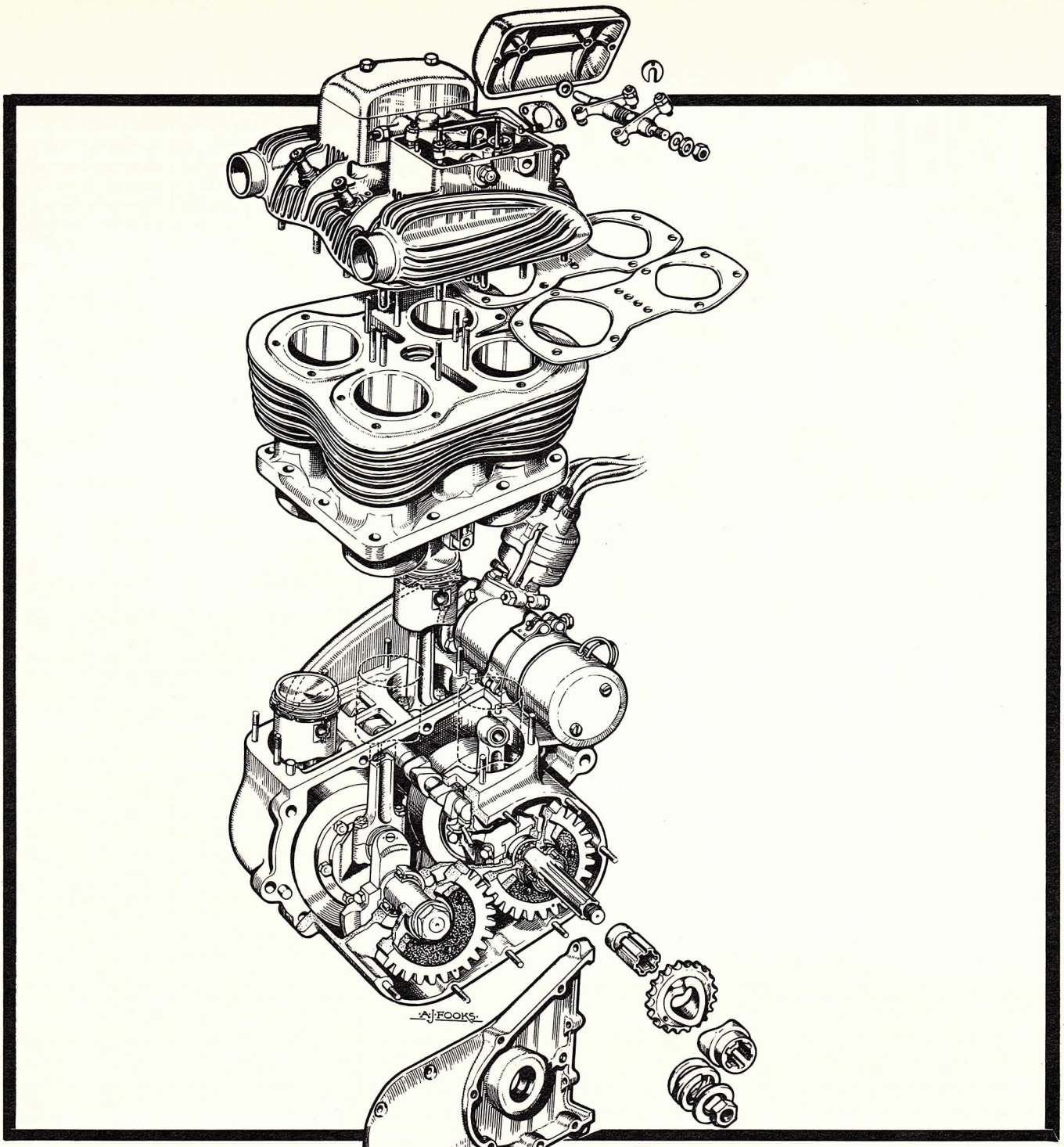
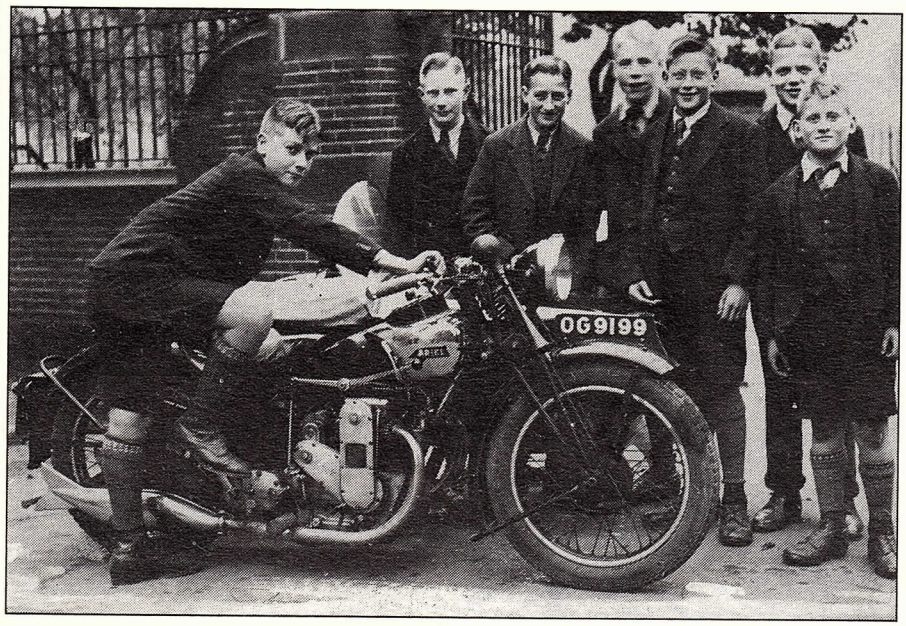


