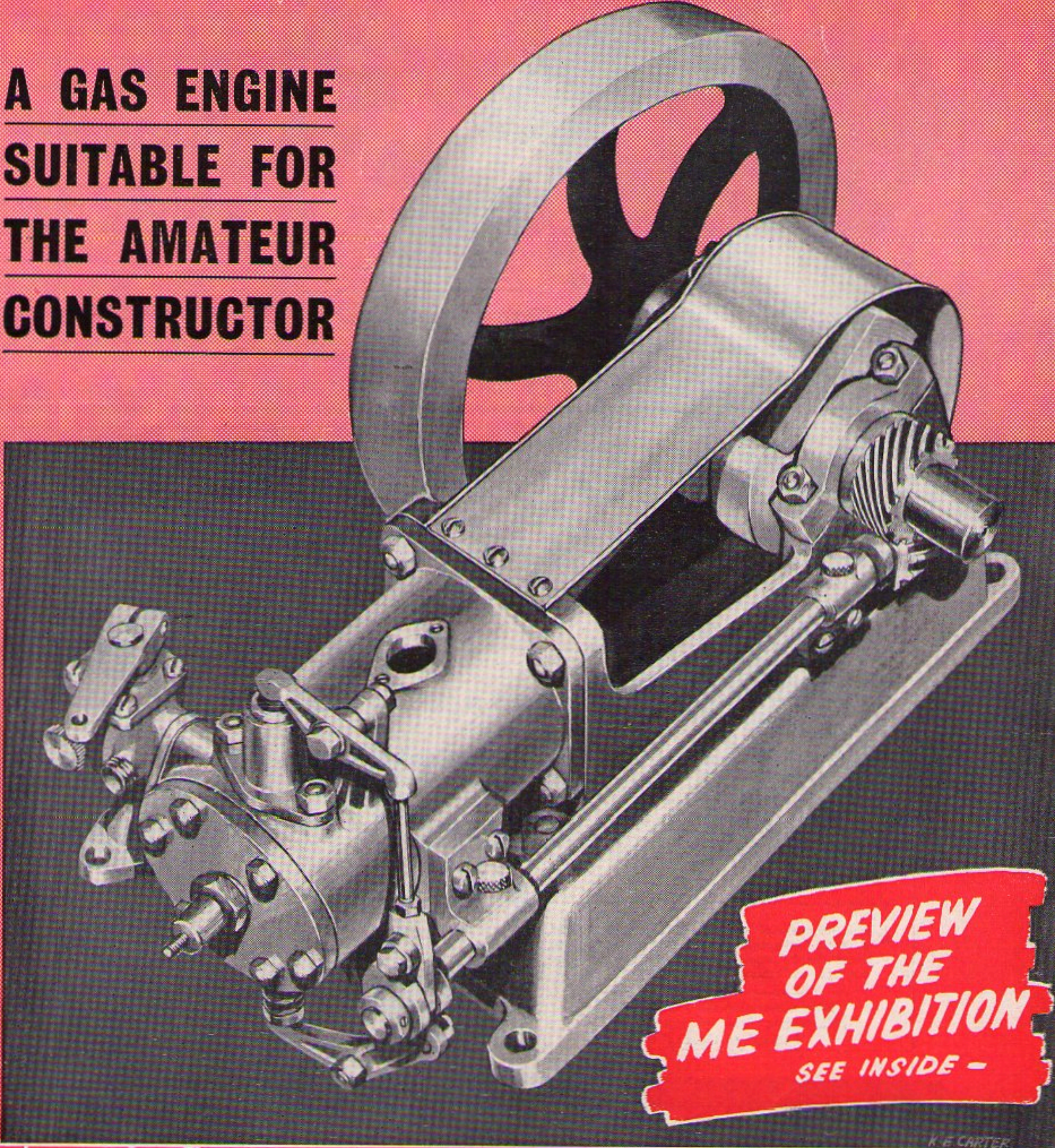
Model Engineer

THE MAGAZINE FOR THE MECHANICALLY MINDED

A GAS ENGINE SUITABLE FOR THE AMATEUR CONSTRUCTOR

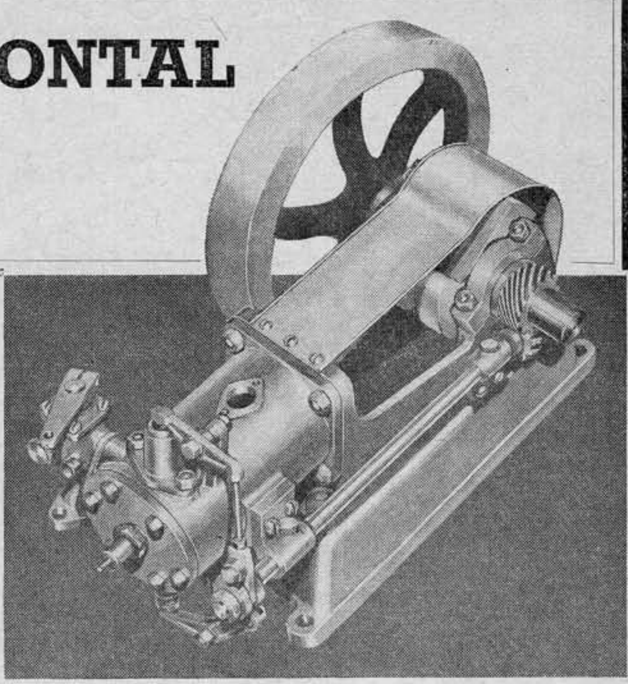


PREVIEW OF THE ME EXHIBITION

SEE INSIDE –

ONE SHILLING 15 AUGUST 1957 VOL 117 NO 2934

A 60 c.c. HORIZONTAL GAS ENGINE



EDGAR T. WESTBURY begins a new series on an adaptable and simply built power unit

Artist's impression of the 60 c.c. horizontal gas engine

IN recent years constructors of miniature i.c. engines have mainly concentrated their attention on high-performance, fast-revving, engines suited to the propulsion of competition models.

While there are many who would argue that this is the most important line of development, it does tend to confine design to a narrow channel and lead to the neglect of many interesting and varied types of engines, which are just as effective in their own sphere as those whose only purpose in life is to produce the last ounce of efficiency in relation to their size.

One of the types which was very popular in the early days of model engineering, but seems now to have become almost extinct, is the horizontal open-type stationary engine, designed to run at relatively low speed, either on gas or liquid fuel. At one time castings and parts for the construction of such engines were available from several firms, a notable example being the Stuart Turner 600, the design of which was based on that of the large National gas engine which then supplied power to the Stuart Turner works.

No doubt the decline of interest in this particular type of engine in recent years may be attributed, in part at least, to the fact that few model engineers of the present generation have seen the full-size engines at work. However, those old enough to have had experience with them will agree that they were not only a serious rival to the steam engine for driving small-sized and medium-sized factory machinery, but also just as interesting, and gave very little trouble in running and maintenance.

My early experience in engineering was acquired in a works employing about 100 men, in two machine shops each driven by a Crossley gas engine rated—I believe—about 25 to 30 h.p. In all the time I was there, the only involuntary stoppages were due to the infrequent breakage of porcelain ignition tubes, which were replaced in about five minutes. Maintenance and periodical overhauls were carried out during weekends and holidays, and, of course, those modern nuisances of "power cuts" and "load shedding" had not then been invented!

A few years ago I published an account of reconstruction work carried out on a very ancient and primitive example of a small gas engine, which excited a good deal of comment.

In replying to some of the correspondence on the subject, I dropped a casual hint that I might be prepared to produce a design for an engine of an improved type, but still adhering to the general features of the orthodox horizontal open-type engine. I have not been allowed to forget this . . . many readers have assured me that it would be very popular among constructors. Because of other demands, it has taken me quite a long time to get down to completing this design, but I trust that the enthusiastic supporters of the idea have not tired of waiting.

In the rebuilding of the old engine, the extent to which design could be improved was severely restricted, and most of the improvements were purely functional; but a great deal was learnt in carrying out this work, and it has been possible to apply some of this experience to the new design. Several very important considerations have been taken into account in deciding the essential features of the design, and the primary requirements may be listed as follows:

1 The engine must conform, in general features and appearance, to the type of gas engine most popular in its day, but at the same time incorporate such improvements as are possible in the light of modern knowledge to promote efficiency and reliability.

2 It must be of a size sufficiently large to produce useful work, and to avoid the need for small, delicate parts or adjustments, yet enabling all components to be machined with the aid of a 3½ in. lathe by straightforward methods.

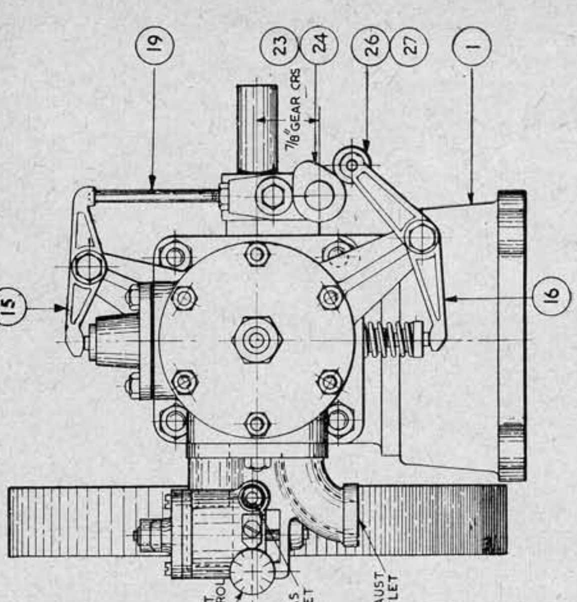
3 All materials, including castings, bar stock, and ready-made components, must be of such a nature as to be within the scope of the model supply trade or small foundry accustomed to normal model work.

4 The design must be adaptable, to suit the requirements of constructors who have individual preferences for details, or for various kinds of duties; also to make the engine capable of running either on gas or liquid fuel without mechanical alteration.

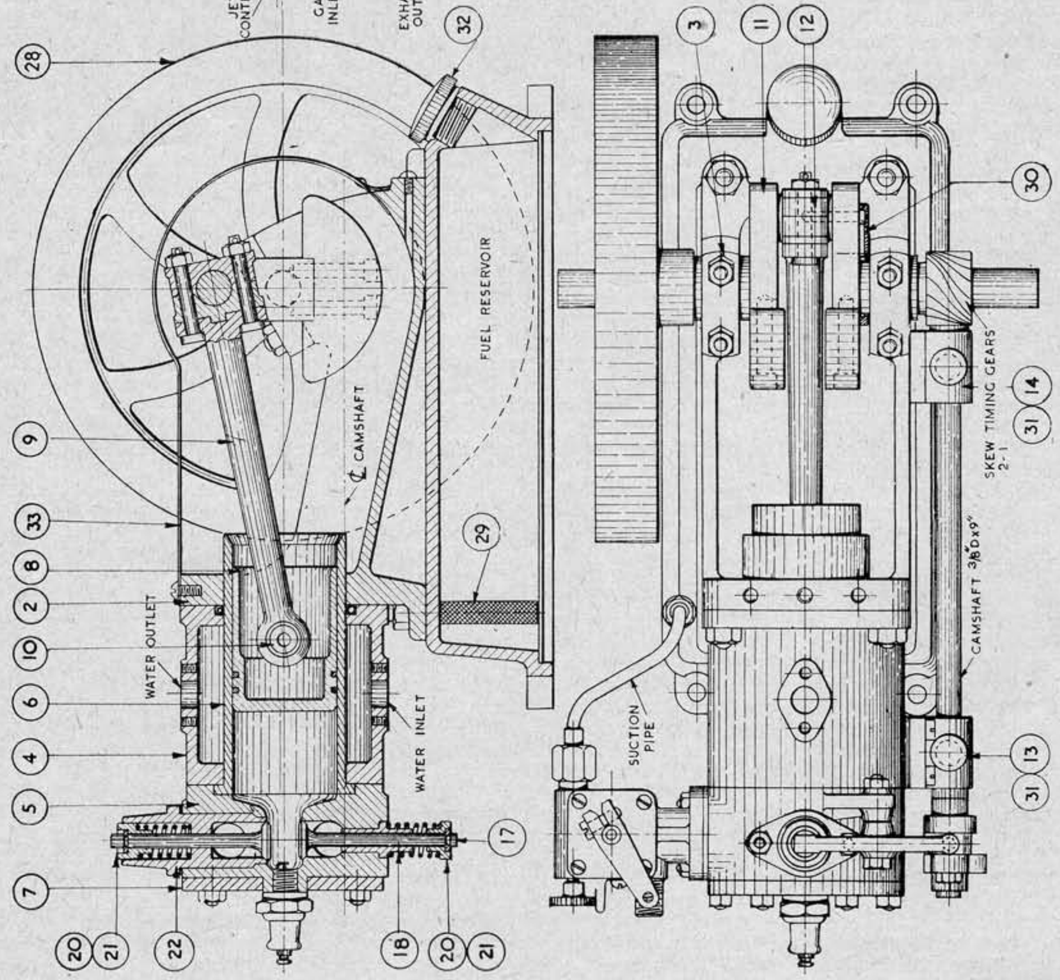
It will be generally agreed that this specification amounts to a pretty tall order, but by studying all aspects and redesigning every component about half a dozen times, I believe I have complied with the foregoing conditions. Unfortunately, I cannot claim that an engine conforming to this design has been built and tested, but it has the backing of many years of experience and, as readers will know, I like to feel the initials ETW mean Engines That Work.

GENERAL DESIGN

The engine has a bore of $1\frac{1}{2}$ in. and a stroke of 2 in. giving a displacement capacity of just over $3\frac{1}{2}$ cu. in. or just under 60 cu. cm.; the bore-stroke ratio is thus a little lower than those usually adopted for horizontal gas engines, but more in keeping with modern ideas. Stroke-bore ratios are logically related to rotational speeds, but there are no fixed rules in this matter, and whereas in the old days the tendency was towards extremely



Plan view and side and front elevations of the engine



General arrangement of the Centaur gas engine long stroke, it is now much more usually in the other direction.

As to power output, I would prefer not to make any definite claims because my experience is that engines made by different constructors have different power characteristics, depending on accuracy and minor details, and the publication of performance figures, however well founded, always lays one open to argument—either with those who fail to obtain the specified results or with the armchair critics who compare them with those claimed for some other engine (usually a totally different type), or what should "theoretically" be possible.

Full-size engines were often rated on a purely nominal basis, though many makers would guarantee brake horse power "tested at sea level." Maximum power is, however, largely dependent on running speed, and small engines, in particular, need to run fairly fast to develop reasonable efficiency; those who insist on a low running speed must not expect a high power output for a given engine capacity.

Engine speeds

It may be mentioned that engines of about 8 to 10 horse power were not usually run at speeds in excess of 350 to 400 r.p.m., while 1 h.p. engines generally ran at 450 to 500 r.p.m. In the case of the reconstructed gas engine referred to, I found it ran quite happily at speeds of 1,500 r.p.m. or more, provided that lubrication was carefully watched; this is rather a limiting factor in the speed of any engine having all main working parts exposed.

The general arrangement of the engine conforms to orthodox practice, having the characteristic deep bedplate incorporating the main bearing housings and the strutted vertical bracket to carry the cylinder. It was fairly common to cast the cylinder, or at least the outer jacket, integral with the bedplate, but this was decided against in the present case, as it tends to complicate machining problems to some extent.

The design of the bedplate, or "body," has been simplified as much as possible—not only for the same reason, but also for convenience in casting. Complicated coring is best avoided in small castings, if it is possible to do so, and loose pieces on the pattern, though they may be a means of avoiding cores for a one-off job, are liable to get lost, damaged, or wrongly located in repetition work.

One feature of design which is strictly conventional is the long side camshaft, driven by spiral or "skew" gears; this became almost universal on full-size engines, and has much to commend it, as it provides plenty of space for bearings, cams and other attachments, and facilitates fitting of these parts. It also lends itself admirably to a type of cylinder head or "breech end" as it was often called—in which the valves are efficiently located and readily accessible—and heated surfaces can be adequately water-jacketed. A similar head was used with great success in the engine of the ME Road Roller.

Wet liner cylinder

The cylinder is in the form of a "wet" liner which does not need to be made an interference or shrink fit in the jacket, being located and held by a narrow lip at the head end, and free to expand at the outer end through a rubber packing grommet. This liner may with advantage be made from centrifugal or chill-cast iron tube; steel is permissible, though it is much inferior to iron for wear unless a high-tensile grade is used.

This, however, is more difficult to obtain and machine. Extensive use is made of aluminium alloy in the structural castings, mainly for convenience in casting and machining, though it was never used in the full-size engines, and this feature is, of course, optional.

Either a solid single-piece crankshaft, or one built up by brazing, may be employed; in the former case, rectangular steel bar is suitable, the balance weights being made separately in steel or cast iron and attached by sunk-head tension screws.

A single flywheel is specified, and although two may be fitted I do not consider this to be of any special advantage. One difficulty of fitting a flywheel on the timing side is that it is bound to stand out a good way from the bearing, which may possibly lead to trouble unless an additional outboard bearing—always a nuisance to line up in a small installation—is fitted.

The recommended method of ignition in this engine is by high-tension spark, using either a magneto or coil and battery. Standard sparking plugs, either ⅜ in., 10, 12 or 14 mm. may be fitted, as found most convenient. Other possible means of ignition include the low-tension internal-break type of plug (though I have not made any provision for this as I do not consider it offers any practical advantages), electric heater or "glow" plug, and tube ignition.

A special carburettor has been designed for the engine, providing for use with gas, petrol or paraffin fuel, without structural alteration. It may be mentioned that although there is no *basic* difference in engine design for working on either gaseous or liquid fuel, the majority of full-size gas engines could not readily be adapted to use the latter, because of the specialised mechanism for admitting or regulating the gas supply.

In most cases separate valves were fitted for gas and air, the former being subject to control by the engine governor, which reduced or totally cut out the gas supply at excess speed. Experience shows, however, that a mixing device or "carburettor" of suitable design can be used to admit and control gas just as effectively as liquid fuel.

No governing arrangements are shown in the general arrangement drawings of the engine, but a governor has been designed as an optional fitting, and can be arranged to operate on the throttle valve of the carburettor as an alternative to manual speed control. For use with liquid fuel, a low-level reservoir is formed in the base casting, the fuel being fed by suction to the carburettor. Paraffin (kerosene) cannot be used to start the engine from cold, so that it will call for the addition of a small auxiliary tank and a change-over cock so that petrol can be used until the engine has warmed up.

Visual lubricators

Apart from the provision of suitable oilways and passages for the supply of oil, no details of lubrication arrangements are shown in the drawings as these may be varied to suit requirements. For normal running, sight-drip-feed lubricators, as used on most full-size engines of this type, are generally suitable, so long as they are properly adjusted and replenished as necessary. The lubricators used on the reconstructed engine were of the type supplied for Myford lathes, but are obviously overscale for a small engine, and constructors may prefer to make their own in a more suitable size.

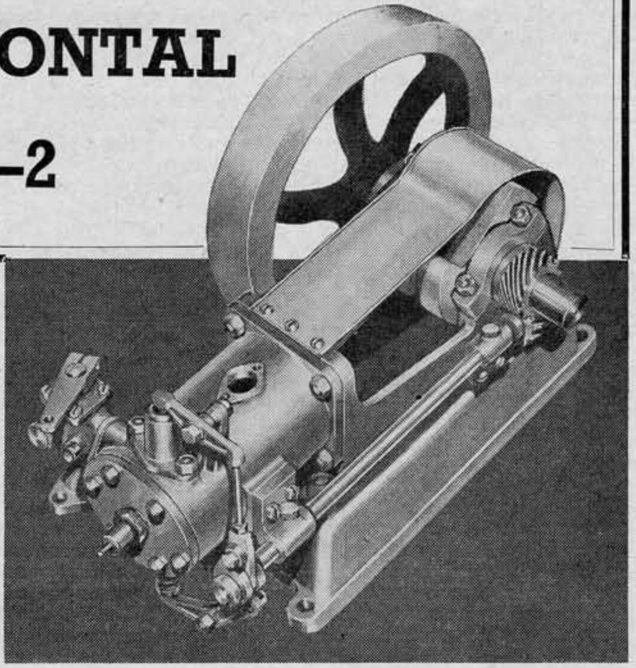
Three of them are required, one for the cylinder and one for each main bearing; crankpin lubrication is provided by a "banjo" or centrifugal lubricator fed from the inner end of the timing side main bearing. The camshaft bearings have wick syphon lubricators.

If, however, the engine is intended for continuous full-load duty, more positive methods of supplying oil to all important bearings would be desirable, and if the demand warrants it this will be provided for.

In subsequent articles, I propose to describe the methods of machining and fitting the various components, giving details of permissible modifications to suit individual requirements or preferences.

● *To be continued*

A 60 c.c. HORIZONTAL GAS ENGINE—2



EDGAR T. WESTBURY makes a start with the machining of the main structural parts

Continued from 18 July 1957, pages 73 to 75

IN PRESENTING any design for construction by readers of the ME, one of the primary considerations is the facility for carrying out all necessary operations with the limited equipment likely to be found in the average amateur workshop.

This matter is never neglected in the engine designs which I describe, but it is of special importance in the present case, because the size of some of the components of the engine is such as to create difficulties for handling when the only machine tool available is a lathe of 3½ in. centres. It is quite obvious that in spite of all efforts to avoid excessively large single castings in the design, some of them are too large to swing on the lathe face plate, and improvised methods of dealing with them must be devised or, where possible, the necessity for machining avoided.

