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By Ned

Indirect indexing with worm gears

THE range of divisions which can be obtained by direct indexing, with the set of change wheels provided on a screw-cutting lathe, or any other accurate gears, will suffice for the requirements of many. But when a much wider range of divisions is needed, the direct or plain indexing gear may prove inadequate. The most practical device then is one which employs a worm reduction gear in conjunction with primary indexing elements such as division plates.

Nearly everyone is familiar with this form of indexing ***gear.*** It has been established since 'the pioneer days of industry. Briefly, it allows a range of indexing to be obtained from a limited number of primary elements through the ratio of reduction provided by the worm gearing. Thus, with a division plate which has 50 equally spaced holes, and a worm which gives a reduction ratio of 60 to I, the maximum number of divisions obtainable is 60 X 50 or 3,000. You can get any factor of this number by counting the turns of the primary wormshaft, or the number of holes in the division plate, required to make it up. The same applies to any other combination of primary elements and reduction ratios.

For instance, you may want to engrave an index with graduations each representing one degree-360 degrees to the complete circle. This might be difficult with direct indexing, but is quite simple with worm gearing. If you use a 60 to I gear and a 60 division plate (a total combination of 3,600), a movement of the primary shaft equal to IO holes in the plate will produce 1/360 of a turn on the indexing mandrel. It is often found that the worm gear will deal with indexing problems which are almost impossible by the other means which you are able to employ.

Assuming that the gearing is accurate, the final precision of indexing is at least as high as the precision obtained by any method of direct indexing. It is often higher, because the worm gear gives more positive locking and resistance to displacement. You can set the worm in close engagement with the wheel so that no backlash can occur, or you can spring-load the shaft bracket to produce the same effect. The accuracy of the primary indexing is much less critical, as any error is divided by the ratio of reduction. A tolerable degree of accuracy can be obtained by the use of hand-divided plates, or anything which provides approximate equality of spacing.

