A PRACTICAL GUIDE COVERING ALL MODELS

THE *Villiers* ENGINE

B. E. BROWNING

MOTOR CYCLE MAINTENANCE AND REPAIR SERIES

THE VILLIERS ENGINE

A PRACTICAL GUIDE
COVERING ALL MODELS

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With 87 Illustrations

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CHAPTER I

THE TWO-STROKE ENGINE

THREE of the principal components of any internal-combustion engine are the piston, connecting-rod and crankshaft, and in the case of the Villiers two-stroke engine, these are the only moving parts.

The piston is made a gas-tight fit in the bore of the cylinder by the fitting of compression rings, commonly called piston-rings, positioned near the crown. The piston reciprocates in the cylinder bore, the length of travel or stroke being controlled by the crank-pin secured between the webs of the crankshaft.

Between the piston and crank-pin is fitted the connecting-rod, its function being to convert the reciprocating movement of the piston into rotary motion of the crankshaft.

The connecting-rod is a steel forging, light in weight and of a suitable section to carry the load imposed by the explosion pressure on the crown of the piston during the downward stroke. The top, or small-end, has a bronze bush in which is fitted the gudgeon-pin, the ends of the pin being located in internal bosses of the piston. Between the hole in the bottom, or "big-end", and the crank-pin are inserted alternate steel and bronze rollers.

For many years the Villiers engine was of the three-port design, the cylinder having one port for the inlet, one for the exhaust and one for the transfer of the charge from the crank-case to the combustion head. With this arrangement of ports the piston crown is shaped to form a deflector, the object of which will be understood later when explaining the cycle of operations.

During 1934 an entirely new design was introduced in which the cylinder has two exhaust and four transfer ports,

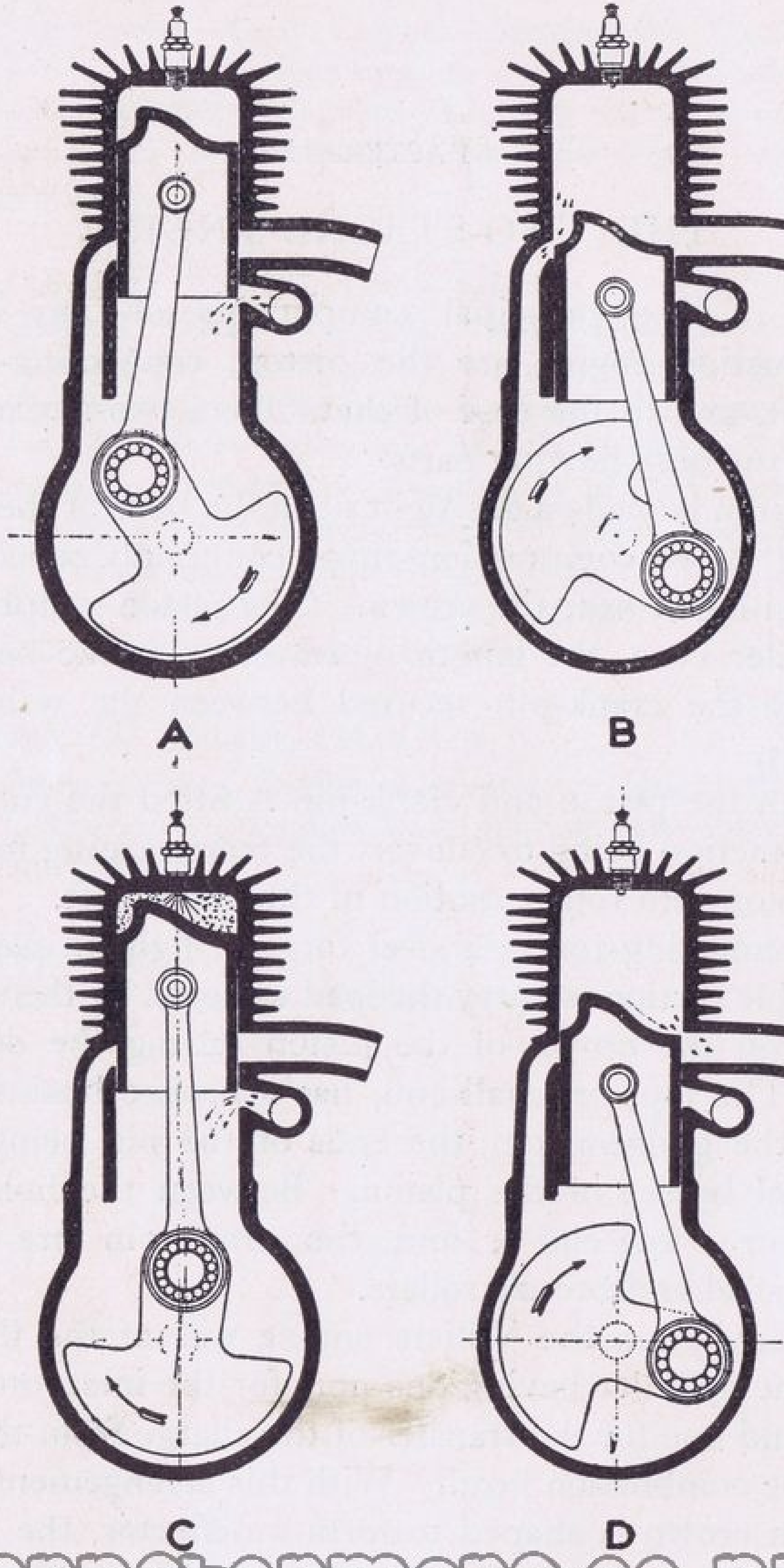


FIG. 1.—CYCLE OF OPERATIONS FOR VILLIERS THREE-PORT TWO-STROKE ENGINE.

1. On the upstroke of the piston a partial vacuum is created in the crankcase. The piston uncovers the inlet port and the mixture enters the crankcase. Meanwhile the charge is being compressed in the cylinder.

2. The compressed charge is fired and the piston descends on the power stroke, compressing the mixture in the crankcase.

3. At the bottom of the power stroke, the piston uncovers the exhaust and transfer ports; fresh mixture enters the cylinder via the transfer ports, and burned gases are expelled through the exhaust ports.

4. Start of a new cycle. The piston closes the exhaust and transfer ports and compresses the fresh mixture.

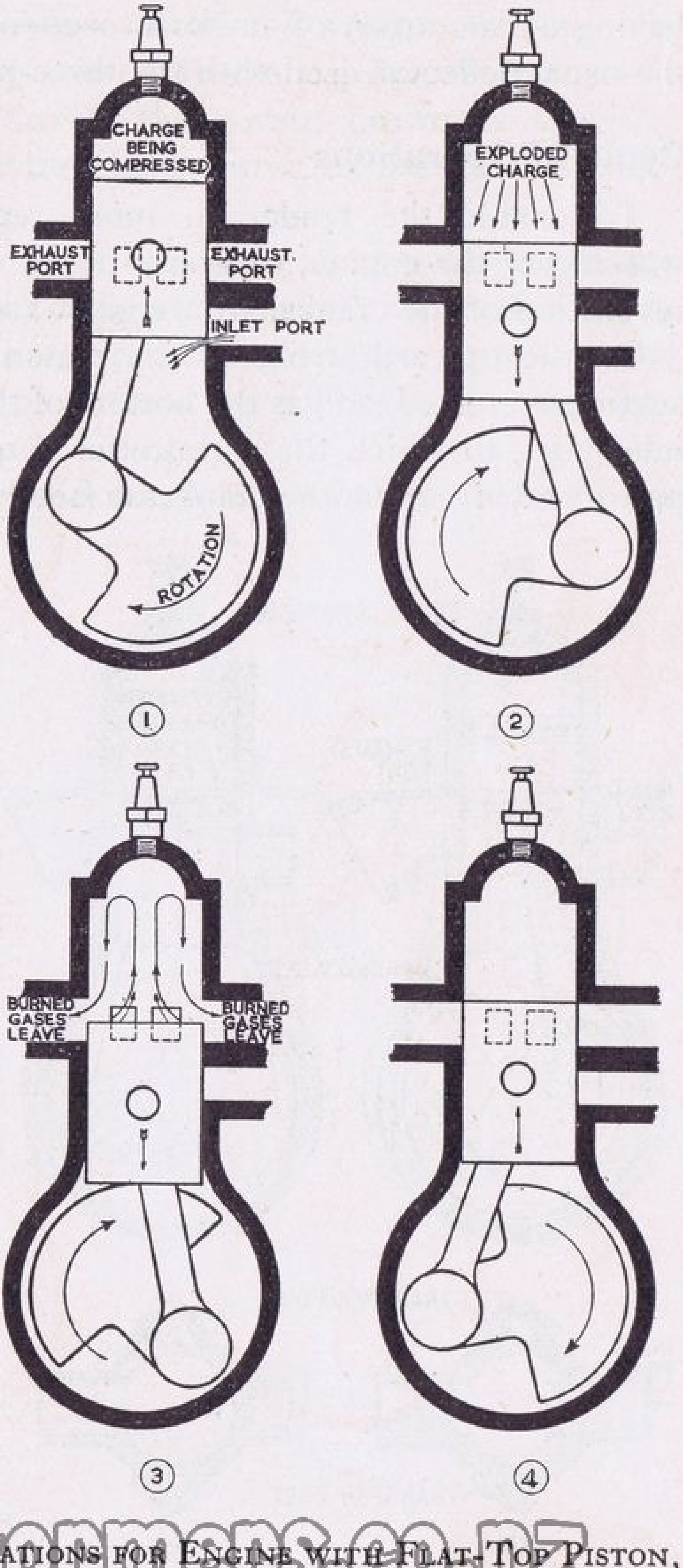


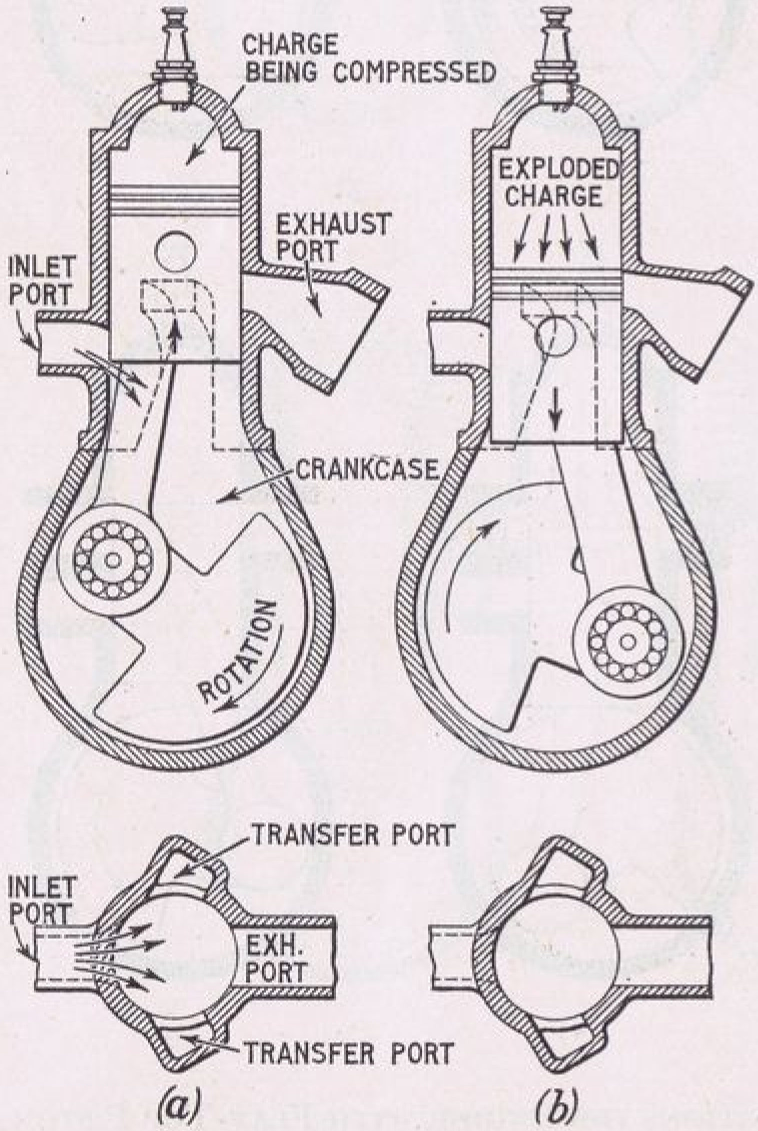
FIG. 2.—CYCLE OF OPERATIONS FOR ENGINE WITH FLAT-TOP PISTON, TWO EXHAUST PORTS AND FOUR TRANSFER PORTS.

the latter being so arranged that it is possible to use a piston having a flat crown of uniform section, thereby eliminating the usual deflector used with the three-port design.

