★ A 15-c.c. FOUR-CYLINDER ENGINE

By Edgar T. Westbury

HAVING completed the camshaft by turning the journals to size, case-hardening and polishing the cams and journal surfaces, the bushes in which it runs can now be made. These are plain bushes, made from medium hard gun-metal or bronze, and pressed into the ends of the camshaft tunnel. If desired, they may be secured or positively located by grub screws tapped into the walls of the main casting, but with reasonably good fitting, this should not be necessary.

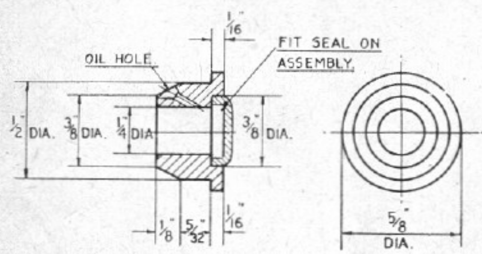

Fig. 26. Flywheel end camshaft bush

Oil holes should be drilled obliquely from the inner end of each bush, and well countersunk to catch oil splashed up by the cranks, the holes being disposed upwards or slightly inclined towards the cylinders. A blind-ended bearing is desirable on the flywheel end of the camshaft, to avoid oil leakage at this point, but in view of the difficulty of finishing a blind bore accurately, it is suggested that the bush should be drilled and reamered right through, and the seal, if any, fitted afterwards. As there is only ⅛ in. between the end of the camshaft tunnel and the flywheel, however, there is not much room to fit anything projecting beyond the flange of the bush, and the best thing to do will be to make a little recessed cap, to be pressed or sweated into the counterbore at the mouth of the bush. (Fig. 26.)

This fitting is only advocated in the interests of keeping the engine externally clean, and in the event of it not being considered necessary, the counterboring of the bush may also be dispensed with.

The inner end camshaft bush (Fig. 27) is turned down to act as a dowel or aligning spigot for the timing endplate. It is, of course, essential that the outside of each bush should be quite concentric with its bore, and the usual precautions should be taken to ensure this.

Timing Gears

The gears specified for this engine are 40 diametral pitch, with 20 and 40 teeth respectively; both the size and the pitch are very common, and the gears should not be difficult to cut in the lathe, or have made to order. I strongly recommend that model engineers should tackle their own gear-cutting problems wherever possible; the equipment necessary is by no means elaborate, and sufficient information has been given in THE MODEL ENGINEER articles, including the recent series on "Milling in the Lathe," to enable even the beginner to grasp the essential procedure.

Should it happen that 40 d.p. cutters are not

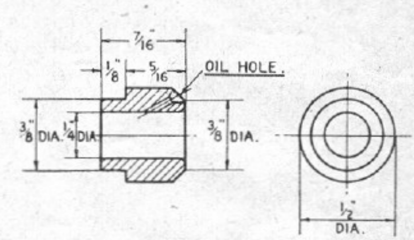

Fig. 27. Timing end camshaft bush

available, the pitch of the gears may be modified within fairly wide limits, so long as the correct ratio of gearing is maintained, and pitch diameters approximate. Gears from, say, 30 d.p. to 60 d.p. are permissible, though the finer pitches require to be cut very accurately to run sweetly; with ordinary gear-cutting facilities, it will generally be found that gears with a small number of teeth work quieter and wear better than those with a large number of teeth. It is quite in order to use metric pitch teeth, despite the slight variation in diameter which these entail, because the use of a "staggered" idler enables the meshing of the gears to be adjusted to compensate discrepancies in this respect.

For best results, the gears should be made of dissimilar materials. I recommend that the large spur wheel should be of bronze, and the two pinions of mild steel, that on the crankshaft being left soft, and the idler case-hardened. In this way, each of the gears will mesh with one of different wearing properties.

The spur wheel (Fig. 28) fits a taper on the camshaft, and in addition, a small Woodruff key is shown to enable positive timing location to be obtained. It is possible to cut this keyway with one of the small rotary cutters of the "dental burr" type, and to plane the internal keyway with a tool in the lathe; but keying at this point should be regarded as an optional feature, and speaking from personal experience, I regard a well-fitted taper as ample security.

There is, of course, the objection that in the absence of positive location, the camshaft must be re-timed whenever the engine is re-assembled after dismantling, but this is by no means a

★*Continued from page* 615 *"M.E." May* 15, 1947

formidable undertaking, and the friction fitting allows of small adjustments in timing to be made for experimental purposes. Cutting small keyways is a rather finicky job, even with the best care and skill, as it only needs one or two thousandths error in the centring of the cutter to produce a serious angular error in a shaft of this size. This can be corrected by fitting a stepped key, but I imagine few good engineers would condone this expedient.

