

# The **MUNCASTER** steam-engine models

**EDGAR T. WESTBURY** glances back with a modern eye  
to some classic models of the past

**I**N THE COURSE of the long history of MODEL ENGINEER—now, incidentally, approaching 60 years—many notable designs and descriptive articles have been published which have established traditions or marked milestones of progress in model engineering.

Not only are these remembered by old readers but they are often the subject of considerable discussion, and requests for further information about them are constantly encountered. A few of the authors of these features are still with us, and in one or two cases continue to contribute articles; but most of them have passed on and are no longer available to provide either new designs or guidance on their earlier ones.

Many readers have suggested that the M.E. should reprint some of these earlier features, but while this might be a good idea, from certain aspects there are several reasons why the policy has not been adopted by this journal. In the first place, although the designs for models do not necessarily become outdated the mode of treatment, including methods of construction, is subject to certain changes as workshop equipment and technique improve.

## **In modern setting**

To many modern readers, reprinting of old articles or designs may seem to be a policy of retrogression, or at least stagnation; it may even give the impression that there is a dearth of new ideas in model engineering—which is far from being the case. Therefore the idea of verbatim reprints of articles is not considered desirable, but there is much to be said for the revival of old designs in a modern setting.

There can be few model engineers who have not heard of such pioneers as Henry Greenly, C. S. Lake, Fred Westmoreland, H. H. Groves, George Gentry, or the traction engine specialist “Frost-spike,” who have been acknowledged masters in a very wide and versatile field of design. Last but not least, the name of H. Mun-

caster is well remembered as a specialist in the design of all types of steam engines, whose excellent drawings of many types of stationary and marine engines in early volumes of the M.E., and also in the handbook *Model Stationary Engines*, published nearly half a century ago, provided scope for the talents of innumerable constructors.

H. Muncaster was a practical draughtsman who not only had a wide experience of steam-engine design but also obviously had a love and devotion to his craft, and to all things mechanical. In the introduction to his book he pays due homage

fore, need despise the crude and primitive types of models produced by beginners, so long as they lead on to the more realistic types which were Muncaster’s speciality.

The simplest form of engine described by Muncaster is one having a single-acting oscillating cylinder (Fig. 1) and this will commend itself to many readers, not only on account of its simple construction, but also because it can be built without castings. It is of the type which would now be classed as “inverted” vertical, having the cylinder below the crankshaft, though in the early days the practice of locating the cylinder at a low level—firmly bolted to the floor if possible—was considered normal and orthodox.

## **THE PILLAR**

The main structural component of this engine is the pillar, shown in Fig. 2, the lower portion of which is of rectangular section, with extended feet at the sides for mounting on the flat square baseplate. At the top end, the section is also rectangular and is cross bored to form a housing for the single main crankshaft bearing. In the centre, it is turned to circular tapered form, with simple ornamentation in the form of a beading near the lower end.

To save material in making this part, the foot at the base may be made separate and silver-soldered on; or screwing and sweating would probably be satisfactory. This should be done before machining and I suggest that the front and rear sides should then be faced quite flat and true by filing, or any other convenient method, after which the two ends may be marked out, exactly central both ways, and centre-drilled so that the part can be mounted between centres for turning.

The cross holes for the main bearing and the cylinder trunnion may now be drilled, and it is essential that these should be exactly square with the pillar face, so it will be advisable, after marking out their positions, to set the pillar up on the faceplate of the lathe for these operations.

An alternative to the pillar as the

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## **1-A simple oscillating engine**

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to the many early engineers and inventors who contributed to the development of the steam-engine, and also gives a complete answer to those who would condemn model engineers for “living in the past.”

“For the purposes of the model engineer,” he states, “it does not follow that the most recent and perfect engines are most suitable; on the other hand, some of the older engines form subjects better adapted and more fitted as prototypes for models, being more picturesque and providing better object lessons.”

With which precepts I wholeheartedly agree, and also with his further comments that many of the most popular so-called models “have no prototype in reality, but nevertheless may be useful in illustrating some of the points of the steam-engine, as well as providing a simple motor, where only a small amount of power is required.” No model engineer, there-

support for the crankshaft bearing is given in Fig. 3. This consists of an A-frame cut from sheet metal, with the bearing housing at the apex, either bushed or otherwise reinforced to provide extra bearing surface. It does not, however, incorporate the port block or other cylinder mounting and it is not explained how this should be fitted. For this particular type of engine, I do not consider it so elegant in appearance as the pillar, neither does it simplify construction.

### CYLINDER

The designer suggests that the cylinder (Fig. 4) may be made from a piece of brass tube, with the flange, end cap and portface soldered on,

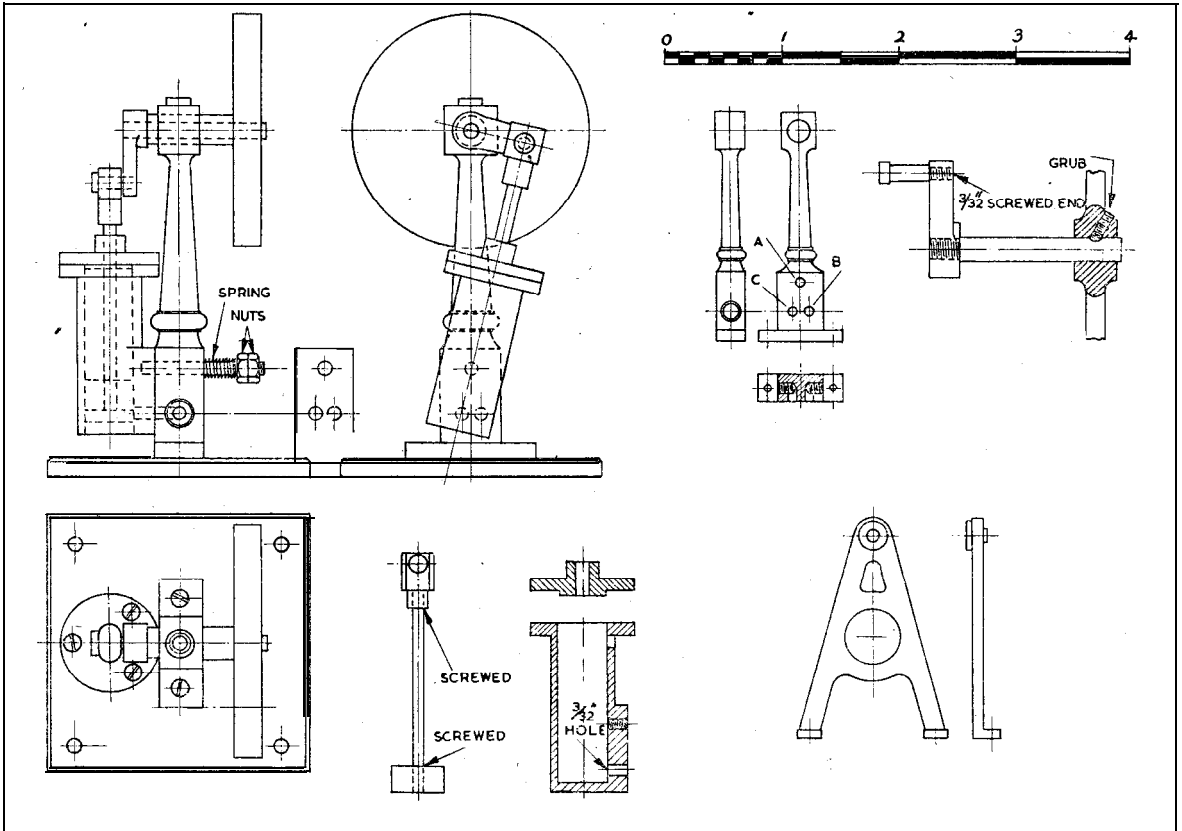
These conditions can be assured by machining, as the bore and flange can be dealt with at one setting; a D-bit is recommended for taking the final cut in a blind bore, after which it should be finished by lapping with aluminium oxide or brick dust on a short copper or aluminium lap-not one which extends the full length of the bore, as this will tend to make it tapered or bell-mouthed.

If the cylinder is machined from the solid the smallest diameter of bar which can be used is 1 in. A good deal of material will be left around the base, after turning as much as possible of the outside, and this will have to be filed or machined away, leaving the portface to be faced flat.

working to the same index reading on the topslide for each cut, the shape may be made practically circular and flush with the upper turned part, needing only a clean-up with a smooth file to take off the sub-angular corners, and a final polish with emery cloth.

The trunnion is fitted to a tapped hole in the face of the portblock, and it is most essential that this should be dead square with the cylinder axis. It could well be drilled and tapped while the cylinder is set up on the faceplate, to ensure this; the hole should not go right through into the bore, though some constructors may find difficulty in tapping a short blind hole.

If it does go through, however,



*The components of the engine*

but in practice it will usually be found just as easy to machine it from the solid, as the manipulation of small pieces, which have to be accurately located and soldered simultaneously, is not as simple as it looks. In either case, however, it is essential that the bore of the cylinder should be exactly circular and parallel, the flange faced square with it, and the portface dead flat and parallel to the axis.

A very efficient way of doing this is to make a short mandrel, of a size to fit neatly in the cylinder, and fix this in an angle-plate or a short piece of angle iron, on the lathe faceplate.

Clamp the cylinder endwise on this, checking it first to see that it is parallel with the faceplate; it can then be turned into any position to machine the portface of "nibble" away the rest of the surplus material. By

make certain that the trunnion stud does not project into the bore when tightly screwed in and that there are no burrs left on the inside to interfere with the free movement of the piston. It is an advantage to machine a shallow recess around the tapped hole to relieve the centre of the face; alternatively, this may be done on the corresponding face of the pillar.

Little need be said about the cylinder

# Muncaster steam-engine models ...

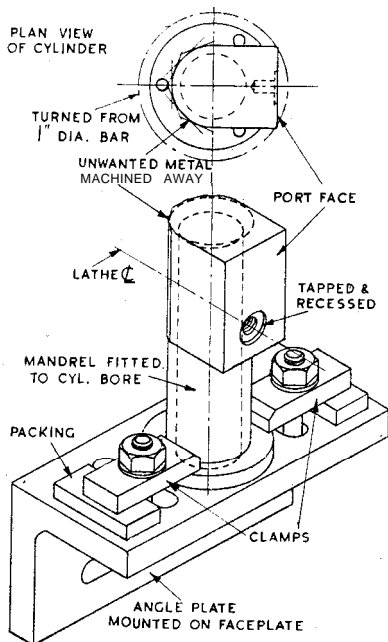
cover (also shown in Fig. 4), as this is a simple job which can be turned at one setting. The spigot should fit neatly in the cylinder bore, and the hole drilled centrally to a working fit for the piston rod. It is attached to the cylinder flange by three 3/32 in. or 8 B.A. screws. The piston assembly (Fig. 5) is built up in three pieces, the rod, of 3/32 in. dia. bright mild-steel, being screwed on each end to take the solid piston at one end and the crankhead bearing on the other, both these pieces being of brass or gunmetal.

In the drawing, the piston is shown as a plain parallel disc, machined to fit closely in the cylinder, but I strongly recommend, at least to those with little experience in these matters, that a groove should be machined in it for packing with graphited asbestos or cotton yarn. The advice I have given in articles on other engines, that the final machining of the piston should be done after it has been screwed tightly on the rod, still holds good. Final adjustment of the length of the rod, so that the piston just stops clear of the end of the bore at the extremity of its stroke, can best be done on assembly.

## CRANKSHAFT

The crankshaft is built up with a web made from rectangular brass bar, into which the main journal and crank-pin are screwed. As an alternative form of construction a disc can be used, and this would not only improve the appearance but could also be balanced if desired. In either case, however, it is essential that both the tapped holes should be square with the web and parallel with each other. No details are given of the flywheel, which is shown as a solid disc, but I recommend that a spoked flywheel with a heavy rim should be fitted.

The main bearing is in the form of a plain bush, made to press tightly in the cross hole at the top of the pillar, and the centre hole in the end of the latter is drilled through into the bush to serve as an oil hole. It is now in order to assemble the parts temporarily, to ascertain that everything works freely and smoothly, without binding or tight spots, and that the piston clears at both ends of the cylinder.



Set up for machining the cylinder block

## PORT LOCATION AND TIMING

The entire success of an oscillating cylinder engine depends on the accurate location of the steam-ports, and this is where many constructors fail to get the best results, as it is by no means easy to mark out and drill holes exactly in the right place. Both the size and position of the two holes in the stationary portblock are dependent on their radius from the trunnion centre, in conjunction with the maximum distance of swing at extreme cylinder angularity—which, incidentally, is not the same thing as half the piston stroke.

In this engine, the maximum distance of swing under these conditions at 3/8 in. radius is 3/16 in., so the ports should be drilled at 3/16 in. centre distance apart, and as the blank space between them should be exactly the same as the port diameter, this dimension should be 3/32 in.; on no account drill larger holes as this would only result in steam wastage between the ports.

Even with the utmost care in locating the holes in the portblock, however, there is still a possibility of error in the position of the single hole in the cylinder face, which may completely nullify all efforts to produce a correctly timed engine. I suggest, therefore, adopting an unconventional method of drilling—these holes, which not only kills two birds with one stone, as it were, but also ensures positively

that they are correctly located in relation to each other.

First of all, the hole in the cylinder is marked out as correctly as possible and drilled undersize, say 3/64 in. or No 48 drill, the hole being continued right through the 'opposite wall of the cylinder. The engine is then assembled and the crankshaft turned to swing the cylinder to maximum angle in one direction, where it is clamped in place by the nut on the trunnion stud with a suitable distance piece.

## LAPPING

By running the drill through the hole in the cylinder the position of the hole in the block may be spotted or drilled to full depth, after which the cylinder is shifted to the other extreme position by turning the crank, and the operation repeated. The ports are then opened out to 3/32 in. or No 42, and the hole in the outer cylinder wall closed by a plug screwed or soldered in.

Finally the two side holes in the portblock, forming steam and admission connections, are drilled to meet the ports and tapped to take screwed pipes, the faces of both cylinder and portblock then being lapped on a piece of plate glass to produce a truly flat and smooth finish.

When finally assembled, a light spring is fitted to the trunnion and the locknuts are adjusted to hold the cylinder against the block, but with no more tension than is necessary to keep it in steamtight contact against the working steam pressure. The engine will run in either direction, according to which of the two connecting pipes is connected to the steam line, so that it could readily be made reversible by fitting a change-over cock.

If made according to directions and carefully finished, this should not only be a satisfactory working model, but also a handsome and dignified one.

● *To be continued.*

## ADDITIONS TO THE LATHE

Instructions for making centring devices; chucking accessories; tool holders and cutter bars; dividing appliances; simple milling attachments; aids to screwcutting; and steadyng appliances are to be found in Edgar T. Westbury's *Lathe Accessories*.

Priced 3s. 6d., postage 3d. (U.S.A. and Canada \$1.00), it can be obtained from Percival Marshall and Co. Ltd, 19-20, Noel Street, London, W.1.

# The **MUNCASTER** steam-engine models

**EDGAR T. WESTBURY** is reviewing some classic models of  
the past in the light of modern techniques

*Continued from 21 February 1957, pages 270-272*

**R**EADERS will no doubt have noticed that the drawings of the simple engine described in the last article were not fully dimensioned, and just in case there should be any complaints about this I will anticipate them by saying that Muncaster, in common with many pioneer model designers, did not consider it necessary to give more than a few leading dimensions on drawings.

I have, however, added a scale which should be helpful in supplying the deficiency, in conjunction either with a simply-made scale rule or a pair of proportional dividers.

The present-day engineer is accustomed to drawings which have every dimension, including in many cases limits and clearances, fully marked, as this is absolutely necessary in industrial production, where different parts have to be made, or even successive operations carried out on single parts, by individual workers out of direct touch with each other.

## Use initiative

In cases where all the machining and fitting on a one-off job are in the hands of a single constructor, however, meticulous marking of every essential and non-essential dimension is by no means so important. While I should be the last to condone inaccurate or slipshod work in any kind of model engineering, I believe that one can become a slave of the blueprint, and it is good engineering practice to work occasionally to what the professional engineer would consider inadequate drawings or specifications, if only because it helps one to cultivate a sense of proportion.

In the field of natural history, reasonably accurate re-constructions of prehistoric animals were made from fragments of fossil bones long before they could be verified by further evidence; and many model engineers have produced good work with nothing more in the way of information than a few rough sketches and possibly a photograph or two.

I must confess that I have not a great deal of patience with the type of reader who makes a major issue out of a missing dimension or a slight discrepancy in a drawing; the more complicated drawings become, the more difficult it is to avoid minor errors which escape the most careful checking, and the more likely they are to deter the timid beginner from tackling construction.

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## 2-Double- acting oscillating engines

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### DOUBLE-ACTING OSCILLATING CYLINDER ENGINE

Unlike the previous engine, the construction of this example, illustrated in Fig. 7, favours the use of castings for the main structural parts, though they can be produced by cutting from the solid and fabrication. For instance, the hollow base, **D**, could be made by soldering or brazing a rectangular frame of strip material to a flat plate, and the bearing supports or A-frames, **F**, could be made by bending strip material to the profile, as seen in the end view, and soldering or brazing in the curved supporting rib or crossbar.

It is most important that these frames should stand exactly perpendicular to the base when fitted and that the top surfaces which form the bearing seatings should be exactly the same height and in alignment. While it is possible to correct errors in these respects by packing under the feet of the frames or the bearings, this is certainly not a practice to be encouraged.

If the cylinder, **A**, is made from stock material, the circular portface may be made from a piece of 7/8in. dia. bar, filed or machined to fit closely to the side of the barrel and preferably secured by silver soldering. At the same time, short half-round pieces can be fitted above and below this face. It will be seen that a boss or spigot is provided on the opposite side of the barrel to receive the point of a pivot screw, and this should similarly be fixed, exactly in diametric alignment with the portface.

The drawing shows a raised beading in the centre of the cylinder; this is not a necessity, but is desirable both from the point of appearance and also to stiffen the cylinder wall. For machining the bore and facing one end flange, I recommend mounting on an angle plate with a strap bearing on the spigot, but care should be taken not to apply so much pressure as to risk distortion of the barrel. The other end flange is faced by mounting on a mandrel.

### Mark off centres

It is absolutely essential that the centre indentation in the spigot should be dead in line with the hole in the centre of the portface, and in order to ensure this, it would be a sound policy to mark off these centres with a surface gauge, with the cylinder resting on the machined flange face to locate the horizontal line, and then mounting it on a mandrel resting in V-blocks for the vertical line. The intersections on both sides are then centre-drilled, and the Cylinder mounted between centres for machining the portface.

Flanged covers are secured, each by four screws, to the ends of the cylinder, and as the engine is double-acting the upper cover is fitted with a gland, or "stuffing-box" as it was termed by the early engineers. It is important that this should be exactly central and truly tapped; these conditions can be ensured by using the methods which I have described for engines of my own design.