Cycle of Operations

To enable the reader to more readily understand the working of the engine, diagrams of the various stages of each revolution of the crankshaft are given (see Fig. 1).

On the upward stroke of the piston a partial vacuum or suction is created, and as the bottom of the piston uncovers the inlet port, to which the carburetter is attached, a mixture of petrol and air enters the crankcase (see Fig. 1A).



(A) On the upstroke of the piston, a partial vacuum is created in the crankcase, and when the piston skirt uncovers the inlet port a mixture of petrol and air is drawn into the crankcase from the carburetter. Meanwhile the previous charge is being compressed at the top of the cylinder.

(B) The previous charge is fired by the sparking plug, causing the piston to descend and compress the mixture in the crankcase.

FIG. 2A.—CYCLE OF OPERATIONS, POST-WAR MOTOR-CYCLE ENGINES (FLAT-TOP PISTON).
These engines have one exhaust port and two transfer ports.

The piston, on its descent, compresses the mixture charge, and when nearing the bottom of the stroke uncovers the transfer port, allowing the charge to enter cylinder (see Fig. 1B).

In the three-port design the piston crown is specially shaped so as to deflect the charge upwards into the cylinder-head.

The next upward stroke of the piston compresses the charge in the cylinder-head, and when the piston reaches the top or end of the stroke, the compressed gases are ignited by an electric spark at the plug fitted in the cylinder-head (see Fig. 1C).

The spark is timed to occur actually before the dead-top

(C) Near the bottom of the stroke, the piston top edge uncovers the exhaust and transfer ports. The burned gases escape through the exhaust port and a fresh charge enters the cylinder through the transfer ports.

(D) The piston starts a new cycle on its upward stroke, closing the exhaust and transfer ports compressing the fresh mixture and continuing as shown in diagram (A).

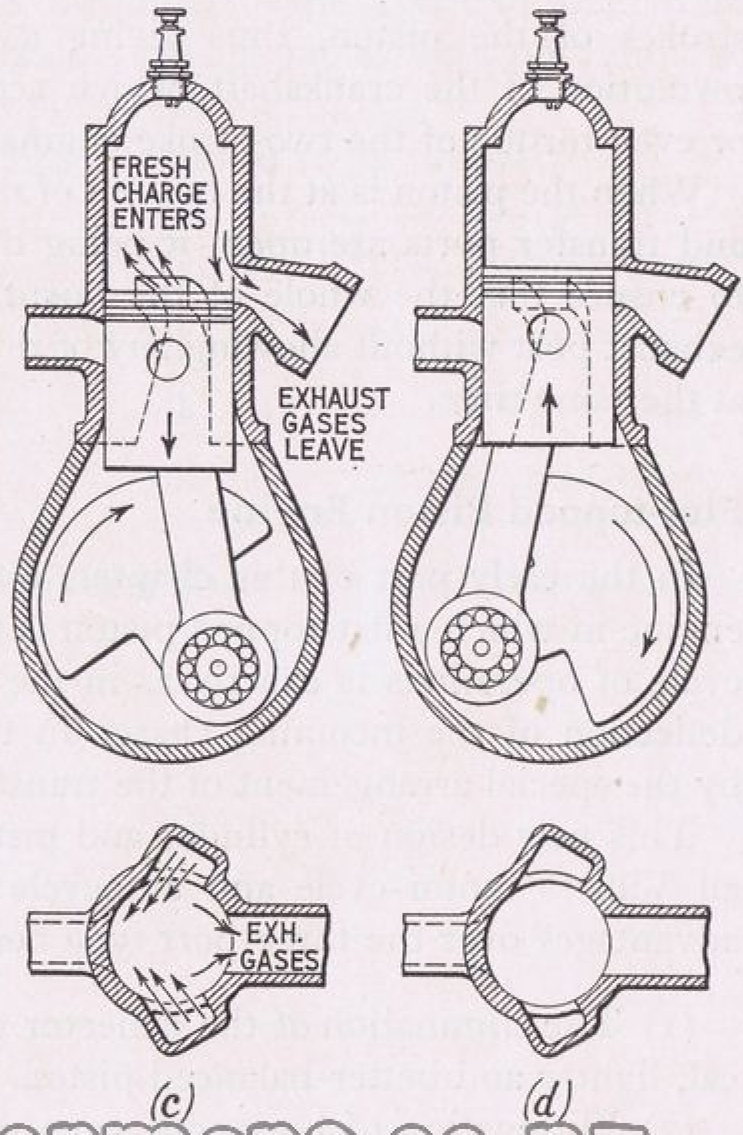


FIG. 2A (*continued*).—CYCLE OF OPERATIONS, POST-WAR MOTOR-CYCLE ENGINES (FLAT-TOP PISTON).

position of the piston, this time lag being necessary to allow the compressed charge to burn so as to give the maximum pressure when the piston has actually commenced its downward stroke. When nearing the end of the down or power stroke, the top of the piston first uncovers the exhaust port, allowing the exhaust gases to escape before the transfer port is uncovered by the opposite side of the piston (see Fig. 1D).

Whilst the piston is descending, the charge which has entered the crankcase on the previous upstroke is being compressed before entering the cylinder by way of the transfer ports.

From the above description the reader will see that the compressed charge is ignited in the cylinder-head every two strokes of the piston, thus giving a power impulse every revolution of the crankshaft, which accounts for the smooth or even torque of the two-stroke engine.

When the piston is at the bottom of the stroke, both exhaust and transfer ports are open, it being the aim of the designer to ensure that the whole of the burnt gases go through the exhaust port without allowing any of the new charge to escape at the same time.

Flat-topped Piston Engine

In the early part of this chapter, reference is made to the engine in which a flat-topped piston is used, and although the cycle of operations is exactly as in the three-port engine, the deflection of the incoming charge in the cylinder is effected by the special arrangement of the transfer passages.

This new design of cylinder and piston is now a feature of all Villiers motor-cycle and autocycle engines, some of the advantages over the three-port type being :—

(1) The elimination of the deflector gives a more symmetrical, lighter and better-balanced piston.

(2) Elimination of hot-spots, even distribution of metal in cylinder barrel and consequently less distortion, which allows a closer-fitting piston to be used.

(3) Hemispherical cylinder-head reducing the surface area and thereby increasing the thermal efficiency.

(4) Increased horse-power.

(5) Better scavenging of the exhaust gases before commencement of the compression stroke.

Fig. 2 shows the cycle of operations in a flat-topped piston engine having two exhaust ports and four transfer ports. This design of cylinder and piston is a feature of the Junior-de-Luxe autocycle engine (see Chapter VIII); Mark VIIID and Mark 9D engine-gear units (see Chapter IX); Mark XVII-A and Mark XVIII-A, 249-c.c. engines (see Chapter II).

At the end of 1948, three new motor-cycle and a new autocycle engine were introduced, the cycle of operations being as Fig. 2, the cylinders having one exhaust port and two instead of four transfer ports (see Fig. 2A).

The four engines referred to above are as follows :—

Autocycle Engine . .	Mk. 2F	98-c.c. Single-speed
Ultra Lightweight Motor-cycle Engine . .	Mk. 1F	98-c.c. Two-speed
Lightweight Motor-cycle Engine . . .	Mk. 10D	122-c.c. Three-speed
Lightweight Motor-cycle Engine . . .	Mk. 6E	196-c.c. Three-speed

Each of the above engines is dealt with in detail in separate chapters.

CHAPTER II

VILLIERS TWO-STROKE ENGINE RANGE

Before describing in detail the various types of engines made, it is advisable to mention the method of marking employed to distinguish each model. Every engine has a number with one or more prefix letters stamped on one of the top crankcase lugs immediately below the cylinder base.

Each type of engine has a different prefix letter or letters, and if these are quoted together with the engine number, the makers can identify the model and date of manufacture, and so supply the correct spares when ordered. The relevant prefix letter or letters allocated to each type of engine is given in the descriptions of engines which follow.

The Earliest Villiers Engines

The first two-stroke engine was introduced in 1913, the bore and stroke being 70 mm., giving a capacity of 269 c.c. This engine had a non-detachable cylinder-head, cast-iron deflector-type piston, fixed gudgeon-pin, and was known as the Mark I.

Ignition was by a horseshoe-pattern magneto fitted in front of the engine, and driven by chain and sprocket from the crankshaft. Lubrication was by drip feed from a combined hand pump and sight-feed lubricator fitted in the tank of the motor cycle, and which at that time was almost common practice for lubrication of motor-cycle engines. The oil entered the crankcase via one of the four crankcase bolts, in the end of which was fitted a special union.

Between 1913 and 1922 models Mark II to V were added to the range, all being similar internally to the Mark I. Later models of the Mark IV, however, were fitted with the Villiers flywheel magneto, since when no other type of magneto has been used on a Villiers two-stroke engine. A feature peculiar to the above models only are the horizontal cooling fins on both the barrel and head of the cylinder.

The engines described above are now obsolete, and spare parts are not available. Prefix letters of the Mark I to V are O, A, B, C and D respectively.

The Mark I to V engines were made for lightweight motor cycles in the days before variable-speed gearboxes incorporating a friction clutch were available, the usual drive to the rear

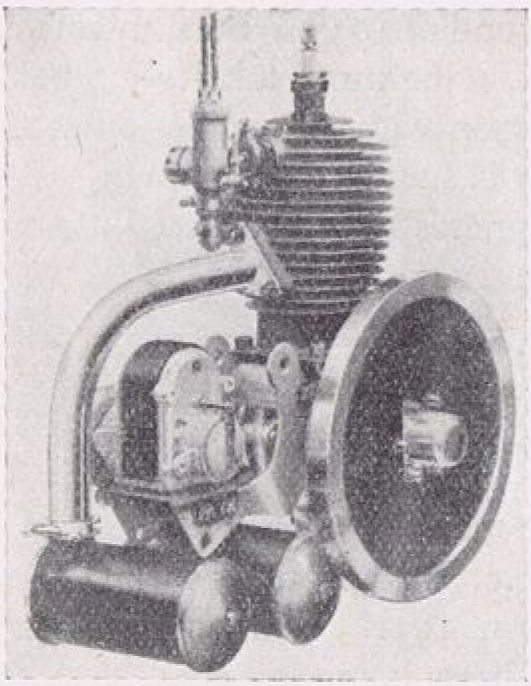


FIG. 3.—MARK IV 269-C.C. ENGINE.

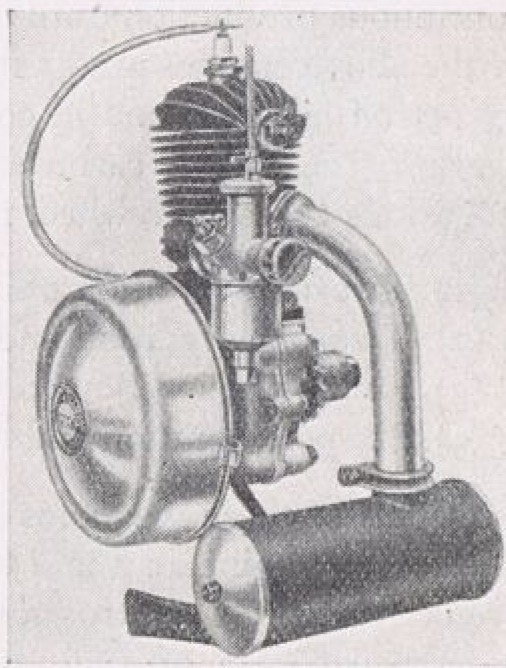


FIG. 4.—MARK VIII-C 147-C.C. ENGINE.

wheel being direct by V-belt, or by chain and belt through a plain two- or three-speed gearbox. To fill the need at that time Villiers designed and produced a multi-plate friction clutch which could be disengaged to provide a free engine; in other words, disconnect the drive from engine to rear wheel and so allow the drive to be taken up gradually from a standing position.