As the design is highly adaptable, it is possible for constructors to incorporate their own modifications in some of the details, so as to simplify these problems still further.

BASE PLATE

In some cases, the particular form of base plate (part No 1) shown is not necessary, as the engine could be mounted on any solid base such as a block of wood or concrete, or a fabricated metal frame. If, however, the cast base plate is adopted, the problem of machining it arises; but where access can be obtained to a large lathe or, better still, a planer or shaper, this matter is easily disposed of.

But many readers will be unable to obtain these facilities, and for their benefit the design is arranged so that machining can be dispensed with. All that is necessary is that the mounting surfaces should be reasonably flat and true, and this can be obtained by filing the edge of the underside, and the four bosses on the top surface. For this operation, a non-clogging file, such as a Dreadnought or the more modern Surform, or Tresa files, can be recommended.

The flatness of the surfaces should be tested on a surface plate; or if this is not available, a sheet of heavy plate glass, mounted on a bed of melted pitch so as to relieve it of uneven stress, forms a very serviceable substitute. It is not necessary to produce the sort of precision surface on the casting that one would associate with machine tool slides, but all trace of rocking must be eliminated.

If the engine is to run on gas only, it is not necessary to use the base as a fuel reservoir; but, otherwise, the orifice for the filler cap must be drilled and tapped, and the bottom closed by a sheet metal plate. A cored hole will probably be provided in the filler boss and will only need enlarging, by reaming or even filing, prior to tapping either BSF, gas thread, or any thread for which a tap can be obtained. The top surface may be spot faced, but as it does not have to make an airtight joint, it will be sufficient to file it reasonably square with the axis of the thread.

The bottom plate may be welded in, if means are available; but I have found it quite satisfactory to cement it in place, in the same way as glass panes are fixed in a window frame, so long as the cement is of a type which is not dissolved or destroyed by the fuel. Some of the modern plastic cements fulfil this condition, the best I have tried being Bondafiller; Loy is satisfactory for petrol or paraffin, but may not be proof against more potent solvents, such as benzol or similar blended fuels.

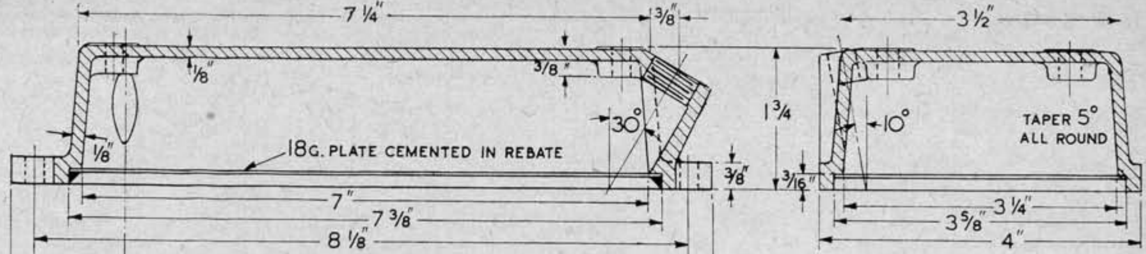
The plate should be fitted as closely to the inside of the rebate as possible; it may be necessary to scrape or chip away any obvious roughness in the casting, after which the plate is bedded in on a thin film of cement, and a liberal fillet then built up on the underside as shown.

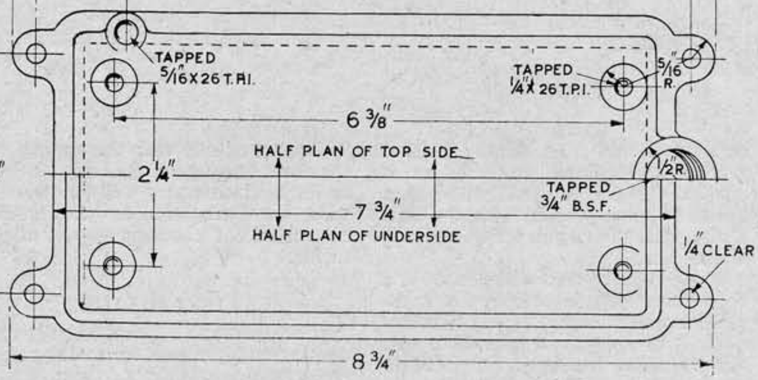
It will be noted that the dead flat bottom of the tank will not allow of using up every drop of fuel by suction feed; but, if desired, a small well may be formed in the plate, immediately under the suction pipe, which will, of course, have to be lengthened accordingly.

BODY CASTING

The underside of this casting (part No 2) may be filed flat as in the previous example, but machining is essential on other surfaces, and this can be done by mounting it on the cross slide of the lathe. Before doing so, however, it is advisable to fit the bearing caps (part No 3) and fix them in position with temporary screws.

The inclined surfaces of the seatings on the body casting may be filed true,





BASEPLATE WITH FUEL RESERVOIR

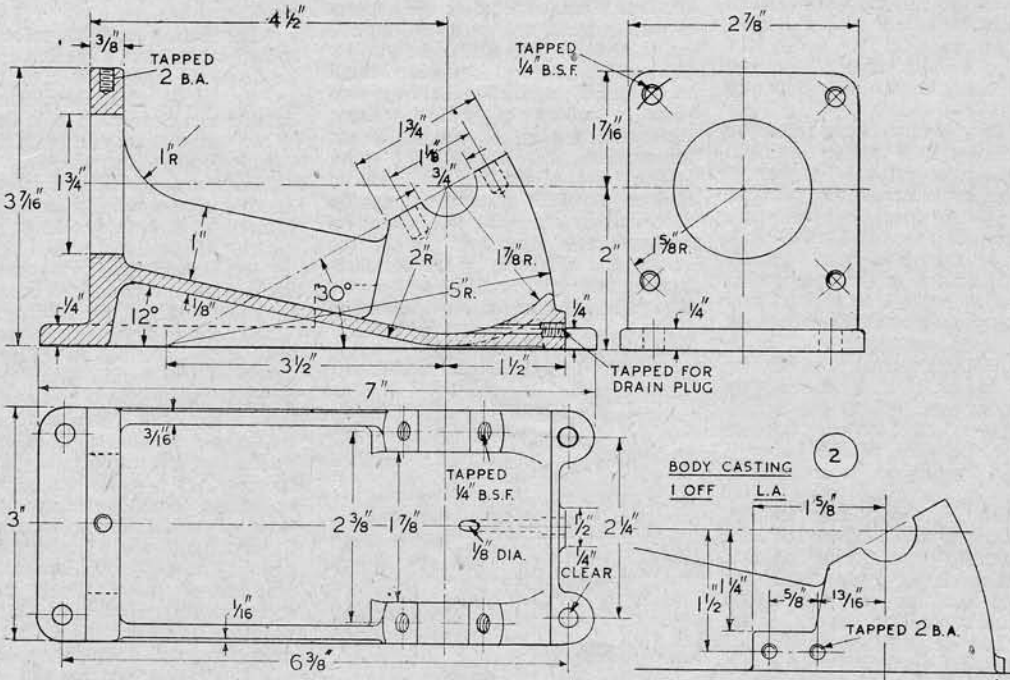
1 OFF (1) L/ALLOY

but those on the underside of the caps can be machined by mounting in the four-jaw chuck, and they should be bedded into close contact before securing in place, also marked so that they can be assembled subsequently in their correct positions. The holes for lubricators should not, however, be drilled and tapped at this stage.

It will be necessary to pack the casting up to the exact centre height when mounting it on the cross slide. Do not use small slips of packing for this purpose, as there is a distinct possibility that they may not locate properly when the casting is shifted for the second operation; a sheet of metal or hard fibre large enough to cover the entire base is much better. The Myford ML7 lathe has a clearance of $2\frac{1}{16}$ in. over the cross slide, so a packing piece $\frac{1}{16}$ in. thick should give correct location.

A strap may be placed across the waist of the casting, with a couple of wooden or fibre pads shaped obliquely to fit over the webs, and two bolts used to hold the job down. In the position for boring the bearing housings, the casting will take up practically the full width of the cross slide, so that there will be no room to fit bolts to the T-slots; this difficulty, however, can easily be surmounted by making a bar of suitable section to fit the slots, long enough to pass right through them and project each side to take the bolts.

Some preliminary marking-out of the centre positions for the bearings

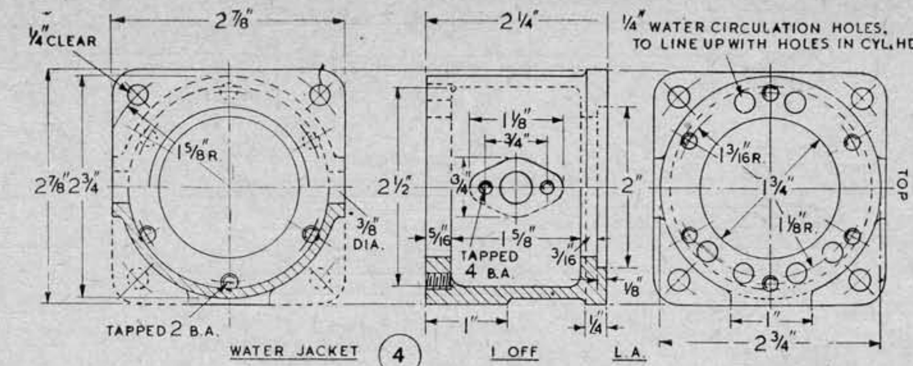


BODY CASTING (2)

1 OFF L.A.

60 c.c. GAS ENGINE

continued



and cylinder seating is desirable, but this need not be elaborate, and I have not generally found it necessary to provide more than a check-up on these locations. The casting should first be set up with the sides parallel to the edges of the cross slide, and adjusted so that the bearing centre lines up with the lathe axis; it is advisable then to tighten the slide gibs so that inadvertent movement is prevented.

The bearing housings have purposely been made large in diameter so that a boring bar of adequate rigidity will pass through them, but if any difficulty in this respect is encountered, preliminary opening-out of the holes can be done with a drill held in the lathe chuck, so long as this is followed by a cutter bar supported at the tail-stock end. The sides of the housings can be faced by means of side cutters mounted in the bar, care being taken to finish them square with the bore. On the timing side, the facing for attachment of the camshaft bearing may be machined with a fly cutter or face mill.

The casting is now swung round on the cross slide to a position at right angles, with the vertical flange now facing the lathe headstock. It can again be held down by the strap across the waist, though the bolt hole positions may have to be readjusted, and the squareness of the setting must be carefully checked. The best way to do this is to mount the face plate on the lathe mandrel, and fit a straight, stiff bar through the bearing housings, clamping it if necessary by the bearing caps. With the saddle locked, measurement between the face plate and the ends of the bar will enable the casting to be set exactly square.

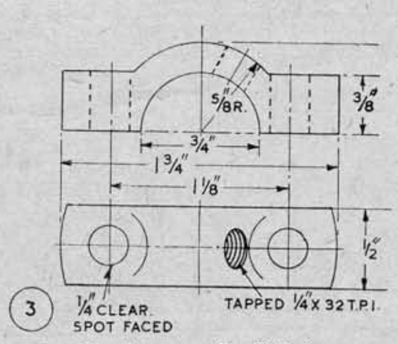
After centring the cylinder seating, it can be bored with a cutter bar held in the chuck, or a boring head if available; the latter is also useful for machining the face, as it provides radial traverse for the cutter. In its absence, however, the best way to deal with the facing operation is to use a fly cutter, and traverse the work by means of the cross feed. This is preferable in some respects, as it enables the cut to be finished in a horizontal line parallel with the base flange, instead of in an arc as with the boring head.

It will be appreciated that by a little forethought in design, a component which might have been very difficult or complicated, both to cast and machine, has been simplified to the utmost without impairing its functional efficiency.

WATER JACKET

This (part No 4) is quite a simple casting to machine, as it may be held in the four-jaw chuck at the head end for facing and boring, also recessing for the packing ring, at one setting. The other end face should preferably be dealt with by clamping the job to the face plate, either over the corners of the square flange, or by drilling the holes in same and fitting bolts. By this method, the end forces are bound to be exactly parallel—unless the face plate runs out of truth! Exact concentric setting, of course, is not important.

The faces of the top and bottom flanges for water connections can be machined by mounting the casting on an angle plate, by a bolt through the centre; the side face for the camshaft bearing may also be dealt with in the same way, but note that this is intended to line up exactly with the seating for the other bearing, on the body casting, so the operation may well be deferred until the parts can be temporarily assembled for checking up on alignments.



Bearing caps, 2 off, L.A.

CYLINDER LINER

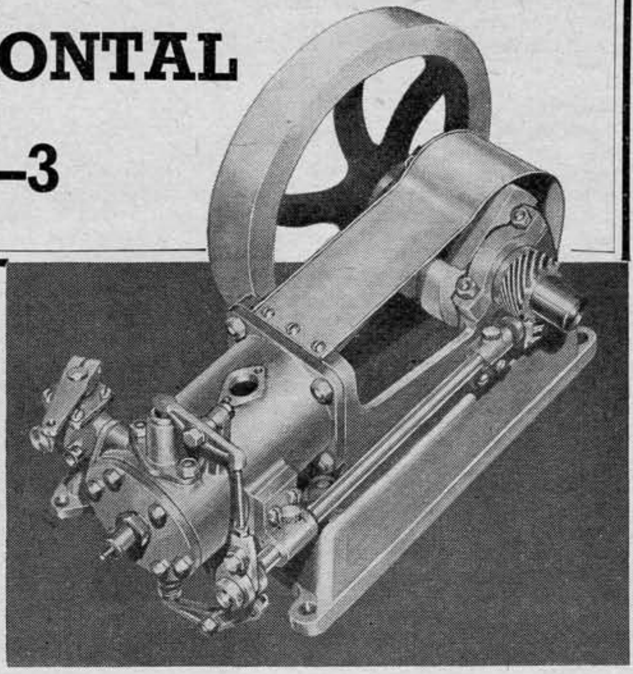
If possible, a centrifugally-cast sleeve should be used for making this; apart from the quality of the material, such castings usually have a fairly heavy flange which can be held in the four-jaw chuck, enabling all the most important machining to be carried out at one setting, and without risk of distorting the thin section by chucking pressure. The inside can then be bored by a heavy cutter bar or solid tool, taking care to ensure that it is parallel, and as well tool-finished as possible, leaving about 0.002 in. for lapping or honing.

After facing and chamfering the mouth of the bore, a centred plug may be fitted to enable tail-stock support to be used while machining the outside to a close push fit in the bores of the water jacket and body castings. Finally the lip is turned on the outside diameter and the liner is parted off. To true up the end face, mounting on a mandrel is best, but as it may be difficult to find a mandrel this size, the job may be held by the outer end in the chuck, with a fixed steady near the other end, for this light operation.

Methods of finishing cylinder bores have been described so often in the ME that one would think it hardly necessary to dwell on this matter, yet the number of queries about it indicate that many readers find difficulty in producing accurate results. Lapping, however, is a quite straightforward operation, demanding more of patience than of actual skill; it cannot be hurried, and the time involved in carrying it out will depend on the amount of metal which must be removed in eliminating errors in roundness or parallelism, tool marks, or dimensional discrepancy.

● *To be continued*

A 60 c.c. HORIZONTAL GAS ENGINE—3



In this instalment EDGAR T. WESTBURY turns his attention to the cylinder, piston and connecting-rod

Continued from 1 August 1957, pages 148 to 150

REFERRING to methods of cylinder finishing, the only process normally available to the amateur and capable of producing the desired results is by lapping, though some constructors may have access to cylinder honing equipment. This enables the job to be done quicker, but not necessarily better.

It is by no means impossible in a cylinder of this size to finish the bore accurately enough direct from the tool, and there are many who consider that the use of abrasives in any shape or form is undesirable on the grounds that some traces of them are bound to be left behind, causing trouble, or at best, rapid wear. But it is by no means easy to produce a perfect tool finish by ordinary methods on a light lathe, and the bedding-down of a tool-finished bore, even though generally accurate, may be slow, and involve wear which results ultimately in excessive piston clearance and large ring gaps.

My usual method of lapping is to employ a split lap on a tapered mandrel with a nut on the end, so that it can be expanded to keep contact with the bore as wear takes place. Soft laps such as lead or copper are readily charged, and have a more rapid action than harder materials. But the latter are easier to control, and I have obtained the best results with cast aluminium for coarse lapping (using carborundum) and cast iron for fine lapping (with aluminium oxide).

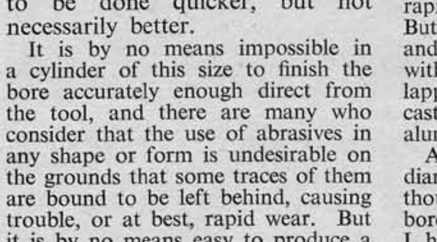
A lap about equal in length and diameter has been found best, and though it is possible to lap the cylinder bore while it is set up for machining, I have generally found it better to run the lap in the lathe and hold the liner by hand so that it is free of all chuck pressure; any local inaccuracy can be felt by the variation in friction.

Spring laps of all kinds should be avoided, as they simply follow inaccuracies in the surface instead of correcting them. Some readers talk of "lapping" with emerycloth, but this can only polish out tool marks or surface scratches; similarly, the use of metal polish can only improve surface appearance because though most polishes act by abrasion, the rate of metal removal is so infinitesimally small that it might be compared with an attempt to shovel away Mount Snowden with a teaspoon.

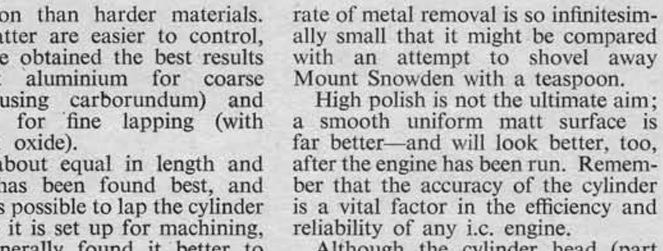
High polish is not the ultimate aim; a smooth uniform matt surface is far better—and will look better, too, after the engine has been run. Remember that the accuracy of the cylinder is a vital factor in the efficiency and reliability of any i.c. engine.

Although the cylinder head (part No 5) may seem at first sight to be a rather complicated component, it presents no special problems—either in casting or machining. The combustion head cavity and the water space can be cast without coring provided that normal taper or "draught" is allowed on the pattern, and although coring of the hole for the inlet valve housing and the gas passages is desirable, it is not absolutely essential.

I have often found it less trouble to machine these parts from solid metal



PISTON (8) 1 OFF C.I.



(6) CYLINDER LINER 1 OFF C.I.

uncommon and are sufficiently exposed to be studied in detail; moreover, the workmanship is exemplary and should be duly noted, especially by novices.

STUDENTS' CUP COMPETITION

Evidence of increasing interest in model engineering in schools and training establishments is shown by the large number of entries in this class; moreover, they are more widely varied than they have been in some previous exhibitions, and there is a welcome tendency to get away from the stereotyped—and often uninteresting—" test jobs " which have sometimes been predominant.

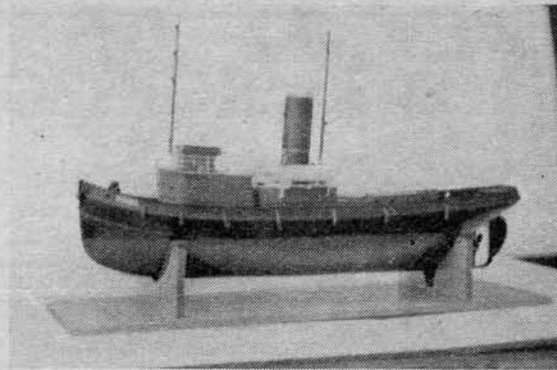
Two team entries are submitted by the technical department of Rayleigh County Secondary School—namely a horizontal double-acting mill engine, built in the course of a year's work by four 5th-year pupils, and a single-cylinder oscillating steam engine built by four pupils during one term in their 4th year.

The Tylers Croft Boys' School at Kingsbury in North-west London also enter a team effort in the form of a group of engines, boilers and small machines, representing the work of 20 pupils. A number of individual entries have also been received from pupils at this school, including model steam engines, drilling machines and a small lathe of original design.

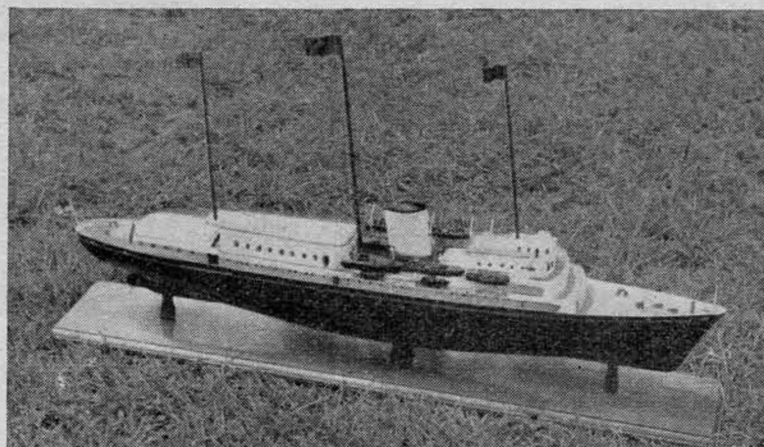
Other individual entries in this class include a scale model house and theatre, both equipped with electric lighting, by R. G. Conradi, of Hatch End, Middlesex; an electrically-driven 1/20 in. scale model of a luxury liner of the future, by Dennis Nash, of Southall, Middlesex; an anemometer, for measurement of wind velocity, by Robert Riley, of Clapham, South London; and a planimeter, for measurement of areas on charts or plans, by David Holt, of Hampton, Middlesex.

