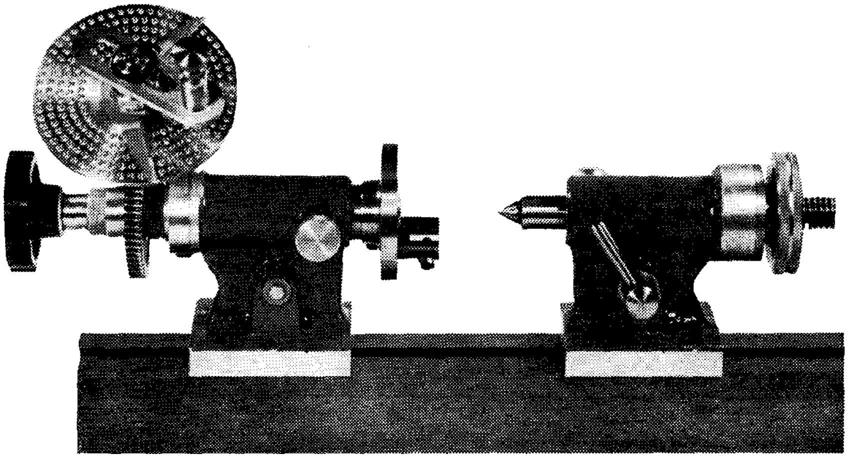
Light vertical MILLING MACHINE

Continued from August 15 by Edgar T. Westbury



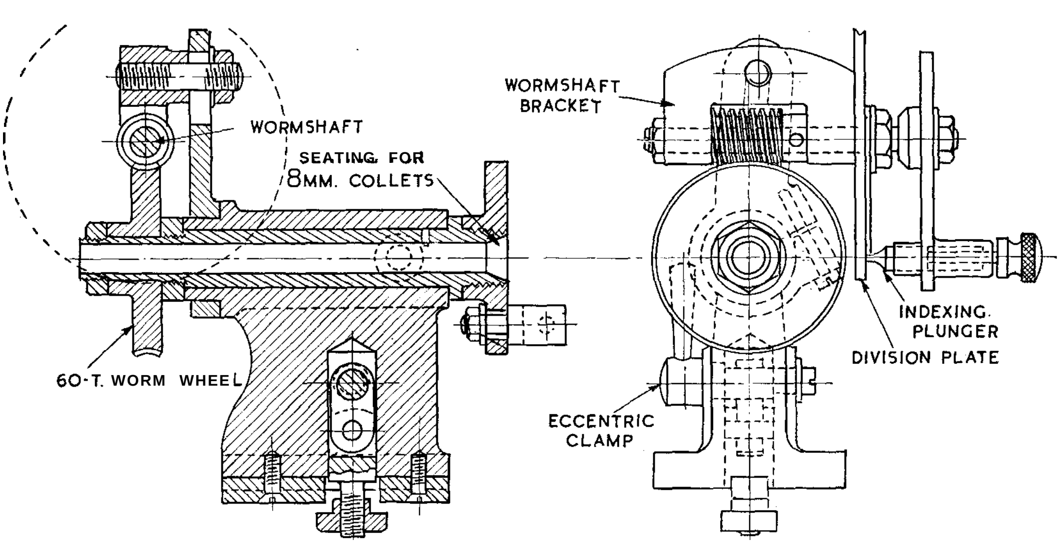
HORIZONTAL DIVIDING HEAD

SOME form of indexing is a necessity in many milling operations, and though the rotary milling table already described can be adapted to indexing about a vertical axis, it is not suitable for dealing with work pieces of any substantial length. A horizontal indexing head has a much wider range of application and can be used in gearcutting, fluting taps, reamers and other cutters, and making long splines or keyways, all of which are commonly encountered in light engineering practice.

The dividing head illustrated (which might be more correctly described as a ***pair*** of heads), was built to meet definite requirements. It is not claimed to be original, as its basic features conform with standard practice in milling machine equipment. Some of them have also been applied to lathe attachments which have been described at various times in ME. But its details have been arranged to promote simple construction without sacrifice of utility or inherent accuracy. While it is intended principally for use on the vertical milling machine, it is just as well suited to horizontal machines, and could be adapted to serve as a lathe attachment in conjunction with a vertical slide.