150-c.c. Class

The range of 147-c.c. engines was introduced in 1922, commencing with the Mark VI-C, prefix letter H, following with the Mark VII-C, prefix letter L, in 1923. Both engines have cast-iron pistons with fixed gudgeon-pins, one-piece cylinder and head with compression-release valve. The Mark VIII-C engine first produced in 1924, prefix letter W, was the first model to have a fully floating padded gudgeon-pin. Later models also had a patent inertia ring fitted to the piston, the object of this feature being the prevention of carbon formation and gumming up of the piston-rings.

This engine proved to be a very popular power unit for lightweight utility motor cycles and invalid chairs, and was in continuous production until the end of 1947. Bore and stroke of the above engines are 55 mm. × 62 mm., lubrication being by petroil mixture, and in common with all engines since the Mark V, the Villiers carburetter is standard equipment.

Various types of flywheel magnetos have been used :—

(1) Two-pole, ignition only.
(2) Two-pole, ignition and lighting.
(3) Four-pole, ignition and lighting.
(4) Six-pole, ignition and lighting.

Details of these magnetos are given in Chapter V.

Another engine in the 150-c.c. class is the Mark XII-C, prefix letters GY, introduced in 1931. This model has a bore/stroke ratio of 1·26, the bore being 53 mm. and the stroke 67 mm., giving a capacity of 148 c.c. On reference to Fig. 5 the twin exhaust ports and detachable induction manifold will be noticed, the latter feature allowing of alternative carburetter positions to suit the lay-out of individual motor-cycle manufacturers. Other features are a cast-iron deflector-type piston with floating gudgeon-pin and inertia ring, roller bearing "big-end", phosphor-bronze main bearings and lubrication by petroil mixture, special ducts being cast in the crankcase walls to convey lubrication to the bearings.

The Villiers middleweight carburetter, stub diameter $1\frac{1}{8}$ in., and having single- or double-lever control, is the standard fitting with the above model.

A similar model to the above but with a single exhaust port was first made in 1934, being known as the Mark XV-C, prefix letters CUX.

172-c.c. Class

Four models of this capacity, with a bore of 57·15 mm. and a stroke of 67 mm., have been produced :—

(1) "Sports", prefix letter T, lubrication by petroil mixture.

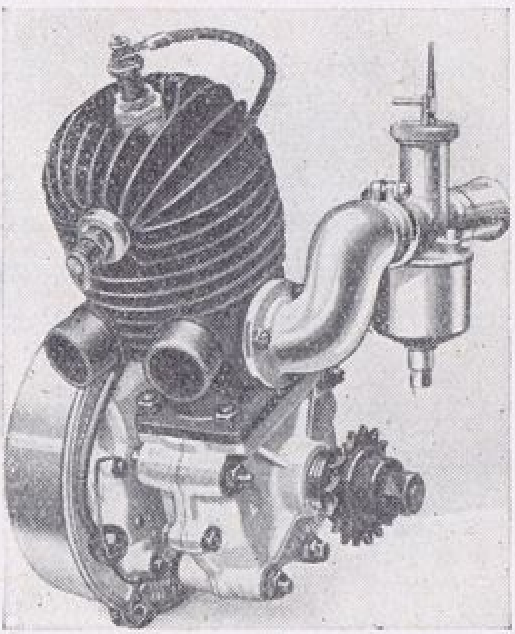


FIG. 5.—MARK XII-C 148-C.C. ENGINE.

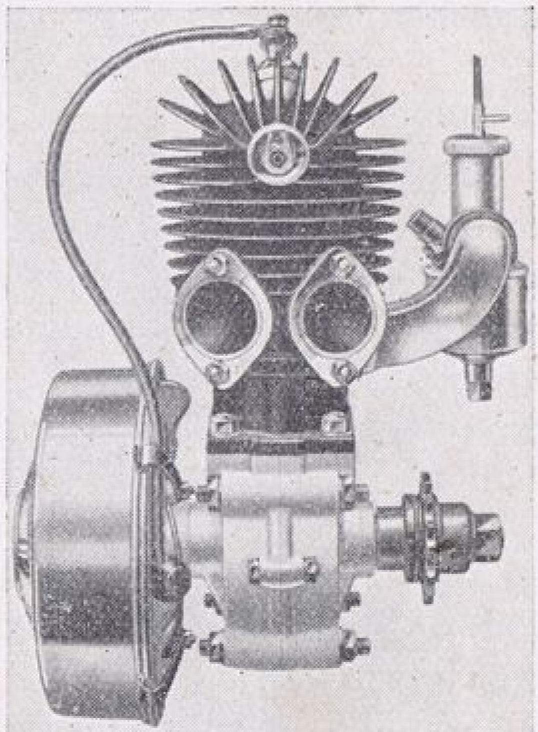


FIG. 6.—"SPORTS" 172-C.C. ENGINE.

(2) "Sports", prefix letters TL, lubrication by Villiers patent automatic system.

(3) "Super Sports T.T.", prefix letters BZ.

(4) "Brooklands", prefix letter Y.

The latter two engines have the patent automatic lubricating system as standard.

The "Sports" engines have one-piece cylinders, cast-iron deflector pistons, twin exhaust ports, detachable inlet manifold, and, except for the method of lubrication, are identical.

The "Super Sports T.T." engine has a detachable cylinder-head, aluminium piston, the magneto giving variable ignition, and a middleweight-pattern carburetter with two-lever control.

The "Brooklands" model was made specifically for racing events, the number produced being comparatively small. The cylinder barrel has a shrunk-on heavily finned aluminium jacket, high-compression cylinder-head, padded crankshafts and large-bore carburetter, the power output being 8·25 b.h.p. at 4900 r.p.m.

The above engines are now obsolete, and spares are not available.

200-c.c. Class

The Villiers engine has always been popular on the Continent, and in Germany before the war motor cycles with engines of less than 200 c.c. were tax free. To meet this demand the Mark 1E model was introduced. This engine has a bore and stroke of 61 mm. × 67 mm., the capacity being 196 c.c., and except for the bore is very similar in construction to the "Sports" model.

Two models were made: (1) for petroil lubrication, and (2) with automatic lubricating system, the prefix letters for both engines being 1E. These engines were in production from 1928 to 1938.

A similar engine but having one exhaust port and suitable for petroil lubrication only, known as the Mark 2E, was introduced in 1930, the prefix letters being XZ. This engine in common with the Mark 1E had a cast-iron piston fitted with the inertia ring, detachable inlet manifold and variable ignition.

A "Super Sports" edition of the 196-c.c. engine was introduced in 1929 (see Fig. 7). The bore and stroke are the same as the Mark 1E and 2E engines, but being designed to give a higher performance, the specification includes a deeply finned cylinder with large twin exhaust ports, detachable alloy head and aluminium piston with inertia ring, lubrication being the Villiers automatic system. The Villiers magneto giving variable ignition timing and the middleweight carburetter are standard equipment. Prefix letters KZ and KZS.

An entirely new 196-c.c. engine–gear unit was introduced in 1938. This model, the Mark 3E, prefix letters VV, had a bore and stroke of 59 mm. × 72 mm., flat-topped piston and cylinder having four transfer ports. The engine was built in unit with a three-speed gearbox having constant-mesh gears, single-plate cork-insert clutch driven by an endless roller chain enclosed in an oil-bath chaincase, the gear control lever being mounted directly on the gearbox. A six-pole ignition and lighting magneto was standard equipment.

At the end of 1948 the Mark 6E engine-gear unit (196-c.c.) was introduced. See Chapter XIII for details.

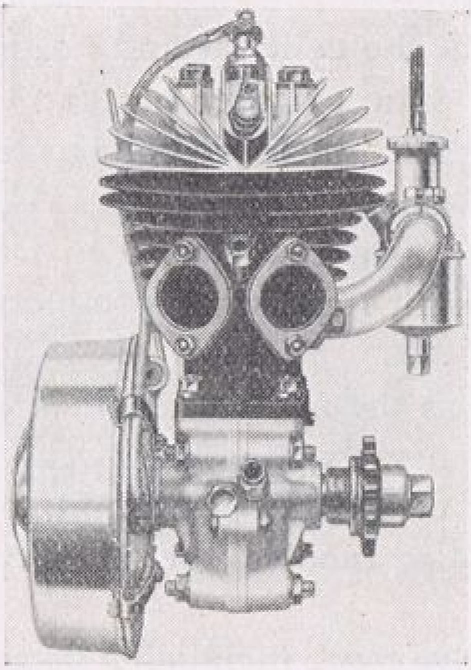


FIG. 7.—" SUPER SPORTS " 196-C.C. ENGINE.

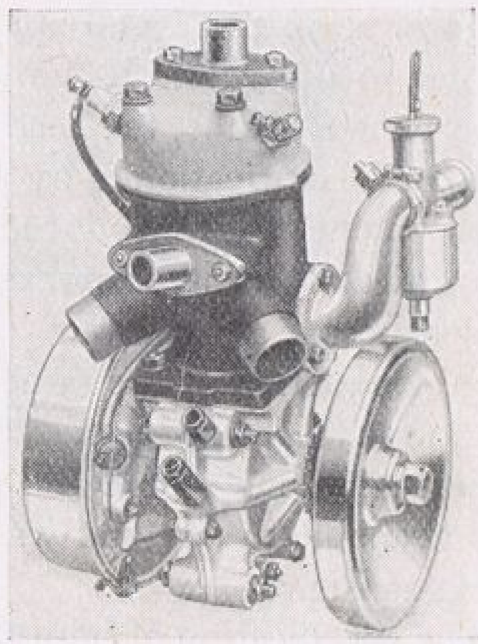


FIG. 8. — MARK XIV - A 249-C.C. WATER-COOLED.

250-c.c. Class

The Mark VI-A model, the first of the 247-c.c. range, was produced in 1922, being followed by the Mark VII-A in 1924, prefix letters being J and S respectively.

These engines were similar in construction, having cast-iron piston, fixed cylinder-head, with carburetter in front, single exhaust port and lubrication by petroil mixture.

The Mark VIII-A engine was of similar internal construction, except that the piston having a window-type transfer port was fitted. The cylinder had twin exhaust ports and detachable inlet manifold, the year of introduction being 1925, prefix letter X.

The next engines of this range, the Mark IX-A and X-A models, were first made in 1926 and 1929 respectively, and had aluminium pistons and detachable cylinder-heads, with automatic lubrication. A feature of these engines is the auxiliary flywheel on the driving side, which, with the even torque of the two-stroke engine, gives extremely smooth running, particularly at low road speeds. These two models are identified by prefix letters DZ and JZ.

The last of the 247-c.c. range is the Mark XVI-A model; this engine has the same bore and stroke as the others, namely, 67 mm. × 70 mm., and apart from the cylinder and head, is similar to the Mark X-A model. The cylinder has two circular exhaust stubs, the head being fixed by three bolts instead of four. Lubrication is by petroil only. Prefix letters AXF. This engine was introduced in 1934 and was used in large quantities for utility motor cycles until 1940, when production ceased because of the war.

In production at the same time as the 247-c.c. engines was the long-stroke model of 249 c.c., namely, the Mark XIV-A. This engine had a bore and stroke of 63 mm. × 80 mm., and was available in air- and water-cooled models, the latter type being as Fig. 8.

