EDGAR T. WESTBURY designs a new internal combustion engine which represents the practice of earlier days

THIS IS THE WYVERN

IN the article on Flame Ignition Gas Engines on February 14 I said that some of the owners of these very primitive models had asked me how to convert them to work on the more efficient and orthodox Otto cycle. While this is possible, it calls for more or less drastic redesign of some of the parts, and the addition of several extra ones. In the circumstances, I have considered it best to prepare a new design, incorporating some of the structural parts of the flame ignition engines, and retaining their general characteristic appearance as far as possible.

It is significant that most of the readers interested in engines of this type are of an elder generation, or at least are old enough to have seen full-size open horizontal engines in action, and to have had experience of their running and maintenance. All who have grown up with the internal combustion engine from its infancy may not have learned to love it, but few will deny that the old engines were of great mechanical interest, and played a very important part in the mechanisation of industry. For many years modellers found scope for their constructive talents in building them in miniature, often to provide useful power for a workshop or an electric generating plant. Recent letters in Postbag have shown that interest is still taken in the history and development of the i.c. engine.

The term " gas," which originally defined an engine which ran on one specific type of fuel, is now used in a wider sense, and includes engines running on liquid fuel as well. Confusion has sometimes been caused by the American use of " gas " for gasolene.

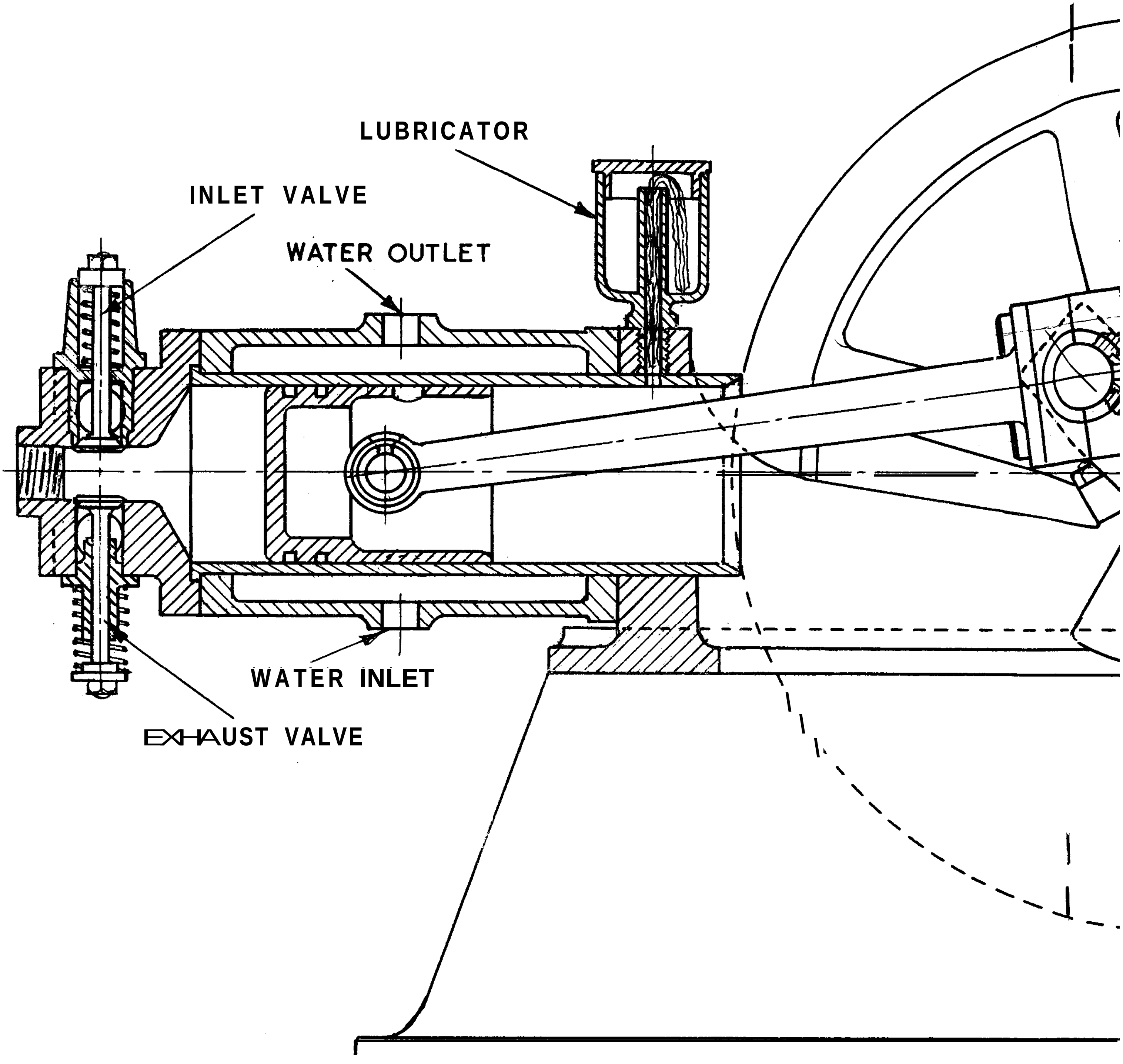
In small stationary engines for amateur construction it is generally desirable to provide for running on either gaseous or liquid fuel. The liquid is, in fact, generally the more popular, as it can be obtained anywhere. It dictates the detail design of these engines, including the mechanism for admitting and metering fuel; here few model engines follow exactly the design of orthodox full-size units designed for one fuel only. I mention this because it has frequently been the subject of comment or criticism. Most constructors are less concerned with producing an exact miniature of a full-size engine than a satisfactory working model, in accordance with their practical requirements.

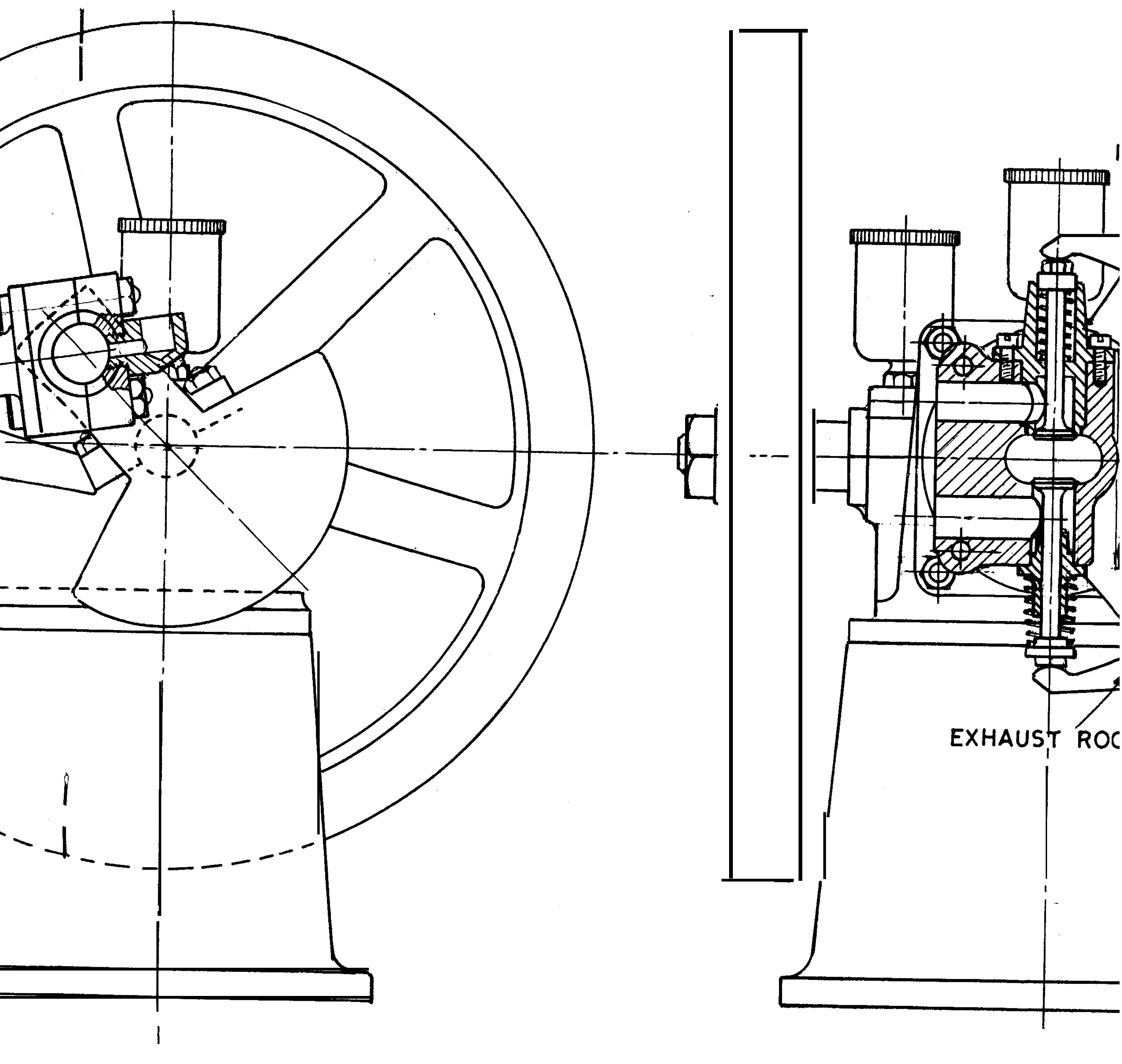
The first Otto engines borrowed many of their structural features from contemporary steam engine practice, including the open horizontal frame of the orthodox mill engine. They also had slide valves, though the valve was different from the one on steam engines and was at right angles to the cylinder. It was reciprocated by a crank or eccentric on a side shaft driven by 2:1 bevel gearing from the crankshaft. For many years the side shaft was standard on stationary gas and oil engines, though it was usually driven by helical or skew gears, and was fitted with cams for operating poppet valves.

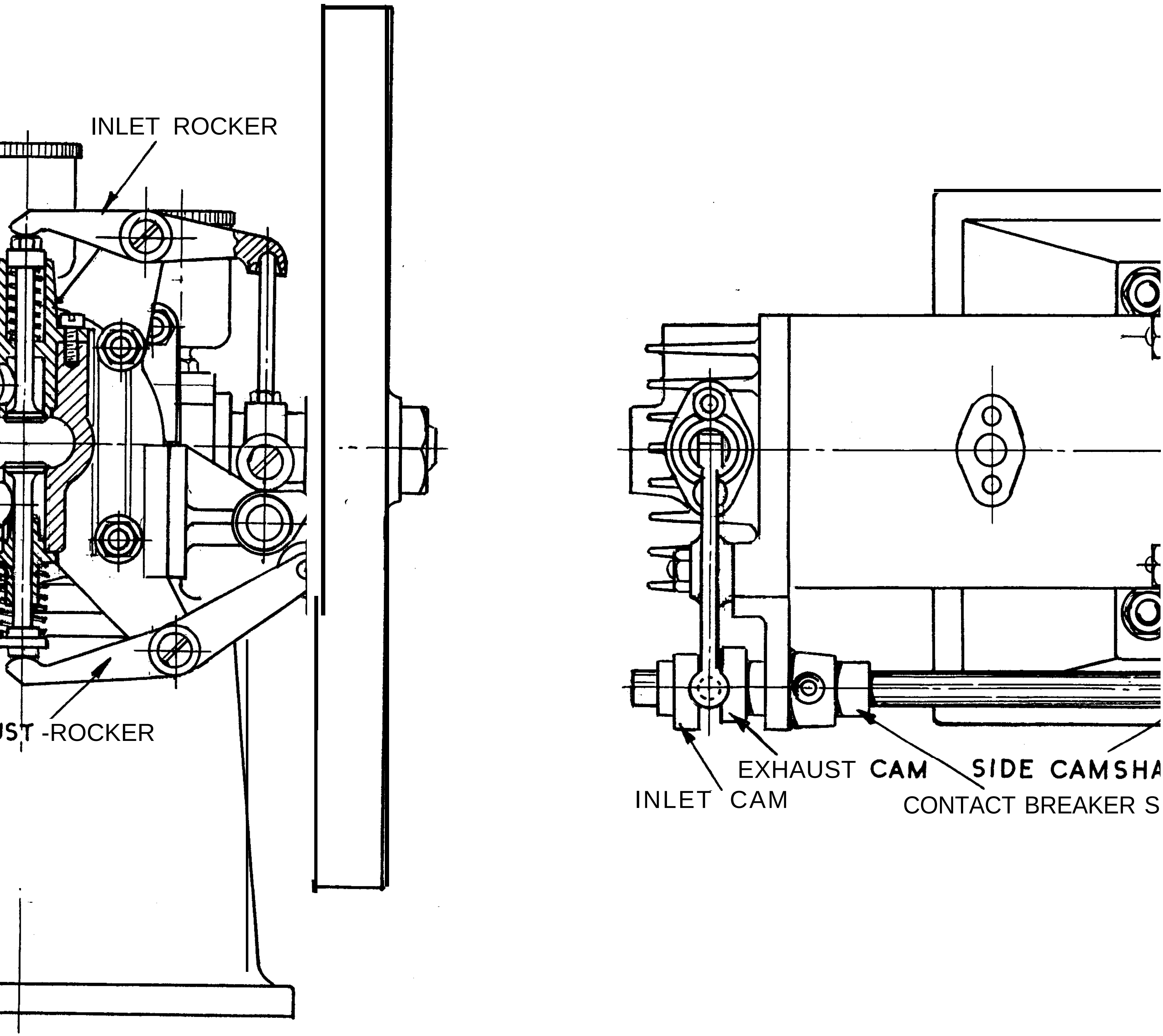
The Otto patents were first applied in Britain under licence by Crossley Brothers, who were responsible for many of the important improvements which contributed to its practical success. They may have been the first to employ poppet valves; they certainly exploded the " stratification " theories of Otto by demonstrating the advantages of turbulence and efficient scavenging. In a bench test of an Otto slide-valve engine, the cylinder head or some part of the internal surface became so hot that the engine could run without the ignition flame. This established the possibility of using a heated surface for ignition, and led to the application of tube ignition, which eliminated leakage, simplified mechanical construction and enabled higher compression and combustion pressures to be employed. At a later date this system in turn was superseded by electric ignition of either the low-tension or high-tension (spark) type.

Crossleys, and other early designers, also found that the shape of the combustion head and the position of the valves had an important bearing on efficiency. A cylinder head which became deservedly popular, though by no means universal, was the one known as the " clerestory " (a term borrowed from architecture, like many others applied in engineering). Its advantages are that it produces a compact and efficient combustion chamber, suited to moderately high compression, and promoting good turbulence; and that it gives an efficient and accessible arrangement of the valves and their operating mechanism.

Features such as these became standard practice well before the end of the nineteenth century, and made the internal combustion engine a serious rival to the steam engine for small and medium power applications. I have sought to follow them in the present design, insofar as they are consistent with practical construction and are without the need for delicate working parts or difficult machining problems. The order in which the details are described may not conform exactly with the sequence of the drawings, but this should not cause any inconvenience as all essential information will be given. Castings and parts for construction are now being prepared by Woking Precision Models Limited, Victoria Road, Woking.


