Continued from May 31. page 669

By EDGAR T. WESTBURY

Main bearings, tappets and rockers

THE three main bearings for the crankshaft are identical in their major fitting dimensions, but vary in minor details. It is important that they should be made of suitable material, but unless the shaft journals can be hardened a hard bronze such as phosphor bronze is not recommended. Lead bronze, such as is supplied by the Glacier Metal Company, will give equally long wear, with much less risk of cutting or scoring the shaft. It can be obtained in the form of cast sticks, and the three bushes can be machined and parted off from a single niece about 3 in. long x 3/4 in. dia.

As the bushes have to be split. it is recommended that the stick should first be sawn in half lengthwise, and the cut faces trued by filing or machining so that they will bed together accurately all over. If desired, an undersize hole may be drilled to a sufficient depth up the centre before splitting. The faces may then be coated with solder paint, clamped together and heated until the solder melts.

Machining the stick

After cooling, the re-assembled stick is set up in the four-jaw chuck with the minimum length projecting, for facing, centring and drilling to about 13/32 in. dia. You can then extend it further from the chuck, sufficient to enable external and internal turning of all three bushes to be carried out at one setting. Only light cuts should be taken, to avoid risk of breaking the soldered joint, and it is not desirable to use a reamer to finish the bore. As the bearing surfaces should be fitted to the shaft by scraping, a high machined finish to the bore is not essential.

As the external surface of the bushes, where they fit in the housings, cannot be offered up to them, they must, therefore, be sized by dead measurement; but if there is any doubt of their correct size. the housing caps may be temporarily fitted and a piece of material machined to serve as a plug gauge, from which the measurement can then be taken. Close contact of the bushes (or "shells," as they are usually called nowadays) with the housings is essential; they should also fit closely endwise, between the locating collars. The two end bushes should have radii at the inner ends, to clear the journal fillets; both ends of the centre bush should have similar radii, and the bush should also have an internal groove in the centre for oil distribution. Radial oil holes in each should line up with the oil passages in the body. When finally fitted, the faces of the bushes should bear hard against each other, leaving a small clearance between the housing faces.

A circular endplate, with a shallow spigot to fit the register in the body and sump assembly, is fitted to the flywheel end and secured by six countersunk screws. The machining of this part is quite straightforward; its object is to enable an oil thrower or other sealing device to be fitted outside the bearing, as seen in the general arrangement, though many constructors may not consider such a device necessary.

For the gudgeon pin, which was illustrated with the piston details, you should use mild steel, machined on the tight side, and after case-hardening should be lapped to fit rather stiffly in the cross bore of the piston. End pads of brass or dural are pressed into the bore of the pin, to remove risk of scoring the cylinder liner if endwise movement should take place.

The valve operating gear comprises a number of small components which are individuallv simple. but call for a good deal of care in machining to close limits. The valves should be made from high tensile or stainless steel for a long and trouble-free life. I am often asked if it is permissible to make them from mild or silver steel. The only objection to the mild is that it does not stand up so well, either to oxidation or heat, as the recommended material. Silver steel is a little better, but is much more difficult to machine, and is liable to become brittle under repeated thermal and fatigue stress.

Many readers have found that the valve stems, owing to their length and slenderness, are liable to spring or bend while they are being machined. You can avoid this by adopting methods which I have recommended in previous articles; namely, by first turning down about 1/4 in. of the end of the bar to finished size, bevelling to 60 deg., and supporting it by a hollow centre in the tailstock, while dealing with the rest of the stem. The standard form of hollow centre is liable to get in the way of the tool, and so it is best to make a special centre by coning and centre-drilling a short length of silver steel., hardening it, and holding it in the tailstock chuck.

Correct tool width

Difficulties in turning slender work are often caused by the use of too broad a tool, which increases side-cutting thrust unduly. The tool used for this sort of job should not be more than 1/16 in. wide on the nose, with ample top rake, and should be keenly honed. You must obviously set it at the correct height; many gadgets have been devised and described to gauge this, but I have never found them necessary. A facing cut on the job-nearly always called for in any event-will soon show whether the tool is the right height. A narrow tool may possibly leave a trace of a spiral tool mark, but that is better than chattering or digging in, and is easily removed by lapping.

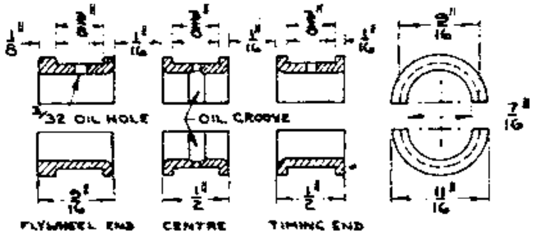
The radius under the head of the valve should be smooth, and can be eased out by careful manipulation of the slide-rest. or bv a hand turning tool. The seating is then turned at an angle of 90 deg. inclusive (45 deg. on the topslide swivel) and the valve is parted off. It only remains to face and round off the head slightly. A screwdriver slot across the head is useful for grinding in, but it should be cut with a small circular saw, so that it does not extend right across the face, and is no deeper than necessary.

There are several other ways of machining the valves, such as by a " running-down " or box tool if you have one, but back centre support will certainly be necessary while you are turning the groove for the retaining cotter-a delicate operation which calls for a special narrow grooving tool. The cotter is not shown in the drawings; it may be a washer, slotted out to horse-shoe shape, or a wire circlip clenched into place with pliers when the spring and collar are assembled. In either instance, it is retained and prevented from opening out by the connterbore in the collar.

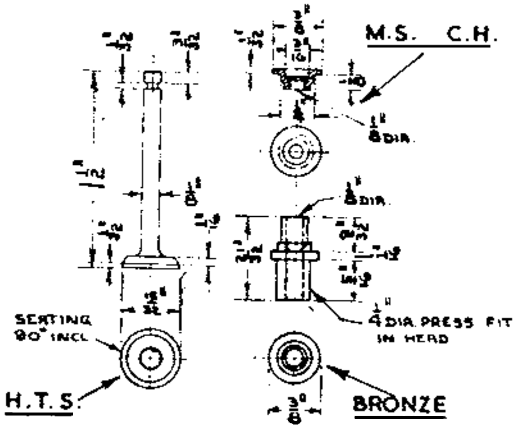
The collar should be drilled and reamed to fit the valve stem closely; it can be machined at one setting from the counterbored end, and stepped down on the underside with the parting tool, before the parting-off. As the collar often gets burred up by the hammering action of the valve gear, I case harden it lightly to avoid this.

In the 1831 engine, the bronze valve guides were screwed into the head casting,, and this method of fitting was quite satisfactory provided that their threads, and also the tapped holes, were perfectly true. But there is a liability of error here, and some constructors encountered trouble in ensuring valve alignment. I have, therefore, decided to revert to the more usual method of fitting the guides by pressing them in. While this is by no means immune from risk of misalignment, it should be fairly simple to ensure that the bore and the outside of the guide are truly concentric. About one thou interference, with a slight lead by tapering the end, should be allowed, to provide a tight fit in the head. The guides can be turned, drilled and reamed at one setting from bronze on gunmetal rod.

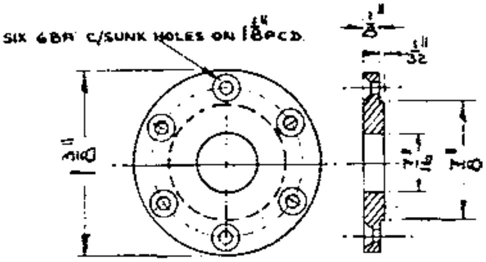
To insert the guides, a screwed



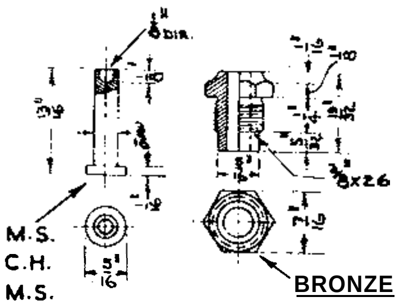
MAIN BEARINGS I OFF: EACH
LEAD BRONZE OR GLACIER METAL



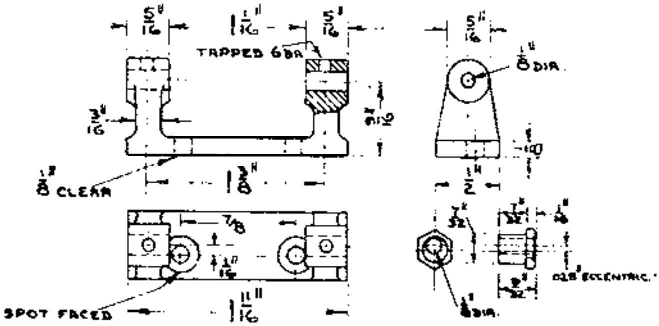
VALVE, GUIDE &
SPRING COLLAR
4 OFF.



MAIN BEARING ENDPLATE
I OFF. L.A.



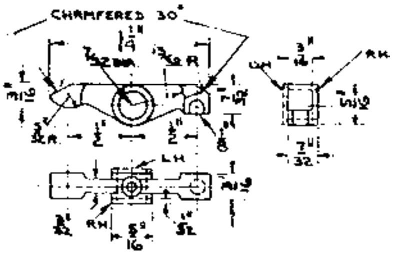
TAPPET &TAPPET GUIDE
4 OFF.



I Off. VALVE ROCKER PIVOT BRACKET. L.A.
& 4 OFF. ECCENTRIC BUSH BRONZE

mandrel with a spigot to fit the bore of the valve port is advised. The shank is threaded 1/8 in. Whit. or 5 BA, and a long nut should be made, in view of the heavy duty imposed on it. A sleeve extension to the nut, or a separate spacer bush, should be fitted to bear on the collar of the guide-not the relatively thin end, which might easily become burred or mushroomed. A little jointing varnish on the guide will make assembly easier, and also prevent risk of leakage around it afterwards. The bore of the guide will contract slightly, and will need to be eased by passing the reamer or D-bit through it again. When fitted, the valve stem should work smoothly and freely, but with no perceptible play; sloppy valve stems are a common source of trouble with small engines, as they cause air leakage of inlet valves and build-up of carbon on exhaust valve stems.

