IN THE WORKSHOP

by "Duplex"

*44—Gear-cutting in the Lathe

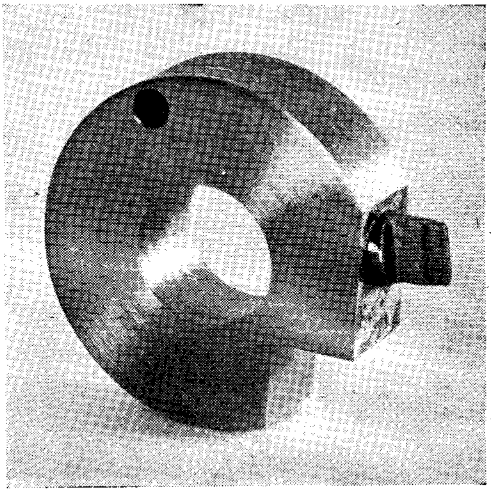

Fig. 43. *Fly-cutter mounted in circular carrier*

THE methods employed for mounting and driving the small circular gear-cutters made in the workshop were considered in the previous article, but reference to an additional feature commonly found in commercial cutters should not be omitted; that is to say, the presence of a keyway to enable the cutter to be positively driven by a key fitted to the cutter arbor.

Mounting the Cutter

The design of both the cutter and its arbor, as already described, should afford a sufficiently secure frictional drive for all ordinary purposes if the arbor clamp-nut is firmly tightened while the arbor is gripped in the vice.

If, however, it is considered that a positive form of drive is necessary, then a key is fitted to the arbor to drive the cutter.

Although a No. 31 drill was specified as being the next smallest drill below ⅛ in. in common use, this and other reaming operations will be facilitated if a drill more nearly to the size of the finished hole is employed.

A No. 31 drill has a diameter of 5 thousandths of an inch below ⅛ in., but drills of the Dormer brand are readily obtainable in diameters of 3.1 mm. and 3.15 mm. which are less than ⅛ in. by 3 and 1 thousandths respectively.

The key shown in the drawing is fitted flush at one end of the cross-hole, and at the other, the rounded end projects for a distance of 3/32 in. The keyway in the cutter, illustrated in Fig. 42C, is formed to shape with a small round file

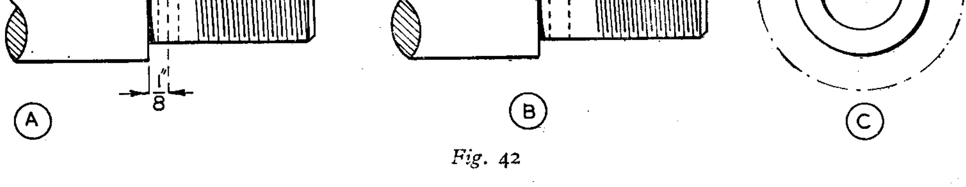

Fig. 42

In the present case, as shown in Fig. 42A, the arbor is cross-drilled with a No. 31 drill and the hole so formed is enlarged with the tip of a ⅛-in. reamer, until a short length of ⅛ in. diameter silver-steel can be lightly pressed into place in the vice to form the key illustrated in Fig. 42B. Do not use undue force when pressing in the key, as this may result in bending the arbor and distorting the cutter seat.

so that its sides are parallel and it fits the key closely; the bottom of the keyway is rounded and should be filed to clear the end of the key.

Furthermore, it should be noted that the keyway is cut directly opposite a tooth, and although in the present instance the location is not of great importance, this procedure should always be followed when cutting keyways; for a small cutter or other similar component may be considerably reduced in strength if the keyway is formed where there is insufficient surplus material.

*Continued from page 191, "M.E.," August 11, 1949.

