MODERN ENGINES

249 c.c. A.M.C.

Designer P. A. Walker, A.M.I.Mech.E., Reveals Details of Highly Interesting Newcomer in Discussion with Alan Baker, B.Sc., A.M.I.Mech.E., the Technical Editor

WHEN a large-scale manufacturer with a world-wide reputation for building four-stroke power units introduces a two-stroke, it is a safe conclusion that the step has not been lightly taken; that those in command are convinced of a satisfactory market for the new product. And when that firm is noted for the general soundness of its engineering there is no doubt about the thoroughness of the pre-production development and testing programme. So it has been with that major attraction of the 1956 London Show, the two-fifty two-stroke of Associated Motor Cycles, destined for James and Francis-Barnett machines.

The decision to embark on the two-stroke programme was taken over three years ago and design work began almost immediately. Because of the novel nature of many of the problems involved the job was bound to be lengthy; in fact, more than six months elapsed before the first prototype had undergone its preliminary running on the bench. Since then an enormous road mileage and very many bench hours have been completed. As is now well known, putting the new unit into production necessitated a considerable extension of the Plumstead factory. The cost involved represents a substantial stake on the future of motor cycling.

Shortly after the Show, by which time production was getting under way, I visited the factory to get the inside story of the two-stroke. Most of my information came from the chief designer, Philip Walker, as the man responsible for the broad outlines of the project. Also most helpful was Mr. Walker's assistant, Horace Watson, who had the vital job of translating the design from prototype to production basis.

By way of a preliminary I asked why the capacity of the engine had been set at a quarter-litre. The answer was that the directors had decided to produce a high-efficiency roadster engine to compete in the popular two-fifty class at present dominated by the Continent.

Question: Why did you select a single rather than a twin, and what governed your choice of bore and stroke?

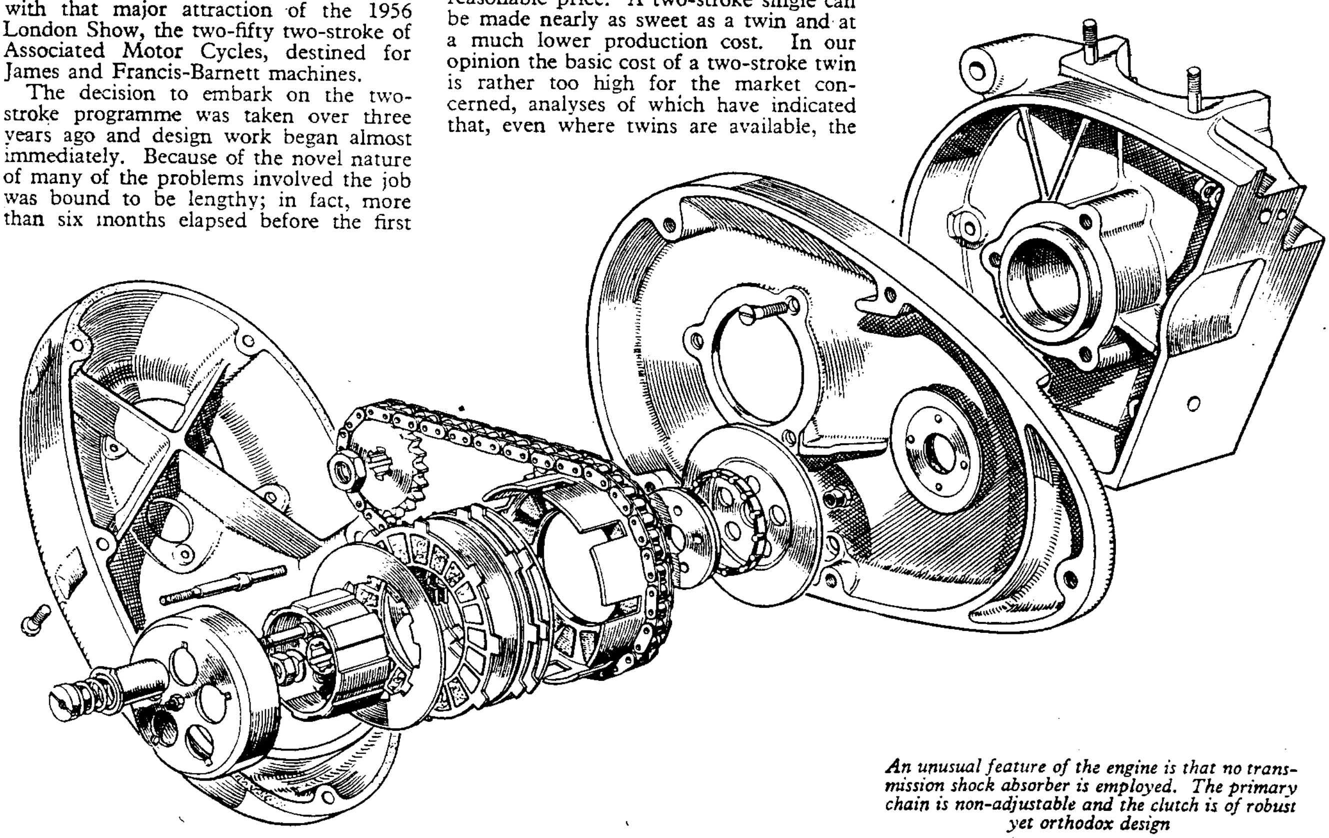
Answer: We wanted an engine that would enable a motor cycle to sell at a reasonable price. A two-stroke single can be made nearly as sweet as a twin and at a much lower production cost. In our opinion the basic cost of a two-stroke twin is rather too high for the market concerned, analyses of which have indicated that, even where twins are available, the singles sell better. The bore and stroke, 66mm x 72.8mm, represent what we think to provide the best compromise between scavenging and combustion-chamber efficiencies.