TURNER'S MASTERPIECE

- The Ariel Square Four is the only truly original engine design to go into mass production in a British factory.
- It was designed by Edward Turner, who had been taken on by Ariel in 1927, as a 500cc overhead cam sports motor.
- The prototype was shoehorned into a lightweight frame which, combined with its compact construction and three-speed gearbox in unit, made it very lively.
- Production rationalisation saw a separate four-speed gearbox and a heavyweight frame and cycle parts; the sports image was slipping.
- The 500 lasted three years, being superseded by a 600cc version in 1933 aimed at the sidecar market.
- In 1935 Edward Turner redesigned the Square Four, making it into a full 1,000 and abandoning the overhead camshaft in favour of simpler, cheaper pushrod valve actuation.
- A 600cc version was made for a short period just before the war.
- As it had developed, the Square Four engine had put on weight, and Val Page was put to work to make it lighter.
- The new unit, with crankcases and cylinder head in light alloy, went on show in 1948.
- Last of the line was the 4G Mk2, introduced in 1953; its most noticeable feature was a four-pipe exhaust system.
- All Ariel four-stroke production came to an end in August 1959.

500/600 cc OVERHEAD CAM ENGINES

From the original technical descriptions.



For a Maudes Trophy attempt a 1931 500cc Square Four underwent a kickstarting test. The seven boys attempted to start the engine seven times each – only once did it fail.

☐ UNCONVENTIONAL in design, but thoroughly sound in conception and construction, the new four-cylinder Ariel carries an engine of outstanding interest. A full technical description would occupy many pages, so it remains to cover the salient features in as concise a manner as is possible.

In principle the design is unusual, in that the four-cylinder unit is composed of two vertical twins having separate two-throw crankshafts set across the frame, but geared together by means of the centrally disposed flywheels. This construction, with its overhung cranks, permits the use of roller-bearing big ends, an important feature for an engine which has exceeded 9,000rpm on the bench.

The difficulty of cooling and housing a four-in-line engine has led to this unorthodox design, but the result is so compact that the engine can be, and in fact is, housed in the standard Ariel frame, employing transmission, wheels, etc., identical with those of the ordinary model, and without modification to the wheelbase. At the same time there is ample draught-space between each cylinder.

The four cylinders are placed vertically in an exact square, and are set at 4½in from centre to centre. Cast in a block, the cooling fins extend longitudinally from front to back, with a clear passage between the two outside pairs.

A total capacity of 497cc is provided by the four cylinders, which have bores and strokes of 51 x 61mm. The head casting, which is attached by eight studs, incorporates all four heads and the inlet and exhaust manifolds.

A single overhead camshaft, chain-driven, with spring chain-tensioners under Weller patents, operates all eight valves and carries an ignition distributor at one end.

To provide a clear description it will be best to begin at the lower end of the engine. Two large double-purpose ball races support each crankshaft. They lie on either side of the central flywheel and between it and the crank cheeks. Each race is housed in an internally ground cup and is clamped in position by a big bearing cap, which also encloses the geared flywheels and forms an inner compartment of the crank case.

This construction necessitates the use of a pair of built-up shafts; each shaft consists of a main chrome nickel steel forging embodying one crank pin, one crank cheek, and the main shaft. To the shaft are keyed a flywheel (having on its periphery ground teeth of a special form developed for the purpose) and the second crank cheek and pin.

The cranks on each shaft are set at 180°, and the two shafts are geared together so that the pistons which are diagonally opposed, are in the same position relative to the stroke. There is, therefore, a very slight couple on each shaft, but this is compensated to some extent by balanced crank cheeks.

When it is stated that each piston complete with gudgeon pin and rings weighs only 3oz it will be realised that the secondary out-of-balance forces are slight. In conjunction with inherent stiffness of construction this arrangement provides a very smooth and vibrationless engine, which in this respect should be superior to the average four-cylinder car engine.

On the near side of the rear crankshaft is an auxiliary flywheel and shaft mounted in a large ball race and extended through the crankcase to carry a sprocket within the oil-bath primary chain case.