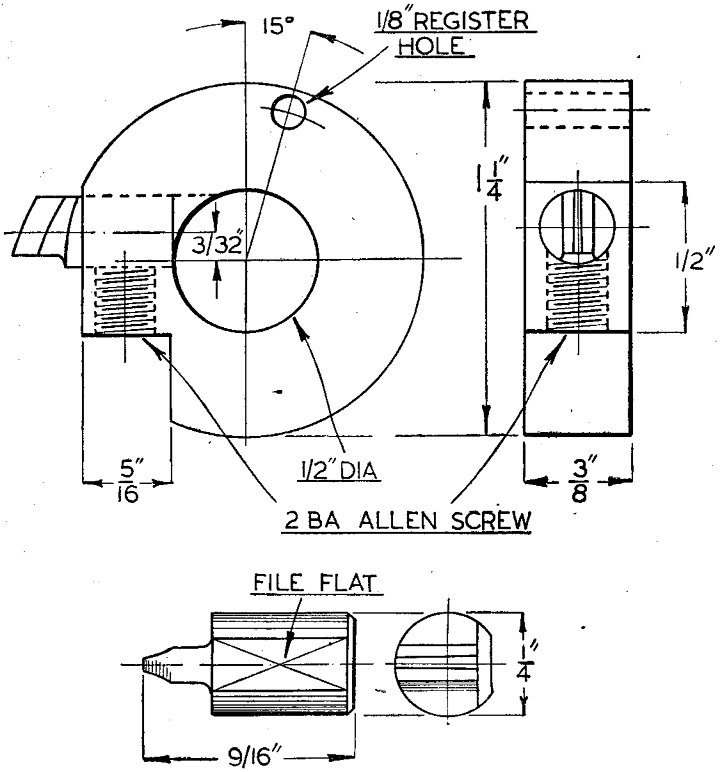

Fig. 44. *Fly-cutter and circular carrier*

machining the body are represented in the operational drawings in Fig. 45.

The cutter body is turned from a length of mild-steel, and is bored and reamed to fit the eccentric and other arbors as well as the jigs already made.

After the 1¼-in. disc has been parted off to a length of ⅜ in., it is mounted in the drilling jig for forming the hole to engage the register pin fitted to the eccentric arbor.

The disc, together with a circular gear-cutter, is next mounted in the sawing jig, so that the position of the cutter tooth lying at 105 deg. from the register hole can be marked on the face of the disc. This procedure is to ensure that the fly-cutter is correctly located in relation to the eccentric mechanism used for relieving the cutting edges.

As shown in Fig. 45 (3), a line is scribed from

Making Fly-cutters

As previously mentioned, fly-cutters may be used for gear cutting, particularly where small teeth are cut in materials such as brass and aluminium; moreover, a simple cutter of this type will often be found fully effective for machining steel and cast-iron gears when only a small number of teeth has to be cut.

The advantages gained are that only one cutter tooth need be machined to shape; also, any of the cutters so made can be mounted in a single holder to form a complete gear cutter.

In addition, the hardening, tempering and sharpening processes are more readily carried out, and there is less danger of the cutter being damaged by cracking or distortion during the quenching operation.

If, as shown in Fig. 43, the body of the cutter is made like that of a circular gear-cutter, then it will be possible both to relieve and sharpen the cutter-bit by using the appliances already made for this purpose.

Reference to the working drawings in Fig. 44 will show the dimensions of both the cutter body and the inset cutter, whilst the successive steps in

