MODERN ENGINES

322 c.c.

BRITISH ANZANI

UNI-TWIN

THE BRITISH ANZANI ENGINEERING CO LTD · WINDMILL ROAD · HAMPTON HILL · MIDDLESEX

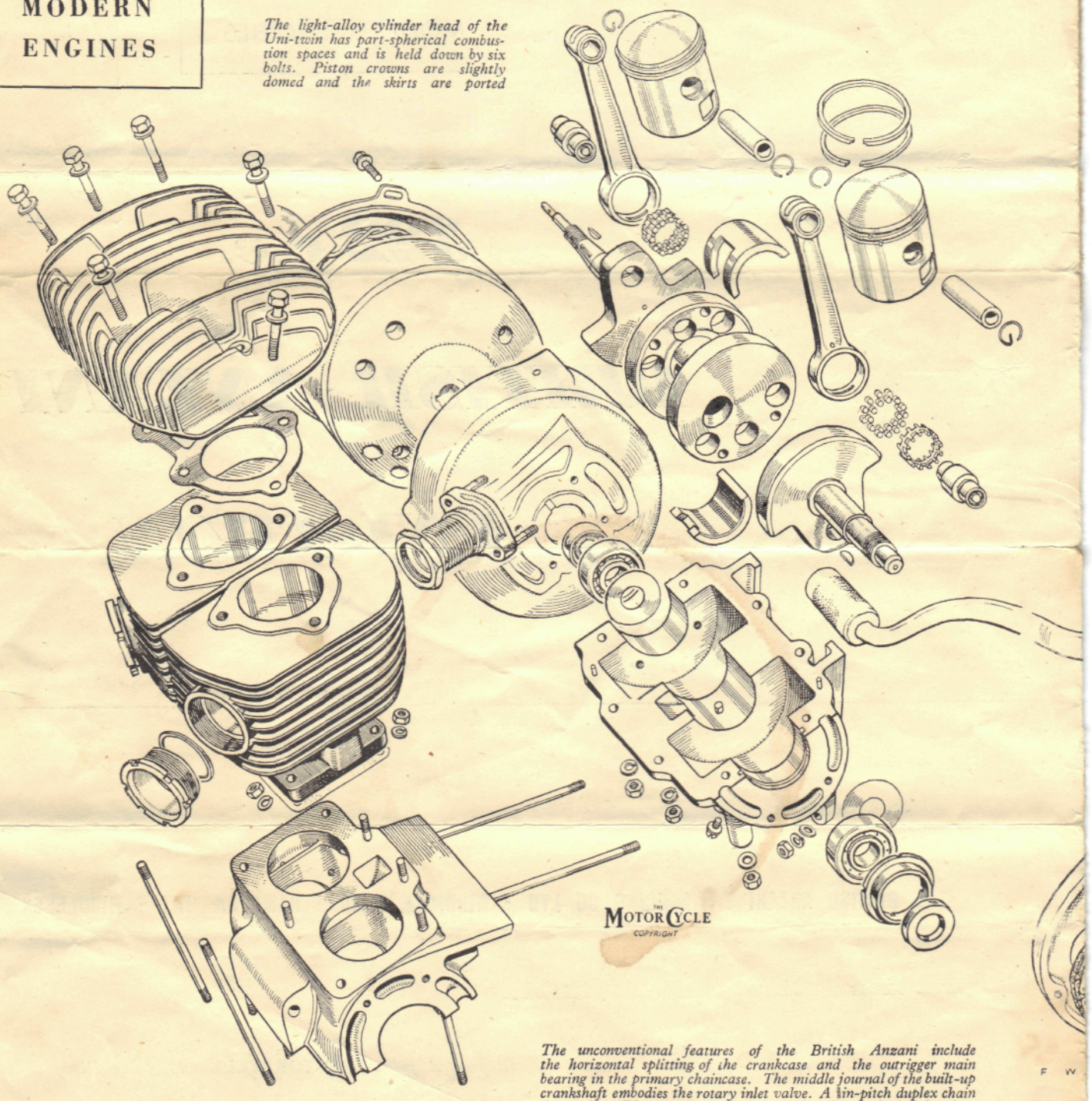
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322 c.c. British Anzani Uni-twin

MODERN ENGINES

The light-alloy cylinder head of the Uni-twin has part-spherical combustion spaces and is held down by six bolts. Piston crowns are slightly domed and the skirts are ported