The last two items have been constructed in the workshops of the Northampton Secondary School, Clerkenwell, London.

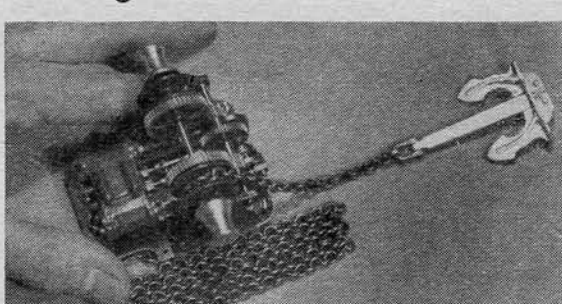
● *To be concluded*



Right: An electrically-driven model of the steam tug S. T. GONDIA *made by C. G. Wheeler*



Below: Lester Wade's model of H.M. Yacht BRITANNIA



Right: Charles Blazdell's seagoing steam-tug ENERGY *with, below, its working windlass, which has $\frac{1}{4}$ in. bore × $\frac{3}{8}$ in. stroke* than to true up and clean out cored holes.

For facing and recessing the front of the casting, it may be held in the four-jaw chuck and set up as truly as possible over the outer diameter and face. The facing cut should be extended to clean up the faces of the rocker bosses, and the recess should be bored to a neat fit over the lip of the cylinder liner; its depth will depend on whether packings of any kind are to be fitted either on the inner (gas joint) face or outer (water joint) face. I favour metal-to-metal joints for the former, if not both, faces; it is true that gaskets of some kind are usual in full-size practice, but this is mainly because of the difficulty of maintaining accuracy of the faces under normal servicing conditions.

Many constructors will prefer to fit a thin gasket for the water joint, the inner spigot joint being lapped or "ground in." The depth of the recess can in this case be assessed by first finding the thickness of the jointing material (tough paper or tracing linen) when under compression, by gripping it fairly tightly between the contact faces of the micrometer—not tight enough to strain the instrument and thus impair its accuracy !—and boring the recess just this amount short of the depth of the lip on the liner.

This can be verified by assembling the liner, water jacket and head temporarily and testing with a feeler gauge. Any correction necessary may be made by machining or lapping either the face of the head casting or the spigot of the liner, according to whether the gap is too small or too large.

In view of the importance of ensuring a tight cylinder head joint—allowing no leakage either of gas pressure or water—the time spent in these operations will not be wasted.

While the casting is set up for these operations, the bevelled mouth of the combustion chamber may be cleaned up, and it is also worth while to drill an undersize pilot hole right through the back end as a guide to setting up in the reverse position. As an ordinary centre drill will not reach the bottom of the cavity, a stiff spearpoint drill may be improvised from silver steel rod not less than 3/8 in. dia. and used to start the hole exactly truly. The oblate cavity does not need to be machined but should be cleaned up with a riffler or rotary file when other operations have been completed.

After setting up in the reverse position, the water joint face and central spigot can be machined, and the centre hole drilled and tapped for the sparking plug. Note that either 3/8 in., 10 mm., 12 mm. or 14 mm. plugs can be fitted as may be most convenient.

I recommend the smaller size; I have found it quite satisfactory in use and more in proportion to the size of the engine than the larger plugs; the full-size 18 mm. plug is definitely too large for the combustion head. Either 12 or 14 mm. plugs will call for some enlargement of the centre spigot diameter, and the "reach" of any particular plug may be accommodated by adjusting the depth of the spigot so that the end face of the plug when fitted comes just about flush with the inside of the combustion cavity.

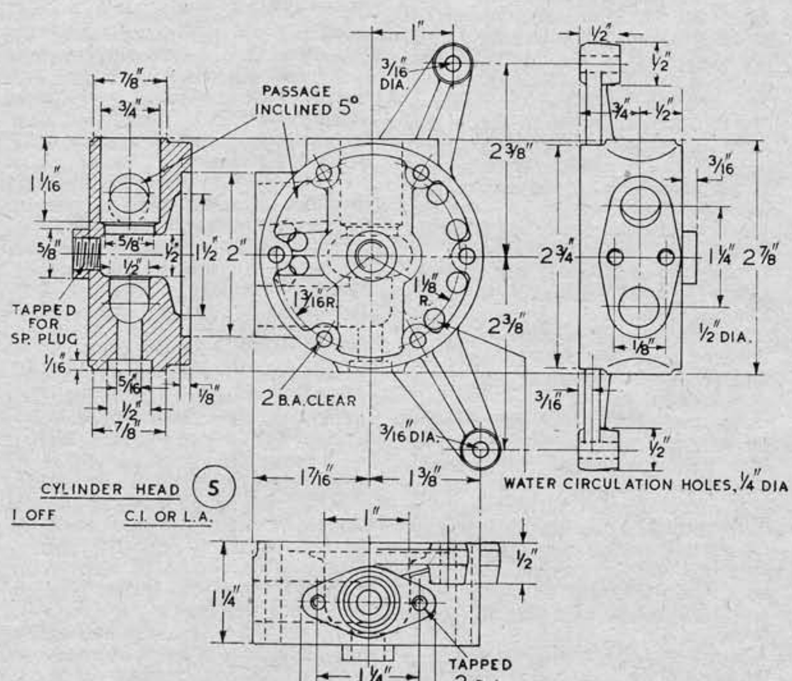
Operations at right angles to the main axis of the head can be carried out by mounting the casting on an angle plate, using either a strap with two bolts or separate clamps, not forgetting the sheet of paper under the machined surface. The use of a single bolt through the sparking plug hole is not practicable for dealing with the valve bores, which should both be machined at one setting if possible. It is not absolutely essential that the inlet and exhaust valves should be in perfect axial alignment, but what is important is the alignments between guide and seating of the individual valves.

The bore for the inlet valve housing should first be machined by facing the top end and boring the two diameters, employing great care to ensure a smooth and accurate seating at an angle of about 120 deg. at the end of the larger bore. It is then necessary to centre-drill the inside of the cavity to start the drilling through the exhaust seating and guide; the spearpoint drill already mentioned can be used for this purpose but an even better plan would be to turn up a mild-steel pilot bar to fit exactly in the bore of the seating and mount a centre drill in the end of it.

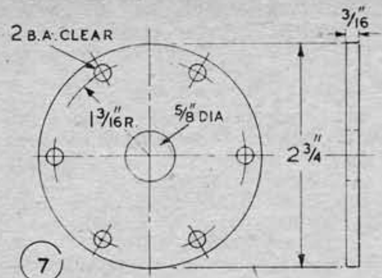
If, however, any difficulty is experienced in getting the drill and counterboring cutter to run dead truly through the exhaust bore, the holes should be trued by means of a boring tool, even though they may have to be made oversize in doing so. The exhaust valve guide can, if necessary, be enlarged to fit, but the size allowable for the valve seating is limited by the fact that this valve can only be assembled by passing it down through the inlet bore. All this may sound rather difficult, but it is not so if reasonable care is taken; many readers have successfully constructed the ME Road Roller engine, which has a similar valve arrangement in a smaller size.

The counterbore on the underside of the exhaust valve guide can be carried out with a piloted cutter; it calls for no special accuracy so long as the recess is square with the bore axis, thus locating the guide in correct alignment.

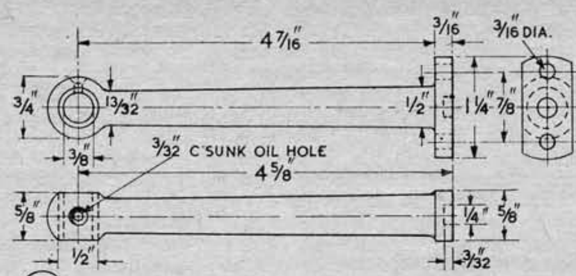
By swinging the casting round on the angle plate at right angles, the



CYLINDER HEAD (5)
1 OFF C.I. OR L.A.



7 COVER PLATE 1 OFF L.A.



9 CONNECTING ROD 1 OFF M.S.

flat surface at the side can be faced, and it is as well to locate and bore the inlet and exhaust passages while mounted in this way. Note that the inlet passage must be inclined at 5 deg. to the horizontal; the exact angle is not critical but it is most important that the passage must emerge above the seating in the housing bore.

It is best to drill an undersize hole first, to see where it comes out, and, if necessary, correct the angle before enlarging the hole further. This passage also runs very close to the hole for one of the cylinder-head fixing studs, and though no great harm would be done if the latter should break in, it is best to avoid it if possible.

Holes must be drilled through the water joint faces of the cylinder head and jacket so as to line up and provide a passage for water circulation; these should provide as large an area as possible but some care will be necessary to avoid encroachment on port and passage positions.

On the gas passage side the holes will have to be drilled obliquely to dodge the passages and also the fixing stud boss; give this matter a little thought before going ahead, as it is easier to see what is required from the actual casting than to illustrate it in drawings or text.

COVER PLATE (Part No 7)

The cover plate is a very simple component which can be made either from a casting or sheet metal—though in the latter case, it is not advisable to rely on the initial surface being dead true; a facing cut should be taken over the inner joint face at least. The casting, of course, will need machining on both sides. Bore the centre hole to a snug fit on the spigot of the cylinder head in either case.

A thin joint may be fitted between the cover plate and the cylinder head, and a disc of the same material should be fitted on the centre spigot. As the function of the cover plate is merely to close the water space in the head, it is unlikely that it will have to be removed again after once assembled. Thus if there should be any trace of water leakage around the centre spigot, it may be caulked or peaned over, taking care not to bruise the sparking-plug joint face; this measure, however, should not be necessary.

PISTON (Part No 8)

It is usual to provide a chucking piece on a piston casting so that it can be machined all over at one setting, but I find that this tends to encourage slovenly setting-up; only too often the rough chucking piece is simply gripped in the three-jaw chuck without due regard to whether the inside, which is the really important surface, is running truly. For this reason I often dispense with the chucking piece and hold the piston by the head end in the four-jaw, setting it up carefully so that the internal part is concentric throughout its length. The accessible part of the outside is then roughed out to a little over finished size, the end faced and the inside of the skirt skimmed out so that a true bore is produced at the mouth.

While in the chuck, the centre line of the cross-hole for the gudgeon pin can be marked out with a scribing block set to exact centre height on the bed of the lathe; this enables the position in relation to the internal bosses to be correctly adjusted. Lateral location of the pin can be marked by means of a point tool in the tool post; no harm is done if a fine groove is turned in the piston at this point.

The casting may now be mounted on an angle plate and set up on the face plate for drilling and boring the gudgeon pin hole. To ensure the hole passes diametrically through the piston centre, a line should be scribed squarely across the middle of the angle plate and the centre lines on the piston set to coincide with this both front and back before clamping it to the plate.

A reamer may be used for finishing the bore of the hole, but it should be left on the tight side for fitting the gudgeon pin. Internal facing of the bosses is not necessary as floating clearance is allowed for the little end of the connecting rod.

Most of the excess metal on the head end of the piston may be machined away by holding it in the three-jaw, either before or after drilling the cross-hole, but for the finishing cut I recommend using a "spigot chuck," which I have described on several previous occasions. It consists simply of a disc held in the lathe chuck—or in any other convenient way—with a spigot turned on it to fit the inside of the piston skirt, and tapped in the centre to take an eye bolt.

A temporary gudgeon pin, well on the short side, is passed through the piston and the eye bolt, and this enables the piston to be drawn up tightly against the spigot, where it is free from any stress which might distort the external surface. The final machining of this surface and the turning of the ring grooves may now be carried out; take great care with the finish of the sides of the grooves, making the rings a free but not slack fit, and with ample clearance in the depth of the grooves.

For a cast-iron piston, a diametral clearance of about 0.001 in. per in. dia. in the bore of the cylinder is sufficient, with a little extra above the top ring. So for this engine, 1½ to 2 thou will be in order.

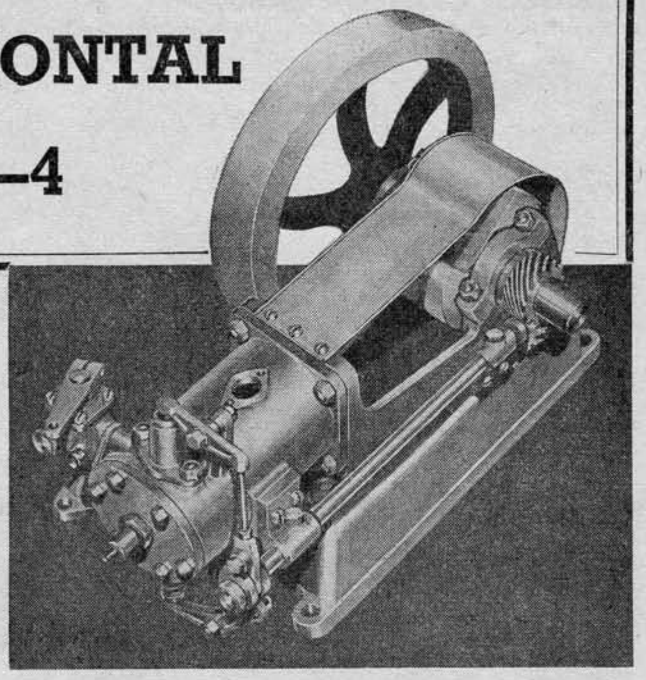
CONNECTING-ROD (Part No 9)

The connecting-rod is turned from mild steel, though it is permissible to fabricate it by brazing on the foot—and also the little end boss, if desired. It is open to question, however, whether this method saves very much either in time or material, but if it is adopted I suggest that instead of building up fillets with the brazing metal, collars should be left on the ends of the rod and turned to form the fillets after brazing.

In this way the joints are almost invisible instead of being obtrusive, as they often are in such cases.

● *To be continued*

A 60 c.c. HORIZONTAL GAS ENGINE—4



EDGAR T. WESTBURY discusses the construction of the crankshaft, flywheel, bearings

Continued from 15 August 1957, pages 226 to 228

In previous articles dealing with steam engine construction, I have described methods of machining circular-section steel connecting rods, and the type employed on the Neptune diagonal paddle engines is practically identical to this one except in dimensions.

I have always recommended that the forming and the cross boring of the little end should be done before reducing the shank of the rod to its final tapered form, due to the difficulty of mounting it accurately; if the rod is turned from either round or rectangular bar, however, these operations can be carried out first, when it is quite easy to clamp the bar squarely and securely, either on the face plate or the vertical slide, according to the method of cross boring which may be preferred.

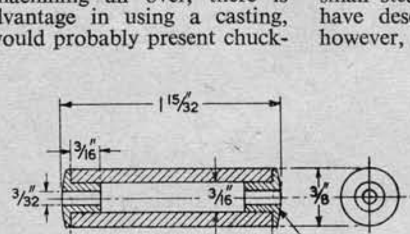
The main operations on the rod can be carried out between centres; the foot end should be counter-bored to form a register for the location spigot on the inner brass of the crankhead or big end bearing.

This bearing (part No 12) is most conveniently made from a solid piece of gunmetal or bronze. As it needs machining all over, there is little advantage in using a casting, which would probably present chucking difficulties in any case. A cast piece of rectangular bar large enough to clean up $1\frac{1}{4}$ in. × $\frac{3}{8}$ in., however, will be found most useful, as the two halves of the bearing can be machined on their end faces and parted off while the bar is held in the four-jaw chuck. The inner half should be spigoted to fit the recess in the foot of the rod, and, if desired, the two bolt holes may be drilled before either piece is parted off, as this will ensure beyond doubt that they line up properly. It should be noted that the bolts are made a snug dowel fit in the holes, no clearance being allowed; this applies also to the corresponding holes in the foot of the connecting rod.

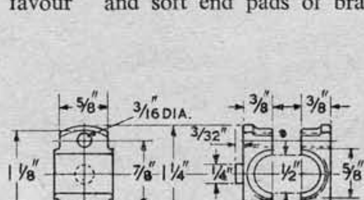
With the two halves bolted together, it is now possible to hold them in the four-jaw chuck for boring and facing. The size of the bearing makes it somewhat easier to handle than the small steam engine bearings which I have described recently. There is, however, much to be said in favour of adopting the machining methods I have recommended for the crankheads of these engines, namely by attaching them first to the rod and locating the little-end on an aligning mandrel attached to the lathe faceplate.

Alternatively, some constructors may prefer to do the job in reverse by machining the crankhead bearing, attaching it to the rod, and machining the little-end last, using similar methods of location. The essential thing is to ensure that the two bearings are exactly parallel to each other and any method which produces this result is "correct practice."

The little-end bearing should preferably be bronze bushed, but if the gudgeon pin is case-hardened, and fully floating—that is, free to rotate in the piston bosses—it will run for quite a long time without undue wear. A hard-surfaced gudgeon pin (part No 10) is desirable in any case, and soft end pads of brass or light



GUDGEON PIN (10) 1 OFF M.S. C.H.



(12) SPLIT CRANKHEAD BEARING 1 OFF BRONZE

alloy should be press-fitted in the ends as shown, to prevent the risk of scoring the cylinder walls if it should move endwise.

Do not use silver steel for this pin, as it is too soft for durability if left in its normal condition, and too brittle if hardened. The essential need is a hard surface and a tough core. It should be slightly on the tight side when initially fitted to avoid little-end knock.

CRANKSHAFT

No pains should be spared to make this highly important part (No 11) as accurately as possible. There are many ways of making a crankshaft, and I think I have described pretty well all of them in connection with the many types of steam and i.c. engines I have designed. However, many fallacies are held with regard to crankshafts, and I have seen several shafts spoiled through errors in setting out or machining—usually by trying to take short cuts in either procedure. For marking out and centring a forging or solid bar, prior to machining between centres, there is nothing to beat the long-established methods, using the scribing block and surface plate to mark both radial and throw centres on both ends of the component, then carefully centre-punching the intersections of the lines and centre-drilling.

Either black or bright rolled mild steel bar may be used, the finished size over the webs being $1\frac{3}{4}$ in. × $\frac{3}{4}$ in., but if cleaning up is necessary it will not matter if the webs are very slightly undersize. The bar should be normalised, by heating to dull red and allowing to cool slowly before marking out, otherwise it may be found that machining will release stresses, resulting in the finished shaft going out of truth, either at once or later on.

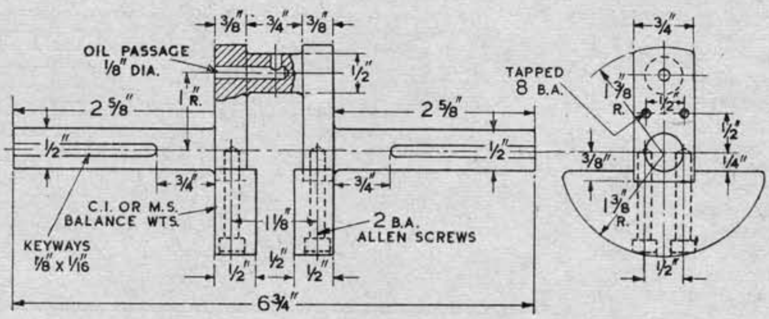
Crankshafts built up by brazing are quite satisfactory if the work is properly carried out so that full penetration of the joints is ensured. Attempts are sometimes made, however, to avoid the need for machining the journals after brazing, but apart from the fact that finish may be impaired by scaling, or superfluous spelter may be left in the region of the joints, there is more often than not some distortion caused by local heating.

Special brazing processes, such as Birlec furnace brazing, will eliminate these risks but these processes are not readily available in all cases. In the circumstances, machining after brazing may be considered the most satisfactory method and little time is saved by fabricating the shaft. There may, however, be some saving in material, which is no small consideration these days. I do not recommend fabrication by welding, as my experience of welded crankshafts has not been very fortunate.

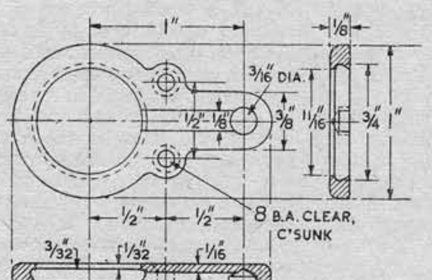
Full-size engines usually have attached balance weights of cast iron, and I have followed the same practice here, though some constructors may prefer to turn the shaft from large diameter round bar with balance weights integral; apart from the greater amount of machining work and waste of material, there is no objection to this. However, the separate weights are quite satisfactory if carefully fitted to the web, and properly secured.

I have suggested the use of sunk Allen screws for this purpose, but I have used mild steel screws, in engines running at quite high speeds, without encountering any trouble. An alternative method, for fabricated shafts, is to make webs and balance weights integral, as in the Unicorn steam engine.

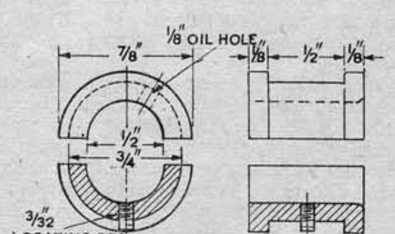
For effective lubrication of the crankpin under continuous running conditions, some means of supplying oil from the inside is highly desirable, and the established method is by means of a centrifugal lubricator, or



CRANKSHAFT (11) 1 OFF M.S.