The headstock and tailstock are simple castings, though they could easily be made from the solid, or fabricated, if either method is more convenient. They were cast from the same patterns, though the machining details and dimensions differ. The material in the one shown is aluminium alloy, though cast iron would be more in keeping with machine tool practice. But the delay in obtaining small castings in iron, and the greater difficulty in machining this material, influenced me to use light alloy castings. While these are less resistant to hard wear, they are well suited to the light duty of an appliance which involves neither high speed nor sliding friction.

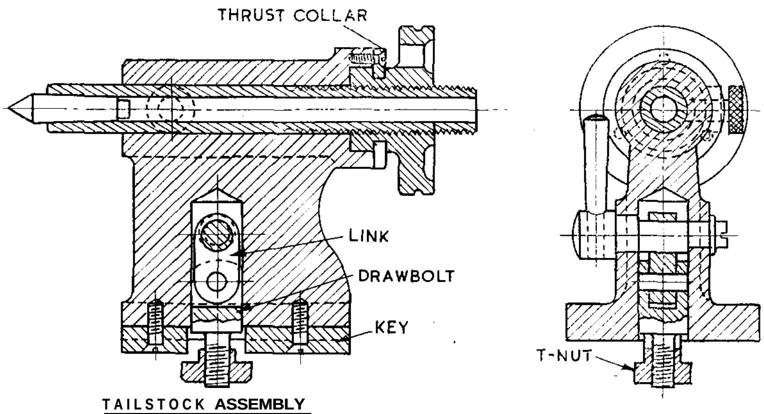
As the machining operations on the two castings are



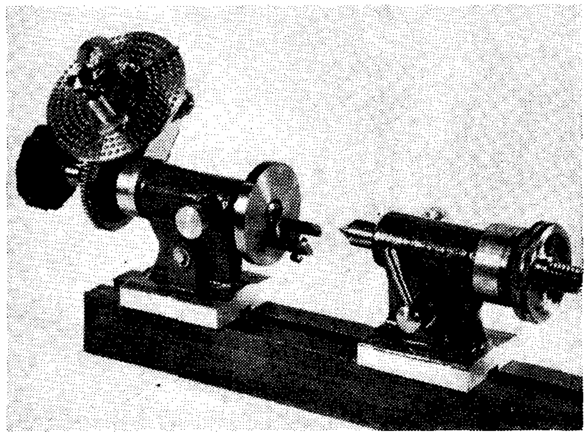
HEADSTOCK ASSEMBLY

similar, they will be dealt with as a pair. The first task in each case was the boring of the main housing. It was carried out by mounting the casting rear end outwards in the four-jaw chuck, with one of the jaws reversed. If the chuck is not large enough to hold the work comfortably, an alternative method would be to clamp it by its flat base to an angle plate on the faceplate.

The boring operation, in each case, should be carefully carried out to ensure a smooth parallel surface; a reamer may be used for finishing if it does not have to take out more than a few thou. At the same setting the back edge of the base, the shouldered end of the headstock, and the recess in the tailstock boss, can be machined. Mandrels, of the two appropriate sizes, may be used to mount the castings for facing off the front ends, and the front edge of the base, which should be flush.



TAILSTOCK ASSEMBLY



The underside of the base should be faced off to within 1/32 in. of finished size. The best way of making sure that this surface is parallel to the axis of the bore is to mount the casting on an angle plate by a bolt through the bore; the machined end surfaces should be protected by thin shims or truly-faced washers. With care in setting-up, and taking measurement from the bore centres, it is possible to finish the base surface at this setting, but for various reasons it is better to do it in a separate operation.

While the height from centre to base is not critical, it is important that both castings be identical in this respect, and also that the bores should be in exact axial alignment. To ensure this, it is well worth while to resort to a simple form of alignment jig. The one I used was very easy to make and consisted of three parts: two angle brackets and a stepped mandrel long enough to take the two castings, nose ends in contact, and a close fit in each of the bores. Each end is turned down to 3/8 in. dia., and screwed to take a 3/8 in. BSF nut. The angle brackets are made as an identical pair, with holes to fit the mandrel ends at the same height and at the same distance from the edge; similar holes in the horizontal side of the brackets provide for fixing them to the milling machine table by short T-bolts.

