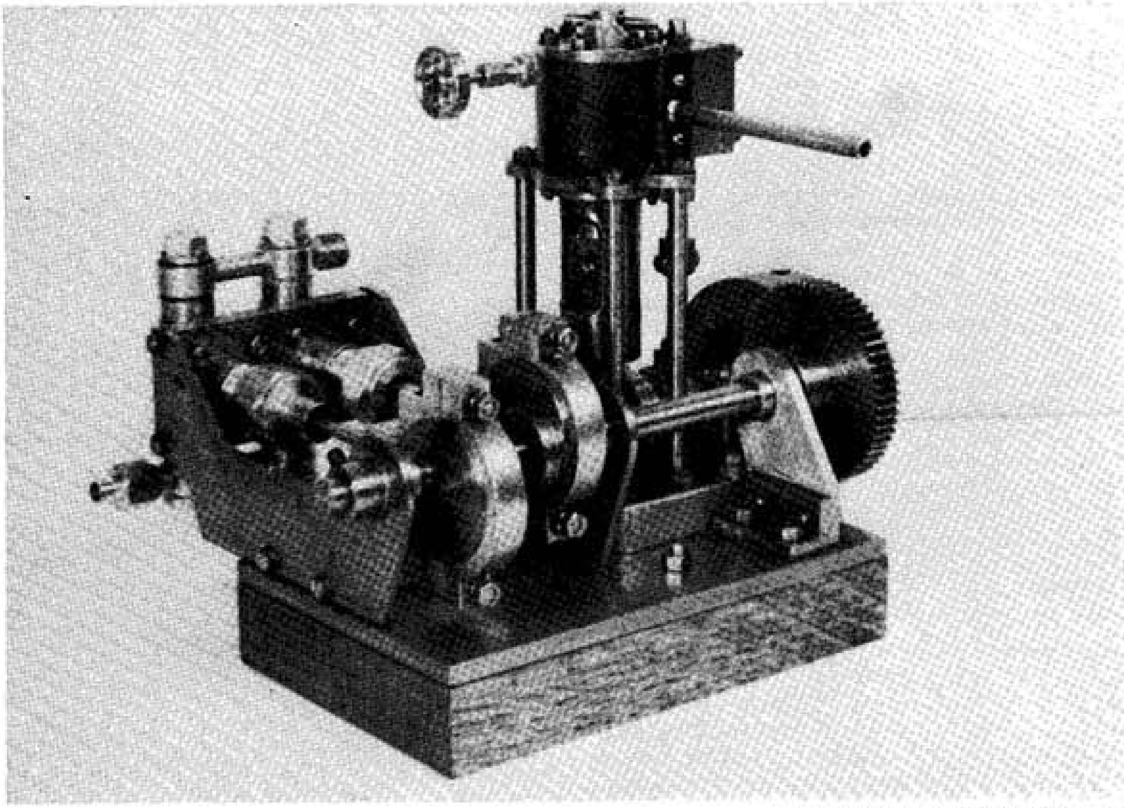


Fig. 2: Fitted with boiler feed pump

MORE UTILITY STEAM ENGINES

by J. P. Bertinat

THE SMALL VERTICAL ENGINE is perhaps the most versatile and widely used model steam engine, finding many applications, e.g. for marine propulsion, generator driving and also as a beginner's exercise. Among the existing designs for which castings are available (in addition to the deservedly popular Stuart Turner range) are the Trojan and the Warrior, both of which were described by the late E. T. Westbury in *Model Engineer* in Feb.-Mar. 1949. These are respectively a single-cylinder engine of ⅝ in. bore and stroke, and a twin-cylinder unit of ¾ in. bore and stroke, both engines having gunmetal cylinders. The gunmetal cylinders will stand up to considerable use with moderately superheated steam, and have the advantage that precautions against rusting up during long standing periods are unnecessary. Both engines were basically excellent designs, but in my opinion the bearing areas were rather small for continuous hard work and I have built both engines to modified detail design, incorporating the standard castings available from Messrs. A. J. Reeves of Birmingham.

I will deal first with the Trojan which is here illustrated. Fig. 1 shows the engine fitted with displacement lubricator and Fig. 2 shows the same engine built into a gear-driven boiler feed pump unit. In this case the engine serves as an auxiliary to a larger Stuart engine.

Older readers (like myself!) will possibly recognise the resemblance of the Mark II Trojan design to that of the Stuart Turner Simplex engine which was very popular with power boat enthusiasts until its production was alas discontinued in the late 1920s. It is of interest to note that the later version of the Simplex was fitted with a trunk guide as to be advocated for the Trojan II, but the design was spoilt by the form of crosshead adopted: a large part of its effective bearing area was cut away to provide a slot for the connecting rod small end. I had good service from one of these engines, driving a 4 ft. steam launch on the Round Pond in Kensington Gardens, and remember as a schoolboy, purchasing a set of machined castings and parts for the Simplex from Bassett Lowke in Holborn for the

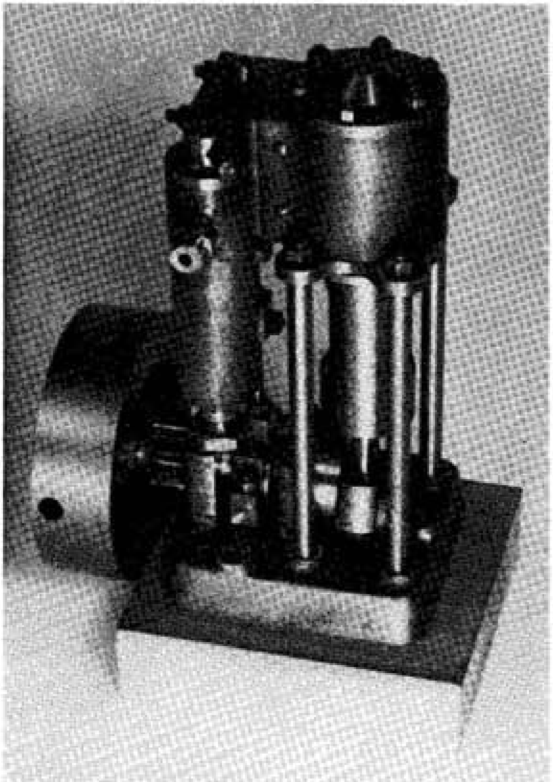


Fig. 1: Engine with displacement lubricator.

sum of 21s. — a lot of money in those days! Still reminiscing, a few readers may remember the outstanding performance of Will Savage's destroyer *Kismet*; this 4 ft. 6 in. model was powered by a Stuart Simplex driving twin screws. While on a recent visit to Stuart Turner's, their Director, Mr. A. Wadley, showed me a set of unmachined Simplex castings which had been recently recovered from New Zealand. I was given to understand that no patterns for the Simplex are now in existence, but I would like to see this engine revived in some form — perhaps this is sentiment, but I think not entirely so.

To return to the Trojan, the main area in which improvement was needed was in the crosshead and guides. The original design calls for a pair of ⅛ in. dia. guide bars which are entirely unsupported at their lower ends; these not only lack rigidity but will prove difficult to line up. Badly fitted crosshead guides are a prime cause of piston rod gland wear and of premature cylinder bore wear. Fig. 3 shows the General Arrangement of the redesigned or Mark II engine and it will be seen from this drawing and from the photographs that a trunk guide has been fitted. This was machined from steel bar and secured by its flange to the bottom cylinder cover. With this type of guide and with careful machining, alignment is obtained automatically. A bronze crosshead is fitted, of such design as to give adequate bearing area in the trunk guide.

The crankshaft and crankpin diameters have been increased from 3/16 in. to 5/16 in., and all moving parts have been stiffened up without (I hope) making them appear clumsy. Some designers criticise the overhung crank on the grounds that it produces a heavy load on the adjacent crankshaft bearing, but in the present case sufficient bearing area has been provided to give a long working life, provided that lubrication is attended to. In any case the bearings are plain unsplit bushes which may be renewed with comparative ease should the necessity arise.

The gunmetal flywheel fitted to the original Trojan engine has been replaced by a larger cast-iron wheel similar to that specified for the Warrior engine, since the boss of the gunmetal wheel was too small to accept the increased bore. Reference to Figs. 1 and 3 shows that a pinion has been fitted for driving a boiler feed pump (I prefer to see feed pump provision incorporated into the original design rather than, as is often the case, tacked on as an afterthought). To avoid the increased overhang that would result from using a separate boss and fastening for this pinion, its elongated boss is a press fit in the hub of the flywheel, and a single Allen screw serves to secure both to the crankshaft. An additional advantage of the alternative flywheel is that its outer face is flat and is thus useful for fitting the pin coupling usually employed in marine drives. It is realised that the pinion used is not a standard commercial item (I usually cut my own), but a similar arrangement could be made with a standard gear, the boss in this case not extending the full length of the flywheel boss; I will detail this alternative.

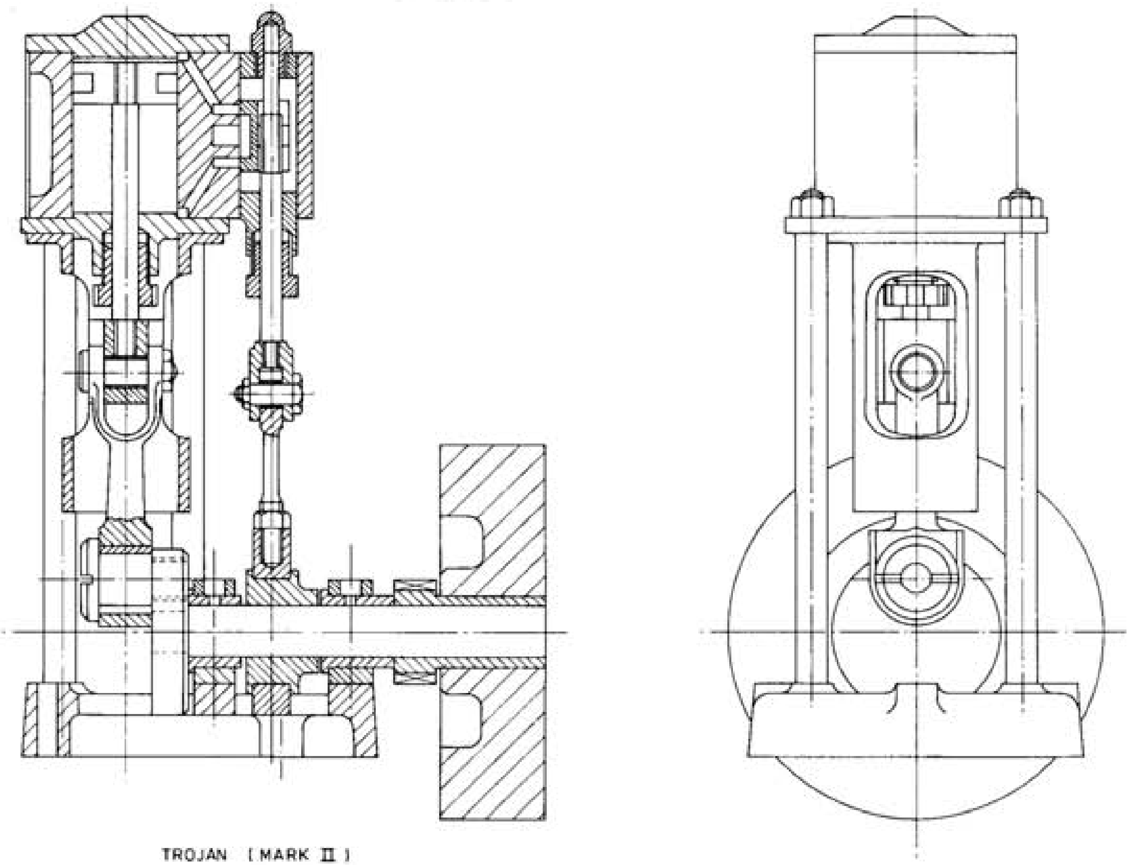
The slip eccentric reversing gear which featured in the original design has been dropped; it is not normally required, and as I have found out with my Reeves Co Monarch engine, it sometimes makes starting up a bit tedious especially when clearing the condensate. In any case the design of the crankshaft is only really suitable for clockwise rotation viewed from the flywheel end, since otherwise the crankpin will tend to unscrew with disastrous consequences. Another wear-reducing feature has been introduced into the valve gear, viz., a tail guide for the valve spindle.

Details of Construction

Fig. 4 shows the Reeves castings used in the construction of the engine and Fig. 5 shows details of the cylinder block and its covers.