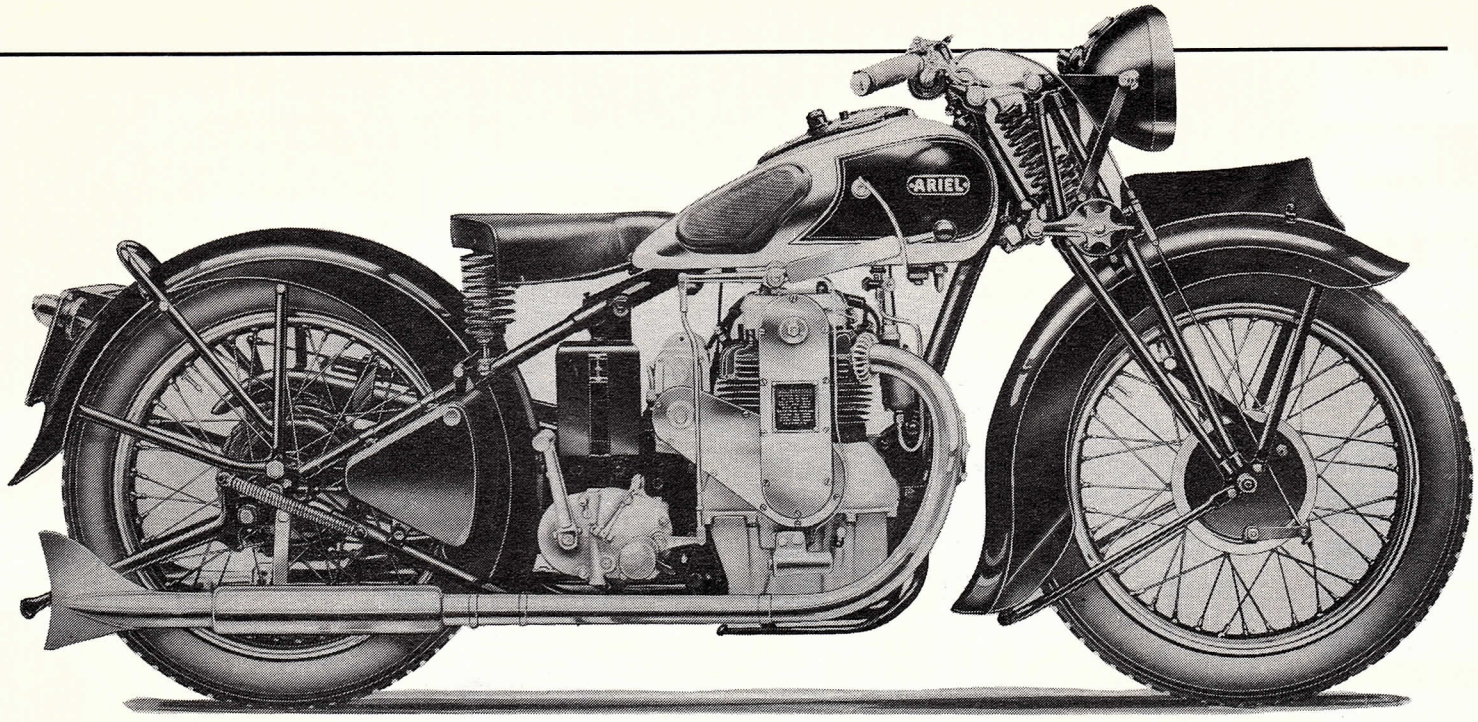
Enclosed within the flywheel casing is the two-to-one gear, which drives a lay-shaft extending to the off side of the engine. On the outer end are mounted two sprockets to drive the camshaft and Magdyno, and in the centre is a worm gear to drive the twin-gear-type oil pumps. Both distribution chains are spring-tensioned, and therefore need no adjustment.

Each connecting rod is a chrome nickel steel forging with a full roller big-end bearing which is interchangeable and replaceable, though the bearing area is so great that there should be no need for replacement over very long periods.

The small ends are lined with bronze bushes and a fully floating gudgeon pin of ⅝in diameter holds the connecting rod to the "Y" alloy pistons. Fully skirted pistons with two 1/16in rings are employed. A compression ratio of 6.5 to 1 is provided by the pent-roof heads, in which are disposed two vertical valves of 29/32in throat diameter.

In order to prevent wear, the valve guides are made very long and substantial. They are constructed of a special chilled cast iron, and in the case of an experimental engine are still in good condition after 24,000 miles of road work.

One spring returns each valve to its seat, and in order to prevent oil leakage



The 600cc version, as it appeared in a 1934 factory photo.

down the stem the usual hardened-steel valve-stem cap is arranged to bear on the spring cup instead of on the stem, so that the whole forms an oiltight "umbrella".

Lying across the frame and parallel to the crankshafts, the overhead camshaft is almost enclosed in a tunnel, openings being provided only for the rocker heels. The rockers are mounted on fully floating hardened-steel pins.

Lying behind the crankcase, and cast with it, is an oil tank with a capacity of well over half a gallon. From it oil is drawn by a gear pump through a filter. There are three points of delivery – through a pressure valve to the camshaft tunnel and pressure gauge, and through a similar adjustable pressure valve to the flywheel casing.

