for short periods and at low speeds in such circumstances—the cylinder keeps sufficiently cool by means of radiation and convection.

Detachable Cylinder Heads

Sometimes the cylinder barrel and cylinder head are two separate castings, as in Figure 9. In this case the cylinder head may be of a material different from that of the cylinder barrel—probably of aluminium, which has a far higher heat conductivity than cast iron. In order to make a gas-tight joint between the two components a packing washer (called a "gasket", and made of copper sheet, aluminium sheet or thin copper enclosing asbestos, that is, a copper-asbestos gasket) is often employed.

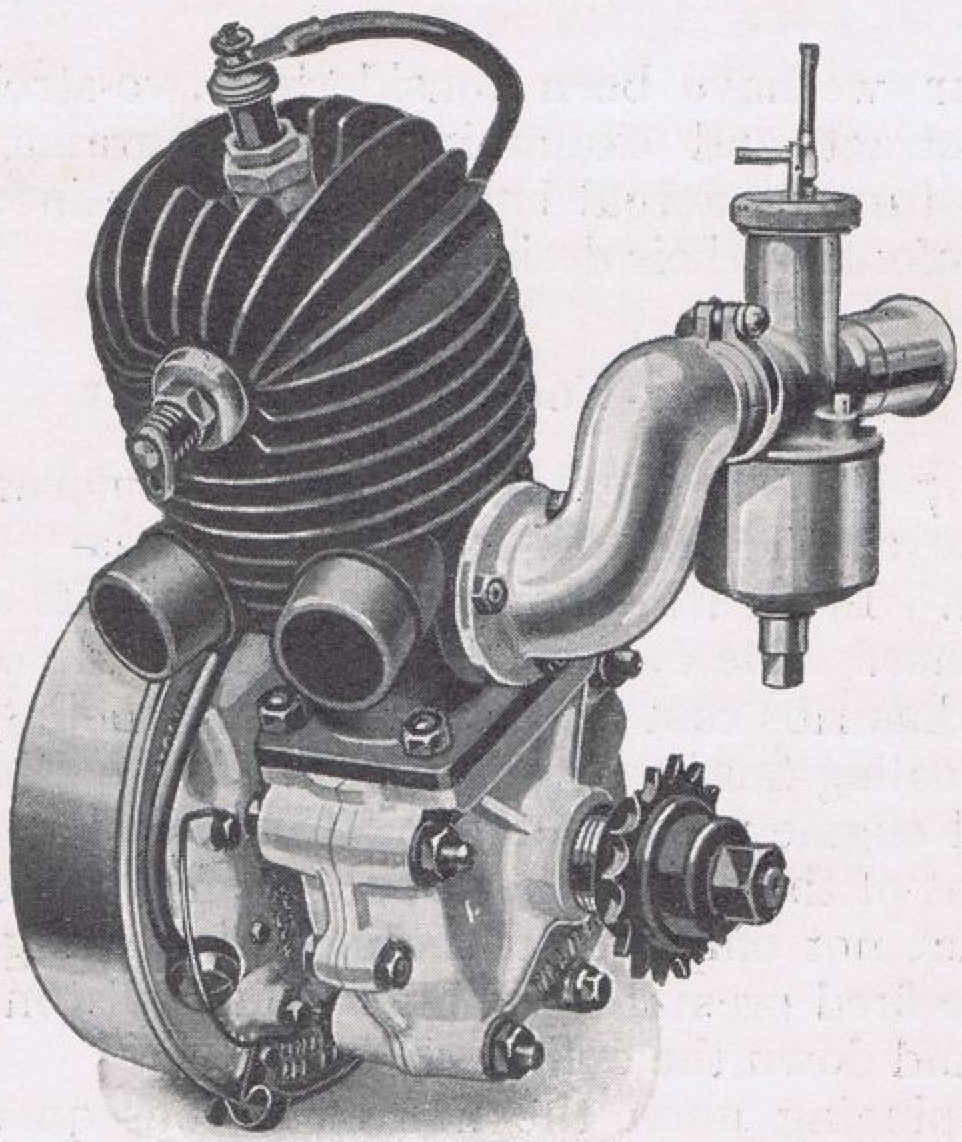

Fig. 7.—External view of the 148 c.c. Villiers Mark XIIC long-stroke engine.