The specification of both the above types included a detachable cylinder-head, aluminium deflector piston with the patent inertia ring, long plain bearings to crankshaft, lubrication being by petroil or automatic system as required. The Villiers middleweight carburetter with separate controls to throttle and taper needle was standard, and either fixed or variable ignition was optional.

Although capable of 60 m.p.h., these engines were well known for their pulling powers at low engine speeds.

Mark XIV-A engines were first made in 1932, and were in continuous production until the early part of the war. Prefix letters BYP (air-cooled, petroil lubrication), BY (air-cooled, automatic system), and RY (water-cooled, automatic system).

The Mark XVII-A engine with a flat-topped piston and capacity of 249 c.c., bore and stroke as the Mark XIV-A, was introduced in 1934. The crankshaft is carried in single-row ball-journal bearings, crankcase compression being retained by bronze bushes bored to a very close clearance on the shafts. The advantages of this design over the three-port type of engine have already been enumerated in Chapter I, and, because of the all-round improvements obtained, all motor-

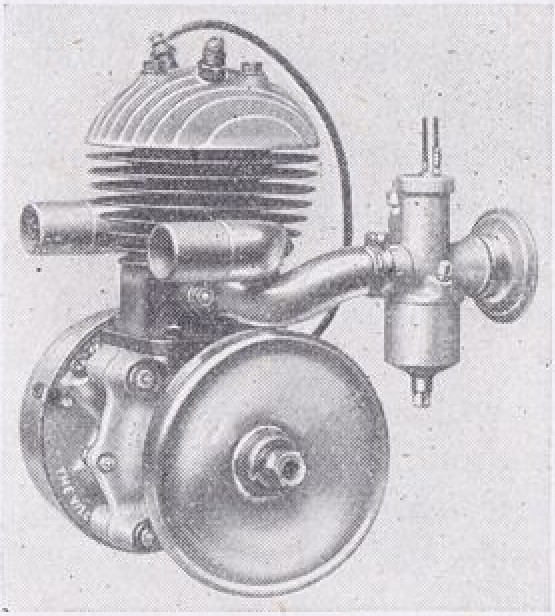


FIG. 9.—MARK XVII-A 249-C.C. ENGINE.

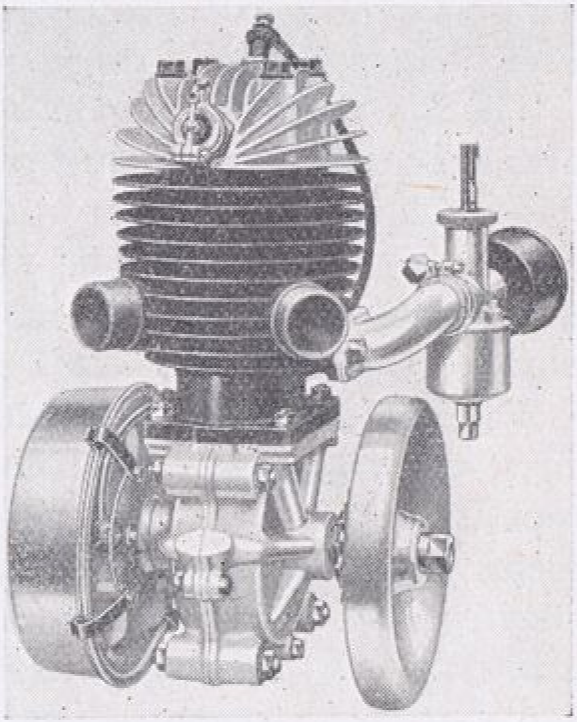


FIG. 10.—MARK XIV-B 346-C.C. ENGINE.

cycle engines introduced since 1934 have had a flat-topped piston and cylinder with four transfer ports.

The Mark XVII-A engine, prefix letters BYX (Fig. 9), was followed by the Mark XVIII-A model having the same cylinder and piston, but a modified crankshaft assembly. Double-row ball-journal bearings carry the driving shafts, the crankcase compression being retained by spring-loaded gland bushes. Lubrication of both engines is by petroil mixture.

The Mark XVIII-A model, prefix letters UU, is the last of the 250-c.c. class to be made for motor cycles.

350-c.c. Class

Between 1922 and 1928 five models, commencing with the Mark VI-B, having a capacity of 342 c.c. were produced, all engines having a bore and stroke of 79 mm. × 70 mm. respectively. The models Mark VI-B and VII-B were similar in construction to the 247-c.c. engines Mark VI-A and VII-A, having fixed cylinder-heads with single exhaust port, carburetter being in front, cast-iron pistons, fixed gudgeon-pin and plain crankshaft bearings, lubrication being by drip feed. Prefix letters K and M respectively.

The Mark VIII-B, IX-B, X-B models had detachable alloy cylinder-heads, twin exhaust ports and detachable inlet manifolds, aluminium pistons with floating gudgeon-pins and inertia ring, and plain driving-shaft bearings, specially grooved to suit automatic lubrication, prefix letters of these three models being AZ, CZ and HZ respectively.

The long-stroke model, the Mark XIV-B, was introduced in 1931, the bore and stroke being 70 mm. × 90 mm., giving a capacity of 346 c.c. This engine embodied all the improvements up to that time, the specification including a detachable alloy cylinder-head, aluminium piston with inertia ring, twin exhaust ports, detachable inlet manifold, auxiliary flywheel and four-pole magneto. The standard model was made for the automatic lubrication system (prefix letters YZ), but an alternative model for petroil lubrication was available (prefix letters YZP).

100-c.c. Class

During the year 1931 several British motor-cycle manufacturers introduced an ultra-lightweight machine powered by a Villiers 98-c.c. two-stroke engine, which was known as the Midget Model. Although of the three-port design, the arrangement of the ports was different from any other Villiers engine. The transfer and exhaust ports were placed on the side of the cylinder in line with the crankshaft and, therefore, the piston deflector was at right angles to the gudgeon-pin.

To prevent the gudgeon-pin entering the transfer port, a retaining disc was fitted in one of the piston bosses. The cylinder with integral exhaust and inlet stubs was inclined forward and had a fixed cylinder-head. This engine has a cast-iron piston with inertia ring, roller-bearing big-end, and crank-pin having parallel ends which are a forced fit in the crankshaft webs instead of the usual taper and lock-nut. The stroke and bore is 50 mm.; lubrication by petroil; prefix letters CY.

Included in the 100-c.c. class are the Junior, Junior-de-Luxe and Mark 2F autocycle engines, and the Mark 1F engine-gear unit. These models are dealt with separately in later chapters.

CHAPTER III

OVERHAULING AND SERVICING OLDER TYPE OF ENGINES

ALTHOUGH practically all Villiers motor-cycle engines now being produced have flat-topped pistons and ball-bearing crankshafts, and are dealt with in detail in later chapters, instructions for overhauling and servicing the older type of engines are given in this chapter. The construction of the two-stroke engine when compared with a four-stroke type appears so simple that one wonders where the power comes from, but to maintain satisfactory running it is necessary to give careful attention to every detail when overhauling.

Tools Required

Apart from the dismantling of the crankshaft assembly, the work can be done with the aid of tools usually found in the kit of the keen motor cyclist: these should include a hammer, a long screwdriver, tubular box and open-ended spanners, and a good-quality adjustable spanner. In addition to the latter, it will be found advantageous to have a Villiers hammer-tight spanner for the removal of the magneto flywheel, and also the sparking-plug spanner specially shaped to go between the cylinder-head fins. A good bench vice will also prove useful when major overhauls are being done and the engine is removed from the frame.

Before commencing even a minor overhaul it is advisable to remove all external dirt from the engine. A dirty engine means dirty hands, and adjustments or removal of parts cannot be properly done when the hands are covered with oil and road dirt. Paraffin and a stiff brush will usually remove all surface dirt, but before starting work place a large tray or pan underneath the crankcase. As the components are removed they should be placed in a large tin or old saucepan containing clean paraffin, in which the parts can be left until given attention.

Cylinder Removal

Assuming the engine is to be completely decarbonised, it is, of course, necessary to remove the cylinder, but before this can be done, components such as carburetter and exhaust pipes have to be removed, and where a detachable head is fitted this can better be removed before releasing the four nuts securing the cylinder to crankcase. Before releasing the head-fixing bolts, take out the sparking-plug and release-valve unit where fitted.

There is no gasket or washer between the cylinder and head, the joint being metal to metal, and after removing the fixing bolts the head should lift away.

When removing the petrol and oil pipes it is advisable to use two small spanners, one on the tap or union, the other to release the union nut so as to avoid twisting of the soldered joint of the pipe.

Having removed the carburetter and exhaust pipe, the nuts securing the cylinder base can be unscrewed, but before attempting to lift cylinder, turn crankshaft until piston is at bottom of the stroke. Now lift cylinder free of piston with one hand, taking care not to turn the cylinder whilst being removed, otherwise the ends of the piston-rings may foul one of the ports, and, with the free hand, prevent the piston falling sharply against the connecting-rod or crankcase top. If it is not intended to dismantle the crankcase place a clean rag around the connecting-rod, so covering the opening in the top of crankcase. This precaution is necessary to prevent entry of dirt and carbon, which is difficult to remove unless the crankcase halves are separated.

Removing the Piston

Early models, including the Marks VI-C, VII-C, VI-B and VII-B, have a fixed gudgeon-pin which is prevented from turning by a split pin at either end and located in a slot cut across the gudgeon-pin hole in the piston. The hole is made slightly taper, the large end being marked "IN" and the opposite side or small end "OUT".

To remove the gudgeon-pin first pull out the split pin on the outside, using a pair of pliers, then remove any formation of carbon on the gudgeon-pin between the connecting-rod small-end bush and bosses of piston. Place one end of a round piece of brass or copper a little smaller in diameter than the hole in piston against the end of gudgeon-pin, and tap with a light hammer until the pin is free, at the same time supporting the piston in one hand. Replace the gudgeon-pin in the same manner, but entering the pin on the opposite side of piston from which it was driven out, refit split pin and open out the ends, making sure that no part of the split pin stands above the surface of the piston.

In later models, a floating gudgeon-pin is fitted; this can rotate in the piston bosses as well as in the small-end bush in the connecting-rod. Aluminium pads are fitted in the ends to prevent damage to the cylinder walls. When cold, this type of pin may be found to be a push fit in the piston, the necessary clearance between pin and piston to allow for floating being given by the expansion of piston bosses caused by the heat when the engine is running.

All engines having flat-topped pistons have parallel gudgeon-pins secured endways by circlips, the actual "float" being reduced to the minimum, because excessive movement will cause hammering of the pin against the circlip.

Always use new circlips, if possible, when refitting gudgeon-pins secured by circlips. Never fit a damaged circlip.

Removal of Piston-rings

Piston-rings, being made of cast iron, are very brittle and, therefore, must be handled very carefully to avoid breakage. Providing the rings are free in their grooves they can best be removed by using three or four thin, flat strips of brass as indicated in Fig. 11, a soft metal being desirable to avoid cutting the piston, especially when this happens to be made in an aluminium alloy. The method employed to position the strips is as follows: Lift one end of each ring sufficiently to allow of insertion of the first strip between inside of rings and outside of piston; then having worked this strip about half-way round the piston, insert the next strip. When all the strips have been placed in position it will be found that rings are free from their grooves, and that they can be withdrawn, the top ring, of course, being removed first.

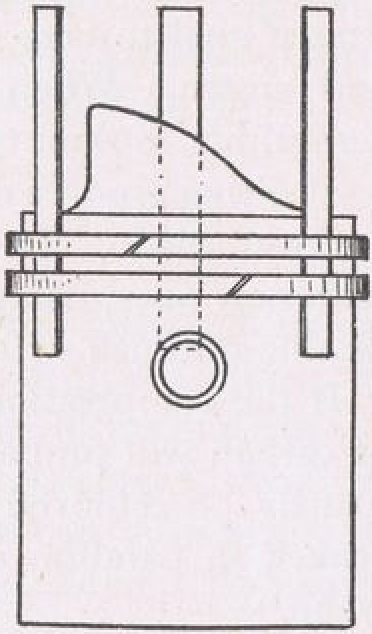


Fig. 11.—Method of Removing Piston-Rings.