LUBRICATOR
INLET VALVE
WATER OUTLET
WATER INLET
EXHAUST VALVE

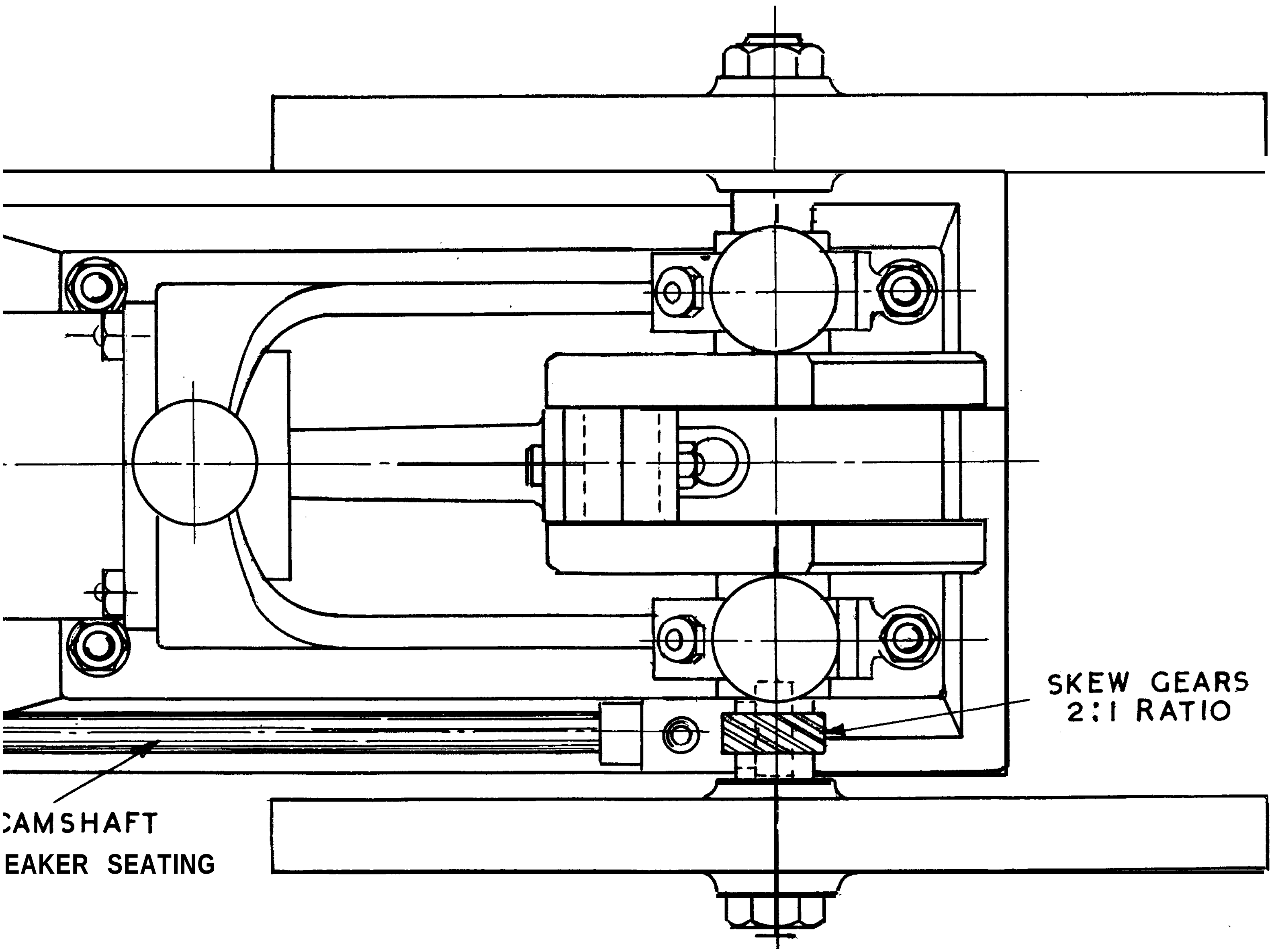

EXHAUST ROC


INLET ROCKER
UST -ROCKER
EXHAUST CAM
INLET CAM
SIDE CAMSHA
CONTACT BREAKER S

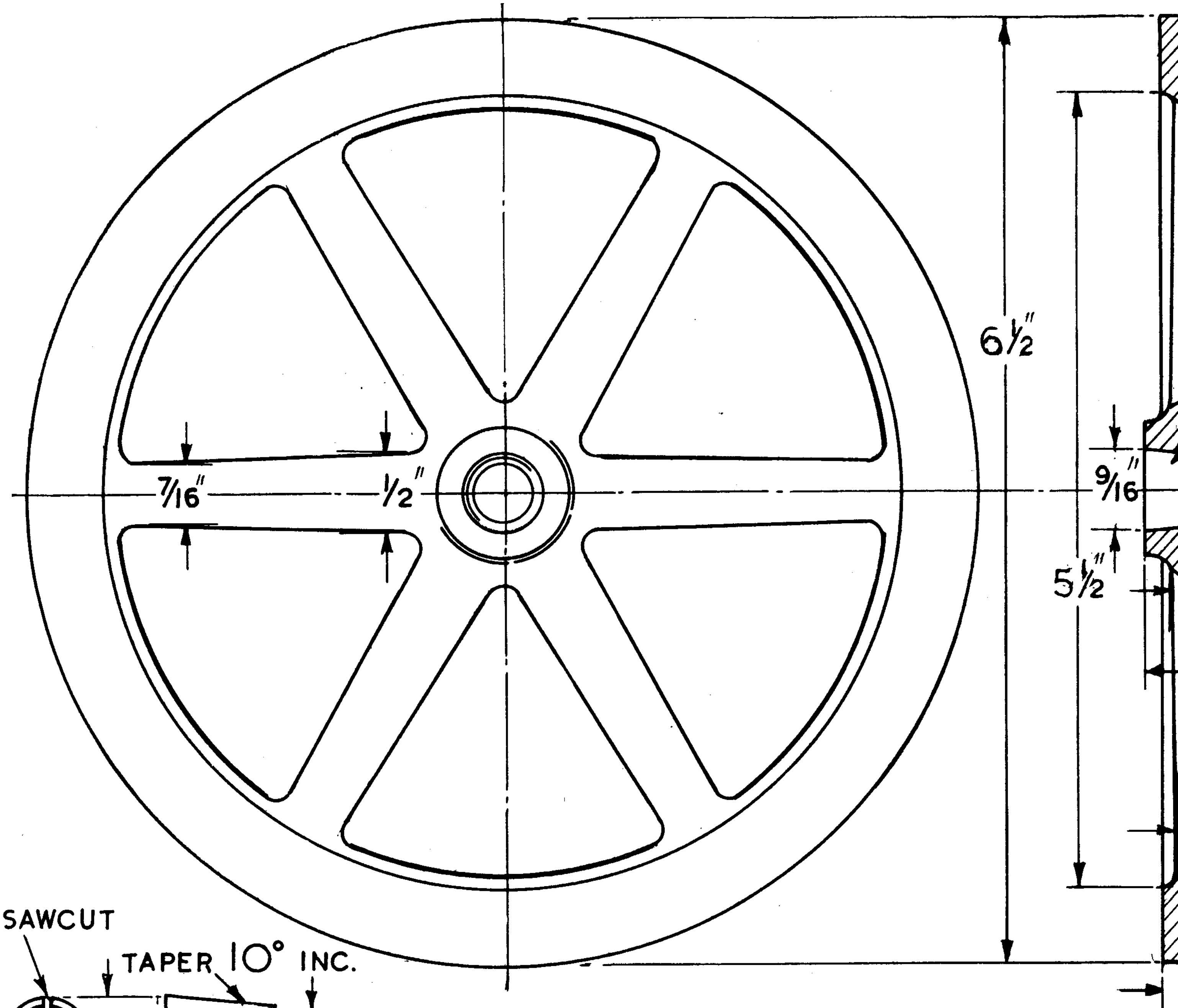
WYVERN GAS-PETROL ENGINE

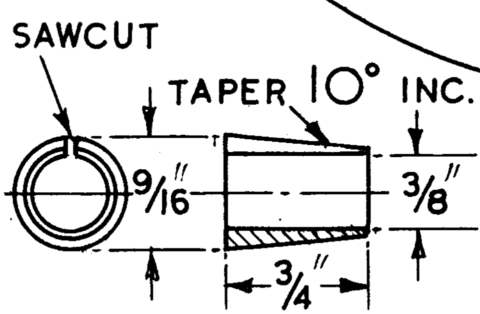
GENERAL ARRANGEMENT

1 1/4 in. Bore x 2 in. Stroke. 40 cc. or 2.4 cu. in. Capacity



DESIGNED BY EDGAR T. WESTBURY

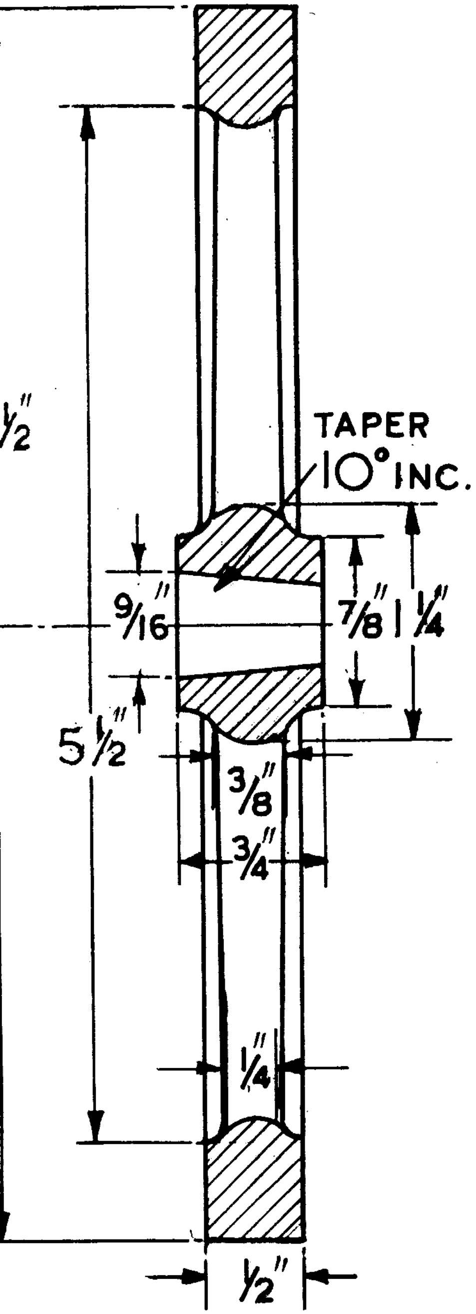




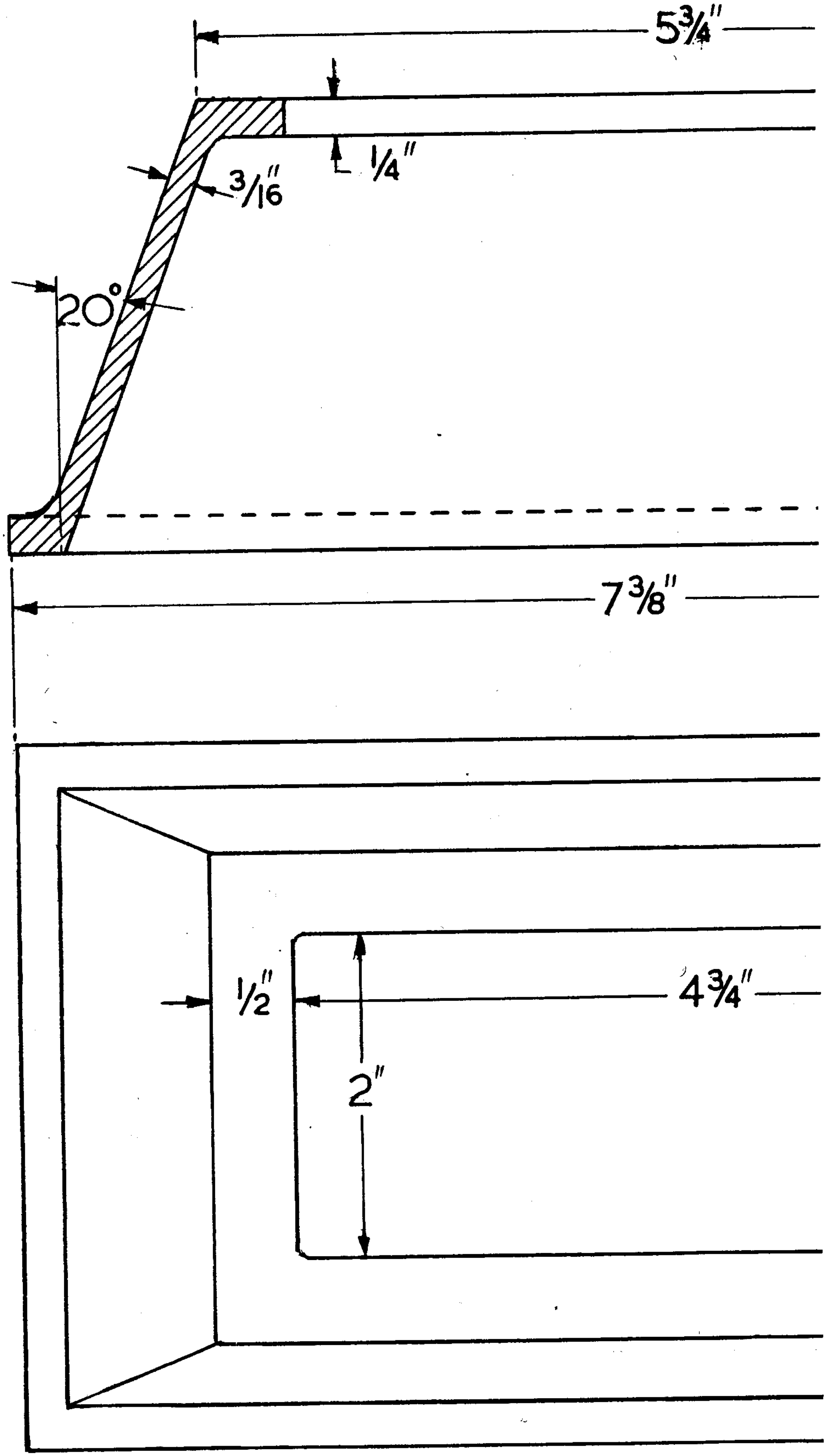
SPLIT COLLET 2 OFF M.S.

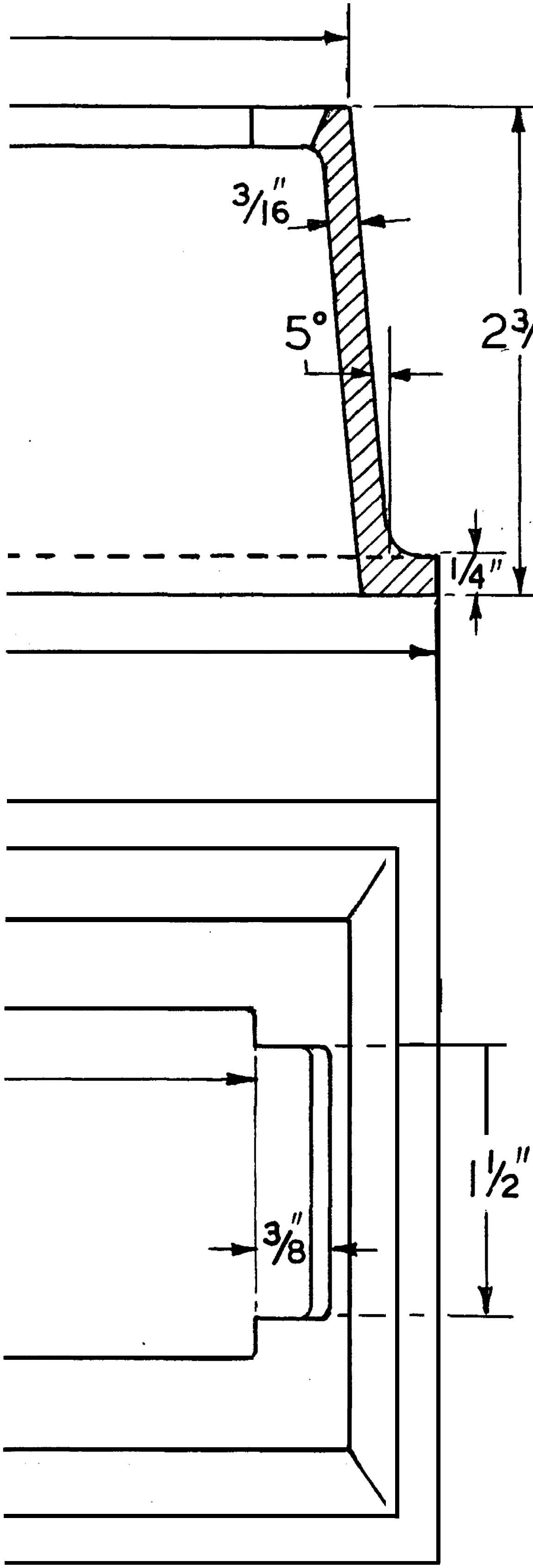
FLYWHEEL 2 OFF

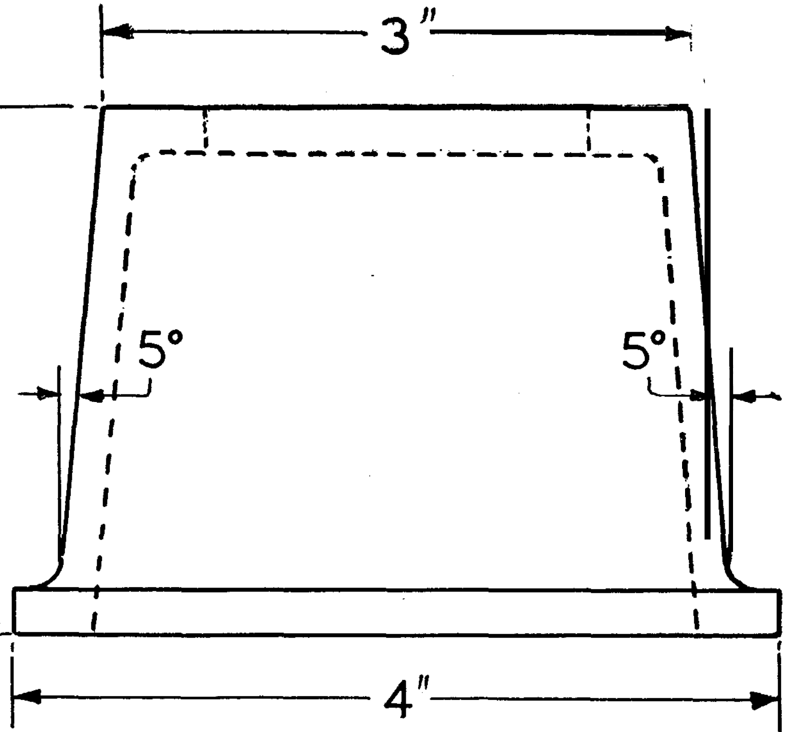
C



C.I.







