IN THE WORKSHOP

by "Duplex"

No. 78—Making a Knurling Tool

AT this year's "Model Engineer" Exhibition, great interest was shown in the knurling tools displayed and many requests were received for a full description of their construction.

The knurling tools in question were made several years ago, following an article on the subject that appeared in THE MODEL ENGINEER; but, to suit personal preferences, the published design was modified in many particulars.

In commercial practice, as exemplified by the automatic machine producing small parts in large quantities, the knurling wheels may be put into cut by being forced directly against the work, and the machine is then designed to withstand the stresses thus set up.

The light lathe, on the other hand, may be less robustly constructed, and as a consequence, the mandrel bearings will probably suffer unnecessary wear if subjected to the heavy side thrust imposed when an ordinary forked knurling tool is fed directly into the work. Therefore, to eliminate this side thrust, a tool of the form illustrated in Figs. 1 and 2 is used instead of a plain knurling wheel holder. It should be borne in mind, however, that a knurling wheel has but a limited cutting capacity, and the impression formed on the work is largely the result of compression forcing the knurl into the material. The tools illustrated, however, are designed to allow the two knurling wheels carried in the head to be pressed into the work by screw pressure, and, as the two forked arms are free to swing, the pressure exerted by the knurls will be equal and opposite and will have no tendency to deflect the work from the lathe axis, or to impose any side strain on the mandrel bearings. To fulfil these conditions, however, it is essential that the two knurls should be applied at diametrically opposite points on the work; the resulting forces are then solely rotational, that is to say the tool itself will tend to rotate with the work, but this is resisted by the shank pressing downwards against the lathe toolpost. When heavy knurling is undertaken on work of large diameter, this turning effort may be considerable and its value can be estimated by turning the lathe mandrel by hand while the tool is engaged. For this reason, it is not, perhaps, advisable when doing heavy knurling, to mount the tool in the ordinary form of back toolpost, as the strain is then in an upward direction and falls on the saddle T-slots and the attachment bolts; nevertheless, this is a very convenient way of doing light knurling and the progress of the work can easily be seen. When the knurling tool is in operation, the resistance felt in the hand feed as the knurls are moved along the work will generally be greater than that experienced when traversing an ordinary lathe tool; to withstand this side strain, the knurling tool must, therefore, be robustly constructed