If the rings are found to be in a good condition, it is advisable to remove them, if only to clean away the carbon which usually forms on the bottom and sides of the grooves. Should the rings be stuck in the grooves it will be necessary to fit new ones and to thoroughly clean the grooves beforehand.

Earlier, mention has been made of the patent inertia ring fitted to some pistons. The object of this special ring is to prevent the formation of carbon, and consequent gumming up of the top piston-ring. The inertia ring is fitted between the piston-ring and top land, being allowed very little up and down movement but being free to rotate in the groove. This movement, which is continuous whilst the engine is running, prevents the accumulation of oil on the faces of the compression ring and consequent formation of carbon. The ends of the inertia ring are made to butt, thus leaving a space between inside of ring and bottom of groove, whilst the section of the inertia ring is such that the outer surface cannot touch the cylinder bore. Do not remove the inertia ring unless, through loss of temper or spring, the ends have become separated.

Cleaning the Piston

Removal of carbon, inside and outside, is made much easier if the piston has been immersed in paraffin for several hours previously.

Having removed the compression rings, commence operations on the inside of the piston, using a blunt screwdriver or similar tool to chip out the carbon from inside the deflector and crown. When dealing with an aluminium piston be careful not to remove the metal also.

The ring grooves can be cleaned by using the end of a broken hacksaw blade. If the ring-locating pegs are worn, replace with new ones, using a piece of screwed brass rod, afterwards cutting off flush with the outside of the piston land.

If the compression rings have not been gas-tight a deposit of carbon will probably be found on the piston skirt; this can usually be removed by rubbing with a rag which has been soaked in paraffin, or, in obstinate cases, by a piece of hard wood.

It is very important that no metal is removed, particularly in the case of an aluminium piston, as any increase in the clearance between piston and the cylinder bore will cause rattle.

The piston deflector should be polished with very fine emery cloth dipped in paraffin and, finally, the piston should be thoroughly brushed in petrol to remove any traces of emery and carbon. Stand to drain and dry out before refitting rings, and cover with a clean cloth.

Replacing Piston-rings

Compression rings must be gas-tight, and if the old rings are not bright all round, or are worn on the sides, they should be replaced with new ones. When fitting new rings it is very important to check the gap between ends when in the cylinder. In pistons not having the inertia ring, the rings are prevented from turning by a round, screwed peg $\frac{1}{8}$ in. diameter, and in such cases the gap between the ring ends must not exceed

0·008 in. (8 thous). Where the inertia ring is fitted the rings are located by a form of Woodruff key pressed into and across the grooves and, therefore, an allowance has to be made for the width of the key. The correct gap for the rings is 0·045–0·05 in. (45–50 thous).

To check the gap, insert the new ring into the cylinder bore, using the end of the piston-skirt to ensure the ring being square in the cylinder ; the gap can then be checked by feeler gauge. Any used ring having a gap exceeding the above figures should be scrapped.

Dealing with the Cylinder and Head

It is assumed that where detachable, the head has already been removed and placed in a paraffin bath in order to soften and loosen the carbon deposit, both on the inside and outside. Quite a lot of the dirt and carbon can be removed from the outside of cylinder and head by using a wire brush and the tang end of a file, and that on the inside of the head by using a scraper. The surface of the combustion space should be as smooth as possible, but care must be taken not to alter the shape or to increase the volume.

Carbon should also be removed from the sparking-plug and release-valve threads, otherwise when fitting a new sparking-plug having a slightly longer body it will be impossible to screw down to the copper and asbestos joint washer. To clean the thread use an 18-mm. tap, or if one is not available, a useful makeshift can be made by using an old long-reach sparking-plug body on which grooves have been filed across the threads so as to form cutting faces.

The seating for the compression-release-valve body should be examined, and if the copper joint ring is still in position, remove and replace with a new one. Care must be taken whilst working on the head not to damage the joint face, otherwise a gas-tight joint will not be obtainable between the head and the top of the cylinder.

Where the cylinder and head is one casting, the inside carbon can be removed by chipping, using a long, blunt screwdriver, which, however, must not be allowed to scrape the walls of the cylinder. All traces of carbon must be removed, the surface of the combustion space being afterwards polished by a piece of emery cloth secured to the end of a piece of wood, the handle end of a broomstick being very suitable.

To remove carbon from the various ports it will be necessary to use bent scrapers, but it is important that no metal is removed, and that the corners are not bevelled. If the corners are bevelled the port timing will be altered, and there is the possibility of the piston-rings fouling when passing the ports.

Before giving the cylinder a final wash in clean paraffin, remove all traces of cylinder-base and inlet-manifold joint washers, and afterwards hang up to dry. The appearance of the cylinder can be improved by a coat of one of the black paints specially made for the purpose.

Cylinder Reboring

After a considerable mileage the bore of the cylinder will have increased in diameter, the amount being greater approximately half-way down, this being due to the thrust of the connecting-rod, which is greatest at this position of the piston stroke.

It is no use fitting new piston-rings of the standard size in a badly worn cylinder, and when the bore is found to exceed the original diameter by 0·008 in. (8 thous), the cylinder should be returned to the makers for reboring, the increase from the original size being 0·015 in. (15 thous) or 0·03 in. (30 thous), whichever is found necessary.

Oversize pistons and rings to these sizes are kept in stock for most of the older-type engines, and when a rebored cylinder and new piston have been fitted, it will be necessary to carefully run in for approximately 500 miles, as in the case of a new engine.

Compression-release Valve

Although only used generally when starting the engine, the head of the valve will in time become slightly distorted and, therefore, to retain compression, it is necessary from time to time to renew the valve seat by grinding. In addition, the valve body must be a gas-tight fit in the cylinder-head, and must seat against the copper joint washer which fits over the screwed end against the shoulder of the body.

Assuming that the complete valve has been removed from the cylinder-head, the hexagon portion of body should be held in a vice, and then holding the special nut next to the spring with a pair of pliers the valve can be unscrewed, using a screwdriver in the slot in head. Remove any carbon from the valve stem, and using a fine grinding paste between valve and seat, grind in the valve, employing a screwdriver to rotate the valve stem. Having thoroughly cleaned the parts in paraffin, place valve in body, fit a new spring, and screw on the special end-nut until really tight. In later models the valve stem has a groove into which the cable-clamp screw enters, so that should the end-nut become unscrewed the valve cannot drop into the cylinder. When replacing the control-cable clamp and screw a little free movement must be allowed in the outer cable to ensure that the valve returns to its seating. When refitting the valve unit in cylinder-head, it is advisable to use a new copper joint washer.

Engine Bearings

The engines dealt with in this chapter all have plain phosphor-bronze bearings for the crankshaft, and roller bearings for the crank-pin, and an examination for possible wear should be made whilst overhauling. The bearings in the crankcase carry the crankshaft, and also act as a seal, preventing the ingress of air into the crankcase on the suction or upstroke of piston, and the loss of compression on the down-stroke. The clearance between the bearing-bush and the crankshaft has, therefore, to be as little as possible, allowing, of course, sufficient clearance for the lubrication of the shaft.

To make the examination the crankcase with crankshaft assembly must be removed from the frame of the motor cycle, and then held in a vice by one of the four main fixing lugs.

First test for amount of end-play between crankshaft webs and faces of bearing flanges by pushing the crankshaft over as far as possible and measuring by feeler gauge the gap between web and bearing flange. This gap or clearance should not exceed 0·012 in. (12 thous), with one 6-thou joint washer between the crankcase halves.

When the engine is originally assembled the total end-play or clearance is approximately 0·007 in. (7 thous). To ensure this amount of end-play alternative joint washers are available, these being 0·006 in. and 0·01 in. thick. Should the play in a worn engine be found to be excessive this can sometimes be reduced by fitting the thinner joint washer. The maximum up and down play or clearance between shaft and bush in a new engine is between 0·004 in. and 0·005 in. with driving-shafts, of course, running dead true; if the clearance is found to exceed 0·007 in., new bushes should be fitted.

To fit new driving-shaft bushes the crankcase halves must be separated. Care must be taken when pressing out the old bush, otherwise the crankcase wall will be distorted. The crankcase should be supported not on the joint face but on a bush or sleeve having a hole large enough to fit over the flange of the bush, and long enough to allow the bush to be pushed out free of the crankcase.

Before fitting a new bush clean out all oil ducts, grooves, etc., and remove any carbon from the crankcase wall. A number of bushes fitted to early types of engines had a flat on the flange which located against a step or shoulder machined on the inside boss of the crankcase, but when replacing bushes having the full flange, care must be taken to ensure that the new bush is fitted with the oil groove in the correct position. The fitting of new bushes is best carried out by the engine makers, who have the necessary equipment and tools for finishing the bore to the correct diameter.

Connecting-rod Bearings

The connecting-rod is made from a steel stamping, the big-end being hardened and ground to a very close tolerance, whilst the small-end is fitted with a renewable bronze bush. When new, the components making up the big-end bearing are selectively assembled to give a total up-and-down clearance of 0·0015 in. (1½ thou) and a side clearance or end-play between connecting-rod and crank-webs of 0·007 in. (7 thous). Providing the necessary attention is given to the mixing of the petroil mixture, replacements of the bearing components should not be necessary until after completing approximately 15,000 miles. Unless the owner has the facilities for trueing up the crankshafts after replacements have been fitted, it is advisable to return the crankshaft assembly to the makers. When checking for up-and-down play, grip the connecting-rod firmly by the hand and attempt to lift vertically. It will be found that the con-rod can be moved sideways slightly, but do not confuse this movement with up-and-down play.

The small-end of the connecting-rod is fitted with a renewable bush. If the clearance between the bush and gudgeon-pin is found to be excessive a new bush and pin should be fitted. When removing the old bush no strain must be taken by the connecting-rod which would cause it to bend. The bush is best removed by using a mandrel hand press, the shafts being removed from the crankcase, but by using two special bushes and a draw-bolt the job can be done with the crankshaft *in situ*. To do this proceed as follows :—

Make a bush similar to the one to be removed, but having an outside diameter 0·03 in. smaller. Then make a bush having a hole 0·03 in. larger than the outside diameter of the bush to be removed. Place these special bushes one at either side of the fixed bush, and through the centre of the three bushes fit a screwed bolt with nut and washer. Tightening up the nut will cause the small bush to push out the centre one into the hole of the other outer bush. The new small-end bush can then be fitted in a similar manner, and after drilling the oil hole the bore should be line-reamered to the original size. It is most essential that the crank-pin and gudgeon-pin are parallel and in line with one another, and as the makers have the necessary equipment for checking and correcting any errors, the work of re-bushing and fitting of new big-end parts should be entrusted to them.

CHAPTER IV

LUBRICATION SYSTEMS

THE life and service given by an engine depend to a great extent on the attention given to lubrication, particularly during the first 500 miles, whether this is by: (1) drip feed, (2) Villiers automatic system or (3) petroil mixture.

Although all engines now being made are lubricated by petroil, there are a considerable number still in service using the other systems mentioned, and therefore the earlier methods of lubrication are also described in the following pages.

Drip-feed System

Early pattern Villiers engines were lubricated by the semi-automatic drip-feed system. In the front end of the petrol tank is built an oil compartment in which is fitted a hand pump. Attached to the outlet end of the pump is a chamber into which the oil is forced by the plunger or piston of the pump. The flow of oil into the chamber is regulated by the rider to suit the varying conditions, the head of the regulating screw having a graduated dial to enable quick settings to be made. In the top of the chamber, and making an air-tight seal, is a glass disc or window through which the oil can be seen. The plunger of the pump is returned by a spring, and when the pump barrel has emptied, the plunger has again to be depressed. In the outlet from the chamber is fitted a non-return valve to prevent air pressure from the engine crankcase blowing the oil back again. This system was fairly successful for the comparatively slow-running engines of the early days, but was dependent too much upon the human element.