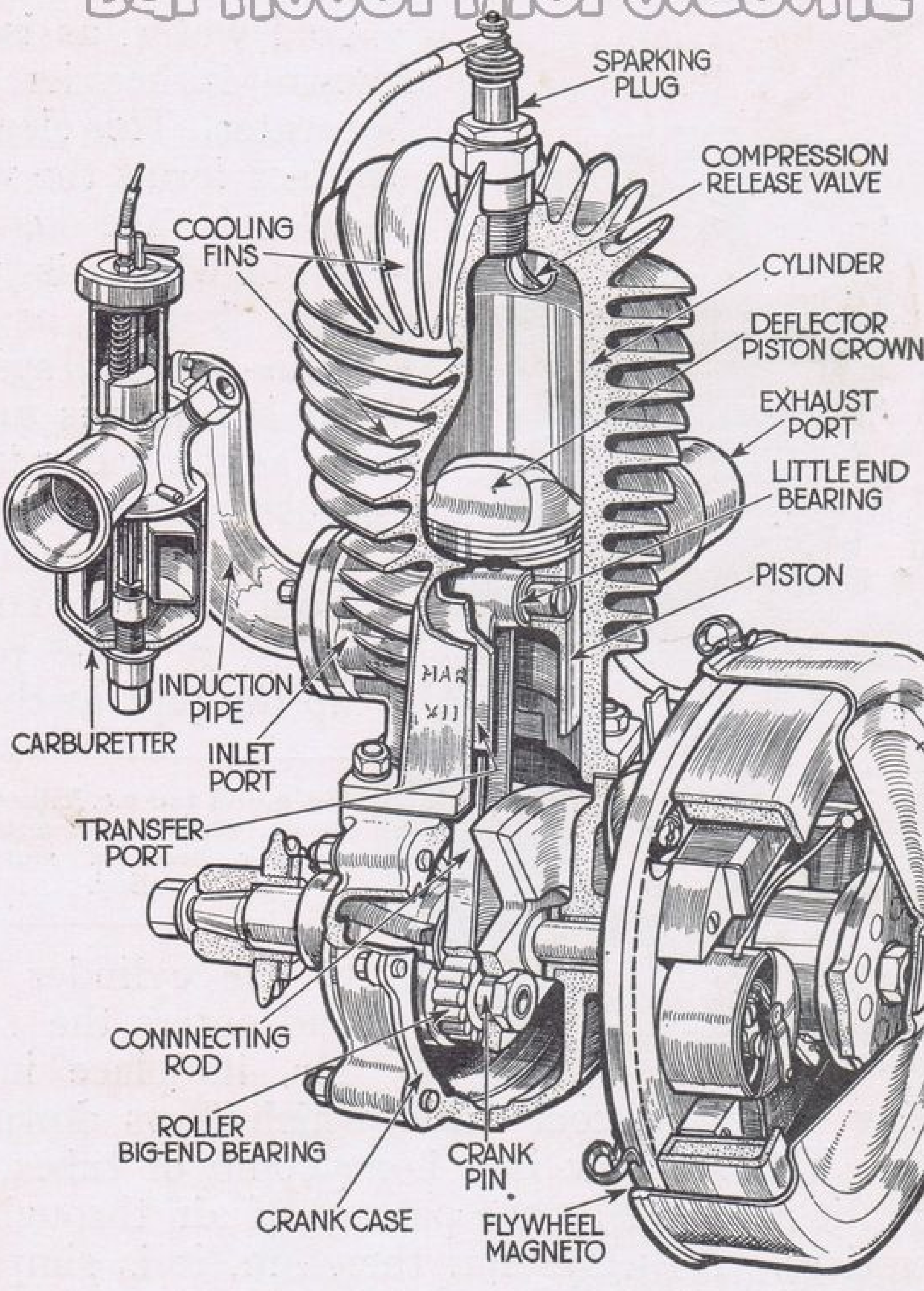

Fig. 8.—A cut-away view of the Villiers Mark XIIC engine (Fig. 7) as seen from the opposite side. It will be noticed that this design has a non-detachable cylinder head and a flywheel magneto.

On a number of engines water-cooling is used instead of air-cooling. Figure 10 shows an engine of this type. As will be seen there is a smooth jacket round the cylinder, which in this case can be likened to a thin tube. Between this tube, which forms the cylinder walls, and the jacket is a space through which the cooling water can circulate. The top and bottom of the jacket are connected to a radiator which is just like a small edition of a car radiator.