BANJO LUBRICATOR (30) 1 OFF L.A. OR BRASS



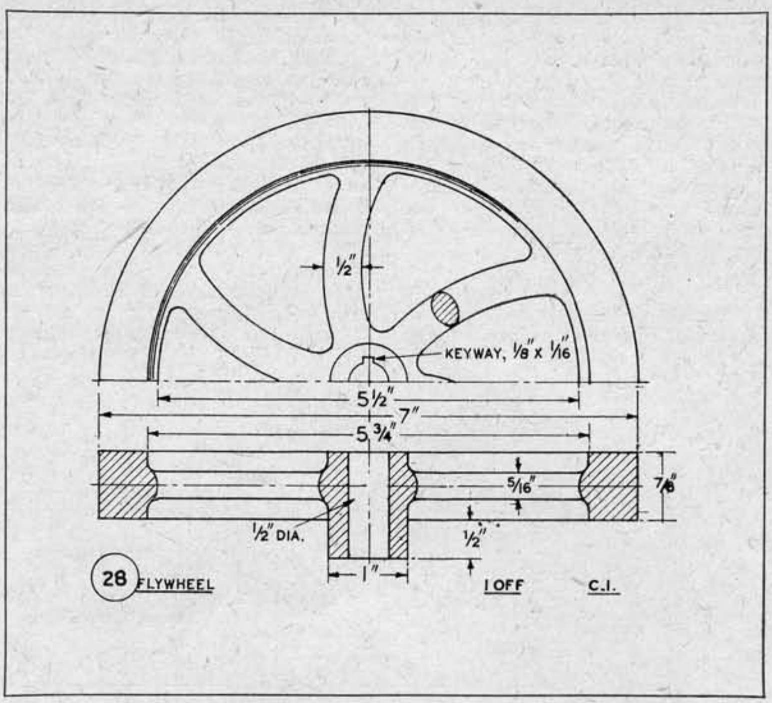
(3) MAIN BEARING 2 OFF BRONZE

NOTE: INNER FLANGE OF L.H. BEARING TURNED DOWN TO 11/16" DIA. TO FIT BANJO

banjo, which leads oil either from one of the main journal bearings, or a separate oil feed, radially outwards to a passage drilled in the crankpin.

This device (part No 30) may be cut out of sheet brass or duralumin, and attached to the side of the crank web by two screws. It does not matter greatly which main bearing it feeds from, but the timing side is usually preferred. The annular collecting channel should be slightly undercut, and the radial passage may be either milled, planed or chipped out. A close-fitting joint should be made between the banjo and the web to avoid oil scattering; a smear of joint varnish should be sufficient, but a thin paper gasket may be fitted if desired.

Keyways are cut in the shaft, either by end or side milling, or planing, to locate the flywheel and timing pinion, unless alternative methods of securing these, which will be referred to later, are adopted. I have shown the keyways at right angles to the plane of the crankpin, but their exact position is not important, so long as other parts are located to suit. They must be accurately cut, with smooth, parallel sides, as the fit of the keys is most important.



MAIN BEARINGS

These bearings (part No 3) may be made from cast bronze stick and, for preference, I recommend a relatively soft bronze, such as lead bronze, which is not only easier to machine than hard bronzes but also wears better in conjunction with an unhardened shaft. Machining split bearings can be a rather tricky business, but the job can be very much simplified by exercising a little forethought.

I recommend using a piece of material long enough to make both bearings with parting allowance, and holding it in the four-jaw chuck, from each end in turn for rough boring and machining, leaving ample metal on the outside to allow for splitting, either with a hacksaw or a circular saw in the lathe. The cut faces are then machined or filed to bed together dead truly and the two halves are temporarily sweated together under pressure.

After re-chucking in the same way as before, as truly as the altered shape will permit, the first bearing can be finish-bored and machined externally. To set up for dealing with the second bearing, a split bush should be made to fit over the waist of the finished bearing, thick enough to clear the flanges and take the thrust of the chuck jaws without risk of damage to the machined surface. After parting off and facing, but before unsweating, the bearings should be marked on the flanges to identify them for pairing and location.

When turning the outside diameter, some difficulty may be experienced in determining the exact size to fit the housings as they cannot be offered up in the usual way. The solution is to turn up a piece of scrap material to serve as an improvised plug gauge, its diameter then being measured with the "mike" and the bearing turned to correspond. Similarly, another piece can be turned with flanges to gauge the exact width of the housing, so that the bearings may be made a snug fit without end play; the bearing caps are, of course, removed for fitting operations.

If machined correctly, the half-bearings should fit the housings so that when the marking agent is applied, they are seen to make contact all over, and take quite an effort to move. It will then be possible to drill the hole for the locating peg in each bottom half, and continue it into the housing.

Incidentally, the bearings are large enough to allow of increasing the shaft diameter to ⅝ in. should this be considered desirable; but the ½ in. shaft is strong enough to stand up to any fair usage which the engine may encounter.

FLYWHEEL

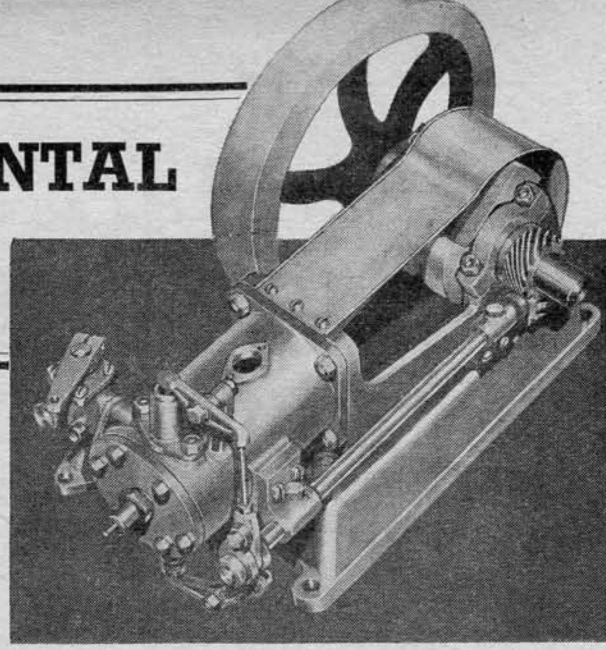
This part (No 28) is, of course, a face-plate machining job, but it will be found very helpful to interpose a disc of wood between the casting and face plate to act as a shock absorber and reduce the tendency to chatter. Clamping plates may be fitted to bear across the spokes, but care should be taken to avoid bolting up so tightly as to strain them; this should not be necessary, as the wood backing will assist the grip.

For the first operation, the flywheel should be mounted with the projecting boss outwards, and it can then be faced and bored, machined on the outside of the boss, rim faced on one side, and the outside diameter turned, at one setting. It is only necessary then to reverse it for facing the other side of the rim. A thicker backing with a recess in the centre, or packing pieces to enable the boss to clear the faceplate, may be necessary for this operation. It is not usually possible to get a good finish on a spoked flywheel of this type by locating off the bore, on a mandrel, as it does not provide a rigid enough support.

The flywheel must be a really good fit on the shaft, and the key must also fit the sides of the keyway in both parts, but not excessively tightly top and bottom. An alternative method of fitting is by means of a tapered collet, such as I have used on many types of petrol engines—on no account should a grub screw be relied upon, except as a *supplement* to a properly fitted key.

● *To be continued*

A 60 c.c. HORIZONTAL GAS ENGINE—5



By EDGAR T. WESTBURY

Continued from 29 August 1957, pages 290 to 292

This week the author writes about the mechanism operating the valve gear

THE use of "skew" or spiral gears for driving the camshaft in engines of this type may be regarded as a disadvantage in some cases, as there are not many constructors who are prepared to go to the trouble of cutting such gears themselves.

It is by no means impossible to do so, however, with the aid of a screw-cutting lathe fitted with simple attachments, and articles dealing with methods and calculations for producing suitable gears have appeared in previous issues of the ME. But most constructors will prefer to make use of ready-made gears if they are available, and before settling the design of the engine I made a point of finding stock gears which could be utilised with slight adaptation; these will be obtainable, together with castings and other essential materials, in due course.

A few words on the subject of spiral gears, in their application to shafts at right angles to each other, may be opportune here, as they do not appear to be as well understood as they might be, to judge by inquiries constantly encountered on the subject. They may be regarded as a development of worm gearing, generally most suitable for low reduction or even ratios; in some cases they are used for step-up or "overdrive" ratios, such as the high-speed shaft of a centrifugal cream separator.

Like worm gears, they introduce a certain amount of end thrust on one or both shafts, depending on the torque transmitted and the angle of the teeth. Their mechanical efficiency is not as high as that of spur or bevel gears, due to sliding friction between the meshing surfaces of the teeth, but if well-finished and of suitable material, they run silently and give long service; worn gears can be given a new lease of life by shifting them slightly endwise.

In common with all other gears, the speed ratio of any pair of skew gears depends on the relative numbers of teeth in them, but this is not necessarily proportionate to the pitch diameters of the gears, as it is influenced by the angle at which the teeth are cut. Thus it happens that a pair of timing gears having a ratio of 2 to 1 may be approximately the same diameter, by making the pitch angle of one about twice that of the other. This is found perplexing to many querists, one of whom, in criticising the design of one of my petrol engines having a skew-geared camshaft, assured me that "it could not possibly work, because both gears were the same size."

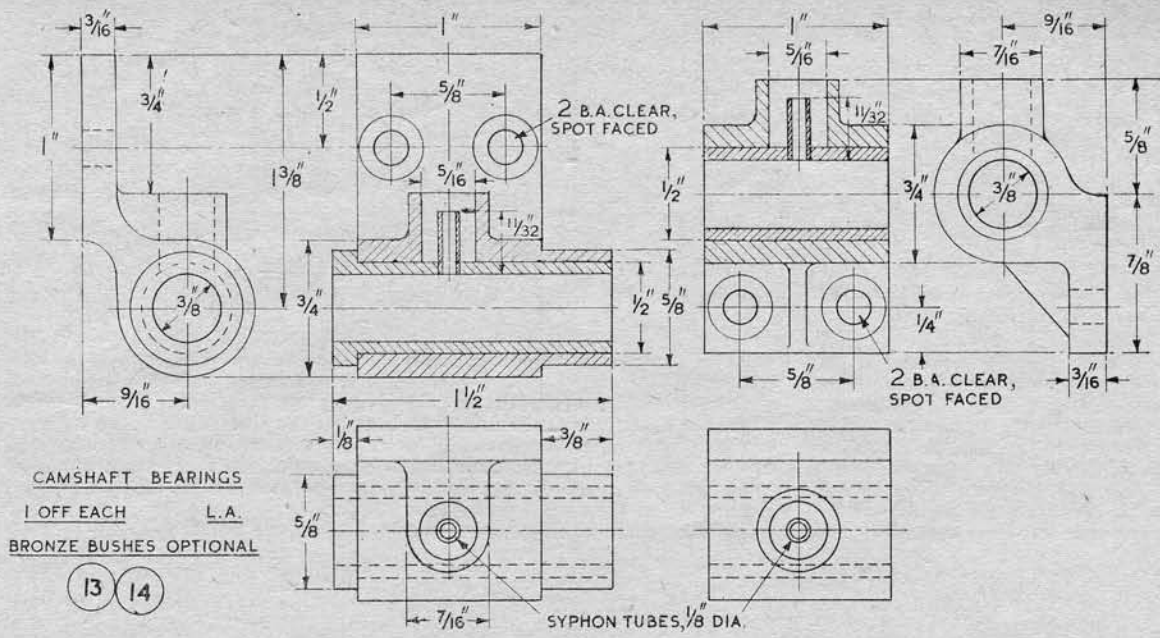
The present design is arranged to use gears having centres $\frac{7}{8}$ in. apart, and any combination which gives 2 to 1 ratio at this distance can be utilised. Suitable gears can often be obtained from motor-car distributor or speedometer drives; the ratio is easily ascertained by counting the teeth, usually few in number. If the centre distance is either greater or less than $\frac{7}{8}$ in., the camshaft can be displaced either upwards or downwards to suit, as the position of the bearings can be adjusted; but any serious discrepancy in this respect affects the geometry of the valve gear, and may call for alteration of the valve rockers.

Precision ground mild or silver steel may be used for the camshaft, which does not require machining, and need not even be cut to length until final fitting is completed. Note that an extension of the shaft is necessary if a governor is to be fitted. The timing gear and the two cams for inlet and exhaust are pinned in position after timing adjustment has been settled; for initial fitting they should be bored a fairly tight fit on the shaft. This applies also to the contact-breaker cam, in cases where coil ignition is employed.

CAMSHAFT BEARINGS

Parts Nos 13 and 14 may be made either in light alloy or bronze; the latter, of course, dispenses with the need for bushing, but a good aluminium alloy without bushes will give quite long wear, and may be kinder to the shaft than a hard bronze. Both bearing housings have a flat bolting face for attachment to the main bed plate and water jacket respectively; this should be machined exactly parallel with the bore of the bearing, and a sound method of ensuring that it is so is to fit both the housings together on a true mandrel, after boring, and machining the faces at one setting, in the four-jaw chuck or on the face plate, with the mandrel set truly square with the lathe axis in either case. Alternatively, the faces may be filed true, using the mandrel to check parallelism on the surface plate or other flat surface.

The bearing at the cylinder end has an extension machined on the outside to form a seating for the contact-breaker, but if this is not required, it may be machined away. Lubrication of the bearings is by wick oilers, having a well $\frac{5}{16}$ in. dia. $\times$ $\frac{3}{8}$ in. deep, and a $\frac{1}{8}$ in. brass or copper wick tube, 11/32 in. long, screwed 5 BA to fit in the centre. Knurled caps having the skirt split across to provide a friction fit (part No 31) serve as dust covers for the oil wells.



If the facings on the bed plate and water jacket are correctly machined, no trouble should be encountered in lining up the camshaft bearings, but any discrepancy in the level of these surfaces can be adjusted, if necessary, by means of shims; it will be better, however, if the need for them can be avoided.

To test the alignment, a close-fitting mandrel should be inserted through the bearings and the contact faces smeared with marking colour (such as " mechanic's blue "); they should bed down over the whole surface, thus ensuring that when bolted in position, the bores will be in exact alignment.

The camshaft, with the timing gear in position, may now be inserted through the bearings and their location adjusted to give correct meshing of the gears, which should be such as to allow of just the least suspicion of backlash in the teeth, with the shaft axis exactly horizontal. Fixing holes may then be drilled and tapped, and the bearings secured by studs or setscrews. Some constructors may prefer to provide more positive and exact location by fitting dowels to the seatings, but I do not consider this essential, provided that due care is taken in any subsequent assembly.

INLET AND EXHAUST CAMS

Part Nos 23 and 24 are of a very simple type and can be produced without any special equipment. In previous articles on i.c. engine construction, I have laid great stress on the need for accuracy in producing the cams, and recommended that the two cams should be made in one piece so that their relative location can be positively ensured.

This, however, applies particularly to high-speed engines where the cam functions are critical; it is by no means so important in engines which run at slow or moderate speeds, and in this case angular location of the cams is influenced by the use of pivoted rockers, instead of straight-line motion of tappets both in the same plane. As a result, it will generally be found easier to make the cams separately and locate them by trial, finally fixing them in position by taper pins.

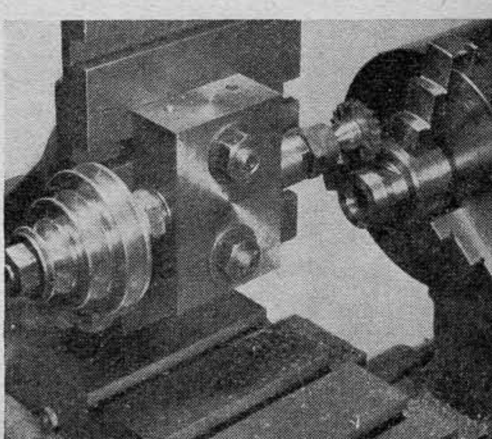
It will be seen that the cams are of the tangential flank type, as employed in most orthodox full-size gas engines, and it is possible to produce them by hand filing, without mechanical aids, though this calls for a fair amount of skill, and it is not easy to measure angles accurately on small components.

If this method is adopted, I suggest that after turning up the blanks, the first operation should be to file the flanks dead straight, at the appropriate angle to each other, which may easily be tested at this stage with an ordinary bevel protractor. In the case of the exhaust cam, which has a lift period of 120 deg., the included angle between flanks is 60 deg., and that of the inlet cam is 70 deg. The depth of the flank, or in other words, the diameter of the base circle, may be indicated by a " witness " circle produced on the end face of the blank with a point tool, and the superfluous metal removed down to this level in any convenient way.

In some of my earlier articles on i.c. engine construction, I described the use of a roller filing rest for forming tangent cams, and this method has great advantages over hand filing, in respect of both flank angle and base circle concentricity. Some method of indexing the lathe headstock to the required angular positions is, of course, necessary; the filing rest is adjusted to a level equal to the base circle radius above the lathe axis (in this case $\frac{3}{8}$ in.) and the two flanks filed down to this level. The work is then inched a degree or two at a time and filing continued to produce the base circle.

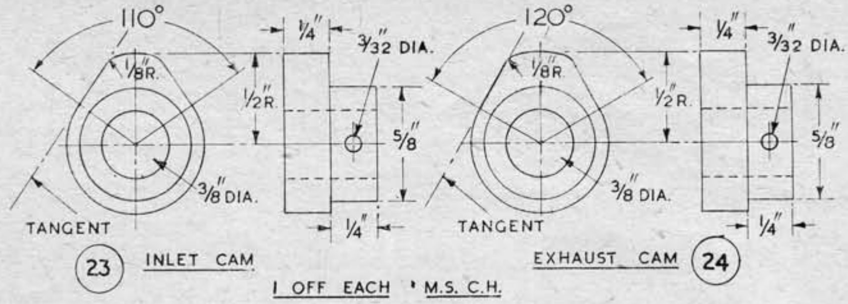
If milling equipment is available, the same methods of indexing the cam blank can be adopted, and the operation is equally straightforward,

Machining tangential cams in the lathe with the aid of a milling spindle

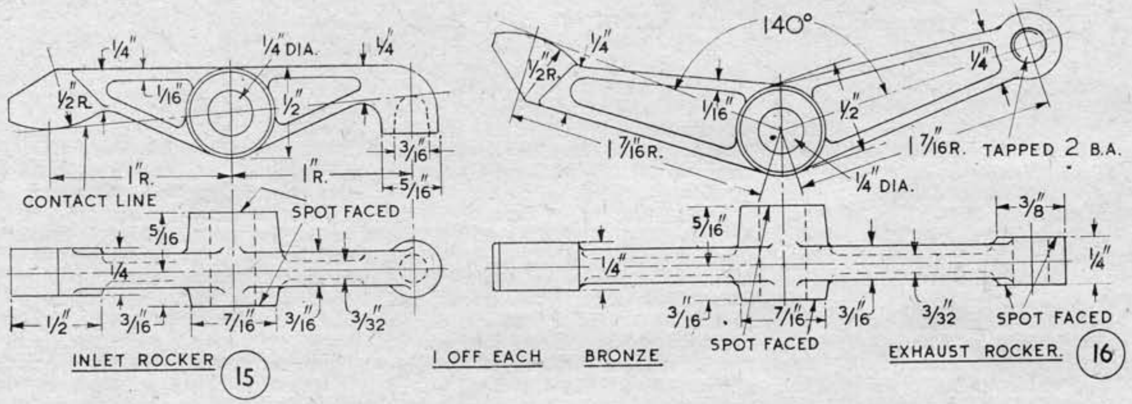


GAS ENGINE

continued



no matter whether the latter is held in the lathe and the cutter mounted on a milling spindle or the blank is held in a dividing attachment and the cutter driven by the lathe mandrel. In either case the cutter is adjusted to cut two tangential flats at $\frac{3}{8}$ in. radius on the blank, at the specified angles for the two respective cams,

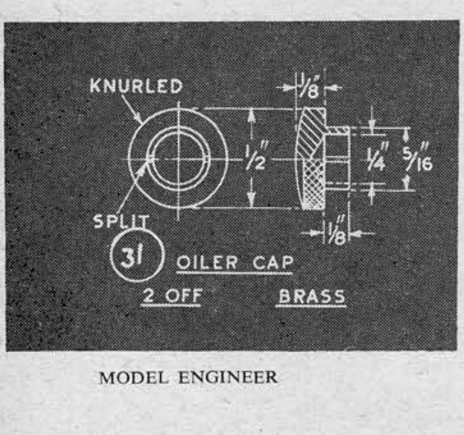


and further cuts taken at the same setting to produce the base circle.

Whether the cams are filed or machined, the simplest and, indeed, almost the only practical way to produce the nose radius is by hand filing, using a radius gauge (this can be improvised by drilling a $\frac{1}{4}$ in. hole in sheet steel and cutting out a segment of appropriate angle) to check the contour.

The sub-angles produced by inching round the base circle can be smoothed off and the contour finished highly and accurately prior to case-hardening.

As the only part of the surface required to be hard is the actual cam track, the rest, and particularly the bore, may be protected from contact with the carburising powder by clamping the two cams together on a $\frac{1}{4}$ in. bolt, with a piece of steel tube over the bosses. Finally the tracks are polished with fine emerycloth, or better still, an India oilstone slip.