Villiers Automatic System

The Villiers automatic system was used in order to overcome the disadvantages of the mechanical oil-pump and the hand-operated drip-feed system. A mechanical pump delivers oil only in proportion to the engine speed, and a hand pump depends entirely upon the human element, whereas actually oil should be fed to an engine in proportion to its load, and be entirely independent of human forgetfulness. In the Villiers automatic system, variations in the crankcase pressure are utilised to supply oil direct to each bearing. As the pressure in the crankcase varies according to the throttle opening, it will be realised that the more the throttle is opened, and consequently the heavier the load on the engine, the greater is the oil supply. Reference to Fig. 12, together with the following description, makes the oil circulation of this system quite clear.

Compressed air from the crankcase passes along the centre of the shafts to the holes J, which register with grooves in the crankcase bushes when the piston is descending. The air passes on through holes drilled in the crankcase to a union situated in front of the crankcase. From this point it is conveyed through the pressure pipe A to the top of the oil tank, raising the pressure in this, and forcing oil up the pipe B in the same way as soda-water is forced up the centre tube of a soda-syphon. The oil passes the regulating screw F, and issues into the cup of the sight feed, except in the Mark III lubricator, where it passes straight to the engine. From this the oil descends to the engine through a union D on the front of the cylinder, except in certain models where it passes straight to the crankcase. Here the oil divides, part of it being sucked through a hole in the cylinder wall uncovered by the piston, and the rest passing down to the crankcase, where it is again divided between the two main bearings. Grooves in these register with ports K in the crankshaft when the piston is ascending, and the surplus oil is sucked through the drilled oil-way E to the big-end.

When the engine stops, the pressure in the tank is released via the main bearings of the engine, but oil would continue to syphon out of the tank into the engine if provision were not made for this. The vent hole C prevents this, as, by per-

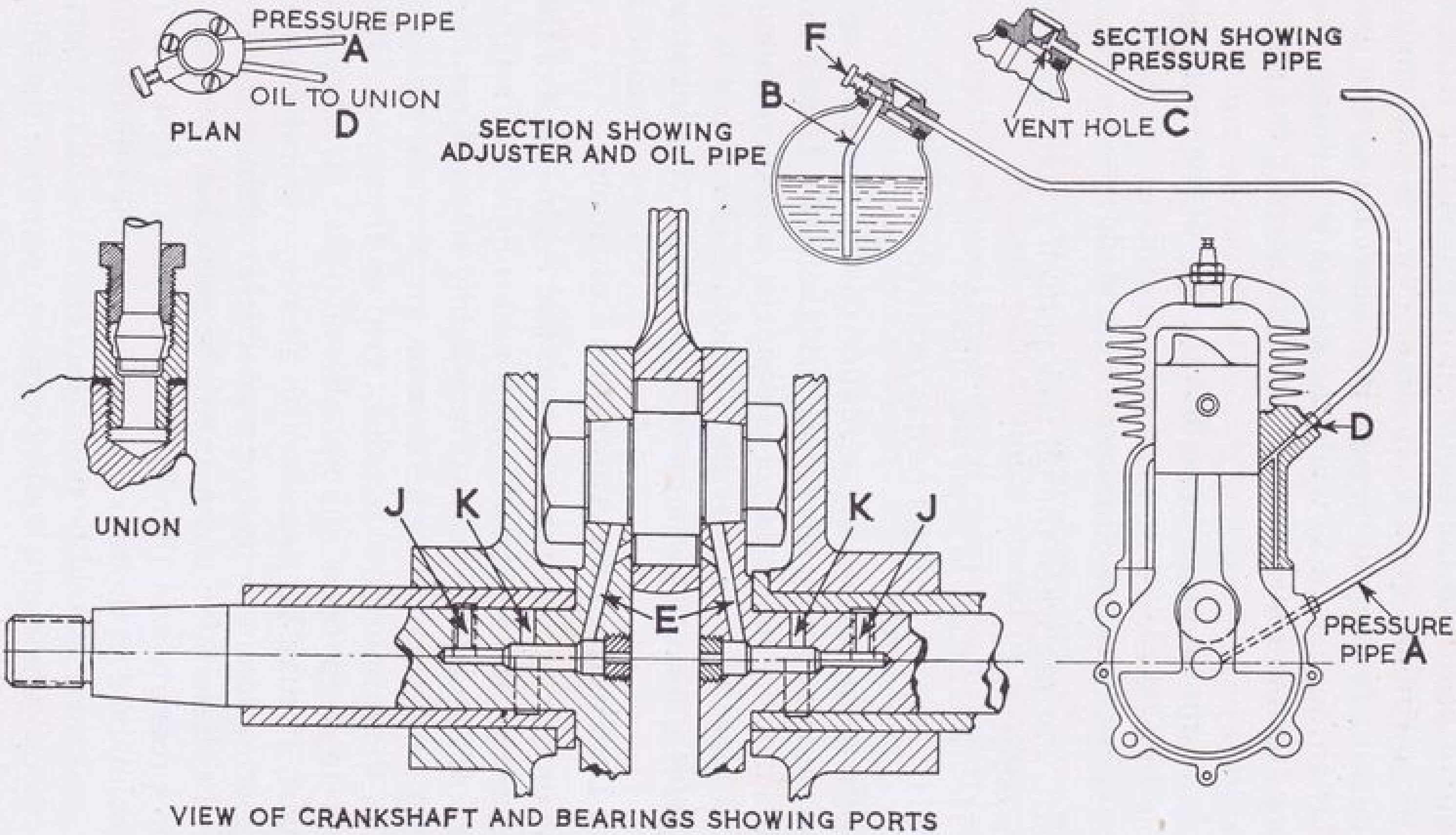


FIG. 12.—VILLIERS AUTOMATIC LUBRICATING SYSTEM.
It is important that all union nuts are screwed up tightly so as to ensure that nipples on tubes make oil- and pressure-tight joints. Copper pipe to project through nipple.

mitting air to pass into the sight-feed cup from the tank, it enables the oil in the pipe D to drain down to the engine without sucking further oil up pipe B. There is a continuous flow of air through vent C while the engine is running, and this passes down to the engine with the oil, keeping the sight-feed cup clear.

It is of the utmost importance that the size of the vent hole should not be altered.

Three types of Villiers lubricators were made :—

Mark I. For use when the oil tank is itself a compartment of the main fuel tank.
Mark II. For fitting in separate oil tank.
Mark III. Where no sight feed is required.

The differences are merely a matter of arrangement, and the principle is precisely the same. In the Mark II and III lubricators the vent hole is larger in diameter, and there should be a small piece of wire loose in this hole. The object is to keep the hole quite clear and prevent an oil film choking it.

Running Instructions for Automatic Lubricator

All the unions, both at the lubricator and engine ends of the oil-pipes, are of the solderless type; each nipple has a taper at either end, and there is a corresponding internal cone on the unions and nuts. When the nuts are screwed up they squeeze in the nipples, making them grip on the pipes. It is important to keep these unions always tight. If they are taken apart, it may be necessary to fit new conical nipples when replacing to ensure getting a good joint again.

From the description above it will be seen that the system works on pressure, and therefore it is important that this is always maintained in the tank; consequently, the unions must be tight, and there should be no air leak from the oil compartment. Special attention should be paid to screwing the filler cap down firmly and making quite sure that it seats on its leather washer. *There must be no vent hole in the filler cap.* A common cause of pressure leakage is due to enamel on the threads of the filler cap collar, preventing the cap from screwing down fully. A similar trouble can arise from the washer being creased. It should always lie quite flat. The average pressure in the tank is about 4 lb. per square inch, and the maximum is only 6 lb., but the pressure must be maintained.

Failure to comply with this will result in over-oiling at low speeds and shortage of oil at speeds over 25–30 m.p.h.

Should the lubricator continue to deliver oil after the engine has stopped, this is due to syphonic action caused by the vent hole being choked. The vent hole, which is very small, should be cleaned with a single strand of Bowden wire. If the sight-feed bowl fills with oil, this is due to an air leak under the sight-feed glass.

The vent hole in the Mark I lubricator is in the sight-feed bowl itself. In the Mark II it is as shown in the diagram, whilst in the Mark III lubricator the vent hole is in the annular groove under the top washer.

It is important that all washers are kept in good condition, as any leakage will interfere with the correct working of the lubricating system.

Setting the Oil Supply

The flow of oil varies automatically according to the engine load and throttle opening. The screw F is used for adjusting the oil supply, being screwed in to reduce the supply. The correct setting has been obtained when a faint blue haze of smoke issues from the exhaust pipe as the machine is running normally in top gear on a level road. The sight feed is provided to ascertain if oil is flowing, and not to gauge the quantity. In very cold weather it is advisable to increase this setting.

Petroil System

Most riders of machines fitted with two-stroke engines are familiar with this system, but to obtain satisfactory results certain rules with regard to the mixing of the oil and petrol should be carefully observed. First, one brand only of lubricating oil should be used where possible, and after many years of experience Patent Castrol XL oil (SAE 30) has been found to give good results; therefore riders are recommended to use this brand regularly. Secondly, the mixture should be made before putting into the tank, but should at any time this not be possible, always put the petrol in first. The correct proportions are one part oil to sixteen parts petrol, or ½ pint to 1 gallon. Thoroughly mix by shaking in a clean can, and pour through a fine-mesh gauze into the fuel tank.

Except for replenishment this system calls for no further attention from the rider whilst the machine is being ridden, but if the cycle is to be laid up for more than two or three days, it is advisable to drain the carburetter, which, of course, can be done by turning off the tap before reaching one's destination. This will obviate difficulty in starting due to the oil separating and settling in the carburetter jet after standing for some time. The fact of the lubricating oil being suspended in the petrol is a big advantage, as the amount of oil entering the crankcase and cylinder is controlled by the carburetter throttle opening, which varies according to the load on the engine.

CHAPTER V

THE VILLIERS FLYWHEEL MAGNETO

BEFORE giving details of the various types which have been made since the introduction in 1922 of the first flywheel magneto, it may be of interest to explain the manner in which the electric spark is produced. The magneto really consists of two main components: the armature, on which is mounted the high-tension coil and lighting-coil cheeks, and the rotating flywheel which carries the magnets, pole pieces and the cam which separates the contact-breaker points once every revolution.

Now the magneto is really a small dynamo, but so constructed that the electricity is generated at a very high pressure, or voltage, and delivered as a rapid succession of sparks at the points of the sparking-plug fitted to the engine cylinder.

The ignition coil, in which the high voltage is built up, consists of a soft-iron core on which is wound a coil of comparatively heavy gauge copper wire known as the primary coil. Wound around but insulated from the primary coil are many turns of very fine-gauge copper wire which make up the secondary coil.

Rotation of the flywheel induces a current in the primary coil circuit, and when this circuit is broken by the separation of the contact points, a current of high pressure is induced in the secondary coil, causing a spark at the plug points. The circuit is easily followed by reference to the diagram, Fig. 13.

The armature plate D is secured to the engine crankcase, A is the ignition or high-tension coil, the heavy lines denoting the primary winding, and the fine lines the secondary winding. The condenser E, the function of which is explained later, is actually situated immediately underneath the contact breaker B. The sparking-plug C completes the circuit.