The unconventional features of the British Anzani include the horizontal splitting of the crankcase and the outrigger main bearing in the primary chaincase. The middle journal of the built-up crankshaft embodies the rotary inlet valve. A ½in-pitch duplex chain drives the Albion gear box; on the motor-cycle unit the box has four speeds but a variant has three forward speeds and reverse

Charles Harrison, A.M.I.Mech.E., Designer and Managing Director, explains to the Technical Editor, Alan Baker, the Whys and Wherefores of a Dual-induction, Parallel-twin Two-stroke

ALTHOUGH the British Anzani parallel-twin two-stroke has existed as a motor-cycle unit for less than three years, it has become one of the more successful engines of the post-war era. To the smooth torque and refined behaviour inherent in the type it adds a lively performance in the lower and middle speed ranges and an ability to run up to high revolutions without distress.

The name British Anzani was one to conjure with in the '20s, the heyday of the big twin. Production of motor-cycle engines ceased in 1929, and for many years the firm's activities were concentrated on contract engineering plus the building of some engines for tractors and light aircraft; hence the name came to mean little or nothing to the rising generations of motor cyclists. Then in 1938 British Anzani was taken over by Charles Harrison, an ex-apprentice of J. A. Prestwich and a keen motor cyclist in his younger days. Highly interested in outboard motor-boats, both for racing and non-competitive purposes, and dissatisfied with the units available on the market, Mr. Harrison decided after the war to devote some of the Anzani resources to the manufacture of outboard engines.

Late in 1951 the first Uni-twin outboard unit was evolved and examples began to reach the public towards the end of the following year. The main objective in its design was to combine nippy performance with the smooth running necessary in a light boat. So successfully was the compromise achieved that Mr. Harrison's thoughts turned to his old love, the motor cycle. At that time—early 1953—choice in lightweight power units was more restricted than today, and he felt that, in a modified Uni-twin, he could offer something possessing worthwhile advantages.

Because of the ready availability of water and the difficulty of arranging air cooling in a small boat, the outboard Uni-twins are liquid cooled. For use in a motor cycle, however, such an engine would necessitate a radiator, a relatively expensive item of equipment which could present installation difficulties. Hence the decision was taken to employ air cooling for the motor-cycle versions.

By mid-1953 the first prototype two-fifty was completed and installed in a James Captain frame. The gear box was a three-speed Burman, and a Wico-Pacy flywheel magneto-generator replaced the magneto of the outboards. I had the privilege of trying the machine on the local by-pass and was impressed by its zestful acceleration and its flexibility. As a result of the encouraging performance of the prototype, production was quickly put in hand and the first batch reached the public in April, 1954.

One of the major differences between the prototype and the production motor-cycle units is that the latter employ a four-speed Albion gear box. Before deciding to adopt the extra ratio Mr. Harrison measured the additional weight and cost against the benefits in traffic and hilly country. Also to be considered was the fact that, although his engines possessed good low-speed torque, he was producing units for the connoisseur.

The heart of the Uni-twin series is the rotary inlet valve embodied in the middle journal of the crankshaft. When I visited the Hampton Hill factory to discuss the design, this feature formed the basis of my first question to Mr. Harrison.

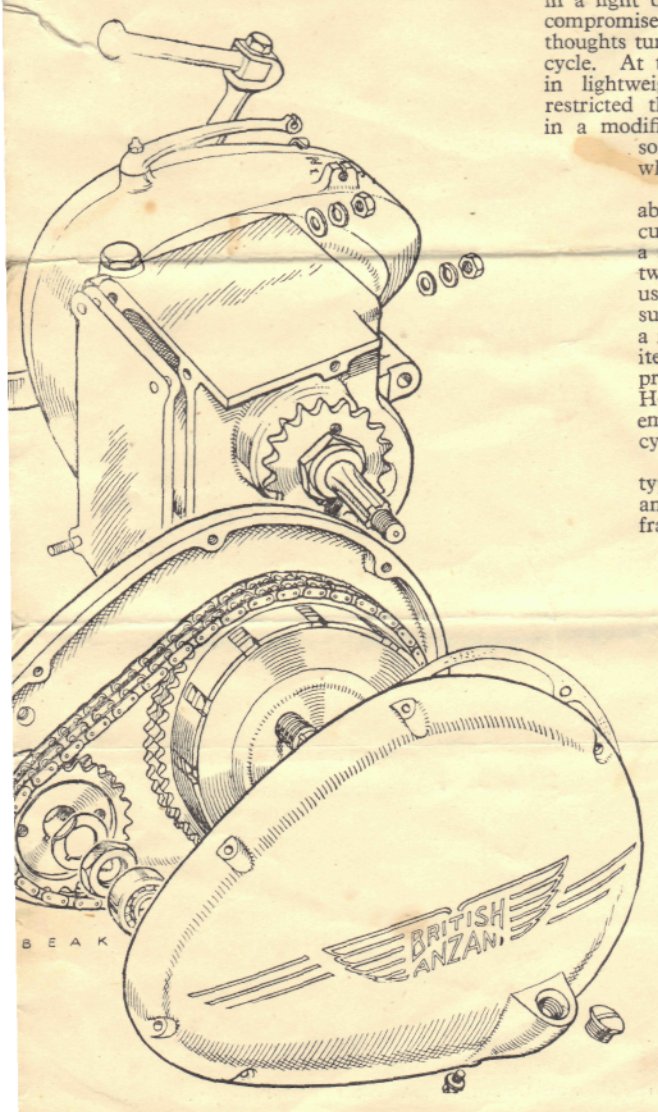
Question: "Why did you decide on a rotary valve in the first place and what do you consider to be the advantages of your particular layout?"