The crankshaft pinion (Fig. 29B) not being on a taper, is rather different in this respect. My usual practice is to fit a small "snug" key in the boss of the pinion, adjacent to the shoulder of the shaft. This can be located on assembly, after the position of the pinion has been determined. It is only necessary to drill a No. 53 hole through the boss and into the shaft, sufficiently deeply to provide a secure seating for a pin made of 16-gauge steel wire, slightly tapered at the end. The hole in the pinion is then slotted out, as at C, Fig. 29, so that it can be assembled or removed from the shaft, the pin, after driving in, being filed off so that it does not project above the pinion boss.

It should be noted that pre-location of both crankshaft and camshaft keys is hardly practicable, because the three gears in the train are not in a straight line, or even necessarily in exactly determined relative positions, so that it would be a complicated (and in this case, rather unnecessary) matter to set out the positions of the keyways relative to the gear teeth. Incidentally, this difficulty is by no means non-existent, even in production practice; I have recently encountered an instance where several thousand gears were ordered from a well-known gear-cutting firm, with very explicit instructions regarding the position of the keyways. The instructions were accepted as quite explicit and practical by the gear specialists, but when delivered, all the keyways were found to be at different angles to the gear teeth!

Idler Gear Stud

The idler gear (Fig. 29A) is intended to run on a "dead" shaft in the standard arrangement of the engine, though an optional arrangement, should it be desired to take an external drive from this gear, is to fix it on a "live" shaft running in a bush in the timing cover. One disadvantage of this arrangement, however, is that it is a little more difficult to ensure the meshing up of the gears in their correct timed positions before putting on the timing cover; and as auxiliary drives can be provided in other ways, it is considered better to use this pinion as its name implies, and nothing more.

On account of the proximity of the idler gear centre to the edge of the ball race housing, it is not practicable to screw the fixed stud into the face of the endplate, unless the rather awkward arrangement of a "joggle" stud with a considerable amount of eccentricity is adopted. The best way, therefore, is to make the stud with a flanged foot, as shown in Fig. 30, and secure it to the endplate by two screws, the outer end of the stud being secured in the timing cover by a nut. This makes the location and fitting of the stud, to give correct gear meshing, quite a simple matter.

The procedure recommended for this operation is as follows: Temporarily assemble the camshaft spur gear and the crankshaft pinion in their running positions, either by assembling the essential components of the engine, or preferably, by fitting dummy shafts to work in concentric bushes in the timing endplate. Assuming the idler stud to be made from $\frac{7}{8}$-in. dia. steel, one side of the flange will have to be cut away, but the other may be left on temporarily, to facilitate holding the stud in place on the endplate by means of a small tool-maker's clamp or similar means. Adjust the position of the stud, with the pinion on it, till the gears run quite smoothly and silently with the minimum backlash; then mark out and drill the holes for the two countersunk fixing screws.

It will be seen that the idler stud is hollow, and cross drilled on the under side to form an oilway. A hole should be drilled through the timing endplate, to line up as closely as possible with the bore of the stud, and thus allow oil mist to pass through from the crankcase to lubricate the bearing. It may be mentioned that "dead" shaft bearings are often difficult to lubricate, because the common practice of drilling a radial hole in the boss of the running member only defeats its own object by throwing the oil out by centrifugal force. This trouble is very prevalent in certain engines which have the cams and timing gear mounted on a sleeve which rotates on a fixed stud. The only way to lubricate this type of bearing properly is from the inside of the shaft.

After fitting, and completing the shaping of the base flange, the stud should be case-hardened, leaving the threaded end soft, or "letting it down" by subsequent re-heating. The heads of the fixing screws must not project above the base flange, or they will foul the gears.

Location in Timing Cover

It is not absolutely necessary to fix the idler pinion stud at the outer end, but it is desirable on the grounds of extra security. This entails drilling a hole in exactly the right position in the boss of the timing case, to take the threaded end of the stud, and some constructors may consider it rather a difficult matter to locate this hole properly.

The method recommended is as follows: First set up the timing endplate in the lathe, with the idler stud fixed in position, and set to run dead truly. A convenient way of setting up is to pack the endplate up with a parallel ring or flat plate having a hole large enough to take the endplate spigot, and clamp it to the faceplate with a single bolt through the camshaft bush seating, leaving the main joint face clear. The stud should be centred with the aid of a test indicator, if available, to the closest possible limit of economic accuracy.

