Introducing the WALLABY

EDGAR T. WESTBURY redesigns the 30 C.C. petrol engine which he made for locomotive 1831. It can be used to power a model boat

More than twenty years ago I set out to design a model locomotive propelled by an internal combustion engine, in response to many requests from readers who were interested in this form of motive power. That was in the dark days of the war when I had time for contemplation while I was carrying out fire-watching and other necessary duties.

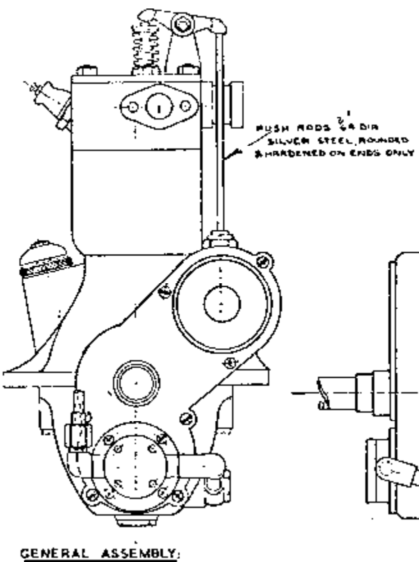
So far as I am aware, no very serious attempt had been made to design a model locomotive of this type before. It involved special problems which called for very careful consideration. The original engine which I selected for the design dictated to a great extent by the information obtainable-was the LMS diesel shunting locomotive 1831, which began its working life as a steam-driven 0-6-0 tank and had been experimentally converted by the fitting of a diesel engine and a hydraulic torque converter.

I do not propose to discuss the model locomotive as such, beyond saying that while it proved itself capable of carrying out the task for which it was designed, it did not, because of its unorthodoxy, make any great impression on model locomotive builders-nor was it expected to do so. But the engine incorporated in the unit attracted the attention of many model engineers who were not particularly interested in putting it into a locomotive, and it proved to be very well suited to other duties, including model power boat propulsion.

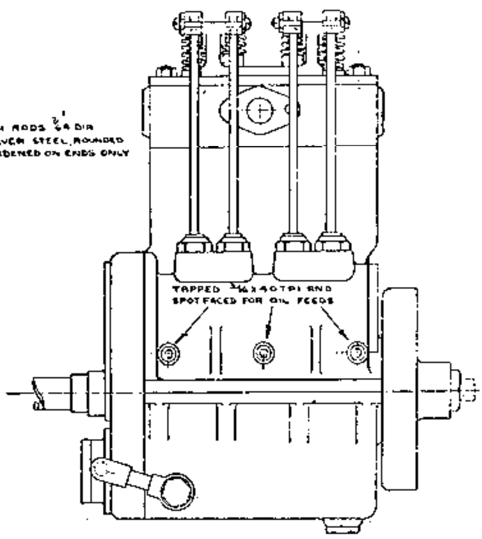
In the years following the war, interest in the construction of model petrol engines tended to decline, mainly because ready-made i.c. engines could be bought. Power boat builders who needed engines simply as a means of propulsion generally found that these engines were more or less satisfactory for their purpose and saved the time and effort of producing engines themselves. There has, however, been a revival of interest in engine construction in recent years, particularly in the larger sizes of engine, which are suited to heavy duty at moderate speed, and are more readily controllable than most of the small high-rewing ones; moreover, their ability to run on normal motor fuels, instead of expensive diesel or glow plug fuels, gives them an economic advantage.

The engine of the 1831 locomotive has features of design which have proved very successful in modern power boats, particularly those equipped for radio control. There has been a widespread demand for the revival of the design. The castings and parts were originally supplied by Mr W. H. Haselgrove of Petts Wood, Kent, but, unfortunately, Mr Haselgrove has now retired from business and there has been some difficulty in arranging for another source of supply. It has, of course, been necessary to make entirely new patterns, and to provide for other special raw materials. After many delays, I am able to announce that Woking Precision Models of 32 Mount Hermon Road, Woking, Surrey, have undertaken to supply castings and parts.

Though the engine design has achieved maturity in age, it is by no means archaic or out of date. The essentials of design do not change as rapidly as some people think, and many " advanced "features in full-size practice are little more than old ones improved in detail, and perhaps made of better material, or more accurately. On careful investigation of the 1831 engine design, I found little which called for drastic alteration



GENERAL ASSEMBLY:
TIMING END ELEVATION



SIDE ELEVATION

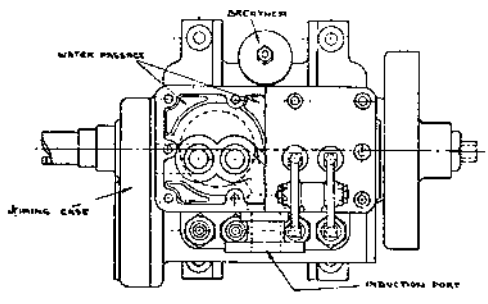
in any of the major components, to bring them fully into line with modern practice. and only a few details have been modified and improved.

The characteristics of the engine design are, I think, worthy of a brief review for the benefit of readers not already acquainted with it. First, I may mention that the choice of a twin-cylinder engine for the 1831 was determined by the installation space. More than one cylinder was desirable, to ensure even torque, but the longitudinal space in a short wheelbase 0-6-0 chassis made it difficult to accommodate four cylinders. At the time when I designed the engine. the vertical twin was not very popular: it has since proved one of the most successful engines for motorcycles, and has been produced by various manufacturers for this purpose.

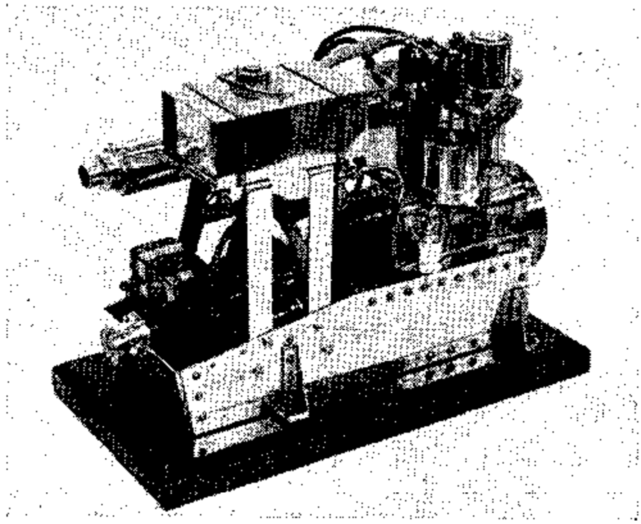
In a small engine, the twin has some compromise between the single and the four-cylinder, with some of the virtues of both and the worst vices of neither. The result, assuming sound detail design and construction, is an engine capable of packing a good punch for its size, yet docile and flexible withal, and not too difficult to construct. Some of its features have been introduced to make it suitable for running continuously for longer periods than are usual in model practice. Among them are the heavy split main bearings, with provision for forced lubrication, and the robust valve operating mechanism which includes unusually broad timing gears. Vertical overhead valves, conducive to high performance, were preferred to side valves, which tend to limit combustion efficiency. To avoid mechanical complication, they are operated through plain rockers, push rods and flat-based tappets.

fins. While such engines may be moderately successful, the difference of temperature between the head and the barrel must inevitably introduce a liability to distortion and also limit the power output, especially on long runs.