Cylinder Block. Fig. 5.1

For the first operation, this component may be mounted in a four-jaw chuck and set so that it is



TROJAN (MARK II)

Fig. 3

Scale 2:1

0·19" Valve Travel
0·055" Steam Lap } 60 % Cut Off

square to the chuck face and the outer flange is running truly (this is safer than setting by the cored bore although the latter seems quite central in the casting I have in front of me). When all is secure and the lathe is started up, both flanges and the body of the cylinder should appear to run truly, and if this is the case a facing cut may be taken over the cylinder flange, of sufficient depth to clean up the casting. We now come to the all important operation of boring. Fig. 6 shows a cylinder set up for boring, and another which has just received similar treatment is resting on the boring table. For the purpose of taking the photograph, the top slide of the lathe has been removed to show the "Duplex" rear tool post and boring bar holder in position. Readers may recognise the Drummond 3½ in. lathe which type has been discussed at length in recent issues of *Model Engineer*. Mine has been my constant workshop companion since I purchased it new in 1938, and although now motorised, much of its work (including the boring of the cylinders illustrated) is still done by one foot power. Unlike Mr. G. Thomas, I find my Drummond lathe no more of a "chatterbox" than my ML7, but I must admit that the Super 7 is a great improvement in this respect.

Commence the boring operation by taking a cleaning-up cut through the bore, using as stiff a tool as will enter the bore (I use a HSS cutter in a ⅜ in. dia. shank for jobs such as this), and try to clean the bore at one cut since any rubbing of the tool on the sandy surface of the casting will play havoc with its edge. I suggest you start with the lathe running at its lowest direct speed and feed by hand for the first cut — you will then be able to feel if the edge of the tool goes. The bore can now be opened out to its ⅝ in. dia. in stages; it should be possible to slightly increase the speed of rotation and with a well-sharpened and slightly radiused tool a good surface finish should be obtained. When approach-

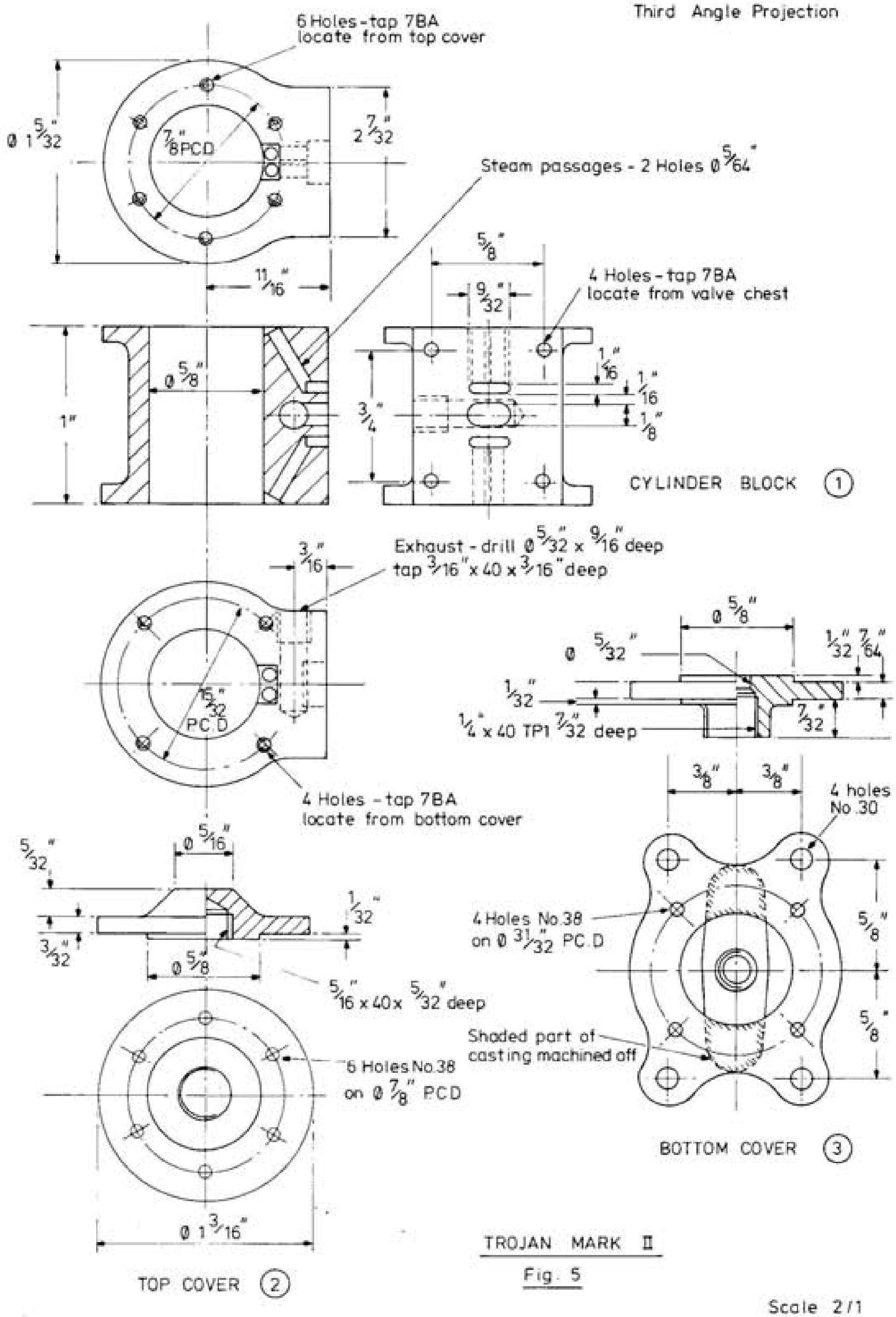

Third Angle Projection
6 Holes - tap 7BA locate from top cover
Ø 1 5/32"
7/8 PCD
2 7/32"
Steam passages - 2 Holes Ø 5/64"
11/16"
5/8"
9/32"
4 Holes - tap 7BA locate from valve chest
Ø 5/8"
1"
3/4"
1/16"
1/16"
1/8"
CYLINDER BLOCK (1)
3/16"
Exhaust - drill Ø 5/32" x 9/16" deep tap 3/16" x 40 x 3/16" deep
15/32" PCD
4 Holes - tap 7BA locate from bottom cover
Ø 5/8"
Ø 5/32"
1/32"
7/64"
1/32"
1/4" x 40 TPI 7/32" deep
7/32"
3/8"
3/8"
4 holes No.30
4 Holes No.38 on Ø 31/32" PC.D
5/8"
5/8"
Shaded part of casting machined off
BOTTOM COVER (3)
5/32"
Ø 5/16"
1/32"
3/32"
Ø 5/8"
5/16 x 40 x 5/32" deep
6 Holes No.38 on Ø 7/8" PCD
Ø 1 3/16"
TOP COVER (2)
TROJAN MARK II
Scale 2/1

Fig. 5

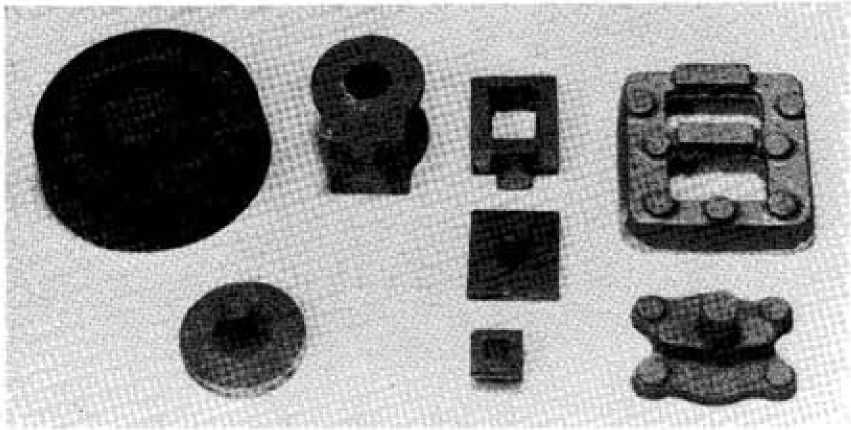


Fig. 4: Castings available from A. J. Reeves & Co. (Birmingham) Ltd

ing the finished size, only small cuts must be taken and the tool passed through twice at each setting to eliminate the effect of any slight springing of the tool shank. Prior to removing the last thou or two, the tool edge is carefully honed. In the absence of any precision equipment for internal measuring, a piece of 5/8 in. dia. silver steel can be used as a gauge or, prior to boring the cylinder, a 5/8 in. dia. plug gauge can be turned up from any available bar material. Since commercial piston rings are not being used, dimensional accuracy of the bore is less important than its parallelism and surface finish; modern lathes take care of the former and your tool grinding and setting looks after the latter. With a keen, slightly radiused tool, the facing of the cylinder end may now be completed: feed outwards from the finished bore so that the tool comes into contact with only the minimum of "raw" cast material. Check that the amount of material removed will, when the other flange is machined to bring the casting to its 1 in. length, leave the two flanges of equal thickness. Before removing the work from the chuck a slight chamfer may be formed at the entry to the bore (this must be very slight since the locating spigots on the covers are only 1/32 in. thick. Before proceeding any further, put some identification mark on the face of the machined flange (in some place where it will not be obscured by the cylinder cover), to denote that this flange was machined at the same setting as the bore, and must be the one used to attach the bottom cover and trunk guide.

The upper flange of the block is readily machined by mounting the work by its bore on a truly running stub mandrel. The recognised way of machining the port face is to use the face plate/angle plate combination and my set-up is shown in Fig. 7. Note the large washer under the bolt head and the paper washers at each end of the cylinder block — these serve the dual purpose of increasing the grip and preventing bruising of the already machined surfaces. The port face will be correct in relation to the cylinder bore when it is 3/8 in. from the adjacent edge of the latter, and this distance should be marked out before setting on the angle plate.

To be continued

Fig. 6: Cylinder set up for boring.

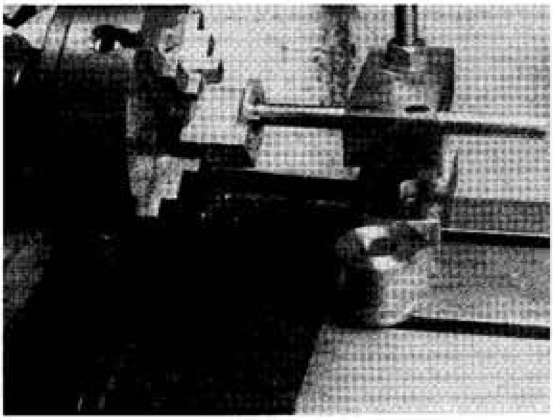
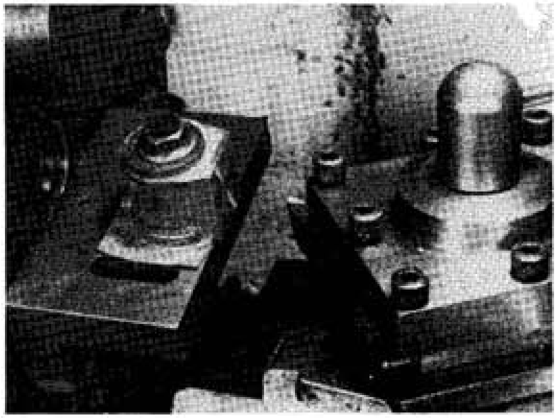
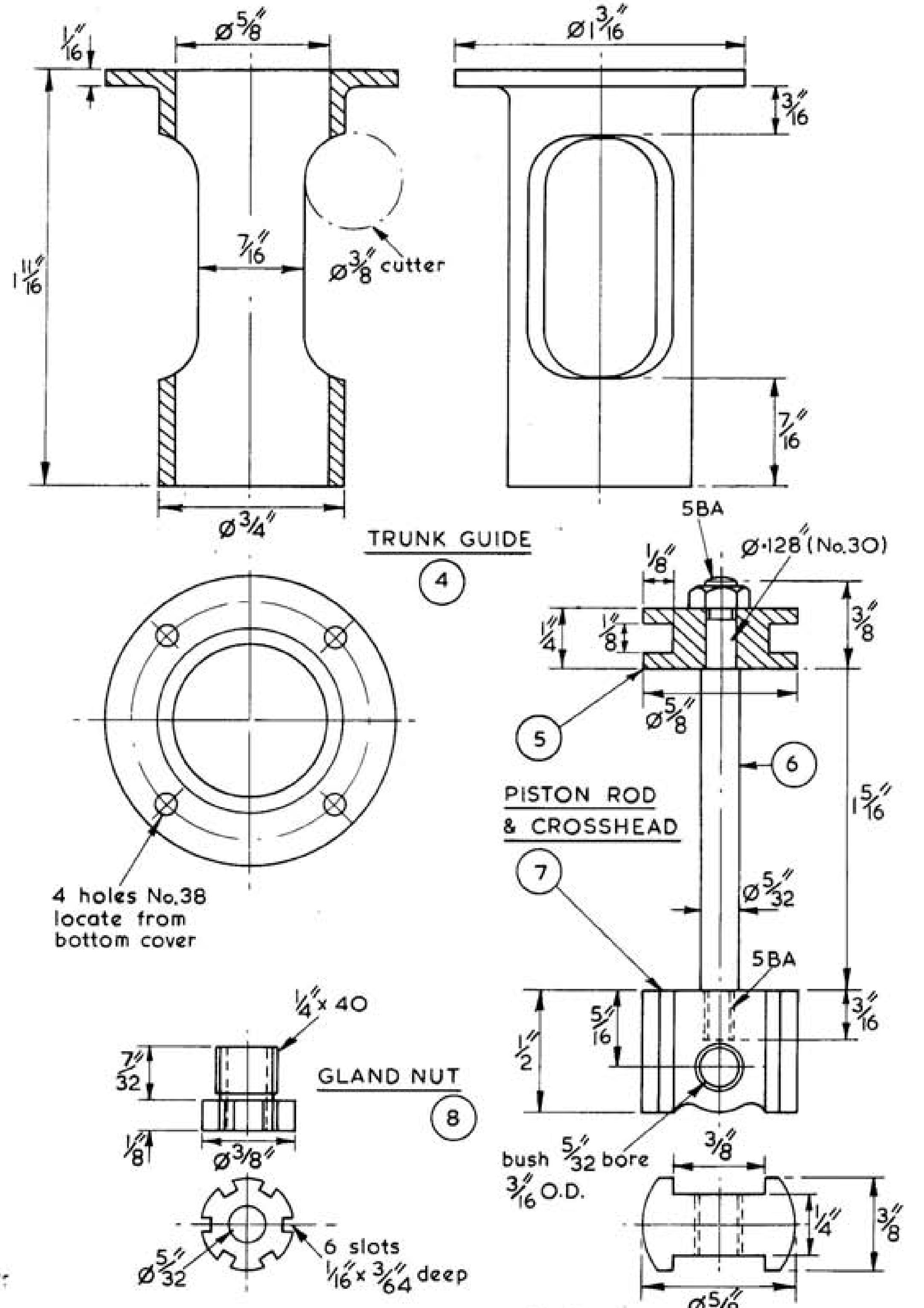