ROCKERS

The best material for the rockers, parts Nos 15 and 16, would be steel, as it would enable the contact tips to be hardened and thus made extremely durable, but machining them to a reasonably light section, while retaining adequate strength, would be a rather complicated operation. The alternative of employing a bronze casting is, however, quite satisfactory, and I have used cast rockers even on high-speed engines with heavy valve springs without trouble from excessive wear. Aluminium alloy rockers could be used if one is prepared to attach steel facings to the contact fingers.

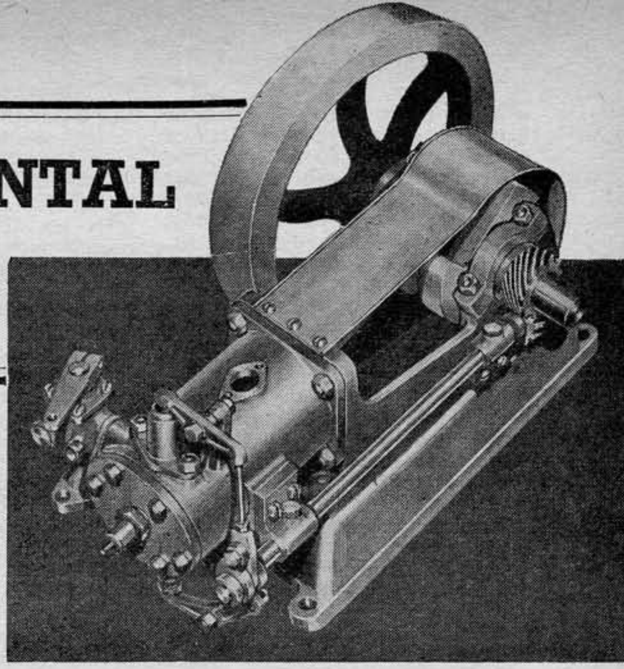
The castings may be held by the centre boss for boring, reaming and facing the pivot hole; a cut is taken across the side of the contact finger, to true it up, at the same setting, after which the rockers are mounted on a pin mandrel for facing the other side.

It will be noted that the exhaust rocker requires facing also at the roller end, and this can be done at the same time. The inlet rocker, on the other hand, has a fairly deep recess to take the rounded end of the push rod and this should be drilled, or at any rate finished, with a round-ended drill or D-bit. Note also that the drawing shows a centre line passing through the rocker axis and touching both the base of this recess and the contact face of the finger; this condition is essential to the geometry of the system, to reduce side thrust and sliding friction to the minimum, thereby promoting mechanical efficiency.

I may observe that neglect of the rules of simple geometry is often responsible for serious inefficiency of valve gear and many other mechanical motions—I have made many mistakes in this respect myself, but I have learned, by bitter experience, how to avoid most of them nowadays !

● *To be continued*

A 60 c.c. HORIZONTAL GAS ENGINE—6



By EDGAR T. WESTBURY

Continued from 12 September 1957, pages 368 to 370

Further valve gear details

THE rocker pivots (part No. 25) may be turned from hexagonal mild steel bar, the most suitable size being approximately ⅜ in. across flats, or the nearest spanner size, though personally I have always found it difficult to obtain material which fits any spanner in my possession !

For producing the eccentric shanks, the purpose of which is to facilitate tappet adjustment, I recommend the following procedure. Take a piece of bar long enough to make both pivots, with adequate extra allowance for chucking. This is held in the three-jaw chuck and turned down to the finished bearing surface diameter (¼ in.) for a length of 1¼ in., after which the bar is reversed end for end and the operation repeated at the other end. It is now necessary to set the work over for turning the end eccentrically; the exact amount of offset is not critical, and with some chucks I have met, it would only be necessary to take the job out, rotate it half a turn, and put it back in the chuck again !

But to be serious, a simple method of setting over (provided that the chuck jaws are not worn bell-mouthed) is to insert a slip of packing about 0.020 in. thick between one jaw and the work; note that the amount of offset is *not* equal to the thickness of the packing, but about a quarter to one-third less. The shank may now be turned down and screwed 2 BA, then finally the bolt is parted off.

Alternatively, the eccentric turning may be done as the first operation; but note that the head should be concentric with the pivot bearing surface and not the shank, in either case. A thin washer is fitted to the shoulder of the shank; this should not have the usual clearance but be a snug, if not an actually tight, fit.

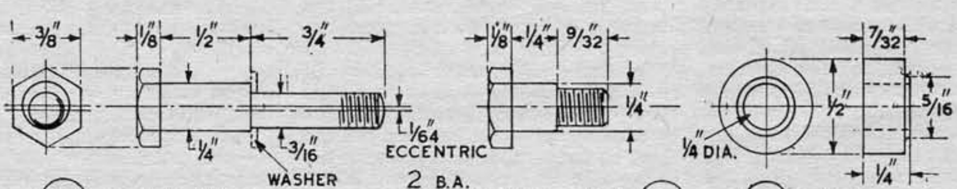
ROLLERS AND ROLLER PIVOTS

The rollers (parts Nos 26 and 27) should be machined all over so as to be perfectly concentric inside and out, and high finish of working surfaces is essential. They should run freely on the pivots, which may be made from the same material as those of the rockers, and the machining is so straightforward as to call for no comment. All these parts should be case-hardened and polished, but the threads should preferably be left soft. Incidentally, the use of roller tappets does not necessarily reduce friction, as they do not always roll in true relation to the cams; but they do creep round and thus distribute wear to a substantial extent.

In order to avoid an excessively long and cumbersome inlet valve rocker, a short push rod is interposed in the operating system, one end being socketed in the recess of the rocker and the other screwed into a rectangular piece terminating in a fork which locates it on the camshaft (part No. 19). The side of the fork is drilled and tapped to receive the roller pivot, and in order to enable this to screw right home to the shoulder, the first thread or so should be counterbored out of the fork piece. It is best to do this before tapping, both to ensure concentric accuracy, and also to avoid the drill or cutter taking charge and clearing the thread away altogether.

Incidentally, it may be opportune here to call attention to the common, and as I believe, pernicious, practice of machining clearance grooves in setscrews and other parts which have to screw up to a shoulder. This is often expedient, and excusable, on parts commercially produced on capstan or automatic lathes, where dies may be damaged by running them too close to a shoulder—provided that these parts are not too highly stressed.

But it cannot be denied that the clearance groove seriously weakens a



25 ROCKER PIVOT — ROLLER PIVOT 27 — 26 ROLLER

2 OFF EACH M.S. C.H.

small screw, particularly if, as often happens, it is machined with a square-ended tool, so as to produce sharp corners. Moreover, if a plug or cap which is to be fitted with a fibre washer is grooved in this way, the washer is inevitably a slack fit, so that it is forced out of centre when tightened, and often fails to produce a sound joint.

I make a practice of avoiding the need for grooved parts wherever possible, by counterboring the tapped hole or nut; but when a groove is absolutely essential, I machine it with a round-ended tool, and no deeper than is absolutely necessary. Some workers, both amateur and professional, however, turn grooves in screwed parts at the least provocation; I once had some drawings made by a draughtsman of long experience, who insisted on grooves whether they were necessary or not, and strongly resented my disagreement with what he regarded as "standard practice."

The fork piece should fit easily over the camshaft, and the surfaces the cams will be given later, when dealing with final engine assembly.

INLET VALVE HOUSING

This is specified as a bronze casting (part No. 22), though a good aluminium alloy is permissible, and it is quite easy to machine it entirely from the solid if desired. The lower extension should be machined to a close fit in the bore of the cylinder head, and the lip and seating also carefully fitted to make good contact with the mating surfaces in this bore; the length should be adjusted so that there is a slight clearance (not more than 10 thou at most) between flange faces when fully home. If found necessary, the housing may be "ground in" to its seating in the head, like grinding in a valve, but with good machining there should be no difficulty in making a perfect joint without such measures.

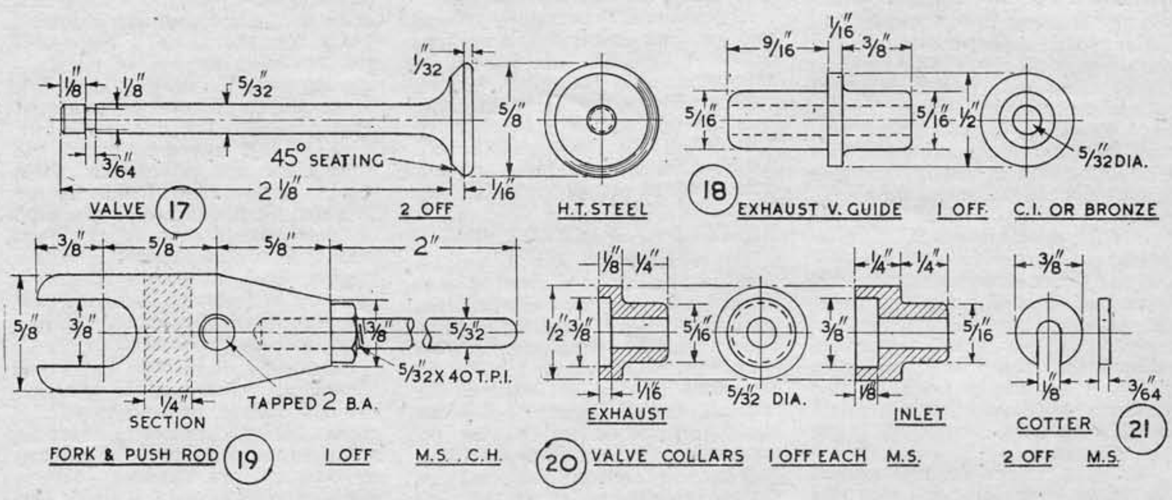
At the same setting as the external machining, the internal drilling of the valve guide, counterboring the port, facing and chamfering, can be carried port undersize, then replace it for finishing with a reamer or D-bit, so that it lines up exactly.

INLET AND EXHAUST VALVES

These (part No. 17) are identical in shape and dimensions, and, in fact, may be made interchangeable. The material specified is high-tensile steel, which term embraces any of the usual nickel chrome or similar alloy steels, and an old motor car or diesel engine valve, if not too badly burned, will provide quite suitable material. Note that many valves have only the head made of heat-resisting material, with lower-grade butt-welded stems, so make certain the part utilised for the head comes from the right region.

I have found that stainless steel aircraft bolts also provide suitable material; mild or low-tensile steels can be used but are liable to excessive deterioration of the seatings by burning or pitting.

I have on several occasions given instructions for turning valves, an operation which some workers find



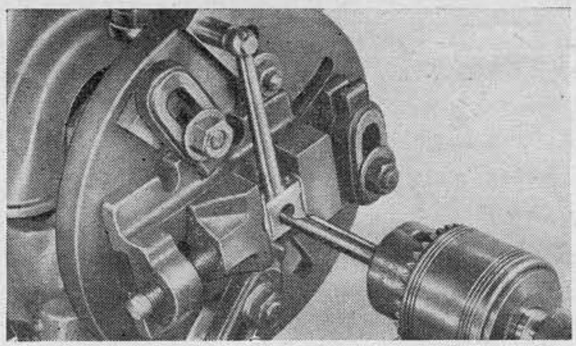
should be finished so that it works quite freely, the depth in relation to the roller pivot being such that it allows the roller to make contact with the base circle of the cam before bottoming on the shaft. It fits between the cams, which are arranged with the bosses outwards, and a peculiarity of this particular method of assembly is that it does not matter which cam is fitted nearest to the bearing, because the rollers may be located on either side of the fork piece and the exhaust rocker respectively. But obviously, when once located and timed, the arrangement must be adhered to, as the cams themselves, and their angular locations, are *not* interchangeable. Directions for timing

out, with due care to keep all these surfaces concentric. A pin mandrel may be used to mount the component in the reverse position for counterboring the top end, which must also be concentric with the previously machined bores, and the top flange face, also, if found desirable, the tapered external surface, can be machined while thus set up.

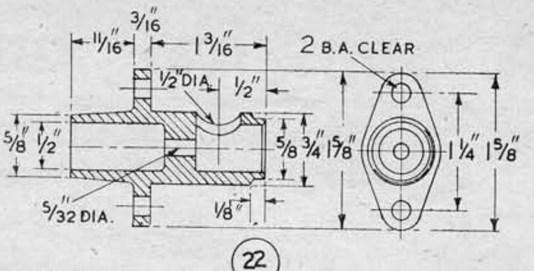
Finally the housing is fitted in position, with the stud holes drilled and tapped, and temporary screws used to secure it for marking out the port in the side to coincide with the passage in the head. It may be found practicable to drill this in position, but generally it will be found more satisfactory to remove it and drill the

rather formidable, due to the slenderness of the stems, especially when using tough material. One method I have seen recommended is to turn them in pairs, between centres, by the "back-to-back" arrangement often adopted for making bolts, and finally parting or sawing off between the heads; but I consider that more rigid support can be obtained by holding the material in the chuck and turning one at a time, over all essential surfaces, then parting off.

It is practicable and very desirable to use back centre support, but undesirable to drill the slender stem to take point centres; I prefer to turn down a short length of the stem to the finished diameter, and chamfer the



Showing how the crankhead bearing can be machined in position on the connecting-rod, to ensure exact parallelism with the little-end bearing



INLET VALVE HOUSING (22) 1 OFF C.I. OR BRONZE

end to an included angle of 60 deg., to take a hollow centre. This enables the rest of the stem to be machined without difficulty, provided that good tools, properly set, are employed.

Do not forget to leave an ample radius under the head, and to finish the surface as clean and smooth as possible. The seating should be machined with a narrow-nosed tool, the top slide being set over to 45 deg., and a very keen, well-raked grooving tool, approximately 0.050 in. or 3/64 in. wide, used to turn the retainer groove near the end of the stem.

VALVE COLLARS AND COTTERS

The two valve collars (parts Nos 20 and 21) vary somewhat in shape and dimensions, but can be made in the same way from mild steel bar, the spigot end being turned and drilled first, then the piece is parted off and reversed in the chuck for facing and counterboring. It will be seen from the general arrangement drawing that the inlet valve collar forms a kind of trunk crosshead, to give guide support for the valve, consequently the outside of this collar must be machined exactly concentric and fit closely in the hole; if it is made from ½ in. dia. bar, it must be chucked quite truly for the main turning and drilling operations.

An end mill or spot facing cutter may be used to counterbore the recess, which must be exactly square with the bore, and the horseshoe cotter should fit snugly in it. This part may with advantage be made of high-tensile steel as it is subject to heavy shear stress. I make these cotters in half-a-dozen or so at a time—a few spares are always welcome—by turning and drilling an aircraft bolt (RR for preference !), then grooving out the gap with a milling cutter, and finally parting off to the required thickness.

As a result of long experience, I have found this form of spring retainer most satisfactory for all kinds of engines, in conjunction with valve collars having a substantial length of bore and fitting the stems so that they have no tendency to tilt, also recessed so that they trap the cutter positively and securely; moreover, they are the easiest type to dismantle or assemble.

There are, of course, other methods of retaining valve springs which can be employed; in one or two cases I have screwed the valve stems and fitted cap nuts which can be used as a means of tappet adjustment, and these are quite satisfactory provided that they can be securely locked. I am not, however, in favour of any method which involves the need for cross-drilling the valve stem, as the latter is thereby unduly weakened, and the local shear stress on a cross pin makes it very liable to failure.

With regard to valve springs, it is very difficult to lay down a rigid specification, because springs having a given number of turns, of a given gauge of wire, may vary greatly in strength, depending on the quality of the steel, its tempering and pre-stressing. I am often asked to give exact details of springs for a particular engine, but I find it more satisfactory to obtain a selection of springs from a manufacturer and try them out; the one found most suitable is then recommended to the firm which supplies castings and materials for the particular engine, and thereby made available to constructors.

It may, however, be said that for the engine now under discussion, the strength of the valve springs is not at all critical, as they do not have to operate at extremely high speed or to cope with high lift. Springs made of 19-gauge piano wire, $\frac{5}{16}$ in. inside dia. × ¾ in. free length, and with not less than six complete turns, excluding end turns (which should be ground off square with the axis) should be generally satisfactory; no hardening and tempering is necessary with this material.

The exhaust valve guide can be made from bronze or cast iron stick; the latter is preferable as it will work with fine clearance and is largely self-lubricating when once run in with graphited oil. The guide may be machined all over at one setting, ensuring that the bore and external surface are exactly concentric with each other. When fitted, the top end should project into the valve port sufficient to protect and guide the valve stem as much as possible without restricting port area unduly. It does not need to be an excessively tight fit in the head as it is held in place by the valve spring, but it should not be so slack as to allow the valve stem to be displaced sideways under working thrust.

REQUEST ITEM

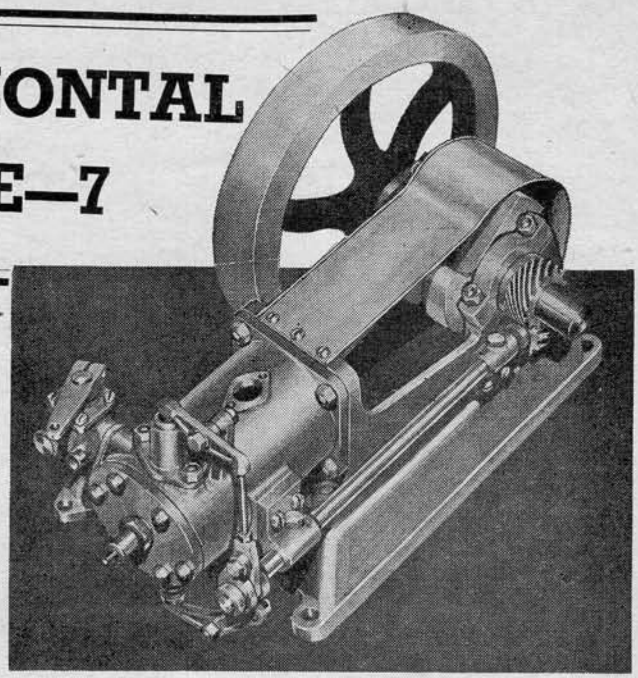
With reference to machining the connecting rod, I stated that methods had been described in connection with previous engine designs, but readers have reminded me that many constructors may not have access to the issues in which these methods were described, and have asked me to repeat the information, or illustrate the method referred to.

In compliance with this request, I reproduce herewith the photograph showing the set-up for machining the connecting-rod and crankhead assembly of the Neptune diagonal paddle engines, which is the same as the corresponding component of this engine except in detail and in dimensions.

It will be seen that the little-end bearing (previously bored while the rod is in the rough) is located square with the face plate by a pin mandrel, and with the part-machined crankhead brasses bolted in place, the assembly is set up to centre the bearing accurately for boring and facing, then clamped in position by any convenient means. By adopting this principle it is possible to ensure that the crankhead and little-end bearings are exactly parallel all ways.

● *To be continued*

A 60 c.c. HORIZONTAL GAS ENGINE—7



By EDGAR T. WESTBURY

Continued from 26 September 1957, pages 455 to 457

Assembly and accessories

IN all open type engines, except those which run at very slow speeds, it is desirable to provide some means of preventing the broadcast spattering of excess oil from the crankhead bearing. The splash guard (part No 33) designed for this purpose is very simply made from sheet metal, suitably stiffened at the two edges by wiring or beading.

Readers who have had experience of coppersmithing will not need advice, but the novice may find it rather difficult to make a really neat job without the aid of special appliances. Further guidance on this and similar operations, including the tools employed, can be obtained from Herbert Dyer's book "How to work Sheet Metal." However, the desired result can be obtained by soldering a 16-gauge brass or copper wire along each side of the guard after it has been bent to the required shape.

The guard has a short apron strip attached to the lower end by three rivets, the object of this being to allow the bottom of the main strip to go inside the crankpit and thus prevent oil from creeping down the front edge of the casting. A gap in the centre of the apron gives clearance for fitting a drain tap or plug to the crankpit.

Two screws at this end and three at the other are used to secure the guard in position; the shape should be neatly arranged to produce a concentric arc around the shaft. As indicated on the drawing, the front of the guard may be utilised to carry a monogram or other insignia when finally completed.

MAIN ASSEMBLY

The essential parts of the engine now being complete, it may be assembled and set up for running in from a separate source of power while the auxiliary components are being made

The body is first secured to the baseplate by four studs or setscrews, care being taken to see that it beds down truly and naturally so that there is no tendency for it to be distorted when tightened down. Before assembling the crankshaft in the main bearings, a final check on their alignment should be made with a test bar; if this is found in order the shaft is then put in position and the caps fully tightened down, when it should be free to turn without either up-and-down play or excess friction. The flywheel and timing gear may be fitted to the respective ends of the shaft and keyed in position—either at this stage or later on.

It will be seen from the general arrangement drawing that the cylinder liner is located and secured by the rim end only, the skirt being free to take up its own position in case of differential expansion of the adjacent parts.

To prevent leakage of water at the front end of the jacket, a groove is provided for a rubber ring, which should be slightly compressed when the jacket is secured and thus act as a resilient gland. Rubber rings of all shapes and sizes are readily obtainable, but if any question of a substitute material should arise, ordinary water gland packing (plaited cotton impregnated with tallow) could be used.