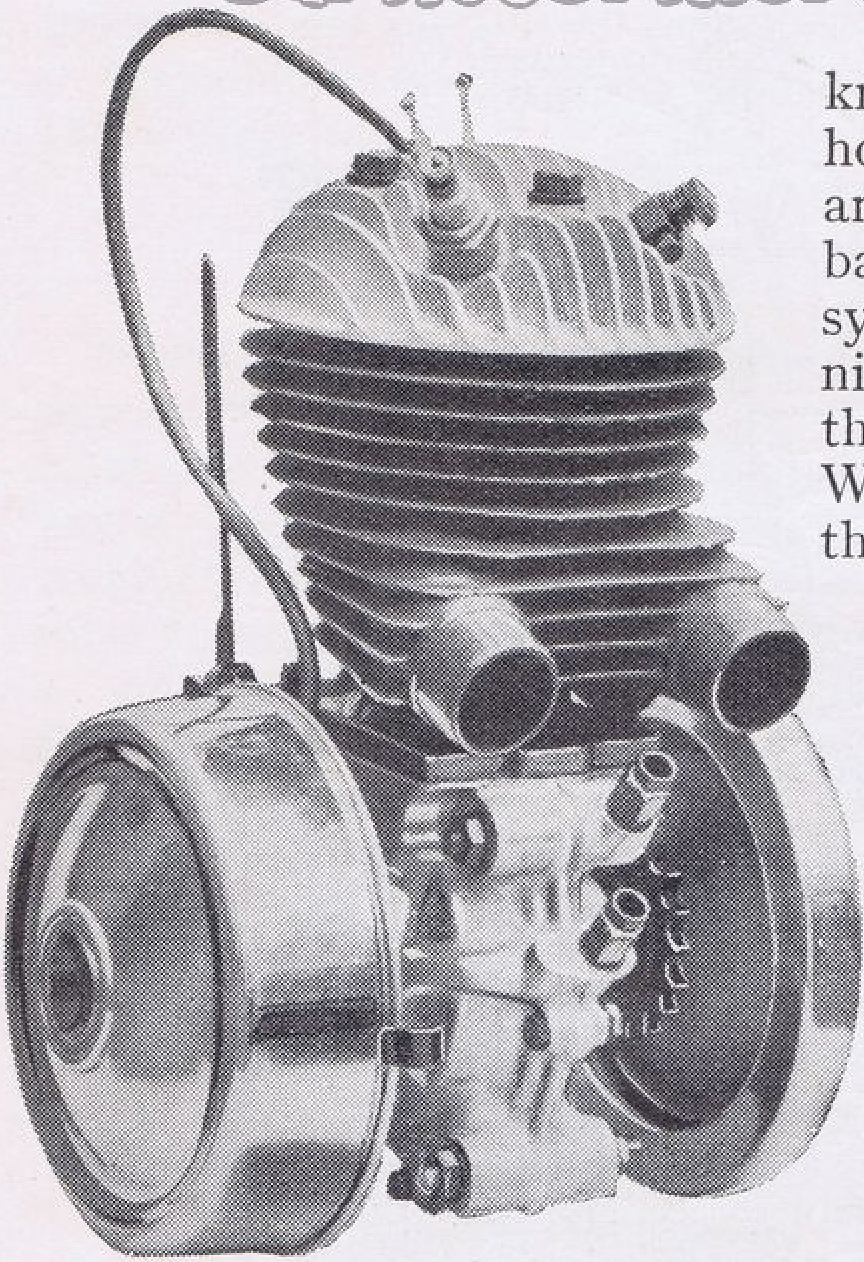

Fig. 9.—A 249 c.c. Villiers two-stroke, which has a detachable cylinder head of aluminium alloy.

Cold water, as is well known, is heavier than hot water. This elementary fact forms the whole basis of the cooling system, which is technically known as the thermo-syphon system. What happens is merely this: as the water in the jacket becomes hot, due to heat conducted from the cylinder walls, it rises, passes up the pipe at the top of the cylinder head and enters the radiator, its place in the jacket being taken by cool water which flows down the lower pipe. The radiator is a honeycomb of tubes, and the water in it is cooled by the passage of air through the little interstices. As a system, therefore, it is simple in the extreme and entirely automatic.

Avoiding Internal Friction

Internally the cylinder, whether air- or water-cooled, is like the inside of a piece of large steel tubing except that it has a glass-like finish. Great care is taken with this finish since the piston has to slide up and down with the least possible friction.

In a touring engine the piston is usually made of cast iron, but in a sports unit very often it is of aluminium, which besides having, as already stated, a higher conductivity is also lighter. The reason for the "hump" or messy, due to the need for flooding it prior to starting the engine from cold.

It may be asked why the petroil system is so effective. One reason, namely, the supply being proportional to the engine load, has already been mentioned. There is another: the engine induces into the crank case very finely divided oil in the form of mist and this mist becomes automatically distributed to all the bearing surfaces in the engine by means of the rotating crankshaft, the connecting rod, the piston, and also its own momentum.

Mechanical Pump Lubrication

Next in the list of systems comes mechanical pump lubrication. The pump is driven from the engine and generally consists of a small cylinder and plunger or piston, with simple valves or an arrangement of ports which enable the plunger to suck in oil from the oil tank, and on its upward stroke force it out and into the engine. The feed to the engine may be straight to the crank case, the rotating crankshaft being left to distribute the oil automatically, or to the end of the crankshaft, whence via ducts or holes in the shaft the oil is led to the main bearings and the big end bearing; in this latter case a lead (i.e. a pipe leading the oil) may also be taken to the cylinder walls.

Pump and Throttle Linked

A refinement fitted to some machines using pump lubrication is a device linking up the pump with the throttle so that the greater the throttle opening the more oil is passed to the engine. This is an advantage, for without it the oil supply depends upon the engine speed and not upon the nature of the work the engine is being called upon to do. And the engine may on, say, a downhill stretch be turning over very fast and, therefore, receiving large quantities of oil although, because it is running light, it needs next to none.

Lastly there is the very simple Villiers automatic pressure system (Fig. 31). In this design advantage is taken of the fact that the amount of pressure in the crank case varies according to the throttle opening; the greater the opening the higher the pressure.

How the Villiers Pressure System Works

In order to be clear as to how the system works one must refer to the diagram, Figure 31. On the descent of the piston compressed petrol-air mixture passes from the crank case along ducts in the middle of the engine shafts to holes registering with grooves in the crank case bushes; thence through holes in the crank case and via

