IN THE WORKSHOP

by "Duplex"

*42—Gear-cutting in the Lathe

BOTH the operation described for relieving the front edges of the cutter teeth and the succeeding operation for relieving the flanks of the teeth will be faciliated, and the possibilities of error reduced, if an adjustable form of stop is fitted to the lathe cross-slide to control its inward movement in a positive manner.

An easily made and fitted stop, for use with the Drummond type lathe, is illustrated in Figs. 32 and 33, which shows the stop in position and also its component parts. Here, the base (A) of the attachment is secured in place by the $\frac{3}{8}$-in. Whitworth bolt (B) inserted in one of the threaded holes normally used for clamping the travelling steady in position. The actual stop (C) slides on the threaded spindle (D), and is locked in position by tightening its clamp-bolt. To afford a means of fine adjustment, and to give greater security, a locking collar (E), threaded 40 t.p.i., is fitted to the threaded spindle.

There is usually no difficulty in fitting an adjustable stop of this type to lathe saddles of other patterns, but as an alternative, it may sometimes be found simpler to fit to the keep-plate of the cross-slide a fine-thread stop-screw, which impinges on the front face of the saddle and thus controls the movement of the slide.

It is advisable, when fittings stops, to position them as close as possible to the feed screw concerned in order to overcome any tendency for the slide to tilt, but the attachment illustrated has been fitted to one side to make room for the automatic cross-feed device which is normally kept in position ready for use.

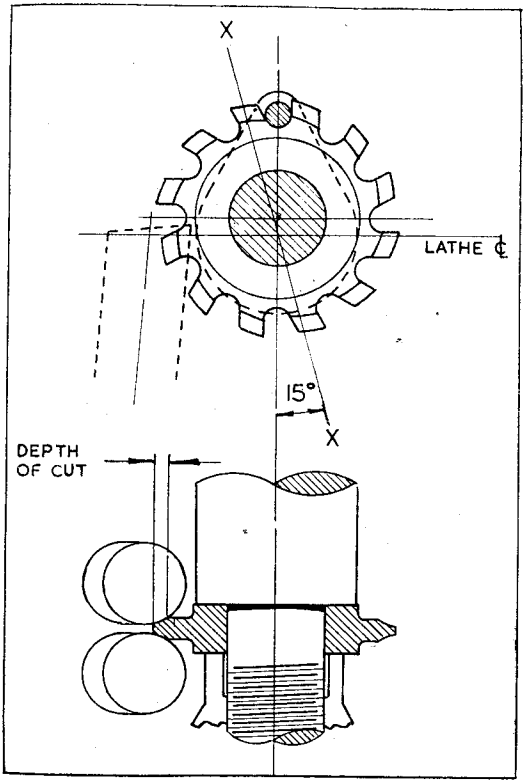

Fig. 31. View showing mounting of cutter and relation to forming pins. Note axis XX coincides with axis XX in linkage view

In passing, it may be noted that Fig. 31 shows the method adopted for the end-location of the cross-slide gib strip; in addition, the hexagon-headed screws for locking the top slide, and the lever locking-screws for the saddle can also be seen.

The next operation, illustrated in Figs. 29 (G) and 31, is, with the aid of the form tool, to relieve the flanks of each tooth in turn. Reference to Table A will show that, for the cutter under consideration, the diameter of the cutter pins fitted to the tool is $\frac{10.26}{40}$ which equals 0.2565 in., and the centre distance between the pins is $\frac{11.03}{40}$ or 0.2757 in.

Set the form tool with its cutting edges at centre height, and bring it up to the cutter blank, as shown in Fig. 29 (H), so that the pins make contact equally with the corners of the blank at the level of the tooth's flat, radial face. Then set the cross slide index to zero and lock it in that position.

Before the actual machining is begun, it is essential to lock both the saddle and the top slide to prevent any traversing movement during the shaping of the cutter teeth; this leaves the cross-slide alone free and able to move in the direction required for the relieving operation. Start the lathe and feed in the form tool carefully so that it takes a small cut each time the work rocks forwards. Again, as shown in Table A, the amount of this in-feed (E) is equal to $\frac{2.88}{40}$ that is 0.072 in.

If an adjustable stop is fitted to the cross-slide, it should be set by means of the feed screw index

*Continued from page 59, "M.E.," July 14, 1949.

