eccentric bushes at both ends, to adjust the shaft position by rotating them as required, and then to lock them in position with grub screws. The object of the groove in the steady bush is to enable it to be held by a single grub screw in the housing, without risk of bruising the finished surface.



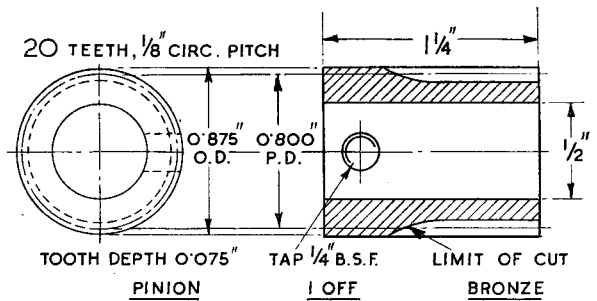
ARRANGEMENT OF FINE FEED GEARING



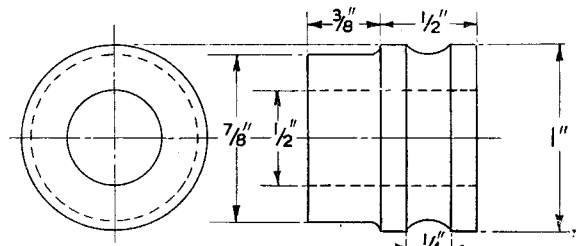
SECTION OF MAIN FEED GEAR FROM REAR SIDE OF HEAD



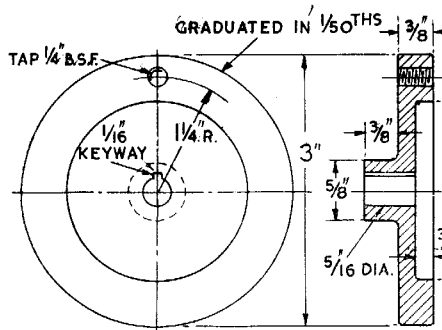
RACK AND PINION IN ENGAGEMENT



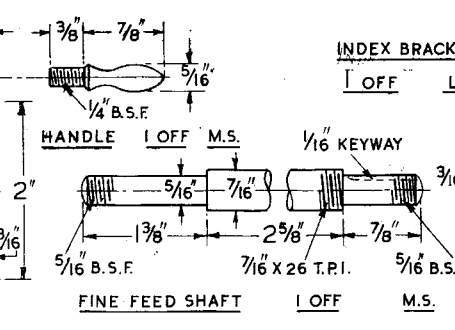
TOOTH DEPTH 0.075" TAP 1/4 B.S.F. LIMIT OF CUT  
PINION I OFF BRONZE



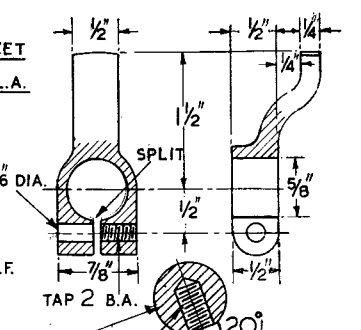
STEADY BUSH I OFF BRONZE



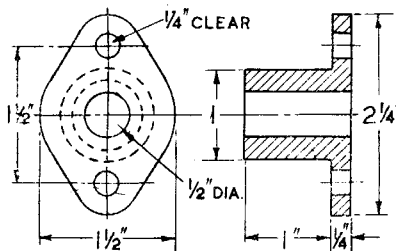
FINE FEED HANDWHEEL I OFF C.I.



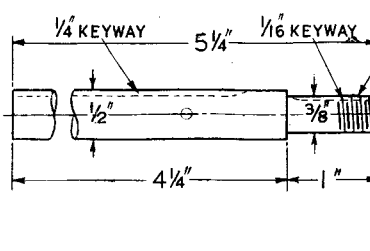
FINE FEED SHAFT I OFF M.S.



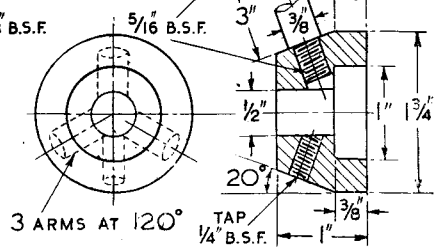
INDEX BRACKET I OFF L.A.