Each cam dips in a trough of oil, and excess drains back to a sump below the crank case. When the oil in the flywheel case reaches a predetermined level it overflows to small troughs directly below each big end, and a dipper on each connecting rod distributes it throughout the engine. The oil which drains to the sump is filtered and returned to the tank by a second and larger gear pump. A simple breather communicates with the primary chain case.

On either side of the head casting, and cast with it, is an exhaust branch connecting the two ports on each side and facing forward. These branches are liberally finned above and below, and provide a very neat appearance. Cast with the head, also is the inlet manifold, of cruciform arrangement.

The carburettor faces forward, and the pipe leads to the centre of the cross, so that there is an equal distance to each inlet valve. The arrangement of the junction at the centre has been the subject of considerable experiment to ensure the distribution of an equal weight of gas to each cylinder.

More than once the opinion has been expressed that the maintenance of a small four must be difficult; but accessibility has been studied on the Ariel. All four plugs can be reached with ease. All eight cylinder bolts are reasonably placed. The rocker box cover can be removed after slackening four thumb nuts, and there is plenty of room to do the work. After removal of the head bolts the upper sprocket of the camshaft drive may be drawn by a special extractor provided in the kit, and the cylinder head may then be removed.

The sprocket cannot fall, as it is held in position by a special false bush, and it cannot be replaced wrongly owing to the position of the single key fixing. Placed at the end of the camshaft, the ignition distributor is easily reached, and the contact-breaker is to be found in the usual place on the Lucas Magdyno. This instrument, by the way, is mounted on top of the oil tank behind the engine, where it is well clear of obstructions.

As before mentioned, the engine fits into the standard Ariel frame, and the complete machine weighs almost exactly the same as the overhead-valve single-cylinder model.

Though this machine will not, in all probability, become available to the public before December, it should be emphasised that it is not an experiment. It has been undergoing development tests for many months, both on the bench and on the road. It has been handled by the staff of *The Motor Cycle* in various stages of development and in its final form; and from this experience it can be truthfully said that the machine presents a most attractive and practical proposition.

600cc changes

☐ In order to accommodate the four-cylinder engine in this frame, some modification has been necessary to the base casting, and this has had the effect of simplifying and cleaning up the design to a very considerable extent.

All the oil is carried in a special base chamber instead of in a separate tank, with the result that a single-plunger pump, driven from an eccentric on the camshaft, is sufficient to maintain oil circulation. As before, oil is delivered to the chamber which encloses the geared flywheels and overflows to troughs into which the big-end dips.

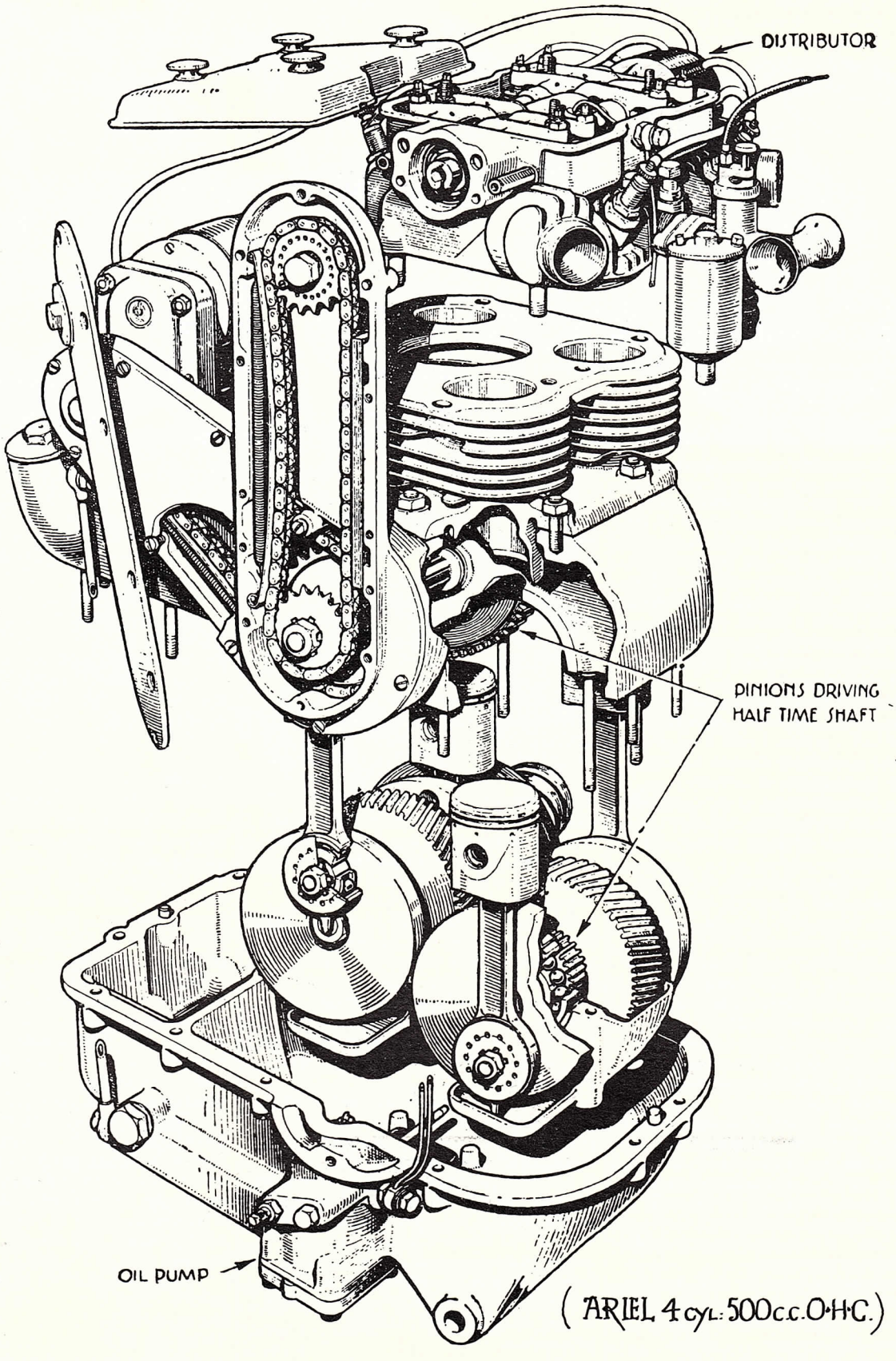
A separate lead is provided for the camshaft, and surplus oil drains by gravity to the sump. There is a suction filter in the base and a special Tecalemit filter on the delivery side which is quickly detachable for cleaning purposes. The ball valve of the pump is equally accessible, and it is claimed that the new system maintains the oil at a lower temperature. A dip-stick is provided to check the oil level.