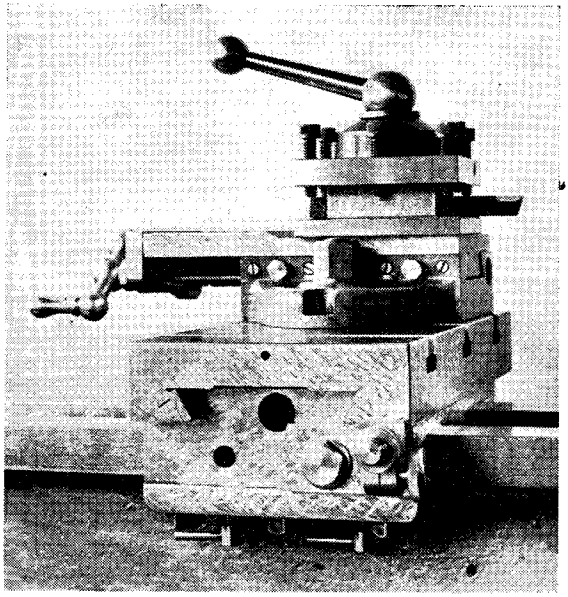

Fig. 32. Back of the cross-slide, showing stop in position

to limit the feed-in to this figure. Thereafter, when machining the remaining cutter teeth, the cross-slide is fed up to the stop and the index need not be further consulted.

It may not be possible to machine the first tooth to the full depth owing to interference from the tooth below, but when the remaining teeth have been relieved it will be found that the machining of this tooth can then be completed.

Where a cross-slide stop is not fitted, great care must be taken to cut all the teeth to exactly the same depth by making use of the cross-slide index.

As the machining of each tooth is completed, the clamp-nut on the arbor is slackened and the cutter is advanced one tooth on the register pin; the clamp-nut is then retightened, and this procedure is continued until all the teeth have been relieved, thus finishing the machining of the cutter.

Hardening the Cutter

The next operation is to harden and temper the cutter, and after the teeth have been sharpened, as will be described later, the cutter will be ready for use.

Before the carbon-steel cutter is hardened, it may be found advisable to anneal it to remove stresses present in the material. As an alternative, the cutter blank or the material as a whole can be annealed before the teeth are machined; this procedure has the advantage that the cutting edges are not damaged by the scaling of the metal which normally occurs during the heating process. Furthermore, annealing will remove any undue hardness of the steel which would increase the difficulty of machining the cutter blank.

Annealing is carried out by heating the steel to a bright red and then allowing it to cool very slowly. A small electric furnace, designed to attain the temperature required, will provide an ideal means of heating small components like gear-cutters, but a gas blow-pipe or petrol or paraffin blow-lamp will be found satisfactory for this purpose, if the work is well packed round with pieces of fire brick or asbestos cubes in order to promote slow cooling. On the other

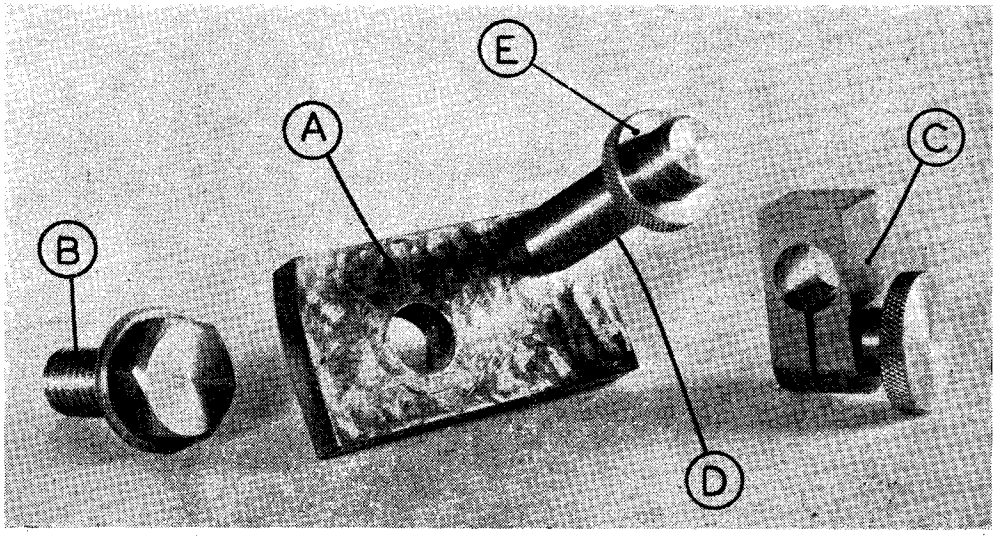

Fig. 33. Component parts of the adjustable cross-slide stop

hand, direct exposure in a coal fire may damage the steel owing to the sulphur present in the fuel.