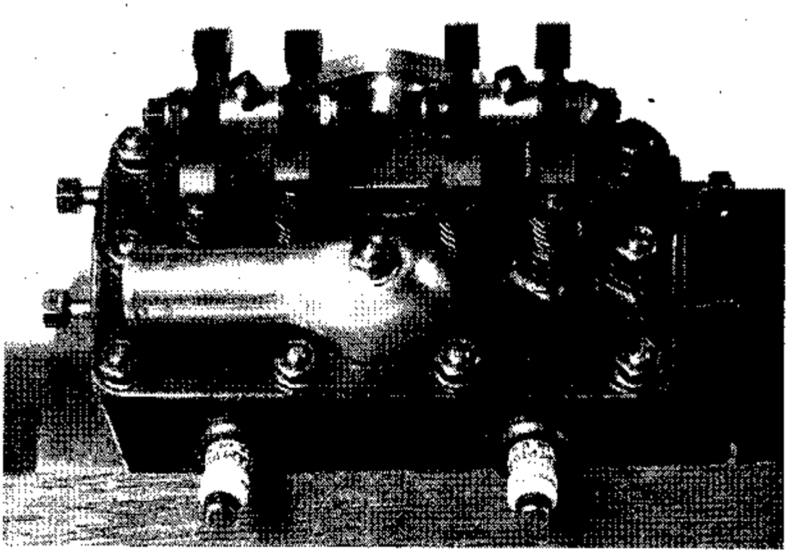
The valve rockers are pivoted in a bracket casting,, which comprises two pedestals carrying the pivot studs. It should first be machined on the underside face, and then marked out for the pivot centres at 9/16 in. height. To line up the pivot holes, I advise you to centre-drill at each end, and drill in the lathe, by resting one end against the back centre while you are dealing with the other. A short



VALVE ROCKER

4 OFF. M.S. C.H.

drill, or one not extending farther than is necessary from the lathe chuck, will help to ensure that the holes do not wander too far out of line. A No 31 will be found about correct for this job, followed by a slightly undersize reamer or D-bit, to make the pivot studs a tight fit. The inner and outer ends of the pedestal bosses should be spot-faced or otherwise trued. to nrovide seatings for the rocker bushes. Holes are-drilled and tapped 6 BA in the tops of the pedestals to take screws, which engage notches in the centre of each stud to lock it in place. The studs, of 1/8in. mild steel, are each 1-1/8 in. long and are screwed 1/8 in. Whit. or 5 BA at each end.



Cylinder head of Ian Bradley's 1831 engine, with valve gear, sparking plugs, and water outlet connection. The picture was taken by N. F. Hallows

The rocker bushes, of bronze or gunmetal rod, are shown with hexagonal heads to facilitate adjustment, but it has been found that round knurled heads about 7/16 in. dia., enable them to be turned quite easily when the nuts on the studs are loosened. This method of tappet adjustment, used on several of my engines, is the most facile and positive I have found so far. The exact eccentricity of the holes is not important, and after turning the outside you may offset the work by packing one of the chuck jaws with a thin shim, before centre-drilling and following up with a No 31 drill and 1/8 in. reamer. The finished bush can then be parted-off from the bar.

Valve rockers are made from mild steel and case-hardened; if any other material is used, it will be necessary to face the toe and socket with hard metal to provide long wear. There are several ways of making the rockers, the essential thing being to preserve their geometry by taking care that the points of contact at the two ends are in a straight line passing through the pivot centre. Note that the centre bosses are slightly offset, two to the right and two to the left, to line them up with the valve centres. I generally make the rockers from rectangular bar, which is first cut to length and drilled squarely through the centre to fit on a pin mandrel. This enables the sides to be shaped by a facing tool in the lathe; the outside contour of the bosses can be turned at the same setting. The four rockers can then be strung together on a bolt, and you can shape the underside contour by filing or machining to get uniformity. At the heel end of each rocker, a hole 1/8 in. dia. x 1/8 in. deep is drilled, and finished to a semicircular contour by a spherical burr, or an old drill ground to the required shape at the tip. This surface, and that of the toe and the pivot hole, should be as highly finished as possible and given special attention when you are case-hardening.

The tappet guides are a straightforward turning job. They are preferably made from hexagonal bronze rod, and are turned, screwed, drilled and reamed at one setting and then parted-off. It is equally simple to machine the mild-steel tappets at one setting, but special care should be taken that they are a smooth and close fit in the guides; finishing with a split lap is well worth while. If desired? two or three grooves may be turned in them to assist oil control. The end faces should be hemispherically socketed like the heels of the rockers. After parting-off, face the heads flat and finish them as highly as possible. My method of dealing with these surfaces is to use a flat copper lap charged with fine abrasive.

With the job running in the lathe, bring up the tailstock drill pad with the lap in between. Light end pressure, with the lap kept on the move all the time. will give vou a plane surface which, when hardened, works with the minimum friction in contact with the cam

To be continued on June 28

Continued From June 14, page 736

This is the best way to make the camshaft

In the fifth instalment on the engine developed from the power unit of locomotive 1831, EDGAR T. WESTBURY solves a problem which deters some from attempting a petrol engine

SEVERAL of the minor details of the engine are subject to modification according to the purpose for which it is to be used, the mode of installation: or the preference of the constructor. To take an example, I have already mentioned that the inlet stub, originally designed to screw into the cylinder head casting, and to be locked by a ring nut, may be altered to suit the carburettor, or perhaps incorporated in it. The parts described as the ignition cam, and the starting dog which screws on the end of the crankshaft, may not necessarily be required to serve either of these two functions, and may be replaced by a sleeve nut or a screwed coupling, with or without the cam.

The spiral groove on the sleeve, which runs in the boss of the timing cover, is intended to prevent the escape of oil at this point, without the need for maintaining a fine clearance. In full-size practice, various forms of seal can be used for this purpose, but they usually involve some friction, which is undesirable in a small engine. Where positive register of the aperture in the casing is difficult to achieve, the sleeve or shaft is not usually made a close fit, and the bore is not intended to act as a bearing. Several readers in the past have queried this feature, which occurs in some of my other engine designs, and I trust that my explanation will clear up any doubts as to why it is employed.

As the engine is capable of working equally well in either direction of rotation: if the timing is appropriately orientated, the "hand" of the groove should be arranged to suit. In the 1831 engine, rotation was clockwise at the timing end, and the spiral of the groove was left-hand. But most marine engines run in the opposite direction, so that they can employ right-hand screwed shaft couplings in driving from the timing end; the spiral groove should then be right-handed.

These matters are influenced by convenience of installation and by other circumstances. From the mechanical aspect, it is much the best to drive from the flywheel end. This may be quite necessary in full-size practice, as the inertia of the flywheel helps to steady the drive and to insulate the engine itself from transmission shocks. But in model power boats, to find room in the hull for a large flywheel at the after end of the engine is often difficult unless the engine is raised to an inconvenient height or set at a steep shaft angle. With the starting methods usually employed, it is also more convenient to locate the flywheel, with its starting pulley, in the more readily accessible forward position. Most constructors will probably favour this mode of installation, but where the specially designed centrifugal clutch is used for transmission the drive must obviously be taken from the flywheel end.

The starter dog permits the starting gear which was employed for the 1831 engine to be engaged during the starting operation only. It is obviously unnecessary when different methods- of starting- are employed. In these, as in many other details of engine design, I have always avoided rigidity, and sought to allow for individual requirements. Constructors should always check details, and consider how the engine is to be installed and used before they begin to build it.

The camshaft bearings,. one of which has a flange to fix it by two screws to the flywheel end of the crankcase, while the other is a press fit in the timing end of the camshaft tunnel, may be made from castings of bronze or gunmetal, or from bar stock. In both bearings, concentricity of the bore and outside seating is essential: thev mav therefore be machined at one setting.

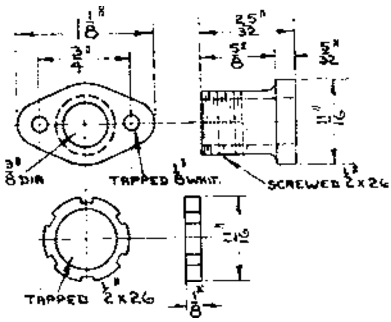
Flats at about 45 deg. to the axis, and countersunk holes normal to them, are provided to collect and convey oil to the journals. They should, of course, be located so that they are at the top when inserted. The flanged bearing may sometimes be closed at the outer end by the drilling of a blind hole, or the fitting of an external plate.

Most full-scale engines nowadays have camshafts made from castings in high-tensile iron, which require the minimum machining to produce accurately formed and timed cams from the solid. This procedure is hardly practicable in a model. It is generally necessary to machine the camshaft from solid steel, or to make separate cams and attach them to the shaft. To manv constructors either method may appear to present formidable difficulties, sufficient to deter some of them from attempting to build an engine, especially if it has more than one cylinder. I have given serious thought to this problem in the past, and have tried out every possible method of making camshafts. The methods which I have used and recommended to readers for the 1831, Seal, Seagull and *Sea Lion* engines differ only in minor details, and are the simplest which I have been able to devise. Many readers, some of them with no previous experience of petrol engine construction, have followed these methods and achieved complete success, though not always at the first attempt.

In all engines intended to run at high speed, the form of the cams is important, and no less so is their timing, or in other words, their angular location in regard to each other and to the engine crankshaft. Though the formation of the cams to the required contour may perhaps be simplified by making them separately, it still involves the problem of setting them at the proper angles on the shaft. I have found it better, and in the long run simpler, to deal with both operations simultaneously by machining the cams integral with the shaft.

A good quality case-hardening mild steel is recommended for the camshaft; high tensile steel offers little or no advantage unless it can be hardened locally as by induction heating, which is rarely available to the amateur worker. Heat treatment of any kind can be avoided by having the shaft chrome-deposited after machining, in which event any kind of steel is suitable. The risk of distortion in heat treatment can be considerably reduced if the steel is normalised., by heating it to redness and allowmg it to cool naturally, before final machining.

The material for the camshaft blank should be large enough to clean up 5/8 in. dia. by 4-3/16 in. long. It is first centre-drilled at both ends, so that subsequent turning operations can be carried out between



INLET STUB & LOCK NUT
I OFF. EACH L.A.

centres. In the 1831 engine, provision was made for an auxiliary drive from the camshaft by the drilling and cross-slotting of the end as shown in the detail drawing. Some constructors have used this to drive a small air compressor for an air brake system. If the drive is not required, the shaft may be cut 1/4 in. shorter at this end, and the bearing may be blanked off as I have mentioned.

It is an advantage to leave the camshaft journals and the taper at the drive end slightly oversize in the initial operations to allow for the final fitting, but the parts between the cams are not critical in diameter and the cam blanks should be left at 5/8 in. outside diameter by 3/16 in. wide. Before you begin to form the cams study the cam sequence thoroughly, as this may save much time and trouble later. A slap-happy worker may get along by a policy of " cutting and contriving," but it is much better to do all the contriving first and the cutting afterwards.

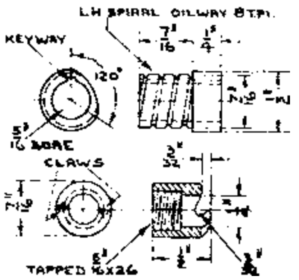
First of all, note that in this engine the outer cams, Nos. 1 and 4, operate the exhaust valves, and the inner cams, Nos. 2 and 3, operate the inlet valves. As the positions of the timing gears are adjustable, locate the cams in relation to each other, and do not worry about their timing in relation to the crankshaft at this stage.

In visualising the sequence of the cams, I always start from the exhaust valve as it is the first to come into action after the firing point. In multi-cylinder engines you can best set off from No. 1 cylinder (normally counting from the timing end), but in a twin of this type it does not matter, because the pairs of cams are opposed at 180 deg. to each other.