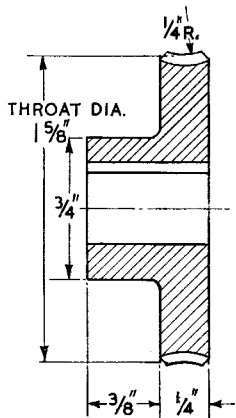
MAIN FEED SHAFT BEARING I OFF C.I.



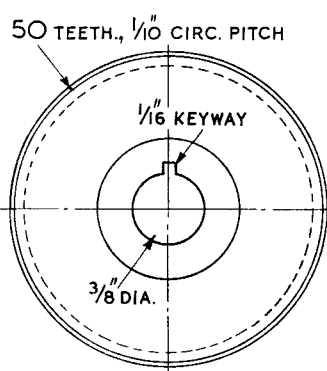
MAIN FEED SHAFT I OFF M.S.



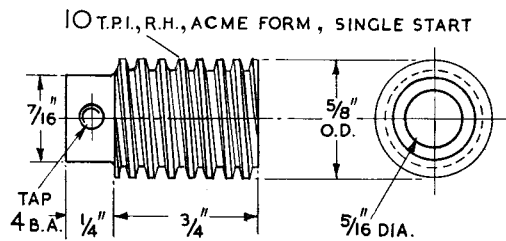
FEED WINDLASS I OFF M.S.



WORM WHEEL I OFF BRONZE

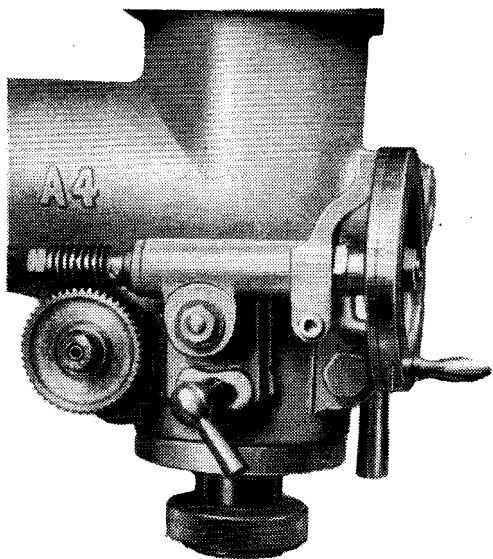


50 TEETH, 1/10" CIRC. PITCH  
WORM I OFF BRONZE

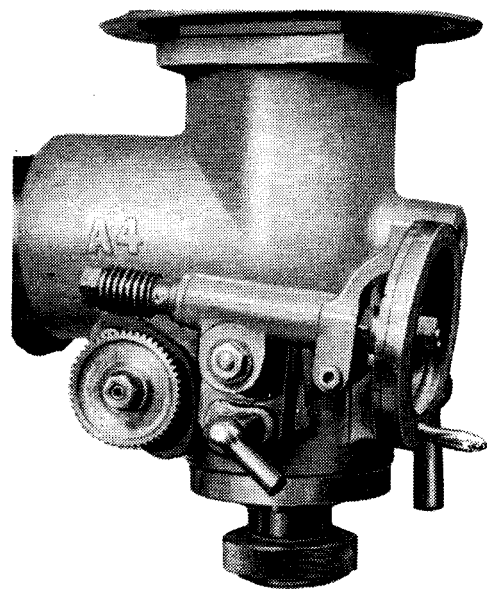


10 T.P.I., R.H., ACME FORM, SINGLE START  
WORM I OFF M.S.

The pinion at first fitted to my machine was cut by the milling spindle in the lathe, with a 40-tooth change wheel to index the blank. A fly cutter, shaped as closely as possible to the correct tooth form, was used to form the teeth. This pinion worked fairly well, but after the machine had been finally assembled I borrowed a cutter of correct pitch and form and made a new pinion on the milling machine itself, using the cutter on an arbor in the collet chuck. The bronze blank was mounted in an improvised indexing fixture, and after fixing it to the machine table I adjusted the cutter to the exact height of the blank centre, and locked the quill by the clamp bolt. As the photograph on page 454 (June 15) shows, simple gearcutting operations, or any others which involve indexing, can be carried out on this machine just as easily as on more orthodox horizontal spindle millers.