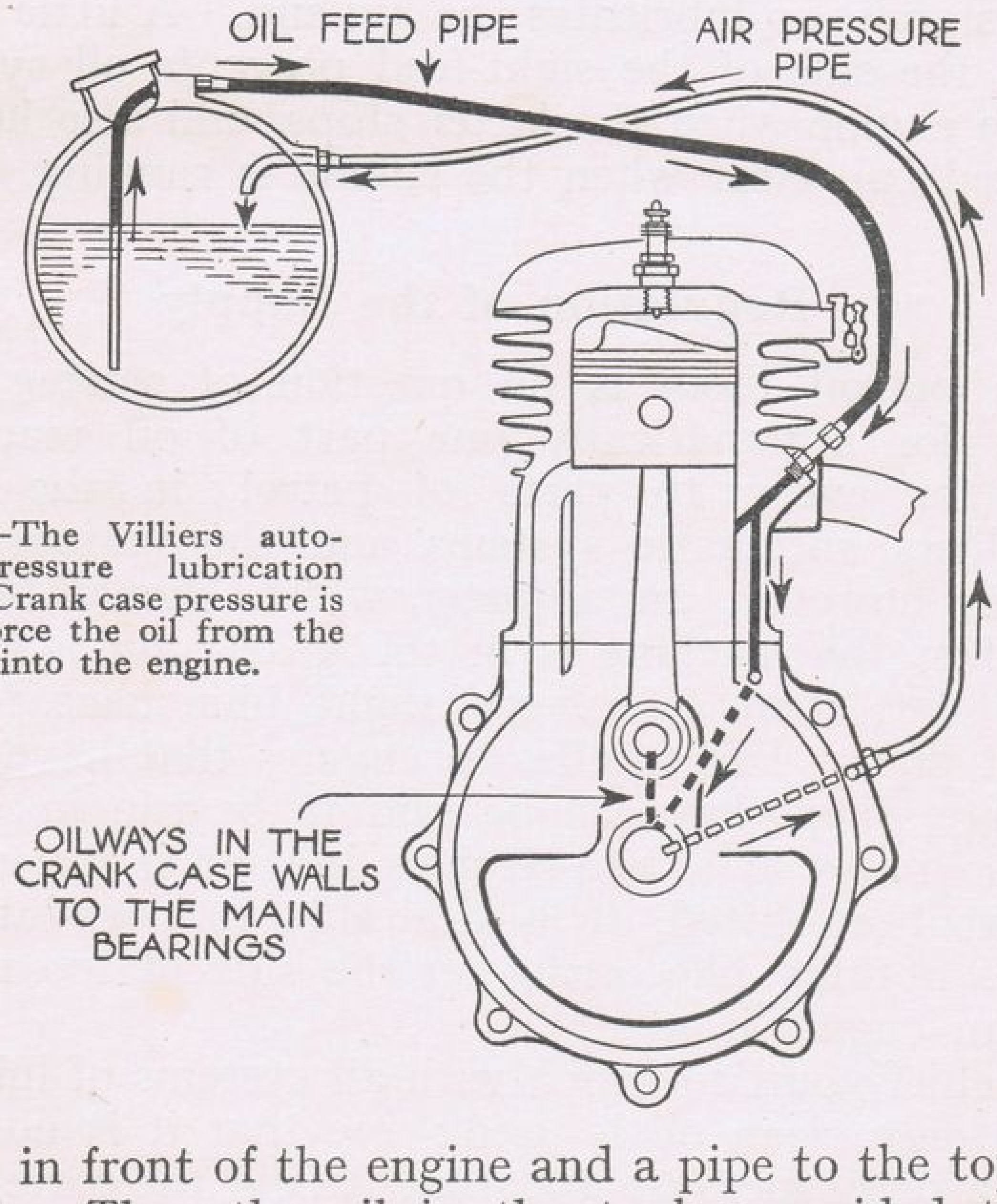

Fig. 31.—The Villiers automatic pressure lubrication system. Crank case pressure is used to force the oil from the tank into the engine.

a union in front of the engine and a pipe to the top of the oil tank. Thus the oil in the tank, provided that the filler cap is screwed down tightly and its washer intact (both important points), is maintained under pressure and is forced up the second pipe, which protrudes down nearly to the bottom of the tank, past a simple adjustable valve or tap, through a glass chamber—a sight feed that enables the quantity of oil passing to be checked—and into the engine. As already mentioned, the pressure in the crank case, and, therefore, oil tank, varies according to the throttle opening, and the greater the pressure in the oil tank the more oil will be forced past the adjustable valve and into the engine.

When it reaches the engine the oil is divided into two portions, one going through a hole in the cylinder wall to lubricate the cylinder and piston and the other to the crank case where it is divided between the two main bearings and also lubricates the big end. A little air-vent hole at the side of the sight-feed prevents oil syphoning into the engine when the latter stops, and also keeps the sight-feed cup clear when the engine is running.

Regulation of the Supply

With petroil there is no question of setting the oil supply, for automatically one part of oil reaches the engine for every 16 parts of petrol; in the case of the Villiers automatic systems and the various pumps, there is, however, an adjuster which should be set so that when the machine is in top gear running normally on the flat, there is a very slight blue haze from the exhaust pipe. This applies to engines that have reached the stage when they can be said to be run in; for the first 800 miles of a two-stroke's life, or if a new piston has just been fitted, it is desirable to over-lubricate—there is nothing like erring on the side of too much oil when an engine is new.

The chief point to watch with all systems of lubrication is that only clean oil is used; see that it is not poured out of a dirty measure and that it is of the correct grade. Beyond this it is only necessary to watch that the sight-feed glass and the various connecting unions in the pipe line are in order and leakproof, and in cold weather that the oil is flowing at the correct rate; with one or two designs low temperatures may involve a more generous setting of the adjuster. Any actual trouble is generally due either to an air leak caused by a fractured pipe, a loose union, or a faulty washer at the sight-feed glass or in certain pumps to a little ball valve situated at one of the pump unions being held off its seat by dirt—washing it out with petrol will cure this.

an almost spherical combustion chamber formed by the piston crown and the cylinder head. The sparking plug is situated on one side of this chamber, so that as the rapidly swirling compressed charge sweeps past it ignition occurs and the inflammation is transferred very quickly to the rest of the mixture.

The cylinder head in this case is detachable, vertical ribs being formed on the detachable part, for cooling purposes.

The connecting rod has a roller-bearing big end, but plain phosphor-bronze bushes are employed for the main crankshaft bearings. The crankshaft has internal counter-balance weights and an external flywheel.