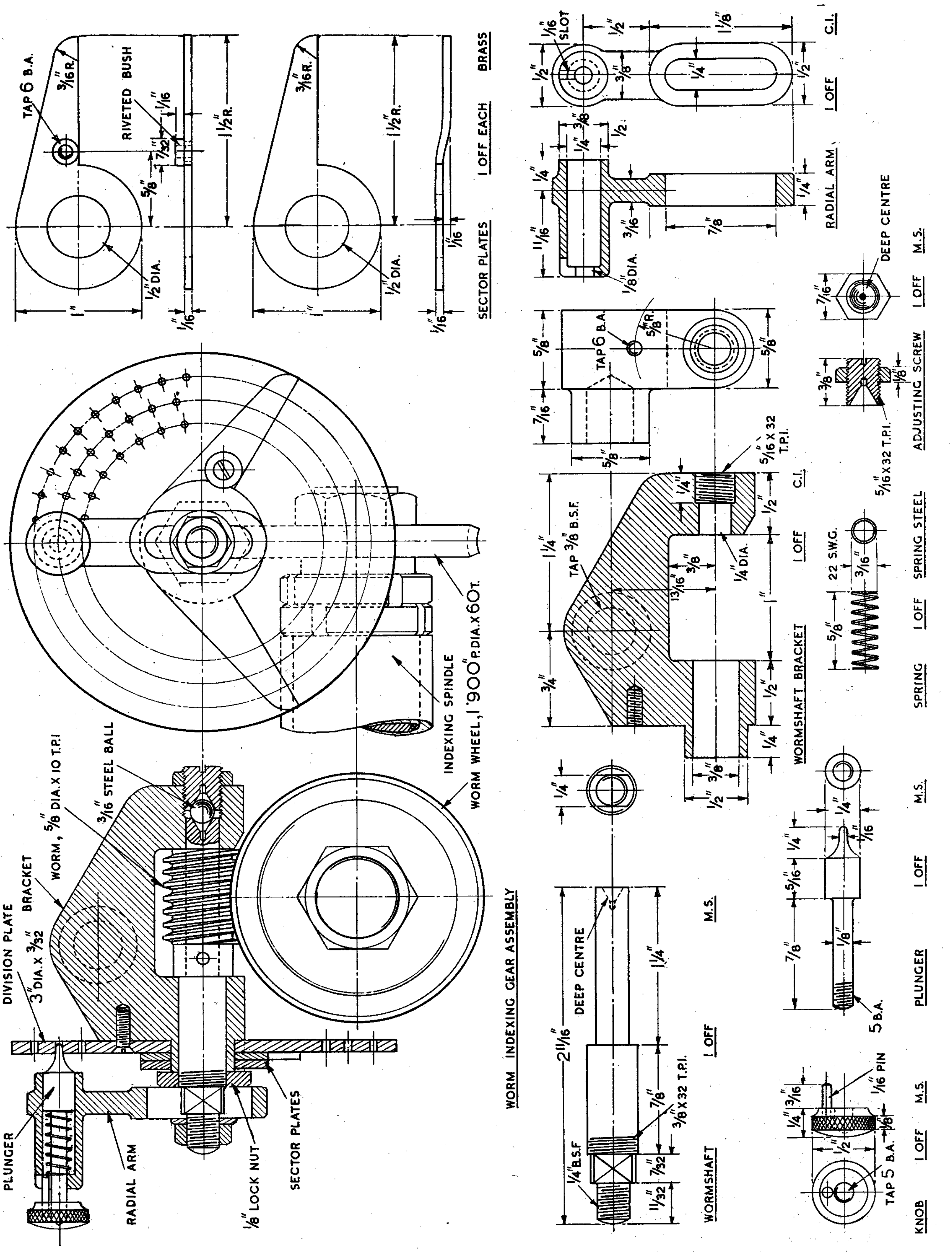
Many years ago George Gentry (a noted exponent of good workshop practice) described a worm indexing device which used cards produced on the drawing board and marked out by trial and error with dividers. I once knew a skilled clockmaker who used a mixed collection of old gear wheels, some of them well worn, in a worm-geared appliance which he used to cut some very fme gears and pinions. **Primary** accuracy is capable of some latitude, but obviously should be observed as closely as practical conditions permit.

Precision in the worm and worm wheel is another matter. Quite apart from pitch accuracy, any error in the concentric mounting of either will have serious results. The thread of the worm must have a constant pitch angle; a drunken thread will produce a periodic error in any work which involves varying angular rotation of the worm. It is not necessary to use a throated worm wheel, or to observe all the fine distinctions of'tooth form which are necessary in worm gears intended for the efficient transmission of power. The contact area between the worm and wheel teeth may be quite small; it is in order to use an accurate spur ***gear*** as a worm wheel if the wormshaft is suitably inclined to match the pitch angle of the thread. A slight error in the pitch of the worm does not atfect the accuracy of indexing, because it will automatically accommodate itself to the pitch line unless it is prevented from doing so by insufhcient tip clearance. So long as the meshing of worm and wheel is fairly good, one complete turn of the worm must necessarily advance the wheel by exactly one tooth, no more or less.

It is not beyond the skill of model engineers to produce both the worm and wheel for themselves. But in view of the importance of these components, most modellers will no doubt prefer to buy them ready-made from a reliable gear-cutting specialist. Two well-known ME advertisers, Bond's o' Euston Road, London, and S. H. Muffett of Tunbridge Wells, Kent, produce a range of worm gears; I have examined samples of their products and can recommend them with confidence. The worm and wheel shown in the assembly drawing is taken from Bond's range, and is about the right size for this purpose. It is, as a general rule, advisable to make the worm gearing and division plates of ample size, because the risks of inaccuracy are usually greater when they are very small. But the entire assembly needs to be compact, and in proportion to the rest of the appliance, Remember that it is all supported from the 1 1/2 in. square column; you will gain nothing from making it unduly large or massive.