The porting of the cylinder head casting is somewhat unusual, as it has the exhaust outlets at the two ends, with a single inlet port, leading to siamesed passages, in the middle of one side. In order to keep the push rods transversely in line with the valves, and thereby avoid offsetting the rockers, no adequate space for exhaust outlets could be found on the same side as the inlet, and it was undesirable to locate them on the same side as the sparking plugs. Some coppersmithing is, therefore, called for in the exhaust pipe system, but this does not appear to have given constructors any particular trouble so far. Pipes with nice sweeping bends are certainly no disadvantage; if anything, they enhance the appearance of the engine as a whole.



PLAN EXPOSING CYLINDER HEAD



Here is an* 1831 *engine adapted as a marine power unit by G. L. Jones of the Victoria MSC

advantages over an engine with a larger number of cylinders, because the fewer and more robust working parts permit running friction to be reduced, with an improvement in mechanical efficiency. Even torque is attainable by locating the two crankpins in the same plane, so that the cylinders fire on alternate revolutions; though this would appear to be bad from the aspect of balancing reciprocating masses, the effect is less serious than might be expected. In twin cylinder engines with equal firing intervals, mixture distribution is less likely to be troublesome than in irregular-timed engines such as V-twins,. or even flat twins, in which long induction pipes introduce complications. Four-cylinder engines have their own induction troubles, too, and in the very small sizes I have found that the best palliative-I will not say cure-for these is to use a hot-spotted induction-exhaust manifold.

Altogether, it may be said that a vertical twin represents a good

In any small engine with more than one cylinder, there is some difficulty in finding room for all the ports and passages in a single cylinder head casting, and at the same time providing an adequate number of securing studs or screws, evenly spaced to ensure that the joint faces are not liable to distortion. The problem is further complicated by the need to provide space and communicating passages for the flow of cooling water. I know that many engines have been built in which only the cylinder barrels are water-jacketed, and the heads are left to look after themselves, with the dubious aid of one or two rudimentary

As the two pistons of the engine move in unison, they create a displacement of air in the crankcase. The air must be released to prevent mechanical pumping losses. A breather, combined with an oil-filler cap, is provided for this purpose, and fitting it with a light disc valve keeps the mean crankcase pressure slightly below atmospheric. The suction could be used to feed oil to the crankcase when it is not convenient to fit an oil pump, but in any event it helps to keep the engine clean externally, by preventing leakage of oil from bearings and tappets. In a small engine, however, it is very difficult to prevent the escape of some oil mist from the breather; extending it to the highest possible level will help to some extent, but the most effective method would be to connect the breather to a pipe discharging into the carburettor intake.

In the original version of this engine, the structural castings were made in gunmetal, whose weight was an advantage in a locomotive from the aspect of adhesion. But boat work nearly always calls for some economy in weight and, therefore, aluminium alloy is specified in the revised design. Another feature of the locomotive engine, which is optional when the engine is employed for other duties, is the centrifugal clutch. This enables it to take up tractive drive more gradually than with a positive coupling. It also serves as an anti-stalling device, for the clutch would slip if the engine speed was slowed down by overload. In boat work there is less risk of stalling, unless an oversize or otherwise unsuitable propeller is fitted, but a " free engine " may be an advantage when it is throttled down to idling speed. If the clutch is not fitted, you can well increase the size of the flywheel so that its momentum is sufficient to cope with the slowest speed of the engine. Apart from the actual weight, a large flywheel is only a disadvantage when an engine is required to change its speed very rapidly; not a common condition in model practice, except possibly for racing engines. But most boat builders these days wish to keep the weight of the power plant as low as possible, and are reluctant to use larger flywheels than are absolutely necessary.

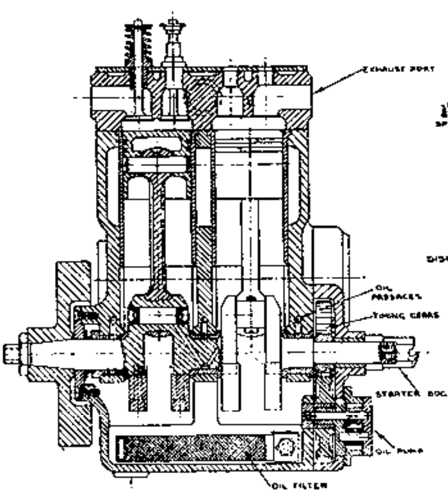
A special carburettor was designed for the 1831 engine, to cope with the conditions encountered in traction duties. Its main features were flexibility of control over a wide speed range, and a prompt pick-up, or response to control, after a slowing down by throttling or overload. After some experimental work, it was found that these conditions were met by a somewhat similar carburettor to the one employed successfully in the ME Aveling road roller, but with the addition of float-feed. This employs a needle-adjusted jet in a small primary choke tube,, a barrel throttle, and an air valve with a spring-loaded piston and ported sleeve.

At idling speed, the air valve remains closed, and the small choke tube supplies all the air required; but as the throttle is opened and suction increases, this acts on the piston of the air valve and opens the ports to a greater or less extent, to restore the balance of pressure and keep the strength of the mixture fairly constant. This principle, with infinite variations, has been applied to many carburettors in the past, including the early Longuemare and Krebbs, which were among the first really automatic carburettors to be used on motor cars.

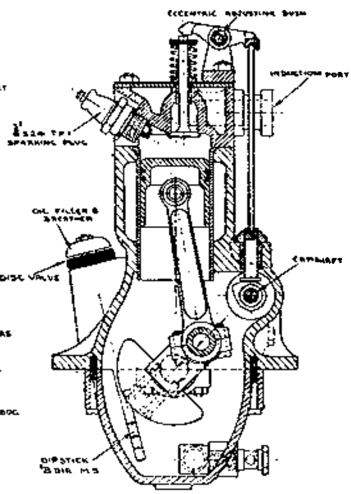
Some constructors have considered the carburettor too complicated, and bulky, and have asked about the possibilities of designing a simpler one. It is, of course, quite practicable to use some of the carburettors designed for other engines, such as the Kiwi or the ***Atom Type R,*** which are smaller and have fewer parts. The ***Kiwi*** has been tried, and gives fairly satisfactory results, but as its compensation is purely mechanical (by throttle action), its anti-stalling properties, and acceleration under full load, are not quite so good. This may not be very important in marine work, where the load is always more or less in proportion to the engine speed.

Three optional systems of coil ignition were specified for the original: normal single-pole coil, contact-breaker and h.t. distributor: by double-pole coil and single contact-breaker only; and by twin coils and double contact-breaker. With the first two, the contact-breaker is fitted on the engine shaft, but could be fitted to the camshaft with a double-break cam, as is required for the third. Magneto ignition can also be applied, with the Atomag Minor, direct-coupled to the engine shaft or gear-driven from it at the same speed. The h.t. lead of the magneto is connected to the input terminal of the distributor, and no other wiring is needed. Yet another course is to substitute the Atomax four-pole system for the standard flywheel. in which event the first arrangement is employed. All this may sound a little confusing, but in actual practice either system is extremely simple, and involves only elementary electric principles.

The locomotive from which the design of the model was adapted never had a name, so far as I am aware (though it might have had quite a few names bestowed upon it at various times by its running and maintenance crew!) and was distinguished only by its number, " 1831." This is not a very appropriate appelation for identification, as many readers. in referring to it, have mixed or misquoted the number, and I have even been asked if it applies to the date of construction! I have, therefore, decided to give the improved engine a new name. which should be more distinctive and easier to remember than a numter. As with many of my earlier designs. 1 have borrowed the name from the animal kingdom, and for the benefit of those not well versed in zoology, I will explain that a Wallaby is " a marsupial of the genus or sub-genus ***Halmaturus,*** indigenous to Australasia." In later articles I shall describe the construction of the Wallaby which will. I trust. be found as lively and energetic as its original. ❑



SECTIONAL SIDE ELEVATION



SECTIONAL END ELEVATION
TIMING END VIEW

More information on small i.c. engines can be had from Edgar T. West bury's book ***Model Petrol Engines,*** price 8s. 6d., or 9s. 2d. by post, from these offices. The book deals fully with the design, construction and application of the miniature i.c. engine.