Answer: "A disadvantage of the piston-controlled inlet port is the restricted opening period necessary to avoid excessive blowback through the carburettor. With a rotary valve, induction can begin much earlier without risk of blowback. In our case the rotary valve starts to open 120 degrees before top dead centre yet closes only 60 degrees after t.d.c. With a parallel-twin design—which we had already decided on—the layout chosen was an obvious one. We had to have a middle bearing for the crankshaft and we had to seal one crank chamber from the other. All we did was to make a virtue of necessity by putting ports (one for each cylinder) in the journal and casting the necessary feed passage in the crankcase.

"Two incidental advantages of the valve are the excellent big-end lubrication which it affords and the improvement in breathing and carburation resulting from there being no period when both ports are closed. With piston-controlled ports the gas column is repeatedly stopped and started."

The middle journal is forged (in En. 32 carbon case-hardening steel) integrally with the full-disc inboard flywheels which are drilled on each side of the crankpin holes for balancing. Two diagonal holes are drilled, in the same plane but on opposite sides of the axis, from the outer faces of the bobbin, as it is called, through to the bearing surface of the journal. In order to increase the effective opening and closing rate of the valve a keyway milling cutter is then employed to make a square opening in the journal. The square is blended into the drilling by hand.

A split, phosphor-bronze main bearing supports the bobbin and is suitably ported by being slotted with a milling cutter. To prevent rotation of the bearing (which would affect the timing and restrict the induction tract), the lower half is located by a dowel peg in the bearing housing. The inlet passage in the crankcase is cast



roughly in the form of a horizontal letter S.

Question: "The induction tract is rather tortuous since is involves two 90-degree bends and one of 180 degrees between carburettor and rotary valve. Would you not have achieved better filling by turning the rotary-valve ports through 180 degrees and feeding them through the rear of the bearing housing? By this means the induction tract would have been shorter, involving only two 90-degree bends."

Answer: "Your suggestion has undoubted attractions and was seriously considered in the initial stages of design. The arrangement, however, would have resulted in the heaviest loading being applied to the cut-away area of the bearing—dubious engineering which would militate against long life."

On the two-fifty Uni-twin, on which the design was finalized before that of the 322 c.c. engine under review, induction is by rotary valve only. In that form the 242 c.c. engine has a top-end performance comparable with that of other two-fifties made in this country, coupled with unusually brisk acceleration and smooth pulling powers lower down. But the bigger engine is giving away at least 25 c.c. to the three-fifties with which, obviously, it is classified. For that reason Mr. Harrison decided to make an important change in the specification but before dealing with it I interjected a query on the engine capacity since it was clearly relevant.

Question: "Why did you decide on so unusual a capacity as 322 c.c.?"

Answer: "It is the same as that of the larger outboard engine. The racing-outboard categories include 15 and 20 cubic inches which are respectively 245.8 and 327.7 c.c. I decided to make one bottom half do for the two engine sizes and to be under-square (52×57mm) on the smaller unit and over-square (60×57mm) on the larger. When the motor cycle units were being evolved I gave a lot of thought to the possibility of increasing the larger to a nominal 350 c.c. but decided it could not be done on the existing cylinder centres."