Division plates, with several rows of holes, are obtainable in the instrument trade, but they are expensive if made to guaranteed accuracy. You will not find it diflicult to drill the plates on the dividing spindle itself, using ***change*** wheels or other components for indexing, and running a centre-drill in the chuck. The pilot end of the drill should be about 1/16 in. dia. and it should enter to a uniform depth (a stop for the lathe saddle is helpful), just sufiicient to produce a slight chamfer to each hole. Sheet brass, 3/32 in. thick, is suitable for the plates, and if it is truly flat they need not be machined on the surface. The centre of each plate is bored concentrically to a push fit on the spigot of the bracket, and is secured to it by a single 6 BA countersunk screw. Three rows of holes, to give different indexing ranges, are shown; more can be added if required.

As supplied, the worm gear has a boss 3/4 in. dia., which is hardly large enough to bore out to fit the tail of the indexing mandrel, if this is made to fit the lathe change wheels. A smaller, diameter seating for the gear would be satisfactory, but if it is to be interchangeable with the wheels used for direct indexing you had better make a collar not less than


DIVISION PLATE 3" DIA. X 3/32"
BRACKET
WORM, 5/8" DIA. X 10 T.P.I.
3/16" STEEL BALL
INDEXING SPINDLE
WORM WHEEL, 1.900" P.DIA. X 60T.
PLUNGER
RADIAL ARM
1/8" LOCK NUT
SECTOR PLATES
WORM INDEXING GEAR ASSEMBLY
TAP 6 B.A.
RIVETED BUSH
SECTOR PLATES 1 OFF EACH BRASS
SLOT
RADIAL ARM 1 OFF C.I.
DEEP CENTRE
TAP 3/8" B.S.F.
5/16 X 32 T.P.I.
WORMSHAFT BRACKET 1 OFF C.I.
ADJUSTING SCREW 1 OFF M.S.
22 S.W.G.
SPRING 1 OFF SPRING STEEL
1/4" B.S.F.
3/8" X 32 T.P.I.
WORMSHAFT 1 OFF M.S.
5 B.A.
PLUNGER 1 OFF M.S.
1/16 PIN
TAP 5 B.A.
KNOB 1 OFF M.S.

1 in. in diameter, which can be pressed or sweated over the existing boss to strengthen it and provide a broader face. In boring out the worm gear to fit the seating, great care must be taken to preserve concentric truth. If a collar is fitted over the boss, it can be used as a cup chuck (before it is parted off) to hold the gear during this operation. Make a check over the gear teeth and the machined side face, using a dial test indicator if you have one, to make sure of exact truth before boring. A keyway may' be made in the bore, or any other means of positive location can be employed, so long as it does not tend to force the gear out of truth when fitted. It is clamped endwise by the same nut used for securing the change wheels on the indexing mandrel.

The wormshaft bracket, made from the solid or from a casting, has a boss on the back face, drilled and tapped to take a 3/8 in. stud by which it is secured to the banjo of the indexing gear. Instead the boss may be omitted and a double-ended shouldered bolt used; this will enable the bracket to be fitted either way round, which may sometimes be more convenient. The important thing is that the bracket should have a means of mounting squarely and securely on the banjo. For this reason, you are well advised to mount the bracket on an angle plate for drilling and boring the wormshaft bearing, using the bolt or stud of the boss to secure it for this operation. Take care to drill the bores of the bracket in true alignment; if you have difficulty, finish the large bore first, and then mount the bracket on a stub mandrel for boring, counterboring and tapping The inner face of the front bearing must be machined true. You can best do it with a facing cutter introduced in the gap before it is attached to its arbor, which should be turned to suit both bores and act as a pilot. The spigot on the front bearing should be concentric with the bore, and fit closely in the bore of the division plates.

The wormshaft is a straightforward turning exercise which can be carried out between centres. One end is deeply centre-drilled to take the steel ball for the endwise adjustment, to eliminate play when the worm is secured. This should be a light press fit and firmly cross-pinned or grub-screwed in position. To enable division plates to be removed or replaced without removal of the worm&aft, a thin fine-thread nut is used to provide a seating for the radial arm, which is clamped by the end nut and washer. The part of the shaft immediately in front of the thin nut is turned down to the root diameter of the thread, and has flats milled or filed on the sides for the slot of the radial arm.