SUB -BASE 1 OFF **C.I.** OR **L.A.**

FURTHER DRAWINGS OF
THE WYVERN GAS ENGINE
WILL APPEAR ON ANOTHER
FOLD-OUT IN THE NEXT
ISSUE OF MODEL ENGINEER

The sub-base casting is almost identical in shape and size with that of the flame ignition model which was sent to me. It is not the most elegant of its kind, but is generally typical of the small engine practice of the period. Deep bases were generally used for mounting engines up to five or six horse-power; larger engines were more often mounted on shallow metal or concrete plinths, or set directly on floor level. Those who do not wish to use the sub-base casting may mount the engine in one way or the other. They should note that the main engine frame, or bedplate, is not deep enough in itself to accommodate the full sweep of the big-end bearing, and a clearance hole or crank race must therefore be provided in the sub-base. This need does not arise with the casting, which is open at the top, but some may prefer to fit a drip tray under the main bedplate, in the form of a sheet metal partition, with the clearance depression beaten out or soldered in, as they choose.

The sub-base casting, like the other structural parts, may be of either cast iron or aluminium alloy. As I am not concerned with absolute fidelity to the original in the use of materials, I favour the lighter metal; it is much easier to machine, without heavy wear and tear of tools. I have been accused of anachronistic practice; but, generally speaking, there was only one reason why early engineers did not use aluminium-they simply did not have any ! It was only when motorcar manufacture began in earnest that the demand for light metals led to their production on a large scale. I should not recommend aluminium for parts with large and conspicuous areas of bright surface exposed, but here the structural parts will eventually be painted nearly all over, and discrepancies in the appearance of the metal will not offend. In any event, the choice of metal is for the individual to make.

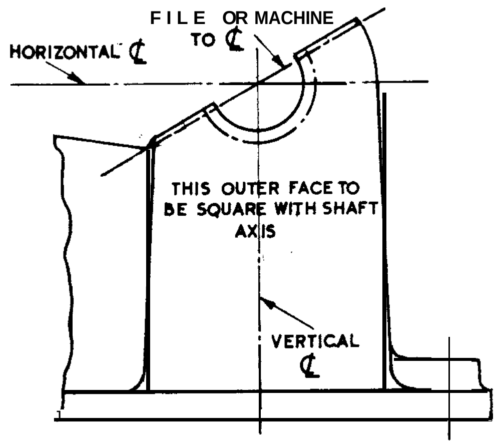
No machining of the sub-base casting is necessary. It would, indeed, be difficult to carry out in the usual amateur workshop. Those who have access to a large surface grinder will undoubtedly find it very useful for truing the top and bottom surfaces of the casting. Otherwise it can be done by filing, as the surfaces have been designed to reduce the labour involved. The underside does not need to be finished all over, but only needs the high spots removed so that it will stand fairly on a flat surface.

A little more care is required on the top surface, which should be taken down to clean metal all over, and tested for flatness on a surface plate, so that when the underside of the main bedplate is similarly treated it will bed down properly without leaving any perceptible gaps. There is, of course, no need for the standard of accuracy which would be called for on a machine tool component, but the surfaces should be generally flat and true.

When the engine is intended to run on liquid fuel, the base may well be used as an enclosure for the fuel tank. It will then be necessary to provide apertures for the fuel pipe, and also for some means of filling the tank, but drastic cutting out or other alteration is not necessarily entailed. Although a fairly large filler aperture is usually fitted to fuel tanks these days, the practice of filling through a small injector pipe by a flexible tube from a squeeze bottle is becoming popular, and is generally cleaner and less liable to waste than the use of a can and funnel. Do not neglect to provide an air vent in the top of the fuel tank, wherever it is fitted.

Truing up the main bedplate on the underside should be the first operation on the casting. This casting has a bridge piece on the open end to stiffen it during the essential machining operations. The piece should be left on for the present, until it is ready to be attached more or less permanently to the base. The only really essential machining processes on the casting are the boring and facing of the cylinder seating, and the similar operations on the main bearing housing. Very little in the way of marking out is therefore necessary. The horizontal line, 1 3/8 in. from the bottom surface (this is an arbitrary dimension, which need not be strictly observed) defines the cylinder and crankshaft axis, and vertical lines are then marked to locate the bearing centre and the cylinder bolting face at 4 in. apart.

It will be seen that the bolting faces for the main bearing caps are at 30 deg. to the horizontal line. This is different from the corresponding feature on the flame ignition engine, in which the faces were flat and level with the axis. Inclined joint faces for the bearing housings were conventional practice on gas and oil



End of main bearing housing

engines, and the reason for them is fairly obvious. In an internal combustion engine, where maximum thrusts on the bearings are generally higher than in steam engines, it is generally undesirable to split the bearings on the thrust axis. The inclination of the housings enables the major thrust pressure, which generally occurs when the crank is 30 to 40 deg. above horizontal centre line, to be taken well down in the trough of the bearing. Quite a number of engines had horizontal bearing caps, but these generally had specially designed brasses which provided the necessary thrust resistance.

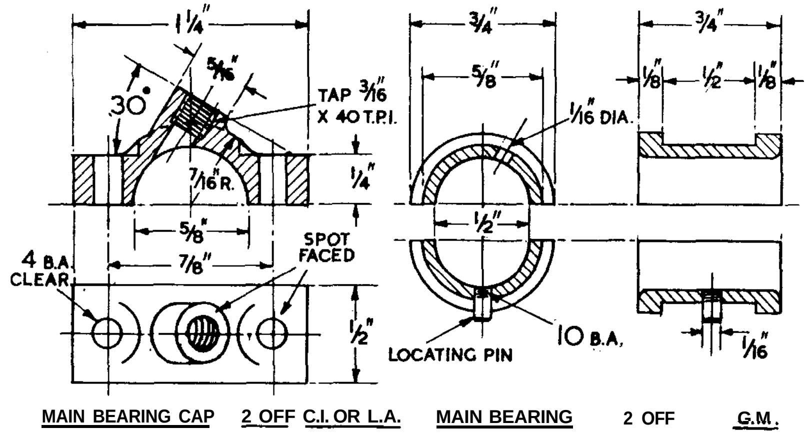
The inclined joint faces may involve a little more difficulty in fitting than horizontal faces, but the trouble is well worth while. You should fit the bearing caps before machining the housings. First of all, the joint surfaces on the bedplate should be trued up, exactly in line with each other, and on a line intersecting both the vertical and horizontal bearing centres. This is more important than observing the exact angle of the faces. While no great harm would be done if the housings were not perfectly symmetrical above and below the joint line, any noticeable error is to be avoided.

As machining of the faces is liable to be difficult, filing is the only alternative. It is quite satisfactory if due care is exercised. A rectangular bar of metal of known truth, ı) in. wide, and long enough to span the two housings, may be used to test flatness, with marking colour to show up the high spots. A smooth file of the same width as the test bar will help in keeping the faces in line during the finishing stages.

You can machine the bearing caps on the joint faces by holding them crosswise in the four-jaw chuck. When you have made sure that they bed down properly on the housing you may drill and tap the holes for fixing studs. Mark the caps for subsequent location, and fix them temporarily in position for boring and facing the housing.

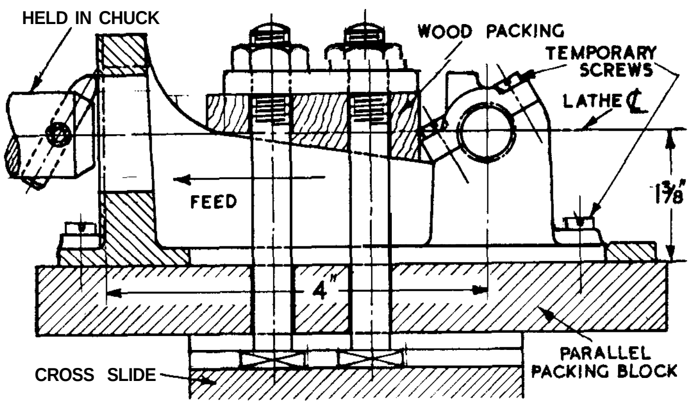
For the two main machining operations, it is most convenient to mount the casting on the cross-slide of the lathe, placing the cylinder and bearing centres exactly level with the lathe centres. You will have to provide a parallel packing piece of such a thickness as to raise the casting to this level. For the Myford ML7 lathe, the thickness will be approximately 11/16 in., and the length and breadth should be at least as large as the underside face of the casting. While metal packing is desirable, well-seasoned hardwood, such as oak, beech or mahogany is satisfactory, provided that care is taken not to crush or distort it locally in clamping it down.

Main bearing cap and split bearing



If you are not a skilled woodworker, the truing of the two sides can best be done by facing them in the lathe, screwed to a true-running faceplate. Get the thickness just right, and avoid using odd thin bits of sheet metal or paper to make up the thickness. The casting may with advantage be drilled for the holding-down screws, so that it can be fixed to the packing piece during both operations and the relative positions left undisturbed.

A smaller piece of hardwood packing, with one side tapered to match the angle of the webs between the bearings and the cylinder seating, is fitted to the middle of the casting with a metal plate on top of it to distribute pressure, and is held down by two T-bolts anchored in the T-slots of the cross-slide. The mounting must, of course, be quite secure, but it is not necessary to use extreme force in tightening the bolts. To line up the casting you may fit the faceplate to the lathe, and make a check with a square against ***both*** the long sides. If the casting is found to be slightly tapered, the difference should be split.

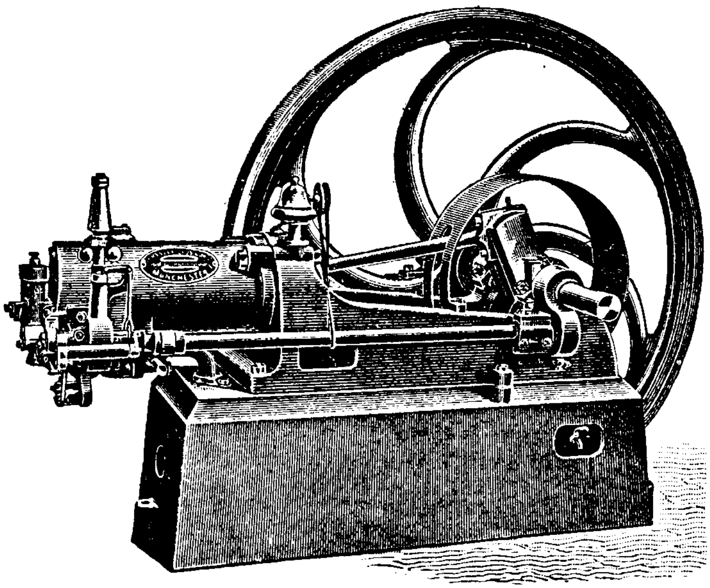


This is the set-up for the borilig and facing of the cylinder seating

Cross location of the cylinder axis can be obtained by the cross-slide movement. When it is arrived at, you should tighten the slide gibs to prevent the risk of inadvertent movement. As it is not practicable to use a cutter bar supported at both ends for boring the seating (unless a different method of bolting down the casting is employed), a short bar held in the four-jaw chuck may be used. The bar should be about fin. dia. and fitted with a cutter bit, preferably at an angle of about 60 deg. The length of the bit is, of course, limited to about 1/4in., to pass through the cored hole.

If an iron casting is used for the bedplate, you will have to run the lathe in back gear, with fine feed, for boring and facing. Light alloy can be machined at much higher speed. The adjustment of the cutter, to bore the seating to the correct diameter, must be done by easing off the grub screw and tapping it through the bar. If you have a shell reamer or other form of sizing cutter you may use it for the final cut. A close register for the cylinder liner is desirable, but exact dimensions are not critical if other parts are made to fit.

The facing operation on the cylinder seating can be carried out by a flycutter fitted to the same cutter bar as was used for boring. It will need to be longer than the boring bit, so as to be capable of sweeping a radius of about 1 1/8 in. at the tip. The most suitable form is like a left-hand side tool, slightly rounded on the leading edge.



Crossley 7 ***h.p. gas engine of*** 1889

The cross-slide gibs, after having been tightened for the boring, should now be eased to permit normal sliding action, but the saddle should be clamped-not merely locked by the leadscrew clasp nut-except while the work is fed up to the cutter.

It is now possible to mill the flat face of the casting right across, and down to the level of the screw bosses, by traversing the cross-slide backwards and forwards in relation to the rotating cutter.

* ***To be continued***

* Wyvern: in heraldry, an imaginary animal; a kind of winged dragon with two legs, and a body terminating in serpentine form.

? CAN YOU HELP ??

Readers who can offer information to those whose queries **appear** below are invited to write **c/o** Model Engineer. Letters will **be** forwarded

Model cannon for yacht club

I am interested in getting plans and details of a model cannon to be used as a starting gun for our local yacht club. The cannon would be required to fire 12 bore or 0.410 blank cartridges. Can anyone help?-S.L., Brierley Hill, Staffordshire.

Power feed

Many readers of ME are interested in making and fitting devices to improve the scope of their standard machine tool-the lathe.

Has anyone any ideas on how to fit a power feed to the cross-slide of, say, a Myford Super 7 ?-W.E.M., Purley, Surrey.

Weight of Britannia

I wonder if readers would like to give their own experiences with laminated springs ? If any reader has completed a 5 in. gauge Britannia, could he please give the completed weight ?-A.R.G., Reading, Berkshire.

The engine that Andrews stole

Continued *from page* 7

will burn applewood, but the more practical source of power is butane gas.

When the Missouri Historical Society held its first class of the 1960 season at the Jefferson Memorial in St Louis, schoolchildren were thrilled to hear the story of the Andrews Raid and to see before them the model built by Leo Myers, an exact representation of the real engine, which was scheduled to reach St Louis under her own steam in June during a spring and summer tour of thirty states.

There is no doubt that this sturdy woodbumer of 1855 provides, in miniature, the world's favourite model locomotive, whether she is seen in the perfection of detail that Leo Myers has given her, or as a little engine that can be bought at a Woolworth store, or as an even smaller thing that may drop into one's breakfast bowl from a cereal packet. Many engines have been equally picturesque; many have been grandly ornate-think for instance of the gorgeous ***Wyoming*** built two years later by Richard Norris and Son of Philadelphia in a fairground ebullience of blue and gold and red-but none has the fame which the ***General*** won in less than eight hours on a wet April Saturday after James J. Andrews, the Union spy, had decided to steal her in the service of a cause that he valued more than his life.

* ***To be continued***

Continued from May I, page 17

Machining the main parts

By Edgar T. Westbury

To machine the main bearing seatings we swing round the bedplate casting-still attached to its parallel packing block-at go deg. on the cross-slide and set the centre line of the shaft central with the lathe axis. The plan view shows this set-up, including the top packings and bolts, and the boring bar in position for the machining of the left-hand bearing. As we are unable to use a bar larger than about 7/16 in. dia., I have not made it long enough to traverse both bearings completely at one pass. It is better to keep the bar short to avoid undue spring, and, after boring one bearing, to reverse it end-for-end to bore the other at the same cutter setting. Hold the driving end in the chuck if you can, as this gives better support than running the bar between centres.