Machining the main castings

Take care in the early stages. EDGAR T. WESTBURY tells you how to avoid those headaches at a later date

THE body casting is the largest component of this engine, and as it involves a number of machining operations, all of which have a relation to the fit and location of other parts, it is desirable to take it in hand first.

In the design of any engine intended for construction in a home workshop, the limitations of equipment must be taken into account, and in common with nearly all my engines, the ***Wallaby*** has been designed so that all its components can-be machined on a 3½ in. gap-bed lathe.

Castings on which a number of surfaces have to be machined usually call for some preliminary marking out to ensure that surfaces will all clean up to specified dimensions and in correct relation to other unmachined areas.

Continued from 19 April, poges 475 to 477

I do not believe in making an elaborate ritual of marking out, as I usually find it sufficient to check general locations, and then to machine one of the most important surfaces, which can be used for a reference face.

The main reference surface on this casting is the bottom face, and this can be machined by holding it- at the top end in the four-jaw chuck. It is not essential to centre it, but it should be set to run true on the outer face, so that the feet will machine to even thickness and the sides of the water jacket will be vertical, in other words, square with the base.

A smooth and truly flat surface is essential, as it forms a joint with the sump casting and also a seating for the main bearing caps.

Before removing the casting from the chuck, a longitudinal centre line may be scribed on it to mark the bearing centre, by a scribing block on the lathe bed, or on a flat, parallel plate laid on it to provide a continuous surface. The small Myford surface plate. which is speciallv designed to form a seating on the lathe bed, is very useful for operations of this nature.

Before scribing the centre line, check the position of the casting to see that its sides are horizontal and end faces are vertical: the height of the scriber should be adjusted so that it is central with the boss of the flywheel end of the casting. This centre line should be continued up both end faces of the casting so that it can be ioined up later with a centre line on the top face, after this has been machined.

The casting may now be removed from the chuck and mounted on the faceplate, in the reverse position, by four clamps over the feet. Before doing so, any roughness or inaccuracy in the edges of the feet should be corrected, for reasons which will be seen later. The top surface of the casting may now be machined,. but preferably not quite to fiinshed dimensions, as it is advisable to leave a few thou to be skimmed after the cylinder liners are fitted.

In order to locate the centres of the cylinder liner seating, it is advisable to plug the cored holes in the castings with hardwood or similar material. The longitudinal centre line may be picked up from that already scribed on the side faces, and cross lines by measurement from the ends and middle.

As the wood may not take a very good scribed line, I have found it best, after locating the centres roughly, to drive flat-headed drawing pins into the wood, and mark the exact centres on them. The casting is then moved on the faceplate to set each of these centres true in turn for boring the cylinder seatings, the plugs, of course, being removed for this operation.

It will be noted that the diameters specified for the bores of the top and bottom liner seatings are different. This is optional. as the only really important point is that the liners should fit properly at both seatings. But thev are easier to insert if thev do not have to be pressed all the way with the risk of getting them out of square. A tapered bore might appear more logical, but it is difficult to gauge accurately.

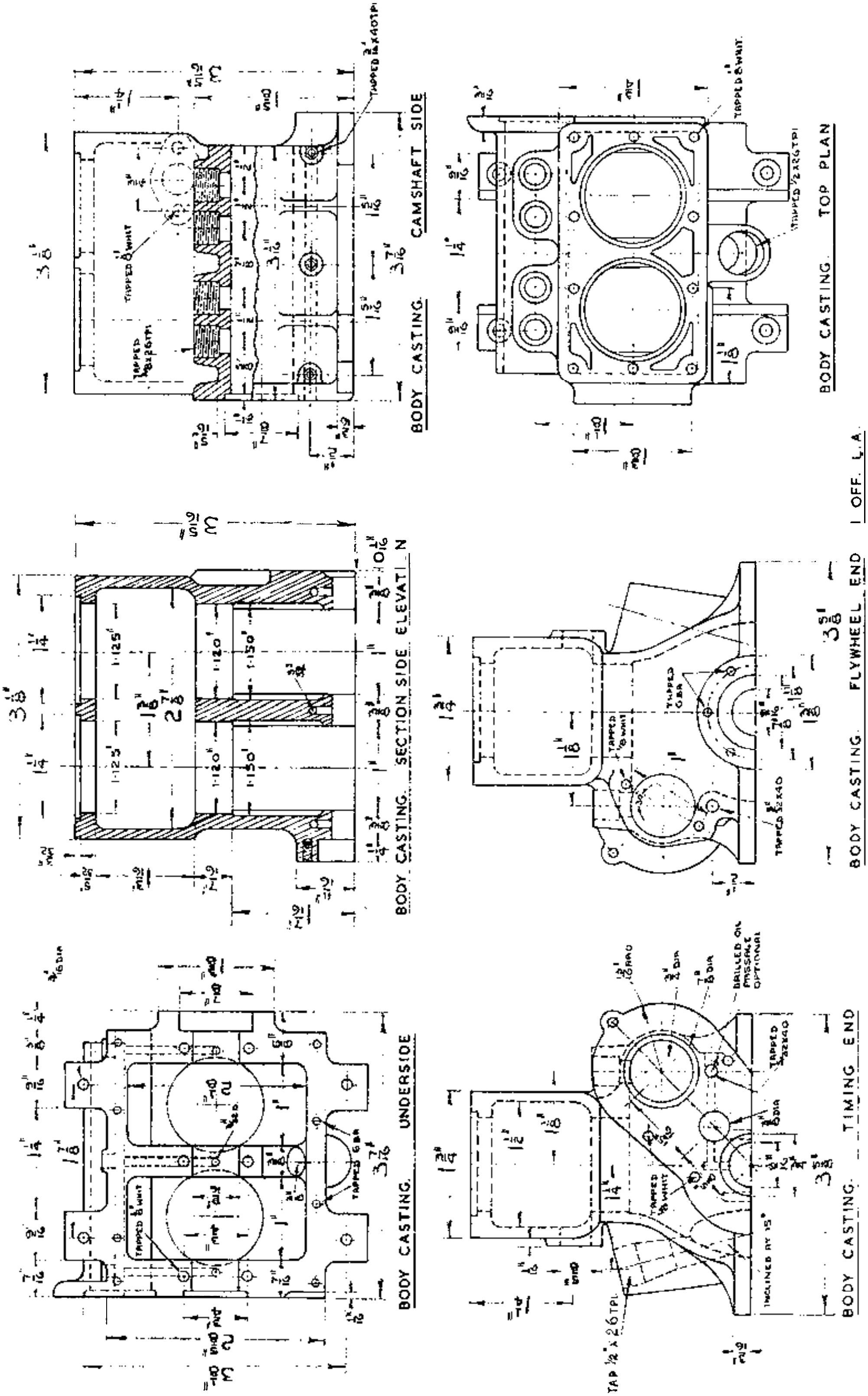
Instead of setting up the casting on the faceplate, it can be machined by mounting it on the vertical face of an angle plate on the cross slide, and bored with a rotating cutter held in the chuck. It is also possible to dispense with plugs for marking out the centres, by working to dead measurements in setting the height of the casting, and in the traverse of the cross slide.