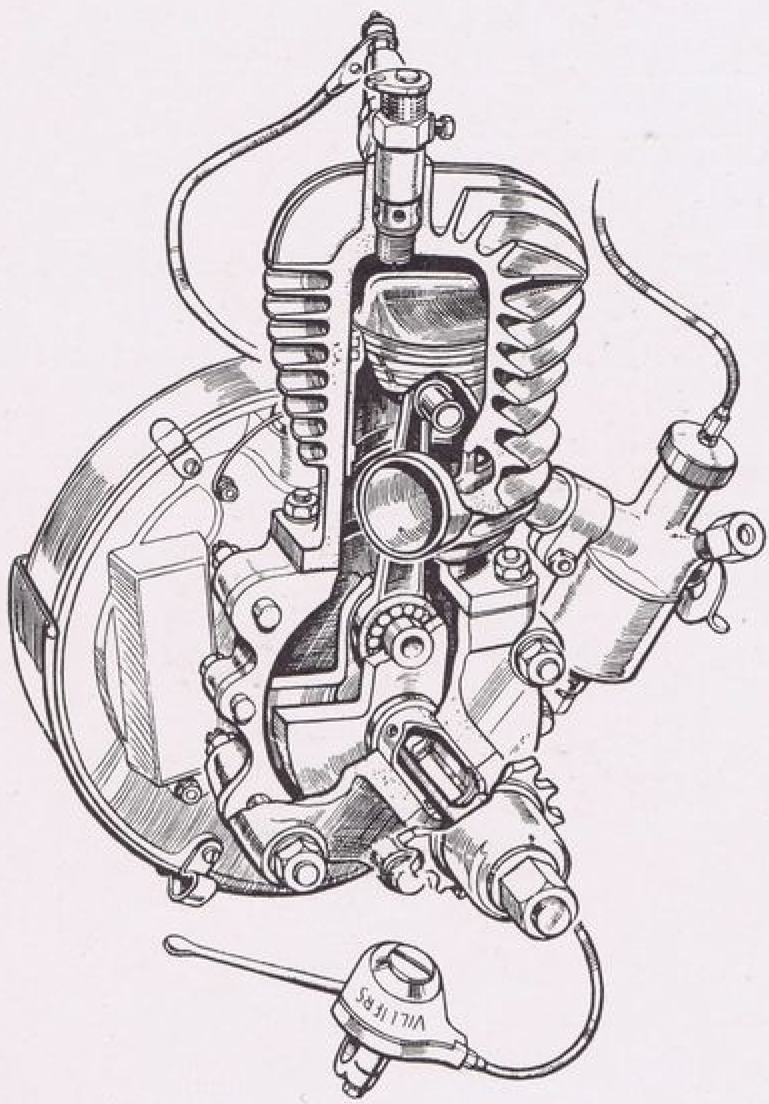

Fig. 74.—The Villiers 98 c.c. Engine (*The Motor Cycle*).

THE VILLIERS ENGINES

This well-known range of engines represents a high standard in the development of the two-stroke variety. The engines in question are made in the following sizes, viz. 98, 147, 148, 196, 247 and 346 c.c. capacities. They are fitted to a large number of motor-cycles.

Dealing first with the very small 98 c.c. model, shown in part section in Fig. 74, this is a fairly recent comer to the two-stroke field.

It has a bore and stroke of 50 mm. and 50 mm., respectively, thus giving what is generally known as a "*square*" engine.

The cylinder is cast with inlet, transfer and exhaust ports integral; the cylinder itself is arranged to slope forwards as shown in Fig. 75. As arranged in the frame of a motor-cycle, the transfer and exhaust ports face *across* the frame instead of the more conventional "in line" arrangement.

The exhaust ports are duplicated and lead into a single well-ribbed exhaust chamber, and thence to the exhaust pipe.

The piston is of cast iron and carries two compression rings; in the upper groove is a special device patented by the makers of this engine, known as an *inertia ring*. The object of this ring is to prevent the piston rings from sticking in their grooves. This inertia ring is clear of both cylinder and piston walls, and is free to move within its own clearance limits, thus tending to keep the ring and groove clear of carbon deposit.

The gudgeon pin is free to float in both the small-end bearing and the piston bosses; it is provided with alloy end-pieces and incorporates a special device for preventing the piston pin from entering the ports during the travel of the piston.

No small-end bush is provided in the forged-steel I-section connecting rod, but the big end is of the full roller-bearing type, and includes a special feature associated with Villiers design, in that alternate rollers are of steel and bronze, with the object of preventing seizure.

Each crank axle is forged with its crank cheek and balance weight, and each runs in a long bronze bearing. To ensure adequate lubrication, each of these bearings has circumferential grooves formed at each end, joined by longitudinal grooves, and oil from the crankcase is led into these grooves by special helical ducts cut in the inner faces of the crankcase.