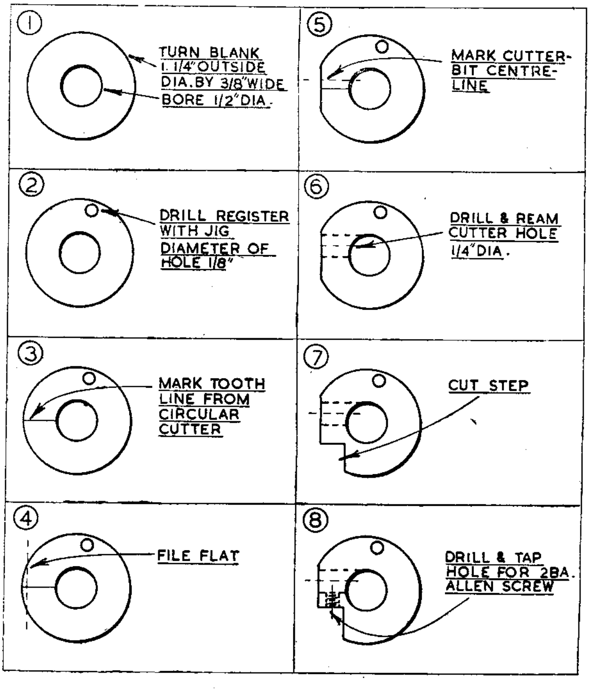

Fig. 45. *Machining the fly-cutter carrier* the outer end of this tooth line towards the centre of the bore, in order to denote the position of the inset cutter-bit; the centre-line of the cutter is then marked-out by scribing a line 3/32 in. above the previous line.

Next, a flat, ½ in. in length, is filed at right-angles to the cutter centre-line, and when the latter line has been continued across the filed flat, a hole is drilled at its centre and then reamed ¼ in. through to the bore to receive the fly-cutter.

Following this, the step shown in the drawings is cut out to allow the 2 B.A. Allen clamping-screw to be fitted. This completes the body of the cutter, and it now remains to make the fly-cutter itself.

The fly-cutters are made from ¼ in. diameter round silver-steel in accordance with the drawing

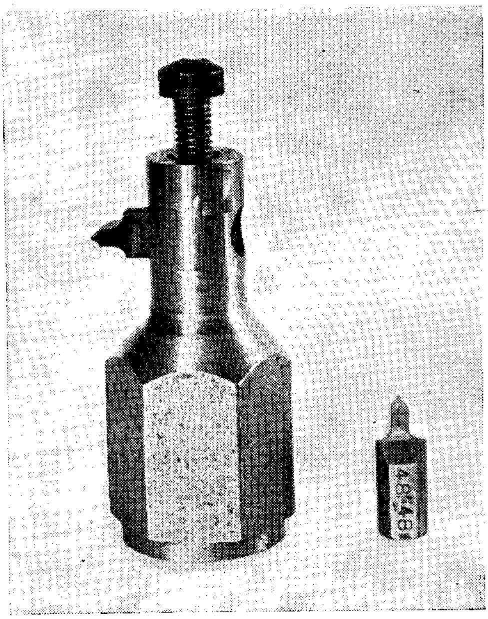

Fig. 46. Alternative mounting for fly-cutter

in Fig. 44, and it will be seen that a flat is formed on the lower surface to afford a seating for the clamp-screw which thus locates the cutter correctly. When the short length of steel has been securely clamped in the cutter body, it is machined and the tooth is relieved in exactly the same manner as described for making a circular gear-cutter.

After the finished fly-cutter has been hardened and tempered, it is again secured in its carrier, and the latter is mounted on an arbor to enable the honing jig to be used for sharpening the cutting edges. It will, however, be found that the gap in the table of the honing jig must be enlarged to accommodate the fly-cutter.

In order that gear teeth may be machined as rapidly as possible, the fly-cutter should be run at the maximum cutting speed; this in the case of a silver-steel cutter will be some 50 ft. per minute for steel; and it follows that if the radius of the fly-cutter is halved, the number of its revolutions per minute can be doubled for the same cutting speed. This in effect means that the shorter cutter has the equivalent of two cutting teeth for the single tooth of the longer cutter mounted in the manner already described. When the fly-cutter is mounted as represented in Fig. 46, its turning radius is reduced to ⅜ in. as opposed to ¾ in. when the large circular carrier is used.

The arbor seen in Fig. 46 is made to screw on the mandrel nose of the lathe or milling machine, but it can equally well be held in the lathe chuck. This fly-cutter and arbor were used for cutting the gear wheels depicted in Fig. 48.