Most notable feature of the A.M.C. unit is the unusual scavenge and charging system. The majority of motor-cycle two-stroke engines work on the loop-scavenge principle in which the transfer passages and ports direct the ingoing gas streams backward and upward so that they converge at the rear of the combustion chamber and then flow forward and downward, sweeping the burnt gases ahead of them towards the exhaust port.

Referred to as laminar flow, the A.M.C. scavenging system differs considerably in that the diametrically opposed transfer streams are made to flow axially up the sides of the bore to meet at the top of the combustion chamber. There they unite, become turbulent and displace the exhaust gases downward.

Question: What decided you to adopt the laminar-flow system instead of, say, the more common loop scavenging?

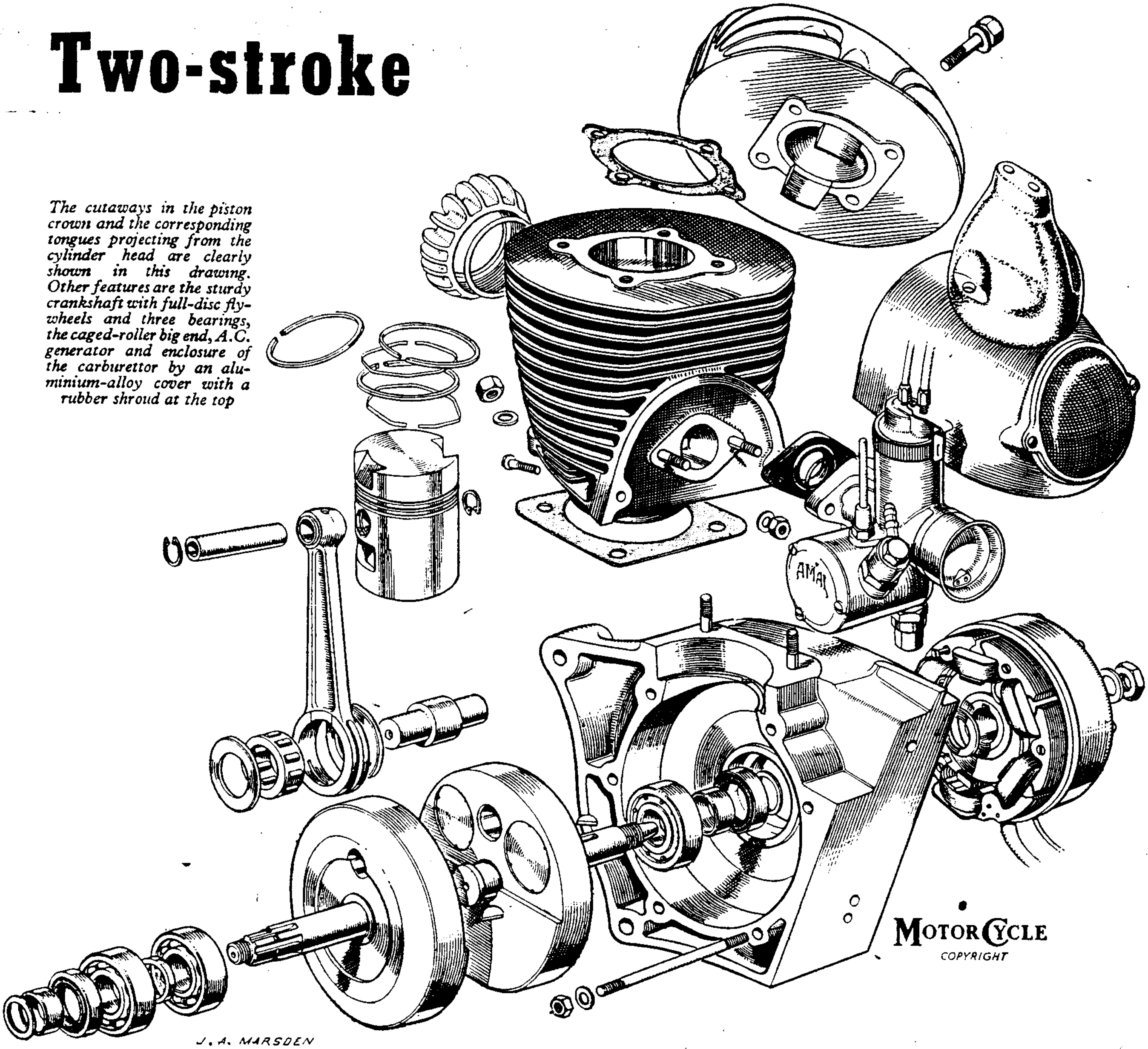
Answer: Our system is a Piatti patent and tests have revealed that it provides an excellent performance and better-than-average two-stroking under light load. In fact, we consider it to combine the power



An unusual feature of the engine is that no transmission shock absorber is employed. The primary chain is non-adjustable and the clutch is of robust yet orthodox design

Two-stroke

The cutaways in the piston crown and the corresponding tongues projecting from the cylinder head are clearly shown in this drawing. Other features are the sturdy crankshaft with full-disc flywheels and three bearings, the caged-roller big end, A.C. generator and enclosure of the carburettor by an aluminium-alloy cover with a rubber shroud at the top



output of the modern flat-top piston with the good two-stroking and low-speed torque of the earlier deflector type.

The gases are made to follow the required path by a combination of design features. First, the transfer passages are open to the cylinder throughout their length and have a shallow outlet angle. Secondly, there are part-conical cutaways in the piston crown having the same angle. Thirdly, tongues on the cylinder head extend downward into the cylinder. Purpose of the tongues is two-fold: they help the transfer streams over the step caused by the combustion-chamber maximum diameter being less than the bore, and they also enter the piston cutaways as top dead centre is approached, thus providing a squish effect and avoiding pockets in the chamber.

Question: I can see that the layout provides a compact combustion space with good turbulence characteristics, but are not the sharp edges of the cutaways and tongues likely to reach excessively high temperatures and cause pre-ignition or detonation?

Answer: We have encountered no trouble at all in this direction because the tongues are directly in the streams of fresh mixture. Moreover, the edges concerned, though sharp, are the ideal shape for feeding the combustion heat back into the main mass of metal.