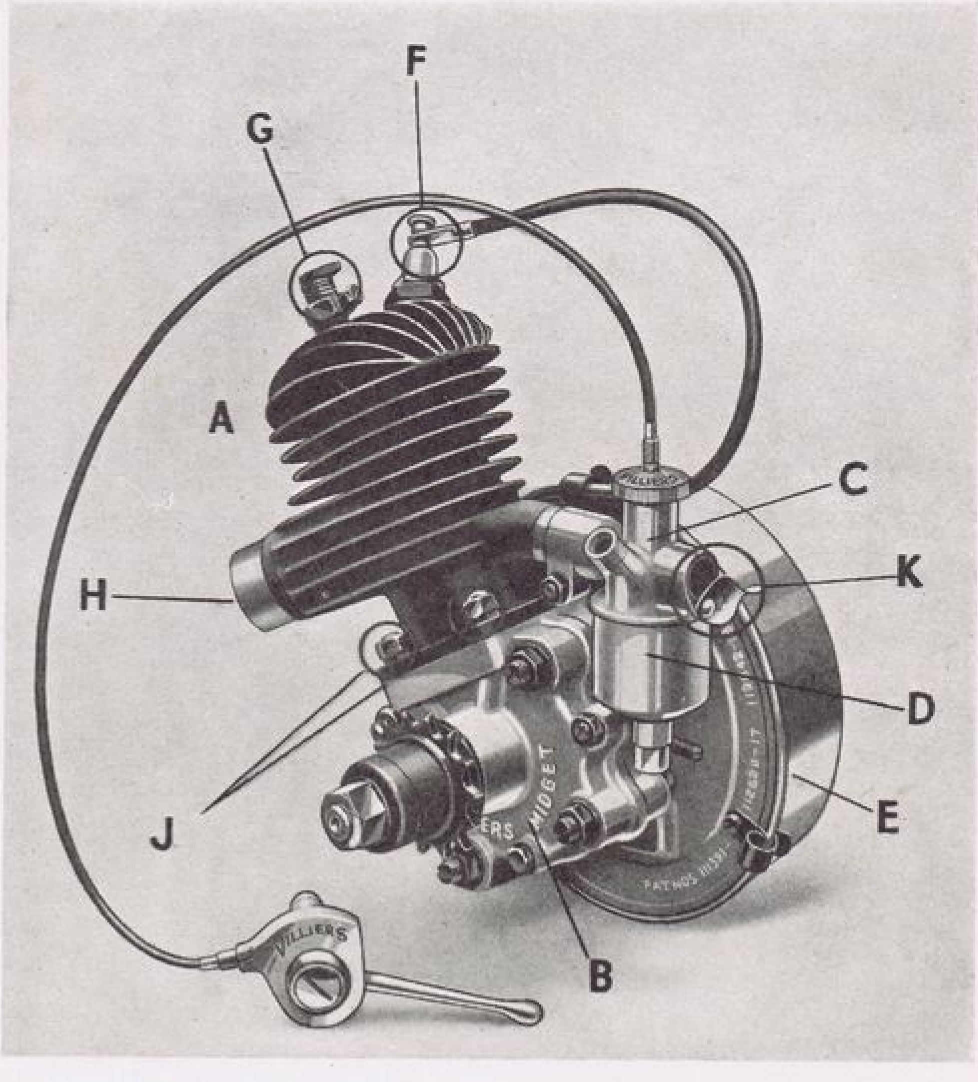

Fig. 75.—The Villiers 98 c.c. Engine.

A—Cylinder. B—Crankcase. C—Carburettor. D—Annular Float Chamber. E—Flywheel Magneto. F—Sparking Plug. G—Compression Release Valve. H—Exhaust Port. J—Cylinder Holding-down Bolts. K—Main Air Supply Shutter.

The arrangement of the crankshaft, with its roller-bearing big end, provides a narrow crankcase—advantageous in that a high crankcase compression ratio becomes possible, and also in that the crankshaft is supported close up to the loading point.

On the offside of the crankshaft is a full-sized flywheel magneto, which gives remarkably easy starting and smooth running; it can also be arranged to provide a source of direct lighting.

A Villiers central-float-type carburettor, of the type described in the previous chapter, is mounted on the induction stub. It is of the single-lever pattern, but a strangling shutter is provided to ensure an easy start.

This little unit is quite self-contained. There are no auxiliary drives to be fitted up, or to need adjustment, and, since the lubrication is on the "petroil" system, there are only the petrol pipe, throttle and release-valve levers to be connected up. It is a masterpiece of compact and eminently sensible design.

The Villiers 98 c.c. engine gives 2 h.p. at 3,250 r.p.m. It has other possible applications apart from that of driving a lightweight motor-cycle.

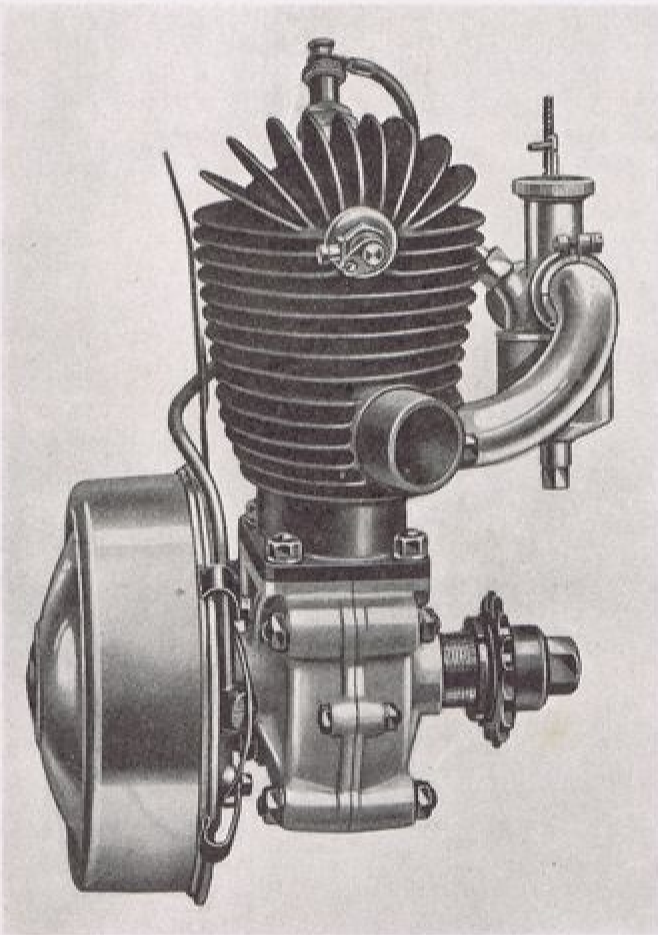

Fig. 76.—The Villiers 196 c.c. Touring-type Engine.