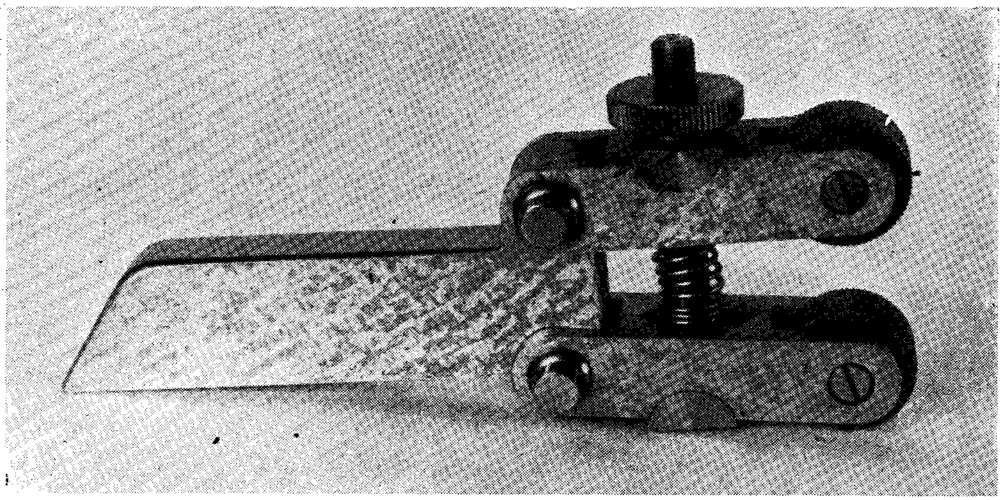

Fig. 1

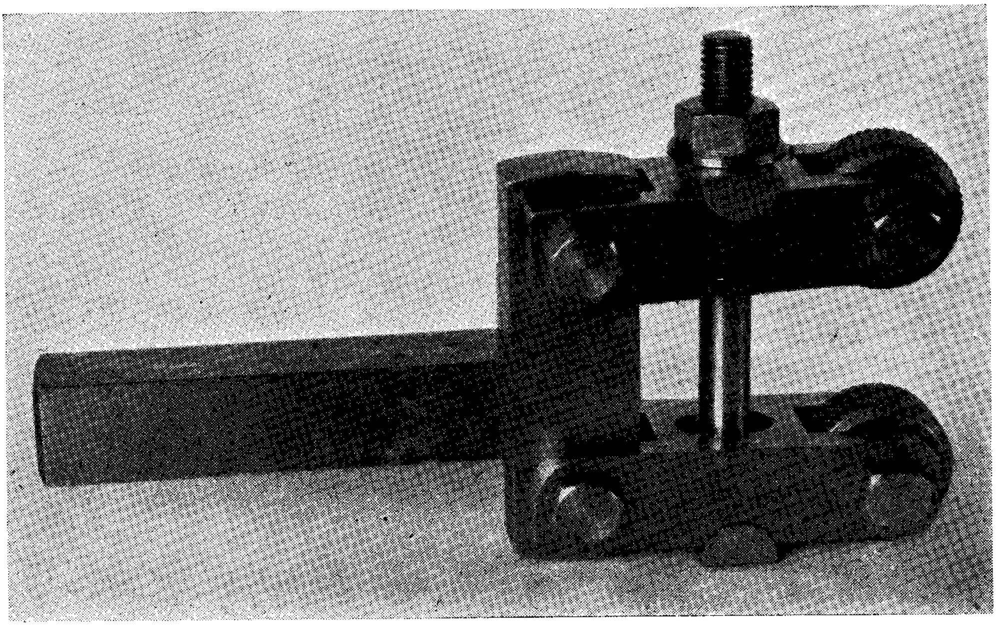

Fig. 2

and have enough rigidity to overcome any tendency to bend or whip even when heavily loaded. It is for this reason that the individual parts of the tool have been machined from the solid and afterwards very closely fitted; in addition, the components are case-hardened to resist wear and mantain accuracy in the moving parts.

Constructional Work

The following constructional details apply to the tool illustrated in Fig. 2, which has a working capacity of from 3/32 in. to 1¼ in. Should a larger tool be required, the depth of the throat can be increased by lengthening the arms and, at the same time, the hinge joints of the arms are spaced farther apart. The main components

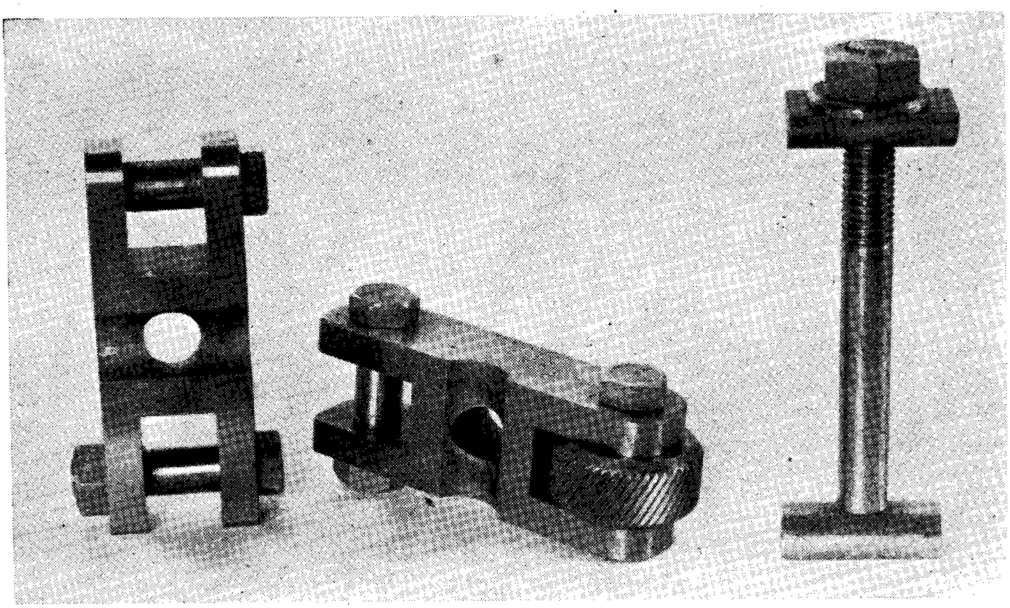

Fig. 3. *The arms and pressure-bolt*

with their fittings consist of: the arms (A), the body (B), and the pressure bolt (C).

The Arms

These two parts are exactly similar in construction, except that one is made, as it were, right-handed and the other left; this is done in order to locate all the bolt heads on the side away from the chuck. As depicted in the working drawings in Fig. 5, the arms are made from the solid, using mild-steel bar $\frac{1}{2}$ in. by $\frac{3}{4}$ in. After the material has been filed flat and square, it is marked-out; this is followed by forming the bores to receive the hinge pins and those for the wheel pivots.