Consider the direction in which the camshaft is going to rotate, looking at the drive end. It will rotate in the same direction as the crankshaft, because there is an idler gear between the gears on the respective shafts. At this stage, therefore, you must decide in which way you want the engine to run. Now, moving in the chosen direction, the exhaust cam comes into operation, followed ***immediately*** by the inlet cam, after which there is a much longer interval before the exhaust cam operates again. This settles the sequence for one cylinder, and it is then only necessary to remember that No. 4 cam ***is*** exactly opposite No. 1, and No. 3 is opposite No. 2.

These simple rules apply to all engines with a similar valve arrangement, no matter what the methods of making and locating the cams. The relative positions of the four cams, for rotation in a clockwise direction, is shown in the diagram. I hope that this will not only save inexperienced constructors a good deal of head-scratching, but also save me a good deal of correspondence in trying to help them out of their individual difficulties.

Having laid down the essential requirements for the camshaft, I must now explain how they can be put into practical effect. Although I have several times described the

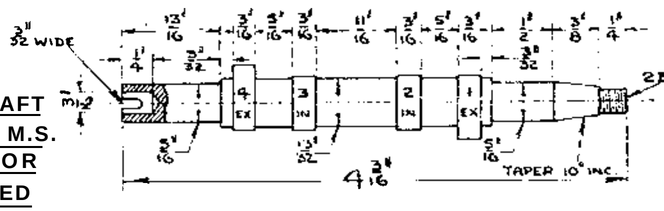


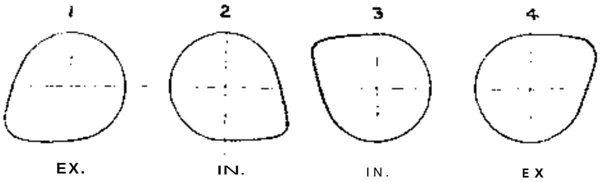
IGNITION CAM &
STARTER DOG
I OFF. EACH M.S. C. H.

methods of forming the cams by eccentric turning methods, I still get many queries on the subject, and no apology should therefore be necessary for my dealing with it again in detail. I shall first explain that these methods apply only to cams in which the flank contours are convex circular arcs, and not to tangential concave flanked or specially contoured cams. But the convex-flanked cam, which works with reasonable efficiency in conjunction with a flat-based or " mushroom" tappet, is widely used in full-size motor car engine practice, though for convenience in quantity production it is usually formed by a copy-grinding process.

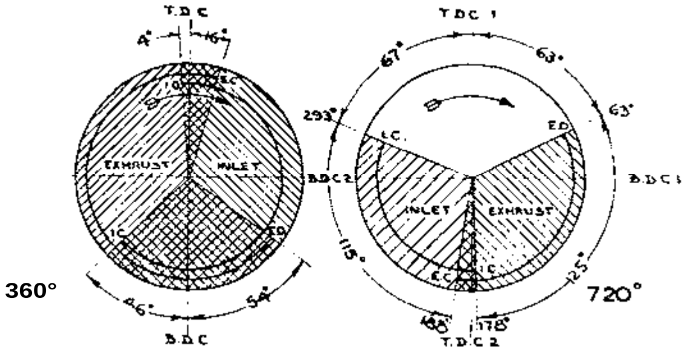
Many readers, because of the speed with which cams can be copied in this way, wish to adopt the method in model engines, and ask me how to set about it. The process is certainly applicable to any size of cam, and I know of several instances where it has been used, but it is only of advantage when a fairly substantial quantity of cams has to be made. In the first place, it is necessary to produce accurate master cams, which involve almost as much work as forming the set of cams directly on the shaft (when only one set is required). Secondly, the process of copy-grinding calls for precision methods, and is subject to errors which are often difficult to detect and to correct. While the choice of process is open to the constructor, the eccentric turning method can be

CAMSHAFT
I OFF. M.S.
C.H. OR
CHROMED

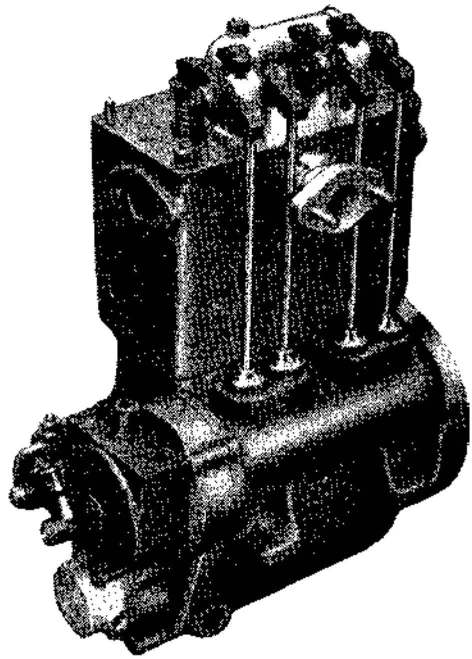




RELATIVE POSITIONS OF CAMS



TIMING DIAGRAMS



Ian Bradley's engine in progress

recommended as calling for only very simple and rugged-equipment, and the results obtained are absolutely positive.

The timing of the cams is set out in the two diagrams which show opening and closing angles of inlet and exhaust cams. On the left is the familiar diagram showing crankshaft angles, which can be used for checking up on assembly-in other words, the " garage mechanic's " diagram. It is useless for the purpose of designing and forming the camshaft? which of course rotates at half engine speed, and covers 720 deg. of crankshaft movement, as shown in the right-hand diagram. This is marked out with two crank top dead centre positions opposite each other, and bottom dead centres at right angles to them; but the degrees marked around the edge represent actual camshaft angles for the opening and closing of the valves or, in other words, the points at which the flanks of the cams start to rise from, or descend to, the concentric part of the cam, known as the base circle.

A replica of this right-hand diagram should be set out on a metal disc about 2-1/2 in. dia., which can be used as a division plate. It is not necessary to work to toolroom precision on this operation, as an error of a fraction of a degree will not prevent the engine from working with reasonable efficiency; but highly-tuned racing engines call for exactness in this respect.

engine is to run anti-clockwise, the diagram should be reversed, or strictly speaking, " mirror-inverted." The jig for forming the cam flanks, to which the disc is to be attached, will be described in the next article.

To be continued on July 12

BOOK *REVIEW*

Standard Gauge Railways in the North of Ireland, ***by R. G. Morton (Belfast Museum and Art Gallery, 5s.).***

THE Railway Age in Northern Ireland began in 1837, with the construction of a short stretch of line from Belfast to Lisbum, 7) miles away.

Mr R. G. Morton points out that the Ulster Railway was the second line to be built in Ireland, preceded only by the Dublin to Kingstown railway. Like the railways in England and Wales, the Ulster lines reached their peak during 1900 to 1914. By the First World War, lines stretched from Dundalk to Sligo on the West Coast, from Greenose on the East Coast to Portadown and Londonderry, and from Belfast to Ardglass and Portrush.

The introduction of locomotives of Derby lineage to Ulster in about 190.5 came about as the result of the purchase of the Belfast and Northern Counties Railway in 1903.

After the First World War, the various Ulster railways faced a serious situation. The increased cost of raw materials, the higher wages paid to railway servants, and the growth of road competition, all combined to make their financial position difficult; and the railway strike of 1933 added to their troubles.

The closing of lines followed the Second World War, and in 1943 the Ulster Transport Authority was set up to take over the NCC and the Belfast and County Down. Further closures were made when in 1953 a joint board was found by the CIA and the Ulster Authority to run the GNR.

Mr Morton has, in the small space of thirty-six pages, given us an excellent insight into the problems of the railways of Northern Ireland. There are maps showing the railways running in 1850, 1914 and in 1961, a useful bibliography, and 27 illustrations of good quality showing some of the stations, locomotives and rolling stock of the various railway companies.-R.M.E.

By EDGAR T. WESTBURY

Why be scared of making cams?

Continued from June 28, page 813

THE jig employed for machining the cam flanks integral with the shaft is identical with the one for the 1831 engine; it differs in detail from the jig employed later for the *Seal, Seagull,* and *Sea Lion* engines though the principle of operation is the same in all of them.

Essentially, the jig is nothing more than a device which allows the camshaft to be set up in a position eccentric to the lathe axis, and to be turned on its own axis to time the opening and closing points of the individual cams. This particular jig embodies a circular mandrel, centred at each end, and with rectangular-shaped cheeks clamped to it to carry the end journals of the camshaft.

The cheeks must be rigidly attached to the mandrel so that they cannot move inadvertently, though one of them at least must be removable. The method of attachment shown is by split clamps, with bolts which intersect the mandrel and act as keys. But other methods which attain the same ends, such as Allen grub screws with well sunk points, are permissible.

Clamping the shaft

It is equally important that the shaft is held firmly in its bearing. For this purpose brass set screws are used to avoid risk of bruising the surface of the journals. The cheeks should be clamped together for boring the holes (which, of course, need to be a good fit) so that the shaft axis will be in parallel alignment.

To those readers who are unfamiliar with the process of forming cam flanks by turning methods, I will explain that when this part of the cam profile is a circular arc its contour can be machined to a high degree of accuracy by setting the shaft to the required radius of eccentricity and using a single-point lathe tool in the ordinary way. The flank curve here has a radius of 7/8 in., and the base circle is 7/32 in. radius; hence the camshaft *centre* has an eccentric radius of 7/8-7/32=21/32 in. from the jig mandrel centre.

By making use of a division plate marked with the opening and closing positions of the cams, you can turn the shaft to the appropriate angles, and lock it in position for machining each flank in turn-for a twin-cylinder engine, eight machining operations. The metal disc, marked out as I described in the last instalment, is therefore attached to the face of the cheek. Note that it is necessary to drill a clearance hole in the disc for the mandrel to be mounted between the lathe centres. The hole is located at or near the zero-one (t.d.c.) position so that it is possible to turn the pointer on the shaft to all four opening and closing positions without interference.

The pointer must be capable of secure mounting on the tapered end of the shaft. You should, therefore, turn and bore a boss, to which the blade can be soldered, or otherwise attached. In dealing with the first pair of cams, the position of the pointer on the shaft is immaterial so long as it does not shift in relation to the shaft.

After setting the pointer to one of the marks clamp the shaft by the set screws. Using a keen, fine-nosed tool, and light cuts, remove 3/32in. from the appropriate blank. This amount can be measured on the cross-slide index, or more accurately by micrometer over the work. If the original diameter is exactly 5/8 in., the reading, after you have taken the cut, should be 0.625 in. -0.093 in. =0.532 in. When this is arrived at you should note the reading on the index or, better still, set some form of positive stop to prevent the depth of cut from being accidentally exceeded.

After the machining of one flank, the set screws are loosened, the pointer is set for the other position on the same blank, and the operation is repeated; the second cam for the *same* cylinder is then also machined on both flanks. Now the pointer is turned to zero-one position (it will, of course, be necessary to remove the jig from the lathe) and the shaft clamped by the set screws while the pointer is loosened and re-set to zero-two position on the disc. The machining operations on the cam blanks for the other cylinder are then carried out as before.