Fig. 7: Machining the port face.





Ø5/8"
1/16"
Ø1 3/16"
3/16
7/16"
Ø3/8" cutter
1 11/16"
7/16
Ø3/4"
TRUNK GUIDE
4
5BA
Ø·128" (No.30)
1/8"
1/4"
1/8"
3/8"
Ø5/8"
5
6
PISTON ROD & CROSSHEAD
1 5/16"
7
Ø5/32"
4 holes No.38 locate from bottom cover
5BA
5/16"
1/2"
3/16"
1/4" x 40
7/32"
GLAND NUT
8
1/8"
Ø3/8"
bush 5/32" bore 3/16" O.D.
3/8"
1/4"
3/8"
Ø5/32"
6 slots 1/16" x 3/64" deep
Ø5/8"

Fig.13

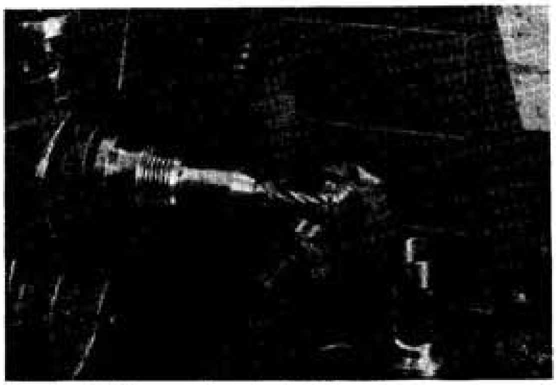


Fig. 14: Milling trunk guide in lathe

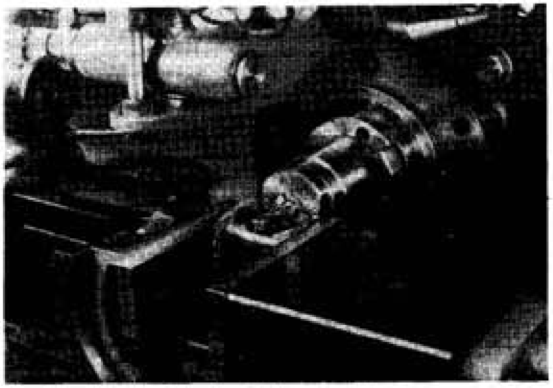


Fig. 15: Trunk guide in milling machine

should be taken when re-setting to cut the second opening that the work is turned through exactly 180°; this is readily ensured by the use of parallel packing or a square in the case of the vertical spindle.

The milling operation will leave a few burrs which must be carefully removed with fine files. To finish de-burring the bore, I found a round "India" oilstone slip of just under 5/8 in. dia. (borrowed from my woodworking kit!) most useful. The final operation on the guide is to drill the four No. 38 holes for the securing studs. For this operation the cover and trunk guide are assembled and clamped, making sure that their relative angular positions are correct, and the holes then spotted through.

Piston. Fig. 13.5

Study of the piston/crosshead assembly (Fig. 13.5, 6 & 7) will indicate that the piston rod/crosshead assembly is intended to be permanent while the piston is itself detachable from the rod.

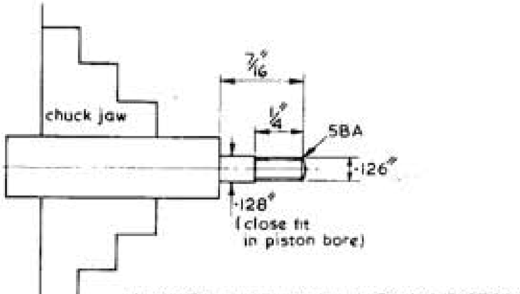
To make the piston, chuck a length of 11/16 or 3/4 in. dia. hard brass or drawn GM bar, face the end and turn down to about .010 in. larger than the cylinder bore. Centre the end, drill 7/64 in. dia. for a depth of 3/8 in. and open up with a No. 30 drill. With well-sharpened drills (from which the lead has been eased off to avoid snatching) and careful feeding, the drill should not wander from its axial position. Use a parting tool to form the packing groove and finally part the piston off to length. Before its identity is lost, mark the outer face of the piston (i.e. that which was machined at the same setting as the bore), since this must be the face to locate against the shoulder on the piston rod. The parted off face of the piston may need cleaning up and this can be accomplished by lightly gripping the oversize piston in the chuck and taking a light skim off the parted-off face.

To ensure true concentricity of the periphery of the piston with the piston rod bore, it will be necessary to machine up a stub mandrel. I used a scrap of 5/16 in. dia. b.m.s. which was gripped in the three-jaw chuck and turned down for a length of about 7/16 in. to a close fit in the piston bore, care being taken to finish with a true and sharp shoulder. The first 1/4 in. of this mandrel was turned down to .126 in. dia. and threaded 5 BA. The reason for the odd size of the piston bore is of course that 5 BA is just over 1/8 in. dia., and the plain part of the rod must exceed the thread diameter for accurate location. Fig. 16a gives details of this mandrel, and it is shown again in Fig. 28a. Now mount the piston on this mandrel with the marked or bottom end against the shoulder (a *very slight* countersink in the piston bore will ensure a snug seating on the shoulder) and secure with a 5 BA nut. If a commercial nut is used, be sure to check that its base is square with the thread or the piston may be sprung out of true when tightening up — skim the nut face if necessary. Assuming that all previous work on the piston has been accurate, the piston should run truly on the mandrel, but the .010 in. allowance will look after any slight errors. Finally with a well honed and slightly rounded tool, turn the piston to an easy (but not slack) fit in the cylinder bore.

Crosshead. Fig. 13.7

This is the next logical item to tackle; the piston rod (item 6) will follow since it is required mounted in the lathe to complete the crosshead. I have specified drawn gunmetal for the crosshead, but I have found that drawn brass rod will give years of normal service in the trunk guide; for either material I prefer to fit a separate GM bush for the crosshead pin since its fitting entails little extra work at the time and greatly facilitates the rectification of a worn small end bearing. Should a gunmetal casting be used for the trunk guide, the materials specified above would be suitable for the crosshead, but for a cast iron trunk, a steel crosshead would be more suitable (and less expensive).

The starting point for the crosshead is a piece of bar, 3/4 or 11/16 in. dia., and of sufficient length to



MANDREL FOR FINISH TURNING PISTON
Fig 16A

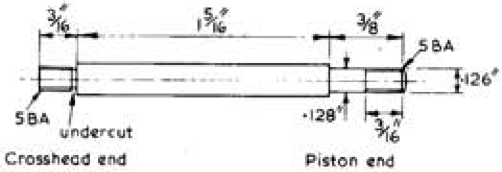


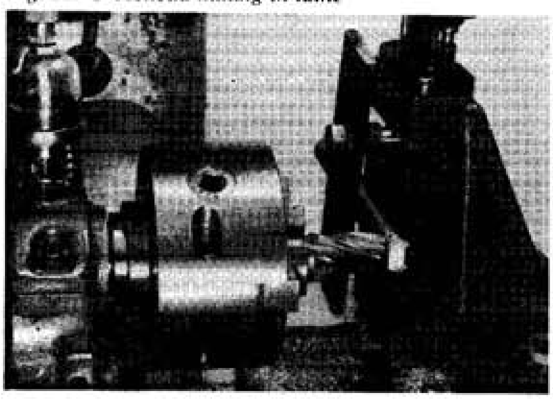
Fig 16B PISTON ROD DETAIL

form a substantial chucking or holding piece — I used a piece about 5½ in. long with the object of making more than one crosshead without leaving too many short ends of brass rod. Incidentally this statement reminds me of one of the unavoidable snags I encounter when working from complete kits; for economic reasons the materials supplied are cut to near final lengths and one often has to employ devious machining techniques in order to hold the small pieces — or scrap the material supplied and work from a longer bar!

The first operation on our crosshead is to mount the bar in the three-jaw chuck, face the end and turn down a length of 5/8 in. to a diameter of .010 in. larger than the trunk guide bore. Do not drill for the piston rod at this stage.

The majority of the subsequent machining can be carried out with the work set up on a vertical slide as shown in Fig. 17. The vertical slide is first set up so that its face is parallel to the chuck face. The bar

Fig. 17: Crosshead milling in lathe



is strapped to the face of the slide and conveniently locates in the centre slot; the vertical slide is now adjusted so that the bar is at centre height (I did this by placing a bar of similar diameter in the chuck and used a DTI to adjust for equal readings on the two bars). Next a centre drill is mounted in the chuck and the cross slide adjusted so that the drill will centre at a shade over 5/16 in. from the faced end of the bar. Proceed to centre drill the bar, drill 5/32 in., open out with a No. 14 or 4.6 mm. drill and finally ream 3/16 in. for the crosshead pin bush. Now mount a 5/8 in. end mill in the chuck and machine a flat on the bar; the final depth of this cut will be (half the outside diameter of the bar less 3/16 in.), i.e. a few thou over 1/8 in. The setting of the vertical slide must not be changed, i.e. the feed must be applied by the cross slide; the centre of the cutter should finish up about 9/16 in. from the faced end of the bar. Now replace the 5/8 in. end mill with one of 3/8 in. dia. and proceed to cut the central groove to a further depth of 1/16 in. To complete the milling of the crosshead, the clamp is slacked off, the bar rotated through 180° and the

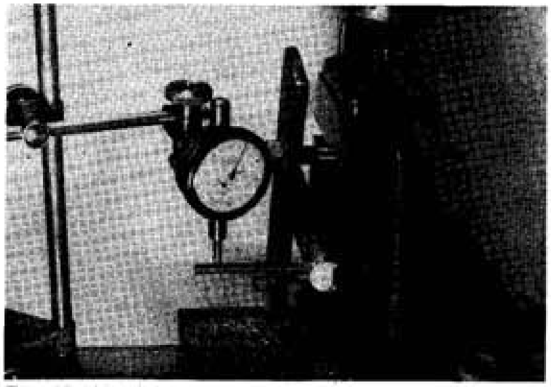


Fig. 18: Checking crosshead milling

process repeated. To ensure that the bar was rotated through exactly 180° I placed a short length of 3/16 in. dia. silver steel in the cross hole and set it horizontally by means of a DTI; Fig. 18 shows this operation. Before unclamping the work, check that the central web of the crosshead is 1/4 in. thick; ideally it should be about .010 to .015 in. less to provide a slight float for the connecting rod. Possessors of a milling machine with a dividing head will be able to carry out this process more directly and quickly; Fig. 19 shows a set-up using the Senior machine with sliding vertical head.