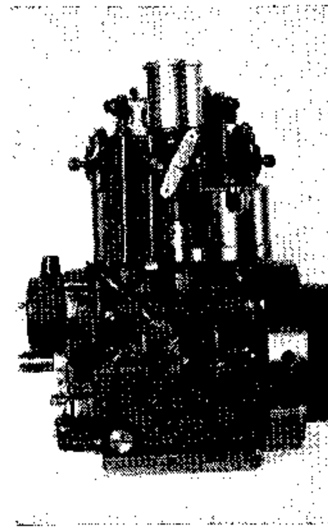
At this stage operations may be temporarily suspended on the body castine while the faces of the bearing caps, and also the sump, are machined These parts can be drilled for attachment screws, located on the bottom face of the body, and temporarily fixed to it. Care is necessary in squaring up and centring the bearing caps; when in place, they should be marked to show where they belong, and which way round. The side faces of the outer caps should line up on the inner sides with the openings of the body casting.

Bearing housings

Preliminary to the line boring of the bearing housings, the centres should be marked out on the two ends of the body casting exactly on the joint line, and carefully centre-drilled. The entire assembly may then be mounted between centres in the lathe, and both the timing end face and the flywheel end boss faced flat and true, but not yet to finished dimensions at this stage.

A drill may then be run in the lathe chuck and used to start the holes from each end of the casting in turn, with the opposite end held against the back





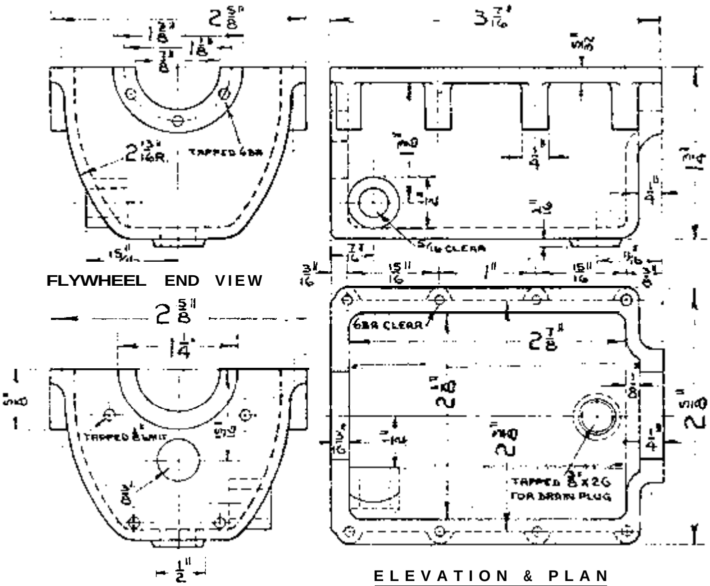
The 1831 engine built by Ian Bradley. The photograph shows the view from carburettor side

centre in each case. It is advisable to start with a pilot drill about 1/4 in. dia., running it in to about halfway through the centre bearing, and opening out to about 1/2 in. dia. in the same way, taking care all the time to watch for any tendency of the drill to wander.

While it is possible to complete the line boring operation by the same methods, finishing with a 9/16 in. reamer or D-bit, it is generally better, on grounds of accuracy, to finish by setting the casting up in the lathe and using a single-point cutter. The sump may with advantage be removed, and the body casting, with bearing caps ***in situ,*** mounted on an angle plate,. with parallel packing strips to clear the caps.

As it is not possible to use a boring bar larger than about 7/16 in. dia., which is obviously liable to spring out of truth, it is advisable to make a special long bar, with a pilot extension to fit a bush inserted in the hollow mandrel. Exact sizing of the bores is less important than getting all three of them in line.

At the same setting, the



FLYWHEEL END VIEW

TIMING END VIEW

ELEVATION & PLAN

SUMP CASTING I OFF. L.A.

side faces of the housings and caps can be trued up, using a suitable cutter in the boring bar. It will be necessary to replace the sump, and mount the assembly on a stub mandrel, to machine the recesses at both ends and finish the end faces.

The centre for the camshaft tunnel may now be marked out, using a plug in the bearing to locate the shaft centre accurately. It should be noted that the important consideration here is to ensure correct meshing of the timing gears As an idler pinion is to be fitted between the main shaft pinion and the camshaft gear,. it is possible to correct a minus error in the centre distance by staggering the idler one way or the other, but a plus error cannot be dealt with in this way, and would inevitably result in slack meshing, with excessive backlash, in the gears.

Camshaft tunnel

When you have located and marked out the position of the camshaft centre, at 1-9/16 in. from the main centre, the body (with the sump and bearing caps again removed) is again mounted on an angle plate and set up on the faceplate, with this centre running truly.

For this set-up, see that the ends of the mounting feet are parallel with the shaft centre, as previously mentioned, so that they can be squared up from the faceplate, and thereby ensure that the camshaft axis will also be parallel.

Having bored through the outer face of the flange, it may be found that, owing to possible slight displacement of the core, there is a lot of unwanted metal to be removed from the inner wall of the tunnel, which may throw the drill out of truth. A boring tool or a D-bit should, therefore, be used on this before attempting to drill through the centre partition, and again before drilling the outer end.

The entire length of the tunnel, with the bearing seatings, may then be bored out to finished size. To face the flange at the flywheel end, the casting may be turned end for end on the angle plate, and bedded firmly against the faceplate; exact centring of the tunnel is not important. The water inlet flange may then be faced and drilled by turning the casting at right angles.

To drill the hole for the crankcase breather, it is necessary to tilt the casting 15 deg. It is possible to carry out this operation in a drilling machine, but better, in my opinion, to set it up in the lathe on a wood block cut to the appropriate angle, which is not critical in this case. At the same setting, the top face of the hole can be accurately faced, and the hole can be screwcut if the required fine thread tap is not available.

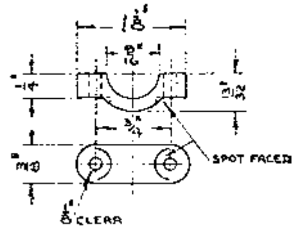
Tapering of the hole, as shown on the drawing, in dotted lines, is not important, and the tapping hole may be continued right into the crankcase, care being exercised when it breaks out into the oblique surface.

It is also possible to drill the four holes for the tappet guides in the drilling machine, as an alternative to setting up each in turn on the faceplate. The surface of the bosses for these holes should preferably be milled parallel to the base, but if this is found difficult, they may be filed true.

Remaining operations on this casting consist mainly of drilling holes for screws and oilways. The latter are subject to several variations to suit individual requirements and preferences, but for heavy or continuous running, I recommend direct oil feed to all main and big end bearings, at least.

In the detail drawings, drilled passages, which should be not less than 3/32 in. dia., are indicated.

The feed passages to the three main bearings may be fed individually from externally connected pipework, or joined up by means of a longitudinal drilled passage so that only a single central feed pipe is necessary. This is the neatest method, and in



MAIN BEARING CAPS
3 OFF. L.A.

keeping with modern practice, but some constructors may not fancy the deep drilling operation, and it certainly needs care, together with a true and reliable drilling appliance, to avoid the risk of the passage breaking out through the wall of the casting.

In either case, the pump as specified in the detail drawings is recommended for continuous pressure feed, but other methods, such as suction or drip feed, are practicable for moderate or intermittent duty. So many readers are reluctant to go to the trouble of making oil pumps or other fittings which they regard as "finicky," that I find it desirable to make distinctions as to what is or is not permissible in the way of simple alternatives to standard equipment.