Machining the base circle

You must now remove a good deal of superfluous metal all round the base circles of all the cams. You are strongly advised that the noses of the cams should first be plainly marked by a spot of quick-drying paint, or Spectra marking fluid. If this is not done, it is all too easy, in later operations, to make a mistake about where the metal is to be cut away, as I know from bitter experience! There are several ways of machining the base circle, such as by a succession of nibbling cuts, shifting the shaft one or two degrees between each. Circular milling is a quicker process, but it is not so easy to control the limits of the cut, to prevent running into the flank.

One of the best devices for finishing the base circle is a filing rest on the lathe cross-slide, the shaft being placed between the lathe centres and gradually turned by hand during the filing operation. It is necessary to set the rollers of the filing rest to the correct height adjustment for the base circle diameter, and to use a dead smooth file, which ceases to remove any metal when it makes contact with both rollers. The filing rest described in the ME Handbook *Lathe Accessories* is particularly suited to this kind of work, as it has micrometer height adjustment and is more rigid than the conventional pillar filing rest.

If desired the base circle can be reduced in diameter to the extent of a few thou to allow for tappet clearance. This is not shown on the drawings, as it is regarded as an added complication by inexperienced readers, who are already terrified at the prospect of making cams in any event. Engines work well enough without this allowance, if the tappet adjustment is set as close as it can be, short of fouling. But in full-size engines, which must run for long periods without attention, it is customary to allow sufficient clearance to take care of wear and thermal expansion in all conditions, while still avoiding hammering or noisy operation. The undercutting of the base circle is eased into the flank contour at the opening point, so that it does not start lifting the tappet abruptly or reduce the angular period; the same applies to the point of closure. Generally about 15 deg. are occupied in this transition contour, or " ramp."

The nose of the cam in each instance can be formed in various ways, such as by form milling, or by setting up from a pivotal point coinciding with the nose centre of radius. But quite satisfactory results can be obtained by filing the nose as accurately as possible to the set radius; the main essential is that the various parts of the cam contour should blend smoothly without abrupt changes or sub-angles. You will find the filing jig quite useful for assisting control when you are forming the nose, or fairing in the contours generally

Those varied operations may sound complicated and tedious, but in fact they take hardly longer to carry out than to describe. The positive accuracy which they provide, in what might otherwise be a very hit-and-miss process, makes them well worth while.

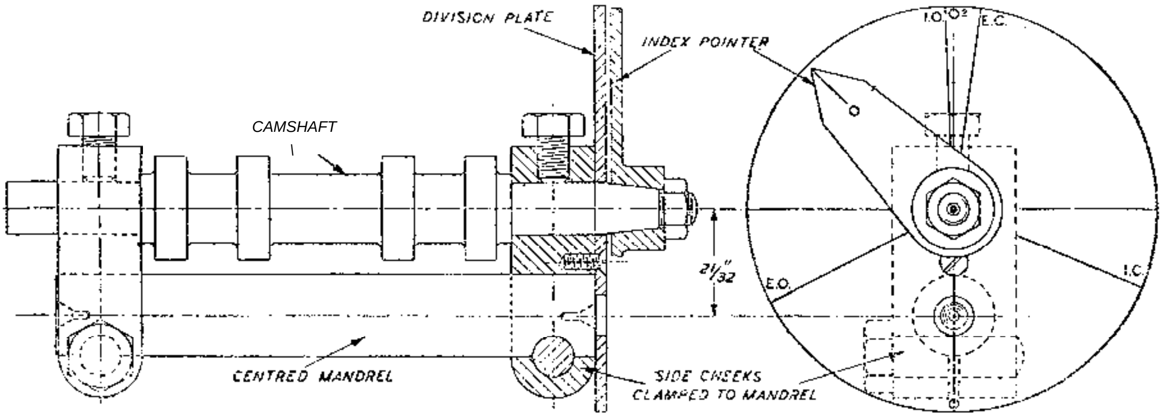
Case hardening of the camshaft involves some risk of distortion, but this is less, and is more easily corrected, than in " crooked" parts such as the crankshaft. Here again, chrome deposition to a depth of two or three thou will eliminate all risk. The enlargement of the cams by this amount will not affect valve operation, as it is the same all round.

For the timing gears, 32 diametral pitch is specified, as it provides ample tooth strength and the gears will run smoothly and quietly if they are properly made. But some latitude is permissible, so long as the gears give the required two-to-one reduction ratio:, it is even possible to vary the diameters of the camshaft and crankshaft gears if the size and location of the idler gear are arranged to enable the three gears to be meshed together properly. Alternative specifications for the gears, maintaining the same pitch diameters, are 24 DP, 15 and 30 teeth, or 40 DP, 2.5 and 50 teeth.

The smaller gears, or more correctly pinions, should be made in steel, and one or both of them preferably case-hardened; but brass or light alloy gears are quite suitable for the larger gears on the camshaft and oil pump (if fitted). I have had several enquiries whether bakelite or nylon gears are suitable for petrol engine timing mechanism, but I cannot give any definite answer to this question, as I have not had an opportunity of testing them. In theory, they should be strong enough, and no harm would come of trying them out. But the *necessity* for them, or their particular advantages, should not arise, as accurately cut and mounted metal gears will run quite smoothly, and without undue noise.

You will have to bore the camshaft gear to fit the tapered end of the shaft, and this will necessitate your settmg it up dead truly in relation to the teeth. Stock gears of good quality may generally be assumed to be cut from accurate blanks on the true mandrels, so that setting up from the outside of the teeth is generally satisfactory. The simplest way is to hold a disc of brass or light alloy in the chuck and turn a recess in it, a light press fit for the gearwheel. If the wheel should tend to slip during machining, two or three centre punch marks in the face of the recess, adjacent to the tooth spaces, will key it sufficiently to prevent this.

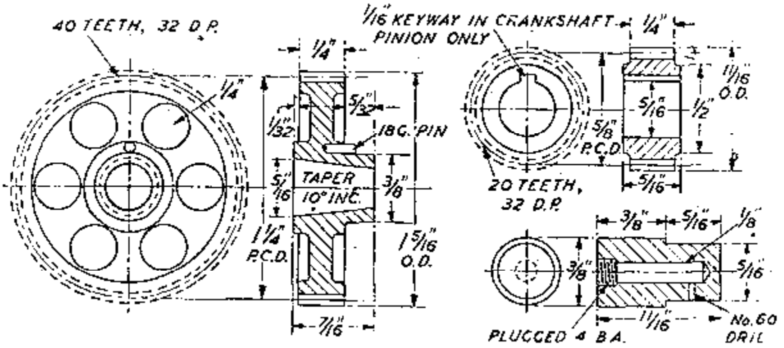
Some stock gears have a pressed-in centre. It is possible to remove this-by pressure, not hammering- and to fit a new hub, pre-machined truly inside and outside to the finished size. Keying of the hub may be desirable, and for this purpose a round pin, located endwise on the joint line of the two parts, will be satisfactory. Gears that are not truly cut in relation to the blank diameter present a difficult mounting problem, as it is necessary to bore the centre true with the teeth. To



Camshaft set up in jig for the turning of flank contours set them up for this operation, a recessed disc may be used as before, but it should be held in the four-jaw chuck so that its position can be adjusted. With the gear fitted in the recess, small pins which will fit between the teeth without bottoming are inserted at three or more points around the wheel and held in place by screws from the outside of the disc. With the aid of a dial test indicator you can now "clock" over the pins and adjust the chuck as required, before boring the centre.

Pinions usually have a boss which simplifies setting up for boring, but you should take the same care to ensure that the teeth run truly. It will be seen that the crankshaft pinion has a keyway. The best way to cut this accurately is by a shaping tool in the lathe, as described several times in ME. The camshaft gear does not need to be keyed if the taper is properly fitted; it is better for the gear to be capable of adjustment for accurate timing.

To adjust the idler gear in correct location for meshing with both gears, the crankshaft and camshaft may be assembled in position and the idler located by trial. I have found it a good idea to adapt the principle of the "toolmaker's button." A bush turned to fit the bore of the idler, and slightly longer, is fixed in position by a screw and washer in a hole drilled and tapped as closely as possible to the position found most suitable. The meshing of the gears is then checked by observation, and also by running them at high speed, if possible. Latitude allowed in the bore of the bush permits it to be adjusted to give the correct meshing



Timing gears (one off each part; extra pinion without keyways used as idler) and the idler pinion stud

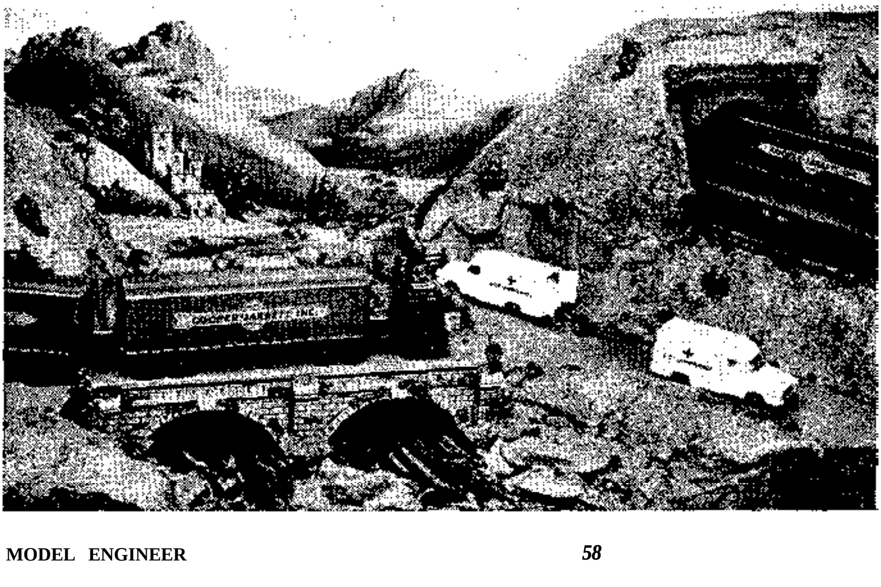
depth in both main gears.

Without disturbing the position of the bush, remove the shafts and mount the body casting on an angle plate on the lathe. It may then be set up with the aid of a dial test indicator, so that the bush runs dead true; the bush can be removed and the hole bored for the idler stud.

As shown in the detail drawings, the stud is intended to be pressed in, but if you find this method of fitting difficult you may screw it in, provided only that both its external thread, and the thread in the tapped hole, are perfectly true. It should have a small collar, fitting a counterbore so as to lie flush with the surface of the casting, and also a slot in the end for a screwdriver. When it is in position, the oil passage to the end main bearing is drilled through it, and thus the stud too will be simultaneously fed with oil.

Lubrication of components which rotate on a stationary pin or "dead axle" creates a special problem; it is no use providing an oil hole in the rotating hub, because any oil which enters it will promptly be thrown out by centrifugal force at any appreciable speed. I have known bearings which have seized up in these conditions, even though they were completely submerged in oil. In fact, the whole idea of the " oil bath " for high speed machinery is a fallacy; it is effective only when the works are stationary! For this reason, the idler stud is made hollow, with a small cross hole to feed the bearing, and plugged at the other end. As both the stud and the pinion are of steel, and there is hardly any room for a bush, one of them (preferably the pinion) should be case-hardened.