This form of mounting is quite effective for light gear cutting, provided the lathe has a rigid mandrel and support from the tailstock centre is not necessary. A special arbor, however, must be made for carrying the cutter when relieving its cutting edges. For this purpose, a mandrel, similar to that shown in Fig. 46, is made, but instead of drilling the cross-hole on the centre-line as shown, this hole is drilled some 3/64 in. above centre for cutters of ⅜ in. radius; this has the effect of mounting the cutter eccentrically, so that after the tooth has been machined in this position, it will have the requisite clearance or relief when the cutter is mounted in its working position on the centre-line of the mandrel.

The marking-out and drilling will be facilitated if a flat is formed on the side of the arbor, as was done in the case of the large cutter carrier.

When the cutter-bit is located above centre in this way, its cutting edges can be relieved by an ordinary continuous turning operation using the two-pin forming tool, and the intermittent motion imparted by the eccentric rocking gear is not required.

Fly-cutters made in this way can equally well be used in a cutter-frame of the type previously described.

Lubricating the Gear-cutter

When machining the profiles of the cutter teeth with the relieving tools, the finish imparted to the tooth flanks and cutting edges will be greatly improved, and the accurate machining of gear teeth in general will be facilitated, if a small but constant supply of suitable cutting oil is fed to the work. Amongst other lubricants and cutting fluids, Houghtolard or Cutmax will be found to give excellent results; moreover, an important consideration in the small workshop is that these fluids do not cause rusting of the tools or lathe slides.

Commercially, a steady stream of cutting fluid is fed under pressure to the work-face by means of a suds pump. This procedure, however, is not as a rule applicable in the small workshop, nor is it really necessary, for the large volume of cutting fluid is employed mainly to dispel the heat arising during the rapid machining normally undertaken, and only a relatively small supply of oil is necessary to lubricate the tool effectively at a slower rate of working.

Applying the oil with a brush may be a tedious proceeding, and moreover, the bristles will be cut off by the cutter teeth; the alternative of

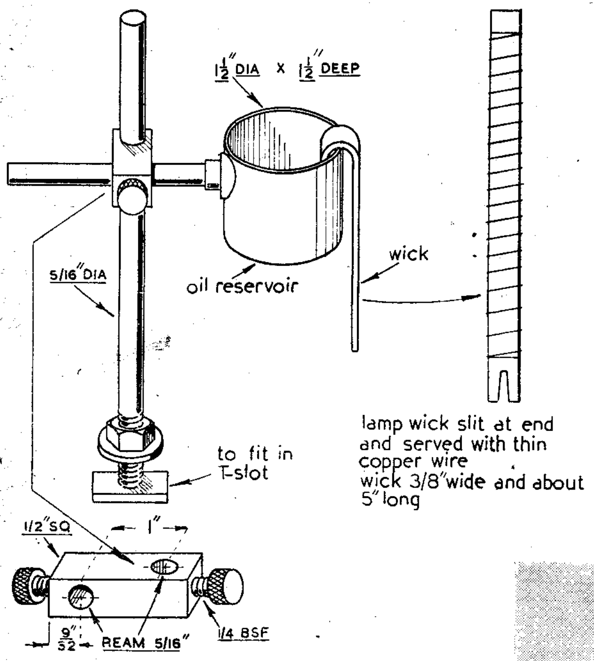

Fig. 47. *A wick oiler for lubricating the gear cutter*

using a continuous drip will not only waste oil, but will also entail unnecessary work in cleaning the lathe.

The form of oil feed illustrated in Fig. 47 can be readily set in any position when attached to the lathe saddle, and the wick will supply a constant supply of cutting oil from the container to any part of the work; in addition, the supply of oil can be automatically maintained when turning a long shaft as the appliance travels with the saddle.

The pillar is secured to one of the cross-slide T-slots by means of its foot-piece and clamping-nut. The construction of the container enables it to be set at both the correct height and overhang and then locked in position by means of the clamp-screws fitted to the sliding bracket. The oil is fed to the work through a length of lamp wick or a strip of felt, which is served with thin copper wire to stiffen it and keep it in contact with the work. After being wound on, the wire coils are pinched flat with the fingers to preserve the original form of the wick, as shown in Fig. 47. The prepared wick is then bent into the shape of an inverted V so that it will hang from the lip of the container with one end submerged in the oil.