After annealing, the temperature of the finished cutter is raised to a bright cherry red and it is then quickly quenched in cold water. A length of iron wire should be attached to the work to enable the cutter to be dipped into the water edge-first, for if the cutter is immersed while lying flat, it is possible that the sudden cooling will cause considerable distortion.

To make sure that the hardening operation has been effective, the heel of one of the cutter teeth should be tried with a file ; if the file slides over the work surface without cutting, it may be assumed that the hardening is satisfactory ; if, on the other hand, the tooth can be filed, then it is too soft and the cutter must be re-annealed

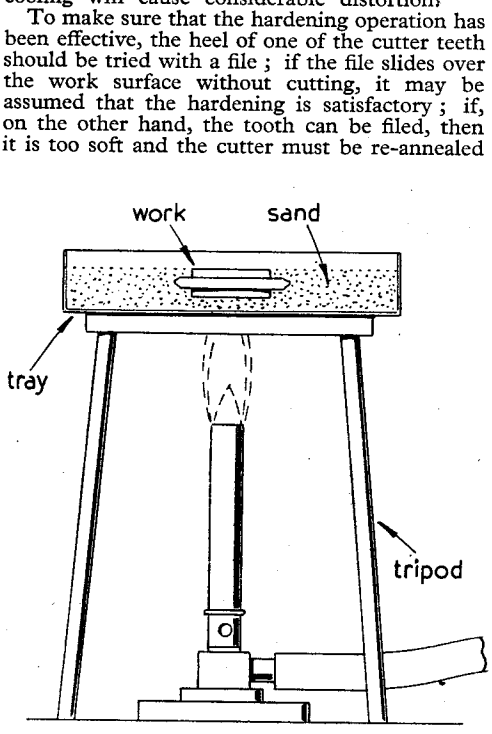

Fig. 34. *Apparatus for tempering cutters*

and afterwards hardened at a rather higher temperature.

The hardening, of course, leaves the teeth too brittle for use, and the cutter must be tempered before it can be put to work.

Tempering to a yellow or straw-yellow colour will in part remove the brittleness, but will leave the teeth sufficiently hard for machining steel gear wheels. It is important that the tempering operation should be conducted so as to heat the work evenly, thus leaving all the teeth with the same degree of hardness. This is, perhaps, most easily effected by heating the work in a sand bath, as it is termed, although a metal plate is sometimes used for this purpose by more experienced workers.

The illustration, Fig. 34, shows the type of sand bath in common use. The tray, resting on the tripod, contains a thick layer of fine, dry sand, and the heat is supplied by a gas Bunsen burner. To enable the colours forming on the surface of the heated steel to be readily identified, the cutter should be cleaned with a strip of worn emery cloth before being embedded in the sand with only its upper surface exposed. As the heat is applied, the surface of the work is carefully watched, and as soon as the required tint appears the cutter is quickly withdrawn and quenched in cold water.

Should the cutter have been made of mild-steel, it will have to be case-hardened and then tempered before use. For this purpose, several well-known case-hardening compounds are available and all will give satisfactory results. The compound "Antol" is especially useful, as it is quick in action, and, after quenching, the work is left with a smooth pearly-grey surface.

A thin layer of case-hardening can readily be obtained by covering the part with the compound and then heating it on the open hearth with the aid of a blow-pipe or blow-lamp ; several applications of the compound should be made in order to increase the depth of the layer of hardening steel formed.

Where still deeper case-hardening is desired, the work is closely packed with the compound in an iron container, such as a discarded cast-iron piston or an old electric fuse box fitted with a cover. In this case, the container can be heated to a red heat in an open coal or coke fire for a period of half an hour or more, depending on the depth of hardened case required.

If several rods of the same material as the work are inserted through holes in the lid of the container into the hardening compound, one can be withdrawn at any time to test the progress of the case-hardening process. On withdrawal, the rod is quickly quenched and then broken across in the vice. The depth of the hardened layer will then be readily apparent from the alteration in the structure of the steel seen at the site of fracture. Whichever case-hardening method is used, the work at the end of the heating process is quenched in cold water, as when hardening ordinary carbon steel.

The case-hardening process must, in this instance, also be followed by a tempering operation carried out in the manner already described for carbon-steel.

Marking the Cutter for Identification

Although a gear-cutter can be identified, with regard to the diametral pitch and the number of gear teeth it is adapted to cut, by engaging it with the corresponding form tool, it may save time and unnecessary trouble if these particulars are marked on the cutter itself.