* *To be continued on July 26*



What's going on here? It *is* not clear what has happened, unless some unfortunate has fallen into the water. Anyway, two new little Matchbox models have met in the mountains-an 00 scale Bedford-Lomas ambulance and a double freighter. The ambulance has a fully-fitted interior and rear doors which open. You would come across the Interstate double freighter on the great turnpikes of the USA.

BY EDGAR T. WESTBURY

Continued from July 12. page 58

Clutch for those who want it

A GOOD deal of latitude is permissible in the shape and size of the flywheel, depending largely on the purpose for which the engine is to be used, and how it is to be installed. In the original 1831 engine, the flywheel formed the driving component of a centrifugal clutch. I have considered it desirable to retain the clutch as an optional feature, because it may be useful, especially when the maximum degree of flexibility is required, as for traction purposes or in radio-controlled boats.

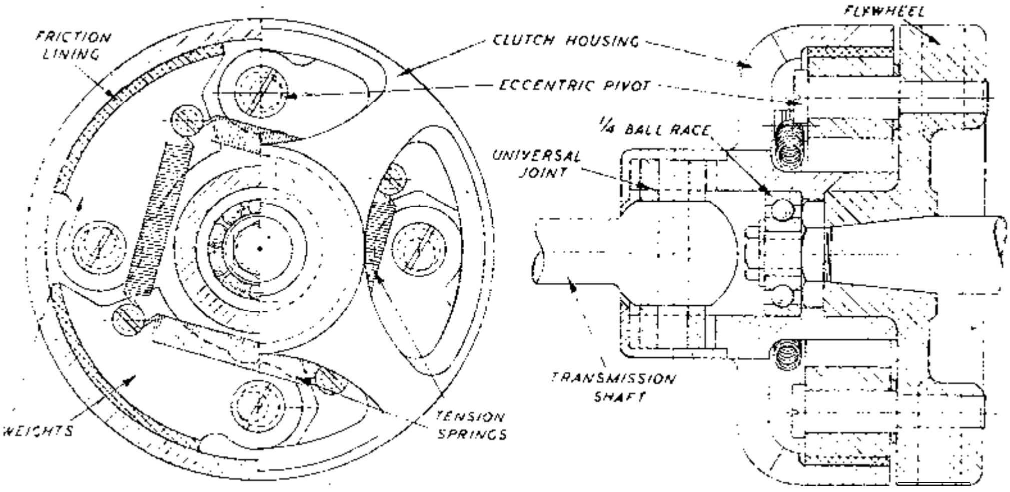
When the clutch is not to be incorporated, the flywheel may with advantage be made larger and heavier; the dimensions shown are the minimum for smooth running over a fair range of speed. As will be seen from the general arrangement drawings, the flywheel is tucked in as closely as possible to the engine. The main reason for this is that in the short wheelbase of the 1831 locomotive, end-space was limited; but it is a sound feature generally, as it reduces the overhanging load on the main bearings.

Apart from these points, it is highly important that the flywheel should run truly, and that the tapered bore should be a really good fit on the engine shaft. In machining the mating surfaces, you should test the fit with marking colour, and adjust the angle until a perfect bearing all over is obtained. A dead smooth file may be used in the final stages. Do not attempt to correct angular error by lapping; it will only produce ridges and scores. You can use fine abrasive for bedding-in, ***after*** the fit is assured. Carry out the final external turning of the the flywheel by locating from the bore on a true mandrel.

With a properly fitted taper, it should be possible to wring the flywheel on the shaft by hand. Without fitting the securing nut, take a light cut over the outside-a very good test of accuracy in mating angles. You are sometimes recommended to relieve the middle part of the taper by undercutting either the shaft or the bore of the boss, to increase local wedging force, but I have never found this necessary.

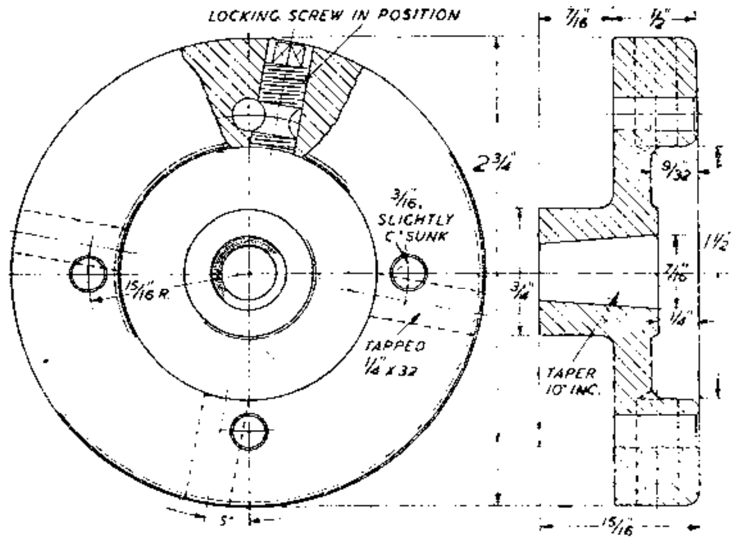
After all machining operations are completed, check the flywheel for static balance by fitting it to a short mandrel with equal-sized ends so that it can be rolled on two levelled parallel strips; you should, of course, correct any error by removing metal, preferably from inside the rim, where it does not show. From experience, it has been found that flywheel castings, however sound they may appear, are not always in perfect balance when they are machined truly all over.

The flywheel should not be keyed on its shaft; in normal conditions, it will not slip if it is properly fitted, and in the event of an abnormal wrench, it is much better for the flywheel to slip than for working parts to be seriously and permanently damaged. These remarks apply

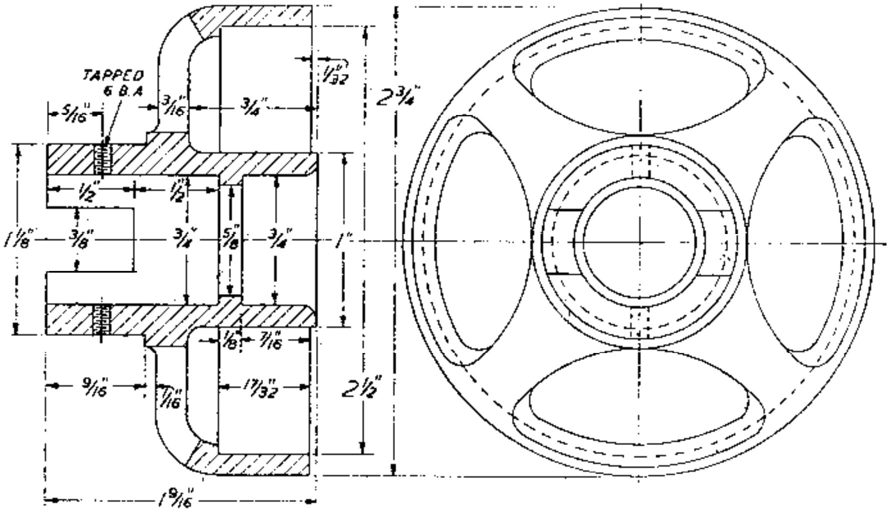


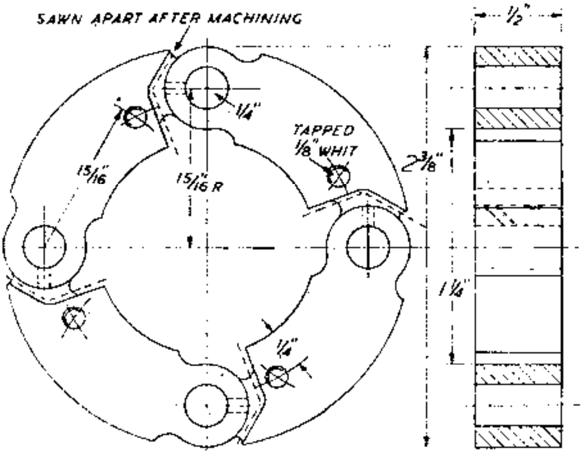
General arrangement of the automatic clutch on the flywheel generally to all taper fits, including those of the camshaft and timing gear. I have encountered many instances where badly fitted tapers have caused trouble, and that is why I have paid special atention to this detail.

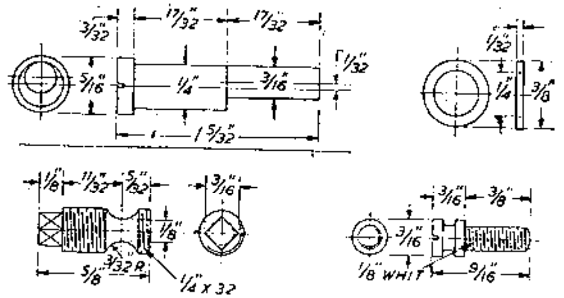
If the clutch is to be fitted, the next item to be considered is the housing, or driven member, which may be made in bronze or high duty aluminium alloy. Set it up by gripping the rear boss in the four-jaw chuck for machining the inside and outside of the rim, and also the mouth of the inner sleeve, which should be a running fit on the boss of the flywheel. During the boring, there may be a tendency for the rim to chatter or "sing," and thus prevent a good tool finish from being obtained. The really effective way to avoid this is to machine a wooden ring which can be pressed lightly over the outside. The next best thing is to wind several layers of



Above: Flywheel with pivot locking screw in place. Right: Details of the clutch housing







Above: Eccentric pivot and washer, pivot locking screw and spring anchor stud. Left: Set of clutch weights made in one piece and separated afterwards

insulating tape, or even string, around it, to damp out vibration.

On the rear side, the boss is machined to form the drive coupling. This part, too, is subject to modification. The form of coupling shown incorporated in the hub of the coupling is cross-slotted to take die blocks, which in turn are fitted to the ends of a swivel pin in the ball-ended transimssion shaft. This coupling ***is*** known as a Cardan joint; it is truly universal, and has been extensively used in motor vehicle transmission.

A simpler form of coupling, such as the " ball and pin " type, which differs only by the elimination of the die blocks, may be quite satisfactory for many purposes. In any event, the boss should be bored out truly to take the ball race, which is of the light duty type, 3/8 in. bore X 7/8 o.d., to fit the engine shaft and housing bore. The Skefko EE3 race is an appropriate type and size.

A stub mandrel, machined in position to fit the front end internal bore of the housing, may be used to set up the work for these operations, as it is important that concentric alignment should be assured. When the work is assembled on the flywheel boss, with the ball race clamped in position by a setscrew in the end of the shaft, a small but definite clearance should be allowed at the rim, and the housing should spin freely, but without slack. The hub should be packed with grease as oiling may affect clutch operation. A light cap is shown enclosing the coupling, but one of the synthetic rubber seals, as now used on motor car steering joints, would be better still.

The clutch weights are made from a solid bronze ring which, after you have machined it all over and drilled the pivot holes (preferably by indexing) is cut into four segments, the ends of which are then trimmed to the shape shown. Uniformity, and exactly equal weight, are essential to avoid upsetting the balance of the flywheel. The friction linings (or, more properly, facings) of 1/16 in. asbestos composition may be cemented on by a latex adhesive such as Pliobond or Evostik. To prevent the risk of movement if this becomes softened by heat, one or two screws in each segment, countersunk well below the surface of the lining, should be used.