The rate of feed will be quickened owing to greater syphonage action if the dependent limb of the wick is increased in length.

It will be noted that the wick is slit at its lower end to enable it to make contact with both flanks of the cutter teeth, and at the same time to keep properly in place. Should the rocking motion of the cutter cause the wick to jump upwards, a wire clip may be used to retain it in place.

Those who fancy a more elaborate form of adjustment can attach the container to its pillar by means of link arms fitted with spring loaded ball joints; this will afford a universal form of movement for quickly setting the position of the oil feed.

Gear-cutting Operations

When either the circular cutters or the fly-cutters made in the workshop with the aid of two-pin form tools are used for gear cutting, the method of machining the gear teeth on the wheel blank differs in one particular from that described in connection with commercial gear cutters; that is to say, an allowance, termed backlash and listed in Tables A and B already given, has to be added to the tooth depth cut in order to produce the correct tooth form.

The theoretical depth to which the

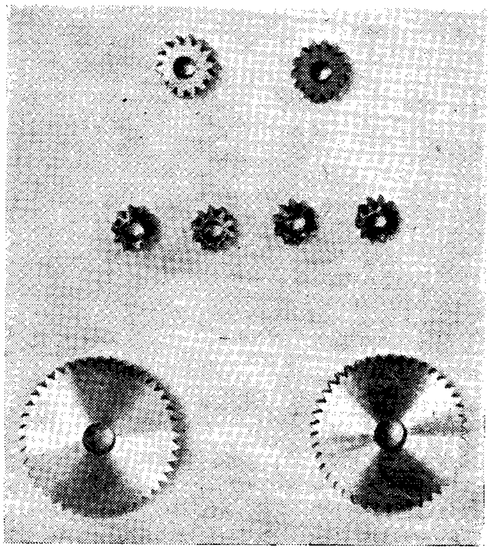

Fig. 48

gear teeth are cut, when using commercial gear cutters, was given previously in a table showing this dimension for gears of from 10 to 40 diametral pitch; but this can be readily calculated, for it is equal to the Constant 2.157 divided by the diametral pitch, so that the tooth depth of 10 D.P. gears is 0.2157.

It will be remembered that, as an example on a previous occasion, a description was given of making a form tool and gear cutter suitable for cutting a gear wheel having 30 teeth of 40 d.p. and 20 deg. pressure angle.

When this gear wheel is machined with the cutter described, the theoretical depth to which the teeth are cut is 2.157 divided by 40, or