Likewise, to save having to measure the diameter and distance apart of the cutter pins of the form tool in order to establish its identity, it is advisable to indicate on the shank the exact purpose for which the tool is intended.

These particulars can be marked on the form tool with figure and letter punches ; but where these are not available, and when the hardened gear-cutter has to be marked, an etching process is usually employed.

Metals can be readily etched by the application of strong acids, whilst to confine the action of the acid to the outlines of the figures or letters required, a substance, termed a resist, is applied

to the surface of the work and the inscription is scratched through this layer with a pointed tool or style.

Recipes culled from text books include pyroligneous acid, glacial acetic acid, Burgundy pitch, asphaltum and gum mastic as appropriate materials, but experience has shown that commercial nitric acid is a suitable etching fluid and beeswax an excellent resist.

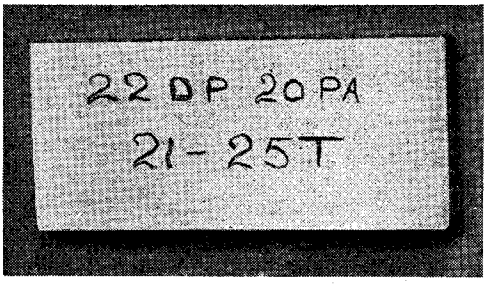

Fig. 35. An inscription etched on steel

Before applying the wax, the surface of the metal should be well cleaned with metal polish to remove any grease. The work is then warmed over a spirit lamp and the wax is rubbed on until a flat, even coating is formed. For fine writing, an ordinary sharp scriber can be used but if thicker lettering is required a style with a rounded or square point will give better results ; at the same time, care should be taken to ensure that the marking tool penetrates right through the wax and exposes the surface of the underlying metal.

The etching is best carried out with diluted nitric acid, using one part of acid to two parts of water. The acid is applied with a small piece of cotton wool twisted on to the end of a match stick to form a swab ; this enables the inscribed furrows to be filled with acid without damaging the wax coating.

As soon as the acid attacks the metal, bubbles will appear, and after a time these should be brushed away with the swab to bring fresh acid into action.

It will usually be found that the etching has reached a sufficient depth after the acid has been in contact with the metal for half an hour. The work is then well washed in water to remove all trace of acid, and the wax is brushed off with a rag moistened with lighter fluid.

The appearance of a piece of steel etched in this way is shown in Fig. 35, but the irregularity of the lettering is due to indifferent writing and not to any fault in the process itself.

Nitric acid, it should be remembered, not only attacks steel, but will also burn holes in the skin or clothing with equal facility.

To avoid any possibility of error, it is advisable, as illustrated in the photograph, to inscribe both the form tool and the cutter with its diametral pitch, also the pressure angle and the number of gear wheel teeth it is adapted to cut.

On larger work and where neat lettering is essential, a stencil may be used instead of free-hand writing.

The smallest size Uno stencils used by draughtsmen have capital letters and figures only 3/32 in. in height, and when these are used as an aid to engraving, a style of the same diameter as the standard Uno pen should be employed for tracing the inscription.

Before the cutter is brought into use, it is advisable to sharpen the cutting edges of the teeth ; in the next article, therefore, a simple method of honing the tooth faces will be described which ensures accuracy without the need of employing a cutter grinding machine.

(To be continued)

"In Town Tonight"

THE spectacle of a dark green van, somewhat resembling an ambulance, surrounded by a dozen or so cars, with the whole of the local population and most of the local constabulary in attendance, does not necessarily indicate a road accident or murder. On July 9th, some members of the Society of Model and Experimental Engineers were witness to the fact that it can mean merely that the B.B.C. is going visiting ; and on this occasion, two venturesome members of the constabulary, following the tangle of cables down to the basement of No. 20, Nassau Street, W.1, found themselves in the society's smoke-filled workshop. Having approved, with some misgivings, the spectacle of the society's engine No. 1928 churning away laboriously at the rollers of the new test stand, the applied load of 40 lb. giving rise to a shattering display of noise and vibration, they returned hurriedly to the purer atmosphere and safer occupation of directing cruising taxicabs clear of the model traction engine which was bowling merrily up and down the street outside.

As an " Intownee," I am craving this small corner to place on record, on behalf of those in the society concerned in the broadcast, our appreciation of the courtesy, good humour, and patient understanding of our difficulties and limitations, shown by Mr. Brian Johnston and his technicians.—" 1121."