As the drawing shows, the casting is set up with the cylinder seating towards the front of the lathe. This is generally most convenient with the normal length of cross-slide, but from some aspects you might do better to reverse it (for reasons which will be seen later) if suitable mounting arrangements are possible. The cylinder seating face can be set exactly at right angles to the lathe faceplate with the aid of a large square; or you can clamp a straightedge to it, and measure between the straightedge and the boring bar, at both ends.

The preliminary opening-out of the bearing bores can be done with a drill-as stiff and short as possible. A twist drill is not rigid enough to be certain of following the axial line; a flat spearpoint drill is much better. You should be able to drill out to about 1/16 in. undersize and then use the boring bar for final sizing, or to leave just sufficient allowance for reaming if you have a reamer or D-bit of the right size. It is then necessary to face the two sides of each bearing seating. For this purpose I recommend a bar 5/8 in.dia.-aclose running fit in the machined bores-with a side cutter fitted to it of about 3/4 in. radius at the tip, to sweep the full width of the seating and the bearing cap.

One side of the main bearing needs to be faced off square with the axis, to form a seating for the camshaft bracket. This may have to be done by filing, but if the casting can be set up in the reverse position a fly cutter can be used, in the same way as for facing the cylinder seating. Dimensional accuracy on these parts is less important than the obtaining of truly flat and properly aligned surfaces. The fitting of the bearings and drilling and tapping cylinder fixing holes may be left for the present; but while the casting is on its packing block, it is a good idea to drill and tap the vertical holes for the lubricators, and spot face their surfaces. The bridge piece can then be cut away from the bedplate casting, and rough edges trimmed.

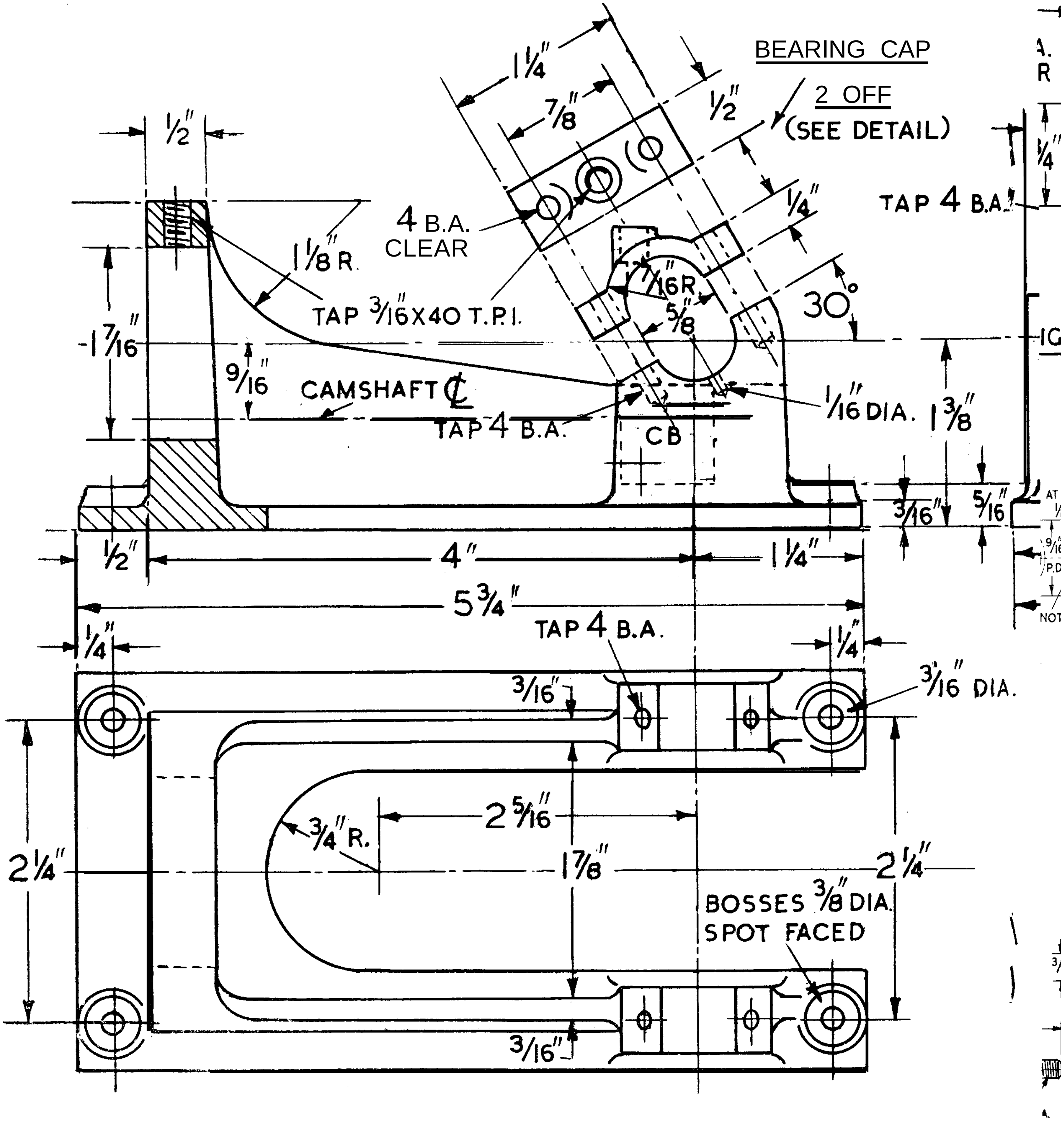
The cylinder jacket is in the form of an iron or light alloy casting which needs to be bored at the two ends only (as the chambered centre is cored out) and faced on the. joint surfaces at the cylinder head and bedplate seatings, and at the top and bottom water connection flanges. A square flange is provided at the bedplate end, while the cylinder end joint is round with four bolting lugs. You may hold the casting by the square flange in the four-jaw chuck for boring both liner seatings at one setting. They should be exactly the same size as the seating in the bedplate, and if there is any discrepancy at all it should be on the large side; you can slightly reduce the end of the liner more easily than you can put a bit on! The cylinder head joint face should be machined at the same seating.

In facing the reverse end, take care that it is exactly square with the bore. The best way would be to mount it on a mandrel, if you can get one of the correct size. You should also face the two water flanges (by setting the casting up on an angle plate in the lathe) and drill the clearance holes in the square flange for securing the jacket to the bedplate.

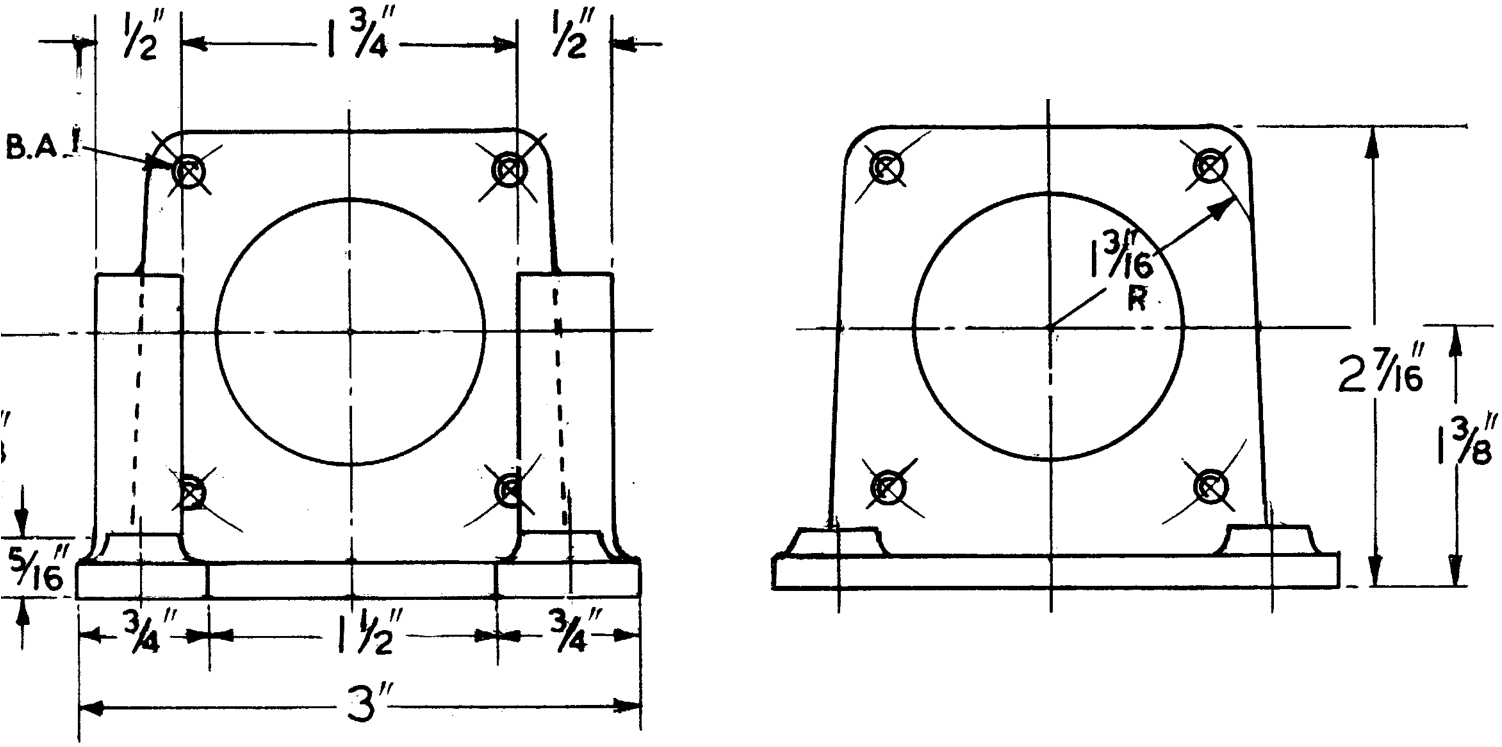
The machining of the cylinder liner is one of the most important operations, as the liner must be circular, parallel and concentric throughout its length. It is machined all over, preferably from a close-grained iron casting with a thickened end for holding in the four-jaw chuck without risk of distortion. After setting it up as truly as possible, fit a metal or hardwood plug in the open end and centre-drill it, so that it can be supported for machining the outside. A three-point steady can then be used to support the end for the boring. A heavy boring tool or cutter bar is required, to eliminate spring as much as possible; it must extend nearly four inches from the toolpost.

While you may find it best to run the lathe at bottom or middle back gear speed for roughing operations on the liner, a somewhat higher speed is permissible for finishing cuts. Use a keenly honed tool, with a rounded nose and little or no top rake. Several passes through the bore, with no increase of in-feed, will help to produce a smooth and accurate finish.

The outside diameter of the liner should be turned to a light press fit in the cylinder jacket; there is no advantage in making it excessively tight, but it must make a

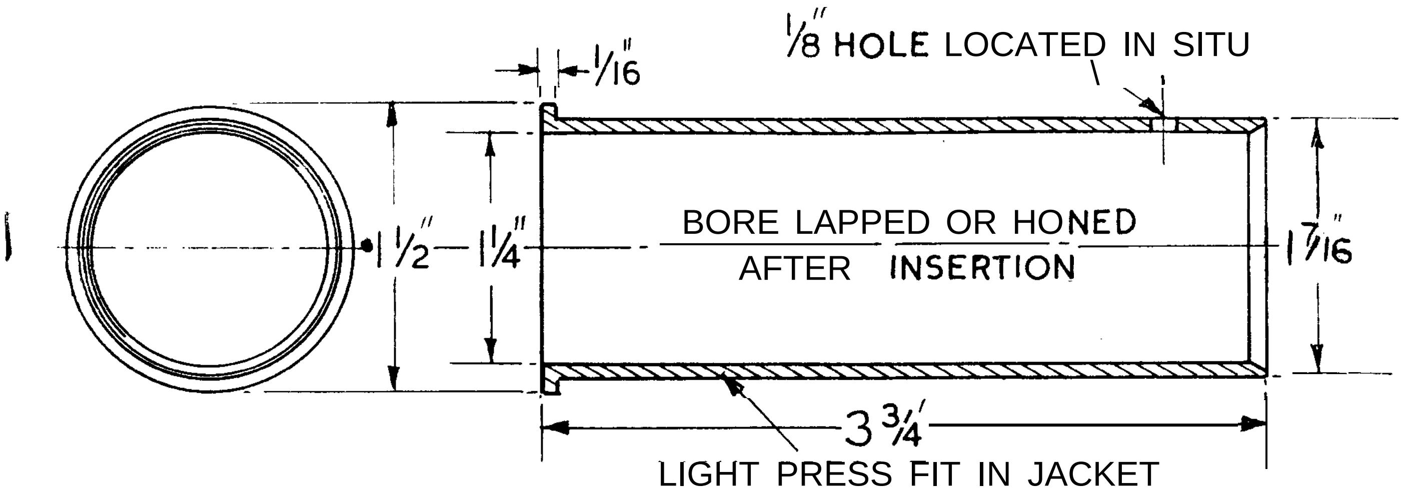


BEARING CAP
2 OFF
(SEE DETAIL)
1¼″
7/8″
½″
¼″
½″
4 B.A.
CLEAR
1⅛″ R.
TAP 3/16″ X 40 T.P.I.
7/16″ R.
5/8″
30°
TAP 4 B.A.
1 7/16″
9/16″
CAMSHAFT ℄
TAP 4 B.A.
CB
1/16″ DIA.
1⅜″
3/16″
5/16″
½″
4″
1¼″
5¾″
¼″
TAP 4 B.A.
¼″
3/16″
3/16″ DIA.
2 5/16″
¾″ R.
2¼″
1⅞″
2¼″
BOSSES ⅜″ DIA.
SPOT FACED
3/16″



MAIN **BEDPLATE**

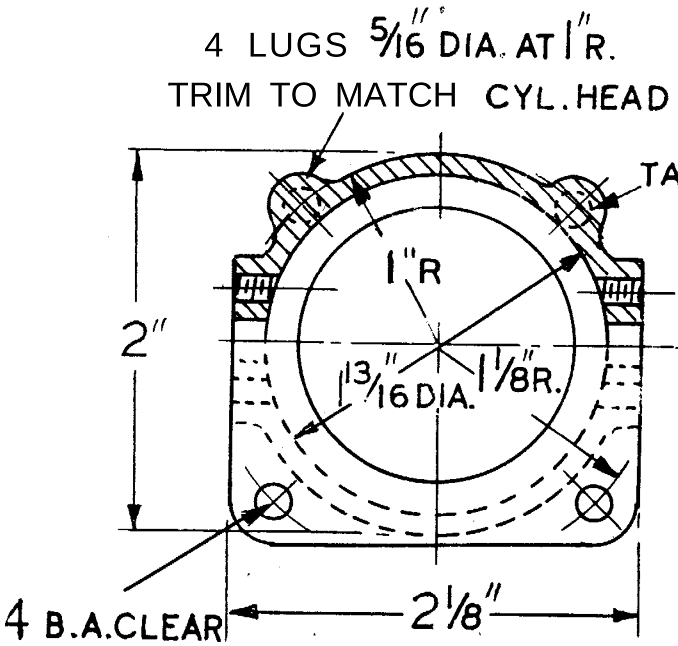
1 OFF C.I. OR. L.A.

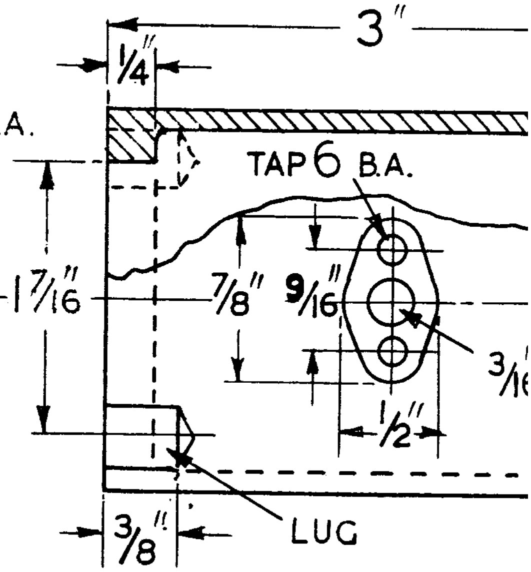


CYLINDER LINER

1 OFF

C.I.