* *To be continued on May 17*

Continued from May 3. page 561

EDGAR T. WESTBURY re-designs the

30 c.c. petrol engine built for Locomotive 1831

Now for the cylinder head

IN the original castings for the 1831 engine, the cylinder head was cast in bronze, and had the ports and passages cored in it. As bronze is harder than most aluminium alloys, its use for valve seatings is generally to be recommended. but unless it is used for the body casting as well, electrolytic action is liable to be set up in the parts of the casting in contact with cooling water. Experience has shown that a good aluminium alloy gives satisfactory results for valve seatings, but it is possible to fit inserted seatings of harder metal.

While cored ports and passages would also seem to be desirable, they present moulding difficulties, and do not simplify machining as much as might be expected. In the revised design, some of the first castings were made with cores, but problems in locating and supporting them properly have arisen, and it has been decided to supply them in this form only when it is specially requested. On the whole, I prefer to machine the passages from the solid, although they call for methods which some constructors may find rather unusual.

The first operation on the head casting is to machine the top and bottom faces exactly flat and parallel. With the top faces, location depends on the depth of the cavity for the water circulation, which at its shallowest part, over the valve passages, should be not less than 1/16 in. The four bosses for valve guides should be exactly flush with the joint face around the rectangular rim.

Both these operations can be carried out by holding the casting in the four-jaw chuck, two of the jaws of which may be reversed if its capacity is limited. The oarallel accuracy should be checked, and if necessary corrected, after a trial cut has been taken on the underside face.

After facing on both sides has been completed, the centres for the combustion chamber recesses may be marked out and circles 1-1/8in. dia. scribed to locate their position. The casting is then again set-up, preferably on the faceolate. and each of the circles in turn is set to run concentrically for machining the recesses, which are 3/16 in. deep, with a 1/16 in. radius in the corners. This gives a compression ratio of slightly over 7 to 1, which is satisfactory for general purposes, but may be raised or lowered by making the recesses either shallower or deeper.

Many constructors place an unduly high importance on exact compression ratio; but we should not jump to conclusions. The most suitable ratio for any particular duty is generally a matter for experiment. High compression increases power at the top of the range, but only if other things are in vrovortion. and often at the expense of flexibility. A low compression is conducive to docility, and to slogging performance at lower ranges of speed. I mention these points because they are so often the subject of queries or critical comment by makers of model petrol engines of all types.

The positions for the valve ports may now be marked out on the insides of the combustion recesses; if these have been cored, you will have to plug them temporarily, as described for the liner seatings. As you will see, the ports are offset 1/8 in. from the longitudinal centre line of the casting. You can simplify the setting up for boring the ports, whether from cored holes or from the solid, by bolting two straight strips of metal to the faceplate, one on either side of the casting, to locate it in this plane.

Any roughness or unevenness in the side faces of the casting should first be removed by filing or machining. After setting up and machining one port, and fixing the strips in position, you may locate the other ports by dead measurement. without the need for separate marking out.

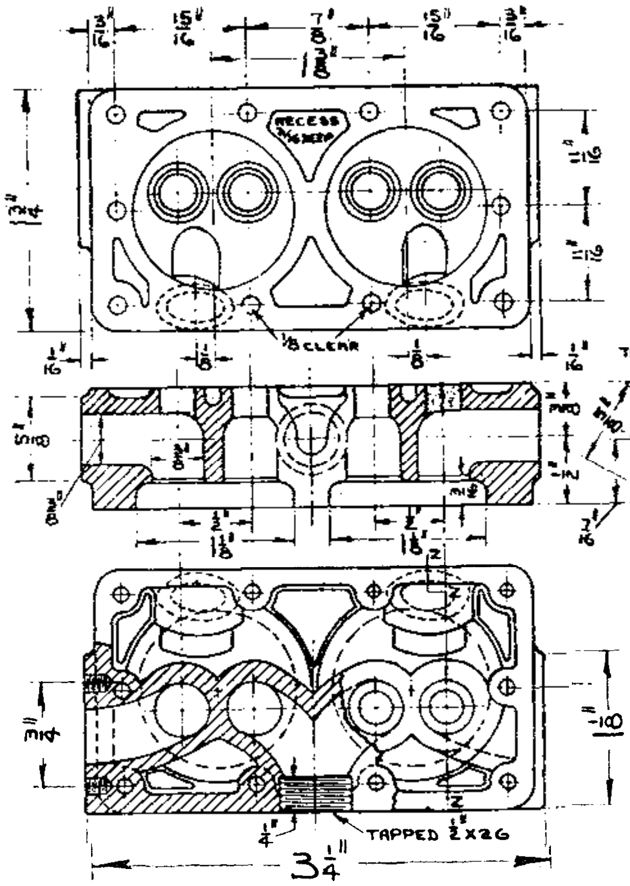
The utmost care should be observed in machining the ports and guide bores, as the entire success of the engine may depend on perfect alignment of valves with their seatings. I have encountered so many leaky valves caused by slipshod methods of machining ports or fitting guides that I must emphasise this point.

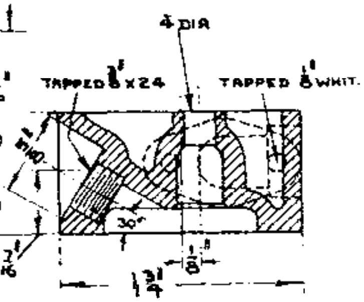
After the preliminary undersize drilling or boring of the port, you may use a piloted centre-drill to follow through into the guide, to ensure that it is equally true and concentric. Coring of passages is, in my experience, much more difficult than drilling from the solid, which should be quite straightforward.

A useful tool for simultaneously finishing the port and guide bore is a two-diameter D-bit, which is not liable to be deflected like a drill or reamer; it should have a radius to form the top end of the port, and may also have a chamfer to form the angle of the valve seating as well, though this is less important. If you intend to fit inserted seatings, you should counterbore them 15/32 in. dia. x 1/16 in. deep at the mouth. The seatings should be made in hard drawn bronze, with 1-1/2 thou interference, and drawn into the counterbores by a screwed mandrel, with a step to centre the seating ring truly. Warming the casting in hot oil will simplify this operation; in any event it is a rather delicate operation, as the seating rings are very fragile.

You can machine the flanges for the exhaust pipe connections by setting the casting on an angle plate bolted to the faceplate, and drilling their centres 5/16 in. dia. for a depth of about 1/4 in. For the inlet port, a hole not more than 3/8 in. dia. of similar depth may be drilled and spot faced. All three holes must then be joined up with the respective valve ports by curved passages. When these must be formed from solid metal, you may well wonder what kind of drill to use. I have been faced with this problem on many of my engines, and it is not as difficult as it looks.