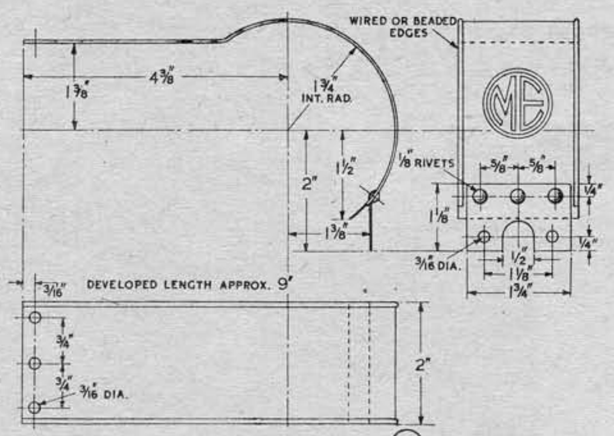
There is, however, a risk of trapping the material between the joint faces of the jacket and body casting, and this should be carefully guarded against, as it may throw the whole assembly out of truth. A precaution against this would be to fit a metal compression ring outside the packing and thus ensure that it is all positively pressed into the groove.

PISTON AND CONNECTING-ROD ASSEMBLY

Before fitting the piston in the cylinder, the piston ring gaps should be checked by inserting them separately, pushing them in with the end of the piston or a truly-faced plug so that they are square with the axis. The gap should not exceed 0.005 in. or be less than 0.002 in. for initial fitting in an engine of this size.

It is hardly necessary to warn constructors that piston rings should be handled with care, especially when springing them over the piston—experience will soon teach !

The piston, with its rings and gudgeon pin, is next assembled on the little end of the connecting-rod and inserted in the cylinder liner. This may be done from either end, but as the skirt of the liner is internally



SPLASH GUARD   1 OFF   M.S. (20G.) OR AL. (18G.) (33)

chamfered this will help to guide the rings into position. If assembled from the other end, the rings will have to be carefully compressed to go into the cylinder, and the use of split band or hose clip will be found helpful. One of the features of most well-designed horizontal engines was that the piston could be inserted either from the cylinder head or skirt end, the latter being useful to enable the piston to be inspected or overhauled without breaking the breach end joint and, though of less importance in a small engine, the point has not been overlooked.

If the machining of the parts has been done correctly, there should be no doubt about the correct alignment of the connecting-rod, but if any question should arise it may be settled by assembling the rod and crankhead bearing *without* the piston, and checking its central position in the cylinder at all points of the stroke. Assuming, however, that all is in order the assembly may proceed as indicated, and the crankhead permanently bolted up.

CYLINDER HEAD ASSEMBLY

Directions have already been given for making the cylinder head joint both water-tight and gas-tight. Before fitting the head it is in order to assemble the exhaust and inlet valves, with their springs and collars.

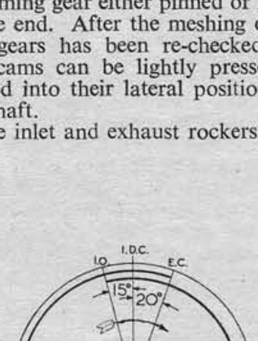
By the way, I have had one or two criticisms regarding the use of an aluminium cylinder head and, particularly, in respect of the exhaust-valve seating directly in this metal. On the strength of experience with previous engines, however, including the Apex Minor, which was capable of very high speed and power, I can assure readers that this is a perfectly sound feature—provided that sound castings of a good quality alloy are employed and that the machining and fitting are accurate.

One very important virtue of aluminium is its high heat conductivity, which helps to prevent overheating of both the valves and their seatings. There is certainly no objection to making the cylinder head of bronze or cast iron, or fitting inserted valve seatings of these materials, if it is considered desirable to do so.

CAMSHAFT ASSEMBLY

The camshaft bearings may now be attached to the side of the body and water jacket respectively, and their alignment checked with a test bar before fitting the shaft itself, with the timing gear either pinned or keyed to the end. After the meshing of the two gears has been re-checked, the two cams can be lightly pressed or tapped into their lateral positions on the shaft.

The inlet and exhaust rockers, with their rollers in position, are then fitted and clearances roughly adjusted so that both valves are just closed when the rollers are resting on the base circles of the cams.



VALVE TIMING DIAGRAM

If the fit of the cams on the shaft is as recommended—just sufficiently tight to enable them to be moved stiffly with a pair of gas pliers, not forgetting a strip of leather or soft fibre between the jaws—they may be timed in position. Alternatively, a grubscrew may be temporarily fitted to the boss of each cam to hold it in its correct place until it can be pinned permanently to the shaft.

The timing diagram should be marked out and attached in any convenient way to the shaft. Many constructors may prefer to mark it out on the rim of the flywheel, where it may remain as a permanent check but, if so, remember that the diagram is set out for clockwise rotation and should, therefore, be marked on the *inner* side of the flywheel or else reversed if marked on the outer side.

A fixed index pointer should be temporarily attached to any convenient point on the body or base, and set first of all to check up on the *TDC* and *BDC* positions.

The crank is now rotated to the opening and closing points of each cam in turn, and the cams set to correspond. It will be found that there is a small amount of lost motion in the operating gear owing to necessary working clearances, and the opening periods will thus be slightly shorter than as specified.

If the opening points are set exactly to the diagram the valves will close a little early; it is thus necessary to "split the difference" or, alternatively, to reduce the base circles of the cams to allow for tappet clearance.

As I have explained this complicates cam design, and as timing is not critical I have not worried about it unduly. It is only at really high speed that these matters become of vital importance. The cams are finally fixed by well-fitted taper or parallel pins.

One minor error, or rather omission, will be found in the camshaft design—namely, the lack of any positive means of eliminating end play, but this is easily remedied by fitting a distance collar or lengthening the boss of the inner cam. The thrust of the timing gears tends to keep the shaft in place, but positive location is much to be preferred, especially as endwise movement will alter the timing of spiral gears.

Incidentally, these gears cannot be marked for subsequent assembly in quite the same way as spur gears, but as the teeth are few in number no great difficulty will arise in re-timing.

CONTACT BREAKER

If coil ignition is to be employed, a substantial and reliable form of breaker mechanism is necessary. The old type of coil, with its vibrating breaker, will work in conjunction with a very simple "wipe" contact. Some of the devices employed were extremely crude, both in design and construction; they all worked after a fashion, but inevitably gave trouble sooner or later. At the present day trembler coils are unobtainable, unless one is lucky enough to pick them up on the junk market. The old Model T Ford used four of these coils, and some of them may still be in existence.

However, the only real merit of the trembler coil is that one can check whether the circuit is working by the buzz when it makes contact—though that does not prove whether it is producing an effective ignition spark! The modern motor-car coil, with its separate condenser and mechanical breaker is, generally speaking, more reliable and efficient provided that the required battery power is available.

The contact breaker shown here is designed to clamp on the extension of the rear camshaft bush, and employs a standard form of motor-car breaker arm which can be obtained from most dealers in car spares.

I have found that many garages have dozens of discarded ignition parts on the scrap heap which, if one takes the trouble to dress the contact tips, are quite serviceable. But if the latter are almost burnt away then they are, of course, useless.

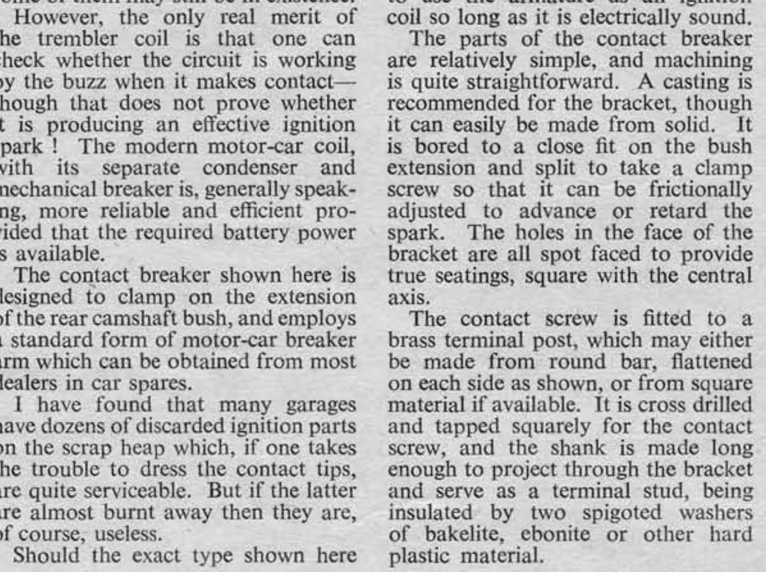
Should the exact type shown here not be readily available there are others similar—except for details and dimensions—which will serve equally well if the necessary modifications are made to other components.

The stationary contact in most modern car ignition equipment is attached to an adjustable plate, but for present purposes a screw is more convenient, and standard tungsten-tipped screws are available.

If one is fortunate enough to possess an ancient magneto with platinum contacts, this will be better still in all respects apart from durability. Incidentally, it is also possible to use the armature as an ignition coil so long as it is electrically sound.

The parts of the contact breaker are relatively simple, and machining is quite straightforward. A casting is recommended for the bracket, though it can easily be made from solid. It is bored to a close fit on the bush extension and split to take a clamp screw so that it can be frictionally adjusted to advance or retard the spark. The holes in the face of the bracket are all spot faced to provide true seatings, square with the central axis.

The contact screw is fitted to a brass terminal post, which may either be made from round bar, flattened on each side as shown, or from square material if available. It is cross drilled and tapped squarely for the contact screw, and the shank is made long enough to project through the bracket and serve as a terminal stud, being insulated by two spigoted washers of bakelite, ebonite or other hard plastic material.



Care must be taken to locate the respective parts so that the contact faces line up truly when assembled. If necessary, the pivot screw may be made in the form of an eccentric bolt, like the valve rocker pivots, and secured by a nut at the back of the bracket.

A very simple form of cam is used to operate the breaker; it may be made in a similar way to the valve cams, but the simplest method for forming the contour is to set the blank over about $\frac{5}{16}$ in. eccentric to the axis and turn away about 90 deg. of the surface as shown.

Its position is not critical, as ignition timing can be adjusted over a wide range by shifting the lever, but it will be convenient to arrange matters so that the lever is near the vertical position for normal running.

Alternative methods of ignition include the use of a magneto, a low-tension or "glow" plug, and tube ignition. The former can be recommended for reliability, but a standard type of magneto is somewhat out of proportion to the size of the engine. Small flywheel magnetos, as employed on cycle motors, are quite satisfactory but they call for a rather high starting speed to produce an efficient spark.

The type of glow plug as employed on miniature racing engines is not satisfactory for use with gas or petrol unless it is kept permanently connected to the electric supply, and, as the current consumption is relatively heavy, it would not be so efficient in this respect as a high tension coil.

I am, however, of the opinion that it would be possible to produce a heater element, which would keep hot enough for ignition after the engine has been started, with any kind of fuel —though this would call for some experimental work.

Tube ignition was the most popular method on stationary engines for many years, and various materials were employed for the tubes, including iron, porcelain and platinum, all of which were reasonably successful in practice. The principal disadvantage of this method on small engines is that it may take more fuel to heat the tube than to run the engine!

However, the use of a very small capillary tube of heat-resisting alloy reduces the heating problem besides increasing efficiency, and Mr D. H. Chaddock has made some interesting experiments in this method, the results of which he has promised to put on record.

I would choose high tension ignition, either by battery and coil or magneto, on the strength of general experience with all methods of ignition over a period of many years.

●*To be continued*

A 60 c.c. HORIZONTAL GAS ENGINE—8

Edgar T. Westbury discusses carburation and the machining of the carburettor body in this instalment

Continued from 10 October 1957, pages 503 to 505

One of the first examples of the Centaur to be built by a reader, an all-fabricated version by Byron G. Barnard

IN keeping with the general principle of making this engine as versatile and adaptable as possible, a special carburettor has been designed capable of working either on gas, petrol or paraffin.

There are, however, many constructors who will prefer to make other arrangements in this respect, either to save trouble or to satisfy their own preferences. It may be said that the engine will run on almost any type of carburettor or gas-mixing device, though the results obtained may possibly be affected by the limitations of the particular design.

Good carburation is essential to the success and efficiency of any type of engine, and whether one decides to use a ready-made carburettor, such as that used on a cycle motor, or a plain "mixing tube," as fitted to miniature glow plug or c.i. engines, it will need to be correctly adjusted to suit the engine's requirements.

An engine will run on gas with no more elaborate equipment than a gas tap fitted to the induction pipe—and many users have expressed satisfaction with the results attained—but it is an extremely crude arrangement, and the lack of any automatic quality control of the mixture may render starting difficult. This objection applies also to liquid fuel carburettors of the simpler types, though in these cases speed control is most affected, as the mixture strength varies with the degree of throttle opening.

If any modification of carburettor arrangements is made, it will probably be necessary to alter the port-face side of the cylinder head to comply with the means of attaching the carburettor and exhaust pipe.

It is practicable to counterbore and tap the ports to take screwed connections, the bore of which should not be less than that of the gas passage in either case. An alternative method of fixing separate inlet and exhaust pipes, which does not entail altering the cylinder head, is to provide collars on the ends of the pipes and secure them with a double-ended fork clamp, such as was often used on some early car engines; the two fixing studs may be located as specified on the drawing.

These variations from the set design are mentioned because it is my experience that the majority of constructors like to exercise their own ideas or whims in some details of design, and strict adherence to blueprint in every detail is the exception rather than the rule.

If, however, the carburettor is made specially—to the general design shown here—there is still some latitude in respect of details; in cases where only one kind of fuel is to be used, certain parts may be omitted. Running on gas is provided for by a screwed connection to take a standard $\frac{1}{8}$ in. gas cock or stop valve, while liquid fuels are fed, either by suction from the base tank or from a suitably located gravity tank, through a needle-controlled jet orifice.

Provision for running on paraffin is made by using a single "manifold" casting for the carburettor and the exhaust branch, the latter serving as a hot-spot to prevent deposition of the heavy fuel without heating the mixture so much as to rarefy it and thus reduce engine efficiency.

This feature has been introduced at the request of many readers; the engine will certainly run on paraffin when once warmed up, and the lower cost of this fuel may be considered to justify its use, but it produces less power than petrol, and is a rather dirty fuel, tending to produce greasy carbon in the engine and exhaust system, and also acting as an anti-lubricant, which increases the rate of cylinder and piston wear.

It may be added that an engine can be made to run on practically any combustible fuel at a pinch, and exhaustive experiments were made to explore these possibilities in the early days of development, but whether the saving of fuel cost compensates for the disadvantages of low grade fuel is another matter.

CONSTRUCTION

In machining the carburettor body, it is advisable first to hold the casting in the four-jaw chuck and machine the bolting face; beyond getting this reasonably parallel to the faceplate no elaborate setting up is necessary as it does not have to be centralised. The exhaust passage is cored, and the inlet passage need not be considered at this stage. The remaining major operations can be carried out by mounting the casting on an angle plate, with a slip of paper under the machined face and clamps over the side lugs.

In this position the vertical axis of the throttle housing can be centred, and after machining the top flange face it is centre drilled, bored and counterbored as specified. It is best, however, not to attempt drilling right through to produce the lower valve guide, as there is a risk of the small drill running out of truth in this considerable depth.

A more prudent course is to drill and bore out the valve chamber and throttle housing to finished or roughed-out dimensions, and then use a small centre drill or rigid spearpoint drill to spot the centre at the base of the chamber before drilling and reaming the $\frac{1}{8}$ in. hole.

It will be seen that the lower end of the chamber is in the form of a rectangular bridge piece, $\frac{3}{8}$ in. wide, and when the chamber is bored $\frac{9}{16}$ in. dia. it breaks out at the sides of this bridge to form the air inlet apertures. These may need to be filed out slightly to remove knife edges and provide an adequate area of opening.

No provision has been made for controlling intake of air by a shutter or choke plate on this carburettor, but it could be modified to incorporate this if thought desirable.

The most delicate machining operation on this casting—though not really difficult—is the formation of the grooved valve seating. It can be first turned to the included angle of 90 deg. by setting over the topslide to 45 deg. after which a small round-nosed boring tool is used to form the groove, the topslide being swung to 45 deg. in the other direction to enable the tool to feed in squarely with the face of the seating.

The casting is reversed end for end to face the exhaust flange, and in the interests of accuracy it is a good policy to carry out the drilling operations for the horizontal fuel and air passages in the lathe set up in this way as well. It is, perhaps, a little more tedious to centre these positions accurately than to locate them in the drilling machine, but it does ensure that the holes are exactly where you want them and that they proceed in the right direction; the necessary spot facing operations are also more likely to be clean and accurate.

The induction passage should, preferably, be left slightly undersize at first for boring or reaming afterwards with the throttle barrel *in situ*.

Both ends of the jet passage are tapped $\frac{3}{16}$ in. × 40 t.p.i., taking care to ensure that the threads are truly in line with the axis, and the gas inlet tapped to take a standard fitting. Holes are drilled from the groove in the valve seating to connect with the fuel passages, that on the jet side being No 60 and the other 3/32 in. dia. In localities where gas pressure in the mains is liable to be low, it may be found desirable to drill two or more holes in the seating for gas admission.

THROTTLE BARREL AND COVER

The barrel should be made of material definitely harder than the housing, and resistant to corrosion. It is machined all over, care being taken to get the outer diameters concentric with each other and also with the $\frac{1}{8}$ in. central hole. The counterbore is not so important, and may be machined at a second operation in the self-centring chuck, and the fit of the barrel in the bore should be on the easy side, with smooth working surfaces.

If desired, the side aperture may be marked out with the barrel in position, and drilled separately, but it will probably be found easier and quicker to clamp it in place after machining and fitting the cover by inserting a packing ring or washer $\frac{1}{8}$ in. thick under it and tightening the cover screws.

The hole may then be "followed through" from the induction passage, but do not attempt to drill it full size at once or a heavy burr will be formed which will seize the barrel immovably in the housing. It is better to drill well undersize at first and open out by reaming or boring both holes together.

The cover is a straightforward job as the essential surfaces of the flange, spigot and centre hole can all be machined at one setting, and the top side only needs cleaning up. It is then drilled for the four fixing screws, the tapping holes for which can be spotted through into the body casting. The throttle lever is a simple component which calls for no special comment as the only essential requirement is that it should fit the stem of the barrel neatly and clamp securely in place.

AIR VALVE

The air valve must also be made of hard-wearing and non-rusting material, and it may either be machined entirely from the solid or fitted with a pressed-in stem, preferably of stainless steel.

The essential thing is that the seating and stem should be true with each other, and when assembled—with the barrel and cover in position—it should be quite free and drop truly on to its seating. Any stickiness or tight spots would be fatal. Avoid the temptation to correct misalignment by running a reamer right through from the stem of the barrel in to the bottom guide as the result of this would probably be to gouge the latter out of truth with the seating.

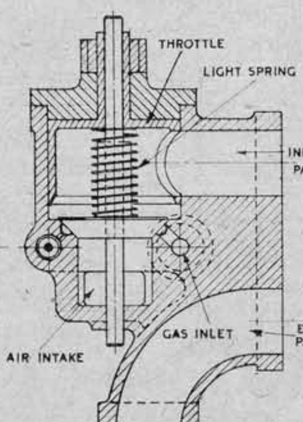
The spring on the valve should only be just sufficiently strong to close it positively; too strong a spring will impose a restriction on the air flow and limit engine performance, and will also cause noisy action. In many cases it will be found that the weight of the valve alone is sufficient to close it by gravity, but a light spring does assist in lifting the fuel from the base tank, especially under starting conditions.

The valve does not need to be ground in to the seating, but its fit should be checked by using marking colour and, if anything, it should bear slightly harder on the lower "land" of the seating than the upper.

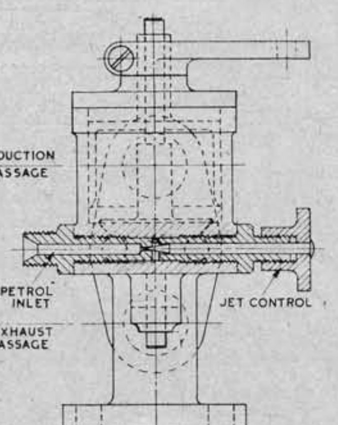
JET COMPONENTS

The jet components are simple, but need to be accurately machined to preserve concentricity and alignment. The jet body should have the long end machined first, including the shoulder, spigot and threaded part, the orifice being drilled No 60 at the same setting and slightly countersunk with the point of a hand graver, square centre, or other tool which can be relied upon not to chatter or throw up a burr.

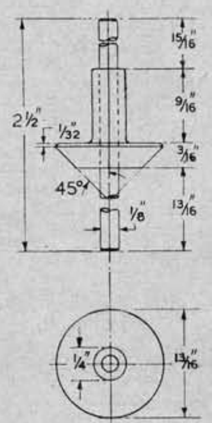
A tapped chucking piece is then used to hold the piece in the reverse position for screwing, coning out with a centre drill, and drilling a $\frac{1}{16}$ in. hole to join up with the jet orifice. This part is, of course, intended for connecting up the fuel pipe by a standard union nut and nipple; it has not been considered necessary to show detailed drawings of these items as they are, or should be, fully understood by readers and



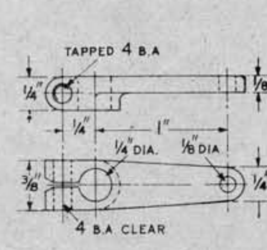
CARBURETTOR



GENERAL ARRANGEMENT



LIFT VALVE 1 OFF
BRONZE WITH STEEL STEM



THROTTLE LEVER
1 OFF BRASS

can be bought ready-made if required.