Tapping-size holes are first drilled with a No. 3 drill right through all four ends, and these bores are then enlarged to the reaming size for a depth of just over $\frac{9}{16}$ in. Although a letter "D" drill, which is 4-thousandths of an inch undersize, is generally used for the latter purpose, reaming will be found easier, if instead, a 6.3 mm. drill is employed, for this is only 2-thousandths under the nominal size. A $\frac{1}{4}$ in. B.S.F. tap is now entered in the reamed holes to thread the remaining portion of the bores.

The next operation is to form the forked ends of the arms; this was done by first removing the surplus metal with a hacksaw and file and then gripping the parts in a machine vice attached to the lathe cross-slide. A circular milling cutter, mounted on an arbor between the lathe centres, was next employed to finish the slots to the correct width and depth. When doing this, the arms were set in the vice so the cutter entered to the required depth, and the width of the slots was determined by working to readings on the lead-screw index. Another way of forming the slots is to grip the work in a machine vice attached to the vertical slide and to do the machining with an end-mill, but an end-mill used in this way does not always give such a good surface finish, and moreover, it is then perhaps rather more difficult to cut the slots accurately to size. Before removing the first part from the vice, make sure that the knurling wheels enter the slot freely but without side play. Best quality knurls are accurately ground to width on the side faces, and the bores are also sized by grinding. Nevertheless, the bore diameter should be checked so that any undersized bore can be corrected by lapping.

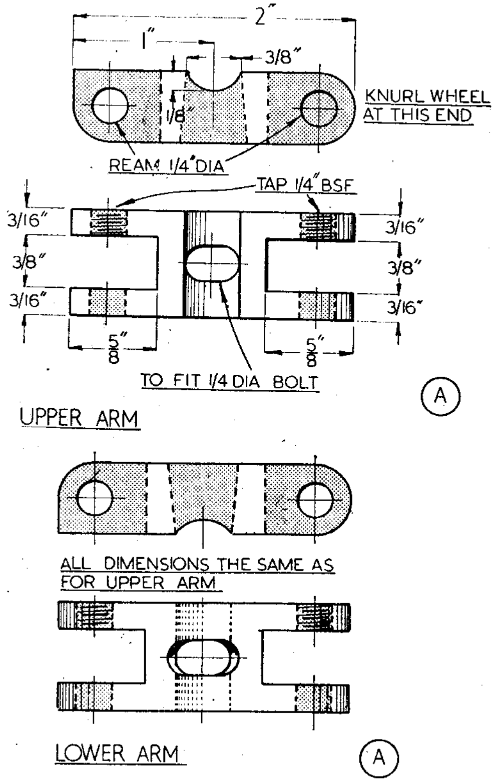

Fig. 5. Details of the two arms

An accurate method of determining the bore size is illustrated in Fig. 6; the wheel is moved along a ground, taper mandrel until the place is found where it becomes a close running fit; a mark is then made with a grease pencil, and the diameter of the mandrel at this point is measured with a micrometer.

This procedure is also instructive in that it will show the difference in diameter required for a running fit, a light push fit, and a firm fit, but when testing a hardened part in this way the bore should first be oiled and care must be taken not to use such force as would damage the surface of the mandrel.

The hole for the passage of the pressure-bolt is now drilled, but it will be finished to its elongated shape at a later stage when assembling the arms on the body. The hollows to accommodate the pressure pads are best formed by clamping the arms in a machine vice, attached to the vertical slide, and then machining to a little less than the half diameter with a $\frac{3}{8}$-in. diameter end-mill.

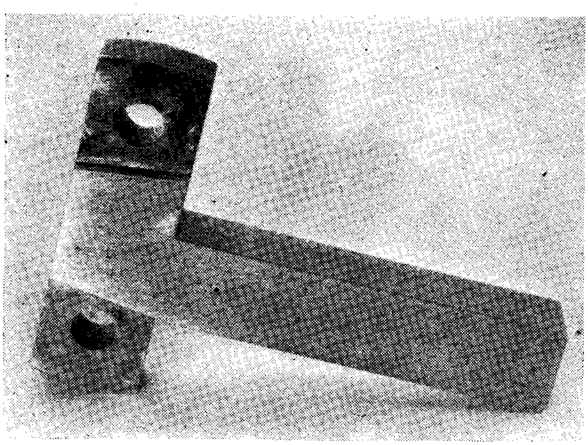

Fig. 4. The body of the knurling tool

The Body

The shank or body, shown in Fig. 7, is marked-out on a length of 2 in. by ½ in. mild-steel and cut to shape with the hacksaw and file. The dimensions given refer to a tool suitable for mounting in the tool turret of a 3½-in. Drummond lathe, but if any other form of mounting is used it is only necessary to ensure that the centre-line of the head portion lies at approximately the centre height of the lathe.