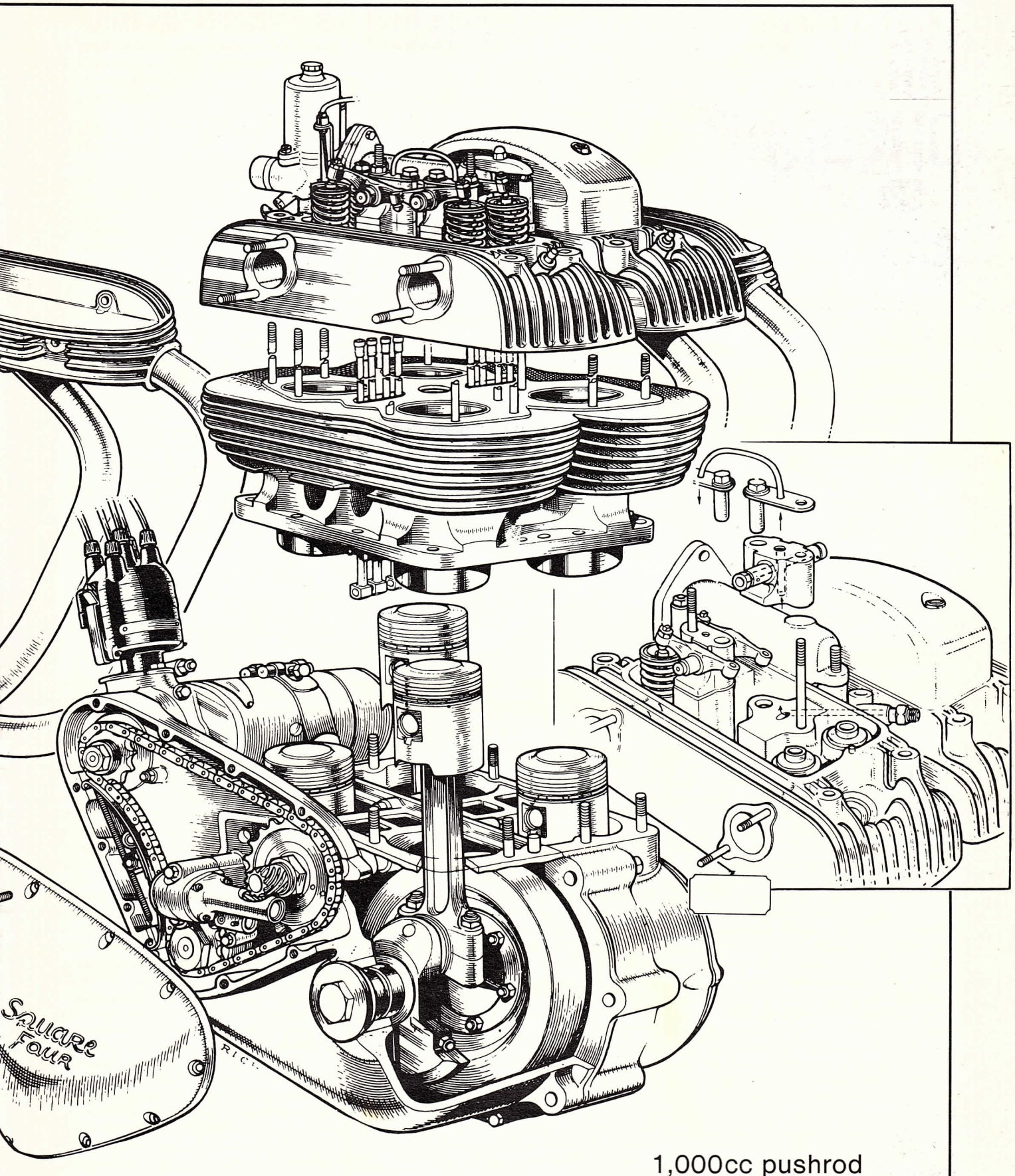
The four-speed Burman gear box is provided with an improved and more accessible mounting which is common to all the larger Ariel models, and is normally fitted with hand control, though a new foot change mechanism, to be described, can be obtained as an extra.