Alternatively, the weights may be made from a solid bakelite-asbestos composition such as Capasco which, though much lighter than metal, has been found to work well if the clutch springs are suitably adjusted.

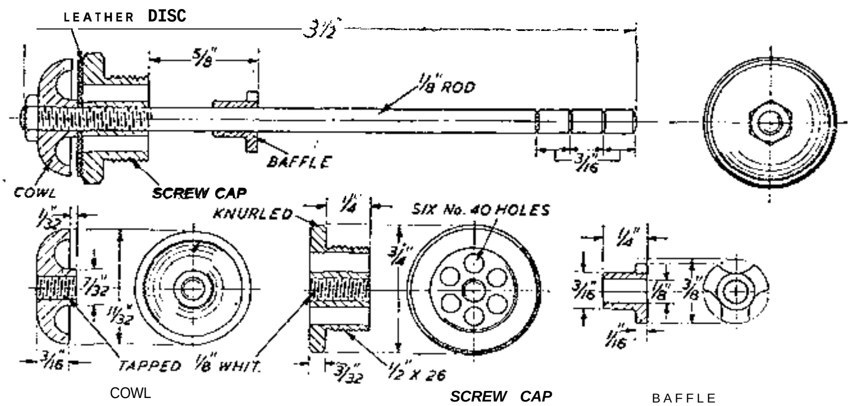
The pivots for the clutch weights, and their method of fitting to the flywheel, may be considered unnecessarily elaborate. Instead, they may be made in the form of shouldered setscrews with hexagon heads, fitting tapped holes in the flywheel. When this clutch was first designed, little experience or other established data about such devices could be obtained, and it was thought advisable to provide for exact heel-and-toe adjustment of the weights, to provide good surface contact of the linings and compensate for wear. Hence the eccentric pivots, and the waisted setscrews for locking them in position. It has since been found possible to get away with much simpler arrangements, but there should be no need for apology in showing a means of obtaining the highest possible efficiency in the operation and maintenance of the clutch.

Four tension springs, anchored to groove-headed screws in the sides of the weights, hold them in contact with each other, and out of engagement with the housing, when the engine is stationary or running at idling speed. To give an exact specification for these springs is impossible because all depends on the torque-speed range required of the engine when it is used for a particular purpose and the speed at which the clutch is required to come into action at the start. Some experiment with springs is therefore necessary; they are easily made or obtained.

For most duties, it is convenient to arrange for the weights to begin to engage at an engine speed of 700 to 800 r.p.m., when a useful torque is beginning to develop. At this point the centrifugal force in the weights overcomes the tension of the springs, and the linings are pressed against the inside of the housing with increasing force as the engine speed is increased. Any tendency to overload or stall the engine causes a reduction of speed, which immediately releases the drive through the clutch.

There is a fairly wide transition range between first engagement and full torque or positive drive, during which some slip takes place. Provided that this not unduly prolonged so as to cause overheating of the linings, it gives an added ability to take up load gradually.

It is thus possible to drive a road or track vehicle from an i.c. engine through the medium of a centrifugal clutch, without the absolute necessity for change-speed gear, though this is desirable to allow the full power of the engine to be usefully employed throughout the full range of vehicle speed. The clutch is ***not*** a torque converter. It does not permit output torque to be increased over that which can be produced by the engine itself; it only allows the available torque to be applied to good effect in difficult conditions. In a radio-controlled boat, it enables the propeller to be stopped by slowing down the engine to release the clutch, and facilitates the operation of the reversing gear, when this is fitted.



These are combined: crankcase breather, oil filler, dipstick

* ***To be continued on August 9***

Continued from 26 July. page I 18

By Edgar T. WESTBURY

WALLABY

O.H.V. TWIN

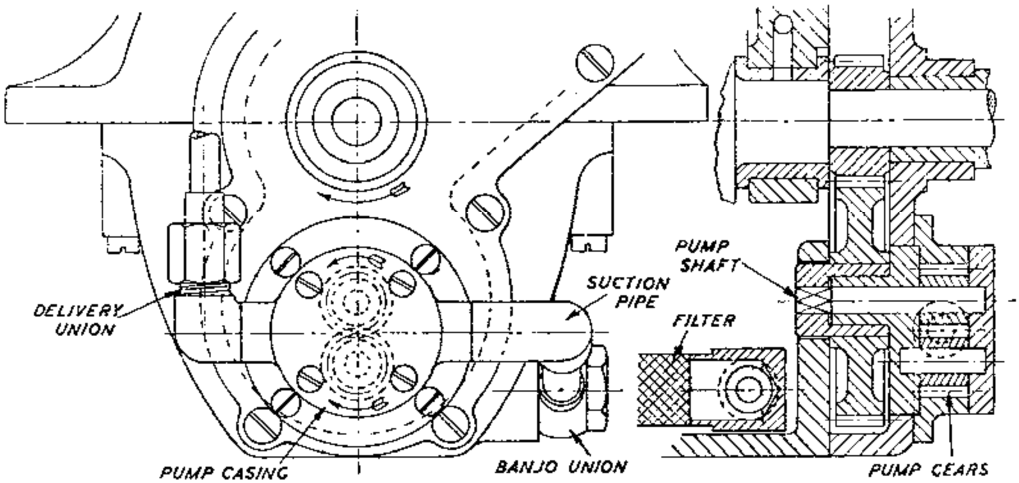
Gearwheel pump for the oil

EFFICIENT lubrication is of primary importance in all high-speed machinery, and internal combustion engines in particular. As I have already explained, a mechanical oil pump is a desirable, though not absolutely necessary, means to this end. It assures continuous and adequate supplies of oil to the main and big end bearings, which are the most heavily loaded. After passing through them, the oil is distributed by splash, or by being partly suspended in air, to all other working parts. Other methods of lubrication are permissible, but are not entirely automatic, and are thus less suited to long periods of running without constant supervision.

The oil pump used on the ***Wallaby*** is of the gearwheel type, which is perhaps the most popular of all for i.c. engines. It is of simple, robust construction, but calls for fairly high precision in the machining of the working parts; though these operations are by no means difficult if sound methods are observed. The pump is kept well lubricated itself, and because of the viscosity of the oil, leakage or " slip" through working clearance in the gears is not liable to be serious. Gearwheel pumps are not self-priming, and it is therefore necessary to fit them at a low level, so that they will at all times be submerged in oil and ready to deliver it immediately they are set in motion., These pumps should never be regulated by throttling either the inlet or the delivery; if excess oil is delivered, control may be obtained by a by-pass or relief valve.

The pinions for the pump on the original engine had to be specially cut, but you can now get pinion wire of high accuracy in the required size. While pump gears, strictly speaking! should have a special tooth form, with minimum tip and root clearance, ordinary small involute gears work quite well. In the assembly drawing the gears are shown as made separate, and pressed on shafts of silver steel, but it is almost as easy to make them integral with the shafts. In either instance, they must be chucked truly for boring or turning operations. The simplest way to do this is to make a chucking bush, bored in position to take the pinion wire a light press fit over the teeth. It may then be faced, bored and parted off, or accurately centre-drilled, so that when it is extended further from the bush it can be supported by the back centre for turning the shafts. Both ends of these can be turned at one setting before the pinions are parted in a finished form.

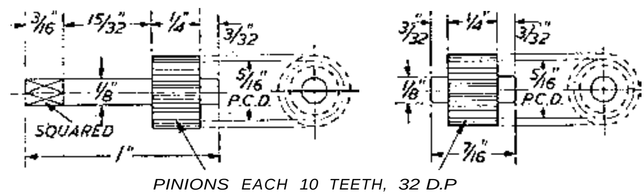
The pump is made in three main parts for simplicity in machining. Though you can reduce them to two by making either the front or back cover integral with the housing the process introduces some difficulties in exact centre locations, unless machining jigs are used. Usually, with either method, you will fabricate the housing by turning it ex-



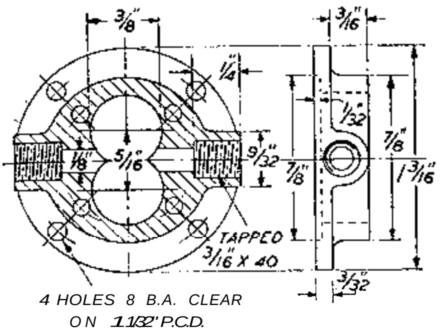
Complete oil pump assembly

ternally and silver soldering the inlet and delivery bosses in position. These may be drilled through, and spigoted for setting, but the final facing, drilling and tapping should be left till they are completed.

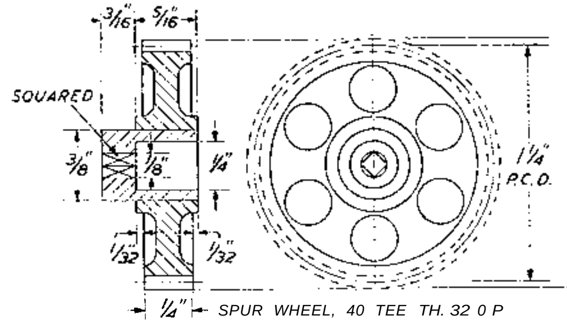
The housing is set up for machining the rear flange and the recess, and reversed for facing the front, which should be exactly parallel. It is then carefully marked out on this



Details of oil pump pinions



Oil pump housing

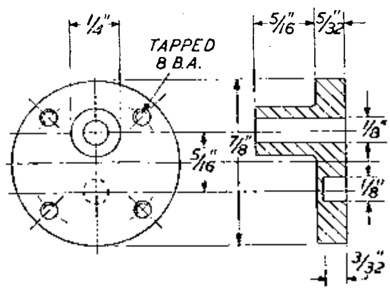


Oil pump delivery gearwheel

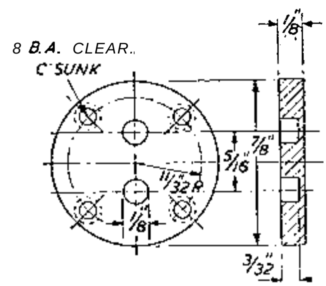
face for the positioning of the pinion centres. Those who are skilled in toolroom work may be capable of setting these out by dead measurement, using a vernier height gauge or toolmaker's buttons. But other and simpler methods are quite practicable. The problem of setting up to find the gear centres will arise; and the method which I recommend simplifies it, besides ensuring the exact coincidence of the centres in both the body and rear endplate.

A piece of bar stock large enough to make the inner endplate is held in a fixture such as a Keets V-angle plate, which will allow it to be set over eccentrically while parallel alignment *is* maintained. The bar should be long enough to permit of secure clamping, with the end projecting for machining. It is first faced and turned concentrically, to a close fit for the recess of the pump housing.