No exact details are given of the

# Muncaster models . . .

piston, but from other engine dimensions it is clear that this should be 5/16 in. wide, and a groove 3/16 in. wide x 1/8 in. deep may be turned in it to take graphited packing. The rod is 5/32 in. dia., and the crankhead bearing, which is screwed to the upper end, must be split as shown in Fig. 8, to enable it to be assembled on the crankshaft.

The cylinder is mounted between the fixed portblock, B, and the pivot block, C, both of which are screwed to the base between the feet of the A-frames, and it is most essential that the centres of these should be dead in line and that the face of the block, B, is squarely located so that the portface of the cylinder beds truly against it while being quite free to swing when the pivot screw is properly adjusted.

This is perhaps a somewhat difficult condition to ensure, at least for the beginner, and I suggest that one method of doing so is to fix the blocks together temporarily by sweating, with an aligning dowel in the pivot holes (leave the tapping of the pivot block *pro tem*), and facing off the base surface by machining or filing exactly square with the face of the portblock. Even this, however, will be of no avail if the mounting surface of the base is not dead flat and true; it is also necessary to locate the two blocks correctly in relation to each other when they are screwed in position.

## Aligning mandrel

To do this, an aligning mandrel is made from a dead straight piece of 5/32 in. silver-steel rod, long enough to extend across the base and pass through both blocks. After squaring up their positions, the portblock should be fixed first by its two screws and then the pivot block; in each case it will be possible to spot the positions of the tapping holes in the base from those in the blocks to avoid the risk of error.

Small clamps are useful for holding the parts in place during these operations and if not already available they should be made or obtained right away, as they will certainly be needed for innumerable subsequent jobs.

When fitted to complete satisfaction, the hole in the pivot block may be tapped and a locking screw fitted to the top (though I should personally consider that a locknut on the screw would be more satisfactory); the portblock is also equipped with a centre stud to fit the hole in the centre of the cylinder portface.

The crankshaft, G, may be either built up or machined from the solid; it is not necessary to give details of either method as they have been described on innumerable occasions in connection with other engines. I may observe, however, that this offers quite a good opportunity for the beginner to get some practice in marking out and machining an orthodox type of crankshaft from a piece of flat bar, which should be of about 1 in. x 3/8 in. section.

I would, however, suggest a slight modification to this component, as drawn; it would appear that the only end location of the shaft is that provided by the flywheel on one side and the driving pulley on the other. I do not consider this to be very good

practice, as although it serves its purpose, in the event of either fitting being shifted, accidentally or otherwise, it would be possible for the crankhead to be forced out of alignment.

A much better method would be to provide positive end location on the inside of the main bearings, either by enlarging the idle portion of the journals to form locating collars, or better still, extending the bearing surface inwards up to the webs of the crank. Incidentally, I do not understand why it should be necessary to place the bearing frames so far apart in this engine as it is a cardinal precept in any engine design to support a crankshaft as close up to the webs as possible.

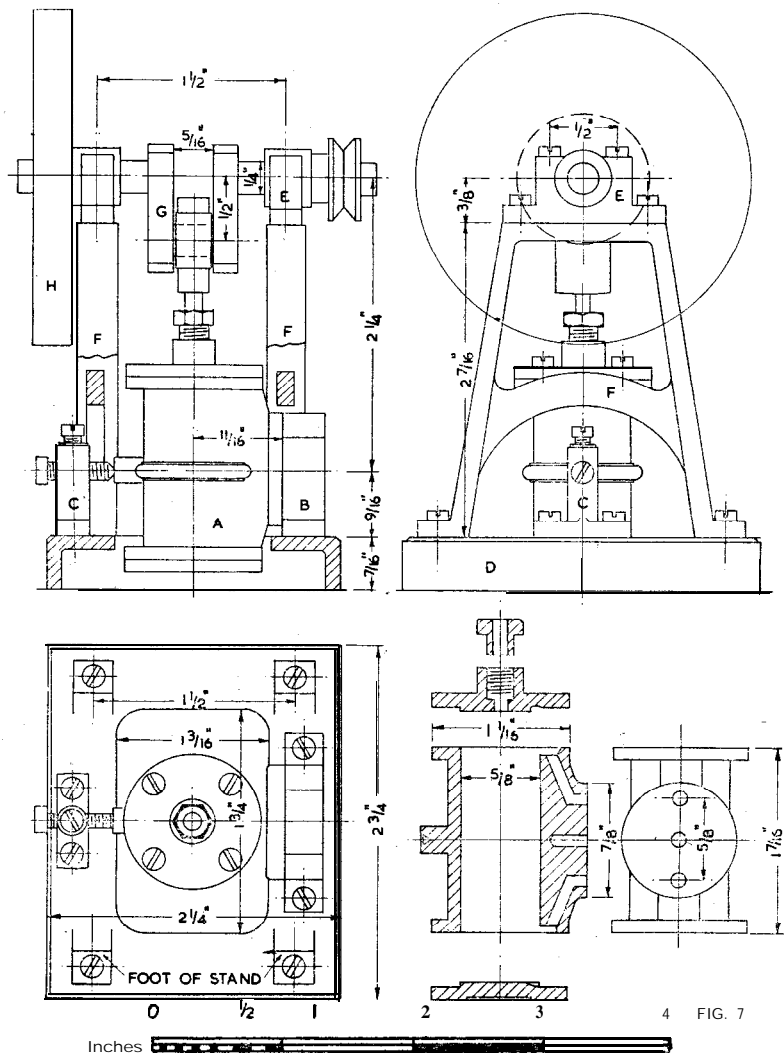


Fig. 7: General arrangement of double-acting oscillating engine, and details of cylinder

*Extreme right, Fig. 8:  
Details of the split bearing  
for piston rod*

*Right, Fig. 9: Portblock,  
showing formation of the  
inlet and outlet passages  
on both sides (to suit  
the twin-cylinder engine)*

*Left, Fig. 10: Arrange-  
ment of complete plant  
with vertical boiler, show-  
ing cylinder portblock,  
reversing valve, etc.*

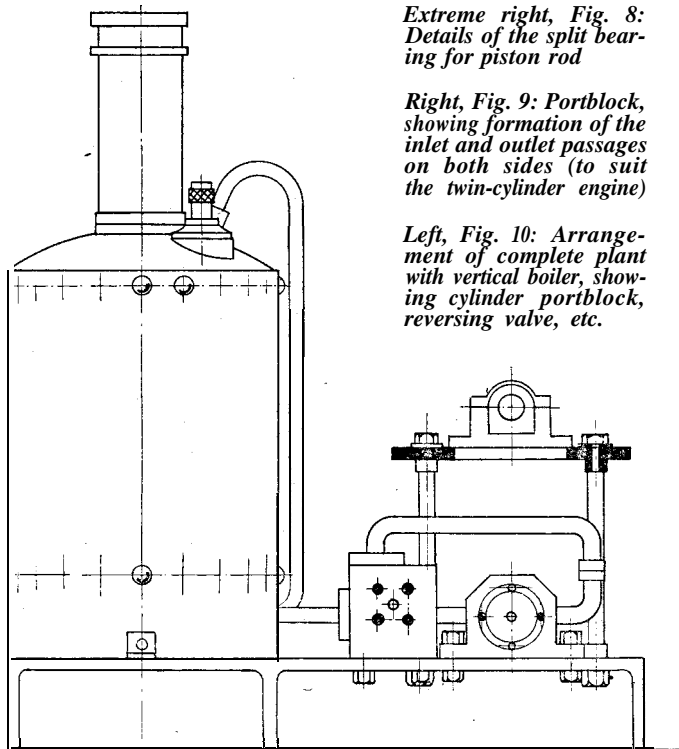


FIG. 10

The main bearings, *E*, are of the plummer block type, and correct practice dictates that they should be split, though this is not a practical necessity in a small engine as solid bearings can be threaded on from the two ends of the crankshaft. They must, of course, be correctly aligned but this is easily ensured if they are made and fitted properly, and any small discrepancy which may cause the shaft to run tight when finally fitted can be corrected by running a reamer or lap through both bearings when they are screwed down *in situ*. (This, of course, pre-supposes that the shaft journals are properly machined or assembled in exact alignment).

### CYLINDER PORT LOCATION

In drilling the steam ports in the cylinder and portblock, it is not practicable to use the simple method of ensuring their correct location recommended in the previous article, as the former ports do not lead directly into the cylinder but communicate with oblique ports drilled from the cylinder ends. It could, perhaps, be done by drilling straight-through holes and plugging them up afterwards, but there might be some risk of leakage with relatively inaccessible plugs.

The method of port formation recommended by Muncaster, however,

is ingenious, and with careful measurement and marking out should give very satisfactory results. In this case, the cylinder ports are located by measurement, and an annular groove is formed in the fixed portblock, *B*, concentric with the pivot pin, and at the same radius as the two cylinder ports (Fig. 9).

At the top and bottom positions the groove is blocked or "stopped off" by fitting plugs, which are faced off flush with the face of the block; and at right angles to these positions, holes are drilled in the groove to communicate with the inlet and exit pipes, one of each thus serving for the two ends of the cylinder.

It will be seen that when the engine is assembled with the cylinder in contact with the block, and the piston on dead centre, both cylinder ports will be blanked off by the stop pegs; but when the crank is turned to swing the cylinder to its extreme angular position (indicated by the line, *ab*) the top cylinder port will be placed, via the annular groove, in communication with the right-hand horizontal passage, and the lower port with the left-hand passage.

At the other extreme end of the swing, the communications will be reversed; thus the conditions are established for admitting steam to

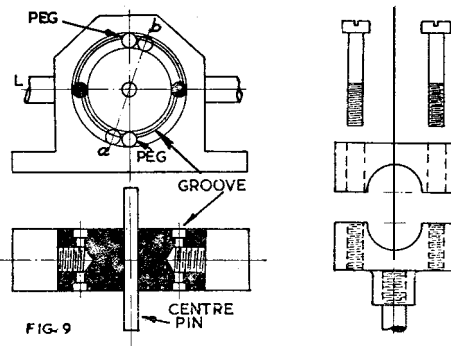


FIG. 9

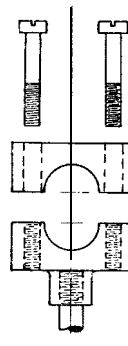


FIG. 8

each end of the cylinder in turn and releasing it to exhaust, on alternate strokes of the piston. As in the case of the single-acting engine, optimum timing is obtained when the "stop" of the groove lines up exactly with the cylinder port at dead centre and is exactly the same width as the port.

The ports in the cylinder and the oblique drilled passages should be 1/8 in. dia., and the entry at the mouth of the cylinder in each case should be unobstructed, which calls for chamfering the edge of the cylinder and the spigot of the cover at this point. The portfaces should be carefully lapped and may with advantage be relieved in the centre as recommended for the previous engine. Thin paper gaskets should be fitted to the covers to ensure steam-tight joints.

### A TWIN-CYLINDER ENGINE

The design of this engine may be adapted to form a twin or "double" engine by simple modifications and additions to the components. The base will, of course, have to be enlarged, and a third bearing support fitted to take a two-throw crank, with the crankpins located at 90 deg. as shown in the general arrangement drawing, Fig. 10, of a complete double-cylinder engine with vertical boiler, in elevation.

The drawing shows a modified form of bearing support, but most components are identical with those of the single engine. A double-sided portblock is fitted between the two cylinders with *both* its faces grooved and ported as shown in Fig. 9.

This drawing is admittedly somewhat sketchy and lacking in detail but it should be readily understood if considered in conjunction with the drawing of the single-cylinder arrangement (see Fig. 7).

Some further details of the twin-engined plant will be given in the next instalment.

● *To be continued.*

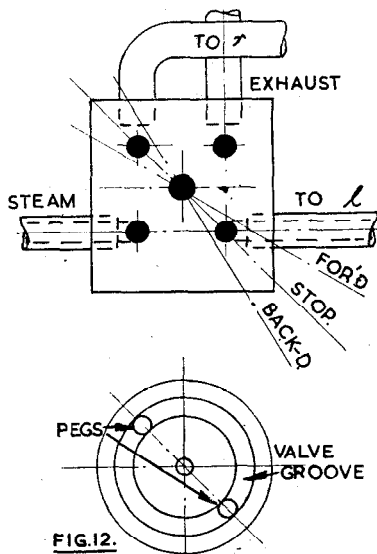
# The **MUNCASTER** steam-engine models

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*Continued from 7 March 1957, pages 337 to 339*

**I**N THE ISSUE of February 21, it was stated that an oscillating engine can be made to reverse its direction of rotation simply by changing over its steam and exhaust connections; this applies to all engines timed to work without lap or lead, whether single or double-acting, and with any number of cylinders, with the exception of those having flat slide valves.

It is therefore possible to equip any of these engines with a simple reversing control, consisting of a four-way change-over cock or valve, and such a control is indicated in the plan view of the double engine, Fig. 11. Details of the reversing valve are given in Fig. 12, where it will be seen to consist of two essential parts, a stationary portblock, with four ports and their connecting pipes, and a rotating valve with interrupted annular groove just like the portblock shown in Fig. 9. These parts are lapped to fit truly together and held in friction-tight contact by a spring acting on the centre pivot.



When the valve is turned into such a position that the blanked portions close two diametrically opposite ports in the block, communication to the cylinders is shut off; this is the "stop" position. By moving it in a clockwise direction, however, steam is admitted to the pipe marked **R**, and exhaust connected to **L**; while moving it the other way reverses these connections. I would suggest, in order to improve the seal of the valve face and make it less critical in angle of movement, that the width of the groove stop should be increased by fitting a peg of larger diameter, or other means.

## A VERTICAL BOILER

The boiler recommended for either of these engines is shown in section in the elevation drawing, Fig. 13, and in plan view, Fig. 14. It is preferably made in copper, about 3/64 in. thick, or 18-gauge, for the shell, with end-plates 1/16 in. thick or 16-gauge, which can be beaten or spun to the shape shown. For relatively low pressures, which should be perfectly satisfactory for these engines, riveting and soft soldering will be safe enough, though as a precaution in case the boiler should ever run dry the joints of the inner flue and cross tubes, which are in contact with the flame, may with advantage be silver soldered.

The flue is 1-1/4 in. dia. by 16-gauge, with cross tubes 3/8 in. dia. by 20-gauge, and the steam-pipe, which may either

be brazed directly into the top of the boiler or fitted with a union joint, is 3/16 in. dia.

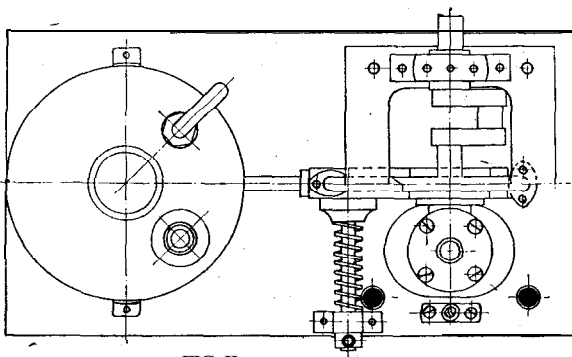
Whatever other fittings are attached to the boiler, a safety-valve must on no account be omitted; this may be of a simple type, combined with the filler plug, as shown in Fig. 15. The boiler should be hydraulic tested to stand 50 p.s.i. without leakage or distortion, and the safety-valve spring (which should be of rustless steel or phosphor-bronze) adjusted so that it lifts at 35 lb. Firing may be by spirit, paraffin or gas, as described in previous articles.

## SIMPLE SLIDE-VALVE ENGINES

The majority of steam-engines, large and small, are equipped with slide-valves for the distribution of steam, and of these, the simpler types employ an eccentric (which is essentially a form of crank) for direct operation of the valve in fixed phase relation to the piston stroke.

To anyone who intends to build engineering models of any kind, I consider that a practical understanding of the simple slide-valve engine is essential, and one of the first essays in construction should be devoted to producing a working model of such an engine. Judging by the many queries received on this subject, it would seem that the steam-engine does not receive the attention it deserves in elementary technical

*Right, Fig. 11: Plan view of a complete twin-engine plant, showing (top half) crankshaft and (at the bottom) cylinder and the reversing valve*



*Left, Fig. 12: The portblock and rotating disc of the reversing valve, showing connections to cylinder portblock*

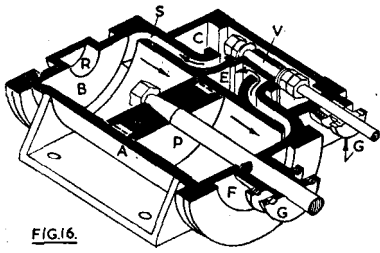


FIG. 16.

Fig. 16: Section through cylinder and steam-chest of slide-valve engine

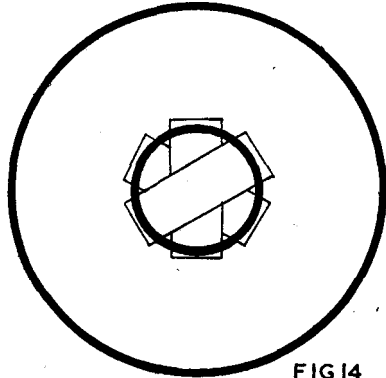


FIG. 14.

Fig. 14: Sectional plan of boiler, showing cross-tubes

Below, Fig. 13: Section of simple vertical boiler, a twin engine

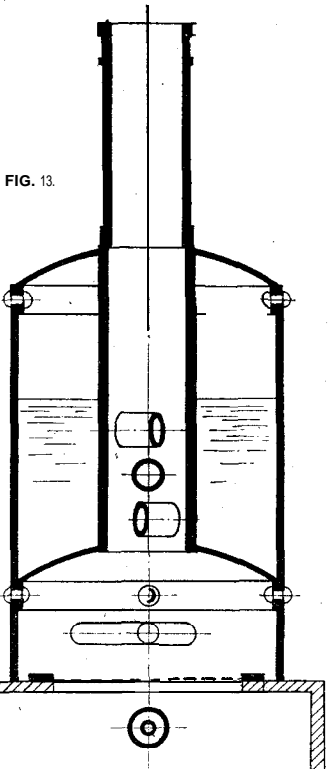


FIG. 13.

education, as many intending constructors do not appear to have mastered its basic principles. I feel sure, therefore, that more experienced hands will not grudge a little space devoted to this important subject.

In my own articles on steam-engines, I have always recommended beginners to start right away on building a slide-valve engine, without worrying about the conventional oscillating engine, which is generally regarded as the first stepping stone to progress in construction.

My reason for this advice is not simply because it is possible to attain higher efficiency with the slide-valve—though this is an undisputed fact—but because the latter gives facilities for the observation of valve events, also for checking and experimenting with timing; in this way it teaches the constructor more about engine functions than is ever possible with an engine in which the means of steam distribution are both invisible and immutable.