In the exhaust system, which incorporates tubular silencers with spiral baffles, a change has been made, for the two exhaust pipes are connected by a cross-tube just in front of the rear wheel. This has the effect of reducing noise and back-pressure, and evening up the exhaust note as a whole.

The combined effect of these modifications is to reduce the weight of the machine by 25lb, the wheelbase by 1½in, and to improve the road-holding and steering to a marked degree. Although the 597cc engine (56 x 61mm) is standardised, the 500cc model is available to special order.

TURNER'S MASTERPIECE

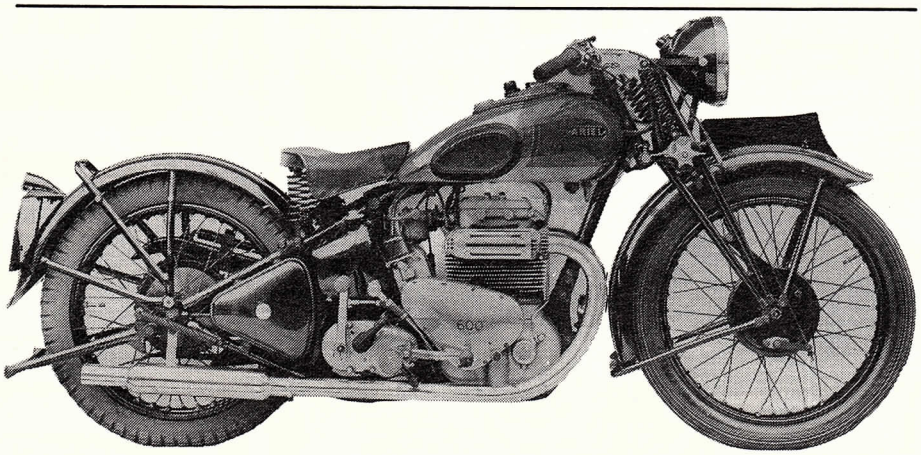




1,000cc pushrod

1,000cc PUSHROD ENGINES

From the original technical description.



The 1939 600cc pushrod variant – it did not survive the war.

☐ FEW engines of unorthodox design have achieved such definite and well-merited success as the 600cc "Squariel". The nick-name itself shows how firmly it has become established in the world of motor cycles. Now there is to be a 1,000cc edition, not to replace, but to be complementary to, the "six-hundred".

Different, yet obviously from the board of the same designer, the newcomer has been laid out with a view to "an adequate performance with a minimum of attention." These are the words of the designer, but surely a performance of 10 to 100mph on top gear is at least adequate, and most people will be satisfied with an engine which, it is claimed, needs no attention for 10,000 miles, and no more than an occasional top overhaul in 40,000 miles.

The performance claim can be substantiated on any production model, and the many thousands of trouble-free road and bench tests more than hint that the claims for reliability are not overstated.

Many of the changes in design have been made to improve production, but in every case silence, reliability and ease of maintenance have been considered, and it is stated, quite definitely, that the cylinder head may be removed and replaced at least as easily and quickly as that of a single cylinder overhead-valve engine from the same factory.

It is easy to write enthusiastically of this model, since a road test of an experimental machine, during last summer, showed silence, smoothness, speed and acceleration of an order seldom contemplated by the average motorist.

Yet it is important to remember that the engine is designed for reliability and smooth running, and the speed is incidental. The engine is not "hotted", and has a compression ratio of only 5.8 to 1, while the fuel consumption at an average speed of about 40mph is said to be 55mpg.

In endeavouring to obtain a mental picture of the new Ariel, the reader must not think of four two-fifties crammed on to one crankcase, for though that is in fact true, yet the arrangement is so neat that, even with adequate air space between the cylinders, the engine appears but little bigger than the "six-hundred", and the whole machine, with full road equipment, weighs only 410lb – a modest figure for a fully equipped "thousand".

The technical description which follows will show with what care the details as well as the main design have been worked out.