The holes for the fixing screws are now drilled in the housing. Holes to coincide with them are drilled and tapped in the bar so that the housing can be secured by temporary screws. Take care to eliminate burrs, so that it seats truly, and interpose a disc of paper between the two parts. The fixture is set over to establish the centre for the lower (non-driving) pinion, and the housing is carefully centre-drilled, and drilled No 31 right through into the bar deep enough to form the pinion



Inner endplate



Outer endplate

shaft bearing. It may then be opened out ***through the body only*** to 3/8 in. dia. so that the pinion wire will fit with the barest possible clearance. The paper insert will serve as a " witness " for accurate depth. If the recess should be too deep, so as to enter the face of the bar, you can machine the bar back after all the other operations are completed. A 1/8 in. D-bit can be used to finish the flat-ended bore for the pinion bearings to a depth of 3/32 in.

You must now fix the centre for the upper (driving) pinion, at a distance of exactly 5/16 in. from the lower one. Instead of relying on marked out centres, you can accurately measure the set-over distance of the fixture by another method. First, a straight strip of metal should be clamped to the faceplate, in contact with the edge of the fixture on the side further from the centre already bored. Use some form of gauge, such as a roller or short piece of bar exactly 5/16 in. dia., to measure the distance the fixture is to be shifted, after loosening, on the faceplate. It is important that the fixture should move ***in a straight line*** away from the locating strip, just sufficiently for the gauge to be inserted; the fixture is then again secured.

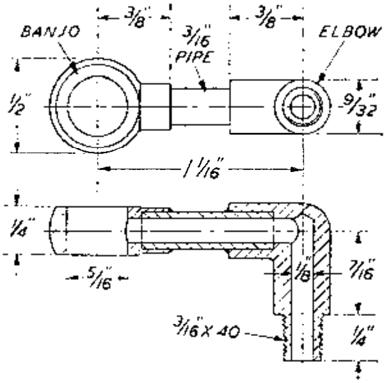
The drilling and boring operations are then repeated, but now the 1/8 in. hole is continued into the bar for a distance of 1/2 in. to form the extended shaft bearing. As no further work on the pump housing is required after you have bored it out to take the pinions-most of this work must be done with a single-point boring tool, as it breaks into the adjacent bore-you can then remove it from the piece held in the fixture. The outside of the inner cover can now be machined to form the bearing, leaving a flange 5/32 in. thick, and parted off at 5/16 in. further distance. The outside of the bearing must be concentric with the bore, and 1/4 in. diameter to fit the sleeve of the driving gear.

The outer endplate is simply a flat disc 1/8 in. thick, truly faced on the inside, and with 1/8 in. blind holes to fit the pinion shafts. To set it accurately you should jig-drill the disc from the housing to take the attachment screws, and temporarily fix it in position. A jig bush, closely fitting in the pinion housings, and concentrically drilled No 31, is then used to position the pinion bearings, which in here also may be finished with a flat-ended 1/8 in. D-bit.

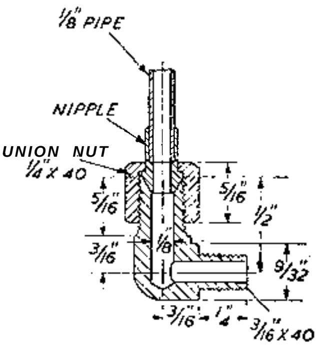
When the pump is assembled, the pinions should mesh closely together and work freely, but with no perceptible end play. You can best carry out the cross drilling, tapping and facing of the inlet and delivery bosses by mounting the housing on an angle plate; take care to remove the burrs thrown up by the drill on the inside.

The gearwheel which drives the pump is similar to that on the camshaft, except for the hub. If the gear has a pressed-in centre, it should be removed; otherwise it needs to be bored out truly. A steel sleeve, drilled 3/32in. and counterbored 1/4 in. to fit on the outside of the pump bearing, is then made a press fit in the gear centre. Engagement with the pump shaft is by squaring out the hole to fit the similarly formed shaft end. This may be done by filing or drifting, but I prefer to use a small shaping tool, such as a small diamond-point chisel or graver, in the lathe toolpost, indexing the work in four positions.

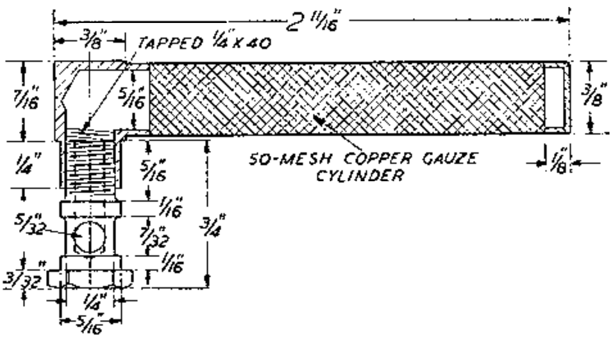
For the attachment of the oil pump to the timing case of the engine, a hole must be bored in the case at a distance of 1-3/32 in. from the main shaft centre. It should be set out as accurately as possible; while some latitude is permissible in the hole for the gears to be adjusted in mesh before the pump is fixed in position, it is better to avoid the need for this. You should mount the timing case on the faceplate for boring the hole. At the same setting, it should be locally faced to form a seating for the pump flange. Before the pump can be fitted, a hole must also be bored in the end face of the sump (see assembly drawing) to accommodate the end of the gear sleeve. The position of the hole may be found by removing the outer cover of the pump, clamping it in position, and using the shaft bearing as a jig to drill a pilot hole in the sump, to be opened out to 3/8 in. dia. While the diameter need not be an exact running fit for the sleeve, it is the better for being so, particularly as it must hold the gear in the approximate position for reassembly if the pump is removed from the engine for any reason.



Oil inlet banjo and elbow



Delivery elbow and union



Suction oil filter

Connecting up

The oil service pipes and fittings call for very little comment, as they are straightforward to make, and are subject to several modifications. Note that, as shown in the assembly drawing, the inlet and delivery pump connections are arranged to suit a clockwise rotation of the engine at the timing end; if this is altered they must, of course, be reversed left to right. The oil delivery pipe is taken to a single connection on the centre main bearing, or to three connections feeding the individual main bearings. A spring-loaded relief valve may be fitted in the delivery line, and adjusted to spill oil back to the sump if the pressure or volume is excessive. A suction filter may be regarded as superfluous by many, as it is generally possible to ensure that the oil is clean, and to drain and renew it frequently.

An engine in which definite air displacement takes place in the crankcase (such as a single or 360-deg. twin) needs to have provision for free escape of air, preferably in the form of a light non-return valve, so that the mean crankcase pressure is maintained slightly below atmospheric. In the combined breather, oil filler and dipstick for this engine, a flexible leather or p.v.c. disc is used as the valve, but a metal or fibre disc, limited to a lift of not more than 1/16 in., is also suitable. The dipstick should preferably be grooved as shown to give a positive indication of oil depth.

* *To be continued on August 23*

WALLABY

OHV TWIN BY EDGAR T. WESTBURY

Concluded

All set to try her out

I HAVE already explained that there are several systems of ignition which can be used on a twin engine of this type. The arrangement and wiring diagrams are obtainable from the ME Plans department (PE10) and I do not propose to deal with them in detail here.

In my experience constructors prefer to employ the orthodox system of single coil and h.t. distributor used on most motor cars.

There are, however, several cars which have more than one ignition coil, and at least one well-known car has an individual coil for each cylinder.

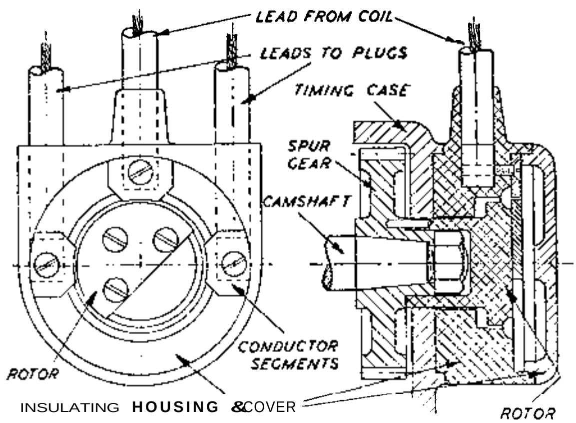
All coil ignition systems, except those which are electronically controlled, have some kind of contact-breaker in the low-tension circuit. For the 1831 engine it was made as a separate part so that it could be applied to different arrangements and also to simplify the construction and wiring. The combination of l.t. contact breaker and h.t. distributor, as on motor cars, involves some difficulties when the size is reduced to scale proportions, though it has been adapted successfully in the case of the *Seal* and *Sea Lion* engines.

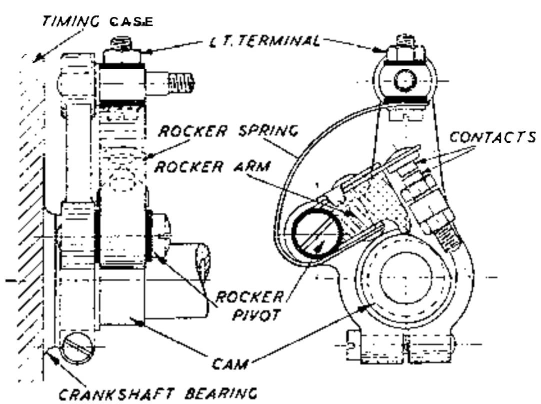
The 1831 contact-breaker, designed to operate from the engine shaft, is simple in construction and employs a ready-made rocker arm and spring, of a type which is readily obtainable from garages and service stores. The backplate may be made from a casting or machined from solid; apart from the outline, it involves no complicated shapes. It is bored to a wringing fit on the spigot of the timing case, and then the clamping lug is split, preferably with a small circular saw in the lathe, though a hand saw is equally effective, if rarely so neat. In any fittings which involve split clamps of this kind, the latitude provided by the width of the sawcut should never be an excuse for sloppy work, or the clamp will be distorted and will fit imperfectly, no matter how tightly it is screwed up.

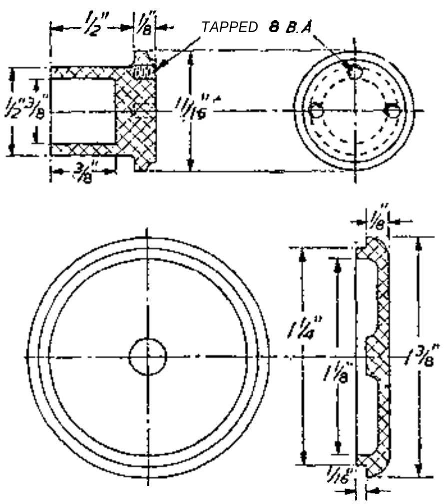
In drilling the holes for the rocker pivot and contact block, it is important to place them so that the stationary and moving contact points line up properly, and it is advisable to check by placing the components in position on the backplate. A dummy cam, with an enlarged rear extension to fit the split clamp, will allow the rocker to be set at the correct angle for this check. The cam itself, which I have referred to in dealing with the crankshaft fittings, can be incorporated in the oil retainer sleeve. Its contour is not critical, but should not be too abrupt in making or breaking contact. The period of " make " should not be more than 90 degrees. For economy on current, you can often work with a very short period. The cam should be timed so that the points are just barely broken, at t.d.c. with the contact-breaker lever vertical.