When once the principles of the direct-acting slide-valve have been mastered, one can, if one so wishes, go on to study the more complicated valve gears which enable the expansion of steam to be controlled or rotation to be reversed.

Muncaster quite rightly devotes careful attention to the elementary principles of slide-valve operation and gives an isometric section of a steam-engine cylinder and steam-chest which I reproduce here (Fig. 16) to illustrate the essential features. The piston, P, is shown at about half stroke, moving in the direction of the arrows, and the slide valve, V, is in the appropriate position in relation to it at this stage.

Steam is admitted under pressure to the steam chest, C, filling the space around the back of the valve, which has a flat face in contact with a stationary flat surface in which three ports are formed. The two outer

ports open into passages, SS, leading to the respective ends of the cylinder, and the central port, E, is in communication with atmosphere, or the exhaust pipe system.

Both the piston and the slide-valve are connected mechanically to the external working parts by rods which pass through packing glands, FG, to avoid leakage of steam at the openings in the cylinder and steamchest.

At the position illustrated, steam is being admitted to the rear or closed end of the cylinder and forcing the piston outwards; the valve meanwhile is moving in the opposite direction, so that it will cut off the steam supply as the piston nears the front end of the cylinder. During this period, the other side of the piston is in communication, through the passage, S, and the cavity in the centre of the valve, with the exhaust port, E, so that the steam in this space, which has already done its work, is displaced by the piston and is free to escape.

By the time the piston has completed its outward stroke, the slide-valve has moved to commence opening the front end of the cylinder to live steam and the rear end to exhaust, so that the motive force on the piston is reversed and it starts on its return stroke.

An engine of this type is said to be double-acting, as power is applied to the piston on both forward and return strokes; it is the orthodox arrangement for most types of steam-engines, though single-acting engines, in which power is produced on one side of the piston only, are employed for certain duties, particularly where it is desirable to keep the weight of working parts as low as possible for the attainment of high speed.

### LAP AND LEAD

In early steam engines it was usual to make the closing faces or lips of the slide-valve on either side of the

Right, Fig. 17: Diagrams illustrating "lap" and "lead", showing corresponding positions of the crank and eccentric (clockwise rotation)

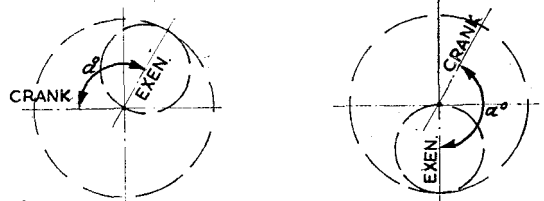
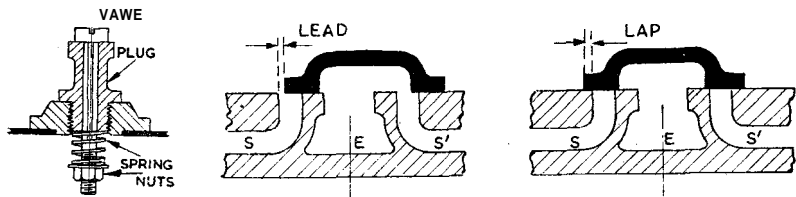


FIG. 17

Below, Fig. 15: A simple safety-valve





central cavity exactly the same width as the steam ports they controlled. The valve was timed to move at 90 deg. in advance of the crank, so that the ports commenced to open exactly at dead centres and a full piston stroke was occupied both for steam admission and exhaust.

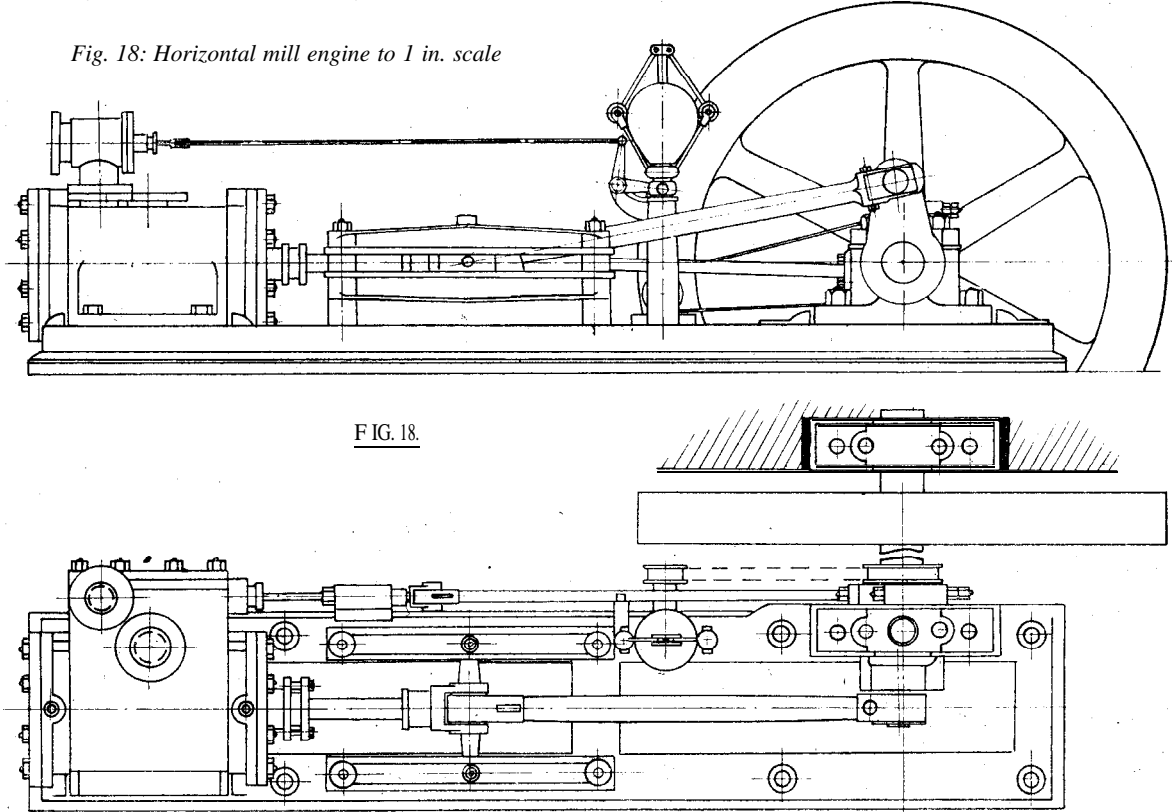
It was soon found, however, that better working efficiency could be obtained by advancing both the opening and closing points, but not necessarily in the same ratio. Early

junction with the previous drawing, should make them quite clear.

It will be seen that the lips of the valve are extended in width (or, strictly speaking, length, in the direction of travel) so that they overlap the ports, SS, when in mid-travel, as seen on the right; the extent of the overlapping is termed "lap." Such a valve, if timed to move at 90 deg. in front of the crank, would give delayed steam opening and thereby reduce efficiency; to compensate this,

Incidentally, I may mention that in my directions, for timing steam-engines in the past I have occasionally been criticised for recommending "rule of thumb" methods—in other words, timing *in situ* by turning the crank to dead centres and checking up on the actual valve position. It might be considered more "scientific" to deal in exact angles of advance, and this would be absolutely necessary in an engine having the eccentrics machined integral with the crank-

Fig. 18: Horizontal mill engine to 1 in. scale



steam opening could be used to cushion the piston movement, thus bringing it smoothly to rest at the end of its stroke and also to ensure that the maximum effort was available to start it on its return. By cutting off the steam supply before the piston reached the end of its power stroke, the expansive properties of the steam could be used to complete the stroke, so that by the time it was released to exhaust most of its energy had been usefully expended.

The means employed to attain this result are by designing and timing the valve to produce what is known as "lap and lead." I have been asked so many times to explain these terms that I consider it worth while to reproduce another of Muncaster's diagrams (Fig. 17) which, in con-

the timing of the valve is advanced by shifting the eccentric so that it begins to open the steam-port slightly before the crank reaches dead centre; the amount of opening at the latter point, as shown on the left, is known as "lead."

The diagrams above the valve sections in each case show the relative positions of crank and eccentric to produce the required timing; on the left, the crank is on its dead centre and the eccentric approximately 120 deg. in advance of it—in the usual terminology, the "angle of advance" is taken as the amount *extra* to the original 90 deg. in front of the crank, so in this case it would be reckoned as 30 deg. The right-hand diagram shows the eccentric at mid-stroke, still leading the crank by the same amount, of course.

shaft, or otherwise rigidly pre-located.

But in actual practice the measurement of angles on very small engine components is extremely difficult—one might easily make an error of two or three degrees in the location of a keyway on a small shaft, for instance, and, moreover, it is not always advisable to regard valve setting as being "immutable as the laws of the Medes and Persians."

● To be continued

### WIN A MYFORD SUPER SEVEN LATHE

Readers are reminded that the closing date for the MODEL ENGINEER competition, the prize for which is a Myford Super Seven lathe, closes on April 5.

# TheMUNCASTER steam-engine models

By  
Edgar T.  
Westbury

## 4-Horizontal Stationary Engines

Continued from 21 March 1957. pages 420 to 422

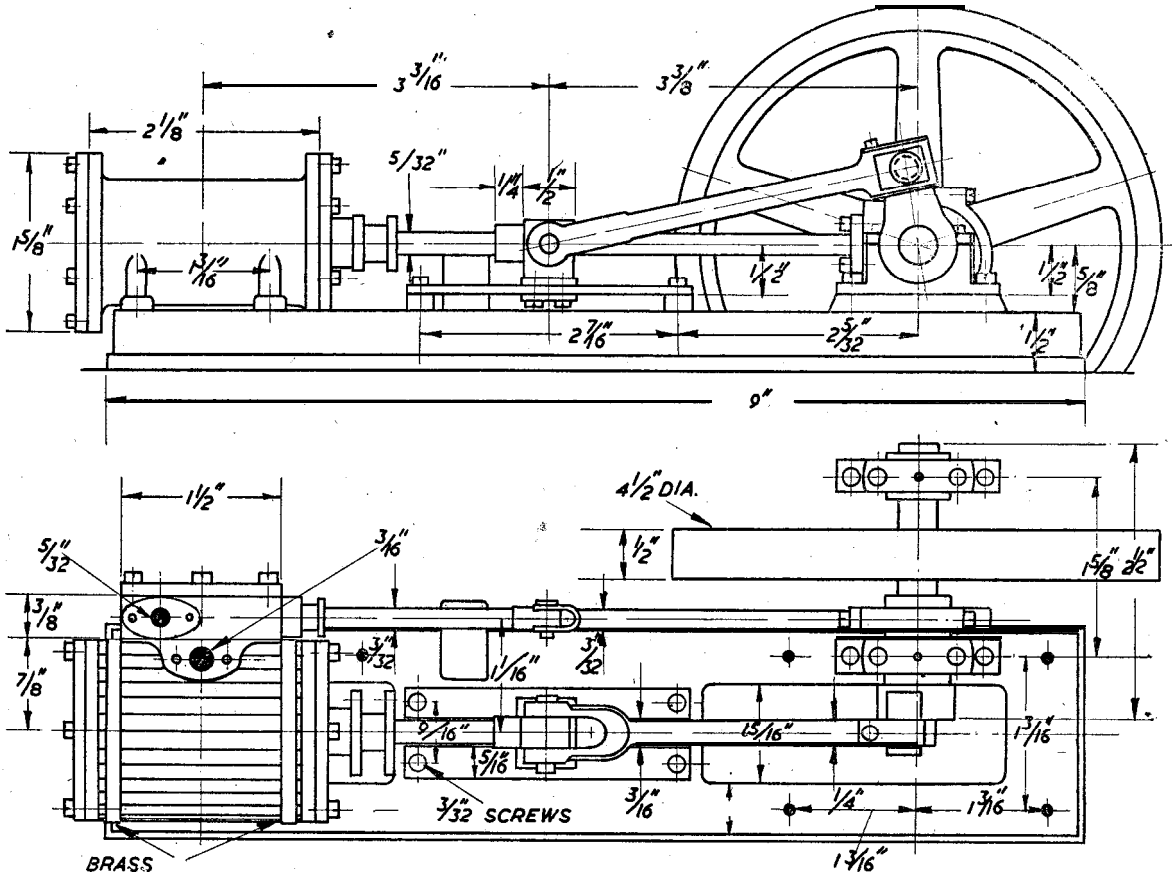
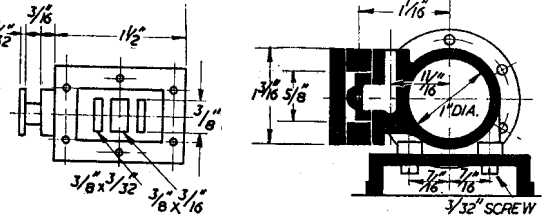
IN DESCRIBING the function of the slide-valve and the effects of lap and lead [Fig. 17, March 12], no particular mention was made of exhaust timing. It would be a mistake to regard this as insignificant, but it is generally satisfactory to allow it to keep in phase with the steam admission, as it must inevitably do so in a simple slide-valve, and it is usual to make the inside edges, in other words the width of the valve cavity, such that they just, and only just, span the inside edges of the cylinder ports at mid travel (right-hand diagram).

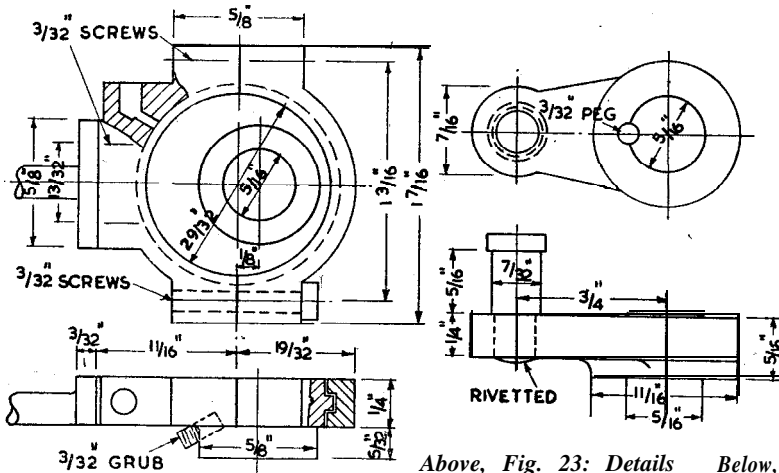
Thus the slightest movement either way opens one or other of the cylinder ports to exhaust. Occasionally, however, engines are timed to give either positive or negative exhaust lap, by narrowing or widening the valve cavity; the latter is the more common and its object is usually to

avoid excessive "cushioning" or compression, or to eliminate risk of back pressure in the exhaust system.

The conventional stationary or so-called "mill" engine forms an excellent exercise in steam-engine construction, and is deservedly popular. Several examples of these engines were

Right, Fig. 20: A cross section of  $\frac{3}{32}$ " stroke, showing the port dimensions. Below, Fig. 19: A horizontal mill engine, 1 in. bore x 1 in. stroke, with bar crosshead slides

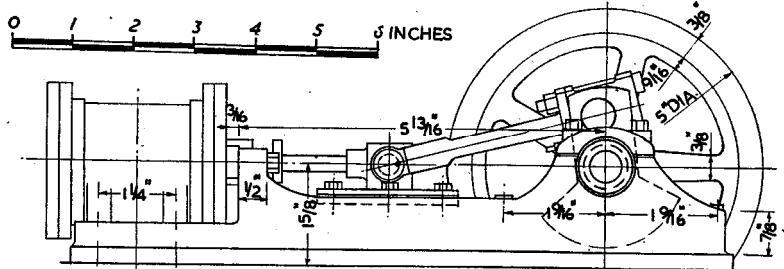




Above, Fig. 23: Details of the crank and eccentric

on a long box-section bedplate, with machined facings where required, and it is desirable to machine these in order to ensure accurate location and secure mounting of the parts, but in the absence of proper facilities they may be filed and scraped, accuracy being checked by means of a surface plate.

It will be seen that both engines have an outboard crankshaft bearing, or "pillow block," which must be accurately lined up with the other bearing mounted on the bedplate; for this reason the actual foundation on which the latter is mounted must also be flat and true. It may be made from a thick slab of well-seasoned hardwood, with a cavity cut out to clear the flywheel.



Below, Fig. 24: A horizontal engine, 1-1/2 in. bore x 1 1/2 in. stroke, with a slipper crosshead

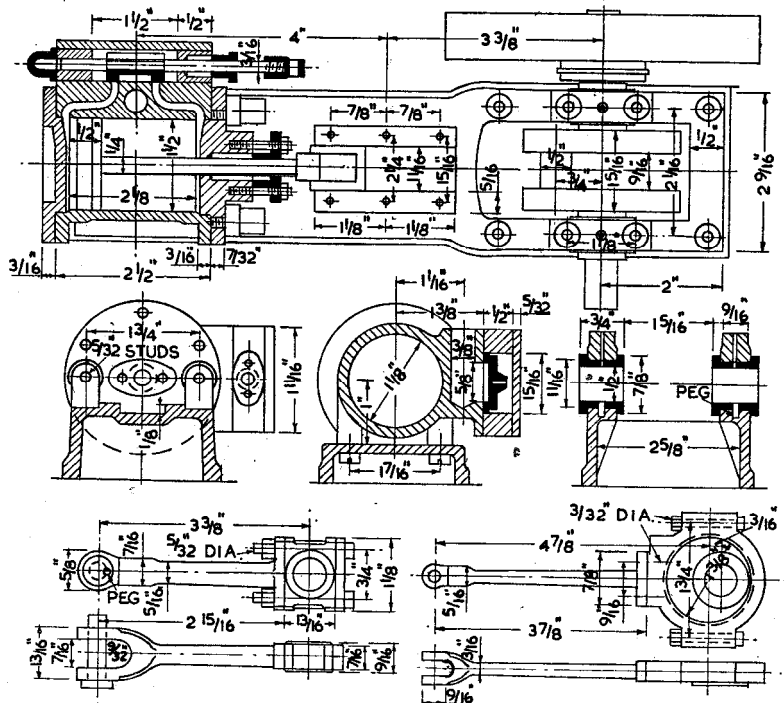
designed by Muncaster, all generally similar in major features but differing in size and certain details. The first, shown in Fig. 18 [March 21], is scaled down from a fairly large engine, 12 in. bore x 18 in. stroke, in the proportion of 1 in. to 1 ft.