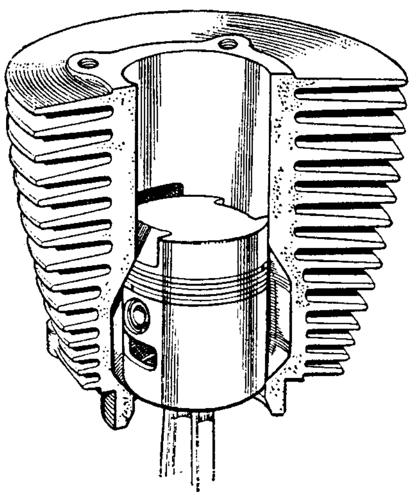
Located just above the cylinder-head left-hand tongue, the sparking plug is considerably offset; I queried whether a medial position in the casting would not be better in terms of minimum flame travel.

"The medial plug would admittedly provide shorter flame travel," was the reply, "but we have not found this critical if the plug is effectively scoured and cooled by the incoming gases, as it is on our finalized design. As t.d.c. is approached the squish caused by tongue and cutaway is directed at the plug and helps greatly to propagate the flame through the charge, thus playing a large part in ensuring good two-stroking at small throttle openings. An incidental benefit of the side plug position is, of course, better accessibility."

Not the least advantages of the open transfer ports are that the cylinder casting is simplified and the accuracy of passages and port timing can be much more readily checked than where there is a wall between passage and bore. To ensure accuracy of timing, all relevant machining is done using the lower edge of the exhaust port as a datum.

It is essential for efficient scavenging that the transfer passages should be exactly opposite each other and truly axial. Any tilting of one of the passages results in a marked adverse effect on performance. However, it can readily be spotted because of the resultant asymmetrical marking which appears on the combustion chamber after a brief spell of running.

As the engine is known to possess a good power output for its size I asked whether details of the port timing would give an indication of how the performance



There is no wall between either of the transfer passages and the cylinder bore

is obtained. The answer was that, on its own, the port timing is not important. It is tied up inextricably with the design of the induction system and of the transfer passages, a critical feature of which is the angle at which their upper ends meet the cylinder wall.

A ported piston (with the edges of the ports thickened to minimize distortion) is employed as the most satisfactory compromise. An unported piston would either have to be too short for proper support and long life or would involve longer transfer passages with consequent complication of the design. Because the sides of the transfer ports are not straight but slightly double-tapered, line wear on the piston is avoided; test engines have not, in fact, revealed any abnormal bore-wear characteristics on account of the open transfers.

The top ring of the flat-top piston is taper-faced and chromium-plated. A.M.C. were one of the pioneers in the motorcycle field of the chromium-plated ring and have found that it contributes enormously to long bore life. Because a ported two-stroke cylinder, with its uneven metal distribution, is more liable to thermal distortion than is a four-stroke cylinder, sealing of the lower two piston rings is assisted by a polygonal expander ring in each groove behind the ring itself.

To prevent resonance the fins of the cast-iron cylinder barrel are linked at front and rear by integral ties. That at the front joins the fins above the exhaust port and the rear tie is situated above the

carburettor cover flange. For the same reason the finning of the DTD424 light-alloy cylinder head is broken up by local thickening known as blistering; blisters were also introduced with highly beneficial effect on the five-hundred twins some four years ago when the head finning area was increased. The blisters and the radial disposition of the outer fins of the two-stroke head result in more costly dies but the respective advantages of quietness and efficient cooling are considered worth while.

Question: The exhaust tract diverges rather sharply to the right outside the port. I appreciate that it is better for accessibility of the transmission to have the exhaust system on the right but does not a bend of this nature hinder the emergence of the gases?

Answer: You will note that there is a sudden enlargement just outside the port which is at 90 degrees to the transfers. We have found that this expansion space, which has quite a considerable beneficial influence on performance, renders negligible the already small effect of the bend.

Question: The exhaust system of a two-stroke can, we know, make or mar the performance. To what extent have the exhaust pipe and silencer been regarded as an integral part of the unit and what

TECHNICAL DATA

CAPACITY: 249 c.c.

BORE: 66mm.

STROKE: 72.8mm.

COMPRESSION RATIO: 8·1.

PISTON-RING END GAP: 0.010 to 0.015in.

PISTON-RING SIDE CLEARANCE: 0.0025in.