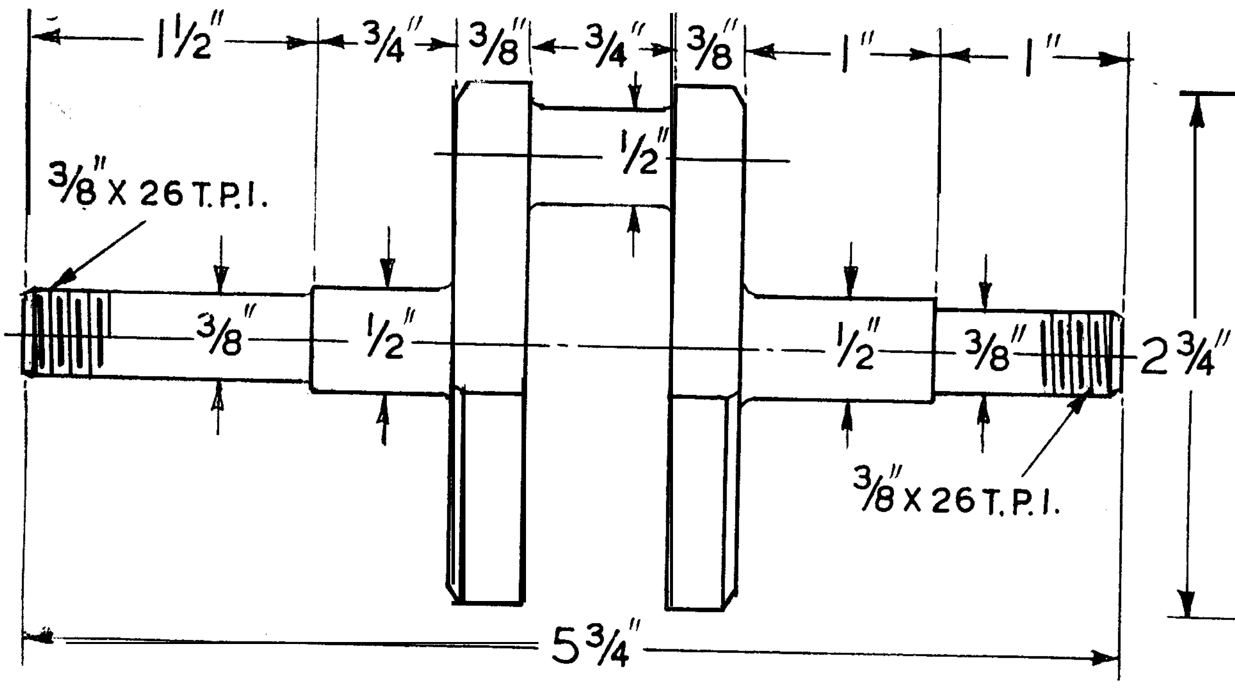


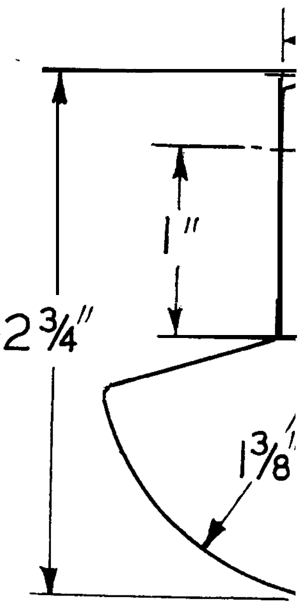


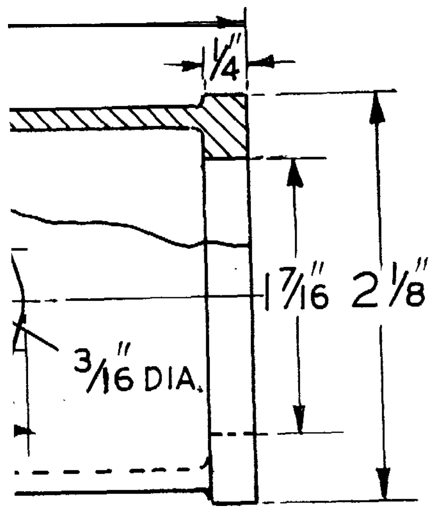
CYLINDER JACKET

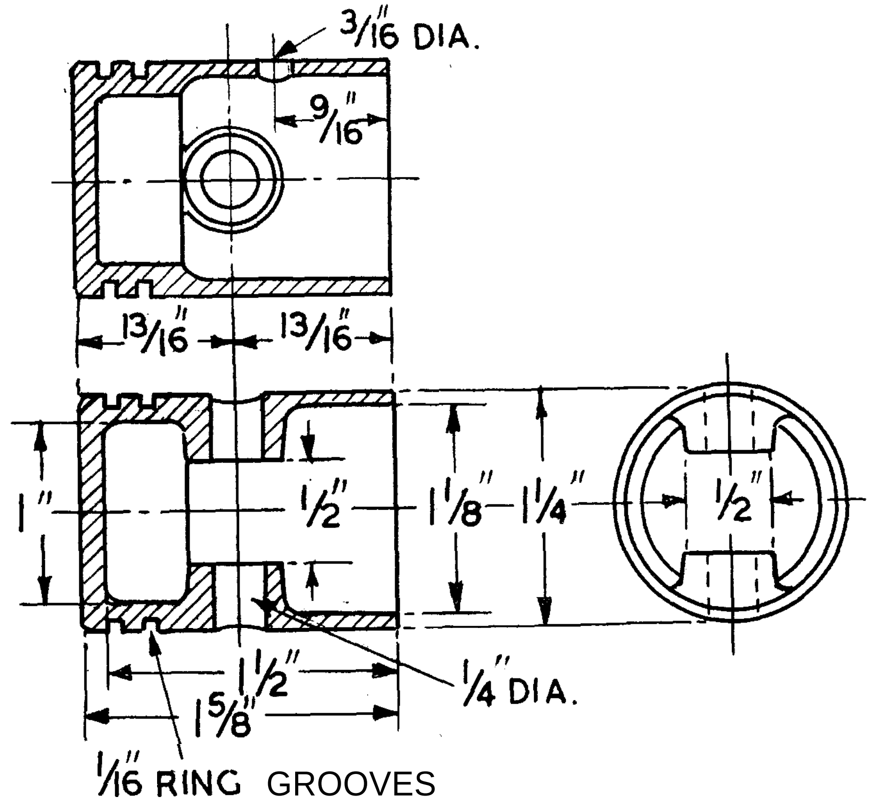
1 OFF

C.I.



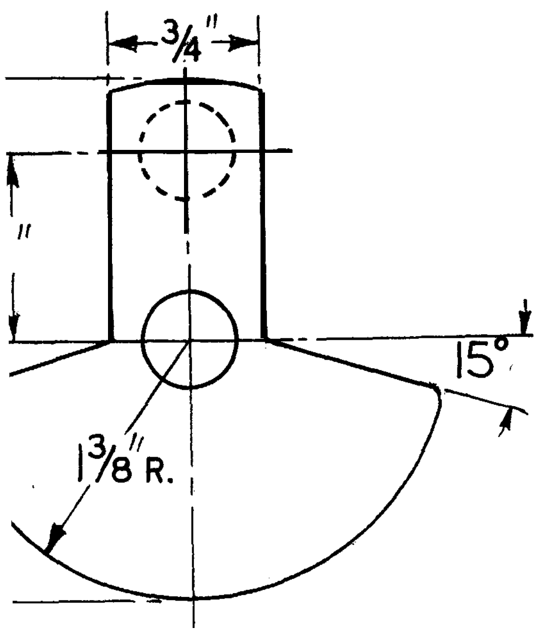






C.I. OR L.A.

PISTON 1 OFF C.I.

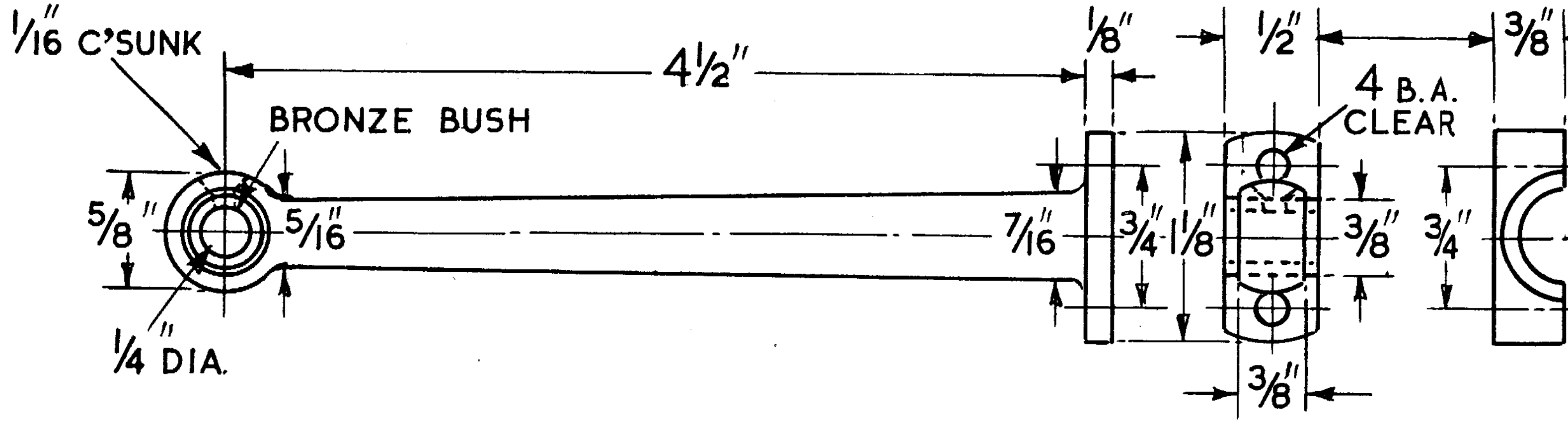


WYVERN GAS-PETROL ENGINE

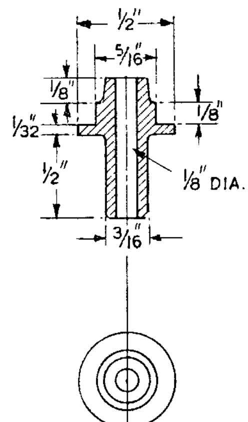
CONSTRUCTIONAL DETAILS

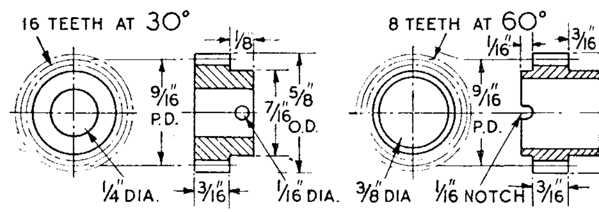
DESIGNED BY

EDGAR T. WESTBURY



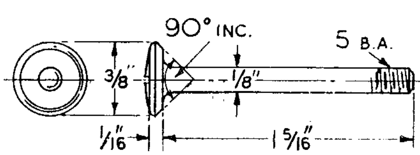
CONNECTING ROD   1 OFF   M.S.   BIG END

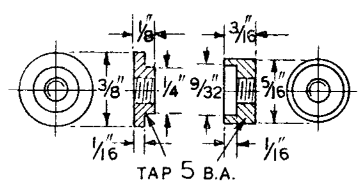




CAMSHAFT   CRANKSHA

SKEW TIMING GEARS   1 OFF EACH   M.S.

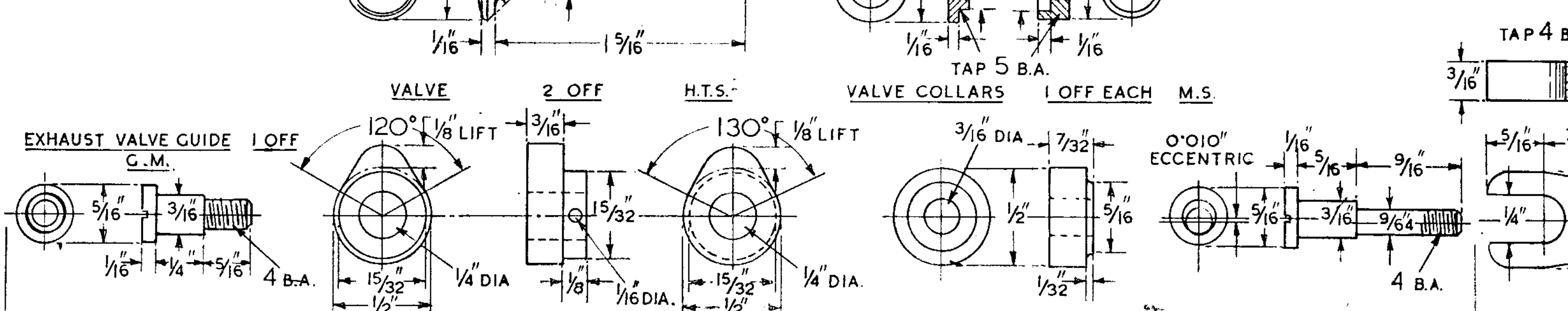




VALVE   2 OFF   H.T.S.

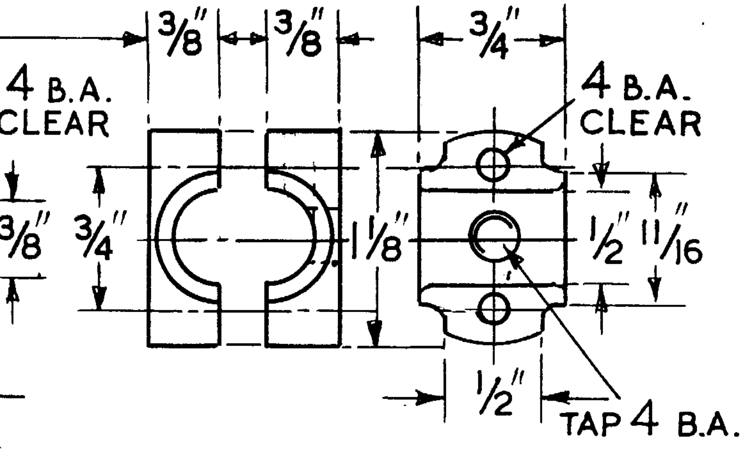
VALVE COLLARS   1 OFF EACH   M.S.

EXHAUST VALVE GUIDE   1 OFF
G.M.

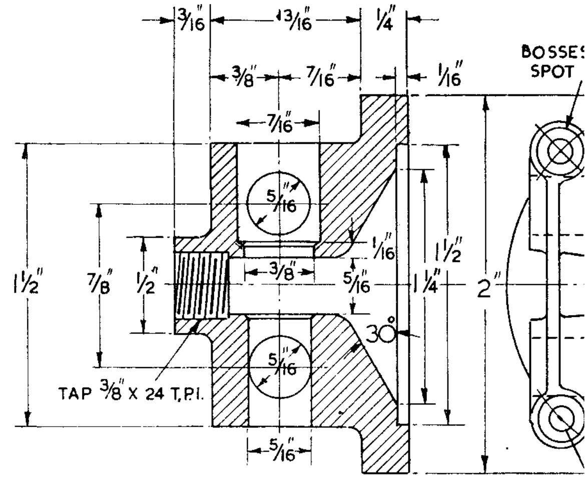


ROLLER PIVOT   2 OFF   INLET   CAMS   1 OFF EACH   EXHAUST   CAM ROLLER   2 OFF   ROCKER PIVOT   2 OFF   ROLLER

ALL M.S., C.H.



BIG END BEARING 1 OFF BRONZE



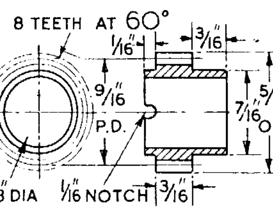
4 B.A. CL

FI

FACING FC

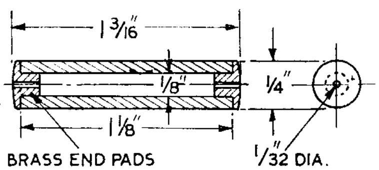
CYLINDER

1 OFF C.

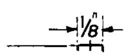


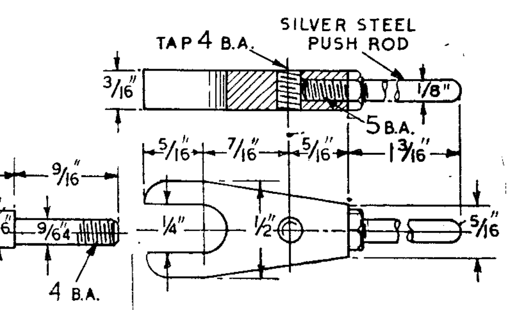
CRANKSHAFT

OFF EACH M.S.