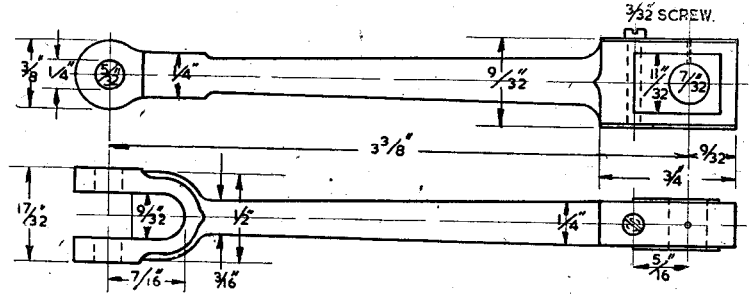
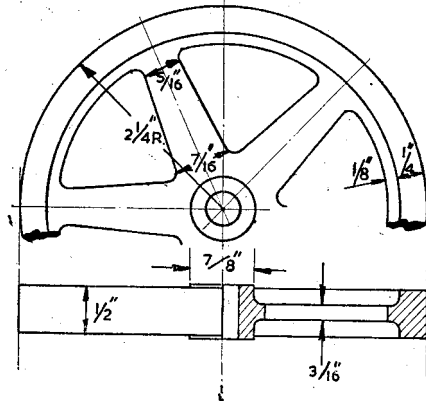
No dimensions are given on the actual drawing, but Muncaster gives a table of dimensions worked out to exact scale. I have taken the liberty of modifying some of these to give round fractional figures, as most constructors would undoubtedly wish to use standard drills, reamers and stock materials wherever possible; but general proportions have been closely adhered to.

The cylinder dimensions for the 1 in. scale model are 1 in. bore x 1-1/2 in. stroke. Piston rod diameter 3/16 in., crosshead fin. wide inside fork, with crosshead pin 3/16 in. dia. Connecting rod, circular section, fish-bellied, 3/16 in. dia. at the two ends, swelling to 1/4 in. centre; length between bearing centres 2-5/8 in. Crankshaft 7/16 in. dia., with journals reduced to 3/8 in. x 1/2 in. bearing length; crankpin 1/4 in. dia. x 5/16 in. long. Flywheel 5 in. dia. with rim section 1/2 in. square. Eccentric throw 7/64 in., rod circular section, tapered from 1/8 in. to 7/64 in. Valve spindle 7/64 in. dia., valve travel 7/32 in. Port dimensions: steam-ports 5/64 in. x 7/16 in., exhaust 5/32 in. wide. Valve travel 7/32 in., lap 3/64 in., cavity 5/16 in., lead 1/100 in. Steam inlet 1/4 in. dia., exhaust outlet 5/16 in.

As, the constructional methods for this and the second engine are generally similar, they may be considered together. In the latter case, illustrated in Fig. 19, leading dimensions are given on the drawing. Both engines are intended to be built from castings, though fabrication of most of the components is practicable.

The main components are mounted





Left, Fig. 21: Details of the flywheel. Above, Fig. 22: Details of the connecting rod. Below, Fig. 25: An engine of similar dimensions with trunk crosshead

Many constructors, no doubt, would prefer to make the engine self-contained by extending the cast bedplate to carry the outboard bearing; I have designed most of my engines to avoid the need for extraneous parts which have to be lined up. A single bedplate with facings for all essential parts, machined off to the same level throughout, greatly facilitates accurate construction.

The cylinders of both engines are bolted down to the bedplate, being provided with cast feet or flanged brackets, and the bearings, which are of the split plummer block type, are similarly fixed. Details of the steam-chest, flywheel, connecting rod, crank and eccentric sheave, with its strap, are given in Figs 20 to 23.

The main difference in the two engines is in the type of crosshead employed; the first example has die blocks fitted to the extended ends of the crosshead pins and working between girder-shaped guide bars mounted on pillars fixed to the bedplate, while the other has a slipper type crosshead working on single guide bars each side. Both types are well established in full-size practice; they require very careful lining up in respect of height and parallelism with the cylinder axis to ensure smooth movement of the piston rod.

In this respect they may possibly be more difficult to fit than the trunk type of crosshead, in which alignment is automatic if machining is properly carried out; on the other hand, they are sometimes preferred because they offer facility of adjustment to compensate wear or initial errors.

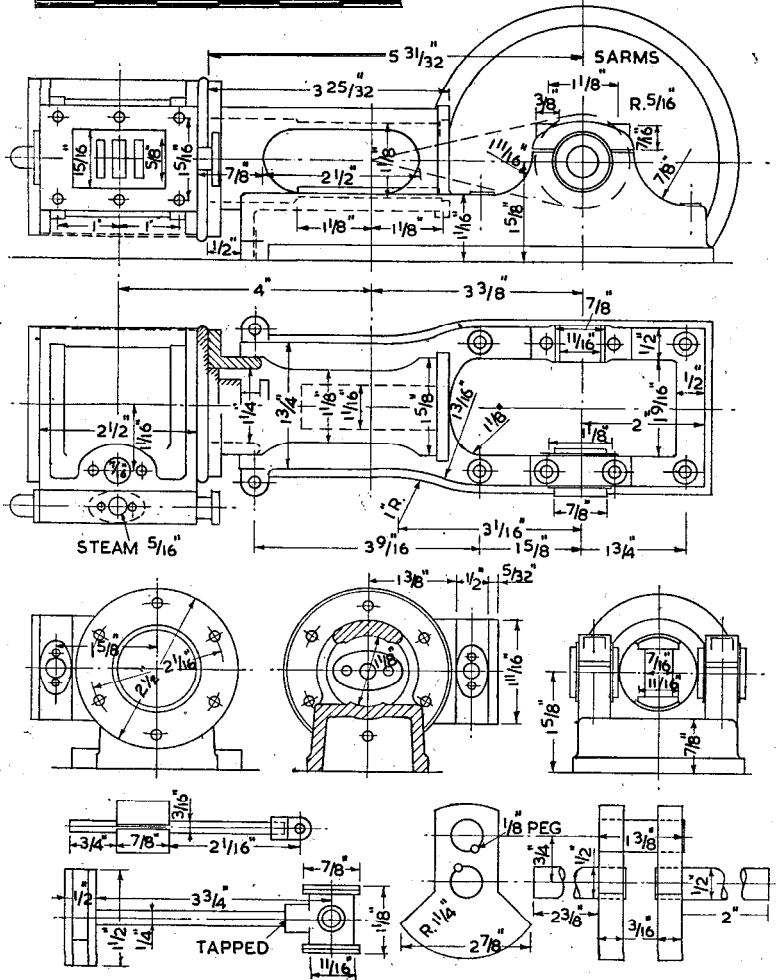
The crosshead of the first engine is forked to admit the little-end eye of the connecting rod, but in the second arrangement matters are reversed by forking the end of the rod to span the slipper crosshead block. This type of rod may be a little more difficult to shape than the previous type, but it looks very nice when properly carried out and I have given instructions on how to produce forked rods from the

solid in articles on the Unicorn mill engine.

Muncaster suggests forging parts of this nature, which is very sound advice-or at least it was in his time,

when nearly all fitters had some knowledge of smith's work; but this seems to be practically a lost art nowadays. There are, however, many

● *Continued on page 515*



Oil-bath lubrication is of course employed, and I recommend the use of a light oil, such as Shell Vitrea, so as to keep down losses due to fluid friction.. It is of course necessary to fit an au vent or breather to the top of the box, but I have not shown this as 'its position will have to be arranged so as not to interfere with any control gear fitted to the cover. The box should be filled to a depth of 1/2 in.

Various modifications of the details of the gearbox may suggest themselves to readers but the general design, in

which all really essential features are incorporated, can be guaranteed reliable and efficient.

One point which should be noted about reverse gears of this type is that the gears are only under load when actually in reverse, which will normally be no more than a very small proportion of the total working time; when running ahead, the gears run idly and the only losses are those due to running friction and oil drag, which can be kept very low; thus there is no appreciable reduction in the performance of the boat.

John N. C. Lewis, in *Ship Modeller's Logbook*, has produced the ideal book for the enthusiast. He shows the reader how to make simple, decorative, miniature and scenic models, including a clipper ship in a bottle and an Arabian Baggala.

There are details of clench and carved built models, and the text is enlivened by stories of eighteenth century smuggling and the work of the Revenue Cutters.

Obtainable from Percival Marshall and Co. Ltd, price 12s. 6d., postage 1s. (U.S.A. and Canada \$3.00).

## Muncaster. models . . .

Continued from page 490

components in model engines which could be produced more efficiently and economically by hand forging than by any other method, and a revival of this skill would be well worthwhile.

The crankhead bearings or "big ends" of both engines are of the solid box type, with split brasses of rectangular section fitted. These were usually secured by a tapered gib and cotter, which enabled the bearings to be adjusted for wear; but Muncaster shows them simply located in place by a screw, which passes through a notch in the rear half-bearing to prevent its moving sideways. The front half would presumably have side lips to engage the sides of the box frame for the same purpose; removal of the screw would enable the rear half to slide back enough to withdraw it over the collar of the crankpin.

Governor gear is fitted to the first engine, and could be adapted to the second- if desired; some further information on this subject will be given later.

Two further examples of horizontal stationary engines are illustrated in Figs 24 and 25. Each has its own distinctive features, but many of the working parts are similar or identical; the cylinder dimensions are 1-1/2in. bore x 1-1/2in. stroke, which may be considered on the large side by many constructors, but it would be quite practicable to reduce the scale to half these dimensions or even less if desired.

The first of these engines has a

crosshead of the slipper type, working on a slideway machined on the top surface of the bedplate, with keep plates secured by three studs or bolts on each side. A rather unusual method of fixing the cylinder is employed, the underside of the casting being provided with four projections or feed, into which setscrews or studs are screwed from the inside of the bedplate.

In addition, two vertical lugs are extended upwards from the bedplate and drilled horizontally to take extensions of two of the cylinder cover studs. This undoubtedly gives additional strength to resist working stresses, but may be regarded as "gilding the lily," to use a popular misquotation.

The height of the cylinder, cross-head and main bearing centres must all be exactly the same, and careful adjustment in machining or fitting will be necessary to ensure this. A very slight error in the height of the shaft centre would not be harmful; but any misalignment of cylinder and cross-head would cause binding of the working parts, and possibly gland trouble.

Errors of this kind are often botched up by making the parts a sloppy fit, which certainly enables the engine to run, with sundry clanks and groans, but such slovenliness should never be tolerated in model engineering.

In the second example, Fig. 25, a bored "trunk" guide is employed, similar to that which I have described for the Theseus and Perseus engines, and this enables all uncertainty in the alignment of cylinder and crosshead to be eliminated, so long as machining is properly carried out. The trunk in this case is cast integral with the baseplate, therefore, unless special machining facilities are available, it will be necessary to mount the casting

on the lathe saddle, packed up to the exact centre height, for boring the guide seatings and facing the rear flange.

It can then be swung round for boring the main bearing housings, the caps of which should previously have been fitted, and facing both their inner and outer sides. All these operations can be carried out with boring bars between centres, and fitted with suitable cutter bits. The centre lines of the trunk and main bearings must be exactly at right angles to each other.

It will be noted that the bearings of both engines are of the same type, also the crankshaft, which may be either machined from the solid or built up as indicated in the details included in Fig. 24. The journals and crankpin in this case are made a press fit in the webs, and accuracy should be checked after assembly, positive location then being ensured by fitting pegs or dowels endwise as shown.

The front end cover of the cylinder (Fig. 25) is sandwiched between the flanges of the cylinder and the trunk; it must be accurately machined on both sides, including the boring of the gland, to avoid introducing alignment error. I have described how to ensure this in connection with previous engines.

In other respects, the components of the two engines are identical, including the connecting rod and crankhead bearing, eccentric sheave, strap and rod (Fig. 24), and the slide-valve with its rod and knuckle (shown in Fig. 25); it will be seen that the method of attaching the valve to the rod, to allow free "floating" location, is the same as in the Theseus and Perseus engines; namely, by reducing either the width or diameter of the rod to fit a slot cut in the back of the valve.

● To be continued.

# The **MUNCASTER** steam-engine models

EDGAR T. WESTBURY is bringing a modern eye to bear on some classic models of the past

*Continued from 4 April 1957, pages 488 to 490*

**A**LTHOUGH the horizontal type of engine has always been favoured for stationary work, the alternative direct-acting form of engine having the cylinder located vertically above the crank-shaft has some advantages where floor space is limited, and is generally considered more suitable for running at high speed than the former type.

It is, of course, more common in marine practice than stationary work, but both on land and sea it has been extensively used for auxiliary purposes such as driving electrical generators, ventilating and forced draught fans, and centrifugal pumps for circulating water in condensing plant, or dock drainage.

One of the earliest engines in this general class was introduced a few years after the Nasmyth hammer made its appearance, and because of its structural similarity to the latter machine it was customary to refer to it as the "steam-hammer" type.

The salient features of such engines, an example of which is illustrated in Fig. 26, include a relatively small bedplate on which is mounted a symmetrical pair of cast columns, usually of channel or hollow-box section, and these in turn support the cylinder assembly. In outline, the structure bears a resemblance to that of a lighthouse, tapering more or less gracefully from the cylinder head to the base, to give maximum rigidity against both dead load and working stresses.

The inside faces of both the columns are flat near the top end, and have machined surfaces which serve as crosshead guides. The working parts are generally similar to those of horizontal engines, except in certain points of detail which may be influenced by their disposition and order of motion.

In one respect, this particular engine may be regarded as an anachronism, in that while its main structure follows the "steam-hammer" tradition, it is fitted with a piston valve, a feature which did not become

popular until later developments, and particularly higher steam pressures, made it desirable. However, Mucaster knew steam-engine practice better than I ever shall and I would never dispute his authority over such details.

A piston valve is nothing more than a slide-valve having a circular instead of a flat face, but this alteration in shape involves characteristics which may have advantages or limitations according to circumstances. First of all, it is capable of controlling ports all round its circumference instead of

adapted to control steam admission either on their outer end faces (as in the case of the flat valve), or the inner faces, which would normally control exhaust events. The latter arrangement, known as "inside admission," is generally preferred as it enables the steam-chest and passage design to be simplified, though it makes no difference to efficiency so long as design is adapted to suit.

It will, of course, be clear that in this case steam lap must be provided by reducing the width of the clearance portion of the valve, corresponding with the cavity of the flat valve, and the total length of the valve must be such that it exactly covers the ports in the steam-chest, unless exhaust lap is specified in other words, normal "line for line" exhaust timing.

Piston valves generally allow the cylinder steam passages to be made shorter and more direct, thus improving thermal efficiency by reducing the dead volume at the ends of the stroke and also the conducting surface area of the passages. They do not, however, provide the same facility for visual valve timing as the flat valve, and it is necessary to adjust their position by exact measurement in most cases.

The piston valve of the engine shown in Fig. 26 is of the inside admission type, the main steam inlet being in the centre of the steam-chest and the exhaust being taken out from two ports at the extreme ends to a passage shown in the plan section *BB*. It is driven by a rod which passes up through a clearance hole in the centre for most of the length of the valve, thus giving a small amount of side freedom for self-centring in the gland, but the vuner end is screwed into a short tapped hole and a locknut, is provided so that lateral position adjustment can be obtained.

It should be noted that for an inside admission valve the eccentric timing must be adjusted so that it trails behind the crank instead of leading it. The angle of advance, however, is still in the same direction, so that for a valve with fairly orthodox lap and lead, calling for 30 deg. angle

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## *5-Vertical stationary engines*

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over a limited width of face, and thus it can give much more rapid and efficient valve events than a normal flat valve, though this feature is not always used to full advantage.

Secondly, it is not pressed hard against the portface by the steam pressure, and therefore works with much less friction, especially where high working pressure is employed; this is perhaps its most important practical advantage.

But because of being pressure-balanced it is not self-seating, and unless it is very carefully fitted to the bore of the steam-chest or liner, it is liable to leakage, much more so than the flat valve. Many small piston-valve engines have been found less efficient than those with flat valves for this reason, especially when wear has taken place; large engines have piston rings fitted to the valve to avoid leakage, but this is hardly practicable in a model.

Thirdly, piston valves may be

# Muncaster models.

of advance, the setting will be  $90 - 30 = 60$  deg. behind, the crank in the direction of engine rotation.

Details of the piston valve and the two short half-liners, which are pressed into opposite ends of the steam-chest, are shown in Fig. 27. Three ports are shown in each of the half-liners, giving a large total area, and the sides of the ports are cut obliquely to minimise ridge formation on the valve as a result of wear. Alternatively, a greater number of round holes may be used, and personally I should favour this method.

A groove is turned in the outside of the liner to form an annular passage when it is inserted in the steam-chest. The liners must be accurately located to give the designed port timing in conjunction with the valve dimensions. A stainless steel valve with bronze liners is recommended.

## MAIN COLUMNS

In order to ensure accuracy in cylinder location and guide alignment, I recommend that the columns should first be machined on the guide faces and then clamped together for facing the top and bottom surfaces. When erecting the columns, they should first be bolted to the bedplate with a gauge block between the guides to locate them the correct distance apart. To locate the cylinder, the machined crosshead, or a dummy made to the same dimensions, may be fitted to the piston-rod to ensure correct alignment.

If straightforward machining methods are used accuracy should be positive, but it is not advisable to take anything for granted and routine checks should be made at all stages of assembly!

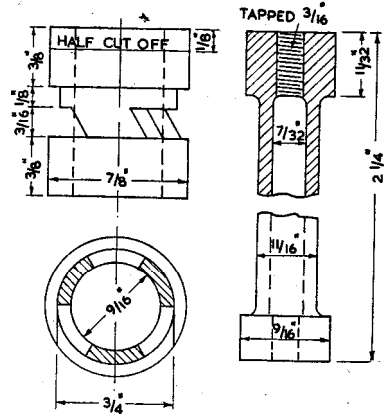
## SINGLE-COLUMN VERTICAL ENGINE

The "steam-hammer" type of engine is suited equally well for running in either direction, as the crosshead guides are symmetrical and of equal bearing area each side; but this is but rarely called for in stationary work. Even marine engines do not often run for very long, periods in the reverse direction. In such cases, a lighter but quite adequate form of structure can be adopted in which only one cast column is employed, and the crosshead is of the slipper type, having its major bearing surface on the soleplate, which slides on the face of the column.