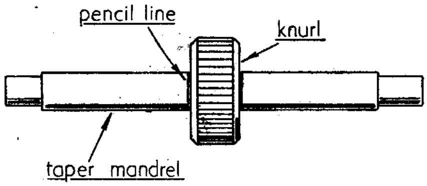

Fig. 6. Method of measuring the bore size of the knurling wheels

After the holes for the arm hinge-bolts have been located on the head, they are drilled right through and then reamed to size, as previously described. It now remains to machine the recesses on the head lugs to fit accurately in the slots cut in the inner ends of the two arms. This can be done conveniently by gripping the body by its shank in a vice attached to the vertical slide, and then cutting out the recesses with an end-mill or with a circular facing cutter. It will be noticed that the shoulders formed by these recesses lie at an angle of 8 deg. to the long axis of the part; the vertical slide is, therefore, swivelled in either direction by this amount for the two stages of the machining operation. As the arms have to fit accurately and without shake on the head lugs, it is advisable to leave the lugs slightly oversize so that they can be hand-fitted during assembly by careful filing with a smooth file followed by scraping or oil-stoning. The fitting should be completed at this stage, and during this process temporary hinge-bolts should be used.

The Pressure-Bolt

As shown in Fig. 8, this consists of a ¼ in. diameter stud threaded 2 B.A. at its foot and ¼ in. B.S.F. at the upper end. The two pressure pads are made from a piece of ⅜ in. diameter round rod filed down until it is semi-circular in section. The lower pad is screwed on to the stud, which is then riveted over, but the upper pad is made a free sliding fit.

The pressure-bolt can now be put in place in the arms assembled on the body, but, to enable the arms to move over the full range, the holes through which the bolt passes must be filed to an oval shape.

The Hinge and Pivot-Bolts

To give a neat appearance, all four bolts are turned from 2 B.A. nut-size hexagon rod, and it is essential that they should be made an accurate fit in their reamed holes. The lock-nuts fitted to the two hinge pins are made from No. 1 B.A. hexagon rod which measures approximately ⅜ in. across the flats.

Case-Hardening

The next step is to case-harden the two arms and the four bolts. As the wheel pivot-bolts are heavily loaded when the tool is in operation, these parts at any rate should be deeply case-hardened. It will save trouble, however, if all six components are packed with a case-hardening compound, such as Antol, in a cast-iron receptacle and then heated in accordance with the manufacturers' instructions. If, after hardening, it is found that the parts fit too tightly, the pivot-bolts can be polished with a strip of worn abrasive cloth, but the arms are refitted by using an oil-stone or an India stone to remove the high spots. In this connection, it will be noticed that a spring for opening the arms has not been fitted; the reason for this is that if the pressure of a small spring will move the arms, the fitting is not then sufficiently close to give the tool full working rigidity.

The hinge pins are fitted with lock-nuts as well as being screwed into the arms; this allows the slots to be closed by a very small amount to counteract wear, but will hardly make up for indifferent fitting. The tool described has been in use for many years, but as yet there is no discernible shake in any of the moving parts. It might be thought that, for adjusting the tool, a knurled finger-nut would be more convenient than the hexagon nut shown, but when the knurls are set to the work while the lathe is in motion, the fingers may be perilously near to the jaws of the rotating chuck and it is then safer to use a small spanner.

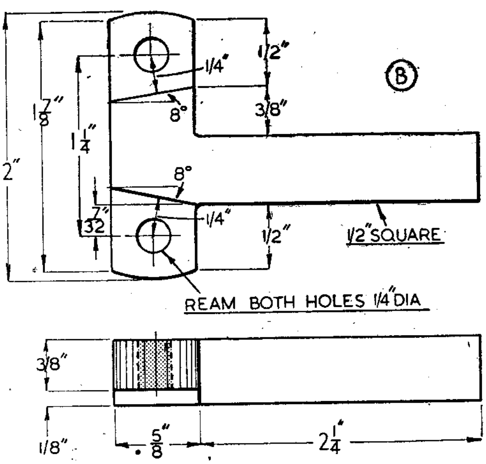

Fig. 7. Constructional details of the body

The Tool in Use

In the course of machining a part such as an adjustable index collar for a feed screw, one operation will be to knurl the rim to provide a finger-hold; therefore, to avoid having to scrap the work when partly finished, it is essential that the method of knurling adopted should be certain in action and should also provide for the correction of any faults that may arise.