The two two-throw crankshafts follow normal car practice, except that all journals are hardened. there is a plain white-metalled bearing on the timing side of each shaft, and a large roller bearing on the drive side. Outside these roller bearings are gear wheels, having a special tooth formation, by which the shafts are coupled together. In each gear wheel is a pressed-in fibre disc to prevent "ring", and on the outer side of the rear shaft gear wheel is a second roller race to take the pull of the primary drive.

The shafts are in static and rotational balance, and the balance weights on each outer crank cheek are dove-tailed on to the web so that the fixing bolts are relieved of centrifugal loading. A flange on each centre web carries a steel flywheel of 6½in diameter, the two flywheels being off-set so that they can overlap without fouling.

These flywheels are machined all over, and form "steadies" for the centre of the shafts, and may, in a sense, be regarded as centre bearings.

Each shaft is drilled for lubrication purposes, the drillings being arranged to reduce the centrifugal force on the oil supply as much as possible. Oil feeds from these drillings lead to the inside (i.e., the side nearest the crankshaft centre) of each big-end bearing.

Hiduminium RR56 light alloy connecting rods are employed, and this material forms an admirable bearing on hardened steel. It has, however, been decided that, to facilitate replacements, a lining is desirable, therefore a bronze bush is employed in the small end, and the big end is lined direct with white metal. The big ends are of 1⅜in diameter, and the white metal lining is only .020in thick, so that in the unlikely event of a big-end seizure, it would be possible to get home with a "run" bearing. Full skirted pistons carrying two pressure rings and one oil-control ring are employed; they are coupled to the small end by hollow gudgeon pins of 1 1/16in diameter, and are designed to eliminate slap.

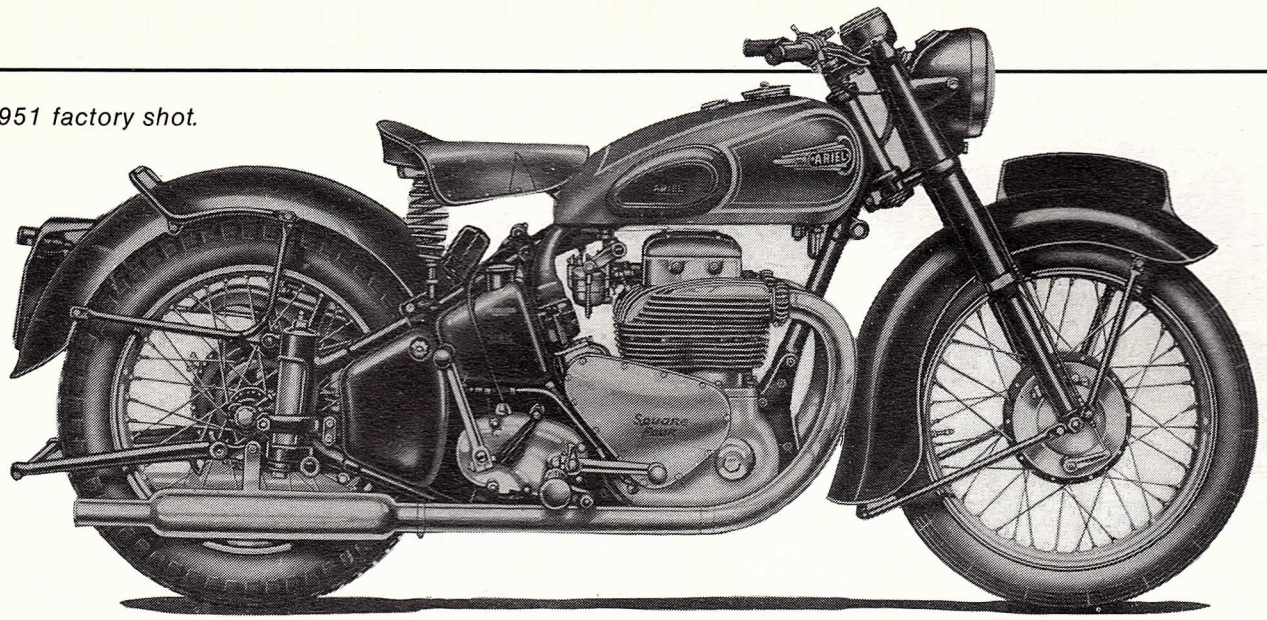
All four cylinders are cast in one block, and form a very rigid unit; there is no less than two inches between the adjacent bores, so that there is ample air space, and the finning is generous. The swept volume of each cylinder is 249.25cc (bore 65mm, stroke 75mm), giving a total capacity of 997cc.