*Left: View of spindle head showing the worm gear in engagement. Right: The worm gear disengaged and the sensitive feed in use*



The flanged bush which forms the bearing for the main shaft may be held over the edges of the flange in the four-jaw chuck for external and internal machining at one setting, and then reversed for facing the outside surface. If you have difficulty in obtaining correct meshing of the pinion with the rack, you may have to bore the bearing eccentrically, or to enlarge the concentric bore and fit an eccentric bush. This contingency will only arise if errors occur in the pinion dimensions, or the centre distance of the bored tunnel for the feed shaft from the spindle axis.

A piece of 1/2 in. bright mild steel rod may be used for the main feed shaft, so long as it is truly chucked for turning down the end to take the worm gear. This should be a light press fit on the shaft, and may be keyed, pinned or grub-screwed to the shaft, with a nut for further security. A key-way or flat is provided over the major part of the larger diameter so that you can secure both the pinion and the hub of the feed windlass by socket head grub screws, without risk of bruising or otherwise damaging the journal surface.

The windlass for sensitive feed is built up, and comprises a steel hub, with three equally spaced radial arms, each fitted with a ball at the end. After facing and boring the hub, you can mount it on a mandrel for turning the outside, including the 20-degree bevel. To drill the tapping holes for the arms, and the hole for the grub screw exactly perpendicular to the bevelled surface, you should make a simple mounting jig, with a base at 20 degrees, and a spigoted stud to fit the bore of the hub, to fix on an angle plate set up on the lathe faceplate. The

seatings for the arms should be counterbored just enough to allow the shoulders to screw right home, and not leave an unsightly gap at the sides. This applies also to the fitting of the plastic balls, which are usually obtainable ready drilled and tapped, but may require some attention to give a neat fit.

As the hub of the windlass provides endwise location for the main feed shaft, a dummy collar may need to be provided, if it becomes necessary to remove the windlass during milling operations, in which it may cause obstruction. This does not occur in any of the operations so far encountered. But to anticipate the possibility, a slight modification may be made to allow a collar to be fitted permanently behind the hub, or in its back recess. End location is essential to cope with the slight thrust produced by the worm gear, and to prevent the

error in the feed measurement which might be caused by its movement.

The fine feed shaft, or wormshaft, is turned down at both ends, and screwed 5/16 in. BSF, to carry the worm at one end and the feed handwheel at the other. Both components must be keyed or otherwise positively fixed against rotation. End play of the worm must also be taken up. This is provided for by a thrust collar behind it, and a check nut on a 7/16 in. fine thread at the remote end of the major diameter. The nut is locked by the boss of the handwheel, when the wheel in turn is secured by its end nut.

A ready-made worm and wheel are available for the fine feed gearing; their major dimensions are shown in the drawing. This was the only worm and wheel of convenient size which I could get, and a somewhat larger pair would have been more in proportion to the rest of the gearing. But the duty it performs is not at all heavy, and it works quite satisfactorily. If a worm and wheel have to be specially made, the pitch of the worm may be increased to 8 t.p.i. and the wheel enlarged to 2 1/16 in. throat diameter, 1/8 in. circumferential pitch. Other dimensions need not be altered, though the angle of the wormshaft, in the engaged position, will be different unless the bracket pivot and locking lever are moved about 3/16 in. higher than is shown on the spindle head detail drawing (April 15).

The handwheel should be machined all over. To ensure truth of all the essential surfaces, it may first be held by the

Continued on page 494

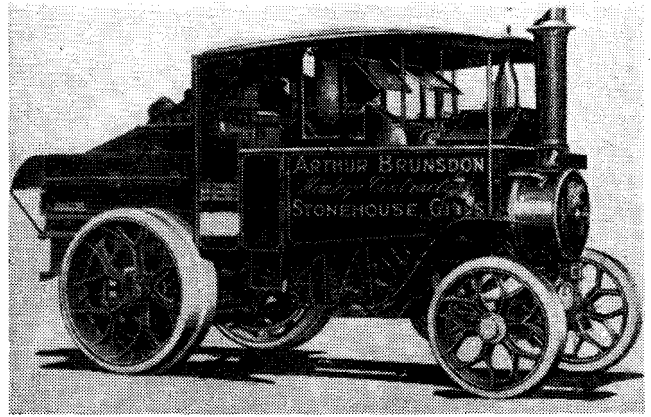
This success set the seal on Foden fame. Eventually, in order to keep up with orders for wagons, the firm had to cease making traction engines and road locomotives, although steam tractors, based on the wagon, continued to be built.

In 1929 the far-seeing William Foden proposed the design of a diesel lorry, and in 1931 the vehicle went into production—fortunately, for legislation had been introduced which virtually killed the road steamer stone dead.