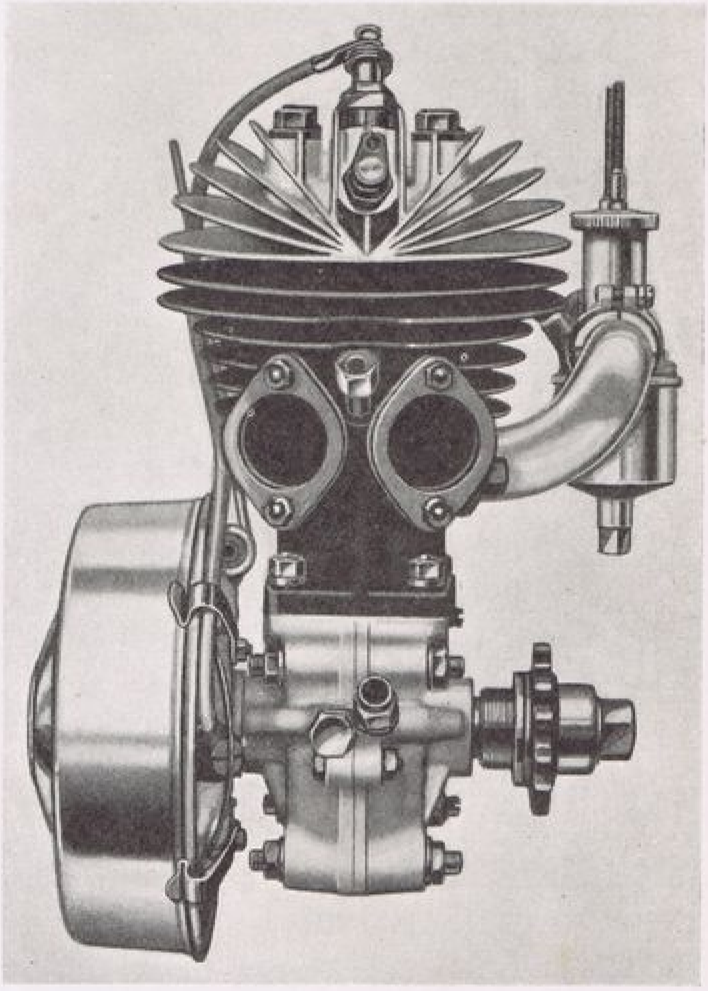

Fig. 77.—The Villiers 196 c.c. Super-sports-type Engine.

Fig. 76 shows the Villiers 196 c.c. Mark 2E engine. This has a bore and stroke of 61 mm. and 67 mm., respectively. It has a single exhaust port non-detachable head cylinder.

Among the special features of this engine may be mentioned the following: The full roller-bearing big end; long phosphor-bronze main bearings; fully floating gudgeon pin; compression release valve arranged horizontally in the head of the cylinder; Villiers flywheel magneto (described later in these volumes); Villiers single-control carburettor, and the use of the "petroil" system of lubrication.

When fitted in a good design of light motor-cycle, this engine enables a maximum road speed of 45 m.p.h. to be attained. The petrol consumption averages 90 miles to the gallon, and oil consumption 1,600 miles per gallon.

It is interesting to compare this 196 c.c. engine with the sports model of exactly the same capacity, known as the "Super Sports 196 c.c." engine (Fig. 77).

The engine in question has the same bore and stroke, but is fitted with a detachable cylinder head of special aluminium alloy, held in place by studs and nuts. The piston in this case is also made of aluminium alloy, combining great strength with lightness. The engine has twin exhaust ports and twin exhaust pipes; this gives better exhaust scavenging than the single port and pipe arrangement.

In other respects the design of this engine resembles that of the other 196 c.c. engine previously described.

When fitted to a suitable machine, a maximum speed of 50 to 52 miles an hour can be attained. The petrol and oil consumptions are, respectively, 90 and 1,600 miles per gallon.

It is not proposed to describe the other models of Villiers engines, as they follow similar lines to those we have already mentioned, but it may be of interest to refer, briefly, to the largest engine, viz. the $3\frac{1}{2}$ h.p. long-stroke engine (Mark 14B).