For the preliminary stage, a drill not more than 3/16 in. dia. should be put through at an angle which joins up the ports as directly as possible. You can do it easier in the lathe than in the drilling machine, if a platform of suitable height to centre the holes is fixed-not merely rested-on the



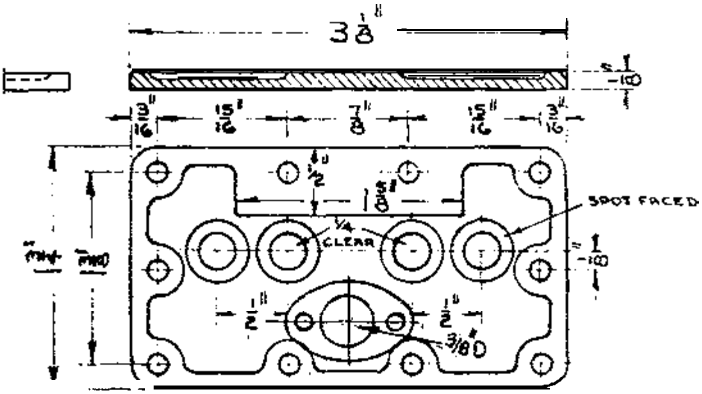


SECTION Z Z Z

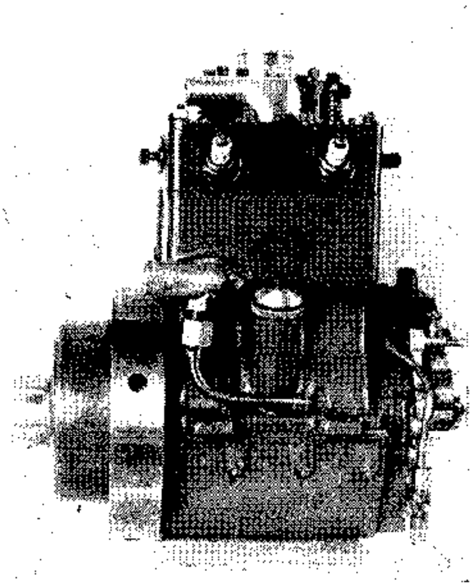
CYLINDER HEAD

1 OFF. L.A.

Right: Photograph by N. F. Hallows of Ian Bradley's LOCOMOTIVE 1831 from the breather side. Dr Hallows and Mr Bradley are contributors to MODEL ENGINEER



CYLINDER HEAD COVER PLATE



cross slide. By this method the casting can be manipulated at the required angles and the progress of the drilling watched.

Having established communication, you can then open out the passages to size, and work them into a curve, by a 3/8 in. spherical-headed burr or rotary file, held in the lathe chuck and run at high speed. When I first used this method, only the small dental burrs were readily obtainable and I made a burr from silver steel with filed teeth. While it was slow, it did the job quite successfully.

After forming the passages, you can set the head casting up again on the faceplate for opening out the mouth of the inlet passage and tapping it 1/2 in. fine thread. This operation should not be done at an earlier stage, as there is a risk of damaging the thread while the drill or burr is manipulated. A flange fixing for the inlet stub, or direct to the carburettor, is a practicable alternative, but beware of fouling the push rods.

To drill the holes for the sparking plugs, a piece of hardwood tapered to 30 deg. may be mounted on the angle plate, and the casting attached to it by wood screws through the valve guides. Note that, beginning from the flat side of the casting, the centre is 7/16 in. above the base side. Having located this, you should deeply centre-drill it, takmg care because of the oblique surface, and drill it through 1/4 in. dia., with the same precautions when you are breaking through on the inside.

Some constructors have found that the 1831 engine, because of its efficient oiling system, is rather liable to oil up plugs. This trouble can be cured in various ways. One method which is very effective is to "pocket" the plugs by restricting the bore of the hole which communicates with the combustion chamber. If this course is adopted, a smaller hole, say, 1/8 in. dia., may be drilled through, and the facing surface brought a little further out. In either instance, this surface should first be machined into the side of the casting, sufficiently deep to provide a seating for the plug washer, and large enough in diameter to clear the plug body.

In all machining operations where clamping or locating on already finished surfaces are necessary, a slip of paper should be inserted between contact faces, and packing slips of copper or aluminium be used to prevent brusing by the clamps.

The drilling of holes for securing the head to the body may now be carried out; it is a good policy to mark out and start them from both sides, as small drills have a notorious tendency to wander from the straight and narrow path! Ample clearance should be allowed in the holes, as jamming sideways is liable to introduce distorting stresses. The tapping holes in the body are specified as 1/8 in. Whit., but as studs or bolts of this size are not easy to obtain nowadays, 4 BA, which is some 15 thou larger, may be substituted.

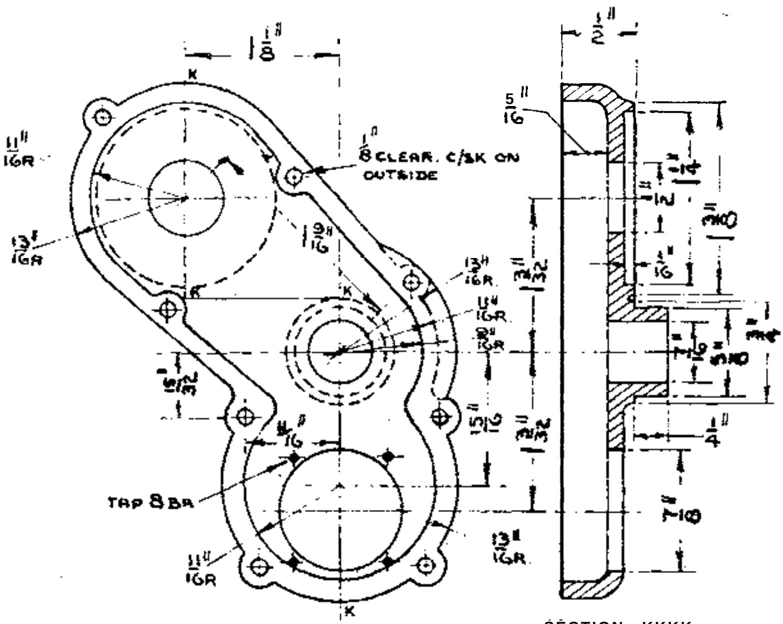
For communication between the head and body water spaces, holes are pierced in the contact faces in both parts, of the largest permissible area. If they are made of the shape and size indicated on the detail drawings, water circulation by convection, or thermo-syphon action, is sufficient without further aid by a mechanical pump or other means, provided that the tank or radiator is set at a convenient elevation.

Another way of connecting the water spaces is by external bridge pipes. For boat work, when water is taken from the pond, some kind of a pump or scoop is necessary.

The cover plate casting needs only to be machined on the underside and on the top rim, including the rocker bearing seating and the face of the water outlet flange. The fixing holes can be jigged from the holes in the cylinder head casting, and snot-faced to form seatings for the holding down nuts. To spot the holes for the valve guides in the cover plate, you had better use a centre drill or a spearpoint drill with a shank which exactly fits the holes in the head, as it is highly important that these should not be scored or otherwise damaged. The holes in the cover should be opened out to 1/4 in. clearance, and spot-faced on the top surface. Finally, the joint surfaces of this, and of the head casting, should be lapped on a sheet of plate glass for perfect flatness.

The inner face of the casting for the timing cover should be faced off flat by holding it in the four-jaw chuck; centring is unnecessary. It should then be drilled for the fixing screws. Tapping holes are spotted and drilled in the flange of the body casting, and the timing case is temporarily secured in position. You can carry out the boring and machining of the main shaft boss in position, by mounting the body on a chuck-mounted stub mandrel, through the main bearings, thereby making sure that the bore in the case is truly aligned.

A similar procedure may be employed to line up the distributor seating with the camshaft centre. As these are light operations, the overhung mass on a small mandrel can be tolerated, provided that you take only light cuts with a keen narrow-pointed tool. It may not be easy to get a good finish, but the important thing is concentric location. The bore for the oil pump (if one is fitted) may be left to a later stage of the construction.



SECTION KKKK

TIMING COVER

I OFF. L.A.

* *To be continued on May* 31

Continued: from May 17, page 608

Making the crankshaft

EDGAR T. WESTBURY deals also with the cylinder liners, connecting rods and pistons of the petrol engine which he has developed from his old unit for locomotive 1831

IN the form shown in the drawings, the crankshaft is made from mild steel bar. of rectangular section, to finish up to 1-1/8 in. x 9/16 in. x 5-13/16 in. long. While this is conducive to economy both in material and in machining time, there are other methods of making the crankshaft which may be adopted with equally satisfactory results.