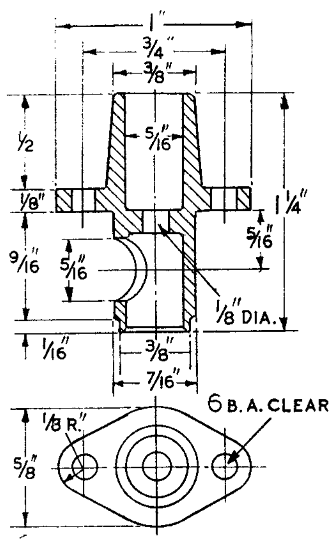
GUDGEON PIN 1 OFF M.S.,C.H.

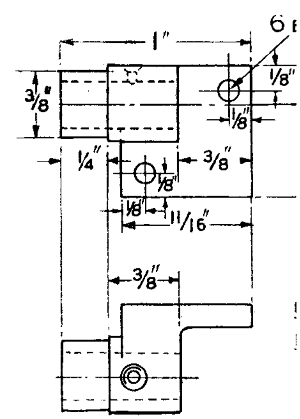


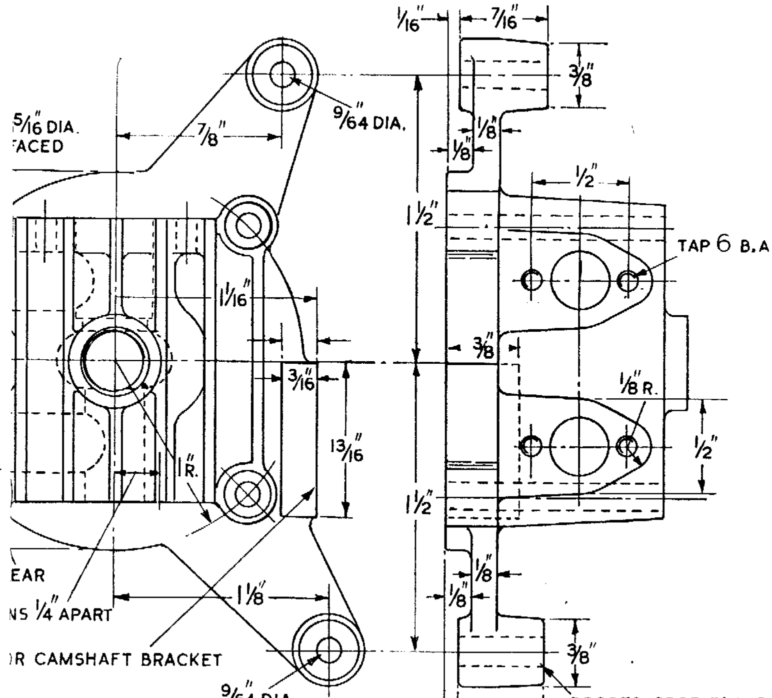


2 OFF

ROLLER GUIDE 1 OFF G.M

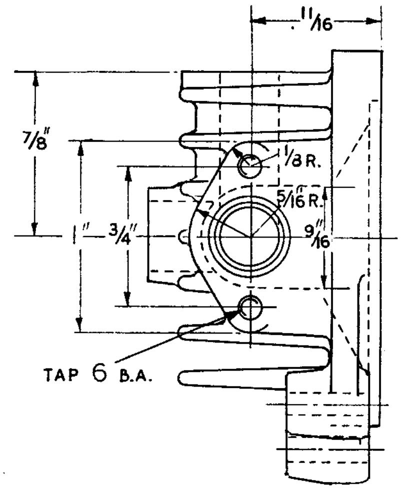


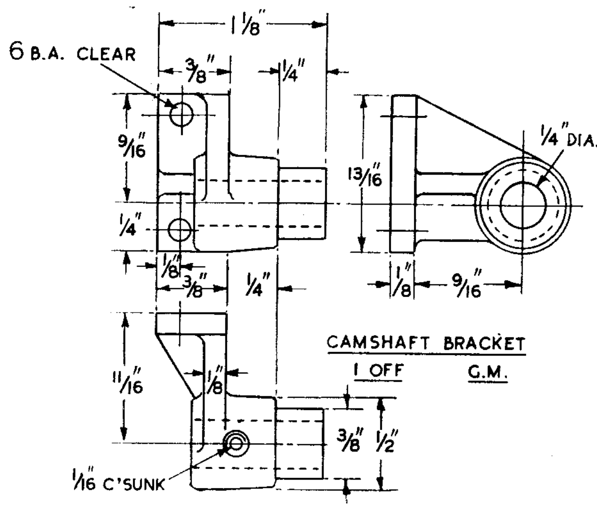




HEAD

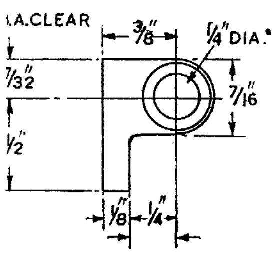
I. OR L.A.





CAMSHAFT BRACKET

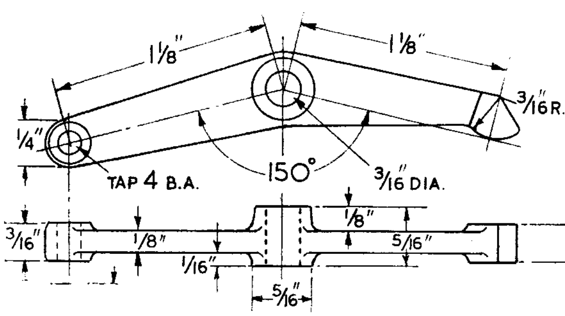
1 OFF G.M.

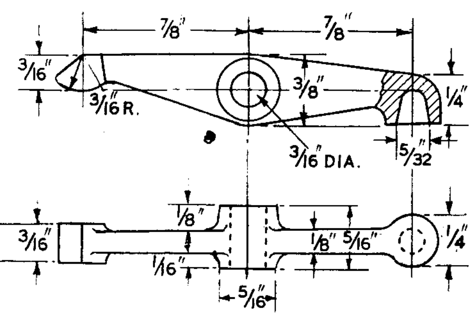


INNER CAMSHAFT BRACKET

1 OFF G.M.

(ATTACHED AT CB)





EXHAUST VALVE ROCKER

INLET VALVE ROCKER

1 OFF EACH BRONZE

watertight joint. A little varnish or goldsize applied to the liner when it is inserted will help. The rim of the liner must also register in the recess of the cylinder head, and its back face must be machined flat and true. At the mouth of the liner, a pronounced internal chamfer at about 60 deg. included angle provides for easy assembly of the piston and its rings. After insertion, the liner should be carefully lapped for circular and parallel accuracy.

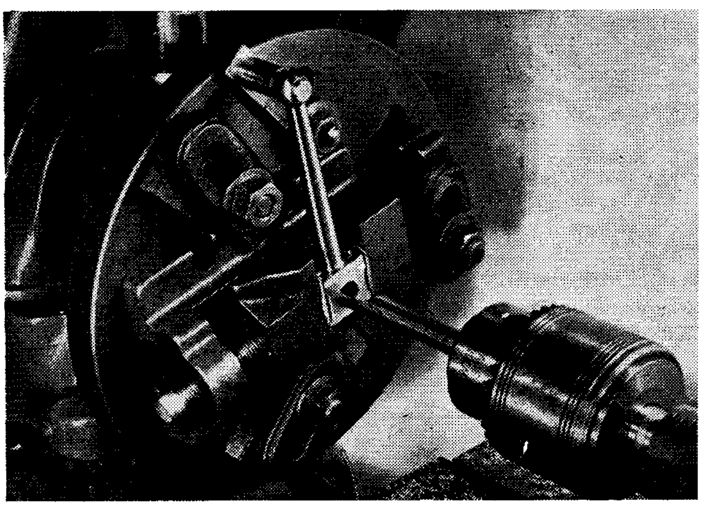
In the machining of the piston, the methods which I have recommended for earlier engines may be followed. A chucking piece is provided on the casting, and should first be trued up so that it can be held securely in the four-jaw chuck. Setting up should be done from the ***internal*** cored surfaces as these may not always be true with the outside. The mouth of the piston may be faced and internally chamfered so that it can be supported by a pipe centre for external turning. Cast-iron pistons can be fitted to very fine clearance in the cylinder bore. If lapping is resorted to, it should be done with a ring lap; not in the liner itself.

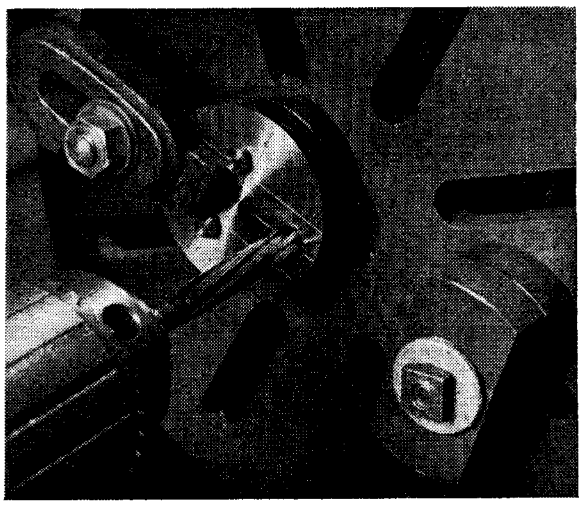
Drill and ream the gudgeon pin hole by setting up the piston on an angle plate in the lathe to have it perfectly square with the bore. Ordinary drilling methods are not reliable, however accurate the machine may be. The gudgeon pin can be made of mild steel, turned and drilled at one setting, and tinally casehardened and polished. It should be a light press fit in the piston. The soft pads fitted to both ends are a safeguard against the scoring of the cylinder if it should move endwise.

As the machining of a solid crankshaft, either from stock material or a forging, would be a rather difficult operation, the alternative is a fabricated component with two discs cut away to form webs and balance weights, and round bar material for the main journals and crankpin. It is possible to build this up by press fitting only, if the fits are good enough (this does not mean excessive interference limits), but brazing or silver soldering gives more certain results and will generally be preferred. As the main journals can easily be machined after brazing, they may first be made oversize, say 9/16 in. dia., and in a single continuous length, to be cut away between the webs afterwards. Machining of the crankpin is more difficult. The need for it can be avoided if care is taken not to let the brazing get out of bounds.

Clamp the two crank discs together for boring the journal and crankpin seatings, which should all be slightly countersunk. They may also be shaped externally while they are still attached. With close fitting, the shafts will not move during the brazing; if they are loose, the surfaces may be straight knurled to make up the fit. There is no advantage in pinning the parts together, but holes drilled in the webs, for feeding the brazing metal into the joint, are sometimes helpful. To prevent the metal from running on the working surface of the crankpm, it may be black-leaded or wrapped with asbestos string. Joint surfaces should be pre-fluxed. For the brazing operation, the assembly can be up-ended in a bed of coke so that each web in turn is exposed. Feed the metal into the sink formed by the countersunk shaft seatings, and build up a small fillet around each shaft. The metal should penetrate right through the joint so that no separate application on the inside of the webs should be necessary. Do not plunge the shaft into a pickle bath while it is red-hot, as this may cause distorting strains; let it cool slowly, so that it is normalised and any existing strains are released. The part of the journal between the webs should be cut out and a packing piece fitted (not forced in) before the final machining of the journals. Nothing more than cleaning up with emerycloth should be needed for the crankpin.

The main bearings may now be fitted to the crankshaft; they are shown as split halves in the detail drawings, according to the correct practice, but this is necessary only so that wear can be taken up, and solid bushes can be fitted if they are desired. To make split bearings, a piece of metal long enough for both of them, with adequate chucking allowance, should be roughed out well oversize, split down the centre, and filed or machined on the faces, which are sweated together. The piece is then re-chucked and both the bore and the external surfaces are machined to finished size and parted





Connecting-rod assembly set up for finishing the big-end bearing (left) and boring and reaming the two crank dies

off. The seating surfaces must, in any event, be sized by dead reckoning, unless you have a plug gauge to check the bore of the housing, and the end collars should be spaced so that the bearings fit the housing endwise. When in position, the inner faces of the two bearings should be of just sufficient distance apart to admit the crank webs without end-play. Split bearings must be prevented from rotating in the housings. A simple way is to fit a short dowel pin in the bottom half, to register in a hole drilled in the bottom of the housing.

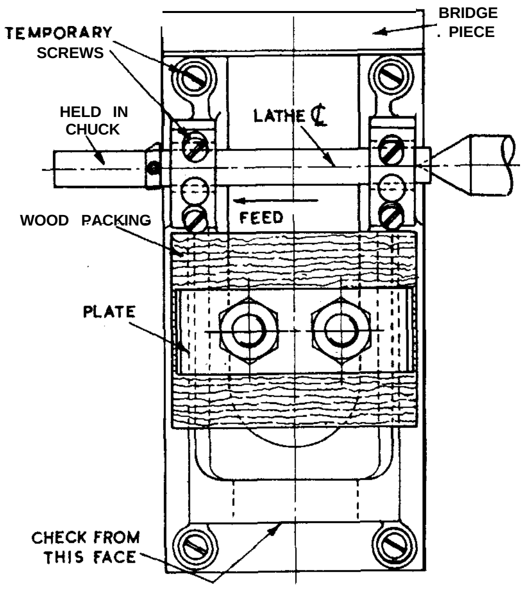
A steel connecting rod is used, either machined from the solid or with a foot brazed on. The big-end bearing is of the " marine " type, with half-brasses bolted to the foot. While the machining of the rod is fairly straightforward, take care in cross-drilling the spherical little end, to be sure that it is perfectly square, and in angular alignment with the big end. In writing of other engines I have described methods which can be used, including those for the finishing of the bore and side faces of the big-end bearing after it has been bolted to the foot of the rod.

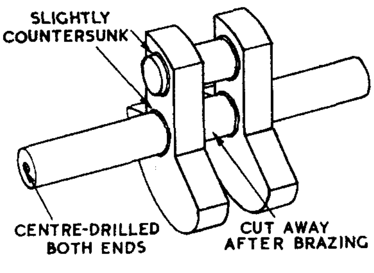
The half-brasses are first machined on the joint and seating faces, and holes are drilled to take the bolts in both of them and also the foot of the rod, exactly in line, and a close dowel fit for the bolts. After attaching them, drill a hole undersize on the joint line, and set up the assembly on the faceplate, with the little end eye located by a close-fitting spigot mandrel, bolted through a slot in the faceplate or attached to a flat plate clamped thereto. The big end is then set up centrally and held either by clamps or in a small machine vice for boring, and facing on one side; for the reverse face, it can be mounted on a stub mandrel. To finish the rounded top and bottom surfaces of the bearing and rod foot, chuck or mount the assembly between centres; this can be done either before or after the boring.

An iron or light alloy casting forms the cylinder head. To avoid the complication of internal water passages, it is provided with fins to promote air cooling.- You can hold it in the four-jaw chuck for machining the joint face, recess and angular part of the combustion head. The spigot of the liner should fit the recess closely to register the head, and its depth should be adjusted so that both the liner face and the broad joint face make contact; lapping is needed for the final fitting. It would be possible to make the recess deeper and fit a thin asbestos composition ring to provide a gastight joint, but this should not be necessary if the machining is accurate.