The specification change previously mentioned is the supplementing of the rotary-valve system by normal piston-controlled inlet ports to improve the breathing at high engine speeds. As long ago as the late '20s, said Mr. Harrison, he had employed an additional air-only inlet on his racing outboard engines; although he had found a considerable performance gain, flexibility was lost.

By adapting the scheme so that the additional ports induced mixture and not just air, a worth-while gain in output was achieved without ill effects on tractability or economy. The two piston-controlled ports branch off the upper portion of the rotary-valve tract, which portion is cast into the cylinder block. The carburettor adaptor screws into the block. Rotary-valve and piston-controlled ports close together 60 degrees after t.d.c. and, as previously stated, the rotary valve opens 120 degrees before t.d.c. On the 242 c.c. engine the tract is in the crankcase only and the carburettor is connected thereto by an external swan-neck.

In view of the success of the dual induction system I asked Mr. Harrison whether he intended adopting it also on the 242 c.c. engine. He pointed out that it was, in fact, embodied in the water-cooled two-fifty unit exhibited at the Show last November, though in slightly different form with external manifolding. The results had been distinctly encouraging and it was probable that, in due course, the two engine sizes would be brought into line.

As I studied the components of the robust crankshaft my mind went back to a similar scene in which I participated some 2½ years ago. Here, surely, was a difference from the outboard engine!

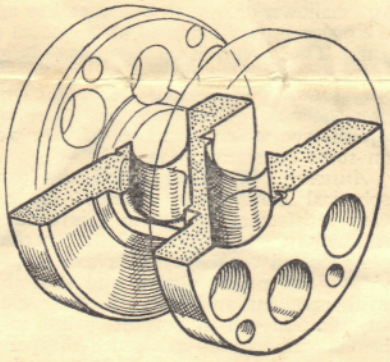
Question: "If I remember correctly, you originally used full-disc webs on both sides of the crankpins. Now you have a web of counterweight form outboard of each pin. Why the change?"

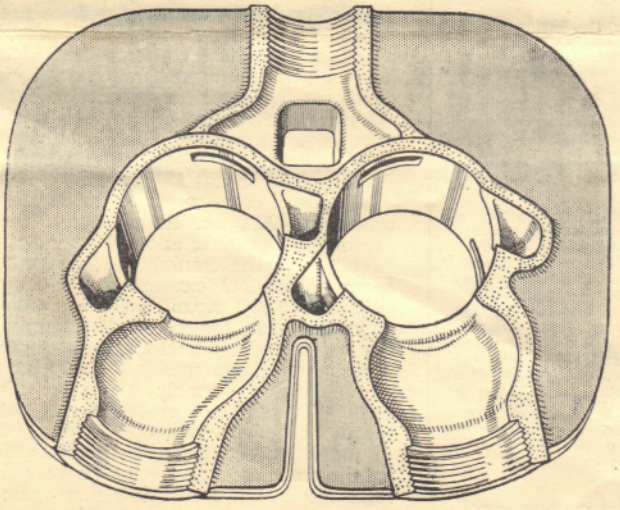
Answer: "Unlike the single-cylinder engine or the 360-degree twin, the 180-degree twin is in primary balance save for a rocking couple. Counterweighting of the crankshaft is thus employed merely to minimize the effects of the couple. Although the engine was satisfactorily free from vibration in outboard guise with disc webs drilled to provide a small counterweight effect, we found that it was insufficient for the different mounting and structural layout of a motor cycle. So we had to discard the outer discs and replace them with counterweights; we now balance all the rotating masses and 25 per cent of the reciprocating masses. The reduction in the primary compression ratio resulting from the change made no apparent difference to the power."

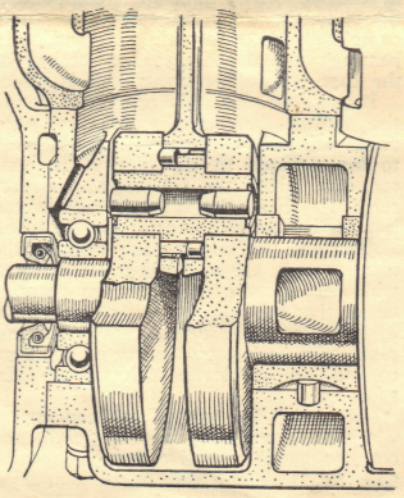
Forged integrally with the counterweights are the mainshafts. Because they are of smaller diameter than the middle journal they are in En.34, a two per cent nickel-molybdenum steel. Of large dimensions, the crankshaft main bearings are amply strong for the duty. That on the drive side is of lipped roller pattern, to resist side thrust, and there is a ball bearing of the same size at the generator end of the crankshaft. The shaft is located axially at the drive end by the flanged housing of the gas seal and at the other end by a spigot on the generator body. The spigot pulls up against the outer race of the bearing.