Procedure in machining the needle guide is much the same as for the previous part, but in this case the $\frac{1}{16}$ in. hole is drilled truly right through, and when re-chucking for turning the outer end care must be taken to see that this hole runs dead truly. The spigot on the inner end of each part should fit closely in the centre of the bore in the body, being intended to provide positive *vis-à-vis* alignment of the two parts, the end faces of which should be not more than about $\frac{1}{16}$ in. apart.

The knurled jet screw should be drilled, counterbored and tapped concentrically, and the fit of the thread on the end of the guide should be easy enough to enable it to run freely down to its full depth. After turning the outside, knurling or serrating the edge, and parting off, the other side is faced and the hole countersunk to form a capillary well for the solder used to attach the needle. (Index marks and numbers on the face are helpful for verifying jet settings.)

Do not cut the needle to length at first as it can be adjusted in position and cut off as required. A simple way of forming the point accurately in cases where precision collets are not available is to improvise a simple fixed steady from a piece of hardwood held in the lathe tool post and drilled $\frac{1}{16}$ in. dia. from the chuck while in this position.

A piece of $\frac{1}{16}$ in. stainless steel rod two or three inches long is then held in the chuck, with the extended end running in the hole in the wood. Pare away the wood until almost exposing the needle, then file away *both the wood and metal* at the required angle while running the lathe at top speed.

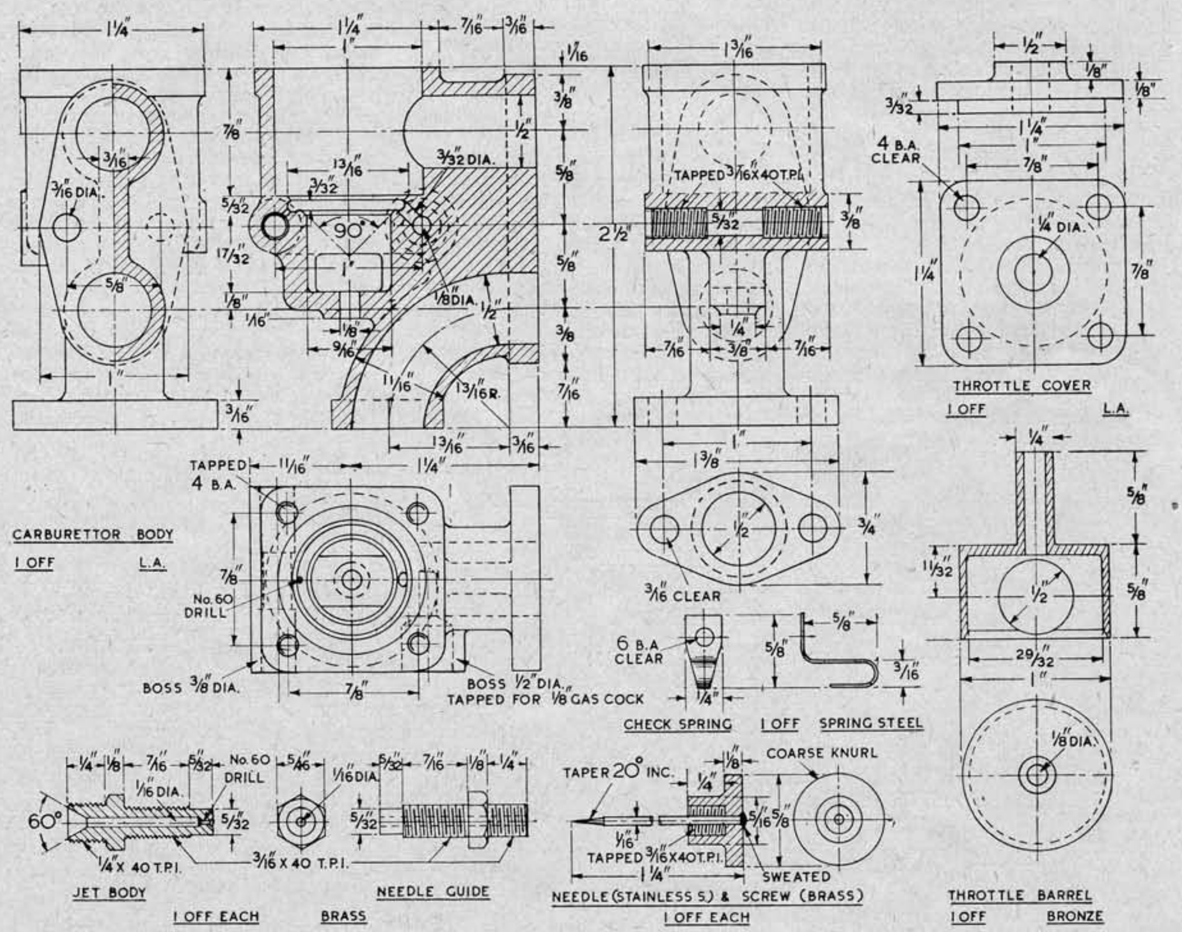
A superfine Swiss pivot file (such as shown by Kennion Brothers at the ME Exhibition) should be used for finishing the point; the angle, by the way, is not critical, but too obtuse a point will render fine jet control difficult.

With the jet assembly in position the knurled head is screwed on as far as it will go, then backed out about one turn and the needle pushed right home in the jet orifice. The exact length can thus be assessed, and the needle cut off slightly proud of the face. It can also be sweated in position, using either a blowpipe flame or a soldering bit large enough to supply adequate heat, but before doing so the needle should be removed and the end tinned to ensure that it does not rely on the blob of solder on the end to hold it.

Some readers find difficulty in soldering stainless steel, but I think the main reason for this is that because the surface is bright they assume it does not need cleaning. This is a fallacy, for there is actually a protective chemical film on the surface which must be removed with fine emery cloth immediately before soldering.

There are special fluxes for soldering stainless steel, but I have not found them necessary as the normal zinc chloride flux, or solder paint, takes

●*Continued on page 593*



GAS ENGINE . . .

Continued from page 570

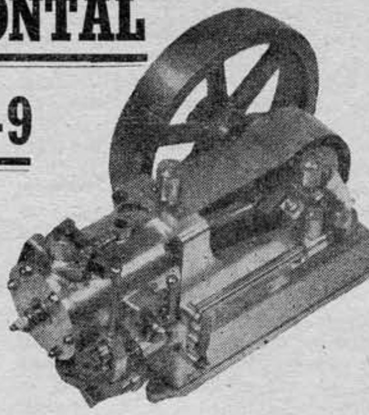
quite well and enables a sound joint to be made. Alternative materials for the needle are phosphor bronze or German silver—not ordinary brass.

A check spring should be attached to the carburettor body to prevent inadvertent movement of the needle control when once set. This may be held in place by a screw tapped into the body (see general arrangement drawing) or shaped so that it can be clamped under the shoulder of the needle guide.

If it is desired to provide for priming the carburettor for starting from cold a hole may be drilled in the throttle cover, and a little shutter plate (secured by a screw or rivet) may be arranged to slide over and close it to prevent air leaks when not in use.

● *To be continued*

A 60 c.c. HORIZONTAL GAS ENGINE—9



This week EDGAR T. WESTBURY deals with the governor control mechanism

Continued from 24 October 1957, pages 568 to 570

THE fact that the basic design for this engine does not include any provision for automatic speed control, or "governing," as it is termed, has led some of my readers to remind me that a stationary engine of any kind cannot be considered complete without it.

This, in a general way, is quite true, because if an engine is left to its own devices, without the constant supervision of a driver, the speed is bound to change with any variation of load, and in the case of load being entirely taken off, such as by shedding or breaking a driving belt, it may race away at a dangerous speed. Apart from the consequences to the engine itself, damage to life or property may be the result, and as a matter of fact some nasty accidents of this nature have occurred, even with small, low powered machinery.

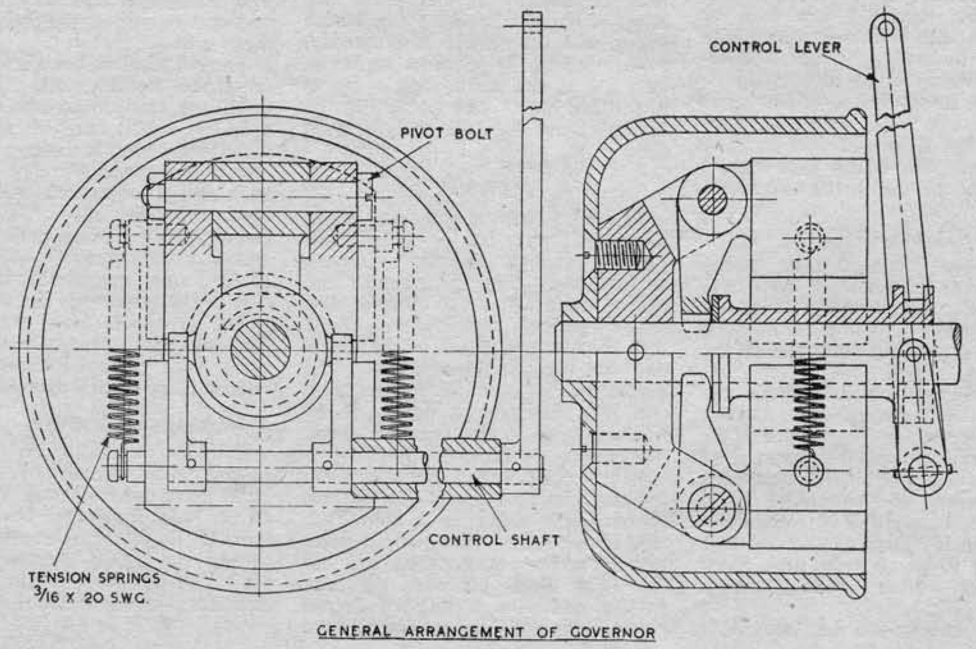
Strangely enough, however, scarcely any mention was made of governing by the many readers who gave suggestions, and even otherwise complete specifications, for the type of engine they would like to see described. It is presumed, therefore, that they would run an engine of this size either under hand control, or direct-couple it to a machine which would run under constant load, such as a charging generator.

While this has been considered satisfactory in many small stationary engines which have been designed and built in the past, I have considered it desirable to provide for the fitting of a governor, as an extra accessory, but without the necessity for any alteration to the basic design.

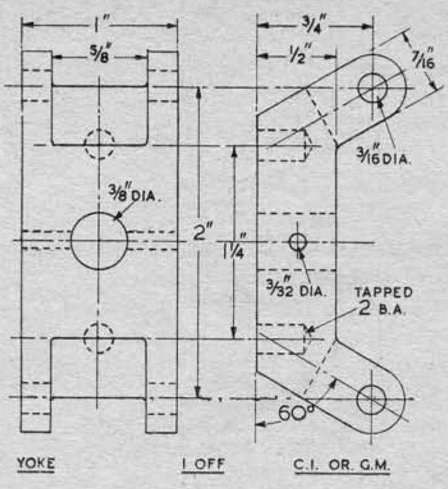
There are several methods of obtaining automatic speed control, all of which have been employed with some practical success. In engines coupled to electrical generators, solenoid governors have been employed; the pressure of the forced lubrication system, or water circulation, the depression in the induction system, and even, in air cooled engines using a ducted fan, the air pressure created thereby—all these have been utilised to keep speed constant within more or less narrow limits.

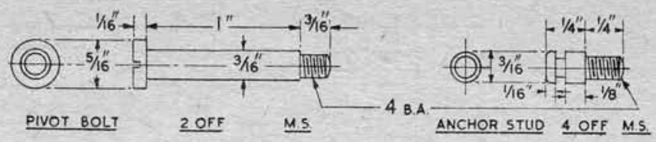
The old inertia governor—known variously as the pendulum, vibrating, or pecker type—with its "hit-or-miss" action, is now quite defunct, and few, I think, have ever mourned its passing. Its only merit was simplicity, and its worst defect was the irritating and unpredictable "syncopated rhythm" in the beat of the engine which it produced. But "hit-or-miss" governing has been applied also in connection with centrifugal governors; a particularly brutal example was that used on some American horizontal engines, where the governor, if speed rose above the set limit, intercepted a catch on the exhaust valve push rod to hold the valve open and thus prevent the normal power cycle from taking place until the speed was reduced.

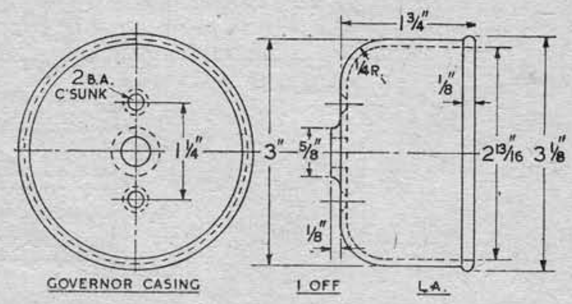
A very simple and effective—though inherently wasteful—application of the centrifugal principle is its use to



GENERAL ARRANGEMENT OF GOVERNOR







operate a cut-out or earthing switch in the ignition system, but apart from the uneconomical pumping of mixture to waste, this is liable to result in silencer explosions—usually noisy but harmless, though not always, as I have reason to know !

Quantity governing

Most modern centrifugal governors on i.c. engines work on the quantitative control system, which sounds highly technical, but means simply that they control the *quantity* of mixture which is allowed to enter the engine, in the same way as the accelerator or throttle control of a car, being quite distinct from older methods which controlled the *quality* (mixture strength) of the charge, or cut it off altogether if speed became excessive.

The mechanical part of the governor itself is a direct adaptation of the original governor applied to early steam engines by James Watt, and it can be driven in any convenient way, by direct attachment to a main or subsidiary rotating shaft, by gearing, belt or friction drive. It may be mentioned that the latter "non-positive" methods have never been trusted by i.c. engine designers, owing to the disastrous effects likely to be caused by governor failure.

The "power" of a governor is defined as the amount of force which it can apply to the operation of the control gear, and it depends upon the mass and velocity of the rotating weights. Thus it is generally desirable to run the governor as fast as possible; some horizontal engines have had the mechanism incorporated in the flywheel (a typical example in a model is the adaptation of the ME Road Roller engine as built by Mr R. L. A. Bell, of Yeovil) or geared up from the camshaft, usually on a vertical shaft.

It might be thought, therefore, that in designing the governor to be mounted on an extension of the camshaft, which runs at half engine speed, I have handicapped its performance; but in fact, this is not so, because this is a favourable position for efficient operation of controls, and it also allows the fitting of a very robust and adequate size of governor without making it abnormally out of proportion to the rest of the engine. To build a really effective and reliable governor in exact scale proportion would be difficult, whatever type of drive or working position is adopted.

CONSTRUCTION

As will be seen from the general arrangement drawing, the main working parts of the governor are enclosed in a bell-shaped housing, and comprise a yoke which carries two pivoted flyweights, having inwardly-extended bell cranks with fingers which bear against the thrust flange of a control sleeve. A grooved collar on the remote end of the latter operates a forked lever, the movement of which is communicated to the carburettor throttle.

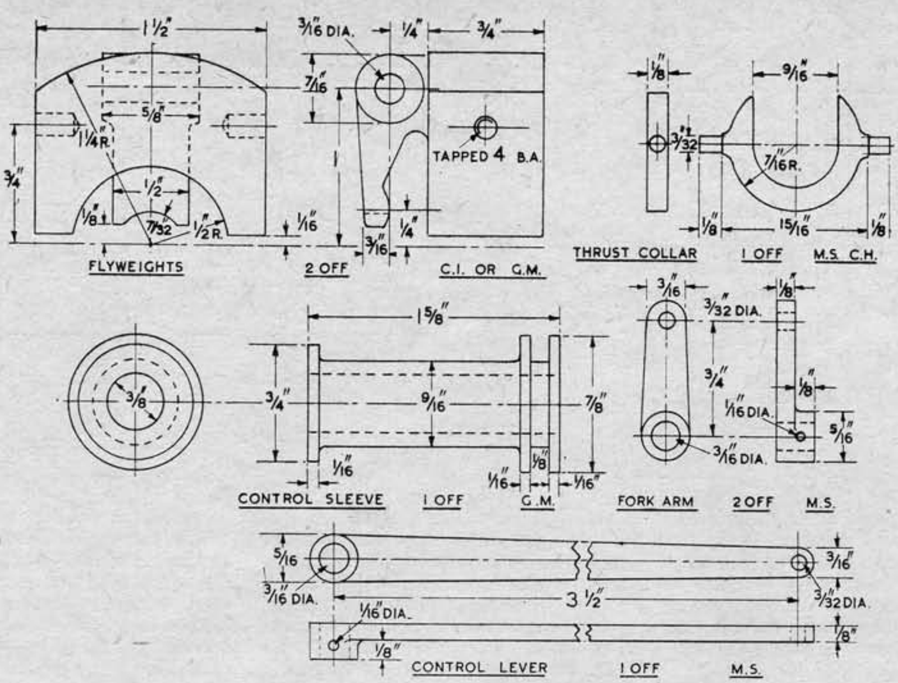
The tension springs attached to the flyweights normally tend to pull them towards each other, so that they rest with the "horns" in contact, but when rotated at appropriate speed, the centrifugal force pulling the weights outwards overcomes the tension of the springs, and the fingers move the control sleeve to the right, displacing the forked lever, the movement of which is multiplied by the increased length of the control lever. Thus a very small movement of the weights will result in a substantial movement of the controls.

It would be possible to adjust the strength of the tension springs so that they exactly balance the centrifugal force of the weights at the speed at which the engine is desired to run, but usually they are somewhat on the weak side, and an extra spring is applied to the control lever. This enables any backlash in the control system to be taken up, and adjustment of tension to be made, while running, if necessary; furthermore, it allows of fitting an "overriding control" so that the engine can be slowed down independent of the governor action.

Most of the components could be made fairly easily from the solid, though castings would simplify the work entailed, and also economise in material. The yoke, for instance, could be cut from a square bar 1 in. × 1 in. × 2½ in. long, and though cast iron or gunmetal is specified, mild steel or duralumin would serve equally well. In any case, it should be chucked truly for drilling and reaming the central hole, which should be a snug fit on the shaft; the rear face should also be machined, and it is possible to machine away a good deal of the unwanted material on both front and rear while set up in the lathe and located from the bore.

It will help in the setting out and machining of the pivot holes if the sides are true, and parallel to the bore axis. These holes must be drilled and reamed square with the bore, and at equal radius from the centre. The gaps between the lugs may be cut out by milling, or by drilling, sawing and filing; their inner faces may be trued, to fit the knee of the flyweight with no perceptible end play.

Readers who are skilled in forming sheet metal may prefer to use this technique for producing the housing, rather than using a casting or machining from solid. It could be spun over a wood or metal former, from copper, soft brass, or aluminium, and need not be thicker than 18 gauge, as



the open edge could be stiffened by beading.

If, however, it is machined from solid, or otherwise, there will be a tendency for the thin section to "sing" or chatter; the remedy, when turning the inside, is to clamp a ring over the outside; even a few turns of insulating tape wound round it may suffice. For external machining, a wooden plug in the inside will be equally effective. It is, of course, essential that the housing should run truly when fitted.

In the absence of a casting, the two flyweights can be machined, and in fact almost completely formed, in one piece, then finally separated by sawing through the middle. Note that the weights of various metals are widely different, and thus light alloy should not be used; brass or gunmetal has the highest specific gravity of normally available metals, and is, therefore, best for this purpose. The external diameter of the pair is $2\frac{1}{2}$ in., and overall length $1\frac{1}{4}$ in., one end is bored 1 in. dia., and the other $\frac{7}{16}$ in. dia., while the centre portion can be chambered out if a suitable internal tool is available.

Next the sides may be machined away parallel and symmetrically to a width of $1\frac{1}{2}$ in., preferably by mounting the work on an angle plate; the rear portion, for a length of $\frac{1}{2}$ in., is further reduced in width as shown, by milling or any other available means.

After marking out the positions of the pivot holes, which again must be quite symmetrical to keep the system in balance, the job may again be set up on the angle plate for accurate drilling and reaming. It is desirable to shape the fingers before separating the two weights, as this enables them to be readily compared, to ensure symmetry. The sides of the weights are finally drilled and tapped to take the spring anchor studs.

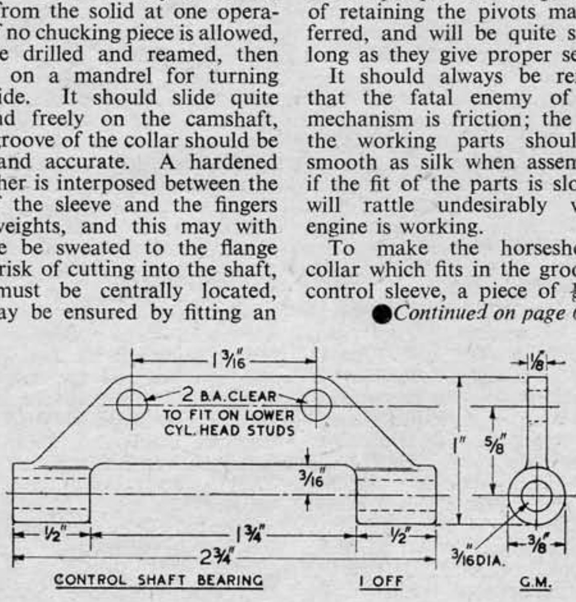
The control sleeve may be turned entirely from the solid at one operation, or if no chucking piece is allowed, it can be drilled and reamed, then mounted on a mandrel for turning the outside. It should slide quite easily and freely on the camshaft, and the groove of the collar should be smooth and accurate. A hardened steel washer is interposed between the flange of the sleeve and the fingers of the weights, and this may with advantage be sweated to the flange to avoid risk of cutting into the shaft, but it must be centrally located, which may be ensured by fitting an aluminium plug in the hole during the sweating operation.