While the endplate is still set up in this position, the screws securing the stud are removed, and the timing cover is assembled in place, securing it by two or three screws. The boss for the stud may now be centred with a centre-drill, then drilled to take the stud, and spot faced, with the assurance that the hole will line up exactly with the stud on assembly.

Poetic Interlude

A few days ago I received the following cryptic message from a reader :

" Just of late, in our dear old " M.E."
Has appeared an engine of 15-c.c.

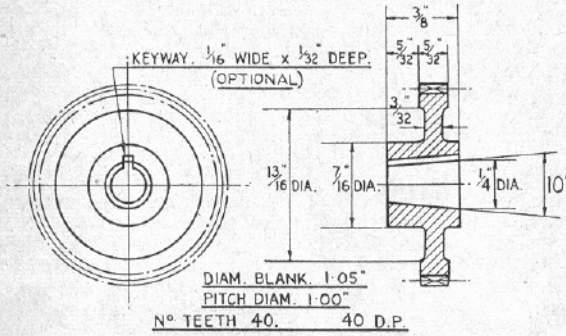

Fig. 28. Camshaft spur gear

With regard to this, your protege,
Your E's, I agree, are quite O.K.,
But although I'm sure you're not a liar,
It's a *three*, not a *two*, that you require."

After much exercise of the grey matter, or what is left of it, I came to the conclusion that this constitutes a reference to a slight error in the type number of the ball races used for the main bearings of the Seal engine, which, are $\frac{3}{8}$ in. bore by $\frac{7}{8}$ in. outside diameter by 7/32 in. wide, and were described as EE2's, but which I find are actually EE3's.

My reply to this very helpful correspondent was as follows :

Dear friend, I thank you for your mild correction,
I find 'twas my mistake, on close inspection ;
Not only must I mind my P's and Q's,
But also, it would seem, my 3's and 2's !

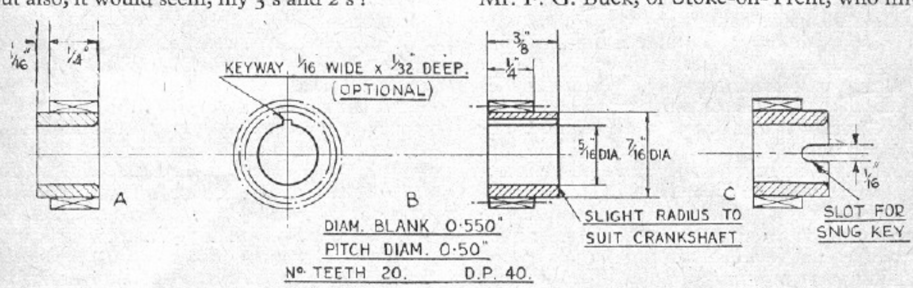

Fig. 29. Pinions : (A) idler, (B) crankshaft pinion ; (C) alternative and simplified method of keying pinion

Castings and Parts for the " Seal " Engine

Despite the assurance that these would be available, as soon as possible, and that an announcement would be made when they were ready, hardly a day passes but enquiries are received on this subject, and I have been rebuked by quite a few readers because of the delay in arranging for supplies. Although one is now deprived of the well-worn excuse so popular but a couple of years ago—" There's a war on ! " — I should think hardly any reader would need reminding that at the present time there are many factors which are equally effective in holding up and delaying work or the delivery in goods. Castings are particularly difficult at present,

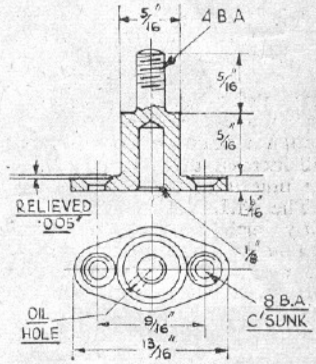

Fig. 30. Idler stud

owing to restrictions in both metal and fuel supplies, and I may mention that the last time I called at the foundry I found the proprietor out—touring the district on his bicycle, in the vain attempt to obtain a bag of coke to run his furnace ! In these days of universal frustration, I beg of readers to spare both themselves and me unprofitable and embarrassing correspondence on this matter, even though most of us may feel that the quality of patience is already strained well beyond the elastic limit.

Miniature Coils and Magnetos

Some time ago I referred to the miniature magnetos which are now produced by the Model Ignition and Accessories Co., of Ewell, Surrey. I have now heard from several readers who are using these magnetos successfully, including Mr. F. G. Buck, of Stoke-on-Trent, who informs me that a magneto of this type is working quite well on his record-breaking model car, and has enabled its performance to be still further improved.