Rotation of the flywheel induces a low-tension current in the primary circuit (shown in Fig. 13 by heavy lines). When the contact points are closed, *i.e.*, in contact with one another, the current continues to the other end of the primary winding via the armature plate, which is "earthed" by contact with the engine crankcase. When this primary current is interrupted by the opening of the contact-breaker points the flux collapse which follows induces a very high-voltage current in the

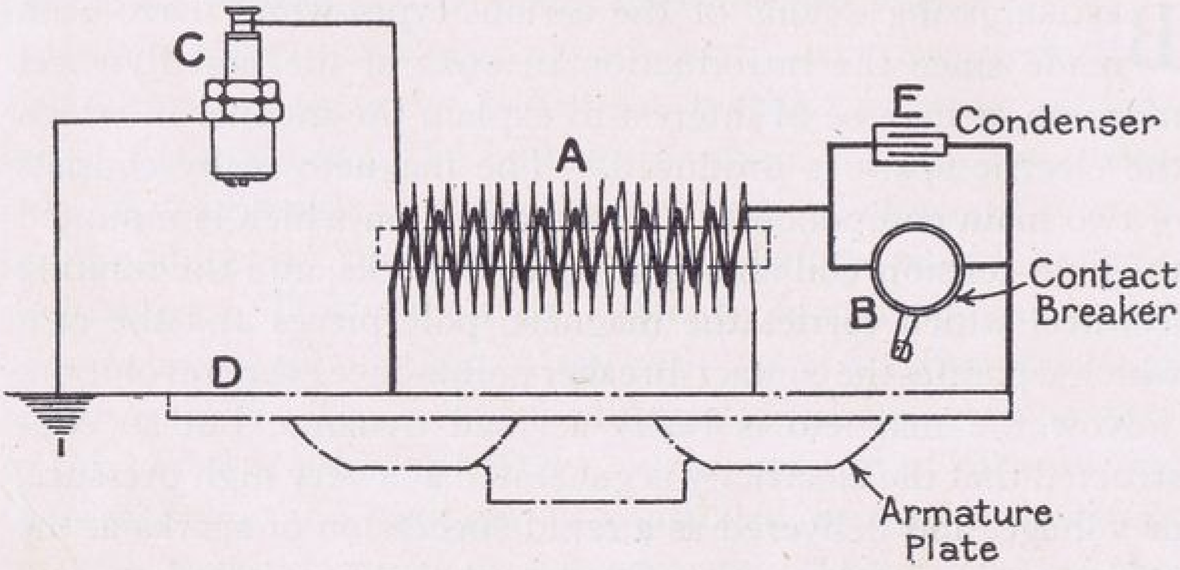


FIG. 13.—CIRCUIT DIAGRAM OF IGNITION SYSTEM.

A, Ignition or high-tension coil ; B, contact breaker ; C, sparking-plug ; D, armature plate ; E, condenser.

secondary winding which is led to the central electrode of the sparking-plug and back to earth through the plug body.

The Condenser

It will be seen from the diagram that this component is put in parallel with the contact-breaker points. One function of the condenser is to prevent sparking at the points when they open ; in consequence of this, the rupture of the primary current is particularly sudden, assisting in the induction of the high voltage required.

The condenser is made up of pieces of tin-foil separated from one another by an insulating material such as waxed paper or mica, and the large surface capacity of the tin-foil carries the induced current in the primary winding when the points are suddenly separated by the cam secured to the magneto flywheel. It must be pointed out that no magneto will function properly if the condenser is removed from the circuit or if the insulation of the condenser breaks down, so allowing a short circuit.

Testing the Condenser

The condenser should be tested on a 200–250 volt direct-current circuit. The reading of a meter should be between 0·2 and 0·22 micro-farads; if a reading lower than 0·2 is obtained the condenser should be discarded. The condenser should hold the bulk of this charge for at least 15 seconds. Discharge the condenser by touching the casing with the end of the attached lead, when a good spark should be seen and heard. The condenser will probably function correctly for a time if it only holds its charge for some 5 seconds, but will cause trouble later and should be replaced.

Testing the Ignition Coil

Check whether the small slotted grub-screw in flange of bobbin makes contact with the end of primary winding, otherwise there is the possibility that although the hexagon-headed terminal screw may be tight against the external lead to contact-breaker, actual contact is not being made with the end of coil in the bottom of the hole. When the hexagon-headed screw is removed, the slotted end of the insert screw can be reached with a narrow screwdriver. The end of the coil wire must not project through the hole in the side of the bobbin end, otherwise a short-circuit will occur through contact with the armature cheek.

A fixture for testing the ignition coil from a 6-volt battery is shown in Fig. 14. The cam which is fixed to the end of the motor spindle should be rotated at about 1500 r.p.m. The coil is held in two V-brackets A, the primary contact in the bobbin end pressing on the spring strip B on the base-board, which is in turn connected to the point plate of the contact-breaker.

A swivelling arm C, as shown, holds the coil down by press-

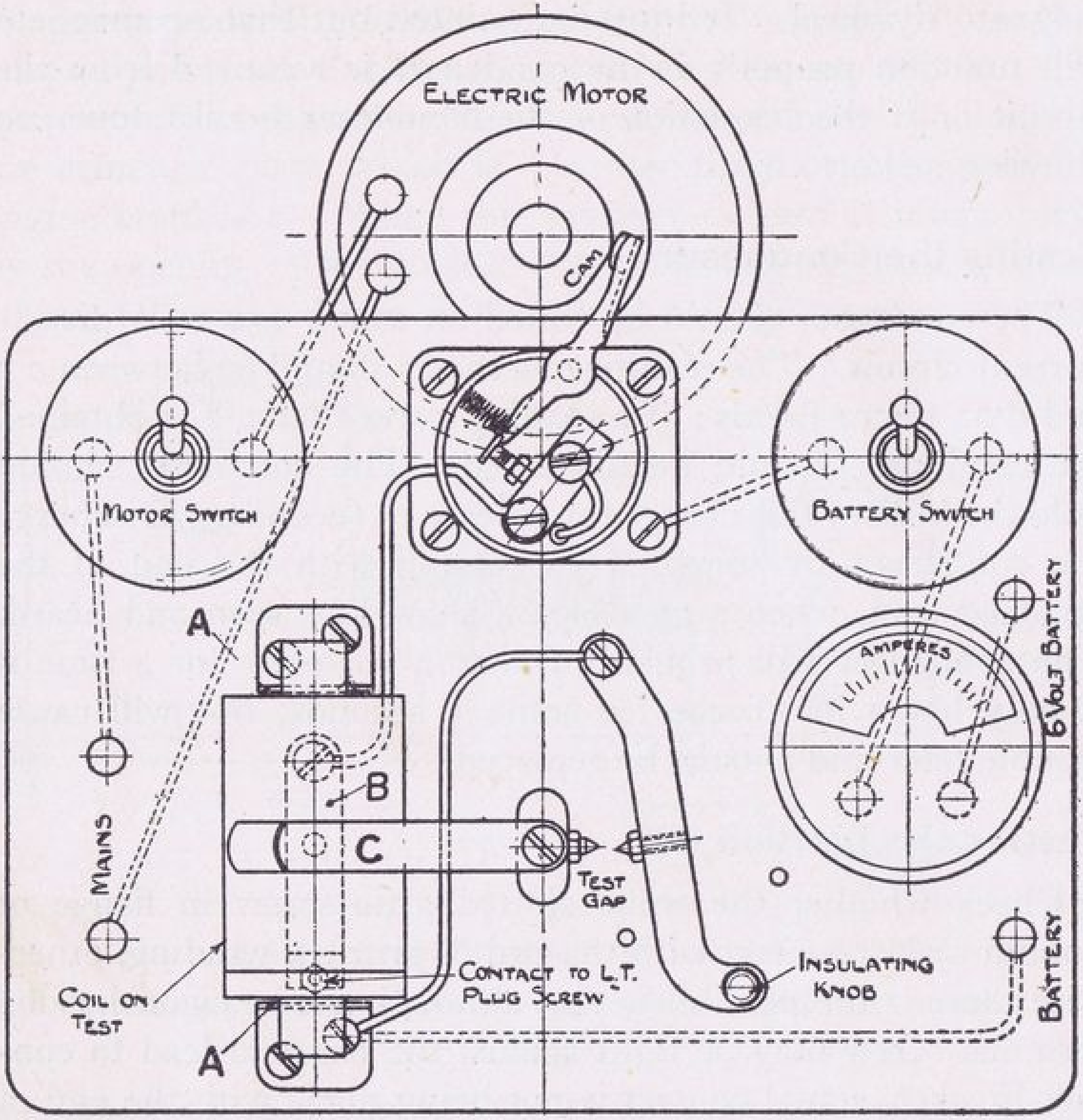


FIG. 14.—IGNITION-COIL TEST SET.

ing on the high-tension button and takes the high-tension current to the test-gap point. A serviceable coil should jump 5·5 mm., and it should also be possible to withstand running for about two minutes with a gap of about half-an-inch even if no spark occurs. If after running with a wide gap there is no missing on the 5·5-mm. gap, the coil can be passed as being in order.

The resistance of the coil as tested with an ohmmeter should be between 2000 and 4000 ohms; if below 2000 the coil should be scrapped, if above 4000 the coil may be serviceable, but corrosion in some form may be setting in, and replacement may be advisable.

A known good coil should be kept on hand in order to check the testing apparatus, because the 6-volt battery may be run down and the contacts of the testing fixture may be defective.

The point gap of the contact-breaker will be the standard of 0·014 in., but of course the points must be kept clean as in the magneto.

The ammeter is put into the circuit to check the continuity and insulation of the primary winding; if faulty the needle will be unsteady.

The Contact-breaker

This is the name given to the mechanism which breaks the contact in the primary winding. It consists of a circular box in which are fitted, on the underside, the condenser and fixing studs, whilst the fixed contact point and rocker-arm are contained in the upper portion.

The rocker-arm end which protrudes from the box makes contact with the flywheel cam whilst the contact points are separated, the correct gap between the points when fully open being 0·015 in. or $\frac{1}{64}$ in. The cam is actually relieved 0·03–0·04 in. to ensure that the rocker-pad is not touching the cam face whilst the contact points are closed.

To the end of the rocker-arm inside the box is fitted what is called a fixed contact point, the adjustable point being carried in a clamp fixed to, but insulated from, the rocker-box. The two screws holding the clamp are insulated from both the clamp and the leads from condenser and ignition coil, by special insulating bushes, which must be correctly fitted should it be necessary at any time to fit a new condenser.

The two leads, one from the ignition coil, the other from the condenser, are fitted next to the clamp, and then followed by the flanged insulating bush, the plain insulating bush being fitted underneath the clamp next to the condenser box.

The construction and assembly are illustrated in Fig. 15.

The contact-breaker assembly, as described above, has been a Villiers feature since the inception of the flywheel magneto.

Very few changes have been made in design and construction. During 1947 a modified design was introduced, in which the circular condenser box is retained, but a different method of point adjustment is employed.

The adjustable point is fixed to a bracket pivoted on one end and secured to the condenser box by one slotted screw, the bracket and screw being insulated from the box by fibre washers.