Some constructors prefer to machine the crankshaft from round bar, with integral balance weights; this calls for material 1-3/4 in. dia., the major part of which must be machined away. Others may prefer a fabricated crankshaft, with straight bars for the journals and discs, or cut-out flat pieces, for the webs and balance weights, built up by brazing. All these methods have been described in ME.

In making the crankshaft from solid material, whether round or flat, the first operation is to set out the throw centres for main and crankpin journals. The ends of the bar should be faced true by machining or filing. When the bar is round, its centre should be located, by laying it in V-blocks on a truly flat surface, and using a scribing block. A flat bar should rest on parallel packings and be marked out in a similar way. Some means of holding it in position, such as the magnetic tools recently described in ME, will help for accuracy. Produce the centre line on the two ends and along the length of the bar,. using a sharp scriber to get a fine line; Spectra marking fluid is helpful in making scribed lines legible.

Turn the bar at right angles, using the same packings, and set the centre line vertical by sighting from a square resting on the surface plate. A cross centre line is then scribed from this location; with flat bar larger than finished section, you may have to set the height of the scriber to allow for metal which is to be removed.

A check should be made of the height of the scriber point. bv some form of height gauge before it is reset 9/16 in. higher, to scribe cross lines to locate the crankpin centres. In these, as in all other marking-out operations, work must be properly bedded down or held on its packings to prevent movement or distortion. The intersections of the cross lines should be marked with a fine centre-punch, checked for accuracy of location and then more deeply centre-punched. A small centre-drill, with a point no more than 1/16 in. dia., should be used to form the running centres.

With flat bar. you can cut away most of the unwanted metal before machining, but first only the gaps between the inner crank webs should be cut out as the ends of the bar must be left intact for the time being. Then you can set up the work between centres for machining the crankpins and the inner faces of the webs-an operation which calls for a tool with a long reach, though this applies more particularly to crankshafts made from round bar. In previous articles I have recommended a tool of deep section, say, 3/4 in. x 1/4 in., ground with side and back clearance, and rounded on the front corners so that it will machine the webs and form the fillets of the crankpin without being re-set .

Avoiding chatter

When a broad-faced tool is used to machine the crankpin journals, there is always a risk of its digging-in or chattering, no matter how carefully it is set or applied. To avoid this. I have found it a great advantage to grind a groove in the centre of the tool face so that light traversing cuts across the journal can be taken without engaging the full width of the edge. This " bifurcated " tool. as I call it. has simplified many crank turning operations and I recommend it to others.

Several readers have difficulty in obtaining deep section tool steel. I cannot help them, but there are several ways of dealing with the problem, such as brazing a bit of 1/4 in. tool steel to a stepped bar of 3/4 in. x 1/4 in. mild steel, or even grinding an old flat file to shape. There are also such expedients as supporting the end of the tool from the cross slide by suitable packing.

Every care should be taken to produce a good tool finish on the crankpin surface, with ample fillets in the corners. This is very important from the aspect of strength, as sharp corners are weak, and often form a focus for cracks. Dimensional accuracy is of minor importance, as split bearings can always be adjusted to fit; but this should not be made an excuse for carelessness. The excess metal beside the main journals can now be sawn away. Before you set up to machine them, gap pieces should be fitted between the inner web. to prevent the risk of springing the shaft under end pressure of the centres. The pieces may be held in place by clamping, or by a touch of soft solder; they should not be too tight, but just a good push fit.

The remainder of the turning operations on the shaft, including the threads on the ends, may now be carried out, but you may defer the finishing of the taper for the flywheel seating until the seating has been machined. The spigot, and the tapped hole in the end of the crankshaft, are required only when the centrifugal clutch is to be fitted.

To drill the holes through the centre of the crankpin, the shaft may be marked out on the faces of the outer webs, located as closely as possible from the journal surfaces to ensure the concentricity of the holes. It is not absolutely necessary to make the crankpins hollow, but this reduces their weight substantially, and thus helps in balancing.

The oil passages from the centre journal into the crankpin are drilled No 48 or 5/64 in. dia. at an angle of about 35 deg. to the crank axis. They should be started by drilling a No 42 or 3/32 in. hole about 1/16 in. deep at right angles in the centre of the journal after which the crankshaft may be clamped to the side of an angle plate at the above angle and drilled in the drilling machine or the lathe; use a good sharp drill and do not force the pace. The hollow crankpins are plugged with brass or aluminium as shown. Cup-shaped plugs, made slightly taper, are lighter and easier to fit than solid ones, as tighter interference limits, up to 2 thou, are possible. They should be pressed in rather than hammered; the inner pair calls for the use of a U-shaped packing piece to span the crank webs.

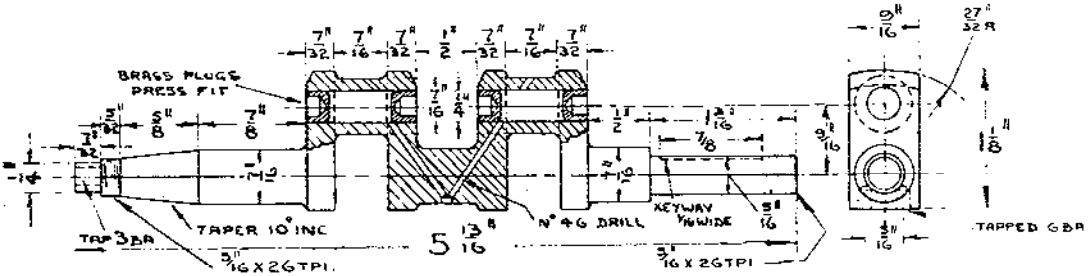
Bronze is recommended for the balance weights because it has a higher specific gravity than steel. But steel may be used if the width is increased by about 1/4 in. to 5/16 in., in between centres. It is also possible to skim the outer faces.

I will add that while hardening of the journals is desirable for long wear, it is difficult to harden them without risk of distortion. The effective alternative is electro-deposition of a thin layer of hard chrome-about 2 thou is sufficient. Several firms undertake work of this kind.

The cylinder liners should be made of good quality cast iron. I recommend either " stick " iron or individual castings, with a substantial chucking piece at the top end so that they can be machined inside and outside at one made a push fit in their housings. But it is most important that they make good contact with both seatings. A smear of varnish or enamel on the surfaces before insertion will help to prevent the risk of water leakage afterwards.

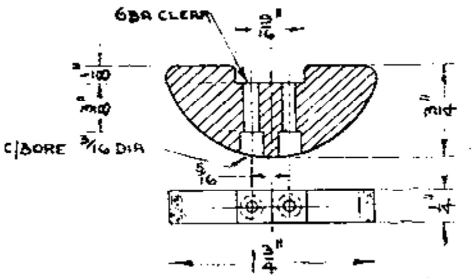
Final lapping should be carried out when the liners are in position, by methods which I have described for earlier engines. A cast-iron expanding lap, charged with fine aluminium oxide abrasive, provides high accuracy; finer abrasives improve *polish,* but have very little other effect.

The cast bronze connecting rods are easy to machine and have proved



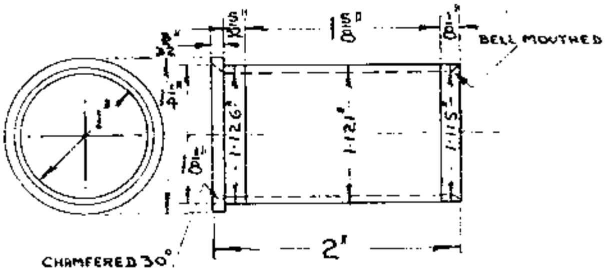
CRANKSHAFT 1 OFF. M.S.