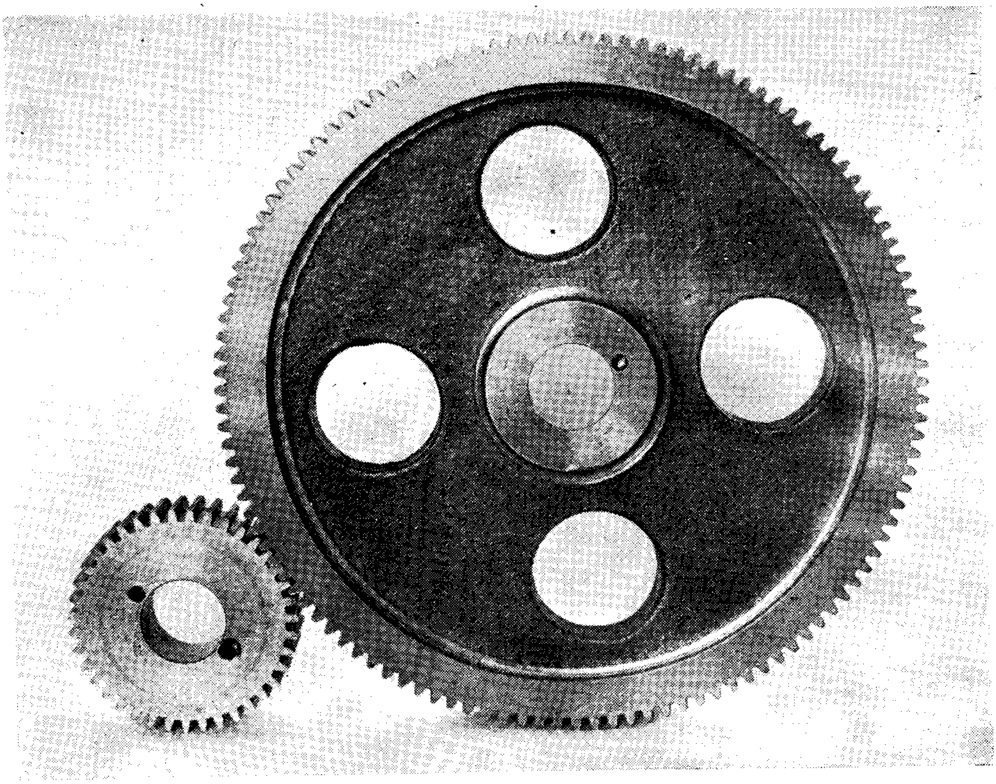

Fig. 49

0.0539, but to this the backlash allowance must be added. According to Table A, the backlash for a 40-tooth wheel of 1 D.P. is 0.070; therefore, it is 1/40 of this amount for 40 D.P., that is to say 0.00175, which added to the previous figure 0.0539 gives a total tooth depth of 0.05565.

In actual practice, the machine slide controlling the depth to which the teeth are cut would have its micrometer index set to 55½ thousandths of an inch.

Cutting Racks

A rack may be regarded as part of a gear wheel whose diameter is so large that the pitch circle has become a straight line, and in consequence the flanks of the teeth are almost, if not quite, straight-sided.

This results in the rack cutter form tool (A) in Table A having cutting pins of very large diameter, but in practice these pins are not made whole circles but segments only of circles which are attached to the tool shank at the specified centre distance apart.

With these cutters, racks of short length can be cut when the work is secured to the lathe saddle and the leadscrew feed is used to space the teeth. This will entail cutting the teeth to their full depth at a single passage of the work across the cutter, for no height adjustment is then available.

If, however, the vertical slide is brought into use, it can be employed to feed the work upwards against the cutter while the cross slide serves to regulate the tooth depth.

To obtain the correct spacing of the rack teeth, the diametral pitch is converted to circular pitch, which represents the centre distance between adjacent teeth measured on the pitch circle, but as this circle, as already noted, has become a straight line, a direct linear measurement can be made.

The circular pitch is obtained by dividing 3.1416 by the diametral pitch, and the more commonly used conversions are listed in the following table.

Diametral pitch	Circular pitch	Diametral pitch	Circular pitch
16	0.1963	30	0.1047
18	0.1745	32	0.0982
20	0.1571	34	0.0924
22	0.1428	36	0.0873
24	0.1309	38	0.0827
26	0.1208	40	0.0785
28	0.1122	42	0.0748

When the linear pitch of the rack has been obtained in this way, a reference card should be made out showing the position of each tooth space in relation to the reading of the leadscrew index.

If this precaution is taken, it should enable errors to be avoided during the cutting of the whole series of rack teeth.

The large wheels are made of bronze and have 42 teeth, whilst the small pinions having 10 and 14 teeth are machined from steel to premit their being hardened to reduce wear.

The two gear wheels shown in Fig. 49 were made for use as lathe change wheels; both are of 24 D.P. and were machined with circular gear-cutters made in the workshop by the method already described. The large wheel has 120 teeth and the smaller 39 teeth. The tooth contact faces are machined to a high finish, and as the teeth appear to mate very accurately, quiet and even running should be assured.