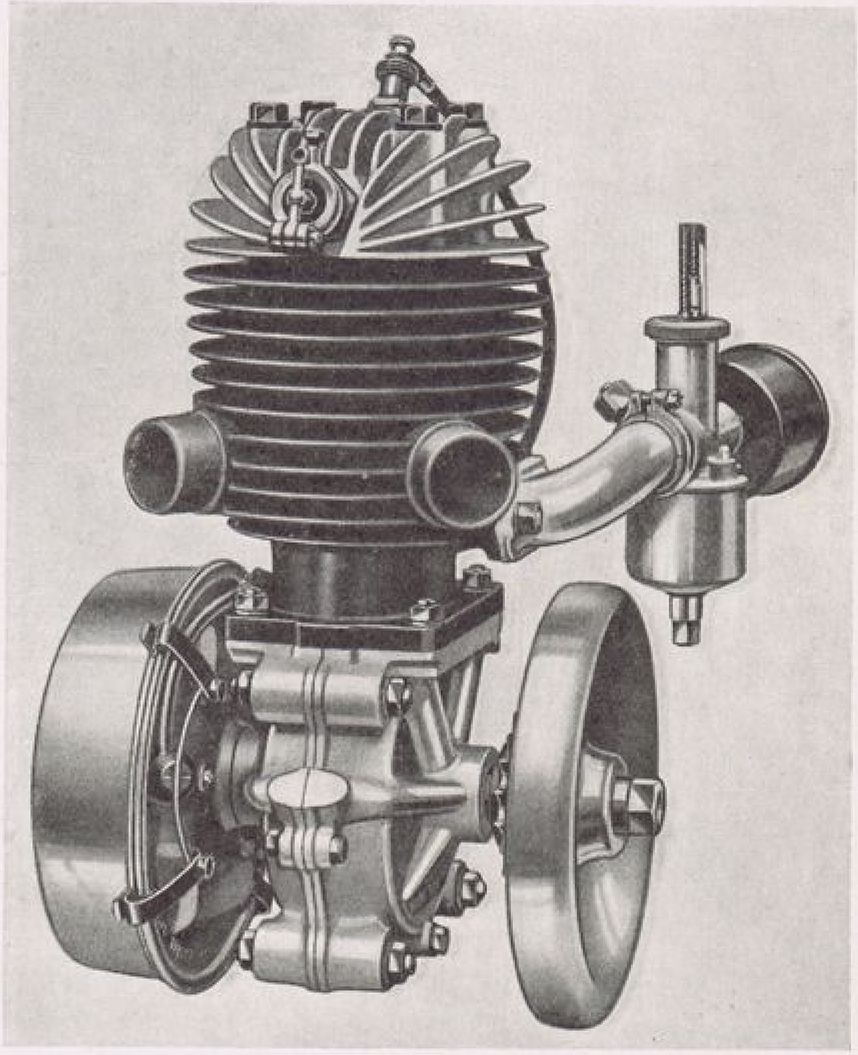

Fig. 78.—The Villiers 346 c.c. Engine.

This has a bore and stroke of 70 mm. and 90 mm., respectively, giving a cylinder capacity of 346 c.c. It has an aluminium-alloy detachable cylinder head, twin exhaust ports and pipes arranged at a wide angle apart; roller-bearing big end; fully floating gudgeon pin; aluminium-alloy piston; long phosphor-bronze main bearings; two-lever Villiers carburettor, and an auxiliary flywheel in addition to the flywheel magneto.

When fitted in a suitable design of motor-cycle it will give a maximum speed of 60 m.p.h. The petrol consumption lies between 70 and 80 m.p.g. and oil consumption 1,800/2,000 m.p.g.

Villiers engines, except in the case of the smallest models using the "petroil" system, are fitted with *a special automatic system of lubrication*. This has no moving parts and requires no separate pump. The sight feed and oil regulator of this system are arranged on the tank. By this method oil is fed to the engine under pressure from the crankcase, and the supply of oil is increased automatically as the load on the engine becomes greater.

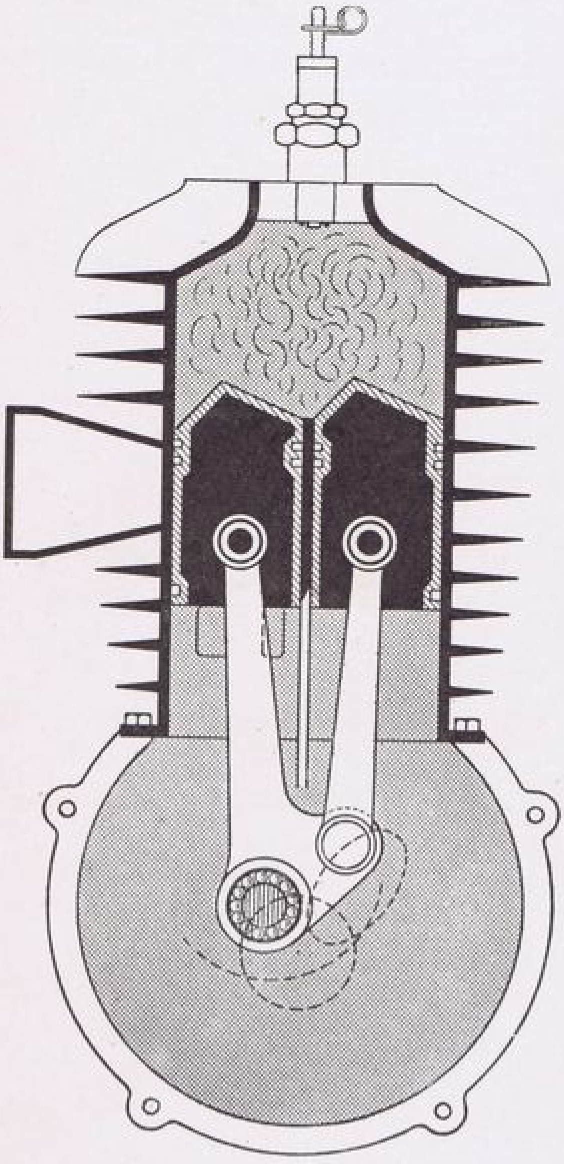

Fig. 79.—The Zoller Supercharged Two-stroke Engine.

ZOLLER SUPERCHARGED TWO-STROKE ENGINE

It is a difficult problem to design a supercharged two-stroke engine without mechanical valves, because the two-stroke cycle of operations necessitates the exhaust port remaining open after the transfer port has closed. The Continental designers of the well-known Zoller supercharger have, however, evolved a simple two-stroke engine without either mechanical valves or a separate supercharger, and they claim that it is cheaper to produce than a four-stroke and more efficient than an unsupercharged two-stroke.

In the Zoller engine (Fig. 79) two cylinders are arranged side by side with a common combustion chamber, and the exhaust port is made to open and close considerably in advance of the transfer port by having a crankshaft slightly offset with a main connecting rod to which is attached a shorter articulated rod carrying the admission piston. A thing of great importance is the actual point of attachment, and a single crankpin is used. The explosive mixture enters the crankcase in the usual way and passes to the rear cylinder via the transfer port. The successful functioning of the engine is due largely to the big lead of the exhaust-controlling piston caused by the arrangement of the main and articulated connecting rods. The path of the point of attachment of the articulated rod is elliptical as shown, but is capable of modification, so as to provide a varying degree of supercharge. The design of the piston-deflector heads and the ports ensures that the combustion chamber is cleared as far as possible of spent gases by the incoming charge of gas from the transfer port.