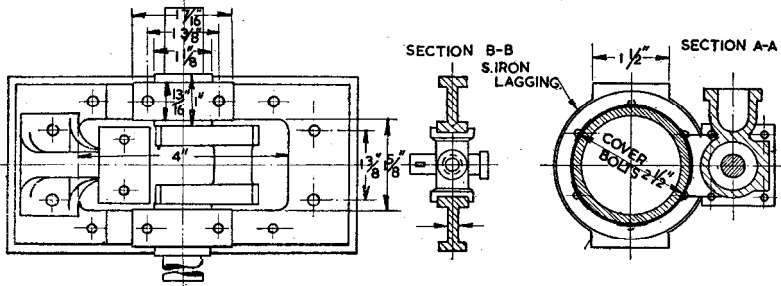
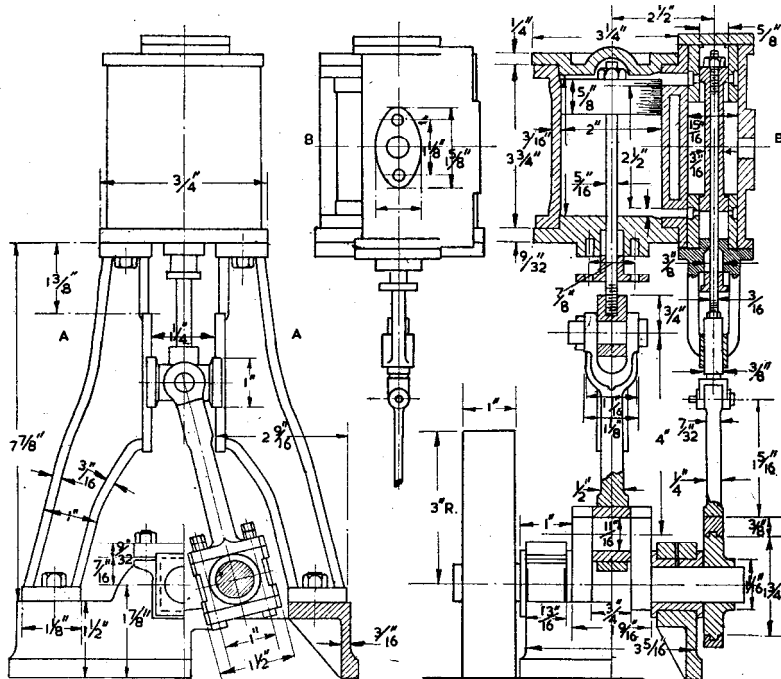
An engine of this type is illustrated in Fig. 28. It is intended to run in a clockwise direction, looking at the end of the shaft as seen in the right-hand elevation. Note that when the piston is on the up-stroke, the thrust, which is tending to straighten out the piston rod and connecting rod linkage, presses the crosshead against the column; but on the down-stroke, the tendency is to increase the angularity of the linkage and thus the cross-head is still pressed against the column.

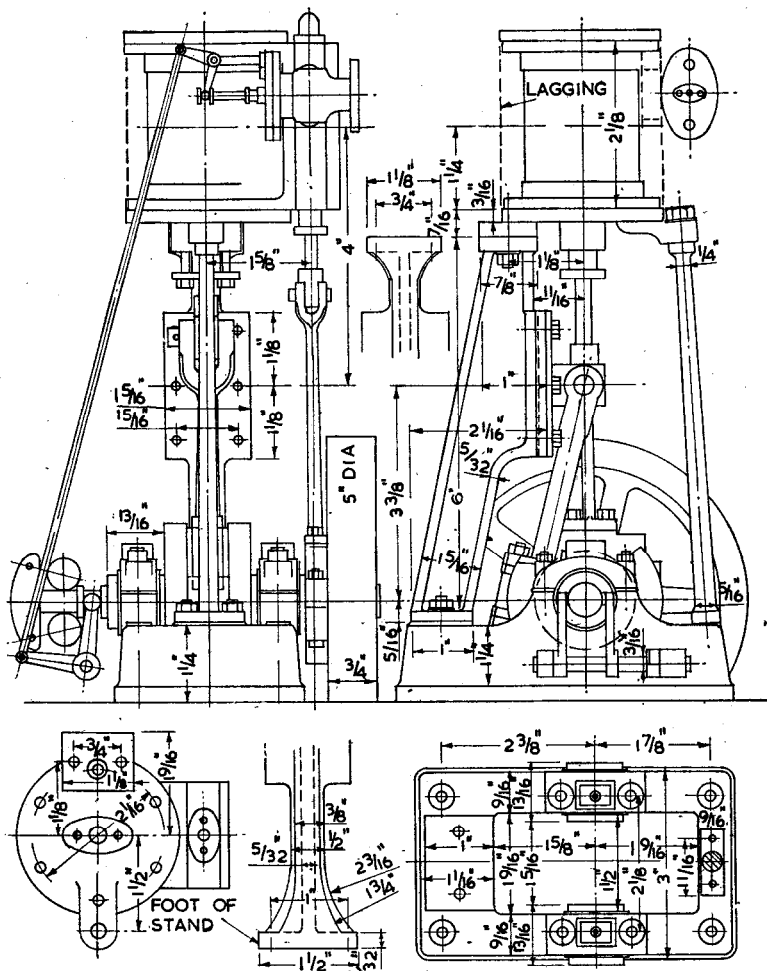
If the engine rotation is reversed, the side thrust on both strokes is in the opposite direction so that the crosshead will pull away from the column and bear against the keep plates, which are of much smaller surface area than the column face, besides having to rely on their retaining studs for security.

*Below, Fig. 26: A vertical engine of the symmetrical double-column or "steam hammer" type*



*Above, Fig. 27: Details of the piston valve and ported half-liners*





excessive projection of the shaft at the governor end. Engines similar to this have been used extensively for driving dynamos, though they were superseded by enclosed engines in later years.

#### Brickbat department

To those readers who, despite my explanations in the March 7 issue, have chastised me for not giving complete details with full dimensions of all these engine designs, I would like to point out that the drawings are copied as exactly as possible from Muncaster's original published designs, and this is what has been asked for by many readers over a period of several years.

Fig. 28: A vertical engine of the single column type, with shaft governor

The descriptive matter is my own, but if I attempt to amplify the drawings in any way their individuality will be lost; in any case, the amount of work involved and the space occupied would be out of proportion to the popular appeal, which is bound to be specialised to some extent.

The value of Muncaster's designs lies in his genius for adapting typical examples of all kinds of full-size engines to reproduction in miniature while retaining true prototype character; exact details are of lesser importance, but my previous articles on steam-engine construction should make up any deficiencies in this respect.

To be continued

As the offset support of the cylinder by a single cast column leaves the structure somewhat weak to resist alternate upward and downward stresses, the opposite side is stayed by means of a single machined steel column (sometimes more than one is used) which, though light in section, has greater inherent strength than cast iron. As this is usually somewhat out of the vertical plane, both its length and the angle of its seating at both ends must be carefully adjusted to hold the cylinder assembly exactly perpendicular.

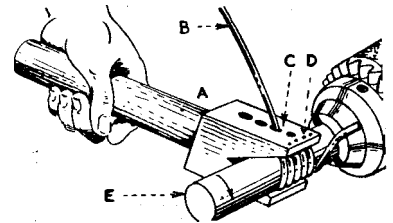
This drawing does not show the interior details of the cylinder, but these may be similar to the previous design, using either a flat slide or a piston valve. It is fitted with a governor, mounted directly on the shaft and acting on the engine throttle valve. The rather unusual position of the eccentric, immediately adjacent to the flywheel, avoids

## GUIDE FOR MAKING SMALL WIRE SPRINGS

**T**HE simple arrangement shown below enables a short run of wire springs to be made without having recourse to normal spring-making machinery.

A wooden block, A, has a handle and several holes of different diameter, C, drilled through into the V-shaped opening. The wire, B, is then threaded through the appropriate hole, passed under a core rod, E, and secured in a chuck carrying the rod. The diameter of the rod is chosen to suit the internal diameter of spring required.

After making the wire taut and completing a few turns by manipulating the wooden tool, the core rod is rotated mechanically until the



correct length of spring is reached. The spring is of the closed variety, but by driving a pin or nail through one of the holes, D, open springs can be made with spacing as desired.

The holes, C, will probably wear out quickly so that the wooden tool may need frequent replacement.

*Digested from "A Device for Forming Small Lots of Wire Springs," in "Wire Industry," 1956 (October)*

921. The illustration is reproduced by courtesy of the publishers. □



# The **MUNCASTER** steam-engine models

-By Edgar T. Westbury

**T**HE term "simple" as generally applied to steam-engines does not denote simplicity in the mechanical sense, but may be more fully defined as "simple expansion," or, in other words, the use of available steam pressure range in one stage. This does not necessarily mean a single cylinder; such engines may have any number of cylinders, but each of them is fed with live steam at full pressure, and they each exhaust directly to atmosphere or into a condensing system. All the engines so far described in this series come within this definition.

At a very early stage in the development of the steam-engine-in fact almost as soon as any very substantial steam pressures above that of the atmosphere began to be used-it was found that in order to extract the maximum mechanical power from high pressure steam and avoid the rejection of exhaust steam while it still contained useful energy, a greater range of expansion than could conveniently be obtained in a single cylinder was necessary.

Even with valve gears designed to give very short cut-off, the pressure at the end of the piston stroke was undesirably high, and the logical development, therefore, was to transfer this steam to a second cylinder where a further stage of expansion was carried out before the steam was finally rejected. The best-known pioneers in this were Woolf and Hornblower, who succeeded in improving the economy of steam-engines considerably by this means.

In the further development of the "compound" engine, as it was called, further stages of expansion were added, producing "triple-expansion" and "quadruple-expansion" engines which became popular in very high powers, though the practical advantages of the fourth expansion stage have always been in dispute.

It will be clear that as the pressure of the steam is lowered at each stage, its volume is correspondingly increased (remember Boyle's law-PV

equals a constant ?) and, therefore, the sizes of the cylinders have to be progressively enlarged by a ratio determined by the pressure drop in each stage; it is, of course, desirable in a multi-cylinder engine that each cylinder should contribute a fairly equal amount of power at the driving shaft. For this reason, compound or stage-expansion engines are designed for a definite pressure range and produce their best results when input pressure is kept fairly constant.

I have made this lengthy-but, I hope, lucid-explanation because I have received a good deal of correspondence on engines of more than one cylinder lately, and there has been some confusion as to what constitutes a compound engine and its practical advantages in particular cases. Several readers, including some from remote parts of the world, have asked my advice on the respective merits of simple and compound engines for driving prototype model power boats.

**6-In this article  
the simple and  
compound twin  
engines are dealt  
with**

(Continued from 18 April, page 555 to 557)

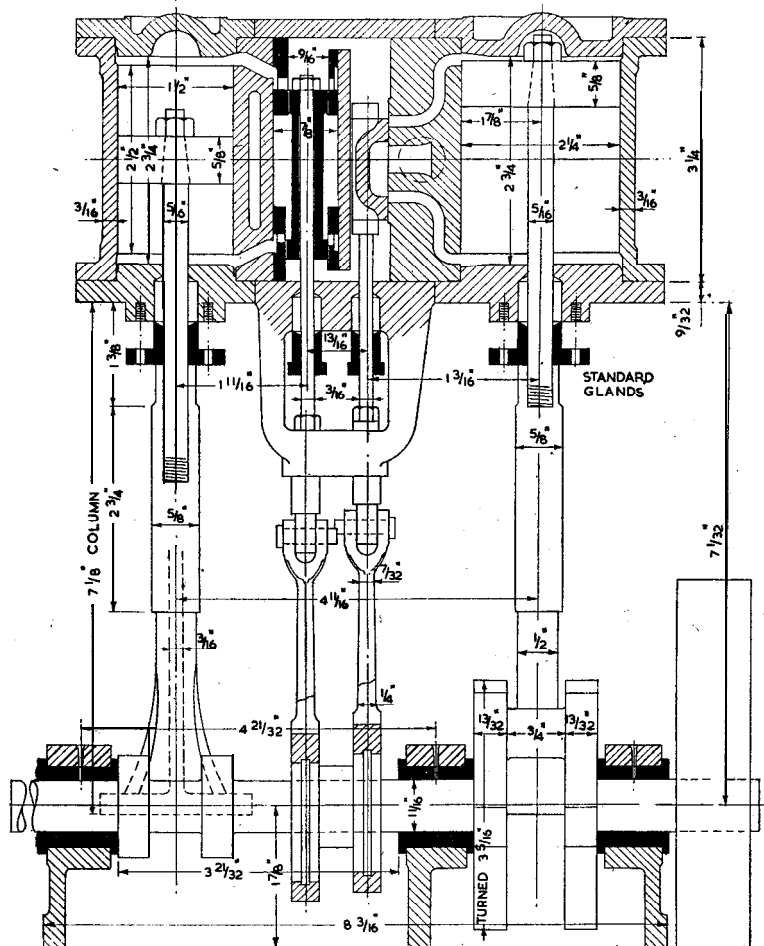
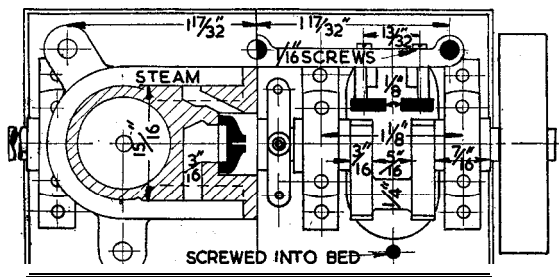


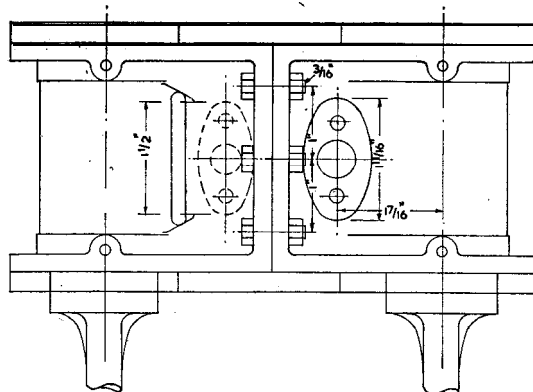
Fig. 3 I: Twin-cylinder compound engine with h.p. piston valve and l.p. slide-valve



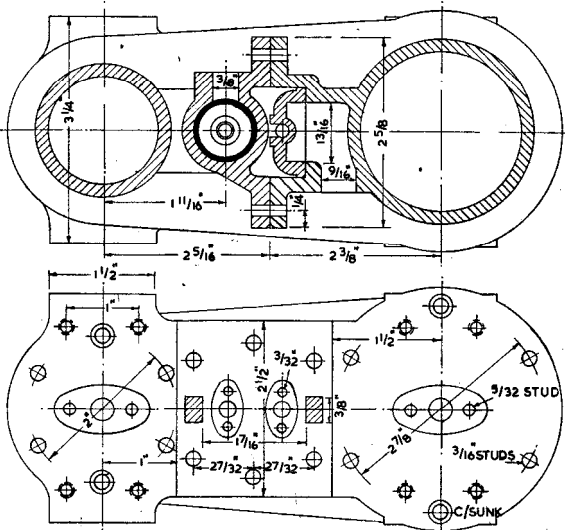
This is not an easy question to answer in definite terms, as so much depends on circumstances, not the least important of which are the conservation of heat and the reduction of pressure at the final exhaust outlet.

In small engines generally it is very difficult to avoid heat loss, as the "scale" conductivity of the metal is high and the effectiveness of heat insulation, which can be obtained by lagging, is low. Some heat loss is almost inevitably incurred in the transfer of steam from one cylinder to the next by way of an "education pipe" as it is termed. Incomplete elimination of back pressure is common, even if a condenser is fitted, as it is extremely difficult to produce a high vacuum such as can be obtained in large steam plants. Incidentally, it may be mentioned that the latter factor has an important bearing on the difficulty of exploiting the potential advantages of the steam turbine in small sizes, though large multi-stage turbines have a great advantage over reciprocating engines, because they enable progressive expansion from

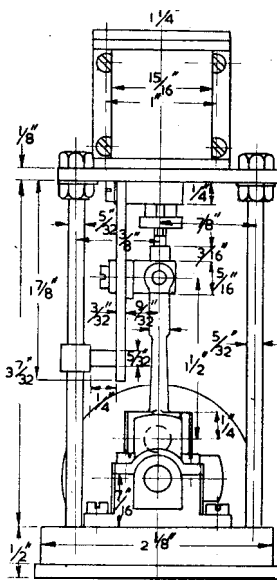
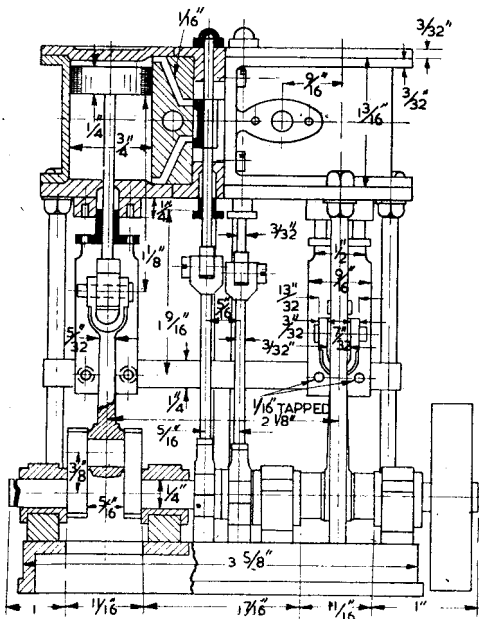
Above, Fig. 30: Plan view of the twin simple engine



Right, Fig. 32: (Top) cylinder elevation (compound engine); (centre) sectional plan of cylinder block; (lower) underside plan of cylinder block



Below, Fig. 29: A twin-cylinder simple engine with central [slide-valves]



h.p. end to exhaust outlet (without transfer pipe losses) to be obtained.

The fact that locomotive engineers, in this country' at least, have never adopted compound engines to any great extent suggests that their advantages, where exhaust is released to atmosphere, are somewhat dubious; much the same applies to traction engines, though some of the compound types have earned a good reputation for efficiency. In marine and stationary practice, however, where surface and jet condensers capable of producing high vacuum are invariably used, there is no question about their superiority.

Whether small-scale engines of any type, working on pressures up to about 100 lb. and little or no exhaust vacuum, can employ compounding without the l.p. cylinder becoming merely a passenger, remains to be proved. In the case of a twin double-acting engine, the compound type is not *positively* self-starting unless fitted with a "simpling valve" for temporary admission of live steam to the

l.p. cylinder, and this may be an important practical consideration in many cases.

The engine illustrated in Fig. 29 is of a type well suited to model marine work, and its size would be suitable for fairly powerful prototype boats such as tugs, pinnaces or fast packet liners up to 6ft or more in length. Its structure is of a type not at all uncommon in light marine practice; I have worked on engines similarly constructed (but of the compound type) in naval picket boats, though total enclosure of these engines was becoming more common at the time. No cast columns are employed, the cylinders being supported by five vertical turned steel pillars—two at the front and three at the back (see plan view, Fig. 30). The latter were used for the attachment of a horizontal member, which supports the lower end of the slide bars, and their top ends were secured to flat faces on the back of the cylinder gland bosses.

#### Demands accurate work

This form of assembly calls for careful location of the pillars, both at the bedplate end and in the cylinder base flange. It also calls for accurate lining up of the slide bars, so that they are exactly parallel with the cylinder axis, both crosswise and sideways.

A rather unusual form of cylinder casting is employed, having a channel-shaped steam chest, open at the two ends, the pair of castings being bolted together at the centre by four screws or bolts in a vertical flange. This gives better accessibility to the port faces than the use of a single cylinder block, while on the other hand it is simpler and more rigid than the common arrangement which uses separate steam chests—generally on the outside instead of between the cylinder.