NOTE: JOURNAL SURFACES MAY BE C.H. OR CHROMED



ATTACH WITH ALLEN CAP SCREWS

BALANCE WEIGHTS
4 OFF. BRONZE



CYLINDER LINER
2 OFF. C.I.

which event they will overlap the webs slightly. The sides faces are first machined, and the seatings are filed to fit closely on the ends of the crank webs. Allen cap crews, 6 BA, sunk 'well below the surface, are recommended for attaching them, though well-fitted mild steel slotted screws are quite safe. A further safeguard, not so much to reinforce mechanical strength as to avoid the risk of loosening by fretting, is to coat the mating surfaces with solder paint, heat the assembly till it melts, and wipe off the excess.

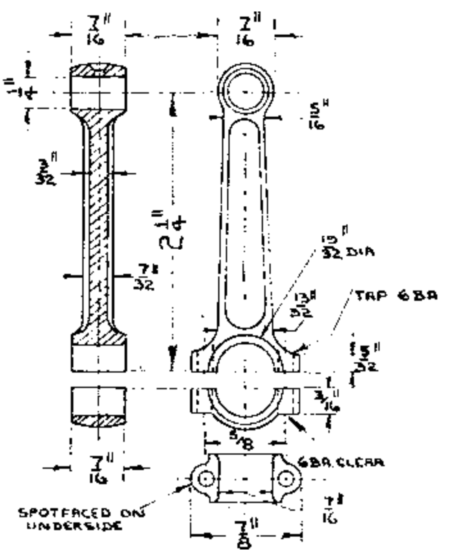
The outer edges of the webs are machined by setting the assembly setting, and finally parted off. A heavy boring tool or cutter bar, providing the utmost possible rigidity, should be used for boring, and a floating cutter is handy for finishing and sizing, before the honing or 'lapping, all of which can be done while the liner is set up.

If the seating in the body casting have been bored to two diameters, insertion of the liners should not be very difficult, as they will fall in most of the way, and the common risk of distorting them by getting them out of line will be eliminated. It is not necessary to fit them very tightly; in full-size practice, liners are often very satisfactory, but lighter rods, machined all over from Duralumin, may be preferred by some. They will make some alteration to the balance, but this is generally all to the good, as overbalance can always be corrected by machining the edges of the balance weights. The essential thing in boring the eyes of the connecting rod is that they should be exactly parallel with each other. Almost equally important, their length between centres should be the same.

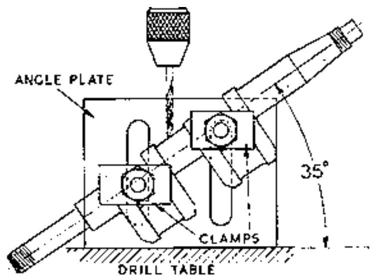
I have described several methods of providing these essentials by simple jigs. One of the most accurate devices is a short length of *rectangular* steel bar, shaped to fit closely in one of the slots of the four-iaw chuck in place of the jaw, and given a stud to fit the little-end eye of the rod after it has been bored. Some means of fixing this in place in the slot, after its radius has been determined, should be provided.

The bronze casting has the cap integral with it, sufficient metal being allowed for splitting and facing the surfaces, which should be exactly flat. Before doing this, you can drill and tap the holes for the fixing screws. Mark the caps to show which is which, and secure them temporarily in place, after checking the uniformity of the length and location of the little end centres. The four-jaw chuck, with one of its jaws reversed, may be used to hold the rods for boring and facing the little ends. Make certain that the rod is set square with the lathe axis-parallel with the face of the chuck.

The jig described may now be brought into operation for boring and facing the big ends, which are first set true by the three jaws. When the first one is centred, the little end location may be fixed to the set radius. It may be desirable to skim the outside of the bosses, at both the big and little ends, as far as can be reached without cutting into the shank, and to fair in the crown of the bosses, by filing, to eliminate unnecessary metal and give the rods a neat finish. You can carry out the facing and so forth on the reverse side of the eyes by setting the rods on pin mandrels.



CONNECTING ROD
2 OFF BRONZE OR DURAL



Drilling oil passages in crankshaft

For engines designed to run at high speed, light alloy pistons are best, and most constructors will prefer them; but for long wear and maintenance of compression, there is much to be said for cast-iron pistons. As they can be fitted to very fine clearances without risk of seizure, they give much less trouble with oil control; on the other hand, the balancing is liable to be rather more difficult.

Graded clearance

Aluminium alloy pistons should have about 3 thou clearance at the skirt, increasing above the gudgeon pin by tapering, or easy steps, to 6 thou. The inside of the skirt should be machined as far as the gudgeon pin bosses will allow. Piston castings, if provided with a chucking piece, should be set up by reference to the ***inside*** surface, as the centring of the core is often imperfect, and if the work is set up to the outside surface the thickness of the wall will not be uniform. I always leave the final machining of pistons, including the ring grooves, until the cross hole for the gudgeon pin has been bored.

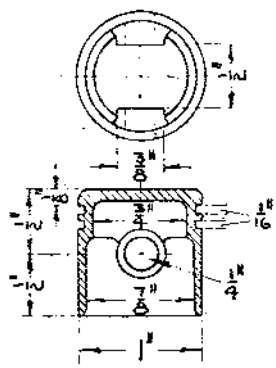
Before this operation, the piston should be rough machined, and the outer end of the skirt faced truly to finished length. The distance of the gudgeon pin from this end should then be marked by incising a ring with a keen point tool. While it is in the lathe, a centre line is marked off front and back to coincide with the centres of the internal bosses. A centre-punch marks the intersection of the cross lines.

The piston should then be mounted on an angle plate by a strap across the crown and two bolts. A line scribed squarely across the angle plate will enable the centre lines on the piston to be properly located to denote the true diametral centre. Set up the angle plate on the lathe faceplate, and without loosening the piston fixture set up the assembly to the punch mark and centre-drill, bore and ream it, with the finished size of the holes preferably on the tight side relative to those in the eyes of the connecting rods.

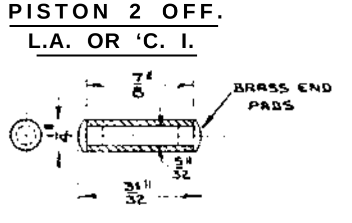
To finish the external machining of the pistons, I always advise the use of a chucking fixture with a spigot machined to fit the inside of the piston skirt, and drilled and tapped in the centre to take an eye bolt. Pass a temporary gudgeon pin, somewhat under length, through the piston and the eye bolt, and by turning the piston, clamp it firmly up against;: step of the chucking piece. spigot locates it truly. This method eliminates the possibility of distorting the piston by chuck pressure in the final operations.

Finished piston rings, made to a guaranteed standard of accuracy, are obtainable. The grooves to receive them should be carefully machined with a keen tool for a good finish, especially at the sides. The fit should be such that when the ring, used as a gauge, is inserted wrong-way-on in the groove, it can be tilted a few degrees sideways, but with no obvious side-play. Depth can be gauged by laying a straight strip along the piston, over the inverted ring; it should be possible to move the ring up and down a little. A very slight chamfer, or rounding-off of the corner, of the bottom edge of the lower ring groove, will help oil control, but because of the limited depth of the groove this must be done with discretion.

* ***To be continued on June 14***



PISTON 2 OFF.
L.A. OR 'C. I.



GUDGEON PIN
2 OFF. M.S. C.H.