IGNITION TIMING: Fixed: contact-breaker points begin to separate 32 degrees ($\frac{1}{4}$in) before top dead centre.

ENGINE DIMENSIONS: Crankshaft drive-side ball and generator-side roller bearings, $\frac{7}{8}$in bore x $2\frac{1}{4}$in outside diameter x $\frac{11}{16}$in wide; crankpin journal, $1\frac{1}{32}$in diameter x $\frac{3}{4}$in long; big-end bearing, single row of 10 $\frac{1}{4}$ x $\frac{3}{8}$in rollers; small-end bush, $\frac{5}{8}$in bore x $\frac{7}{8}$in wide; connecting rod length, big-end to small-end centres, 6in.

CARBURETTOR: Amal Monobloc Type 389; $1\frac{1}{8}$in choke diameter, horizontal; 420 main jet; 389/3 throttle valve; 30 pilot jet; throttle needle clip fitted in 2nd groove from top.

PRIMARY TRANSMISSION: $\frac{3}{8}$in pitch x 0.255in wide roller chain on 5.158in centres; 20-tooth engine sprocket, 43-tooth clutch sprocket.

GEAR-BOX DIMENSIONS: Shaft centres, 1.643in; mainshaft sleeve-gear roller bearing, 32mm track diameter x 52mm outside diameter x 15mm wide; mainshaft sleeve-gear bushes, 0.689in bore x 0.814in outside diameter x $\frac{3}{4}$in long; mainshaft ball bearing, $\frac{1}{2}$in bore x $1\frac{7}{16}$in outside diameter x $\frac{3}{8}$in wide; layshaft drive-side bush (flanged), $\frac{5}{8}$in bore x $\frac{13}{16}$in outside diameter x $\frac{3}{4}$in long; layshaft bush in kick-starter axle (flanged), $\frac{5}{8}$in bore x $\frac{3}{4}$in outside diameter x $1\frac{1}{8}$in long; internal gear ratios, 2.95, 1.85, 1.30 and 1 to 1.

has been done regarding the two firms fitting the engine?

Answer: Once the prototypes had completed their initial running, all bench work was done with an exhaust system fitted and we have carried out a considerable amount of comparative testing. Full use was made of the two-stroke experience of James and Francis-Barnett. Though their production silencers differ appreciably in design, the complete exhaust systems conform closely to what we found most suitable for the engine characteristics. Among other things we have determined that the exhaust system has a marked effect on two-stroking qualities and on the shape of the power curve as well as the height of its peak.

Mr. Walker and I then turned to more mechanical matters and, not unnaturally, the sturdy bottom half of the engine came in for attention first. The mild-steel flywheels are of $5\frac{3}{4}$in diameter with a maximum width of 1.115in; the Ubas mainshafts are an interference fit (nominally the fit is parallel but, for ease of entry of shaft into wheel and the avoidance of damage to the bore, a very slight taper is utilized). Keys provide additional security. Supporting the mainshafts are two $2\frac{1}{4}$in o.d. ball bearings on the drive side and a roller bearing on the generator side.

The shouldered crankpin, of En.351 nickel-chromium-manganese steel, forms the inner track of the caged-roller big-end bearing; the pin is a parallel interference fit in the wheels. It is of interest that cast-iron flywheels were tried in the earlier stages; to get adequate security the crankpin was hollow and expander plugs were driven in after the wheels were pressed on. With the more rigid steel wheels no expanders are needed. Between the big-end bearing and the wheels are washers of cast iron which prevent wear of the wheel faces.

To minimize the crankcase effective volume and so get a high primary compression ratio, full-disc flywheels are employed. They are bored out (not right through) on each side of the crankpin for balancing purposes and the holes are covered by light-gauge steel discs secured by peening. The 60 per cent balance factor employed is a compromise between the different requirements of the two frames concerned.

I commented on the shallow bevel on the outside face of each flywheel; it seemed rather contrary to dynamic principles to reduce the thickness near the rim where mass is most effective. The reply was that, as so often, a compromise was necessary. A feature of the engine is the efficient lubrication of the main bearings: oil settling in the transfer ports drains into a circumferential gallery in the crankcase mouth immediately below the barrel spigot. From the groove, oilways lead to a space between each mainshaft oil seal and its adjacent bearing. The taper on the wheels is necessary to accommodate the gallery and oilways without sacrificing compactness.