The cylinders have separate spigoted covers top and bottom, and the ends of the steam chests are closed by single rectangular covers, the lower of which embodies the stuffing-boxes for both valve rods; the upper is fitted with guides for their "tail" ends.

While this is by no means a difficult form of construction, it demands special treatment, with due care in machining and assembly to ensure success. The two cylinder castings should be bored and faced separately, the length over outside of flanges being made as near exactly the same as possible. Next the vertical joint faces should be machined, either by facing on an angle-plate in the lathe or by milling or shaping. In the latter case, the port face may be machined at the same setting, thus ensuring that it is parallel with the joint face. But whatever method is employed, these surfaces should all be parallel to the cylinder axis.

Lapping of the port face is not as easy as for more conventional types of cylinders, as only a narrow lap, with rectilinear motion, can be operated in the space. But the major error liable to occur is slight convexity of the surface,, which is a fault in the right direction. The ports and passages may be dealt with in the usual way, and are just as accessible as in other types of cylinders.

After bolting the two cylinders together, the end faces should be checked to ensure that they coincide to form an exactly flat continuous surface—any slight discrepancy being corrected by lapping. More drastic treatment by machining may be called for if there is greater difference of level.

This engine is shown fitted with single eccentrics for the individual slide valves; reversing may be obtained by using slip eccentrics, but for positive reverse control, link motion with double eccentrics may be fitted; this may call for a slight increase in

the space between the centre main bearings. As the bearing surface is ample, no harm would be done by reducing their width slightly, and also reducing the width of the eccentric straps and sheaves.

#### A twin compound vertical engine

This is of the symmetrical double cast column or "steam hammer" type, as shown in Fig. 31, but apart from this feature several of the constructional details are similar to those of the previous design. The cylinder block is again divided vertically in the centre, with a bolted flange joint, but, of course, is unsymmetrical as the left-hand (h.p.) cylinder is smaller than the right-hand (l.p.) cylinder, in the ratio of 2 to 3, in bore diameter. This engine is practically twice the size of the simple engine as dimensioned in the drawings, but could quite easily be reduced to the same size.

● *Continued on page 656*

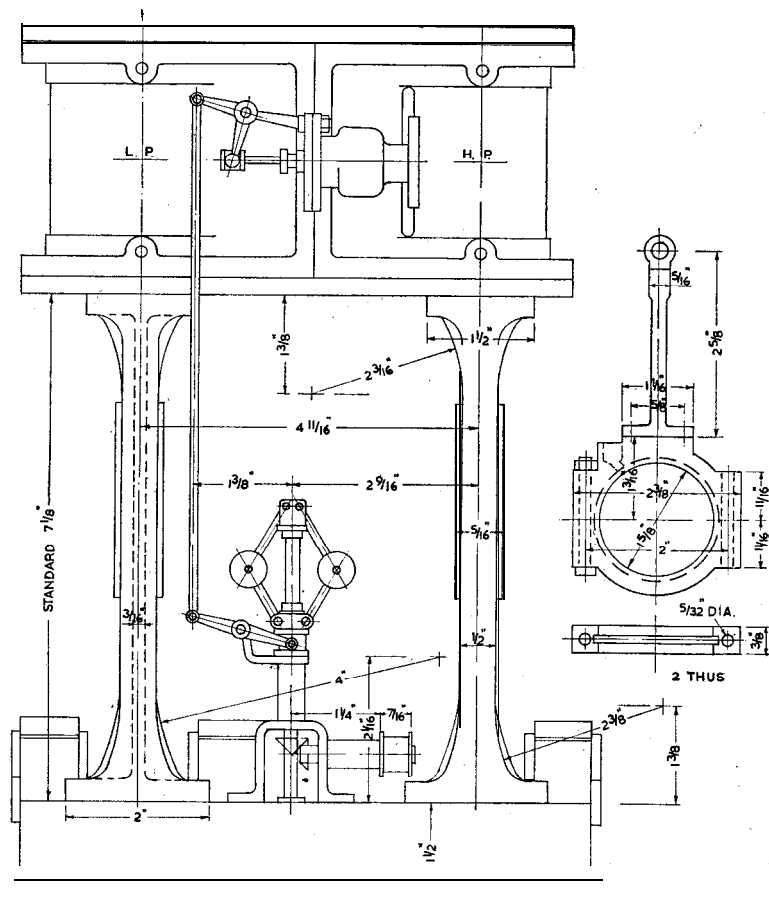


Fig. 33 : Rear view of compound engine, and details of eccentric straps

The steam chest arrangement of this engine is very ingenious in design, as it allows of a single chest for both h.p. and l.p. cylinders—rather unusual in compound engines—thus eliminating the need for an education pipe which, as already pointed out, may be

a source of heat wastage, especially as it often extends the full length of the cylinder block. This improvement is effected by using an inside-admission piston valve for the h.p. cylinder and a flat, slide valve for the l.p. cylinder.

Entry to the piston-valve housing is by way of a port in the side of the cylinder casting between the “lands” of the valve and exhaust escapes at the ends of the valve, directly into the main steam chest space, whence it is admitted to the l.p. cylinder under the control of the flat slide valve. It is finally exhausted by way of the cavity in this valve, in the normal manner.

Details of the piston valve and the ported half-liners are similar to those of the single-cylinder vertical engine, (Fig. 26 in the April 18 issue). Some constructors may prefer to fit a single continuous liner for the full length of the housing, which will serve exactly the same purpose—and it is not necessary to chamber out the centre larger than the working diameter, though this is usually done in large engines to avoid the formation of ridges in the bore of the liner.

Fig. 32 shows three views of the cylinder block, namely side elevation, sectional plan and underside plan. The former shows the position of the exhaust and steam admission ports at the front and back of the engine respectively; each of these has an oval flange joint face. In the sectional, plan, it will be observed that the steam admission port goes directly into the piston valve housing while the exhaust

port communicates with the centre port of the l.p. cylinder port face.

The underside view clearly shows the shape of the lower steam chest cover and the method of attachment by six studs and nuts, as well as the position of the valve rod guide bracket, which is presumably cast on the cover, though this is not as clear as it might be; the sectional elevation (Fig. 31) shows it rather differently, and the top view in Fig. 32 omits it altogether.

In view of the difficulty of aligning the guides with the glands, which in the case of the h.p. valve also have to be exactly concentric with the housing, I should favour making two separate guide brackets and bolting them in place on the cover after lining up. Valve rod guides are not considered essential on many model steam-engines, particularly where the rod has a tail end guide, as very little side thrust is encountered but they are almost universally fitted on large engines.

The rear view of the engine (Fig. 33) shows a belt-driven governor which regulates the speed by means of a throttle valve of the axial piston type. Further details of these items will be given later. The cast columns, together with details of the guide surfaces and crosshead, are as for the engine shown in Fig. 26. There is plenty of room in the ‘centre of this engine for fitting double eccentrics if desired, and either one or two intermediate main bearings may be fitted.

● *To be continued*

## Routemaster buses to have Leyland units

**T**HE mechanical equipment in two new prototype vehicles for London Transport has been produced by Leyland Motors for trial by L.T.E. engineers.

One, a double-decker for the Green Line coach services, will be tested in a few weeks' time on route 721 from Brentwood to Aldgate. It is said to be the last word in double-deck passenger comfort. The other will operate as a bus on a central area service, route 85, Putney Bridge to Kingston.

The vehicles are Leyland versions of the new Routemaster, the bus of the future evolved by London Transport's road vehicle engineers, led by Mr A. A. M. Durrant, C.B.E., chief mechanical engineer for the Road Services.

Designated RM3 and RM4, the two new motels incorporate the Leyland 125 h.p. diesel engine, a type already fitted to over 2,000 Leyland buses in service in London.

Designed as a double-decker coach for the Green Line routes, RM4 is equipped with fully-automatic gear change equipment, the gears sorting themselves out automatically and changing up or down according to the speed and load on the bus. If he desires, the driver can over-ride the automatic mechanism and select gears merely by moving a miniature lever.

Folding doors are provided around the rear platform—and seat spacing is the same as for other Green Line coaches. Consequently it seats only 57 people—as compared with 64 for RM3—but still one more than the present RT buses.

Although all running units, such as engines, axles and springing, have been manufactured by Leyland to their own detailed design, they conform to the overall design laid down by London Transport. One feature which they will have in common with other RM models is special heating for upper and lower saloons.

## A CHILDREN'S LOCOMOTIVE . . .

continued from page 646

### BOILER

The outer casing of the boiler can be made from 22-gauge sheet, any metal except aluminium will do. A 9½ in. length of 2½ in. stovepiping, or a tin canister of same dimensions, will be quite O.K. Just slit one end down for 3½ in. length, make a cross-cut at the end of the slit and open it out to the shape shown in the cross-section. Fit a throatplate of the same kind of material, like that shown for the larger *Virginia* boiler, and fix it with three or four rivets at each side. No brazing is needed on the casing.

The backhead is flanged up from 16-gauge sheet copper and a 7½ in. length of 1½ in. x 22-gauge copper tube is silver soldered to it. Don't use

anything thicker; if this thin tube isn't available, roll up a bit of 22-gauge sheet copper to the given diameter, allow ¼ in. overlap, put a few ⅛ in. rivets in to hold the edges in close contact and silver solder the joint. The front end is closed by a flanged disc of 16-gauge copper silver soldered in. Two 5/32 in. water-tubes can also be silver soldered in as shown, but they are not absolutely essential on an engine of this kind.

The front end of the casing is furnished with a smokebox front carrying a dummy door and adornments. This may be a casting, or it can be built up by cutting a 16-gauge plate to the shape of the smokebox front (drawing next week if all's well) and silver soldering a flange to it. This should be a tight push fit in the end of the casing, but is not fixed as it is removed while getting up steam. The chimney liner is a 1 in. length of ⅞ in. ihin tube silver soldered into a hole drilled ⅝ in. from the end of the casing.

● *To be continued*

# The MUNCASTER steam-engine models

By  
Edgar T  
Westbury

7-Entablature or table engines

Continued from 2 May 1957. pages 634 to 636

IN THE EARLY STAGES of its evolution, the steam-engine assumed various forms, some of which, though now obsolete, are of great interest to the model constructor. Design was influenced by several factors, including expediency or convenience in the materials and methods of construction available at the time; and also by traditional structural styles.

I have already explained that the preferred position for the cylinder—which was then usually the heaviest single component—was on the floor or bedplate; the difficulty of producing accurate straight slides, capable of resisting side thrust without undue friction, favoured the use of parallel motion for guiding the piston rod, or indirect action with long connecting rods, such as in beam, return-crank and steeple engines.

The class of engine known as the "entablature" or "table" engine made its appearance very early in the 1800s, but became most popular in the middle years of the century. Some very fine examples of these engines by Maudslay and other prominent makers were shown at the 1851 Crystal Palace Exhibition; they varied a good deal in design, some being of the indirect-acting type, with the crankshaft below the cylinder and the piston rod extended upwards to a rather spidery crosshead from which motion was transmitted by side connecting rods to the crank.

## Architectural term

Others, such as the types illustrated here, had the cylinders mounted on the bedplate and the crankshaft mounted on an elevated platform—probably the first attempt at what came to be known as "direct-acting" engines.

In common with many other terms in engineering, the word "entablature" is borrowed from architecture, being in fact a legacy from the classic Graeco-Roman era. Its definition (to quote a standard architectural textbook), is "the horizontal member or members supported by the columns, and including the cornice, frieze and architrave."

All engines in this class, therefore,

have the common feature of a flat elevated table supported by four (sometimes more) columns—comparable in fact to the humble kitchen table. Many of the classic examples of these engines had fluted Corinthian columns with decorated capitals and moulded edges to the entablature.

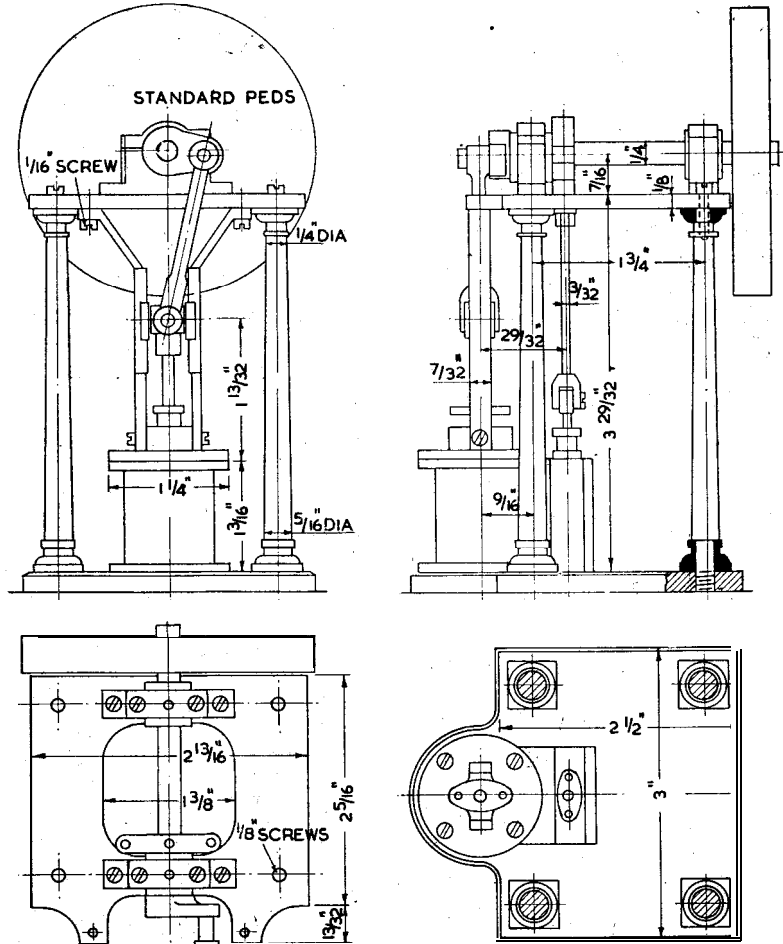
## SIMPLE "BASIC" DESIGN

The engine illustrated in Fig. 34 represents one of the simplest possible designs in this class, being reduced almost to the point of austerity, yet fully in character. It is of the direct-

acting type, having a sliding crosshead with bar slides. Both the baseplate and the entablature are made from flat plate, the former being 1/4 in. thick with chamfered top edges, and the latter 1/8 in. The columns may be built up, as indicated in the part section, the ends being shouldered down to form studs, with separate capitals and pedestals fitted to them.

This is economical with material, but I have a predilection for making things in one piece where this is possible by straight-forward machining and I think I should prefer to turn

Fig. 34: A simple type of single-cylinder entablature engine



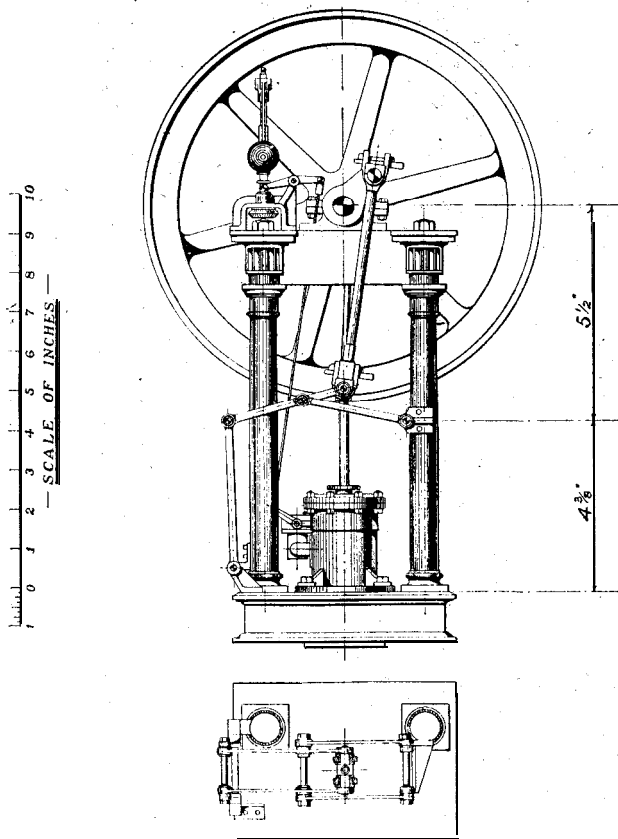


Fig. 35: Side view and motion-workplan of the double entablature engine with parallel motion crosshead.

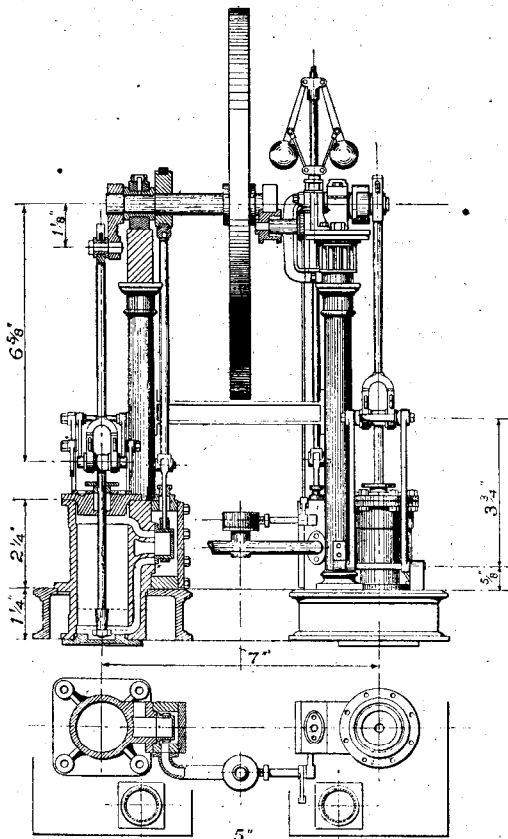


Fig. 36: End view and the cylinder plan of double engine

them from 1/2 in. square bar, leaving flanges about 1/16 in. wide unmachined at each end, with simple mouldings adjacent to them and the rest of the shank tapered from 5/16 in. to 1/4 in. dia. Needless to say, the length between flanges must be the same in all cases, and not only must the flanges be square with the sides of the entablature but the latter must also have square corners, not rounded; as Muncaster says, "it is a sound rule in architecture that no cylindrical part appears about the square cap of a column."

Brass is often used for the structural parts of these steam-engine models on the grounds of appearance, or avoidance of rust, but in the prototypes nearly all parts were made of cast or wrought iron. The cylinder is 3/4 in. bore x 3/4 in. stroke, the design, including slide-valve, etc., following conventional practice. Piston and valve rod glands have oval flanges and the sides of the stuffing-box on the cylinder cover have flat surfaces for the attachment of the slide bars.