The difficulty most commonly experienced when knurling is that both wheels do not keep in step with the work. When this happens, the wheel on its first revolution makes a regular impress, but on the second revolution the tooth marks are formed between those previously cut, and this false knurling will be continued right along the work unless corrected at the start. After the part has been turned parallel and true, the knurling wheels are set across the diameter of the work to engage for a distance of ⅛ in. or slightly less. With the lathe running in the slow direct speed, the pressure-bolt is tightened with a spanner for some quarter of a turn after both wheels have started to revolve. The lathe is then stopped and the work is examined; should the knurling be found to be irregular, the lathe is

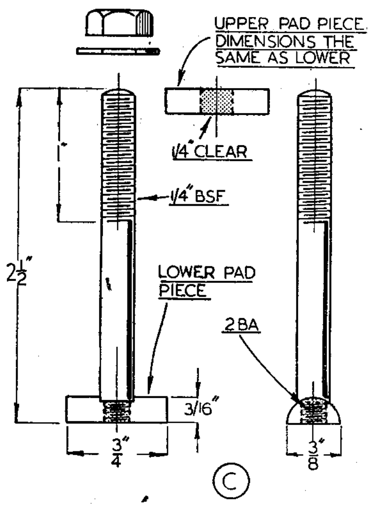

Fig. 8. The pressure-bolt

again started, and the pressure is increased. These operations are repeated until the knurling is satisfactory on the extreme end of the work, then, and only then, is the tool traversed along the work for the required distance.

Several traverses of the tool are usually needed to form the finished impress, particularly when coarse knurling is undertaken.

Although it is usually considered inadvisable to remove the tool from the work until the knurling is completed, no difficulty will as a rule be found in getting the wheels to pick up the pattern should they have to be re-applied to the work.

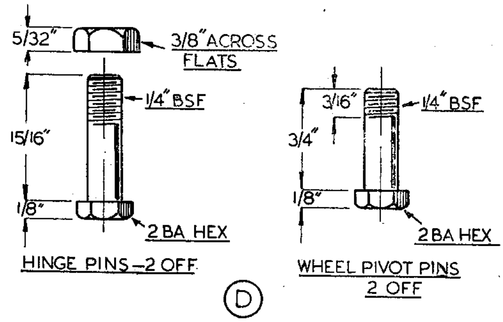

Fig. 9. Left—the arm hinge pins. Right—the wheel pivots

An even simpler method of starting the knurls correctly can be used, and this proved successful in every instance when a length of ⅝ in. diameter round mild-steel was knurled as an experiment.

After each test, the end portion of the rod was remachined to remove the knurling and a fresh trial made. In this way, the diameter of the rod was altered five times in all, so that there was no question of the work diameter matching the pitch diameter of the knurling wheels. The method adopted consists in lightly closing the knurls across the diameter of the work while stationary; the tool is then disengaged by moving the saddle towards the tailstock. Next, the pressure-nut is tightened for some quarter of a revolution, and with the lathe running, the tool is traversed along the work for a short distance. The lathe is now stopped and the work inspected. Should there be any sign of double-cutting, the tool is again withdrawn in the direction of, the tailstock and the pressure-nut is further tightened. When the knurling pressure is adjusted in this way, with the work stationary, there is no need to use a spanner as a matter of safety, and instead, a knurled finger-nut can be fitted for greater convenience in working. The greater depth of cut resulting from the increased pressure applied will serve to keep the knurls in step with the work, and it then only remains to traverse the tool and adjust the depth of cutting to complete the knurling operation satisfactorily.

A Hand-Driven Generator

Messrs. Leslie Dixon & Co., Electradix House, 214, Queenstown Road, Battersea, S.W.8, have submitted to us a sample *ex*-Government d.c. hand-driven generator having an output of 6 V, 5 A, d.c., and fitted with hand-gearing, which enables this output to be obtained at a crank speed of 100 r.p.m. This is a very well made piece of apparatus, and could be adapted as a wind-driven dynamo, or by removal of the hand-gearing, could be driven by a small engine or motor for purposes of charging small batteries. It could also be used as a vehicle lighting dynamo. The machine weighs only 7 lb. and is sold at a low price, which bears little relation to its original cost.