I have recently inspected and tested two of the latest productions of the above firm : the M.I. " Unit " magneto, and the M.I. lowconsumption miniature coil. The former item is intended to simplify the adaptation of magneto ignition either to new or existing engines, be enabling the magneto to be built into the engine structure, instead of being an entirely separaty machine coupled to or otherwise driven from the engine shaft; a method which I have used in my own engines, and recommended in past articles.

The essential components—coil, stator and rotary magnet—are the same as those of the standard magneto, but the unit is not fitted with bearings or contact-breaker, as it will utilise those already fitted or designed for the engine. No condenser is necessary with these magnetos, though a small one connected across the points will increase their working life. The weight of the unit is $2\frac{3}{4}$ oz.

The M.I. "Lightweight" coil is wound on fairly orthodox lines, but achieves unusual economy of current by improved efficiency of the magnetic circuit, which is partially closed, and uses a special high-permeability alloy. It takes only 85 milliamps at 3 volts, and will work off a 2-cell "Penlite" dry battery; weight of coil, $1\frac{3}{4}$ oz. This coil has been used successfully by Mr. J. Cruickshank in his 10-c.c. model racing car.

There is, perhaps, one comment which should be made on the use of any ultra-miniature ignition equipment, to avoid disappointment by users, who are sometimes prone to expect too much from it in the way of electrical output. Although these tiny coils or magnetos are wonderfully efficient for their size, it must be fairly obvious that they deal with very small amounts of electrical energy, and that the spectacular sparking obtained from larger equipment is out of the question.

The ultimate function of any coil or magneto is to provide an effective ignition spark to run an engine at full efficiency; no matter how long or "fat" the spark may be, it cannot do more than this. I have heard the complaint that the spark obtained from lightweight coils or magnetos is very thin and almost non-luminous; but it is a fact that this tiny spark, properly applied to the plug, will effect ignition, just as surely as one absorbing half a kilowatt of energy.

(*To be continued.*)

Fuels for Small I.C. Engines

I SEE in the issue of March 27th a reference made to the use of doped fuels in small high compression 2-stroke engines.

I notice that a mixture of 50 per cent. methanol, 30 per cent. petrol, and 20 per cent. castor oil, is used by one of your constructors.

Frankly, I do not understand this, because petrol and methanol are not mixable, and the addition of castor oil makes matters very much worse. The only way in which it is possible to mix methanol with petrol is to have a considerable proportion of pure benzol present. The mix then is quite satisfactory, provided that the mixture is quite dry and water is not present, and a limited quantity of castor oil can be added. Any attempt to mix methanol and petrol together results in the same sort of thing as when you try and mix paraffin and water, they separate out completely, and no amount of shaking will mix them at all. Also, if you only have just enough benzol present and mixing does occur, the addition of two drops of water will separate the methanol and petrol at once. It is possible your constructor is not aware of this and that his engine is running on a mixture globules of both types of fuel or running wholly on one or the other. We have known several racing cars do this, due to the ignorance of their owners.

From full-size racing practice I would suggest that a far better mix would be as follows:—50 per cent. methanol, 20 per cent. pure benzol, 8 per cent. acetone, 6 per cent. nitro-benzine, 16 per cent. pool petrol, or, better still, 73 octane, if you can get it.

The acetone assists starting and helps to keep the plugs, and that sort of thing, clean, and the nitro-benzine considerably improves distribution and atomisation of fuel and also helps petrol consumption.

The acetone and nitro-benzine are readily obtainable without licence, in limited quantities, from any of the well known houses, such as Imperial Chemical Industries, or British Industrial Solvents.

For the lubrication of two-stroke engines a mineral base oil, such as Essolube Racer, or Essolube 60 can be added, and is much superior to castor oil.

In all cases all mixes require trying in a glass before using in the engine to make quite sure they are mixing properly.

If a simpler mixture is required for 11 : 1 compression ratio, 15 per cent. methanol, 15 per cent. pure benzol, and 70 per cent. petrol, plus oil which may be required, will be found perfectly adequate because on 11 : 1 the compression ratio, with the poor filling that is obtained on two-strokes, would run quite well on the 50/50 petrol benzol mixture, but the addition of methanol will, of course, give a denser charge although, and this may not be generally realised among the small engines fraternity, the fuel air ratio of methanol mixtures are about 7 : 1 compared with petrol at 14, so that a main jet, two to two-and-a-half times the area, is required according to the proportion of methanol used also, the calorific value is less than half that of petrol. I trust that this information will be of interest to readers.

—P. R. MONKHOUSE.