The latter are splayed outwards at the top, with horizontal lugs to fasten

to the underside of the entablature, but the sliding surfaces must be exactly vertical and parallel to the cylinder axis both ways. It is probable that these were intended to be forged to shape, and machined or filed only on the working surfaces; but most constructors will probably find it best to cut them from the solid.

The crankshaft, of the overhung type, has a 1/4 in. dia. main journal and runs in plummer block bearings mounted on the flat surface of the entablature; the web or crank disc has a pin 5/32 in. dia. fitted at 3/8 in. radius, either by screwing or pressing in. A spoked flywheel, 3 in. dia., is fitted and it may be observed that if character is to be as faithful as possible both the rim and spokes should be thinner than is usual in modern practice.

The eccentric is attached to the shaft as close as possible to the main bearing, thus serving as an end locating collar, and this should enable the rod to be lined up with the valve rod without bending, which is always unsightly and frequently quite unnecessary. Forked ends are employed

on both the connecting rod and the eccentric rod; the crosshead is of H-section with grooved faces to embrace the slide bars. Despite its simple construction, this design can be made into quite a handsome and dignified model and an efficient worker.

#### TWIN-CYLINDER OR "DOUBLE" ENGINES

The two further examples of engines in this class, illustrated in Figs 35, 36 and 37, are both the "double" type; having overhung cranks at either end of the shaft and a central flywheel; but the design could quite easily be adapted as a single-cylinder engine if desired. They are also much more elaborate in design than the foregoing example and best suited to construction from castings, though many, if not all, of the components could be produced by machining from solid or fabrication by brazing and soldering. The latter methods are often preferred by constructors who wish to obtain the utmost accuracy in details such as fluting and other forms of decoration, which was such an attractive feature of these old engines.

Very little descriptive matter was furnished by Muncaster on these engines; the drawings were considered to be self-explanatory, at least to those readers who were sufficiently experienced to be likely to take an interest in their construction. Taken in conjunction with previous examples of design and functional details, I think that most of the essential information will be found in the drawings.

The major difference between the engine shown in Figs 35 and 36, and that in Fig. 37, is that the former was fitted with parallel motion to the piston crossheads and the latter with slide bars; this would probably, but not necessarily, be a guide to period, as the earlier engines were less likely to be fitted with sliding crossheads.

In the particular type of parallel motion illustrated, the geometry is simple and obvious; it was used on many types of engines, both horizontal and vertical, though in the latter case the ends of the radius rods were more often anchored from brackets fixed to the walls of the engine house than from columns; in a few cases, however, short rods anchored to lugs extended from the

sides of the cylinders were used.

The use of a deep bedplate or plinth with the cylinder partly or completely sunk into it, in conjunction with an equally deep entablature, not only enhances the dignified appearance of the engine, but by enabling shorter columns to be used, increases the rigidity of the structure.

In the two engines shown in Figs 35 to 37 it appears that two separate plinths are employed, and also separate entablatures in the form of box girders; but I should prefer to employ a single plinth and a rectangular frame entablature; even in an engine having only one cylinder this form of construction would give maximum strength and simplify lining up.

Note that the columns are not turned to a straight taper but are slightly convex or "fish-bellied"; this is correct to architectural traditions and improves the appearance so long as it is not overdone. In the details of column pedestals and capitals on the right of Fig. 37, the exact shape of mouldings, etc., is shown, most of the dimensions being given in 32nds of an inch. The connecting rods have gib and cotter fixings for both the crankhead and

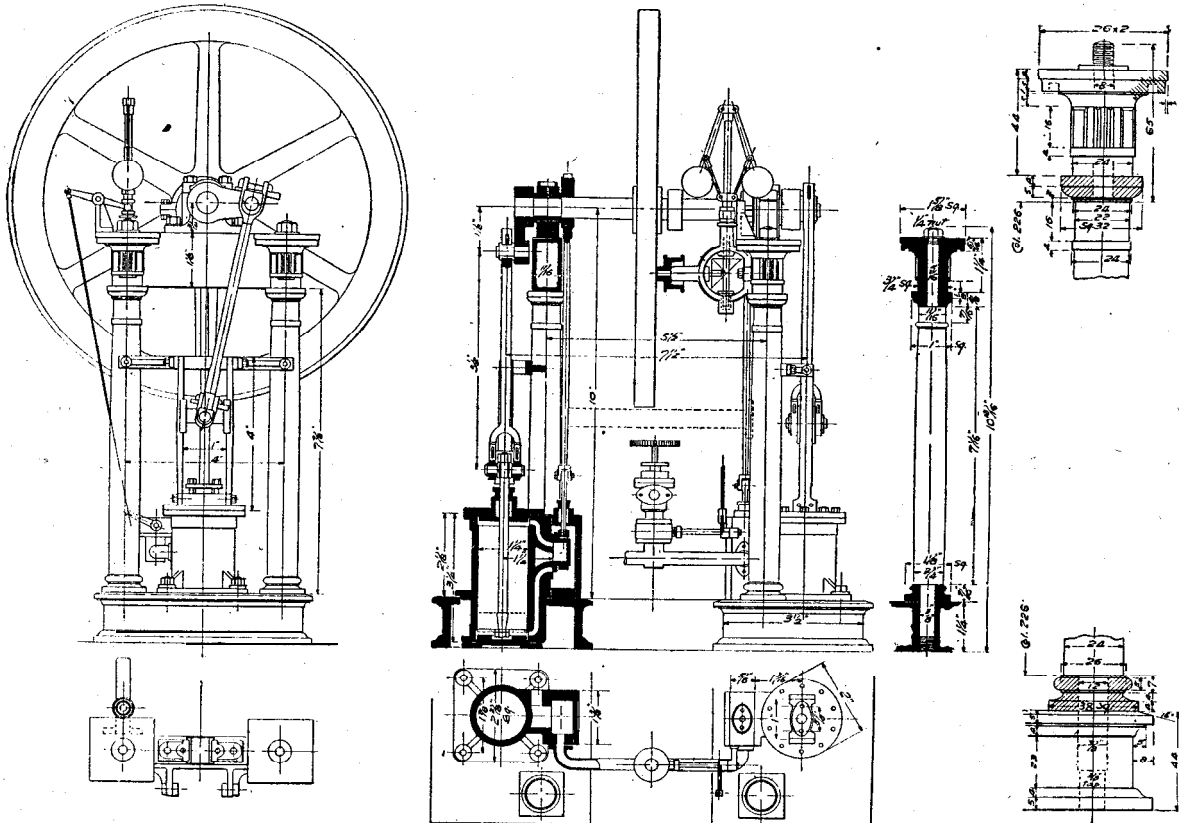
crosshead bearings, the latter being forked. A belt-driven governor is fitted, operating a butterfly throttle on the steam supply line which connects to the two cylinders by a horizontal branch pipe.

When the drawings of these engines were published one or two of the details were mildly criticised by meticulous students of period steam-engine design; for instance, it was suggested that the flywheels had too great a radial depth of rim, and that four spokes should be used instead of six, also that the crankshaft should be of square section, turned only on the journals, with the flywheel and eccentric sheaves staked on.

I have no doubt that the critics were well informed, but apparently Muncaster made some concessions to simplicity in castings and machining procedure—just as I do myself—and if every example of a model purporting to be a true period piece were as correct as his drawings I for one should be very well satisfied. Incidentally, the drawings for Figs 35 and 36 were made by my colleague, J. N. Maskelyne, and are a fine example of engineering draughtsmanship.

● To be continued

Fig. 37: Another double engine with sliding crossheads, showing details of columns



# The **MUNCASTER** steam-engine models - 8

Continued from 16 May 1957, pages 700 to 702

In this instalment EDGAR T. WESTBURY discusses governors and control gear

**S**EVERAL of the engine designs in this series have included governor gear, which is a necessary fitting for engines which have to maintain a fairly constant speed under varying load conditions and, in fact, practically any engine which is not under the constant supervision of the driver.

Nearly all steam-engine governors are of the centrifugal type, based on the original pendulum governor of James Watt, and, in the earlier engines at least, were usually made as a self-contained unit, located at a convenient position on the engine to be driven by belt or gears, and for connecting up to a throttle control valve. I have described governor mechanism in connection with the Unicorn and Tangye engines as well as in a separate article [MODEL ENGINEER, 27 October 1955] dealing with a governor unit suitable for the Vulcan beam engine or other early types.

Although the basic principle of the governor is very easy to grasp—indeed, it is obvious to anyone who has observed the forces exerted in rotating masses—a full explanation of the theoretical considerations involved in its design would take up far more space than could be spared here. Advanced text books on mechanics usually devote one or two pages of mathematical formulae to the phenomena of centrifugal force (for example, see Ganot's *Physics*, para. 55), but

I propose to deal only with simple practical applications of the governor in the examples illustrated by Muncaster.

As first designed by James Watt, the rotating ball weights of the governor not only produced the positive operating effort, under the effect of centrifugal force, but also the negative or restoring effort, under the effect of gravity; no extra weights or springs were used, and the vertical shaft arrangement was essential for its operation. Muncaster states that in this form it cannot be recommended for small engines, and my own experience supports this view; the reason of course is that in a small size, the gravitational effect is reduced to a much greater extent than the friction in the working parts.

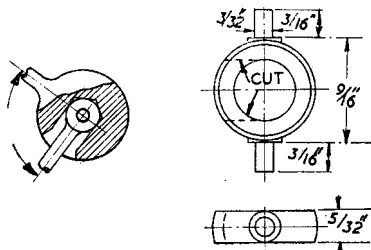
The action of a governor relying on the weight of the balls alone to restore the control on reduction of speed would be very erratic or "sticky." Some governors, such as the Porter type, have an additional moving weight, which slides on the centre shaft and supplements the restoring force, but even this is limited in its effects and has been found inadequate in small sizes. It is also necessary in most cases to increase the positive effort by running small governors at higher speed than the full-size types.

The obvious method of increasing the restoring effort is by fitting some kind of spring. In theory, this com-

plicates matters because there is a definite difference between the action of a spring and that of gravity, but in practice governors fitted with springs work quite well. The governor illustrated in Fig. 38 has a compression spring fitted on the centre shaft, which exerts pressure between the fixed upper yoke from which the weight arms are suspended, and the lower sliding yoke carrying the grooved collar which operates the control lever.

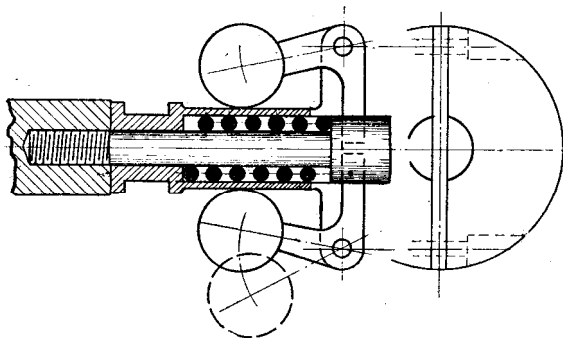
This design has several features in common with the governor of the Tangye engine previously referred to, but the method of articulating the links is somewhat different. Instead of forking the top ends to embrace the ball, the latter is made hollow and the link is made ball-ended to fit inside it; in either case the pivot pin passes diametrically through the centre of the ball. This is a very neat arrangement, but it decreases the weight of the ball substantially so that it must be made larger to produce the same centrifugal effect.

To transmit the movement of the sliding yoke to the governor lever with the minimum friction, a horse-shoe-shaped thrust collar is fitted to the groove, with extended pivots engaging the eyes of short arms which straddle the yoke and are pinned to the lever shaft. These details are illustrated in Fig. 39. The governor shaft runs in a long vertical bearing, in a bracket mounted on the engine frame, and is bevel-gear to the



Left, Fig. 39: Details of the link pivots and thrust collar for the vertical-shaft governor

Right, Fig. 40: A horizontal spring-loaded governor suitable for high-speed engines





drive shaft which runs in a long horizontal bearing.

For high-speed engines, such as those used for driving electrical generators, it is often found convenient to fit the governor directly on the end of the main shaft, thus avoiding the necessity for either belt or gear drive, and making a compact arrangement. In this case spring return is an obvious necessity, and it is also desirable to reduce the number of working parts in the mechanism, thus cutting down wear, friction and any tendency to rattle. The governor (Fig. 40) fulfils these conditions, as it entails the use of only two pivoted joints and a single sliding member, with a totally-enclosed central compression spring. This type is suitable for the engine shown in Fig. 28.

It will be seen that as the balls move outwards under the effect of centrifugal force, the bell crank levers to which they are attached press

against a fixed thrust washer, causing the entire governor assembly to move bodily to the left. The grooved collar on the sleeve operates the governor lever through a thrust collar, as in the previous example, though this is not shown. In the drawing, the shaft extension which carries the governor is shown as screwed into the end of the main engine shaft, but there are practical objections to this arrangement, and I would suggest modifying it.

Apart from the risk of the extension unscrewing if the shaft ran in a clockwise direction or in the event of sudden acceleration or stopping, there might be difficulty in ensuring true running of the extension shaft. It would be better to make this integral with the shaft or devise some more positive scheme of fixing and alignment.

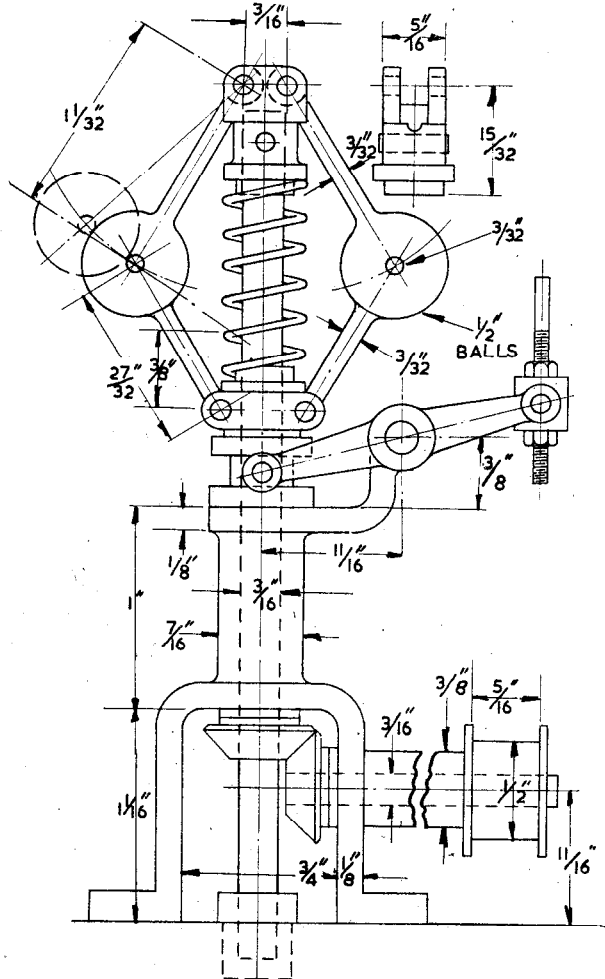
It is hardly necessary to add that the governor assembly should be symmetrical and in balance at all

speeds; this is of special importance not only when it is fitted on a shaft extension as in this case, but also where it projects a long way above a single vertical bearing as in the previous example.

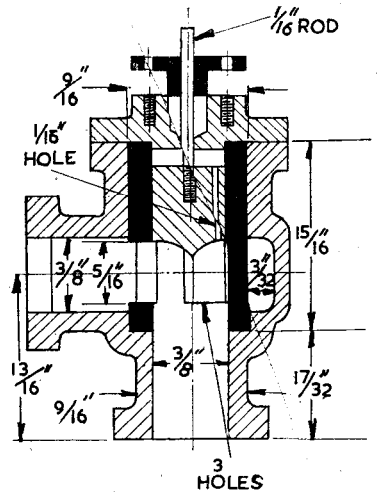
### THROTTLE VALVES

The design of the control gear which regulates engine speed under the influence of the governor is of equal importance to that of the governor itself. The simplest method of governing is by means of a throttle or restricting valve, which may be of any type so long as it is capable of being operated with the minimum effort; it does not need to be capable of shutting completely, as it is generally a supplement to the main engine stop-valve, which should be quite steamtight when closed.

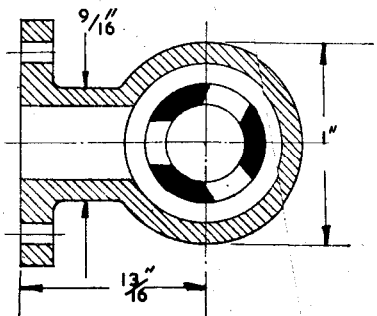
The type of throttle valve shown in Fig. 41 is commonly used in full-size practice and is recommended by



Left, Fig. 38: A spring-loaded vertical-shaft governor, bevel-gearred for belt or direct drive



Right, Fig. 41: Details of the sliding piston-type throttle valve for governor control



# MUNCASTER MODELS . . .

Muncaster for small engines. It is similar to that specified for the Tange engine, but I have found it more difficult to employ successfully than types which have a rotary movement, such as barrel or butterfly valves. The reason for this is that it takes less effort to rotate a shaft in a packed gland than to slide it bodily through the gland, as in this case.

However, the example illustrated is certainly capable of working successfully on the larger models for which it is obviously intended, having a bore diameter of 3/8in. Steam must be admitted from the left-hand (horizontal) branch, the vertical passage being connected to the engine. It is fitted with a liner having three ports which open into an annular passage, so that pressure is even all round the valve and there is no tendency to press it against one side of the liner. The sliding piston should be a smooth, easy fit in the liner, the two parts preferably being of dissimilar metals, such as steel and cast iron, or brass and hard bronze, to give good wearing properties. A hole must be drilled through the piston to balance the pressure on the upper surface, otherwise it will be difficult to move owing to inequalities in this respect or through the trapping of steam or water. Care must be taken to fit the cover, with its central gland, in exact concentric register with the liner, and the piston and rod also concentric with each other.

## GOVERNOR CONTROLLING POWER

The "power" of a governor may be defined as the positive effort which it is capable of exerting on the control valve. It must obviously be capable of overcoming any frictional or other resistance encountered in the control gear, and it is desirable to have a margin of power in hand to ensure reliable action. The power can be increased in two ways: by increasing the weight of the balls, and by increasing the rotational speed. Large slow-spiced engines call for heavy governor weights unless the governor is geared up. But in high-speed engines a governor which appears much too small may be just as effective.

It should be noted that the force available to operate the control gear is influenced by the means by which motion is transmitted from the

governor. Sometimes, in order to obtain sufficient amplitude of movement at the valve rod or spindle from a relatively small governor movement, multiplying levers are used in the connecting mechanism, and the effective force is, therefore, reduced in inverse ratio to the increased movement. Thus the governor power must be adequate to cope with this.

If, however, either the effective weight or speed of a governor is increased, it will come into operation at a lower speed and thus, if the engine speed is to remain the same, equilibrium must be restored by increasing the strength of the return spring or counterweight. Erratic action or "hunting" (alternate rise and fall of engine speed) may be caused by friction in the control gear or by faulty governor design—this includes too great a multiplication of lever movement—so that the control valve moves over too great a range with a slight increase of speed. Steadiness of control is sometimes improved by fitting a damping device, such as an air or liquid dashpot. Speed range can be adjusted by varying the spring tension, or fitting an external spring which can be adjusted while running.