Setting up for milling

The two castings, with the side edges of the base in line, are clamped by the mandrel nuts in an inverted position between the angle brackets. A check should be made to ensure that the mandrel axis is parallel to the edge of the milling table; that is, to the line of table traverse, and also to its horizontal surface. An end or face mill with a fairly broad surface can be used to finish the two base surfaces, with the assurance that they will line up exactly with each other. A side mill can be used to true up the side edges of the bases. Though these do not necessarily play an important part in the use or setting-up of the appliance, they may sometimes be useful for reference if they are parallel to other and more important surfaces.

As the dividing head is intended to be mounted and lined up on the milling table by location from a T-slot, some form of a key or tongue to fit the slot should be provided on the base. It would be possible to form this tongue integral with the casting by leaving a projection in the centre. But in my case, I wished to make it suitable for use on machines in which the width of the T-slot might vary, or which had no T-slot. For this reason, the alignment keys were made separate, and fitted to grooves which were end-milled along the centre of the two bases while they were still set up for surface milling.

Positive alignment

In this way, the alignment of the headstock and tailstock with the milling table is assured, not only individually, but as a pair when set up at any distance apart within the length of the table. The keys must be a good fit, not only in the grooves of the base, but also in the table slots. In the event of discrepancy in the widths, stepped or offset keys may need to be (temporarily) fitted; but should it ever be necessary to set the axis of the dividing head at an angle to the table traverse, the best way would be to provide a supplementary swivelling base to mount on the machine table, with slots for attachment of the headstock and tailstock. The base on which the two components were set up for taking the photographs was made from two mild steel bars, 3/4 in. X 3/8 in., with grooves milled in their inner surfaces to anchor the T-nuts, and they were bolted together with 3/8 in. spacing collars between them. The base can be mounted at any angle on a machine table, or even on the vertical slide of a lathe.

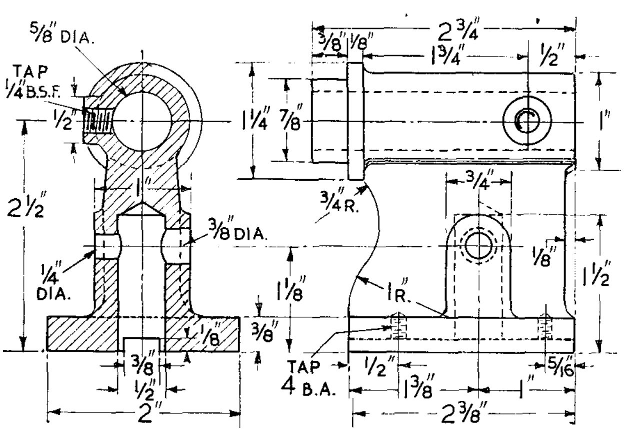
The method of clamping the components to the table is unusual, but it has the merit of being both facile and adaptable, and has proved very satisfactory in use. Similar clamping devices have long been used on instrument lathes for holding down the headstock and tailstock, and for the latter, the principle is often employed on much larger machines. Its essential features comprise a cross shaft having its centre part eccentric to its main axis, and acting on a drawbolt which fits in a dovetail or T-slot.

Often the drawbolt is made in a single piece, with a certain amount of lateral movement in the casting, and of correct length to pull up tightly in the slot within the vertical range of eccentric travel. But this was difficult to arrange in a device intended to operate in slots of different depths, and for this reason the drawbolt is fitted with a T-nut, which allows it to be adjusted to suit the slot before sliding the component into position.