Question: You mention efficient lubrication. Does much oil in fact drain down those oilways? Also what special provisions are made for big-end lubrication?

Answer: Checks show that the spaces

between oil seals and bearings are always flooded with oil after running—need one say more? In addition to the customary circumferential slots in the lower half of the hardened big-end eye of the En.351 connecting rod we machine a relief of arc section on each side face of the eye, above the crankpin. The reliefs are just deep enough to reveal the tips of the rollers, and we have found them to effect a considerable improvement in big-end oiling. We employ a caged bearing, of 7R A.J.S. pattern, because the skidding between rollers which takes place in a crowded bearing is undesirable when petroil lubrication is employed.

An uncommon feature of the A.M.C. engine is the use of an A.C. generator, with rectifier and coil ignition, instead of a flywheel magneto. Because of the potential performance of the unit it was felt that the higher output of the alternator would be desirable to permit a headlamp bulb of adequate wattage and a stop lamp in addition to the tail lamp. The generator rotor is keyed to the mainshaft to ensure correct phasing for emergency starting with a flat battery. The contact-breaker carrier is fitted to the stator by a spigot and its cam is a taper fit on the end of the mainshaft.

I suggested that the enclosure of the carburettor (by means of a polished light-alloy cover and a rubber shroud fitting round the cables and into the top of the cover) might result in heating of the intake air—with consequent reduction in volumetric efficiency—or possibly boiling of the fuel in the float chamber. Mr. Walker's reply was that heat transmission is reduced considerably by the use of an insulating washer between cylinder and carburettor; again, there is an air space between the cylinder and the flange to which the cover is attached; some ventilation of the air space round the carburettor is embodied and, finally, the design of the cover is such that the carburettor draws air direct from the atmosphere.

Question: Why did you adopt an air slide in the carburettor with handlebar control instead of the more common and cheaper shutter-type strangler?

Answer: We tried a strangler but were unable to get it to pass enough air to meet the demands of the engine at high outputs. The handlebar control has the advantage of allowing ready adjustment of the air supply to meet the varying needs during the relatively long warming-up period resulting from the use of large aluminium castings for the lower half of the engine.

The first thing that struck me when I turned my attention to the transmission was the absence of a shock absorber. "Our original thought," said Mr. Walker, "was to embody a rubber-vane device in the clutch centre. However, we decided that with the considerable flywheel inertia and the anticipated sweet running, no such shock absorber would be necessary. Tests both with and without have proved the decision to be absolutely right."

Bolted-up construction of engine and gear box was chosen rather than integral construction for two reasons: it results in castings of more manageable proportions for machining and it permits the use of orthodox splitting of both components for overhaul purposes.

Question: Why did you decide on chain drive instead of gears for the primary transmission?

Answer: We have long set great store by mechanical quietness. This a chain drive will guarantee at reasonable cost, whereas gears are almost inevitably noisy to some extent because of variations of the centres with temperature changes.

Question: The foot-change mechanism, with its double-ended pawl, is similar to that of the A.M.C. heavyweight gear box. However, instead of the right-angle actuation of a cam plate through a knuckle joint you employ a two-track cam segment splined directly to the ratchet spindle. What are the reasons for altering the earlier scheme?