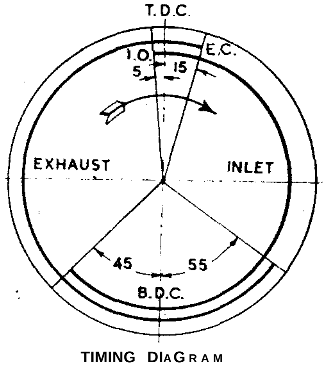
The hole for the sparking plug may be drilled at the first setting, or the casting may be reversed so that it can be drilled, tapped and faced from the other side. To machine the cross bore for the valve housings, and to drill and face the horizontal inlet and exhaust ports, the casting may be mounted on an angle plate by clamps or a cross strap, with packings to prevent damage to the fins, and a piece of paper under the machined front face. The valve housings, after being drilled undersize, should be finished by boring, and particular care should be taken with the step in the bore of the inlet valve housing, as this is required to make a gastight joint. A rotary file may be used to clean out the elongated space between the valve housings and the radius where this joins the angular recess. Be sure not to damage the exhaust valve seating bored in the mouth of the housing. All that remains to be done on the head is the drilling and tapping of holes in port flanges, clearance holes for four fixing studs, and pivot stud holes in the extended lugs of the casting.

The inlet valve housing is a straightforward machining task, most of which can be done at one setting. The housing should be held over the flange in the four-jaw chuck for facing, drilling right through, and counterboring of the port, in concentric accuracy. The underside of the flange is faced, the outside surface is then turned, and the position of the step is located so that when it is fitted there is a slight clearance between the flange and its corresponding surface on the head. This component should fit closely, but not tightly, in the head; the step joint can be ground in before the fixing studs are fitted. Then the side port can be spotted through from

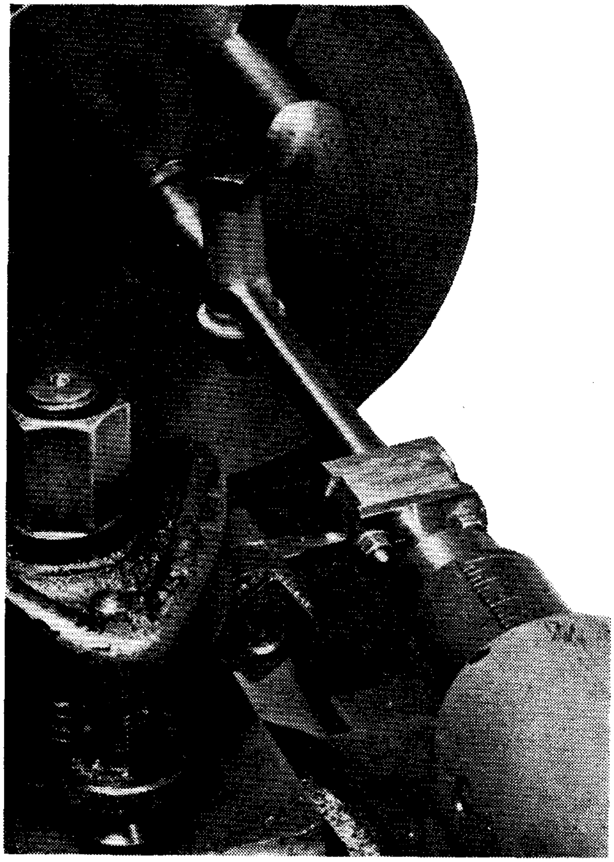




Left: Plan view of bedplate set up for the line-boring of the main bearing housings. Centre: Crankshaft parts a&embled for brazing. Directly below: Timing diagram



TIMING DIAGRAM
FROM GEAR END SET CAMS BY TRIAL



Machining the edges of the big-end bearing between centres

the port in the head; if it is drilled to full size in position, beware that the drill does not raise a burr which prevents the housing from being withdrawn without scoring the bore in the head. To bore and turn the upper part, the housing should be mounted on a stub mandrel, as it is important that the upper counterbore should be in concentric alignment with the seating.

Now the group of components which constitute the valve operating gear may be put in hand; they comprise the camshaft, skew gearing, cams, valves and valve rockers. Bright mild steel rod 1/4in. dia. is suitable for the camshaft; there is little advantage in using harder or more expensive material as its duty, in engines of this type, is relatively light. For those who prefer it, silver steel is permissible. Skew gears suitable for the timing or " 2 to I " gearing, as specified in the details, are fortunately obtainable. It will be necessary to open out the crankshaft gear to 3/8 in. dia., and this calls for careful chucking, and for a rest with a dial indicator so that you are sure rhat concentricity is maintained. Locate the gear on the shaft by notching the boss and fitting a short 1/16 in. pin to engage with it; for further security, it is clamped by the endwise loading on the flywheel collet adjacent to it.

The camshaft runs in two bearing brackets attached to the side of the bedplate and the cylinder head. It is important that these bearings should be exactly aligned with each other, and also that the timing end should be at the correct distance from the crankshaft centre for proper meshing of the gears. Both brackets have flat mounting faces, which must be filed or machined parallel to the bore axis. It is immaterial whether the faces are machined first and the bores located from them, or vice *versa so* long as the desired result is achieved. With due care, it is possible to machine them so that when they are finished, they need only be fixed in position; while alignment can be adjusted by the use of shims, it is much better to avoid the need for adjustment. The bearings are purposely made long, so that errors of alignment can readily be detected; this feature is also conducive to long wear, and good lubrication, through the retention of the oil film. For *fitting* the contact breaker, a machined seating is required on the outside of the bracket at the cylinder head end. It must, of course, be exactly concentric with the bore. The breaker can be mounted on the *timing* end bracket, but this puts it behind the flywheel, where it is not so readily accessible.

The valves, together with their retaining collars, and the long guide (for exhaust only) are all fairly simple components which should not present any serious machining problem. Screwed valve collars are fitted for simplicity, and if the threads are a neat fit and properly locknutted, no trouble should be experienced with them; but for extra security, the threads may be treated with a preparation such as Loctite before assembly. Machining of valves, which some constructors find difficult, can be simplified if the end of the stem, for 1/4in. or so, is turned to size first and then supported by a hollow centre or a steady bush before the rest of the length is reduced. At the same setting, the radius under the head and the angle of the seating can be machined, the thread cut, and the finished valve parted off.

The cams are of the tangent type, with straight flanks and a nose radius which is not specified in exact terms, but needs only to be blended neatly and smoothly into the flanks. Such cams, working in conjunction with roller followers, give quite efficient operation up to engine speeds of three to four thousand r.p.m., though they are not recommended for really high-performance *engines.* It is permissible to file the cam profiles, but I have described more precise methods: they include indexing in the lathe, and milling the tangential surfaces, or using a roller filing rest. The base circle must be exactly concentric with the shaft axis, and this can also be achieved by any of these methods. For the nose radius, it is difficult to devise any simple method other than hand filing, but this is quite satisfactory if carefully carried out. When the cam surfaces are finished, and cross drilled for pinning to the shaft, they should be case-hardened and polished.

Our valve rockers are in the form of bronze castings which need only drilling, spot facing and tapping for pivot bolts, apart from some cleaning up by filing. By fitting eccentric rocker pivots to the cylinder head, the need for adjusting screws and lock nuts on the valve end of the rockers is avoided. The inlet rocker is operated through a push rod, attached to a forked bronze guide which fits between the two cams, and carries the cam roller. As the roller positions in this part, and also the exhaust *rocker, are* reversible, the relative positions of the cams are immaterial, but their end location and spacing

The drawing shows a butt joint between barrel and throatplate, but in reply to J.B. in Queries of July 19 ME recommended a stepped ring at this position.

A piece of tube for the ring will be hard to come by, but I could probably rustle up a piece of 3/16 in. copper bar, bend and braze it into a ring, and turn it up on a mandrel to fit. Would this be satisfactory?

The length of the steam collector pipe is not given. Presumably it is silver-soldered to the regulator tube and passes up through the 3/4 in. hole in the dome bush. How far above the bush should its end be?

LBSC is rather sketchy over the backhead arrangement and refers one to ***Southern Maid*** for further details. Would any of the PM ***Southern Maid*** sheets be of use to me?

I would like a photograph or two of the full-size 5XPs and also a few technical details. To whom should I write for them?

I like to get doubts cleared up as they come to light—there are probably others to be met as the work proceeds. -A.M.S., Bridport, Dorset.

▲ ***Although it is possible to produce a tapered boiler barrel in the way that you describe, this is not an easy method, and it leaves the material on the thin side at the larger end.***

There are two other methods which you could adopt: roll the barrel up from sheet or use a seamless tube 3¼ in. o.d. and cut a V-slot out of it, the width of the V to correspond with the required smaller circumference at the smaller end. Soften the tube and squeeze it in until the new edges meet.

A stepped ring at the throatplate is a safer method for anyone without a good deal of experience in brazing. The ring can be bent up from sheet or strip copper.

The steam collector pipe may reach almost to the top of the inner dome, as long as about 1/8 in. gap is left. Zt is screwed into the regulator tube so that it can be removed when the regulator is withdrawn.

It is not likely that the SOUTHERN MAID ***backhead arrangement will help you.***

Photographs of the 5XP class can be obtained from the PRO, British Railways, Midland Region, Euston House, London NW1 (price ***3s. 6d.).***

Hacksaw machine

Are the full set of castings and the material as supplied by W. H. Hazelgrove, for the small power hacksaw machine still obtainable ?-A. J.B., Croydon, London.

▲ ***The firm of W. H. Hazelgrove is no longer in business.***

You might try Woking Precision Models Ltd, Victoria House, Victoria Road, Woking, Surrey. They have plans for the supply of ***parts for a small hacksaw machine.***

Railway liveries

Although I have been a reader of ME for some time I am afraid that it is only twelve months since I placed a regular order for my copies.

During the time just before I placed the order I missed quite a few issues of ME. Could you please tell me the dates of the issue that contain articles 1 to 4 of Railway Liveries, and if these issues may still be obtained?

Could you tell me if there is any book published on railway liveries ?-R.C.B., Nottingham.

▲ ***The articles on Railway Liveries appeared in ME on the following dates :***

1. ***LNER,*** 20 ***October 1960.***
2. ***GWR, 17 November 1960.***
3. ***LMS, 19 January 1961.***
4. ***Southern, 30 March 1961.***
5. ***GNR, 15 March 1962.***
6. ***Midland, 26 July 1962.***
7. ***LSWR, 18 October 1962.***
8. ***LBSC, 15 November 1962.***
9. ***LNWR, 13 December 1962.***
10. ***LYR,*** 10 ***January 1963.***
11. ***GCR, 7 February 1963.***
12. ***SECR,*** 21 ***February 1963.***

WYVERN

Continued *from page 53*

on the shaft should suit the width and position of the roller guide. When the cams have been timed, to operate the valves according to the timing diagram, with the engine running clockwise at the timing end, they may be pinned to the camshaft, preferably with taper pins in accurately reamed or broached holes. Grub screws, even if sunk into dimples on the shaft, are not secure enough for permanent fixing, though they may be used temporarily to test timing accuracy in the first test runs.

The flywheels are taper bored to take split collets for mounting them on the crankshaft. This is not in accordance with full-size practice, where keyways and long rectangular keys are employed, but I have found it very difficult to fit such keys to scale limits, and I have come to the conclusion that the only way to provide secure mounting for parts with high inertia loading is by taper friction fits. Keying is not adequate, because under heavy inertia they tend to become distorted or crushed, so that hammering occurs and both the keyways and keys are soon destroyed. The split collets can be bored and turned at one setting; they should on no account be loose on the shaft, and their outside taper should match the bore of the shaft exactly, but no attempt should be made to correct inaccurate fits by lapping.

To machine the flywheel rims, I have found it best to mount them firmly on the lathe faceplate, against a wood backing plate. If they are mounted by the bore on a mandrel, it will generally be found difficult to prevent chattering when the rim is turned, in the absence of further support of this kind. The taper bore may, of course, be turned at the same setting as the rim, so that the flywheel runs truly when it is mounted on the shaft.

This completes the essential machining on the gas engine components, and the only further work involved is the drilling and tapping of holes to mate with those already mentioned, and the fitting of studs, and the general assembly, which should be quite straightforward. The engine will, of course, require equipment for carburation, to use either gas or liquid fuel, and also ignition; these accessories will be described later. At present, no provision is made for governing the engine to provide constant speed at varying load, but I am prepared, if there are enough requests, to design and describe the additional components required. r3

Edgar T. Westbury describes the equipment for carburation and ignition

Completing the WYVERN

PUTTING the ***Wyvern*** engine in working order, calls for additional pieces of equipment, as I mentioned on May 15. Many engine constructors have their own ideas and preferences in the design of these details, and it seems to be the exception for engines to be equipped with the carburettor and ignition gear originally designed for them. While a good deal of latitude is usually permissible in detail component design and the ***Wyvern*** design is by no means exacting, it is a sound policy, at least for the inexperienced constructor, to stick to the accessories designed to suit a particular engine.

If the ***Wyvern*** is to be made capable of running on either gas or liquid fuel, it must be equipped with two separate fuel-air mixing systems with a special dual-fuel system. The dual-feed is of course the more compact, and can be designed to be little more complicated or difficult to construct than the equipment for one fuel only. This has been done successfully on some of my earlier engines, including the ***Centaur,*** described a few years ago, but it is really the outcome of still earlier experience, as I once drove my workshop machinery with an engine which could be instantly changed over to run on either gas or petrol-or even, on both fuels simultaneously.

The carburettor designed for the ***Wyvern*** works on a principle that was used on some of the very earliest liquid-fuel mixing devices. It employs a lift valve which, by its variable opening, controls the flow of both air and fuel in more or less correct proportion. Sometimes the valve is lightly spring-loaded, but if it works only in a vertical position, gravity loading is usually sufficient. I used mixing valves of this type (for liquid fuel only) in the experimental stages of the Atom Z (1926) and ***Atom Minor*** (1932) engines.

To adapt this principle for gas and liquid fuels, two fuel control systems must be provided, and also separate orifices for injecting the fuel into the air flowing through the valve. When there is no air flow-in other words, when the engine is stationary-it remains on its seating, and seals off the flow of fuel from the orifices. The area of the valve opening is equal to that of the air intake port when its lift is equal to one-fourth of the port diameter, but we have to limit the lift, to damp its momentum and to make certain that maximum air velocity is kept up through the valve throat. It serves, in fact, as a variable choke tube, and ensures that suction on the fuel orifices is always maintained. Except at the lowest speed, the valve is held open by engine suction or kept floating in mid-position. A normal piston, barrel or butterfly throttle valve on the discharge side of the valve can be used to control engine speed.

In the construction of this carburettor, all machining operations have been kept as straightforward as possible, but some of the parts are rather small and care is needed for proper fitting and concentricity. This is inevitable if the size of the assembly is to be kept in proportion to that of the engine itself, but having parts large and unwieldy does not necessarily make them any easier to construct, and none of these small parts should present any difficulty.

You can hold the body in the four-jaw chuck, bottom face outwards, for facing, boring and drilling it concentrically to fit the throttle. Then you had better mount it on an angle plate to face and bore the discharge flange and passage. As an alternative, it can be held in the four-jaw chuck for this operation if the machined face is protected by a flat slip of metal to prevent bruising by the chuck jaws. The bore should be chamfered or flared at the mouth, to match the diameter of the port in the cylinder head. Some constructors may think that the bore of the air passages are very small for an engine of 40 C.C. Rut the ***Wyvem*** is not intended to run at high speed; it should have a wide speed range, and be capable of throttling down to under 200 r.p.m.

Using the same set-up you may true the back face of the flange with a left-hand side tool, but a fillet should be left in the corner so that it is not unduly weakened at this point. To face the top boss of the casting you should mount it on a spigot. A hole is drilled and tapped horizontally opposite the discharge port to take the throttle stop screw.

The throttle barrel may be machined from the solid, and should fit smoothly both in the centre hole and counterbore. It may be marked out to indicate the position of the outlet port, or drilled in position if you take care to avoid raising burrs which may prevent it from being readily removed. With the port wide open, it is marked to show the limit of the slot for the stop screw, and is then again marked in the (almost) closed position; the slot is cut by end milling, or drilling and filing, between these points. The hole which forms the guide for the valve must be exactly concentric with the rotating surfaces, and an easy fit for the spindle.

You can use a piece of brass bar 5/16 in. X 3/16 in. to make the throttle lever to the shape shown, or you can machine a tapered round shank with a ball end, similar to that of the ***Whippet*** carburettor. The bore for the throttle spindle should be reamed to a wringing fit, and the cross hole for the clamp screw should be drilled and tapped, before the sawcut is made.