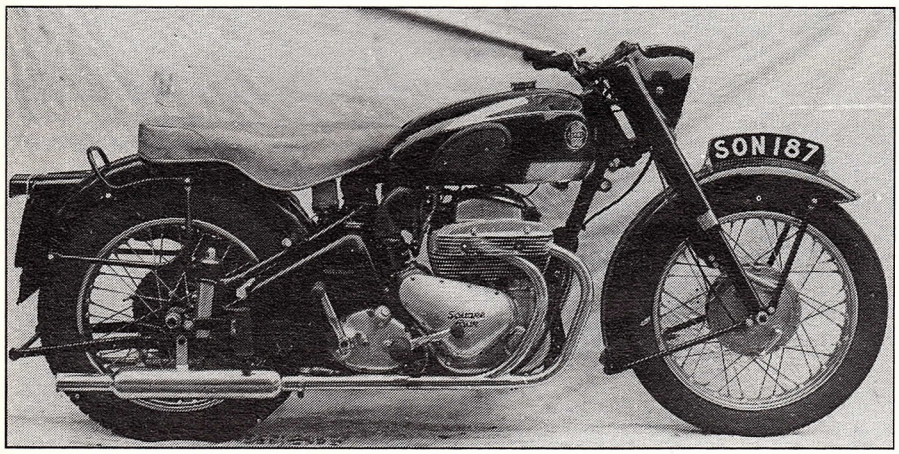
Also cast in one piece, the cylinder head block is held down by twelve studs, a separate copper-asbestos gasket being used for each pair of cylinders.

Each head is of pent-roof formation, with vertically disposed valves of 1⅛in port diameter set well apart. Combined with the head casting is a star-shaped induction manifold of rectangular section leading to a flange joint in the centre of the casting.

By this means it is possible to employ induction pipes of the same length and angle from the central supply pipe, and distribution should be ideal. The passages

A 1951 factory shot.





Four exhaust pipes and an alloy engine – the 4GMk2 (1956).

are arranged so that the incoming gas sweeps the points of the 14mm plugs. The remainder of the induction pipe, including the stub to which the car-type Solex carburettor is attached, is cast with the lower part of the valve enclosing cover, and is bolted to the head casting.

The two exhaust manifolds are separate from the head casting, and bolted thereto. By this means the head is kept much cooler than would be the case with integral castings. The two exhaust pipes discharge into a common silencer, thus producing an even and continuous exhaust note.

In the new engine the valves are operated by short duralumin push-rods through straight overhead rockers, the pivots of which are pressure-lubricated from the main oil system.

The push-rods are situated between the front and back pairs of cylinders, each pair of rods being enclosed in a steel tube.

The tappets, again in pairs, are carried in special light-alloy guide blocks clamped to the under side of the cylinder casting. Each tappet has a base of rectangular section working in a slot to prevent rotation and having a curved foot directly actuated by the cam.

Running in a ball bearing at its driven end, and a bronze bush at the end remote from the drive, the camshaft carries eight cams of smooth contour, and though the seat pressure of the two concentric valve springs is no more than 56lb, it is said that no signs of valve bounce can be detected at speeds up to 6,250rpm.

The camshaft itself lies parallel to but above and between the crankshafts and is chain-driven from the rear crankshaft.

The drive is triangular, since it embraces the Magdyno sprocket; it is spring-loaded by a Weller tensioner, and therefore requires no adjustment. The Magdyno is set at an angle behind the cylinder block, and allows a free flow of air between the cylinders.

Driven from the end of the camshaft are two plunger pumps, the smaller of which draws the oil from the ¾-gallon tank through an armoured flexible pipe, and through a gauze filter. The oil is then fed through a cast-in gallery pipe to both timing-side main bearings, and through the crankshafts to the big ends. A further lead through a small-bore pipe goes to the overhead-rocker shafts, the surplus draining back to the crankcase *via* the push-rod enclosing tubes and the tappet guide blocks.

A release valve in the gallery pipe is set to maintain a pressure of 60lb in the system, and discharges into the timing-gear box, and thus lubricates the chain. The main crank connecting gears – which, by the way, have carefully ground teeth – are lubricated by a constant level bath supplied from the crankcase.

The larger oil pump drains the sump, drawing through a filter of a large area, and returns the oil to the tank. It is emphasised that this is a true pressure system, as opposed to a controlled-flow type, and that at 3,500rpm the circulation is at the rate of 12 gallons per hour.

It is impossible to detail every refinement which has been incorporated in this engine, but, as instancing the care which has been taken to simplify maintenance, two small points are worthy of mention. First, the two halves of the vertically divided crank case are dowelled at each end to ensure absolute accuracy in erection, and secondly, the big-end bolts are marked with a line corresponding to the split pin hole, so that the position is always obvious even when the hole is covered by the castellations of the nut. These big-end bolts are works of art. They are made from high tensile nickel-chrome steel hardened and tempered. The heads are eccentric to prevent the bolt from turning, and the usual step and flat in the connecting rod is avoided. Since the bolts are employed to locate the two halves of the big end, they are reduced in diameter, except where required as guides, and the guide surfaces are ground.

Apart from the engine the new 1,000cc Ariel closely resembles the 600cc model. The frame has been stiffened-up with tapered and butted tubes, and a two-bolt front engine fixing is employed. In addition, the chain line has been increased to enable a 4in rear tyre to be used (as standard) on the rear wheel.

Although it is not considered desirable at the moment to disclose the maximum brake horse power of the engine, it may be said that it is greater than that of an up-to-date overhead-valve car engine of rather larger capacity.