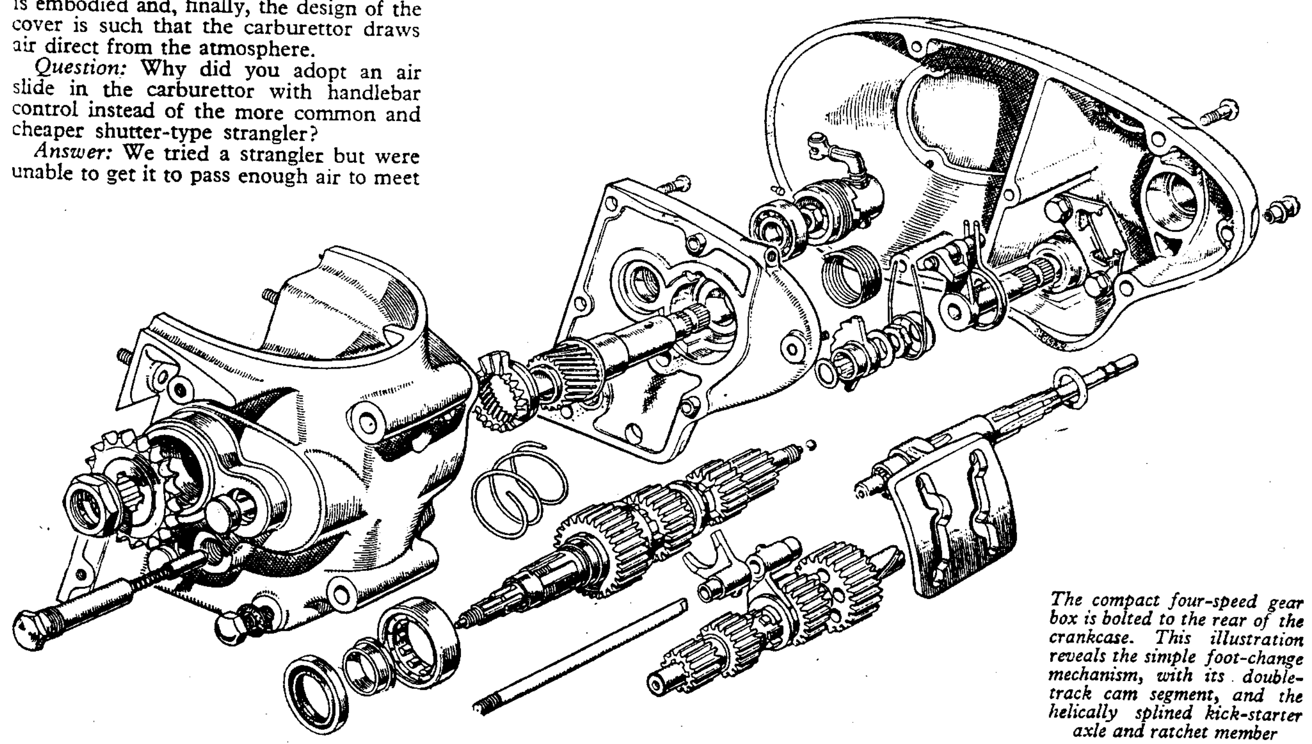
Answer: The layouts of the two gear boxes are quite different. It was necessary to keep the heavyweight box as short as possible and the mainshaft-over-layshaft scheme with cam-plate operation of the selector forks was the most suitable. In the two-stroke the need for minimum length did not arise and hence we were able to locate the layshaft behind the mainshaft. The gear pedal had to be mounted low on the side of the unit so the cam segment followed automatically; it was the best means of obtaining a good track form in the available space. For stiffness of the segment the tracks are grooves and not slots.

Another gear-box feature worthy of comment is the kick-starter mechanism which is of robust face-ratchet pattern. The outer member is mounted on helical splines on the end of the axle and operation of the pedal causes the member to ride along the splines into engagement. An advantage of the method is that the wedging action of the helical splines under pressure makes it impossible for the ratchet to jump a tooth.

Gear shafts and gears are of En.351 steel and are of sensible dimensions. Dogging for second and third gears is of the conventional block type but to save width the mainshaft sleeve gear and the layshaft bottom-gear pinion have drilled holes to take the projections of the sliding members.

Question: One can safely predict that, unless something most unexpected occurs, your new engine will quickly carve a niche for itself in the world's markets. Have you any plans for extending the two-stroke range?

Answer: It is inexpedient to say anything except that in this organization we are always doing a lot of forward development work, much of which is never seen by the public as a finished product.



The compact four-speed gear box is bolted to the rear of the crankcase. This illustration reveals the simple foot-change mechanism, with its double-track cam segment, and the helically splined kick-starter axle and ratchet member