The embryo crosshead is now returned to the lathe; it is gripped in the three-jaw chuck, the previously faced end centred, and drilled and tapped 5 BA. An added advantage of using the separate bush for the crosshead pin is now apparent; the

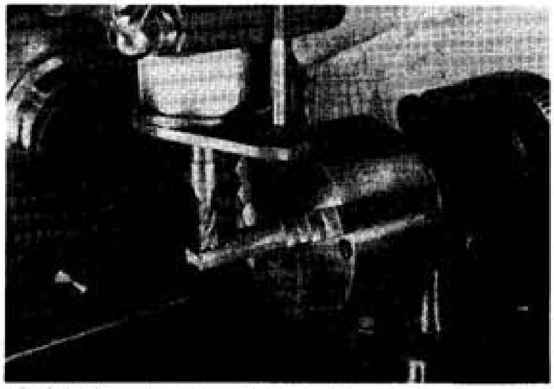


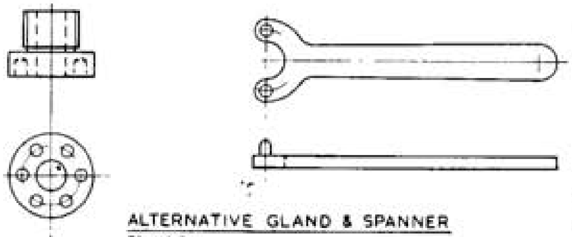
Fig. 19: Crosshead in milling machine

piston rod hole can be drilled right through into the transverse hole, thus avoiding drilling and tapping a blind hole. Finally take a light facing cut over the end to clear tapping burrs and to bring the face to 5/16 in. from the hole centre, and part off. The underside of the crosshead is shaped with small files and it will be fitted to the trunk guide when finally and permanently screwed to the piston rod.

Some readers will note that my photograph shows no evidence of the crosshead having been turned on its outer surface; this is because the 5/8 in. brass bar I had in stock was an excellent fit in the trunk guide.

Piston Rod. Fig. 13.6

This component is turned from 5/32 in. dia. ground stainless steel rod and the first operation is to set up the rod firmly and truly in the four-jaw chuck; this entails some patience with the DTI, but the result is worth the effort. Not only can the rod be gripped more truly than with either a three-jaw chuck or a collet, but it is held much more firmly and can be relied upon not to move during the threading operation. With a keenly sharpened tool, the rod is turned down for a length of 3/8 in. to a light push fit in the piston bore, taking care that the piston seats firmly on the shoulder thus formed on the rod. The first 3/16 in. of the length is then turned down to 0.126 in. dia. and threaded 5 BA, forming a spigot similar to that shown in Fig. 16.



ALTERNATIVE GLAND & SPANNER
Fig. 20

The rod is then removed from the chuck, marked out to a length of 1 5/16 in. between shoulders, returned to the chuck with the crosshead end protruding about 5/16 in. and gripped firmly and accurately (using the DTI again). The end is then turned down to .126 in. dia. for the appropriate length, and a narrow recess .014 in. deep is formed at the shoulder (see Fig. 16b); the end is then carefully threaded 5 BA. A tailstock dieholder is a must for this last operation and if there is any doubt about the quality of the thread produced by the die, I would suggest screwcutting. If as is usual the die used has a considerable lead at entry, it might be necessary to reverse the die in its holder to complete the last thread at the shoulder. The fit of the thread in the crosshead should be on the tight side so that once the crosshead is screwed firmly home to the shoulder it will not come undone either in service or when removing the piston. If any doubt exists concerning the tightness of the thread, a smear of Loctite should do the trick. I have cross pinned such joints in the past, but drilling very small holes in stainless steel rod sometimes poses problems. When the crosshead is firmly screwed home, and while the piston rod is still gripped truly, the crosshead is skimmed down to an easy sliding fit in the trunk guide.

The final operation on this assembly is to make and fit a bronze bush for the crosshead pin. This is turned to a tight press fit in the crosshead; its bore will require clearing with the 5/32 in. reamer after press fitting since the latter will produce some closing of the bore.

Piston Rod Gland Nut. Fig. 13.8

For this component, chuck a length of 3/8 in. dia. brass rod (or 7/16 in. dia. if you intend to enlarge the gland thread), face, centre and drill 5/32 in. for a depth of 1/2 in. Then turn the outside to a diameter of 1/4 in. for a length of 7/32 in., undercutting the shoulder as shown. Use the tailstock dieholder when cutting the thread and adjust the die so that the thread is a close fit in the cylinder cover, to minimise the risk of its coming loose in service.

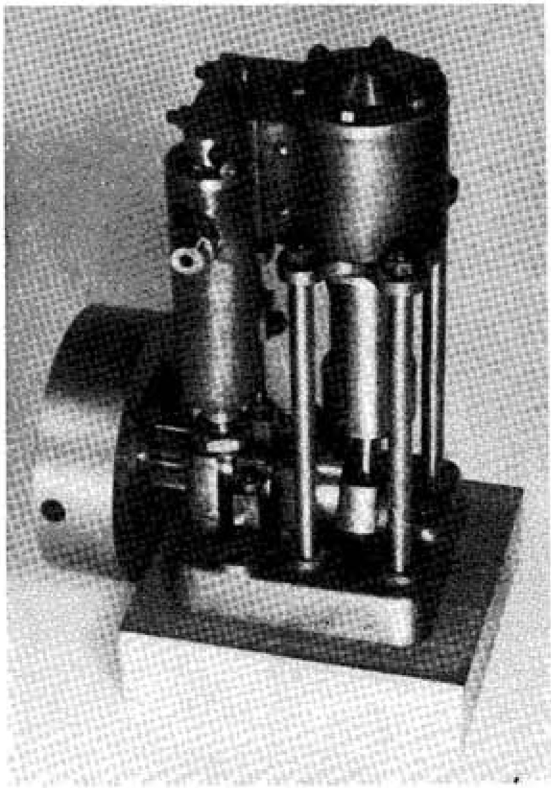
Accessibility of the gland nut is always a slight problem in trunk guide engines (fortunately attention is very seldom needed), and I have shown a slotted head. If desired, these slots could be replaced by a series of radial holes; this eliminates a milling operation, but some dividing device is still desirable for equality of spacing. The slots or holes are ideally intended for use with a "C" spanner, but due to limitations of space etc. the correct tool is often replaced by a screwdriver or other implement with consequent bruising of the nut. I have in the past overcome this trouble by drilling a ring of axial holes in the underside of the flange of the nut and making a pin spanner to suit these; Fig. 20 illustrates this alternative.

To be continued

MORE UTILITY STEAM ENGINES

TROJAN MARK II

by J. P. Bertinat



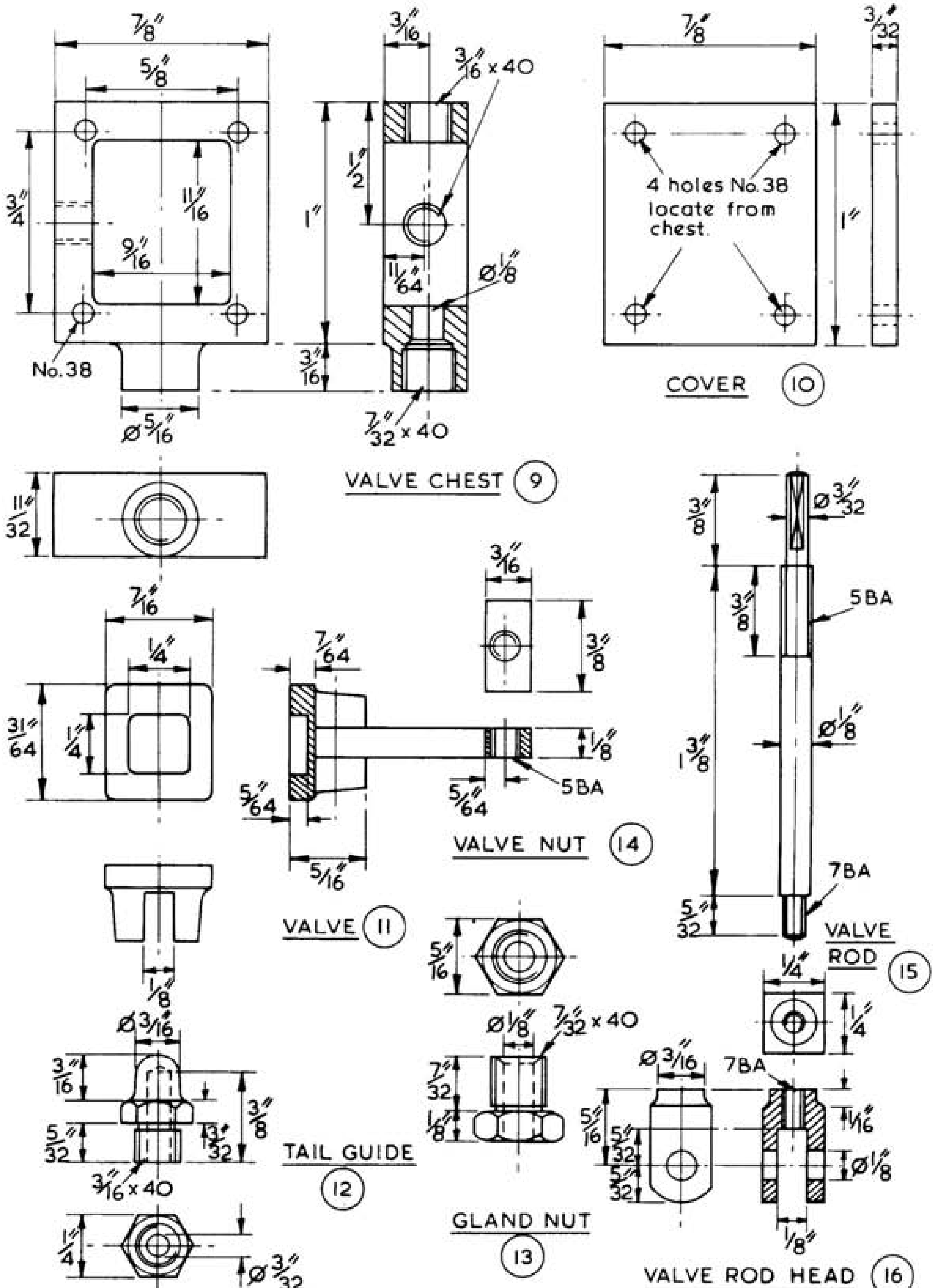
Part III *from page 840*

Valve Chest. Fig. 21.9

First clean up any rough parts of the casting, removing any "flash" from the rectangular opening. In the castings I have, this opening is almost to finished size, requiring only a shade off the lower edge: it is an advantage to have a slight radius in the corners of the opening as shown on the drawing, otherwise the securing studs may come rather close to the edge of the metal.

Commence machining the casting by gripping it by its edges in the four-jaw chuck, ensuring that the faces of the casting are parallel to the chuck face. With a sharp slightly rounded tool face the casting until the centre of the boss is 3/16 in. from the machined face. Reverse the casting in the chuck, using a piece of parallel packing between the already machined face and the chuck surface to ensure parallelism of the two faces of the chest. For facing the four edges and for turning and boring the boss, the usual face plate/angle plate set-up is used and the operation is depicted in Fig. 22. One side of the chest is dealt with first and is then used as a datum for setting the other edges, squareness being assured by the use of a square against the surface of the face plate. It will be found advisable to remove as little material as possible from the top edge of the chest. If the centre of the valve gland boss has not already been marked out, this must now be attended to and the chest returned squarely to the angle plate which is then adjusted so that the marked centre runs truly. Since in our case the tail rod guide is a separate item and its hole cannot be drilled and tapped from the gland end, the single bolt attachment of the chest to the angle plate presents no problem. For the Stuart No. 10 and other engines having an integral tail rod guide, alternative clamping arrangements must be made for this last operation on the chest, so that the tail guide can be drilled through the gland boss. Once the work is set up, procedure is as for the cylinder gland and will not be detailed. I make no apology for using a 7/32 in. x 40 thread, since according to both my Reeves and Stuart Turner catalogues, this handy size is still available.

We now come to the problem of drilling for the tail guide and this drilling must be in alignment with the previously machined gland. My method was to turn up a special mandrel in the three-jaw chuck which located the valve chest against a shoulder, on the gland thread and again on the 1/8 in. bore. Fig. 23 gives particulars of this mandrel which of course must be used without removing it from the chuck. The thread was screwcut (and not finished with a chaser!) and care was taken to make the projecting



VALVE CHEST (9)
No. 38
COVER (10)
4 holes No. 38 locate from chest.
VALVE (11)
TAIL GUIDE (12)
GLAND NUT (13)
VALVE NUT (14)
VALVE ROD (15)
VALVE ROD HEAD (16)
5BA
7BA

Fig. 21

spigot a good fit in the valve rod bore. I have used this type of mandrel with success for many bottom cylinder covers of the larger Stuart and other engines. Fig. 24 shows the valve chest mounted on the mandrel for drilling and tapping the 3/16 in. x 40 hole for the tail guide.