Chuck the valve housing by the intake end for carrying out the essential operations-drilling, counterboring, facing and bevelling the seating-which must all be concentric with each other. At the top, the spigot should register neatly in the bore of the body. You can square out the bore of the passage with either a D-bit or a drill ground flat at the end. The hole at the bottom should be an easy fit for the spindle of the lift valve-to have it a little slack is better than any risk of binding. Three holes 3/16 in. diameter are drilled horizontally at 120 degrees to each other to form air inlets. A cylindrical air shutter may be fitted to help in starting from cold, but there is always a temptation to use it as a running control, and in normal circumstances it should not be needed.

Two holes are drilled and tapped horizontally through the upper part of the body for the fuel control valves. Of course, if the engine is required to run on only one fuel, duplication of controls is unnecessary. It is highly important that both ends of the holes should be faced squarely to produce a true seating for the other fittings. You can best do this by turning and screwing a piece of metal in the chuck to mount the housing truly for dealing with the four faces in turn. At the same setting, the first thread in each case should be bored out-with a small boring tool, not a drill-to enable the fittings to screw right home to the shoulder.

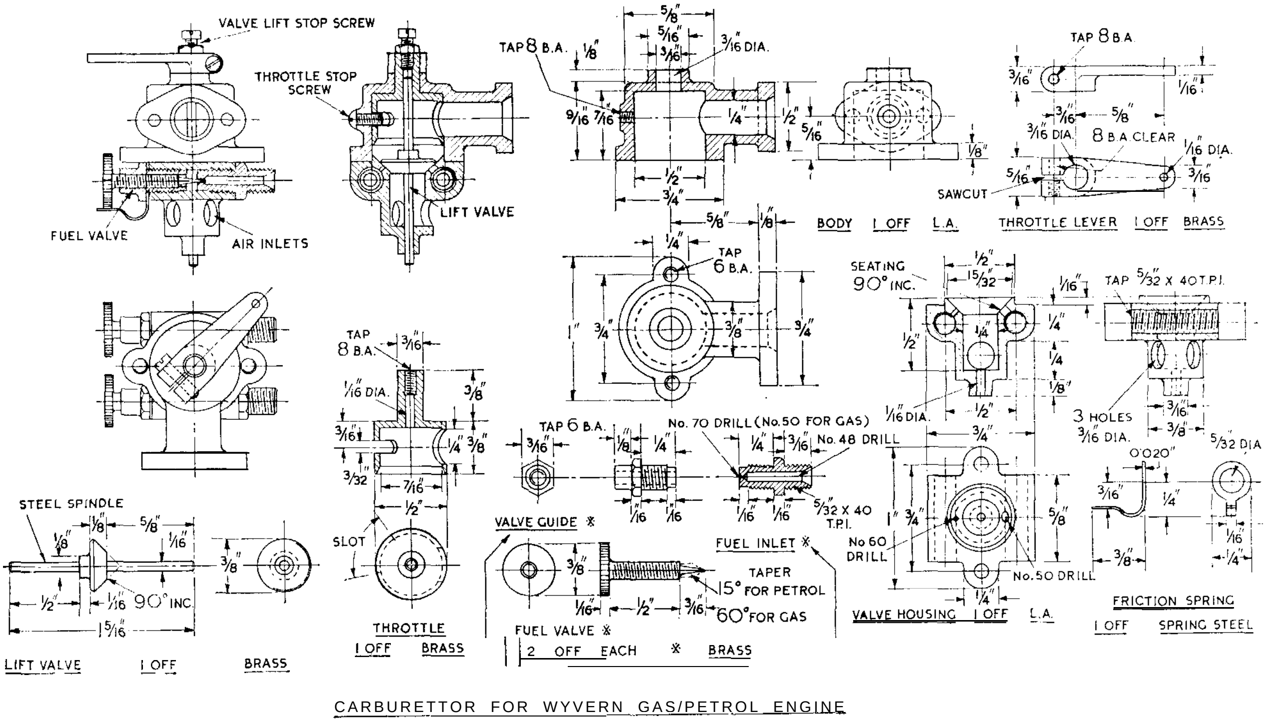
Finally, the orifices should be drilled from the valve seatings into the horizontal tapped holes. The sizes of the holes are not critical, as they do not control the metering of the fuel; but as mains gas pressure varies in different localities, some readers may have to enlarge the gas orifice, or possibly drill more than one hole, to be sure of an adequate supply.

The lift valve is turned and drilled at one setting; it should be a tight fit on the steel, bronze or german silver spindle, and concentrically true all over. A good contact all over the area of the seating is essential, but only light grinding-in, to bed down high spots or burrs, should be required. The parts for the fuel control system (marked * on the detail drawings) are all in brass, and are fairly straightforward to machine from bar stock. Minor differences to deal with the two fuels are indicated. It is important that the drilling, tapping and external screwing of these parts should be dead true so that they line up properly when assembled.

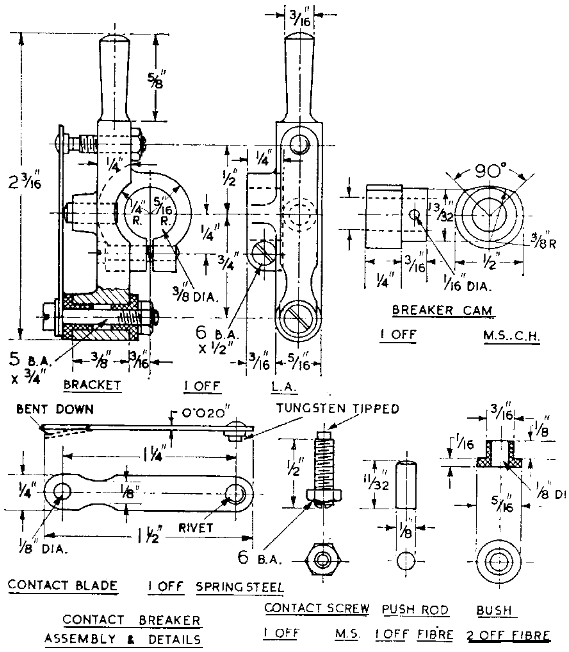
Apart from the size and angle of the conical ends, the two fuel valves are identical. With the petrol valve, an inserted point, such as a gramophone needle, may be fitted, as brass or a similar metal is liable to be damaged if screwed up tightly, Neither of the valves should be used to shut off fuel supply completely, but only as running adjustment of the mixture. Each of them should have a friction retaining spring, which may be made from carbon steel such as is used for the contact breaker blade, and clamped under the head of the valve housing. The tail of the spring should be filed slightly convex where it engages with the knurled head of the valve.

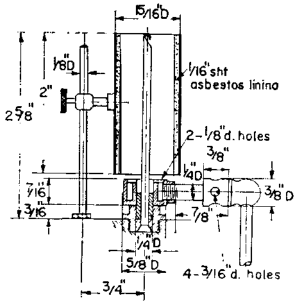
In most horizontal gas and oil engines the exhaust pipe is directed downwards to a silencer below base level. A similar arrangement is suitable for the Wyvern. You will need to fit a short right-angled bend to the flange on the cylinder head so that the exhaust pipe can be kept clear of the carburettor. A simple expansion chamber about the size of a r-pint flask will form an effective silencer, and it may be placed at any convenient point in the exhaust system.

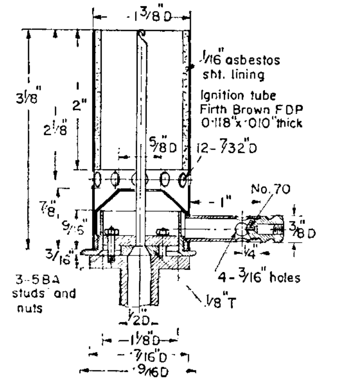
The simple wick-syphon-feed lubricator, fitted to the two main bearings and the cylinder skirt, will sufftce for most requirements. It can be machined from brass bar in two pieces. The outer component is a cup with a hole in the centre, and the inner comprises the wick tube, hexagonal collar and screwed end. If these parts are properly fitted, soft solder will suffice to join them, but silver soldering is better, and is equal in strength to a solid



CARBURETTOR FOR WYVERN GAS/PETROL ENGINE







Above and right: Hot-tube ignition units by Mr D. H. Chaddock

integral component. The lubricator cap is made a light friction fit in the mouth of the cup. For lubricating the big end bearing, the oil cup shown will serve on runs of up to a few minutes, but for long runs you should drill oil-ways in the crankshaft or fit a banjo lubricator.

To run the engine on gas, you had better fit a gas bag or " anti-fluctuator " in the supply pipe, to prevent interference with other adjacent gas supplies. Any flexible container, such as a small football bladder, or a rubber diaphragm fitted to a flat shallow can, will serve this purpose.

The most popular method of ignition-and the most effective and reliable on the whole-is by a high-tension spark, produced by a battery and coil, or some form of engine-driven generator. Low-tension electric ignition, in which a mechanical breaker inside the cylinder produces an inductance spark or so-called arc, is little used nowadays. From such experiments as I have made with this system, it seems not to economise current, and the equipment for it, including the special inductance coil, has never been obtainable in a small size. Glow-plug ignition, using some form of low voltage resistance heating element, is practicable. But it is very sensitive to fuel characteristics, and is not really suitable for modern motor fuels.

There are two coil systems suitable for engines working at low or moderate speeds. The first of these, known as the trembler coil, was very popular in the early days. One of its advantages is that it will work with very simple timing control mechanism on the engine itself. You need only a simple wipe contact, consisting of a projecting stud or segment on the camshaft, to make contact with an insulated spring blade at the appropriate moment. No suitable coils are produced now. But relics of the past, including the coils used on the old Model T Ford (in sets of four), are sometimes to be picked up cheaply. They give excellent results on a small four-volt accumulator.

The modern non-trembler coil demands a rather more elaborate contact-breaker on the engine, and also an external condenser shunted across the contacts. If size is no object, you can use a motor car ignition coil,, which will usually give quite a good spark at much less than its rated voltage. But the Runbaken Mini-coil or the Wipac motor-cycle coil, both of which are much smaller, have given equally efficient results.

In the ***Wyvern*** the contact breaker is mounted on the inner extension of the cylinder head end camshaft bearing. It is a spring-blade type breaker operated by a suitably timed cam through a small fibre push rod. This principle of operation has been thoroughly tried out on several of my engines over a quarter of a century or more. The breaker works with the minimum mechanical effort over a very wide speed range, and is readily accessible and easily adjusted or serviced.

The bracket shown in the assembly drawing is an aluminium alloy casting, which you can hold in the four-jaw chuck for boring the centre to fit stiffly on the camshaft bearing. At the same setting machine the arc in the vertical part to make certain that it clears the cam when this is fitted. The holes for the blade securing screw, push rod and contact screw are then drilled. Those for the contact screw are also tapped and are spot faced for the lock nut; the lower hole should be spot-faced on both sides so that the insulating bushes seat truly. After drilling and tapping the hole for the clamp screw, split the lug by a hand or machine saw.

It will be seen that the securing screw in this contact breaker is in metallic contact with the spring blade, and is insulated from the bracket by the two bushes, so that it can be used as the live 1.t. terminal. This is an alternative to the arrangement on the ***Whippet*** contact breaker, in which the blade must be insulated from the screw. I believe it to be rather better, but either form is practicable, and gives reliable results.

For the rest, construction is generally similar to that of the ***Whippet; the*** same care must be taken in lining up the contacts and making the electrical connections. The blade should be narrowed near the fixed end as shown, to ensure that it flexes here and not at some indeterminate point; it should also be bent downwards to produce a really

O *Continued on page 479*

mill of this diameter is long enough to reach, without its shank fouling the body of the cylinder block. In my next instalment I shall include some pictures showing how this operation is carried out and giving a general idea of the assembly.

Our next operation on the cylinder blocks and the steam chest ***is*** the drilling of the fixing holes. The arrangement on the top flange is different from that on the bottom. This is done to clear various obstructions, for on the top of the steam chest we have the steam pipe flange, and along the bottom we have two large tapped holes which act as observation holes while the valve setting is being carried out. The front hole is afterwards fitted with a tapped plug, and made steam tight, and the rear hole forms a very convenient place to fit a drain valve, so that the driver can clear the cylinders of condensate at the beginning of a run, or after the engine has been standing for any length of time. You had better mark out the holes on both the cylinder block flanges and then drill them about 3/32 in. dia. Assemble the two blocks and the steam chest in correct alignment, and run the 3/32 in. drill through half-way, from each side in turn, so that they meet in the middle. Then run the No 34 drill right through, part them, and clean up the burrs.

My picture shows a two-throw crank axle under construction : this is not for a ***Boxhill,*** but for another type of inside cylinder 5 in. gauge locomotive. While the eccentrics have not yet been fitted, the two pairs of webs and crankpins have been assembled and pinned.

* ***To be continued***

WYVERN

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firm contact when the cam allows it to do so. Some adjustment of the length of the push rod may be necessary to make the blade parallel with the vertical arm. It should be an easy fit in the hole.

The breaker cam has a cylindrical working surface, with about a quarter of its circumference cut away to aliow the contacts to close. Most ignition cams on small rngines simply have a flat cut on them to allow closure; this works quite well, but imposes more shock and wear on the parts than is necessary. A radius or rather more gentle change of contour is much better. You can easily machine it by setting the cam eccentric to the required extent; afterwards the sub-angles where the contours merge are eased off with a fine file or an oilstcne before you case-harden the cam.

To time the ignition, the engine is set at t.d.c. on the firing stroke. The contact breaker is set vertical, and the cam is turned in the direction of rotation until the contacts have closed and are again just beginning to break; the cam is then secured by permanent pinning, or by a grub screw sunk into a dimple in the shaft. The movement of the breaker over 10 to 15 degrees will give all the advance and retard control for the speed range of the engine. If a trembler coil is used, the contact blade may be mounted on the same type of bracket, and adjusted in the same way, but note that the trembler type of coil fires on the ***make,*** and not like the non-trembler, on the ***break*** of contact.

Magneto ignition is practicable for the ***Wyvern,*** but a miniature magneto such as the Atomag Minor cannot be expected to work efficiently at the lower ranges of speed.

Some constructors may like to try hot-tube ignition. Though it is now completely obsolete, it gave thoroughly reliable results in the early days. My old friend Dennis H. Chaddock, whose help and advice on many aspects of engine design have been invaluable to me, has made some interesting and generally successful experiments with this method on two old gas engines of small size. His ignition tubes are made of a special alloy steel (Fir&Brown FDP) with a high resistance to oxidation at temperatures in the region of red heat-a great improvement on the old iron tubes, which rapidly corroded away, or the porcelain tubes, which were fragile and sometimes burst through uneven expansion. Platinum tubes, once used on motor car engines, would be prohibitively expensive even if they could be obtained.

Because of the small size, the tubes can be heated efficiently with very small burners, unlike the old tubes, which often needed more gas to heat them than was consumed by a little engine. Drawings of two of the ignition units used by Mr. Chaddock, including the tube, bunsen burner and chimney, are shown here. Both are intended for vertical mounting, presumably on top of the cylinder. This could not be done in the ***Wyvern,*** but an elbow pipe screwed into the sparking plug hole would enable them to be adapted. I suggest that a better arrangement, though possibly calling for some experiment, would be to use a directly-mounted horizontal tube, with a suitably modified burner and chimney.

Special material for the tubes may be hard to obtain; if any reader with access to special metal supplies can help, I shall be grateful. The securing and sealing of the open end of the tube, and its closure at the other end. may present problems. In the examples shown, the tube is expanded to form an inverted conical joint at the bottom, and is squeezed flat and folded over at the top. Some control of ignition timing is possible by regulation of the heat applied by the burner, or the position of maximum intensity relative to the length of the tube.

Mr Chaddock tells me that, while these ignition devices work perfectly on both engines when mains gas is used, he has so far entirely failed to get them to fire when they are adapted for butane or another bottled gas. No doubt this is owing to the different ignition characteristics of these fuels; as modern petrol also has a high ignition temperature, to inhibit knock or pre-ignition, this might make it less suitable for hot-tube ignition than gases or other fuels with free hydrogen content.

The only other accessory needed to complete the installation of the ***Wyvern*** is the water-cooling system. Most gas and oil engines employed a plain cylindrical tank of sufficient capacity, and connections at top and bottom enabled the water to circulate by natural convection, or thermo-syphon action. The tank for the ***Wyvern*** should be of not less than 1,000 c.c or I quart capacity, and preferably more. It should be placed at such a level that the outlet pipe from the engine has a rise of at least two or three inches; the inlet pipe may be horizontal, or have a slight fall towards the engine. The internal diameter of the pipes should not be less than 3/16 in., to allow free circulation of water through the system. B