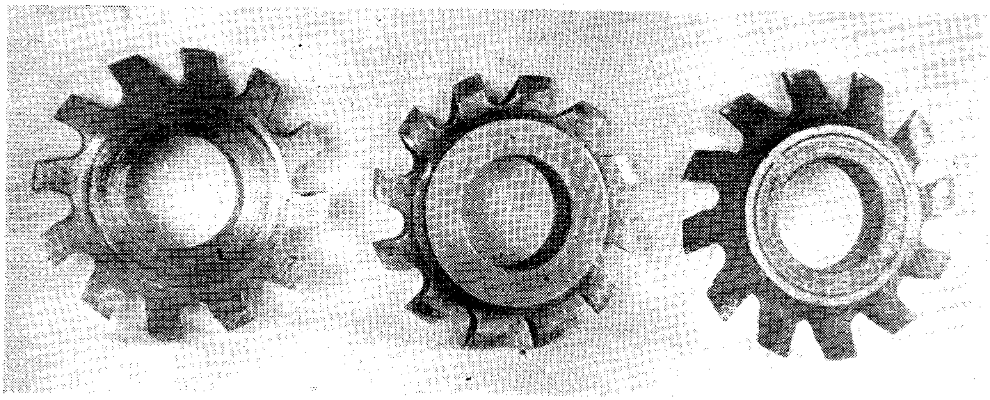

Fig. 50

Examples of Work

Most of the examples here illustrated were put at our disposal by Mr. J. Rodway, A.M.I.Mech.E, who it will be remembered very kindly gave us a full account of his method of making gear cutters.

The set of gear wheels and pinions illustrated in Fig. 48 were made for the drive of an electric locomotive. All the wheels are of 48 diametral pitch and were cut with fly-cutters of the type depicted in Fig. 46. To avoid having to undercut the teeth of the small pinions, in order to prevent interference when running, a pressure angle of 30 deg. was adopted.

Lastly, Fig. 50 depicts three gear cutters; that on the right is for cutting wheels having from 35 to 54 teeth of 34 D.P., whilst the cutter in the centre and the unfinished cutter on the left were made in our own workshop, together with all the necessary jigs, cutter relieving gear, and arbors which have appeared in the published photographs and drawings.

"L.B.S.C."

(*Continued from page* 248)

the faceplate on the lathe nose, run up the rest with the stay on it, then apply your try-square to the job, the stock resting on the faceplate. Set the edge of the stay to the blade, tighten the clamp, and you're all set. Replace chuck, put the end-mill in it, start the lathe, and traverse the stay across the cutter by means of the cross-slide handle, feeding into cut with the top-slide handle. Do the other end same way: and if you haven't a slide-gauge with which to measure the correct overall width, just cut a gap $2\frac{15}{16}$ in. wide in a bit of sheet metal (bit of tin would do) and use that for a gauge. Both ends could, of course, be carefully hand-filed, and the try-square used to make certain the sides were at right-angles to the top and bottom.

To make the stay from $\frac{1}{8}$-in. sheet or plate, saw out a piece $3\frac{11}{16}$ in. long and $1\frac{1}{8}$ in. wide. Scribe a line across this, $\frac{1}{2}$ in. from each end; then put it in the bench vice with one of the lines just showing at the jaws, and hammer the projecting $\frac{1}{2}$ in. over to a right-angle. The $\frac{1}{8}$-in. thickness of metal forming the angles, will bring the overall width to $2\frac{15}{16}$ in., which is correct. File away $\frac{1}{8}$ in. at top and bottom, as shown in drawing.

In either cast or plate stay, find the centre; make a pop-mark, drill it first $\frac{1}{8}$ in., then open out with a 15/32-in. drill, and tap the hole $\frac{1}{2}$ in. by 32 for the pump. Then place the stay between the frames, at the point where the three holes are drilled each side, the flanges overlapping the holes so that the screws will be central. The bottom of the stay should be level with bottom of frames, and the stay itself exactly vertical; test with the try-square. Then put the big cramp across the frames, to hold them tightly against the stay; run the No. 40 drill into the three holes each side, making countersinks on the stay. Follow up with No. 48 drill, tap 3/32 in. or 7 B.A., and put in countersunk screws to suit. That completes the frame erection, and the next job will be the axleboxes and springs, and the hornstays.