The 3/16 in. x 40 hole for the steam inlet is shown in the centre of the side face of the chest on the opposite side of the engine to the exhaust, but this position can be varied to suit any pipe-work needs; in the original design, the steam inlet was in the centre of the valve chest cover. To complete this component it only remains to mark out and drill the four No. 38 holes for the securing studs. I prefer to mark out these holes in the valve chest which is then used as a jig for transferring the holes to the cover and cylinder block; working in this order makes it possible to ensure that no hole comes too near to the edge of the valve aperture.

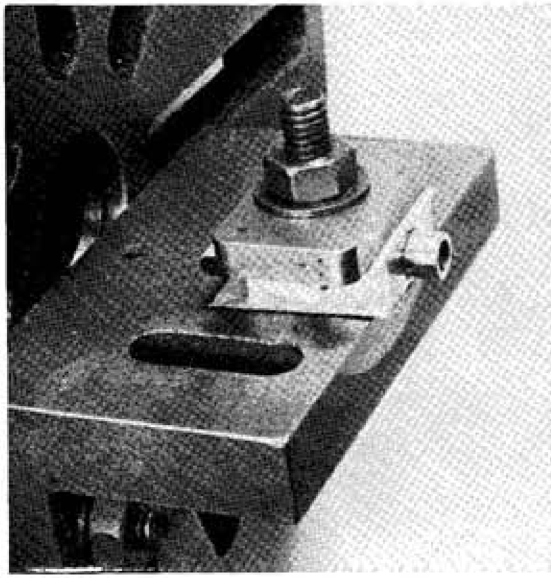
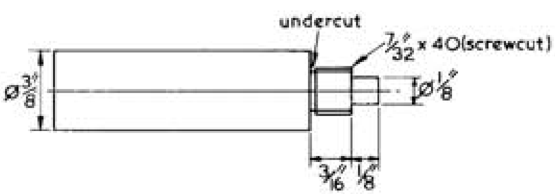


Fig. 22: Valve chest and angle plate.

Valve Chest Cover. Fig. 21.10

The machining of the two faces of this component is a four-jaw chuck operation, care being taken to get the faces parallel. The faced cover is then clamped to the *correct face* of the valve chest, the



MANDREL FOR HOLDING VALVE CHEST FOR DRILLING TAIL GUIDE HOLE. Fig.23

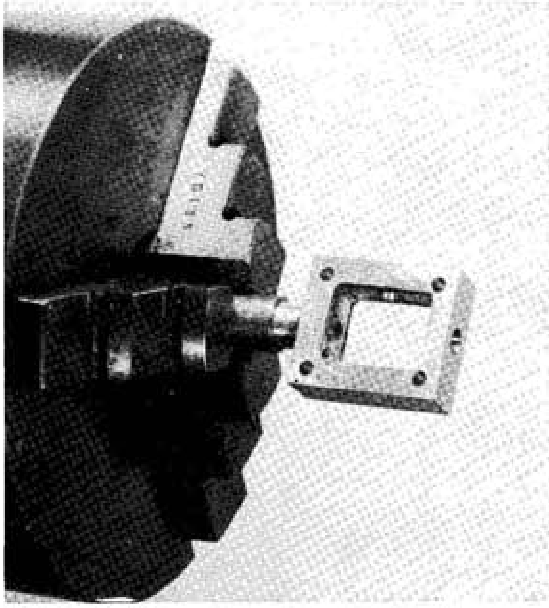
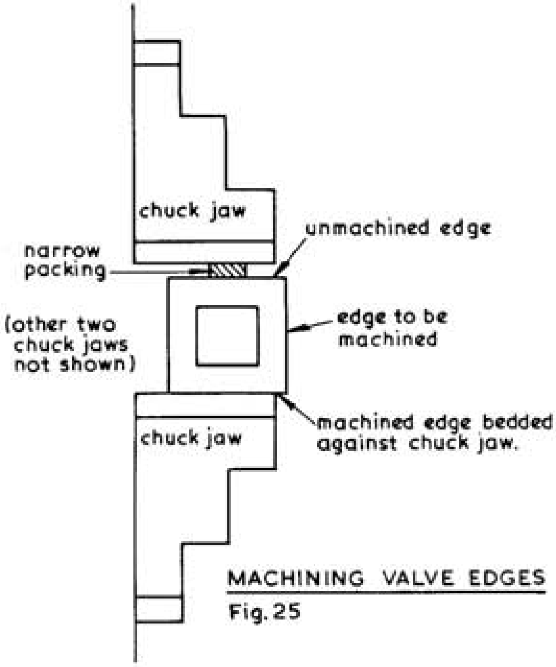


Fig. 24: Valve chest on mandrel.

holes are spotted through with a No. 38 drill and the outer profile of the cover marked out by scribing round the valve chest. The parts are then separated and the holes drilled right through the valve chest, and the outer edges filed to size and polished. Erection and removal of the cover will be made easier if the four holes are very slightly countersunk on both sides of the cover and similar treatment could well be given to the holes in the chest itself.

Slide Valve. Fig. 21.11

The front and back faces of the valve may be skimmed up with the work held in the four-jaw chuck; if care is taken to get these faces parallel, later setting-up will be simplified. The four edges may be machined to size and square with one another with the work again gripped in the four-jaw chuck. To ensure squareness of the second and subsequent edges, the work may be held as shown in Fig. 25. Care should be taken to ensure that the exhaust cavity remains in the centre of the face. On some castings I have had the cavity is so clean and true to size as to need no machining, but if cleaning up is required, a set-up similar to that used for cutting the ports in the cylinder block can be used (see Fig. 8, Part 1). The final operation on the valve is the machining of the slots for the valve rod and nut respectively. If desired the vertical slot for the rod may be replaced by a No. 30 hole drilled 3/16 in. from the valve face: on assembly this hole will probably need slight elongation in a fore and aft direction to ensure free seating of the valve. For cutting the slot(s) a 1/8 in. thick slitting cutter is required, and unless a special jig is made, care



needs to be exercised in holding the part in a machine vice since there is not much to grip; the accurate machining of the valve edges recommended at an earlier stage is an advantage here. The grip can be increased by placing thin paper between the valve and the vice jaws, and the work should also be supported by packing placed between it and the vice base. Fig. 26 shows a set-up for this operation. I have shown a slight radius on the corners of the finished valve; this is to give increased clearance in the chest.

Tail Guide and Gland Nut. Figs. 21.12 and 21.13

The only operation on these two components which has not been covered previously is that of forming the spherical end on the tail guide. This operation can be carried out using a form tool, a hand tool and rest or a spherical turning attachment. I used the latter as shown in Fig. 27. This simple attachment is quickly set up and has proved invaluable for such operations as making bodies of globe valves etc.; it certainly worked overtime on the seemingly endless collection of ball handles on my Quorn Tool and Cutter Grinder. For the spherical turning operation, the partly finished tail guide is held in a threaded mandrel. These mandrels were frequently advocated by LBSC and over the years I have made them up to suit commonly used threads. Fig. 28c shows a pair of these, each accommodating both male and female threads. Figs. 28a and 28b show respectively the mandrel for finish turning the piston and that used for drilling the tail guide hole in the valve chest.

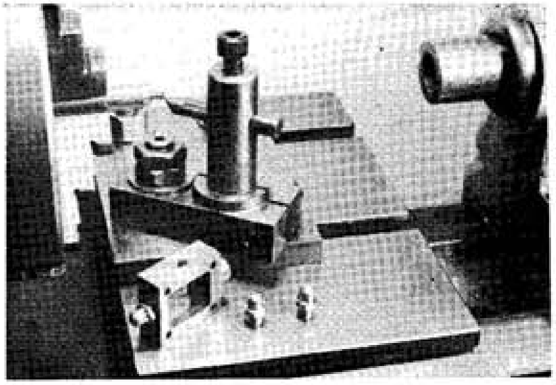
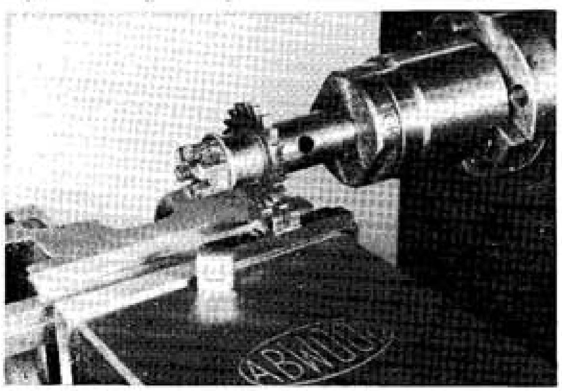


Fig. 27: Spherical turning.

Fig. 26: Milling back of valve.



Valve Nut. Fig. 21.14

This is cut and drilled from a piece of 1/8 in. x 3/16 in. brass rod and needs to be an easy but not slack fit in the valve slot. The tapped hole must be square with the faces of the nut or the valve will not seat readily.

Valve Rod. Fig. 21.15

This is made from 1/8 in. dia. ground stainless rod, and unless the three-jaw chuck is above suspicion, I recommend setting up in the four-jaw chuck with about 1/2 in. protruding and turning the rod down to 3/32 in. dia. for a length of 3/8 in.; erection is simplified if the end of the rod is chamfered or rounded off. The rod is now withdrawn another 3/8 in., reclamped securely and threaded 5 BA for a length of 3/8 in.: the thread should be a good but not tight fit in the valve nut. The rod is now cut to length and returned to the chuck end for end, when it is shouldered to .098 in. dia. and threaded 7 BA. As an alternative to undercutting the thread at the shoulder, the entry to the hole in the valve rod head may be slightly countersunk. This is less precise than the method adopted for the crosshead, but is

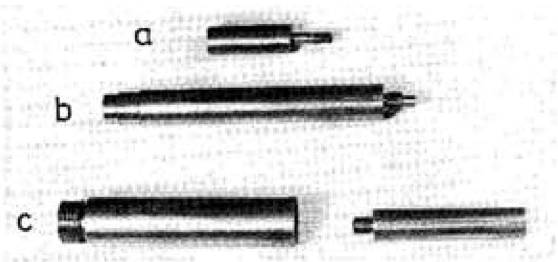


Fig. 28: Mandrels.

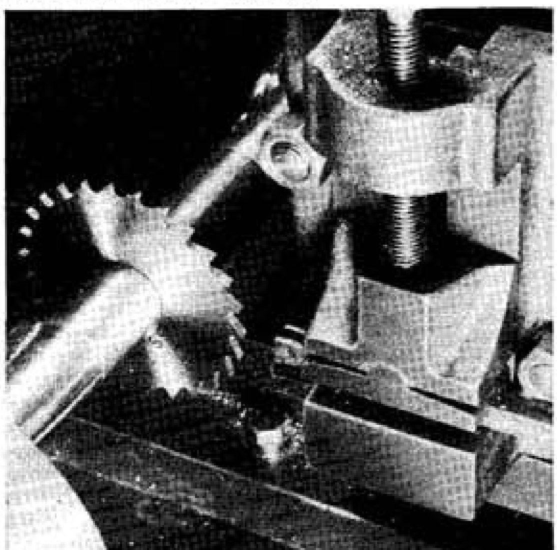
satisfactory in this case. Finally a small flat is filed on the 3/32 in. dia. as shown on the drawing; this will guard against the unlikely occurrence of a fluid lock.

Valve Rod Head. Fig. 21.16

This is made from 1/4 in. square b.m.s. and the fork is first formed on the end of a bar long enough to grip firmly in the machine vice. First drill and ream the cross hole at a shade over 5/32 in. from the end of the bar, and then with a 1/8 in. slitting cutter in either the miller or the lathe proceed to cut the slot to the required depth. Fig. 29 shows this operation in progress on the ML7. The cutter in use is actually 3/32 in. wide since my 1/8 in. slitting cutter (as shown slotting the back of the valve) is too small in diameter to clear the flanged foot of the Myford machine vice unless an unacceptable overhang is given to the work. The slot is of course formed in two stages, advancing the saddle 1/32 in. between cuts.

The partly completed fork is now sawn off from the rod and held in the four-jaw chuck for finishing

Fig. 29: Slotting valve rod head.