The rocker arm has a spring attached to it which serves as a live electrical conductor and must therefore be insulated from the backplate. It will be seen that the attachment stud is flattened on both sides, and fitted with an insulating bush and washer, for this purpose. But sometimes the rocker spring has a looped instead of a flat tail, in which event the means of attachment must be modified; the essential thing is that it must be securely attached and insulated. The contact post, which is drilled and tapped to take a tungsten-tipped screw, is riveted into the backplate just tightly enough for it to be set into alignment, after which it may be made permanently secure.

The distributor is simple, and its design permits the wiring to be neatly arranged, compared with the more usual type in which the leads come out parallel to the shaft axis. I; is important that you select a suitable material for the insulation,. as both its electrical and mechanical properties affect its success. Ebonite, which is a compound of rubber and sulphur, is an excellent insulator,







Distributor rotor and cover

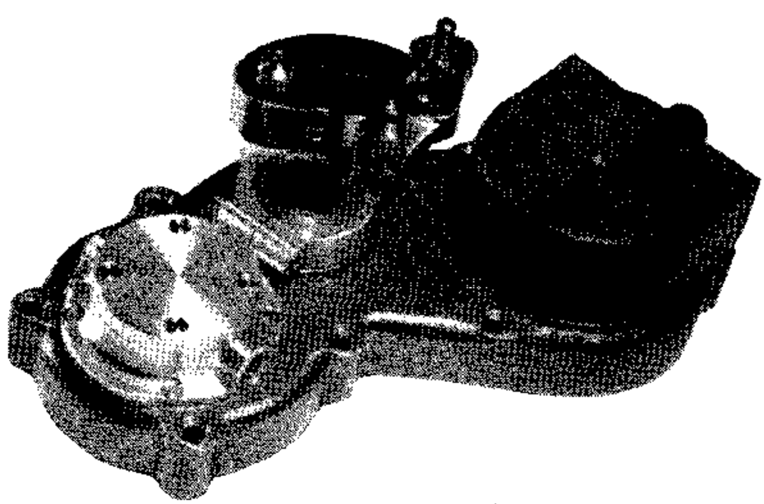
but is not mechanically stable, and is liable to deteriorate in the proximity of oil vapour.

Phenolic compositions with paper or fabric bases are often difficult to machine without their breaking or fraying at the edges, and are also liable to tracking of h.t. current over the surface unless it is prevented by surface treatment. After many experiments, I have found that cast phenolic or acrylic plastics, containing no fillers, are most reliable. Perspex, in its transparent form, will appeal to many as it provides a visible firework display when it is used for this purpose.

Whatever material is used, the surfaces subject to electrical discharge must be highly finished, but polishing by abrasive methods is not desirable, as it encourages tracking. Machining should be done with keen tools, so that little further treatment is necessary. The distributor housing can be machined from solid, including the projecting boss for the centre lead and for boring and recessing the front, and turning the rear face and spigot, which should be concentrically true and a good fit in the recess machined in the outer face of the timing case.

The distributor rotor and cover are machined from the same materials as the housing, and are similarly finished. In fitting the screws which secure the conductor segment to the front of the rotor, take care not to drill the tapping holes too deeply, or there may be a risk of flash-over to the metal of the camshaft gear boss. The rotor sleeve-should be a push fit on this boss, and arranged for timing (which is not at all critical) by a notch in its edge, engaging a pin in the face of the gear. End movement of the rotor is prevented by a small boss in the centre of the cover.

The metal parts of the distributor are very simple. It might be possible to attach the conductor segments to the rotor and housing by Araldite or another special adhesive, thereby avoiding the need for screws, but the screws also serve as terminals to fasten the ends of the h.t. leads, which are pushed into the small bushes fitted to sockets in the housing. In this way a simple, electrically sound and mechanically secure fitting of the three leads is provided. Good insulation of the leads is most essential; I recommend heavy p.v.c. covering. If the external diameter does not fit the sockets, sleeves of the same material should be fitted to take up clearance and exclude water, oil and dirt.



Timing case with oil pump, contact-breaker and distributor in position

The edges of the conductors on both the rotor and housing should be machined after assembly, to give a clearance of about 5 thou between them when the engine is working. It is now accepted practice to allow a small spark gap between conductors in h.t. distributors, as the use of carbon brushes or other rubbing contacts in earlier distributors often caused trouble by tracking or excessive wear. The complete assembly is held in position by a bolt with a spring clip, as used for many years with magneto contact-breakers. This allows some latitude of angular position, but timing movement of the distributor is not necessary, and the only virtue of the fitting is that it provides ready access to the components for inspection and cleaning.

As the wiring of the ignition system is identical with that of motor cars, I need not explain it in detail. Briefly, the contact breaker, shunted by an appropriate condenser, is connected between the coil l.t. and earth on the live side of the battery; polarity is not usually important, but sometimes the engine works better one way than the other. The coil h.t. lead is taken to the centre terminal of the distributor, from which the other leads are run to the appropriate sparking plugs.

A really good ignition coil, such as the Runbaken Mini-coil or the Wipac motor-cycle coil, with the condenser specified by the makers, is essential to successful ignition; avoid super-lightweight coils, unless they can be positively ***guaranteed*** to give the desired results. Equally important is the provision of an adequate current supply. Dry batteries, unless they are of much larger capacity than any of the popular sizes, are not reliable owing to their voltage drop on closed circuit; accumulators, which have a flat voltage output on discharge, are much better, but they must be properly charged and maintained.

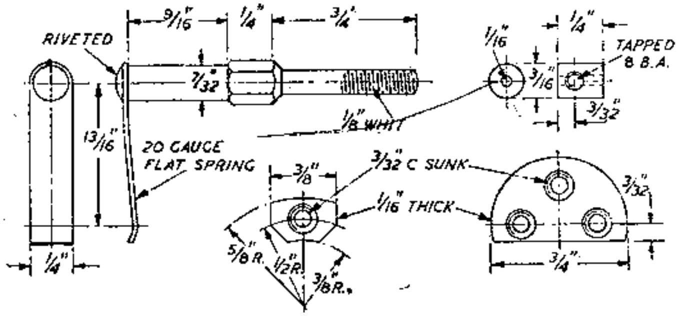
The Atomag Minor is quite suitable and will remove all worries about batteries. It may be gear- or direct-driven at crankshaft speed, with the h.t. lead taken to the centre terminal of the distributor, and the contact-breaker on the engine eliminated.

Several different carburettors have been used with success on this engine, including those designed for some of my earlier units; the ***Wallaby*** is not a temperamental animal where feeding is concerned. I do not propose to give a detailed description of the original I831 carburettor, as you can get a fully detailed blueprint. While it is not really difficult to construct, and gives an exceptional range of control, if it is adjusted properly, many readers have objected to its size in relation to the engine and have demanded something more closely related to scale proportions.

The Atom Type R (PE8) is quite suitable, but many fail to understand its working principles, and as a result it is often found in very im erfect adjustment. On the whole, I think the ***Kiwi*** carburettor (PE12) will suit average requirements best. Although its compensation is incomplete, it will give satisfactory control on almost any old engine (other things being in working order) and is simple to build and adjust. The modern development of this carburettor was fully described in the articles on the ***Kiwi*** Mark II 15 c.c. engine, and detailed blueprints of it may be had.

Whatever type of carburettor you adopt, you should note that the main air passage, at is narrowest point (normally the throat or choke tube) should be related in area to the capacity of ***individual*** cylinders rather than total capacity, unless four or more cylinders are employed. This is because in singles or twins the flow of incoming air is intermittent, not continuous, and the air passage must take account of maximum demand so far as possible. Therefore the ***Kiwi*** carburettor, designed for a 15 c.c. single, will give good results on a 30 c.c. twin.

The natural temptation to open out the size of the throat should be resisted, unless it is found on test that the engine is suffering from bronchial restriction at the maximum ***working*** speed. Too large an air passage is liable to make starting more difficult and to impair the acceleration of the engine, or its ability to slog away under heavy load, and to recover from the effect of a temporary overload.



Details of the metal parts of the distributor

I need not say a great deal about the assembly, as I have dealt with the subject many times before, and there should be no snags if the components have been accurately made by the methods described. The particular design involves much the same methods of assembly as those of motor cars, and demands no more than a modicum of common-sense, plus a little more meticulous care than usual, owing to the size of the parts. The main and big-end bearings may be fitted by the good old-fashioned " scraping and bluing " technique, which, I am afraid, many motor mechanics nowadays have either forgotten or have never learned !

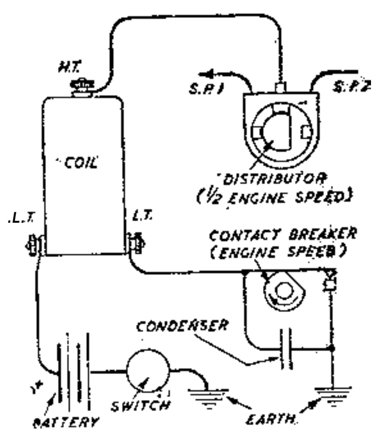
Timing

The camshaft timing may be carried out by reference to top dead centre on either cylinder, with the camshaft gearwheel only lightly secured to its shaft. A copy of the crank timing diagram may be fixed to, or marked on, the flywheel, and used to check the opening and closing of all four valves. If the full opening periods are not attained, owing to errors or lost motion in the valve gear, the differences should be halved out, but the need for this measure will depend on the accuracy of all the parts, including the meshing of the gears. All backlash should be taken up in the direction of drive.

A small i.c. engine, unlike a steam engine, cannot be made to work by the application of brute force, and the presence of any stiffness or high spots in working parts may cause it to run only very laboriously or not at all. You should run the engine in from some outside source of power for several hours before attempting to run it under its own power. This gives you an opportunity to check up on details such as lubrication, valve operation, compression, and (to a limited extent) carburation and ignition. Plenty of oil should be allowed during this operation. However scrupulously the parts have been cleaned before assembly, the oil will at first come out black, owing to the presence of dirt and metal dust. Ideally, running-in should be carried on until the oil comes out clean, but ***ars longa, vita brevis,*** and this process would also preclude the use of running-in compounds such as colloidal graphite, which is undoubtedly beneficial during the early life of most engines.

After running-in, the engine should be sufficiently free to be spun freely by hand, if the plugs are removed; and when they are fitted, the compression should be distinctly bouncy. Attention to these details will go quite a long way to provide efficient and trouble-free working over a very long period.

There are many virtues in ***good*** engines besides sheer power and speed; like friends, they should not be valued merely for what we can get out of them. Few readers, I trust, regard engines, or any other models, as only a means to an end. The pleasure obtained in building, and the satisfaction of a good job well done, are the main attractions; and builders of the ***Wallaby,*** I am sure, will not be disappointed in either respect. ❑



Wiring diagram for single-coil and distributor system. Contacts have just broken and No 1 ***plug is firing***

This serial opened on ***April 29 (page 475). Other instalments were published on May 3 (559), May 17 (606), May 31 (667), June 14 (734), June 28 (81 l), July 12 (56), July 26 (116) and August 9 (173).***