## ACCURACY OF CONTROL

Although a governor is often assumed to be capable of keeping the engine speed exactly constant, this is not so in practice because the governor cannot effect any change in the throttle position until some change of speed has taken place. There must obviously be some margin of error in any type of governor, depending on its design and control linkage, but more still on workmanship and elimination of friction. For most stationary engines of small size, a margin of five per cent. deviation from the set speed is fairly reasonable, but for special purposes, such as generating electricity, closer accuracy is necessary, and the permissible variation may be less than one per cent. in some cases.

Geared or positively-coupled governors are preferred for accurate control, as belt-driven governors may be liable to variable slip—and their reliability may be open to question. Cases have occurred where broken governor belts have caused serious accidents, sometimes with loss of life. Nevertheless belt driven governors gave good results on steam-engines for many years.

## EXPANSION GOVERNORS

While throttle governing is effective, and is probably the most satisfactory method on small engines where rigid steam economy is not the first consideration, it tends to waste steam by the wiredrawing effect of the

throttle valve, which results in lowering the working pressure of the steam before it enters the engine cylinder. To obtain the best efficiency the steam should be admitted at full pressure, but cut off earlier in the piston stroke so that it can be used expansively and its energy utilised to the best effect. This is done in most large engines by using governors which vary the timing of the valve gear.

The governors themselves may be of normal type though they are sometimes of special design; they may operate on the normal slide or piston valve through linkage comparable to that of reversing gear, or on "trick" valves with elaborate porting arrangements. Corliss and drop-valve engines have trip devices which close the steam admission valve suddenly at different cut-off points under governor control.

A very simple and effective expansion governor is that fitted directly on the engine shaft—often in the flywheel—and controlling a movable eccentric, not only by reducing the throw but also advancing the timing. If only the throw and, consequently, the valve travel were reduced, it would certainly result in earlier cut-off, of steam, and, therefore, be effective in speed control; but it would be uneconomical because the admission point would be retarded or, in other words, lead reduced in the same proportion. To compensate for this, therefore, the eccentric is advanced as its stroke is reduced.

As expansion governors are a specialised type in which only a limited number of readers are likely to be interested, I do not propose to describe them further. But for the benefit of those seeking further information: it may be noted that they were fully dealt with by Muncaster in a series of articles in Vol. XXVI (January to June 1912) of **MODEL ENGINEER**.

### ● To be concluded

## SMALLEST AMATEUR WIRE- LESS SET IN THE WORLD

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# The MUNCASTER steam-engine models - 9

By Edgar T. Westbury (Continued from 30 May 1957, pages 778 to 480)

IN the construction of models which have any pretensions to fidelity in respect of type or period, correctness is essential—not only in the general style and character of the main structure but also in the minor details and fittings. I have referred to this in earlier articles, but a further review of this matter may be desirable, especially in view of the errors which are often seen in model engines entered in exhibitions.

These models may be broadly classified as follow:

First, the type of engine which I have described as a "utility" engine. Many constructors wish simply to build an engine which will do a job, such as driving the screw propeller or paddles of a power boat or a stationary plant of any kind; they are not particularly worried as to whether it conforms to any particular period or style, and in many cases the engine works behind the scenes, where it is not visible or obtrusive. In such cases the only things that matter are functional efficiency and mechanical soundness.

Secondly, there is the freelance type of model which is intended to be generally representative of some period or phase of engine development, but not an exact copy of a prototype.

Thirdly, the true scale model of an actual full-size engine, whether period or contemporary type.

It is, in my opinion, the second class of model which presents the worst pitfalls to the unwary constructor because certain features in it must always be optional, and may be determined to some extent by sim-

plicity or convenience. The discreet constructor of a true scale model will take pains to obtain authentic information about the actual prototype before he undertakes construction, and his task consists of making an accurate copy—at least in visible details. But in freelance models, not only may general design and proportions be at fault, but a model which is beyond criticism in these respects may be let down by small details.

Perhaps the worst kind of fault is an anachronism; that is, something obviously out of period, such as a "marine" type bolted crankhead bearing on an early nineteenth century beam engine. Another very serious fault in freelance models is to represent them as models of actual prototypes—ethically, this borders on the fraudulent—but it is often done! How often, for instance, have we seen alleged models of Stephenson's *Rocket* which bore only a very sketchy resemblance to this famous engine.

In Muncaster's models, the need to simplify construction never led him to commit crimes of this nature; both the general character and detail work in his designs were true to type and period though the use of certain ready-made parts, such as slotted-head screws, was allowed to a greater extent than I should consider permissible in a model intended for exhibition. These parts, however, could be changed without affecting actual component design.

## GLANDS

Piston and valve rod glands are very simple components, but their appearance may make or mar a model.

In utility engines, screwed glands may be easiest to fit, and also to adjust in the limited space available. But most full-size engines have flanged and studded glands, the most common being the oval type as illustrated in Fig. 42 (the proportionate dimensions, to suit various sizes of rods, are given in the accompanying table).

Very large engines sometimes have circular-flanged glands, with three, four or more studs; the measurements, however, may be much the same, with the exception of the minor axis *g*. The internal bevel at the mouth of the spigot (shown in dotted lines on this drawing) acts as an internally inclined plane to wedge the packing towards the piston rod; an included angle of about 120 deg. (or normal drill-point angle) will be suitable—also for the counterbored gland recess or neck bush. This applies to either screwed or flanged glands.

## BEARINGS

Several of the engines in this series have been shown with pedestal bearings of the split "plummer block" type, for bolting down to a flat base or entablature. The proportions of these are shown in Fig. 43, and the corresponding table.

In full-size practice, the bearing housings were often fitted with a rectangular bottom "brass," the fitting of which may be somewhat difficult in a model. Unless meticulous adherence to detail is considered necessary, a half-round brass may generally be regarded as suitable, if prevented from rotating by a peg or other means. In many cases, bushings may be omitted, and the shaft run direct in the pedestal casting, of cast iron or bronze.

An alternative type of main bearing, applicable where it is cast integral with the engine bedplate, is illustrated in Fig. 44. Here the horns of the housing extend well above the shaft centre, and are fitted with a keep plate, both the half-brasses being rectangular. The external shape of the cast keep plate shown in this illustration gives a much better appearance than the plain strip of steel bar so commonly fitted, and is also more rigid.

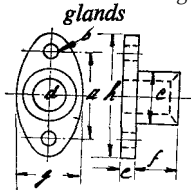
In many horizontal engines, pedestal bearings having both the split bushings and their housing set at an angle are employed, with the object of avoiding maximum thrust being taken on the dividing line; a typical example is seen in the Unicorn engine.

## CONNECTING RODS

Various cross-sections of rods have been used in steam-engines; the earliest types had forged rods of round or rectangular section, but many classic examples of beam engines later had cast-iron rods of cruciform-or

d	a	b	c	e	f	g	h
3/32	3/8	1/16	7/32	3/32	1/8	9/32	9/16
1/8	7/16	1/16	1/4	3/32	5/32	5/16	5/8
5/32	17/32	3/32	5/16	1/8	3/16	3/8	25/32
3/16	19/32	3/32	3/8	1/8	7/32	7/16	7/8
1/4	3/4	1/8	1/2	5/32	5/16	9/16	11/16
5/16	7/8	5/32	9/16	5/32	3/8	11/16	15/16
3/8	1 1/16	3/16	5/8	3/16	7/16	13/16	1 9/16
7/16	1 1/8	3/16	11/16	1/4	1/2	7/8	1 5/8
1/2	1 3/8	1/4	13/16	1/4	9/16	1 1/16	3/4
9/16	1 7/16	1/4	7/8	1/4	5/8	1 1/8	1 7/8
5/8	1 1/2	1/4	15/16	9/32	11/16	1 3/16	2 3/16

Below, Fig. 42: Details of standard oval-flanged glands



ribbed section. Still later, when machining facilities were improved, round and rectangular rods again became popular, but were now bright-finished all over. The bearings of these were usually of the "gib and cotter" type, at least at the crank-head, and often at the crosshead.

Two typical examples of these bearings are seen in Fig. 45; the first has a rectangular strap embracing the top and bottom sides of the rod end, and bolted in position. The split bearing is of rectangular shape to fit the frame thus formed, with side flanges for location, and the inner half has a tapered groove in the back so that it can be secured, or wear taken up, by the wedge or "cotter" which passes through slots in the strap.

In the second example, the strap is eliminated, the rod having an open-ended slot with a gap piece secured by a bolt. The wedge method is again employed for adjustment, but in this case is drawn in by means of a bolt against a tapered face in the rod itself. Many other variations of these bearings were used, but the same principle of adjustment was applied.

### STOP VALVES

In many steam-engine models, realism is marred by the use of crudely-shaped auxiliary fittings, such as drain cocks or stop valves, which may serve their purpose but are quite out of keeping with the rest of the design. An example of a stop valve which is correct both internally and externally is shown in Fig. 46. It is best adapted for construction from castings, or at least one for the body, but could be fabricated or machined from the solid. One or two important points about

d	a	bolts	b	c	h	l	f	g	e	j	k
3/16	3/8	1/16	7/16	5/16	3/16	1 1/16	15/32	7/8	11/32	21/32	3/32
1/4	7/16	3/32	1/2	7/16	1/4	1 11/32	19/32	1 3/32	7/16	27/32	3/32
5/16	1/2	3/32	9/16	1/2	5/16	1 7/16	11/16	1 3/16	9/16	15/16	1/8
3/8	9/16	1/8	21/32	5/8	3/8	1 3/4	13/16	1 7/16	5/8	1 1/8	5/32
7/16	5/8	5/32	23/32	3/4	7/16	2	7/8	1 11/16	11/16	1 5/16	5/32
1/2	5/8	5/32	3/4	7/8	1/2	2 3/8	1 1/16	1 5/16	13/16	1 1/2	3/16

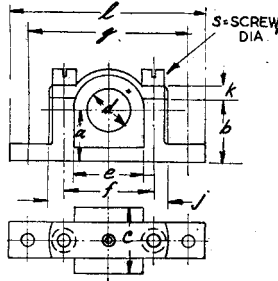


Fig. 43: Standard "Plummer block" type pedestal bearings

the functional design may be noted; first, that the actual valve head is separate from the stem and free to rotate upon it, being retained in place by a tangential pin which intersects the groove in the stem. It may be made with a spherical curve outside, and also on the inside thrust face, as shown; this gives it a self-aligning property, though the "mitred" 90-deg. head and flat internal thrust face is more common.

Secondly, the valve seating in the body is raised, so that metal is available for re-facing if it becomes necessary, and grit or scale tends to fall away from the seating instead of remaining to become imbedded when the valve closes. Last, but not least, the threaded

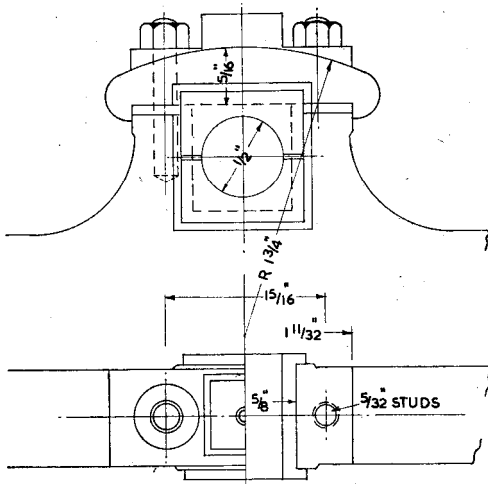
portion of the valve stem is made larger in diameter than the shank which passes through the gland, and a washer or neck bush prevents packing from jamming in the thread.

The main object of this form of design is to prevent any likelihood of the spindle being unscrewed out of the valve and getting blown into the face of the operator-not by any means an impossibility with some types of stop valves used in the past. These, I believe, have long been banned on full-size engines and boilers by Board of Trade regulations.

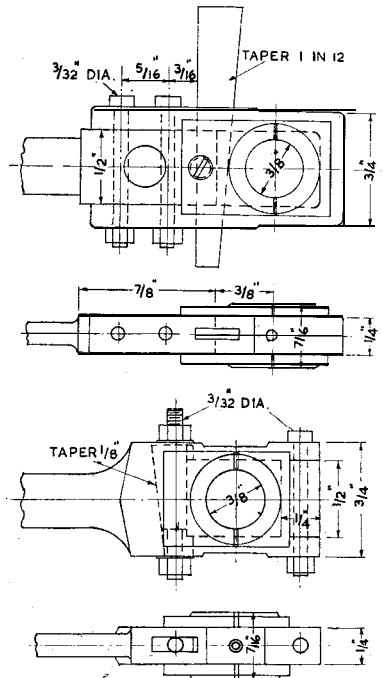
Both right-angled and straight-through types of stop valves are used on engines, according to convenience, the latter being more difficult to make in small sizes, though methods of doing so have been described several times in MODEL ENGINEER. In either type, the entry side should be under the valve head, so that the gland is not under pressure when the valve is closed.

### REVERSING GEAR

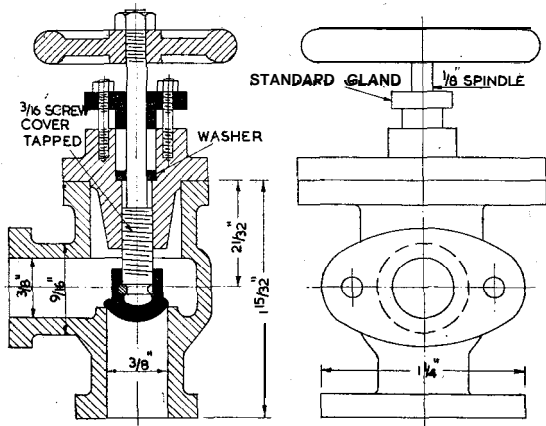
It has already been mentioned that the majority of stationary engines are made to run in one direction only, as the need to reverse them simply does



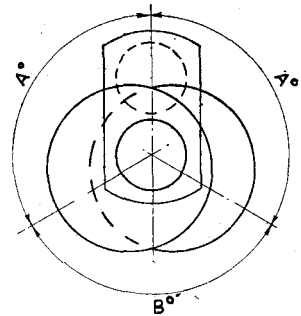
Left, Fig. 44: An alternative type of pedestal bearing, cast integral with the engine bedplate



Right, Fig. 45: Alternative types of "gib and cotter" connecting-rod bearings



Left, Fig. 46: A standard type of right-angled stop valve for the manual control of steam supply



Right, Fig. 47: Diagram showing the positions of eccentric in relation to crank, for forward and reverse rotation

not arise. Certain types of engines, however, such as those for hauling, hoisting or winding, need to be reversible and this also applies to marine engines of all kinds.

In dealing with oscillating engines, it was seen that rotation can be reversed simply by changing over steam and exhaust connections, but this is not practicable in the normal type of slide-valve engine, especially if it is provided with lap and lead for efficient operation. A piston-valve engine with no lap or lead, however, can be reversed in this way, and it is often done on engines for small cranes, ash hoists and ships steering gear, for the sake of simplicity and convenience. Generally, however, reversing entails shifting the phase of

the valve gearing through an angle of 180 deg., minus twice the angle of advance.

This is illustrated in Fig. 47 which shows the positions of the eccentric, relative to the crankpin, for both directions of rotation. The exact angle, of course, will depend on the amount of lap and lead employed, and for an inside-admission piston valve the angle of advance will be on the minus side of 90 deg. from the crankpin in each case.

The simplest method of obtaining the required phase shift is by using a single eccentric, not rigidly fitted to the shaft but capable of a limited angle of movement, so as to take up the relative angles shown when moved to the limit of travel either way.

With this arrangement, an engine once started in a given direction will automatically take up its correct timing so as to continue to run in that direction.

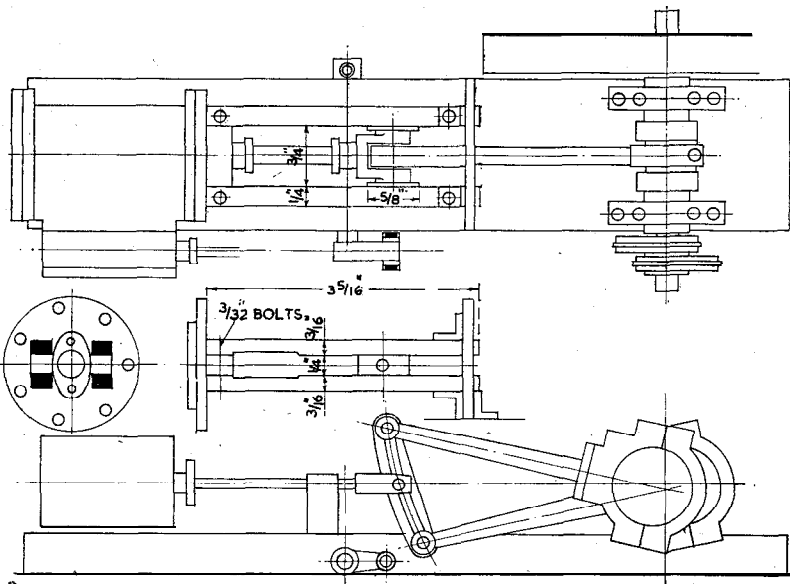
The "slip" eccentric, as it is called, is very popular for simple model locomotives and marine engines, and has also been applied to quite large engines in conjunction with some means of disconnecting the slide valve and operating it by hand for manoeuvring. Such engines are not positively self-starting but this applies to all single-cylinder engines in any case, and is not necessarily a practical disadvantage. A typical example is the Trojan marine engine.

There are several types of positive reversing gears used on steam engines, most (if not all) of them being designed not only to effect the required phase shift, but also to vary the admission cut-off, so as to employ expansion to best advantage—in other words, to "notch up," the notches being those in the reversing gear control quadrant. Of these, the earliest best known, and still most universally popular, is the so-called Stephenson link gear, though its title has often been held in dispute, and is sometimes ascribed to Howe, who was employed by George Stephenson.

Muncaster gives an example of a horizontal engine fitted with this form of link gear (Fig. 48) which may serve as a typical illustration of the general design and proportions of its working parts.

*To be concluded*

Fig. 48: A horizontal engine fitted with Stephenson link reversing gear



#### ADDITIONS TO THE LATHE

Instructions for making centring devices; chucking accessories; tool holders and cutter bars; dividing appliances; simple milling attachments; aids to screwcutting; and steadying appliances are to be found in Edgar T. Westbury's *Lathe Accessories*.

Priced 3s. 6d., postage 3d. (U.S.A. and Canada \$1.00), it can be obtained from Percival Marshall and Co. Ltd., 19-20, Noel Street, London, W.1.