Another version of the 322 c.c. engine intended for three-wheelers and light cars is fitted with the Siba Dynastart motor-generator. To cater for the overhung loading of the heavy Siba rotor, two single-row ball main bearings are fitted on that side.

Mr. Harrison believes that a well-supported, rigid crankshaft makes for long life and smooth running. He also main-







Above left: The passages in the rotary-valve "bobbin" are diagonally disposed. On the left is a section through the cylinder block, illustrating the forking of the inlet tract and the staggering of the transfer ports. Right: Expander plugs lock the crankpins in position. Note the diagonal oil-drain hole feeding the main ball bearing

tains that chain pull on an overhung engine sprocket imposes an undesirable bending load on the shaft and so gives the drive-side main bearing a hard life. In consequence he is justly proud of the outrigger ball bearing which supports the end of the mainshaft in the outer half of the primary chaincase.

The crankpins are shouldered and have parallel ends which are a 0.004in interference fit in the webs; the pins are hollow and are very slightly tapered in the bore at each end. Purpose of the taper is to give a lead for the expander plugs which are pressed in after the assembly has been lined up. The plugs, also tapered, are hardened and have the large end ground off after assembly. This treatment enables the plugs to be drilled out for dismantling.

On the standard outboards, crowded-roller big ends are employed, but on the racing models and the motor-cycle units a double-row caged bearing is featured because of the heavier duty and higher operational speeds attained. The cages are of Duralumin, with staggered slots for the rollers since the arrangement gives a stronger cage than do in-line slots. The cage is a running fit on the crankpin and has a substantial clearance in the big-end eye; depth of the slots is less than the length of the rollers so that the cage cannot rub against the crank cheeks.

Of three per cent nickel case-hardening steel, the connecting rods are hardened in the big-end eye to form the roller track, because a pressed-in sleeve would be too fragile or too bulky. On the outboards the small-end eye is also hardened and runs directly on the gudgeon pin. Although the rate of wear with that arrangement proved very low, it was felt that the average motor cyclist would prefer to be able to remedy small-end wear without renewing the rod. In consequence, only the early motor-cycle engines had the hardened eye; a bronze bush is now standardized.

The aluminium crankcase is split horizontally (actually at right angles to the axes of the inclined cylinders) instead of vertically as are those of most other parallel twins. This method was adopted for two reasons. First, it permits the bobbin to be a single forging, whereas any system of vertical splitting would necessitate a built-up component. Secondly, the crankshaft can be assembled complete with connecting rods and main bearings and placed in the lower half of the case before the upper half is fitted.

Because of the induction tract round the middle bearing the transfer ports could not start in the crankcase but had to be confined to the block. In consequence, since the connecting rods are relatively short, the skirt of each piston is ported to permit transfer to take place.

Question: "While in each cylinder the transfer ports are disposed at 180 degrees, with the exhaust port between them, I notice that the four transfer ports are not in line across the engine. Will you explain why each set of ports is, in effect, rotated anti-clockwise through 15 degrees?"

Answer: "We wanted to keep engine width to a minimum to save weight and cost, to avoid excessive footrest spacing and to minimize the primary rocking couple which is inevitable with a 180-degree twin. Also, a short crankshaft is inherently stiffer than a long one. If we had the transfer ports in line, the distance between cylinder centres would be about an inch greater than its actual 3in measurement. By staggering the ports through the 15-degree angle we were able to overlap the inboard transfers and then merely had to allow sufficient wall thickness of metal between ports and bores."

Question: "The staggered porting necessitates an S-bend in the right-hand exhaust port to provide a symmetrical pipe layout. Have you found the double bend to be disadvantageous in terms of gas flow, and what is the purpose of the small expansion volumes in the ports just outside the cylinder-wall openings?"

Answer: "The two questions are closely related. In common with a number of other two-stroke engineers I believe that to permit the exhaust gases to expand as soon as possible outside the cylinder is beneficial to performance. Casting these expansion volumes in the block is less unsightly and cheaper than fitting the "Oxford bag" type of exhaust pipe, and, further, it considerably eases gas flow through the S-bend. The bend, of course, was dictated by appearance and cooling considerations; it appears to have no disadvantages."