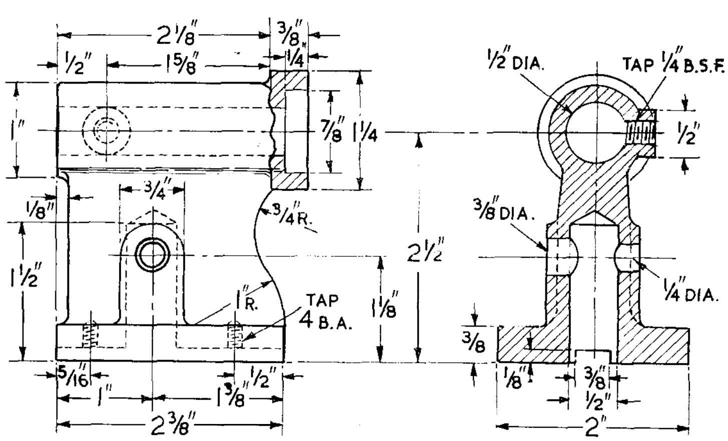
Other methods of clamping may be adopted at the option of the constructor. The simplest and most obvious would be to cut an aperture in the web of the casting and fit a simple T-bolt with a nut at the top. But this is liable to weaken the structure of the casting, and unless the base is lengthened, it is very difficult to make the nut readily accessible for tightening. Another way would be to make the base with a flange wide enough at one or both sides to take a holding-down bolt, but this is not very neat, and involves offset bearing thrust, which is not the best possible fixing where accurate alignment is essential.

If the eccentric clamping method is adopted, a 1/2 in. hole must be drilled vertically in the casting to take the drawbolt. This can be done in the vertical milling machine, while the two components are set up on the jig; or alternatively, they may be set up singly on an angle plate in the lathe.

The horizontal hole is drilled diametrically across this bore, 1/4 in. dia. at one side and opened up to 3/8 in. at the other as shown. Spot facing at both sides of the hole is not absolutely essential, but is desirable for neatness. The final operation (other than the tapping of holes which can be located from other parts) is the drilling and tapping of a hole in the side boss of each component to take the friction screw. Note that the large end of the cross hole for the eccentric shaft should be on the opposite side to this screw, to avoid risk of the two movements fouling each other.



HEADSTOCK 1 OFF C.I. OR L.A.



TAILSTOCK 1 OFF C.I. OR L.A.

Working components

The headstock mandrel is a straightforward turning job; most of the machining on it can be done between centres, either before or after drilling through the centre. I prefer to get the drilling over, just in case the long hole may run slightly out of truth, and then locate from the bore on true-running centre plugs. If the drilling is done last, the mandrel should be chucked truly at the tail end, and supported immediately behind the nose collar, in a split bush mounted in the three-jaw steady. Running directly in the jaws of the steady involves a risk of scoring the machined surface, even when it is kept well lubricated.

The mandrel, as shown, is bored to take standard 8 mm. split collets, as used on instrument lathes, and obtainable through the tool trade. Articles on making collets have been published in ME on more than one occasion, and full details of their dimensions can be found in the ***ME Handbmk.*** I have made many of these, and other types of collets, when the standard article was not obtainable, and have not found it difficult. The seating angle for the collets in the nose of the mandrel is 40 deg. inclusive; i.e. 20 deg. on the swivelling topslide of the lathe. It should be machined carefully, with a small boring tool set exactly to centre height, and with a smooth tool finish-not by lapping to a standard collet.

The bore dimension of 8 mm. is equivalent to **0.315** in., or about 24 thou over 5/16 in. A hole first drilled undersize (1/4 in. or 17/64 in.) and followed by a 5/16 in. drill may be finished with an 8 mm. standard reamer, or if this is not to hand, it is not a difficult matter to make a D-bit from 8 mm. silver steel rod. In fact, this ***is*** really a better tool, because of the inherent ability of a D-bit to produce a straight and true hole.

Deep drilling operations of any kind demand a well-sharpened drill, with plenty of lubrication, and frequent backing-out to clean chips, The lathe may be run at maximum speed (usually from 600 to 750 r.p.m.) for holes in this size range, and the feed rate fairly rapid, but not forced. Holes should always be started with a centre drill and checked for truth in the initial stages of penetration. I mention this because some readers have reported difficulties in drilling true holes, and the deeper a hole is, the greater is the final error if it is not started concentrically.

It is usual to key the shank of the collet by a peg driven into the mandrel behind the nose collar. This provision is not absolutely necessary for normal torque loading, and some operators prefer to dispense with it, relying on the frictional grip of the taper seating to drive the work. For most indexing operations, there is very little torque tending to displace the work from its set position, but as the keyway is provided in standard collets, very little work is entailed in fitting the peg in the mandrel.

The engaging end of the key is 2 mm. or slightly under 0.080 in., and it should not penetrate into the bore of the mandrel deep enough to bottom in the keyway of the collet, as this would tend to force it out of truth.

To be continued