Care should be taken in machining the pivot bolts, to ensure that they are accurate and fit the holes in the weights neatly but freely. As an alternative to turned bolts, pieces of silver steel rod screwed at each end may be used, but the nuts should not screw up hard enough to pinch the lugs and thus bind the weights. The use of split pins or circlips as a means of retaining the pivots may be preferred, and will be quite suitable so long as they give proper security.

It should always be remembered that the fatal enemy of governor mechanism is friction; the action of the working parts should be as smooth as silk when assembled, but if the fit of the parts is sloppy, they will rattle undesirably when the engine is working.

To make the horseshoe thrust collar which fits in the groove of the control sleeve, a piece of $\frac{1}{8}$ in. mild-

●*Continued on page 655*



GAS ENGINE *continued from page 634*

steel plate may be used, and after cutting roughly to shape it may be set up in the four-jaw chuck to machine the pintles which pivot in the arms of the control fork.

These should first be turned oversize and a very fine centre drilled in each of them, so that the collar can be set between centres, or one end held in the self-centring chuck while the other is finally machined, thus ensuring their correct alignment. The collar should be a sliding fit in the groove of the sleeve, and to ensure long wearing properties, it should be case-hardened and polished.

The two fork arms and the control lever call for little comment, as they are simple to make, either by cutting from solid $\frac{5}{16}$ in. × $\frac{1}{4}$ in. mild steel bar or by brazing the bosses into $\frac{5}{16}$ in. × $\frac{1}{8}$ in. bar. The eyes should be a tight push fit on the control shaft, to which they are finally pinned when their position is adjusted. To ensure that the two fork arms are drilled to exactly the same centre distance, they may be fitted back to back on the shaft and one hole jigged from the other.

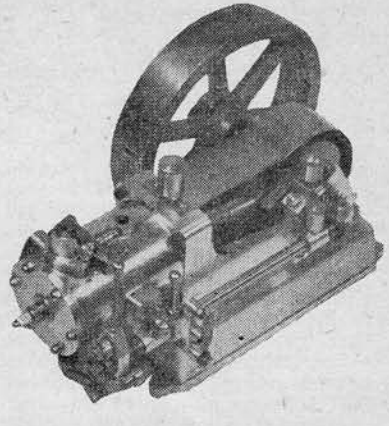
To transmit the motion of the governor gear conveniently to the carburettor on the other side of the engine, the control shaft is fitted to a bearing member bolted to the underside of the cylinder head by the two bottom studs, which are suitably lengthened for this purpose. This part can also be built up or machined from solid if desired. To ensure that the two bores of the bearing are in line, it is advisable to mark out and centre-drill the bosses at each end, then drill them from the lathe chuck with a short, stiff No 15 drill, finally running a $\frac{3}{16}$ in. reamer through both holes.

The governor assembly should be in reasonably good balance to avoid vibration when running. This should be checked by assembling the rotating parts on a short mandrel and rolling this on accurately levelled strips. If it is found to stop only in one position every time, it is obviously out of balance, and this can be corrected by removing metal on the heavy side.

The yoke is the likeliest part to be out of balance and also the easiest part to correct unobtrusively, assuming that other parts are truly machined. The method of checking applies only to *static* balance, but should be sufficiently accurate for practical purposes; *dynamic* balancing is a more complicated matter, but is only important when the rotating parts are distributed over a substantial axial length, and run at very high speed.

● *To be concluded*

A 60 cc. HORIZONTAL GAS ENGINE—10



And now, in conclusion, EDGAR T. WESTBURY deals with the control gear and final assembly

THERE are several ways of arranging the connection from the governor to the throttle lever of the carburettor, and, in the event of the latter being of a different type to that specified, some modifications in this respect will be inevitable. Where possible, however, simple and direct linkage is desirable, and the arrangement shown in the elevation and plan enables this to be carried out with the minimum complication.

As the arcs of motion of the throttle lever and control lever are in different planes, the link connecting them should be capable of articulation in both planes; the use of ball joints enables this to be done simply and without lost motion. I have not considered it necessary to make full working drawings of the components required, as they are identical with those used in motor-car and aircraft engine controls—on a smaller scale. I have also seen miniature joints of this type on the surplus market, though I cannot state if or from whom they are obtainable at present.

However, they are not difficult to make and the spherical turning device recently described by Duplex would enable the ball ends of the studs to be turned accurately. These studs are screwed and nutted to secure them in the ends of the respective levers.

If desired, the link with the two ball sockets may be made in a single piece, instead of two pieces connected by a screwed rod as shown, though the latter enables the relative positions of the levers to be adjusted. If the ball ends of the studs are $\frac{3}{16}$ in. dia., the sockets may be tapped $\frac{1}{4}$ in. × 40 t.p.i., and the side hole is then drilled $\frac{1}{8}$ in. and countersunk with a centre drill to provide the required latitude of movement.

Positions should be adjusted so that the control lever is approximately vertical, and the throttle lever square with the cylinder axis, when the governor is at the middle of its working range. Some adjustment of the throttle barrel, in relation to the lever, may be found necessary to secure the required range of speed control; obviously it must be arranged so as to close by moving the lever towards the cylinder base.

Other types of carburettors may be less suited to governor control than that specified; plunger throttles, generally, have excessive friction compared with the rotating type, but the butterfly type has the least friction of all. If a plain (non-compensated) type of carburettor is employed, governor control may be found quite impracticable as, although the engine will slow down all right when throttled, it may lose mixture strength and peter out —and at least fail to recover speed, when the throttle is re-opened.

Unless the internal springs of the governor have been pre-adjusted to operate at exactly the required speed, an extra spring must be applied to the control gear. The arrangement diagram shows the simplest method of fitting this spring, by adding a short lever (similar to one arm of the control fork) to project downwards from the control shaft and attaching a tension spring between this and some convenient fixed point.

To enable the speed to be adjusted within a fairly wide range, the lever carries a screwed eye bolt with a knurled nut, capable of being operated while the engine is running. Note that in order to work perfectly freely, the bearing for the nut should be capable of swivelling; this may be done by riveting it into the eye of the lever just sufficiently tight to keep it in place while allowing it to turn.

If no governor gear is fitted to the engine, the throttle lever of the carburettor may be connected to a conveniently situated hand lever by any suitable means, such as a Bowden

Side view of the derelict Amanco engine showing flywheel governor, cooling fan and suction carburettor

GAS ENGINE

continued

cable. But if it is not considered necessary to provide such form of control, the throttle should be frictionally loaded by a double-twin spring washer fitted between the throttle cover and lever.

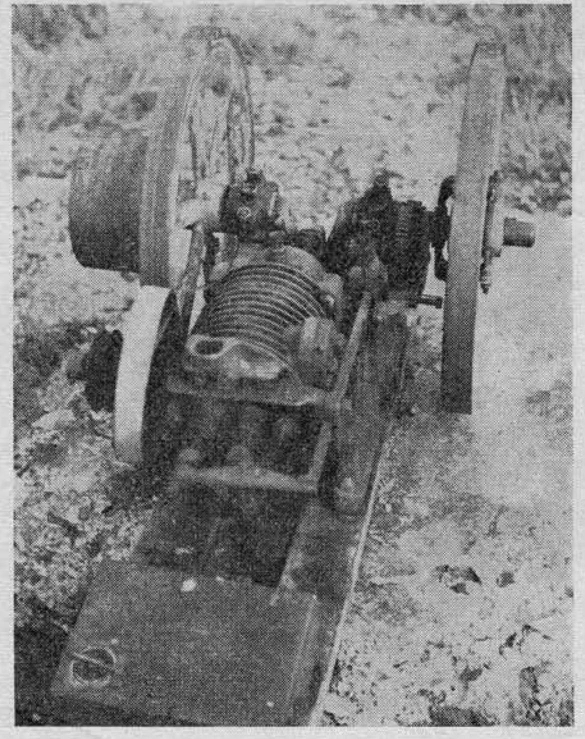
For some purposes, such as driving a lathe, hand control may be preferred to constant-speed governing as it enables a fair range of mandrel speed to be obtained without shifting belts or other manipulation of the machine; but it also limits power at lower speeds, as compared with the mechanical advantage gained by lowering speed ratio in the usual way. However, it may be said that the ability to alter speed does give an i.c. engine at least one advantage over the normal type of electric motor which can only work at a fixed speed.

FUEL FEED FILTER

Although common sense dictates that every care should be taken to avoid getting foreign matter in the fuel reservoir, the fitting of a filter (part No 29) in the feed line is a very desirable extra precaution. The cylindrical sleeve of metal gauge around the feed pipe forms a very effective filter, and is largely self-cleaning; its construction needs little explanation as it is made by rolling a piece of "petrol gauge" around a wooden rod and soldering the seam, then soldering a disc of gauze or a metal cap in the end before attaching the other end to the spigot of the union fitting which screws into the tank.

Take care to avoid an excess of solder when making these joints or the solder will spread over the gauze by capillary attraction and block it very effectively. Note also that the sleeve must be small enough in diameter to pass through the hole in the reservoir.

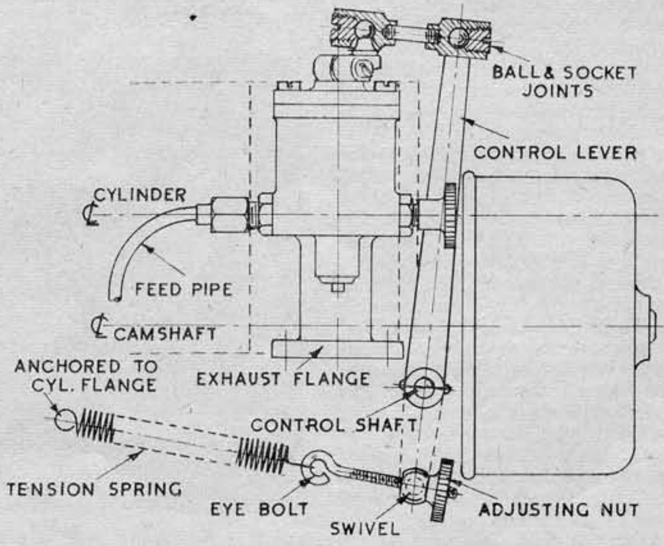
It has already been mentioned that the base of the reservoir could be deepened locally to enable the fuel to be used to the last drop practically; if this is done, the gauze sleeve and internal pipe must be suitably lengthened to take advantage of this added depth. Instead of an internal feed pipe and a union joint at the top of the fitting, the main feed pipe may be made with an extension to go right down into the tank, in which case the top fitting of the filter is simply drilled to serve as a guide for the pipe. Whatever method is employed, however, it is essential that any feed joints should be perfectly tight, or the suction will be lost and no fuel will be fed to the jet.



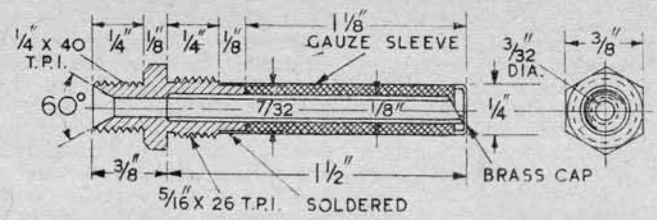
End view of the Amanco engine showing exhaust valve rocker and interceptor catch on the push rod

When starting the engine from cold, it will be found necessary to open the jet from half to one turn beyond the normal running position to obtain sufficient suction; if you object to this, a priming device, as already mentioned, may be fitted to the carburettor. If the main reservoir is used for paraffin fuel, the auxiliary petrol tank for starting and warming up may be located level with, or slightly above, the jet, in which case no priming will be necessary.

The filler cap for the fuel reservoir (part No 32) is a very simple item;



CONTROL GEAR ARRANGEMENT — NOT TO SCALE



SUCTION PIPE & FILTER (29) 1 OFF BRASS

it can be turned from solid aluminium alloy or some other convenient material at one setting. A die may be used to cut the thread if it is available in the required size and pitch otherwise it must, of course, be screwcut. In either case, a relief groove should be turned, preferably with a round-nosed tool about $\frac{1}{16}$ in. wide, at the shoulder of the thread, to enable it to screw right home against the seating.

The small vent hole is necessary to prevent vacuum locking of the fuel feed, but it need not be as large as that shown, provided that it can be kept clear of obstruction.

LUBRICATION

Many small engines of this type have had no other provision for lubrication than simple oil cups fitted to the two main bearings and the cylinder skirt, but it is obvious that for long continuous periods of running something more reliable than this is necessary. Sight-feed drip lubricators were fitted to most industrial engines, and this type could be constructed in a suitable size for fitting to this engine. On the converted gas engine which I described some years ago, the type of sight-feed lubricator as used on the Myford ML7 lathe was used, and gave very good results, though it is somewhat oversize for a small engine.

The wick tube or syphon type of lubricator is quite satisfactory for continuous feed of a small quantity of oil, and may be made in cylindrical form for fitting to individual bearings or in a rectangular box form with multiple wicks and feed pipes to the bearings. This type could be neatly and compactly fitted over the cylinder-support flange.

With either kind of lubricator, the feed to the cylinder wall may be either through a countersunk hole drilled in the projecting skirt or an extension pipe just beyond it to drop oil on the piston at the end of its stroke. In the latter case, however, it will be necessary to fit a collector funnel to the piston or connecting-rod to lead oil to the little-end bearing, otherwise much of the oil will drip into the crankpit without being utilised.

Direct force-feed of oil to the bearings is hardly practicable in an open engine, but many of the larger engines employed a pump to lift oil to a gallery from which the bearings were supplied by gravity. This method has the advantage that it does not rely on the care and watchfulness of

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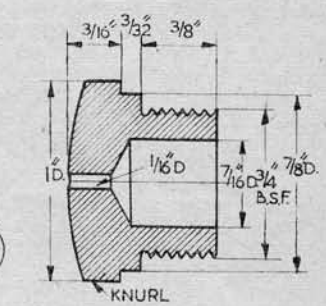


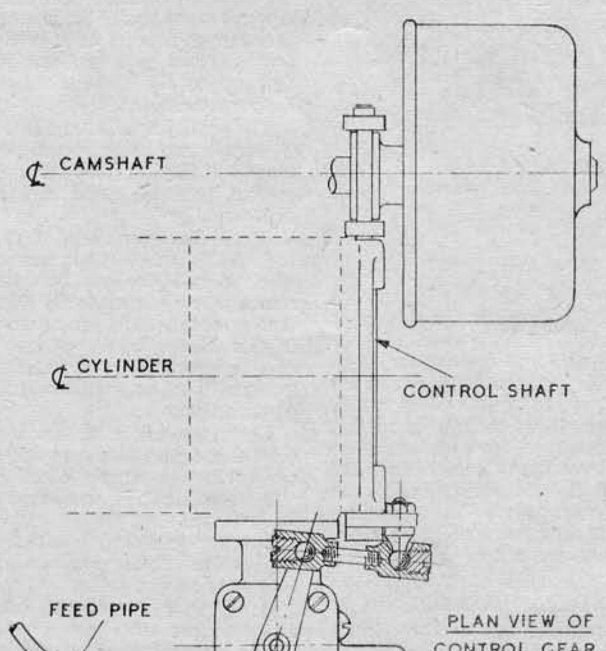
the operator; it would be quite practicable in the present case, using a small plunger pump driven from the camshaft and submerged in an oil tank. To prevent overflow from the gallery, excess oil is returned to the tank by a spill pipe after the specified level is reached.

A 2/3 SCALE CENTAUR

The engine illustrated in the heading of the last three instalments of these articles was constructed by Mr Byron G. Barnard, and was one of the first engines to be completed to this design. It was not, however, made to the specified dimensions, but was reduced to two-thirds scale to suit convenience in construction, particularly in view of the fact that a Dolphin engine of 1 in. bore had previously been built, and a lap for the cylinder—also spare piston rings of this size—were available.

It has been fabricated mainly from duralumin, the body components being fastened together with Allen screws, and the base machined from the solid.

The cylinder head is of gunmetal, with the rocker brackets brazed on. One or two details of the design have been modified, including the contact breaker, which is of the spring-blade type, and it is intended to use the Dolphin carburettor for initial running tests. The only casting employed



PLAN VIEW OF CONTROL GEAR

GAS ENGINE

continued

is the flywheel, which has straight spokes, as the curved-spoke type could not be obtained.

AN IW "SPECIAL"

Mr Sinclair, formerly of Ventnor, Isle of Wight, has built a very interesting horizontal engine, based on my articles on converting an old gas engine published in MODEL ENGINEER some years ago. I first saw this engine in a partially constructed form when I visited the Newport IW Society of Model Engineers, and was very pleased to renew acquaintance with it, now completed, on the Malden SME stand at this year's ME Exhibition. A photograph of this engine is seen on the cover.

It differs from my converted engine in having a full crankshaft, with bearings both sides, but in other respects the general design is similar, including the use of a spur-geared camshaft and long pivoted rockers operating vertical exhaust and inlet valves; the suction-fed carburettor and exhaust silencer also follow my description.

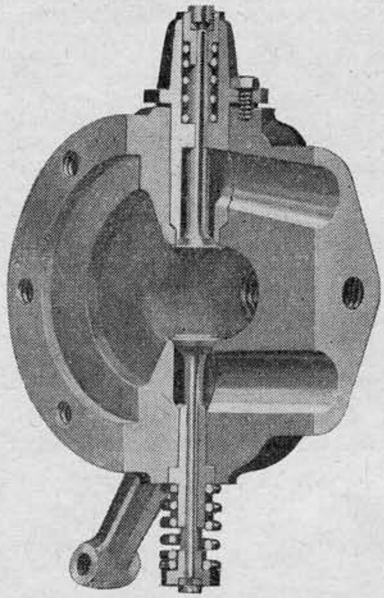
The timing gears were obtained on the surplus market, and a contact breaker made from car ignition parts is fitted. Like the previous example, it is of fabricated construction, and the general appearance is compact and workmanlike; I have little doubt that it performs satisfactorily.

AN INTERESTING ANTIQUE

In the course of correspondence arising from this series of articles, several readers have recalled experiences with gas engines of earlier days, and it is quite clear from these that steam engines have no exclusive monopoly of nostalgic memories. They have fully confirmed my views that the old gas and oil engines were thoroughly reliable, efficient and economical for all industrial purposes; many of them had a record of faithful service for as long as 50 years, and their passing is regretted by all who knew them well.

Mr A. E. Bowyer-Lowe has sent me some photographs of an old air-cooled petrol engine found derelict at Spean Bridge. It is rated at 2¼ h.p., having a bore of 4 in. and a stroke of 6 in. Even without the particulars quoted from the nameplate, I could have identified it as an Amanco engine (Associated Manufacturers Co. Ltd, Indiana, USA), as this type was very common for agricultural work in the early years of this century.

Points of interest about this engine include the early use of air cooling for stationary work (note the belt-driven fan) and the suction carburettor. Ignition gear is missing, but was usually of the low-tension type with internal breaker, current being supplied by a magneto driven from the timing gears or, occasionally, by a battery and single-wound self-induction coil.



Right-angle section of cylinder head, on valve axis

Apropos of my comments on methods of governing, the flyweights in the timing side flywheel will be seen, and also the interceptor catch for holding up the exhaust push rod; the latter, in the course of its travel, was also employed to trip the contact breaker, fitted to the circular flange on the side of the cylinder. The inlet valve was lightly spring-loaded, to work automatically. These engines were made in a wide range of sizes, both air and water cooled.

CYLINDER HEAD DESIGN

I have received one or two queries from readers about the design of the cylinder head and the method of fitting the inlet valve housing, so I am giving a pictorial section of the head, which I trust will make this quite clear. The section is taken at right angles on the vertical axis of the two valves, showing the inlet housing with the complete valve, spring and collar assembly in position; this is fitted to the head as a complete unit.

It will be seen that the housing is a sliding fit in the bore of the head, and abuts on the angled seating near the base of this bore, where it is held down by the two studs in the flange. A clearance between the flange and the top face of the head is, therefore, essential, and the seating must be accurately machined to ensure a perfect gas seal; it is also important that the fit in the main bore should be close, to avoid air leakage.

A suggestion is made that the upper guide of the housing should be vented to prevent air being compressed in the spring compartment. If the fitting of the parts is good enough to compress air it will be pretty clever workmanship; but my experience is that this rarely occurs, and would do no harm if it did; but it could easily be prevented by cutting one or more grooves in the spring retaining collar.

CASTINGS FOR THE CENTAUR

At the time the design for this engine was first prepared, I put in hand negotiations with an ME advertiser for the supply of castings to be made available to constructors. I am very sorry to report, however, that for reasons beyond my control, these arrangements have broken down, and that up to the present, no castings have materialised.

The possibility of alternative sources of supply are being investigated, but there will inevitably be some delay in getting patterns made and castings produced.

It will be appreciated that I (and for that matter, other contributors who submit designs for ME constructors) must necessarily depend on the goodwill and co-operation of friends in the trade, as the success of a design can only be assured by the availability of approved materials for construction.

There are some readers who consider that I should accept full responsibility for the supply of all castings and parts, and, if necessary, market them myself; but for ethical reasons, I have always strictly avoided becoming involved in any commercial transactions of such a nature.

However, I am always willing to assist traders who are prepared to supply constructional materials of the required standard of accuracy and general quality, in accordance with my published designs. ■