To improve cooling and reduce the risk of distortion, the fin area of cylinder head and block has been increased by nearly 100 per cent about a year ago. The finning in the critical exhaust-port region received special attention. A further measure to aid dissipation of heat is a through air space milled vertically between the cylinders from the head joint face to a depth of about 1½in. The laminated aluminium-foil head gasket is of continuous, figure-eight form.

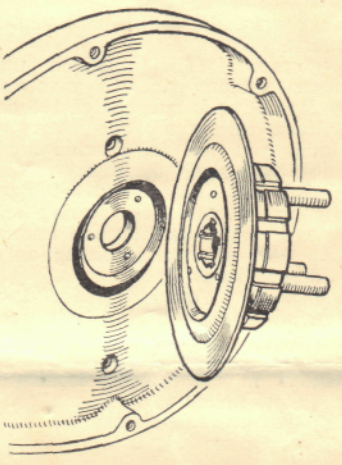
The cylinder head is a liberally finned casting in heat-treated Y alloy and is held down by six ⅜in high-tensile bolts screwing into the block. Combustion-chamber form is part-spherical; the space is some ⅜in shallower than a true hemisphere and the piston crown is domed to the extent of ¼in. The piston is of orthodox design with two compression rings.

Question: "Why have you adopted the part-spherical chamber rather than the squish type which seems to do very well on some continental engines?"

Answer: "We have found the part-spherical combustion chamber to give very satisfactory results in this kind of engine. In conjunction with a sparking plug located on the cylinder axis it provides good power output and flexibility with excellent resistance to detonation. In addition—an important point in a commercial engine—it is much cheaper to impart a good surface finish to such a shape than to a special chamber."

Ignition of the motor-cycle version of the Uni-twin is by means of a Wico-Pacy Series 73 Mark L magneto-generator which, as mentioned earlier, is located by a spigot in the right-hand end of the crankcase. On the three-wheeler or light-car version the rotor of the Siba Dyna-start carries a cast-aluminium fan which cools cylinder block and head through ducting, also of cast aluminium.

No power curve has been taken for a production 322 c.c. engine but a snap reading on the brake at 5,000 r.p.m. gave 15 b.h.p. at the crankshaft. The power curve of the 242 c.c. unit continues to climb to 6,000 r.p.m. and one would anticipate that the better breathing of the larger engine would enable it to peak at a slightly higher speed, so the 15 b.h.p. is probably appreciably below the ultimate. Mr. Harrison estimates that peak torque occurs at about 4,000 r.p.m. but, to judge by the engine's characteristics on the road, the curve must be very flat for some 2,000 r.p.m. below that figure.



Oil leakage from the primary chaincase is prevented by an ingeniously simple thrower behind the clutch. The thrower comprises two dished discs, one on the back of the clutch body and the other on the case; in end elevation, the larger overlaps the smaller

TECHNICAL DATA

CAPACITY: 322 c.c.

BORE: 60mm.

STROKE: 57mm.

COMPRESSION RATIO: 7.25 to *1*.

PISTON-RING END GAP: 0.006in.

PISTON-RING SIDE CLEARANCE: 0.003in.

PISTON CLEARANCES: Top land, 0.011in; at bottom of skirt, 0.004in.

PORT TIMING: Rotary valve begins to open 60 degrees after bottom dead centre and closes 60 degrees after top dead centre. Piston-controlled inlet ports open and close 60 degrees each side of top dead centre. Transfer ports open and close 62½ degrees each side of bottom dead centre. Exhaust ports open and close 72 degrees each side of top dead centre.

IGNITION TIMING: Fixed; contact-breaker points begin to separate 28 degrees before top dead centre.

ENGINE DIMENSIONS: Crankshaft drive-side roller and generator-side ball bearings, ⅝in bore x 2in outside diameter x 7/16in wide; middle plain bearing, 1½in bore x 1 7/16in wide; outrigger drive-side ball bearing, ⅝in bore x 1 7/16in outside diameter x 7/16in wide. Crankpins, 0.896in diameter x 0.505in long over journals; big-end bearings, two staggered rows each of 12 rollers, 3/16in x 3/16in; small-end bushes, 0.6155in bore x ⅝in wide. Connecting-rod length, big-end to small-end centres, 4½in.

CARBURETTOR: Amal Monobloc type 376/38, 1in choke diameter, 15 degrees of down-draught; 260 main jet; 376/3½ throttle valve; 25 pilot jet; throttle needle clip fitted in third groove from top.