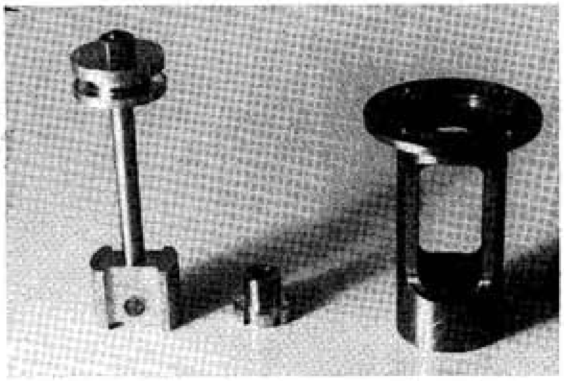


Fig. 30: Finished trunk guide, piston and crosshead

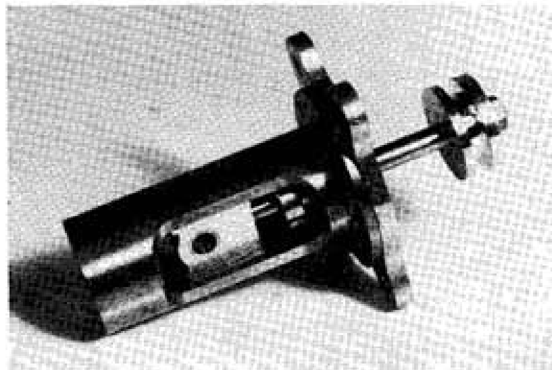


Fig. 31: Piston and guide assembled.

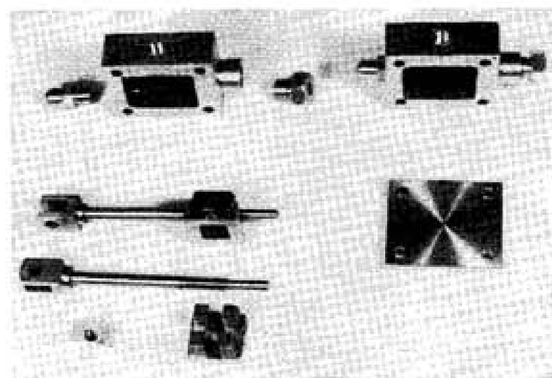


Fig. 32: Finished valve chest components.

its top end. Two of the chuck jaws conveniently enter the slot and grip on their bevelled sides. N.B. Throughout this series, the four-jaw chuck referred to is the Burnard 4½ in. Type 35C; the 6 in. chuck is a bit heavy for the present work. The valve rod head is completed by filing the curve on the lower end of the fork.

To be continued

TROJAN MARK II

by J. P. Bertinat

Part IV

Continued from page 916

THE DRAWING OF the bedplate, Fig. 33.17, shows a transverse rib or web underneath the forward main bearing; this is not present in the Mark I casting, but its addition to the pattern should create no problem. The rib serves to stiffen the casting in its most heavily loaded area and is in keeping with good engineering practice.

The first operation on the casting is to clean up generally with files so that the surfaces which are not to be machined will present an acceptable appearance; make sure that the openings for crank and eccentric are not undersize. To provide a datum for machining the faces, the bosses and the bearing seatings are dressed with a file so that the casting will sit, without rocking, on a flat surface. In order to hold the work for facing the underside of the base, I clamped it to the face plate by means of a drawbar through the mandrel, using a large square washer fitted into the recess in the casting. This is shown in Fig. 34 and this method of holding was used since the slope of the sides of the casting would have rendered the work difficult to grip safely in the four jaw chuck. The actual facing cut is taken with a slightly rounded tool which should be honed before taking the finishing cut in order to obtain a clean finish; aim at removing the minimum amount of material consistent with cleaning the whole of the base of the casting.

Fig. 34

The top face can be dealt with by holding the work in the four jaw chuck in the usual way, the taper on the casting improving the grip in this case. Aim at securing a clean finish on all the bosses and the bearing seatings; The 7/16 in. dimension for the overall thickness of the bedplate is of secondary consideration.

Next to be tackled are the tapped holes for the columns and these must correspond with their counterparts in the bottom cylinder cover (for the drilling of which a jig was made). For appearance sake these holes should come in the centre of the bosses provided for them, and in the Reeves castings it will be found that the bosses are accurately located. Without considerable and unwarranted elaboration, it is difficult to locate the previously made jig on the boss centres and I simply centre popped these boss centres and then applied the jig to check that said centre pops could be centred on all holes simultaneously; this being found satisfactory, the holes were drilled No. 38 and tapped 5 BA. If no tapping device is available, I advise starting the tap in the drilling machine (turning the chuck by hand), since it is imperative that the screwed holes are square with the base. Next the three 1/8 in. dia. holes for the holding down bolts are drilled in the centres of their respective bosses and the casting is then set aside until the bearing housings and their bushes have been completed.

Columns. Fig. 33.18

These are made from a straight length of 3/16 in. dia. b.m.s. The lower ends of the four columns are turned first and threaded 5 BA and it will pay to undercut the shoulder to a depth of .016 in. with a narrow parting tool, in order to ensure that the columns will screw down squarely into the base. It is important that the four columns are of equal lengths between the shoulders since any errors in this respect will produce distortion when the engine is assembled. I coated the top ends of the partly finished columns with marking fluid and then, using the depth gauge attachment on the blade of my combination square, carefully scribed the position of the top shoulder at 2 45/64 in. from the base flange; an ordinary depth gauge or even an adjustable square would serve almost as well. The column was then mounted in the three-jaw chuck with the shoulder position about 1/8 in. clear of the jaws, and a knife tool carefully advanced (without cutting) to the marked shoulder, moving the slide by means of the leadscrew handwheel — or top slide screw; the slide index reading is noted and this reading is used to control the length of subsequent cuts. The reason for this roundabout way is that if cutting up to the line is attempted directly, it will be found that the swarf released by the tool is likely to obliterate the scribed line just before the tool gets to

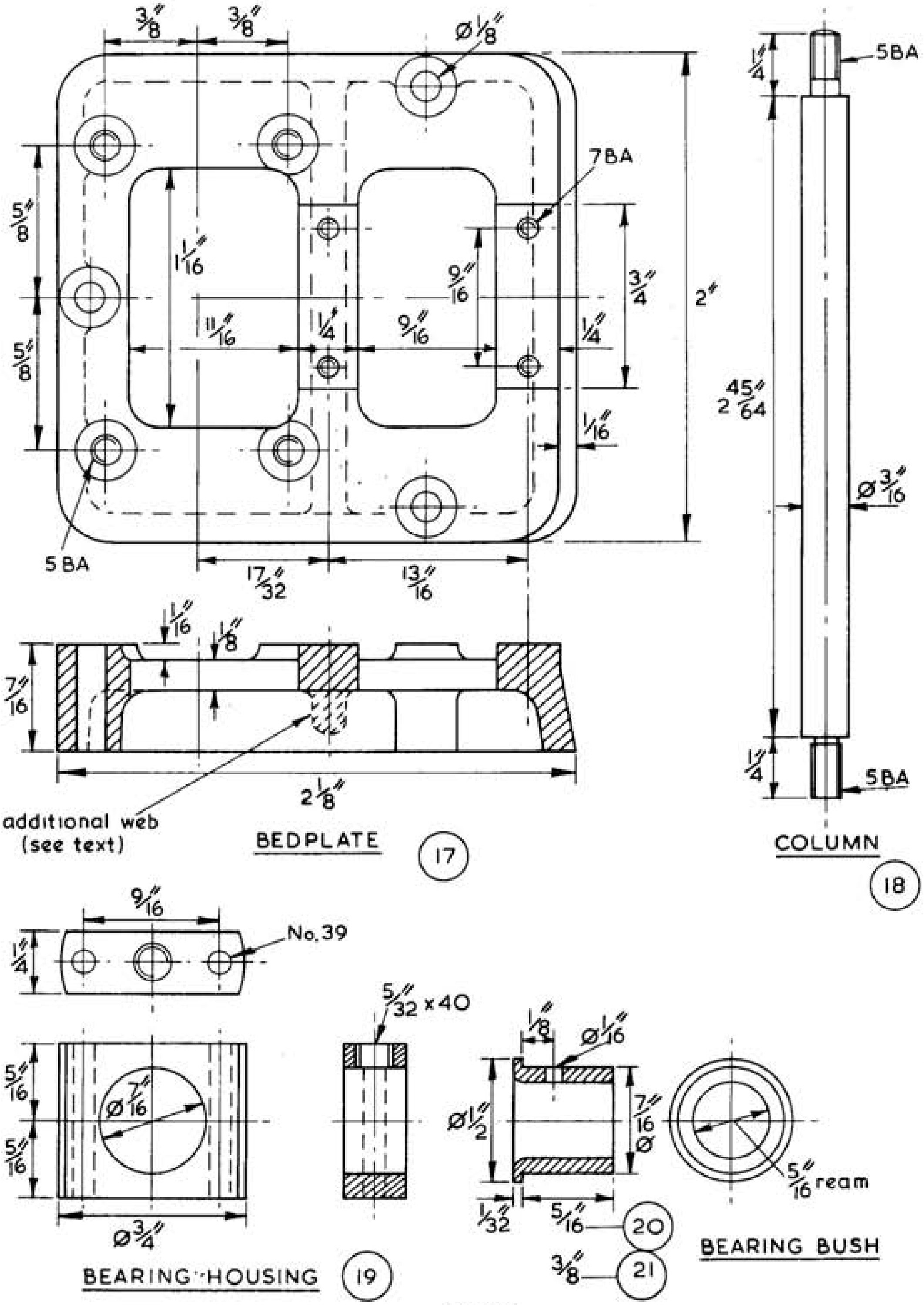

3/8"
3/8"
Ø1/8"
7BA
5/8"
1 1/16
9/16"
3/4"
2"
11/16"
1/4"
9/16"
1/4"
5/8"
1/16"
45/64" 2
5 BA
17/32"
13/16"
1/16"
1/8"
7/16"
2 1/8"
additional web
(see text)
BEDPLATE
17
1/4"
5BA
Ø3/16"
1/4"
5BA
COLUMN
18
9/16"
1/4"
No.39
5/32" x 40
1/8"
Ø1/16"
5/16"
Ø7/16"
5/16"
Ø3/4"
Ø1/2"
7/16" Ø
5/16" ream
1/32"
5/16"
20
3/8"
21
BEARING BUSH
BEARING HOUSING
19

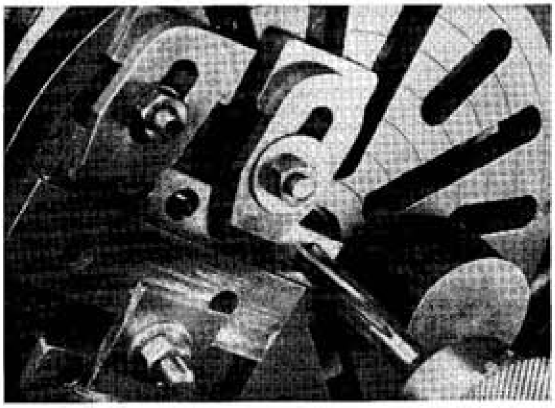
Fig. 33

it! There is no need to undercut the shoulders at the top ends, and the 5 BA thread needs only extend to 3/16 in. from the end, leaving 1/16 in. at full diameter for location.

Bearing Housings. Fig. 33.19

The housings I have made for the engines used to illustrate the machining sequence were made from a length of 3/4 in. x 1/4 in. b.m.s. and I left the bar in its 3/4 in. wide state without forming the radius on the outer edges — this would have meant starting from a larger bar to ensure cleaning up but would, I think, have improved the appearance. A length of bar sufficient to make three pairs of bearings was cut off and the centres of successive bearings were marked along the length of the bar; the centre of the 3/4 in. width was then marked on the end bearing, and the bar clamped to the face plate with this centre running truly. Fig. 35 shows the set up, and also shows another strip clamped alongside the bearing bar; this strip serves as a locating slide along which the bearing bar is slid for boring the sequence of holes. These holes are drilled, bored if necessary, and reamed 7/16 in. If, like me, you are using a Drummond lathe or similar machine with a No. 1 Morse Taper mandrel, take care not to poke the reamer through too far or your headstock spindle will be minus half its taper!