Apart from filing or machining the front and back faces of the arm true and parallel, the only operation on this part is the boring of the plunger housing. You should first skim this on the outside by clamping the casting to the lathe faceplate; it can then be held in the chuck for centre-drilling, undersize drilling, and finishing with a D-bit, in the same way as the direct-indexing plunger housing. The plunger is similarly fitted, but the end is turned to fit the holes in the division plates, and may be slightly tapered to assist engagement. A similar method of holding the plunger out of engagement may also be used. To avoid the need for cross-drilling the slender stem of the plunger, you can employ a device consisting as shown of an axial pin pressed or screwed into the inner face of the plunger knob. The pin enters the slot in .the end of the housing to allow the plunger to engage the division plate; at other times the knob can be withdrawn and partly rotated to hold the plunger back. If desired, a shallow slot may be provided in the face of the housing, opposite the deeper slot, to make disengagement more positive. Only a light spring is required for the plunger, as it does not encounter any stress tending to force it out of engagement. To screw the knob on firmly, you' can hold the tip of the plunger in a pin chuck, and grip the knob in the jaws of a pliers with a strip of thin leather interposed.

The sector plates are made of brass sheet, and are identical in shape, except that one has a tapped bush, flush riveted in position, and the other is bent so that it lies flush with its fellow at the tip. Both are fitted to work freely on the spigot of the bracket and in such a way that they can be locked together by a screw and washer in the tapped bush, the face of which should be slightly lower than the level of the top plate. A more elaborate form of joint and locking device for these plates may be used, but this simple arrangement has proved quite satisfactory. The pair of sector plates serves as a form of caliper to assist the counting of holes in division plates. They are set to span the number of holes requited, plus one, which represents zero or starting point, and locked in position. When the arm is shifted from one position to the next, the sector unit is first turned in the direction of rotation as far as the plunger tip 'will allow, and is held in position on the plate. The plunger pin is then withdrawn and the arm is turned as far as the other sector plate allows and engaged in the nearest hole. This process is repeated for each shift of the arm; besides speeding up operations, it greatly reduces the risk of error, which is always liable to occur when the holes are counted separately for each shift, and is a common cause of disaster in work on which much time has been spent.

When you are setting up the indexing gear, advance the adjustment screw to eliminate end play of the shaft while allowing it to turn freely, and lock it by its nut. The bracket is then secured to the banjo of the indexing spindle, and is adjusted radially so that the worm and wheel engage without backlash, while they are still free to work, before the mounting nut is tightened. With the appropriate division plate in position, the radial arm is adjusted for the plunger to engage freely with the required. ring of holes, and is clamped in position. Turn the arm a few times to verify these adjustments. Make sure that the gears neither bind nor slacken off as they rotate, before work begins.

This indexing gear is capable of a good deal of latitude in dimensions and detail design; it can be fitted to the change wheel quadrant of the lathe for indexing the mandrel, but here I recommend more liberal dimensions all round, as the duty will be a good deal heavier. Similarly it may be applied to the indexing head of a small milling machine. Together with the other units which have been described for the special slide, it vastly extends the range of operations that can be performed, without introducing complicated fittings which take a long time to set up and adjust.

Nearly all kinds of attachments are useful in extending the scope of the lathe, but a multiplicity of them is not conducive to efficiency. We sometimes see lathes so decorated with attachments as to, look like a mechanised Christmas tree, when fewer and simpler devices, if well designed and constructed, would achieve the same purpose. But apart from utility, the practical value of all such appliances depends in a great degree on how easily and quickly they can be set up and brought into action. The multi-purpose attachment described in these articles is designed to give the utmost facility without sacrifice of efficiency, and its construction will, I hope, enable many readers to employ their lathes to the best possible advantage in operations far beyond the range of ordinary turning. El