Today Fodens Ltd is the largest independent family business making commercial vehicles, marine engines, mobile cranes, huge dump-trucks and the like. It is a fitting memorial to William Foden, who was its “guy’nor” for so long, and who was borne to his last rest on one of his beloved steam wagons.

W. J. HUGHES.

#### *A Foden tractor of 1928*



#### MILLING MACHINE Continued from page 474

boss for facing and recessing the front and rough turning the outer edge. For turning the back, drilling the central hole, and finishing the edge, it may be held by the inside of the recess. The keyway here, and in other components, can be cut with a slotting tool of correct width, set exactly on centre height, while the work is still set up for machining.

You can also mark the graduations on the edge at the same setting, using a 50-toothed change wheel on the tail-end of the mandrel for indexing, with a spring plunger or other positive form of detent—not a click spring or a similar make-shift device. The procedure is the same as for the slide feed screw indices.

The handle is turned from 5/16 in. steel rod, first reduced and threaded on the end and then roughly shaped on the rest of its length before it is parted off. A short piece of scrap rod, drilled and tapped truly central in the chuck, may be used to hold the handle for finishing it neatly to shape. The finishing is best done with hand tools, which should be kept keen, and supported on a T-rest or the reverse end of a tool shank, slightly below centre height and as close to the work as possible.

Lubrication by soluble or straight cutting oil is essential. I find that many turners fail to make a neat job of parts which involve contours like this, with sweeping concave and convex curves. Often the shape, such as it is, is produced mainly by filing. It is worth while to put in a little time practising with hand tools, which are very useful for many operations, as a supplement to slide-rest tools.

The detail drawing of the wormshaft bracket was published on page 320 (May 1). It should first be machined on the flat mounting face, drilled for the pivot stud and then clamped to an angle plate by this face, and set up to centralise the cylindrical part for the drilling, reaming and turning of the outside to take the index bracket. The reverse end should then be faced truly to form a seating for the thrust collar.

As already mentioned, the pivot stud for the bracket is turned down on the inner end to engage the keyway in the quill, and prevent it from rotating. The major diameter of the stud is adjusted for length to allow the bracket to swing freely on it with minimum end play, when we fit the nut and washer. An accurate slot is cut in the bracket at a radius of 1 in. from the pivot stud, wide enough to clear the plain 1/4 in. stud to which the clamping lever is attached. The raised facing around the slot should be filed or end-milled parallel to the back face.

*To be continued*

#### BOXHILL Continued from page 482

brass or copper tube, arranged close to the left-hand cab side-sheet. Its top should be plugged, and a hole about 3/32 in. dia. drilled in the side of the tube near to the cab side, and just below the plug. This prevents dirt, coal-dust and so forth from getting into the tank, while allowing free access to the air.

The next part to make is the back of the bunker. It has to be cut away in the centre to clear the toolbox. To hold it in position, put three 8 BA countersunk screws through the plate, into tapped holes in the angle which have been fitted permanently to the sides of the bunker. Do not solder it in any way, as this would prevent the tank unit from being lifted out for cleaning and so forth.

Our footplate—by which I mean the wooden boarding on which the enginemen stand—is best made of brass for a working model, scribed heavily to represent planking, and suitably painted in dead flat colours. The various cutaways shown on my drawings can be checked off on the work itself, as the exact lie of the various pipes can never be determined exactly in advance. Most builders will probably make a second footplate in wood, exactly as in the full-size engine, and use it when the model is not being steamed, and for exhibition. A dark wood looks best, with as small graining as can be found.

After the rear spectacle plate has been made up and fitted—and this plate must be made readily removable for driving—the only remaining piece of platework is the roof. The shape of the roof is a difficult one. I think that the best approach is to use 1/16 in. thick copper and make up a simple press tool in hardwood, such as beech or oak.

This press tool would consist of two parts, the punch and the die, together with a substantial dowel in each corner. The copper sheet is then thoroughly annealed and placed between the two parts of the tool, which are squeezed together by the vice. While this method should work all right, it is possible that a skilled sheet metalworker may be able to suggest a quicker method.

So that the roof fits nicely between the cab sides and the spectacle plates, lengths of 5/32 in. brass angle are soldered in position as shown. A flat bead of 3/16 in. X 1/32 in. brass strip across the middle completes this component. If the fit of the roof is a good one, there should be no need for more positive fixing: most drivers will be able to manage without removing the roof.

*To be concluded*