Fig. 35



The bearings are then sawn apart, the initial marking out ensuring that there was sufficient material for cleaning up after this process. It is essential that the centre heights of a pair of bearings are exactly the same — the actual measurement is of less importance — and to achieve this, the bearings (six in my case) were threaded on to a piece of 7/16 in. dia. b.m.s. which was cut a shade shorter than the sum of the bearing thicknesses and all were machined at one setting. For this purpose the composite block was set firmly and squarely in the milling machine and the bearing bases machined with

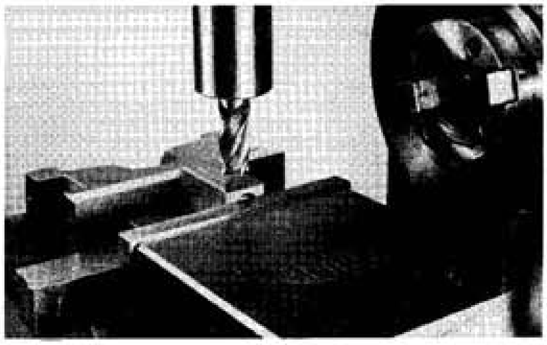
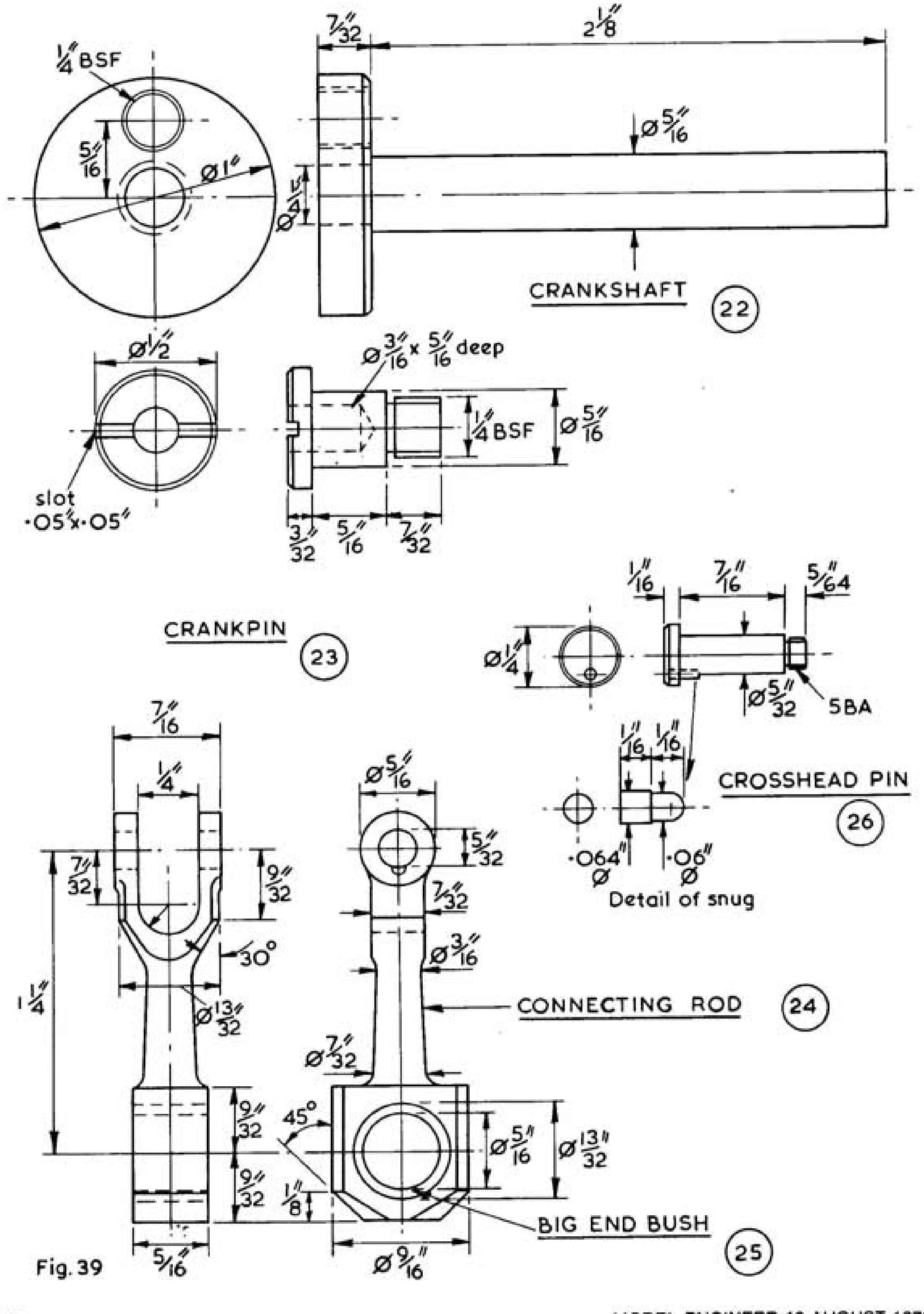


Fig. 36

an end mill. Fig. 36 shows the set up, which could equally well apply to a vertical slide in the lathe, but in this latter case I would not attempt to grip more than two bearings simultaneously. It will be noted that the edge of the 7/16 in. hole projects slightly above the vice jaws in order to provide a measuring point; the milled surface should finish at 3/32 in. above the edge of the hole. The block of bearings is then inverted in the vice for milling the top face; in this case the work can rest on a parallel strip of appropriate thickness. Before the bearings are removed from the mandrel, some identification mark should be made on what should be the bottom surfaces.

For drilling the holes for the holding down bolts and for the oil hole, I favour the use of co-ordinate drilling in the lathe or miller; it ensures uniformity and is much quicker than marking out and drilling, even for one set of bearings. Fig. 37 shows my set up on the ML7; the vertical slide is set up facing the chuck and the machine vice set with its jaws truly horizontal. The slide is adjusted for height by placing a piece of 1/4 in. dia. silver steel in the chuck and setting the bottom or fixed jaw of the vice to just slide over the rod. The work is set laterally against and in front of this rod and the cross slide adjusted so that the work is central in the vice and the feed screw reading is 75, *feeding inwards*. The round bar is now removed, taking care not to disturb the work, and the vice tightened firmly. I also used a piece of 3/16 in. square material at the base of the vice to ensure squareness, this material being removed after clamping and before drilling. The slide is now wound in 1¼ turns, bringing the dial reading to zero and the edge of the bearing housing to the lathe centre. The three holes to be drilled are accurately located by winding in the cross slide to readings of 0.94, 3.75 and 6.56 respectively; the underlined figures are dial readings and the whole numbers preceding them are complete turns of the feed screw. I found it quicker to centre drill all holes first, following with the No. 39 drill for the first and last holes and finally with a No. 30 hole and 5/32 in. x 40 tap for the central oil hole.



1/4" BSF
Ø1"
5/16"
7/32"
2 1/8"
Ø5/16"
Ø1/4"
CRANKSHAFT
22
Ø1/2"
Ø3/16" x 5/16" deep
1/4" BSF
Ø5/16"
slot
·05"x·05"
3/32"
5/16"
7/32"
CRANKPIN
23
1/16"
7/16"
5/64"
Ø1/4"
Ø5/32"
5BA
1/16"
1/16"
CROSSHEAD PIN
26
·064" Ø
·06" Ø
Detail of snug
7/16"
1/4"
7/32"
9/32"
30°
1 1/4"
Ø13/32"
9/32"
9/32"
5/16"
Ø5/16"
5/32"
7/32"
Ø3/16"
CONNECTING ROD
24
Ø7/32"
45°
1/8"
Ø5/16"
Ø13/32"
BIG END BUSH
25
Ø9/16"

Fig. 39

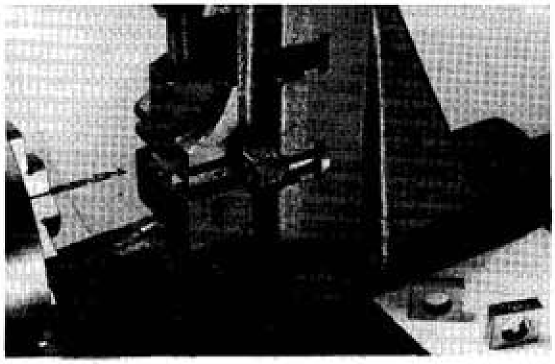


Fig. 37

Bearing Bushes. Fig. 33.20 & 33.21
These are plain turning jobs and are made from 1/2 in. dia. drawn gunmetal or hard brass rod. To avoid collecting too many short ends of this material, I cut off a length sufficient to make a pair of bushes i.e. a piece 7/8 in. long. This was chucked in the three-jaw chuck with 1/2 in. protruding, faced, centred, drilled and reamed 5/16 in. dia. right through. The outside was then turned down to a press fit in the bearing housing for a length of 3/8 in. (I usually turn the part which will ultimately be projecting to a close push fit and then make the remainder about .001 in. larger; this reduces the length which has to be squeezed in, and provides a lead which helps the parts to go together squarely). It must be emphasised that when press fitting parts together, the surface finish should be as smooth as possible; circumferential machining marks indicate the presence of humps and hollows which become flattened during the pressing process and seriously impair the grip. With a parting tool the dividing line between the two bushes is marked, but they are not separated. The work is now reversed in the chuck and the outside of the other bush turned, and the parting off completed. N.B. I have assumed that the chuck is not more than .001 in. out; if this is not the case use will need to be made of a Griptru or four-jaw chuck, or the second bearing finished on a stub mandrel. Finally the flanges of the bushes are faced to 1/32 in. thick.

I found it convenient to drill the oil holes in the bushes after pressing them into their housings. To ensure that the holes were central with the tapped hole, I made a simple drill bush from a short piece of 5/32 in. dia. brass rod; this was threaded externally to fit the hole in the housing and drilled 1/16 in. axially and a slot cut in the top to enable it to be withdrawn from the bearing after use. Fig. 38 shows the bearing with drill and jig in position.

To complete the bearings, the 5/16 in. dia. reamer will need to be poked through them again to compensate for the closing in during press fitting and to clear drilling burrs. *To be continued*

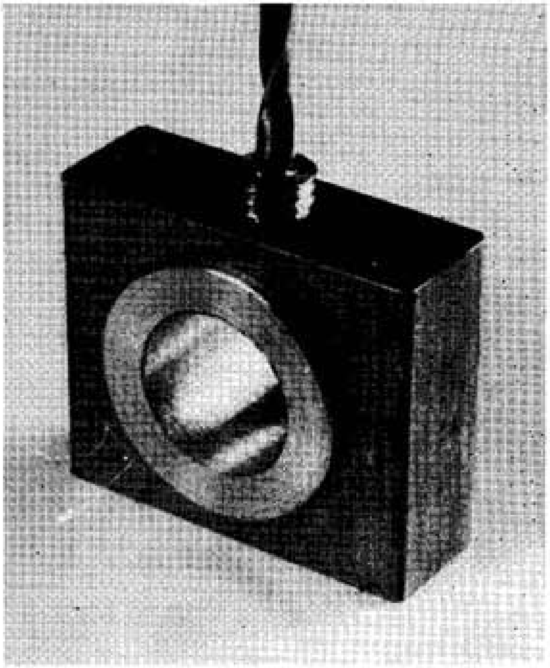
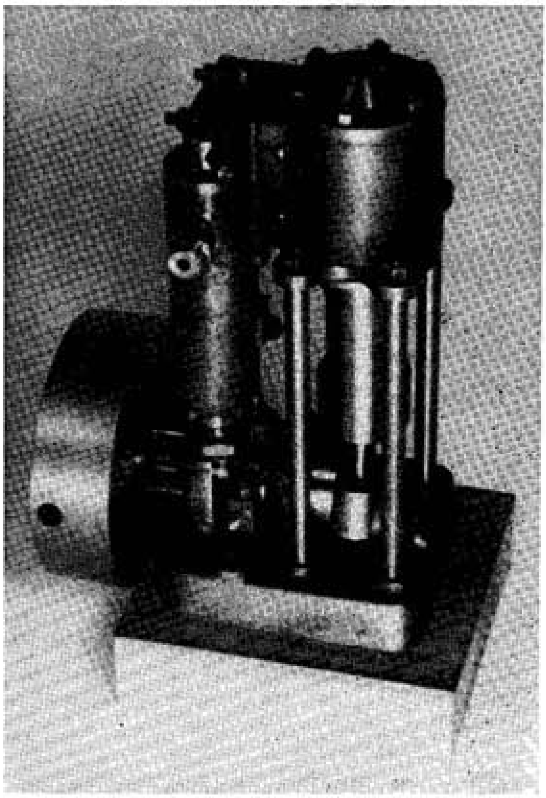
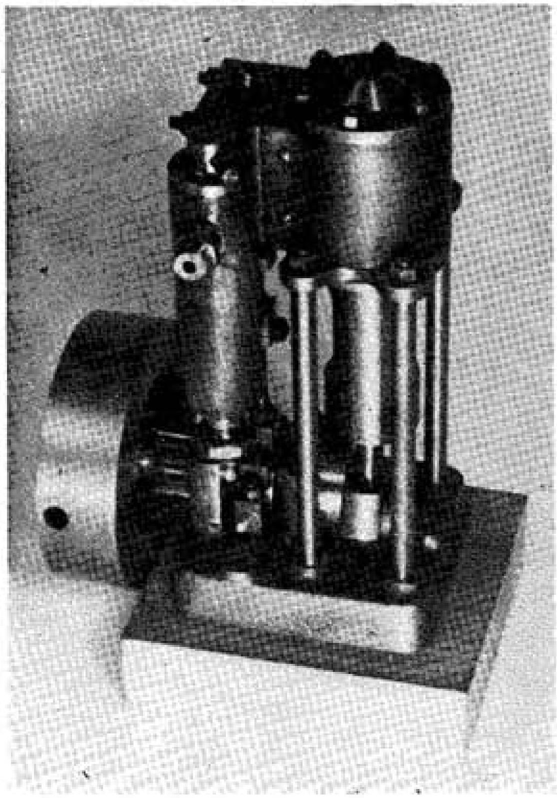


Fig. 38

Engine with displacement lubricator.





View of the completed engine.

TROJAN MARK II

by J. P. Bertinat

Part V *Continued from page 949*

This part describes the production of the port faces and top and bottom covers and was originally to be included in Part I. Unfortunately, this was not possible at the time and details are featured here.

WE NOW COME to the controversial stage of ports and passages and for the former, I favour the end milling process rather than the use of a "gang" Woodruffe type cutter with its attendant shallow ports. I make my own single tooth cutters from 1/4 in. dia. silver steel, making the cutter length only just sufficient for the depth of port required. Before milling the ports, the exhaust exit passage on the side of the block can be marked out, drilled 5/32 in. dia. for a depth of 9/16 in. and the first 3/16 in. or so tapped 3/16 in. x 40 t.p.i. for the exhaust pipe. The ports are then marked out on the port face and as much material as possible is removed by drilling rows of holes. For the exhaust port these holes may be about 3/32 in. dia. and may be drilled to penetrate the previously drilled exhaust passage; for the inlet ports about a No. 54 or 1.4 mm. drill should be used and the depth stop on the drilling machine set to limit the depth of hole to 1/8 in. The actual milling operation can be carried out in the lathe with the work held in a machine vice on the vertical slide, or on a vertical milling machine. One of the difficulties associated with the use of very small end mills is

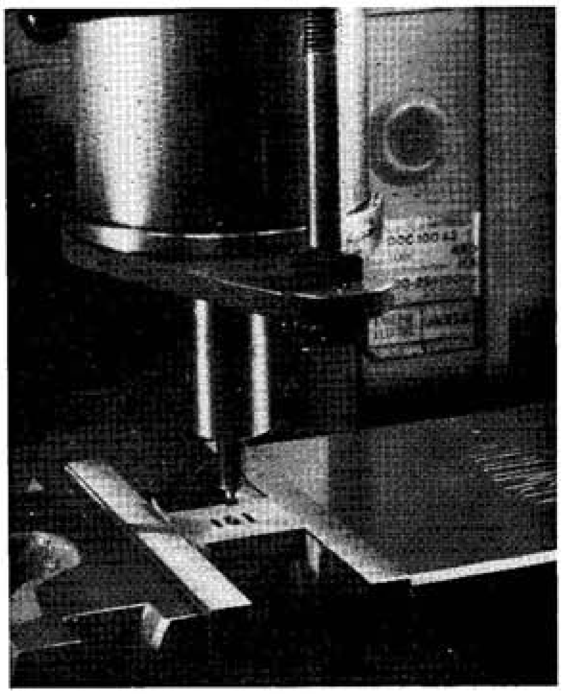


Fig. 8: The set-up on the Senior Miller.

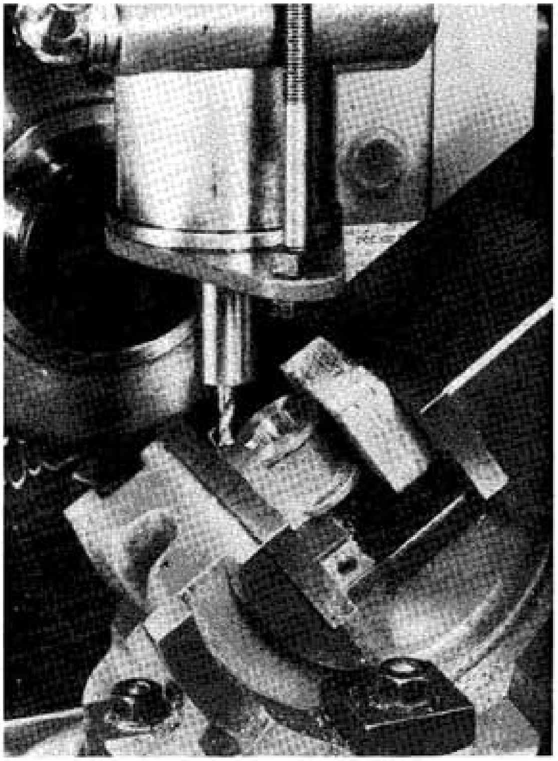


Fig. 9: 7/32 in the end mill for milling entry flat.

that of obtaining a sufficiently high rotational speed if the normal lathe mandrel is used, and some form of auxiliary spindle is called for if much of this work is to be done. Each port will need to be traversed by the cutter several times, taking a depth of cut of 25-30 thou at each pass and using the cross slide or table feed index to return to the same place for each pass. Users of a vertical milling machine are at a distinct advantage since it is much easier to observe the progress of the work than when working on the vertical slide. Fig. 8 shows my set-up on the Senior Miller; a speed of 1600 rev./min. was used, and three cylinder blocks were completed without any intermediate sharpening of the carbon steel cutters. The drilled steam passages from the ends of the cylinder to the ports need careful marking out to ensure that the drill ends up in the right place. I usually mark the position and depth of the required holes in pencil on the outside edge of the block, and then set the block in a drilling or milling machine vice so that the marked line is vertical. A recess is required at the end of the bore to lead the drilled passage into the cylinder and to form a starting surface for the drill. Having a miller with a sliding quill, I was able to carry out both the above operations at a single setting of the work. Fig. 9 shows the 7/32 in. end mill in position for milling the entry flat; this cutter was followed by a 5/64 in. drill with which the passages were drilled. This drilling operation needs care; a drill ground slightly off centre is sometimes advocated so that an oversize hole is produced, from which a broken drill can be more easily extracted in the event of an accident. The depth stop on the drilling machine should be set so that the drill cannot penetrate beyond the point of breakthrough into the steam port, and enter the exhaust port (I did this once only). The cylinder block may now be set aside until some of its mating parts have been made.

Top Cover. Fig. 5.2

The casting is provided with a chucking piece which I promptly removed (but did not discard — I use these for making small bushes), and the casting was gripped by its periphery (cylinder face outwards) in the four-jaw chuck, leaving sufficient material protruding to allow for facing and for forming of the 1/32 in. deep locating spigot. This spigot should be turned to an easy fit in the cylinder bore

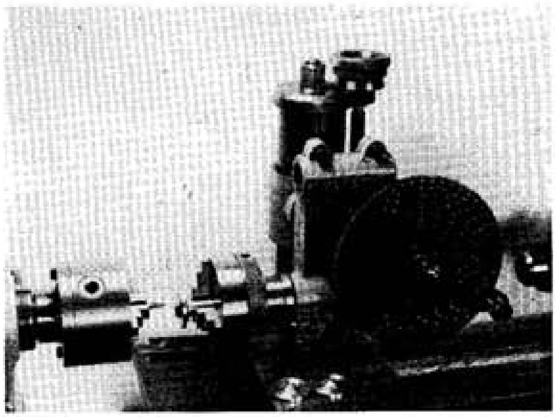


Fig. 10: Drilling the cylinder cover.

to facilitate removal of the cover when the engine is at any time stripped for overhaul. The recess in the cover provides clearance for the nut securing the piston to its rod and is shown threaded 5/16 in. x 40 t.p.i.; this thread is to enable the cover to be mounted on a screwed spigot held in a three-jaw chuck for the purpose of finish turning the periphery and top face and for drilling the six No. 38 holes.

The marking out and drilling of these six holes is greatly simplified if some form of indexing device is available. Many such devices have been described in *M.E.* and I normally use a dividing head made to the design of the late A. R. Turpin (*M.E.* 1951-52). This has some features in common with the Myford equipment, but incorporates its own vertical slide, and it fits readily on to the boring table of my

Drummond. The cylinder cover, still mounted on its spigot, is transferred to the dividing head and the ring of holes is drilled in a very short time; no tedious marking out is required. Fig. 10 shows the operation in progress.

Bottom Cover. Fig. 5.3

This cover requires careful machining since if the full alignment advantage of the trunk guide is to be realised, the top and bottom spigots of the cover need to be truly concentric. First remove the substantial chucking spigot and mark out the centre of the piston rod, making sure that it is in the centre of the gland boss since the restricted width of the latter leaves little margin for error. Now set the work up securely in the four-jaw chuck, with the marked centre running truly and sufficient of the underside of the casting protruding to enable it to be faced and a locating spigot of 1/32 in. depth to be formed. The oval boss has to be turned down to fit the 5/8 in. bore of the trunk guide and the underside of the cover machined flat to accept the mounting flange of this guide; this will involve machining off the bosses provided for the columns, but with care sufficient metal is available to do this and to provide a 1/32 in. register flange for the trunk guide. Next face the central boss to length and centre drill; follow with an accurately ground 1/8 in. drill and follow with a No. 25 or 3.8 mm. drill. Having increased the piston rod diameter with 1/8 in. to 5/32 in., I would have liked to increase the gland thread from 1/4 in. x 40 to 5/16 in. x 40, but unless the casting is very accurately set up, this enlargement may make the wall of the gland boss unacceptably thin, so on the drawing I have adhered to the original dimension in spite of the somewhat restricted room for packing. In my own case I compromised by using 9/32 in. x 40, but since this is alas now a non-standard thread, I am reluctant to specify its use. My own 9/32 in. tap and die was purchased from Kennion senior of Kingsland Road, London — that dates it! The final operation on the cover at this setting is to put a 5/32 in. reamer through the remains of the No. 25 hole.

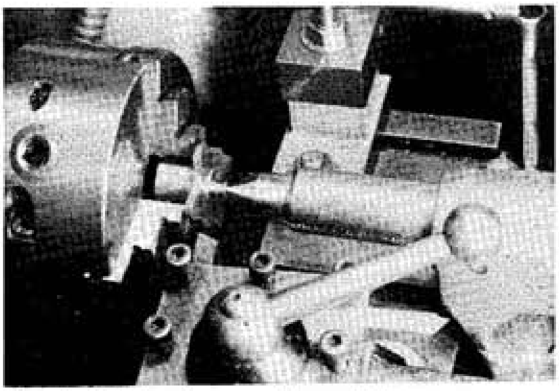


Fig. 11: Final turning operation on the bottom cover.

As mentioned earlier, concentricity of the two flanges on either side of this cover is a must and some form of jig is required to hold the cover truly by the gland boss and spigot. I used a short piece of 7/8 in. dia. b.m.s. for the jig, mounting it in the chuck and boring it to accept the gland boss of the bottom cover as a tight push fit (Note: if the order of machining is carefully planned, the trunk guide itself could well serve as the jig for holding the cover); as an additional precaution against movement while machining, a small flanged plug was previously turned up to fit in the piston rod hole, to enable the work to be steadied from the back centre. Fig. 11 shows the final turning operation on the bottom cover.

The four No. 38 holes used for the studs securing the bottom cover to the cylinder and to the trunk guide may be indexed as for the top cover, but note the increased pitch circle diameter. In order to position the four No. 30 holes for the columns, I recommend the use of a simple plate jig made from a piece of 16 to 20 gauge b.m.s. Two adjacent edges of the plate are squared to provide datum edges, and a 5/8 in. hole is bored in the centre of the plate; to complete the jig, the four No. 30 holes are marked out and drilled to their correct spacing and symmetrical with respect to the 5/8 in. locating hole. To complete the cover, it only remains to clean up and polish the outer periphery with fine files.

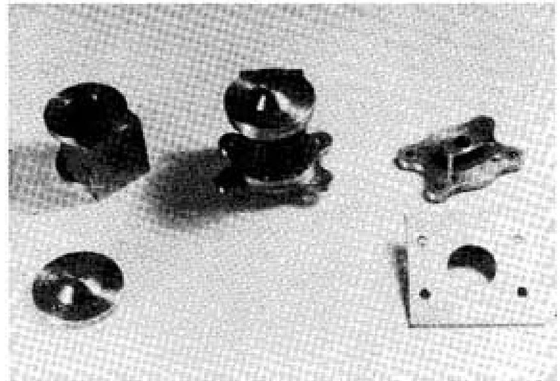


Fig. 12: The completed cylinder and its component parts. Note the drilling jig described in the text which is useful in ensuring correct hole positioning.

Fig. 12 shows the completed cylinder components so far described, together with the drilling jig described above.

To be continued