The complete contact-breaker assembly is interchangeable with the older pattern, but as two types of rocker-pads are

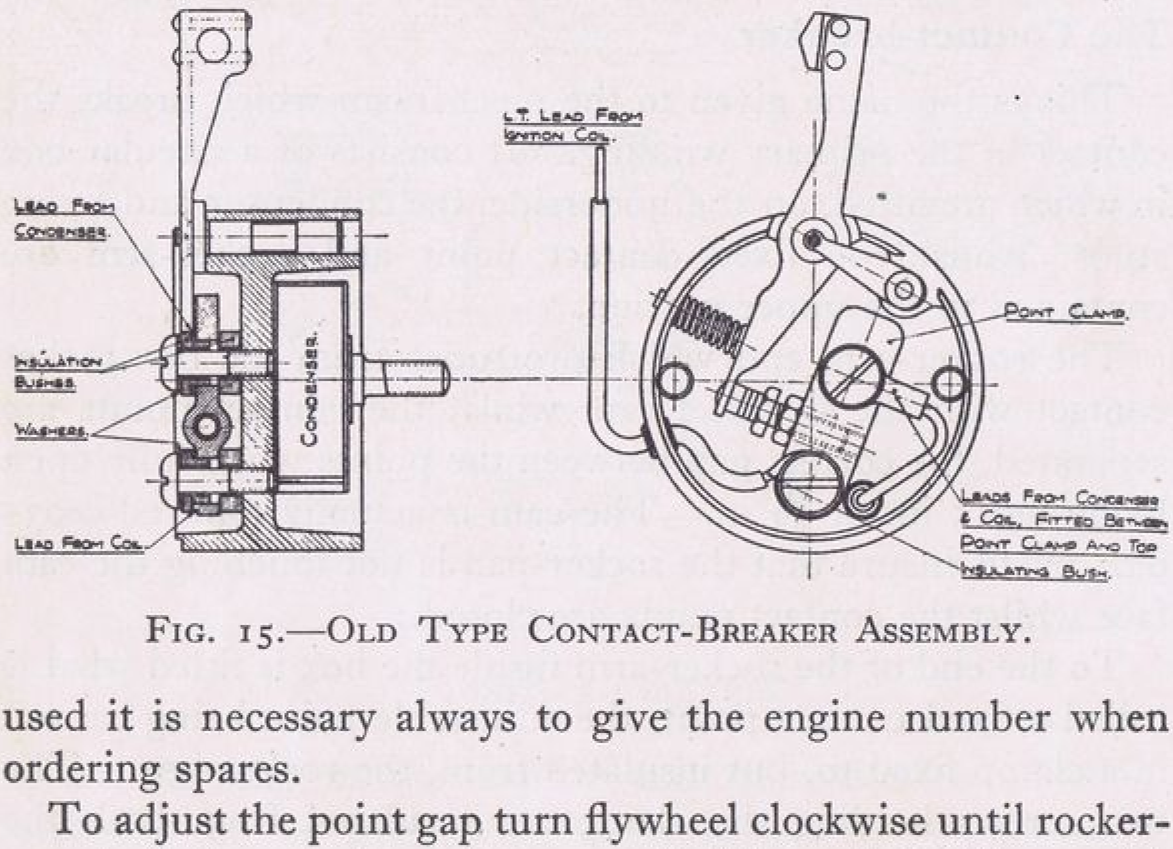


FIG. 15.—OLD TYPE CONTACT-BREAKER ASSEMBLY.

used it is necessary always to give the engine number when ordering spares.

To adjust the point gap turn flywheel clockwise until rocker-arm is fully raised, undo screw A (Fig. 16) holding point bracket B and place between the contact points the feeler gauge fitted to the screwdriver which is supplied with every engine. When tightening the screw use the special screw-driver supplied with each engine. If a too large screw-driver is used, the thread of the screw is likely to be stripped. Should the thread in the rocker-box be stripped, an additional hole, adjacent to the hole in which the screw was originally fitted, is provided.

The leads from condenser and ignition coil are secured to

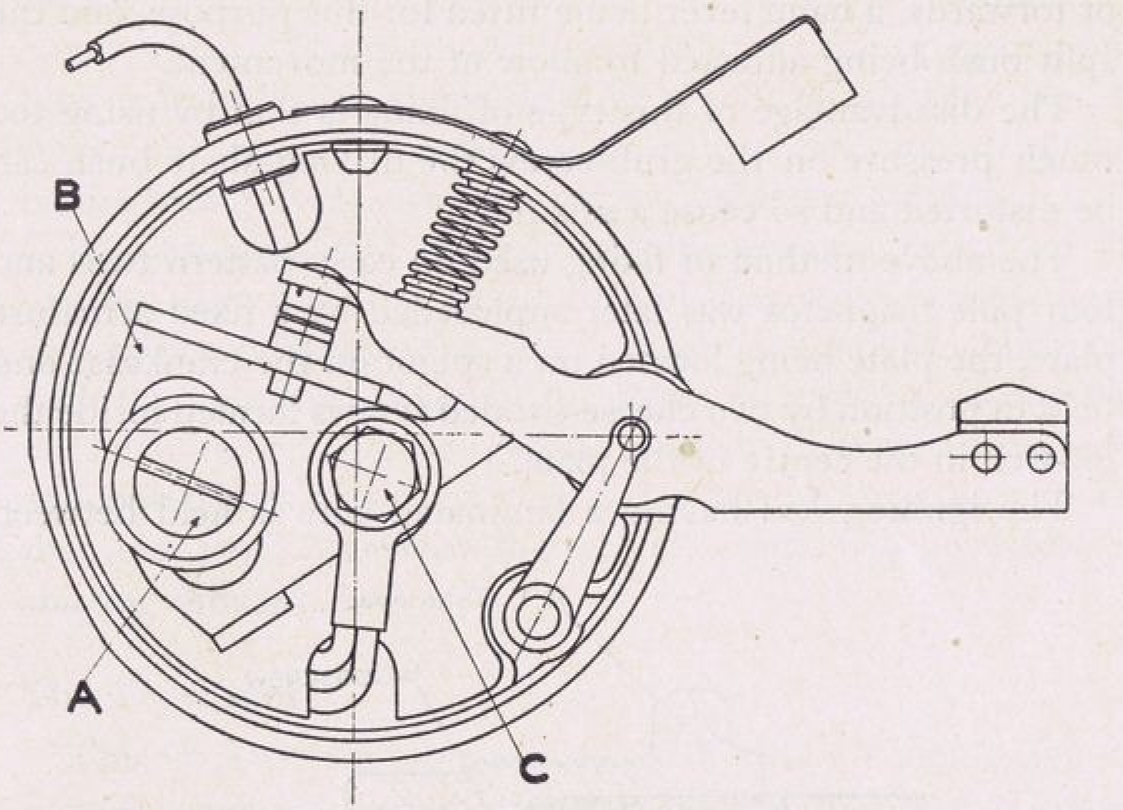


Fig. 16.—New Type Contact-Breaker Assembly.

the point bracket by one hexagon-headed screw C, which should not be disturbed when adjusting the contact points.

Occasionally remove the rocker arm and put a drop of oil on the spindle.

The Armature Plate

This is the name given to the stationary portion of the magneto on which the armature is built.

In later models the armature plate is fixed by screws to the crankcase.

On early engines, in which plain crankshaft bearings are used, the armature plate is located on the outside of the portion of the bush which protrudes from the crankcase. In the centre of the armature plate is fitted a split steel bush which can be compressed by a grub-screw to grip the crankcase bush, and so prevent the plate rotating.

In the days of slow-revving engines it was an advantage to be able to advance and retard the timing of the spark, and this was done by rotating the armature-plate assembly backwards or forwards, a hand lever being fitted for this purpose, and the split bush being adjusted to allow of the movement.

The disadvantage of this type of fixing is that by using too much pressure on the grub-screw the driving-shaft bush can be distorted and so cause a seizure.

The above method of fixing used on early pattern two- and four-pole magnetos was later superseded by a fixed armature plate, the plate being located on a spigot on the crankcase and held in position by two cheese-headed screws located inside the oil-well in the centre of the plate.

The ignition coil having a laminated core is held between

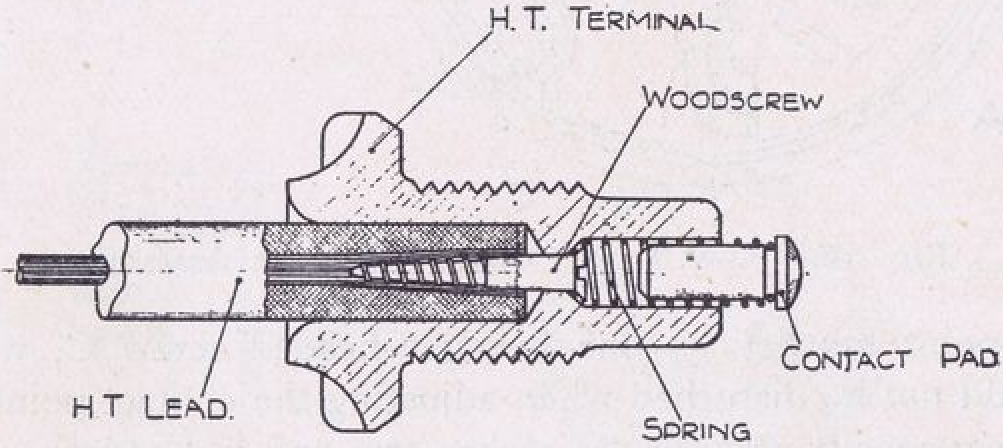


FIG. 17.—HIGH-TENSION PICK-UP ASSEMBLY.

the armature cheeks, and it is essential that good contact is made between the coil core and cheeks and between the cheeks and surface of armature plate in order to ensure a good *earth* connection.

The outer end of the secondary winding of the ignition coil terminates in a soldered disc which is situated about half-way along the outside of the coil, and it is against this disc that the "pick-up" end of the sparking-plug cable is to make contact. When replacing the coil care must be taken to see that the contact disc is in the correct position. The "pick-up" or high-tension terminal consists of an insulated moulding in one end of which is fitted a spring-loaded contact pad, and in the outer end is fitted the rubber-insulated lead to the sparking-plug. This terminal is now screwed into the armature-plate casting, but was for a number of years held in position by a bow spring. The method of securing the pick-up spring and high-tension lead is shown in Fig. 17, and it is a good plan to smear the end of the lead with rubber solution or Bostik before fitting, to ensure the terminal being waterproof.

It is essential that the armature plate is a good fit on the driving-shaft bush, or, in the case of later engines, the crank-case spigot, otherwise the actual cheeks, will not be concentric with the pole shoes fixed in the flywheel, and the air gap will not be uniform. The air gap, or clearance, between the cheeks and pole shoes should not exceed 0·020 in., and be not less than 0·004 in., otherwise the ignition spark will be weak and starting difficult.

The Flywheel

This part of the magneto is made from a non-magnetic material such as aluminium or gunmetal to prevent loss of magnetic flux, the internal components consisting of pole shoes, magnets and the centre boss on which is formed the cam profile and which operates the " make and break " of the contact points.

Dealing first with the centre, or what is known in the works as the cam, it will be noticed that one of the fixing screws is unequally spaced. From this offset hole and the corresponding hole in the flywheel, all machining operations are located, so that the position of the cam " peak " in relation to the tip of pole shoes is always the same in a particular type of magneto.

The cam is secured to the flywheel by countersunk-headed screws which, after tightening, are riveted over, special equipment being used to carry out this work. The pole shoes are fixed in the flywheel, the sides making contact with the end of the magnets which are secured in position by a top plate held by the pole-shoe screws. After assembly and final machining operations, the complete wheel is balanced. The cam has a tapered centre hole having a ground finish, the amount of taper being 1 in 10 on the diameter, and as no key is used it is essential that both the hole and driving shaft are free from oil or grease when fitting the flywheel. The wheel is secured on the driving-shaft of engine by a centre nut which is imprisoned between flywheel and cam, the nut having a flange which draws the wheel from the shaft as it is unscrewed, thus obviating the use of a special extractor. It is very necessary that the centre nut is securely tightened, and this can best be done by using the Villiers hammer-tight spanner as mentioned in the chapter on overhauling. This spanner is obtainable from the Villiers Service Department and is available to suit the two sizes of nut which are in use; the engine number and model should be quoted when ordering. The nut, which has a right-hand thread, is unscrewed in an anti-clockwise direction looking at the face of the flywheel. The spanner should be placed on the nut and hammered round in that direction. After perhaps one turn it will be found to tighten; this is because the flange is now pulling against the flywheel. Continue hammering until the flywheel comes away from the shaft. It is not necessary to release the flywheel in order to adjust the contact points, the wheel being built so that this can be done through the space between the arms and the wheel.

Refitting the Flywheel and Ignition Timing

All the engines described in Chapter II have the ignition timing mark stamped on the face of the flywheel boss. This mark must be in line with the small slot cut in the end of the driving-shaft, but before finally tightening the flywheel centre nut, check the opening of the contact points with the position of the piston. The actual amount of advance, *i.e.*, the measurement from the top of piston to the top of the stroke, depends on the type or model of engine. A chart giving the recommended amount of advance for each model is given on page 62.

On later engines the timing marks are stamped on the outer edge of armature plate and on the flywheel rim, this method enabling more accurate timing to be obtained. The small slot cut in the end of driving-shaft is retained as an indication of

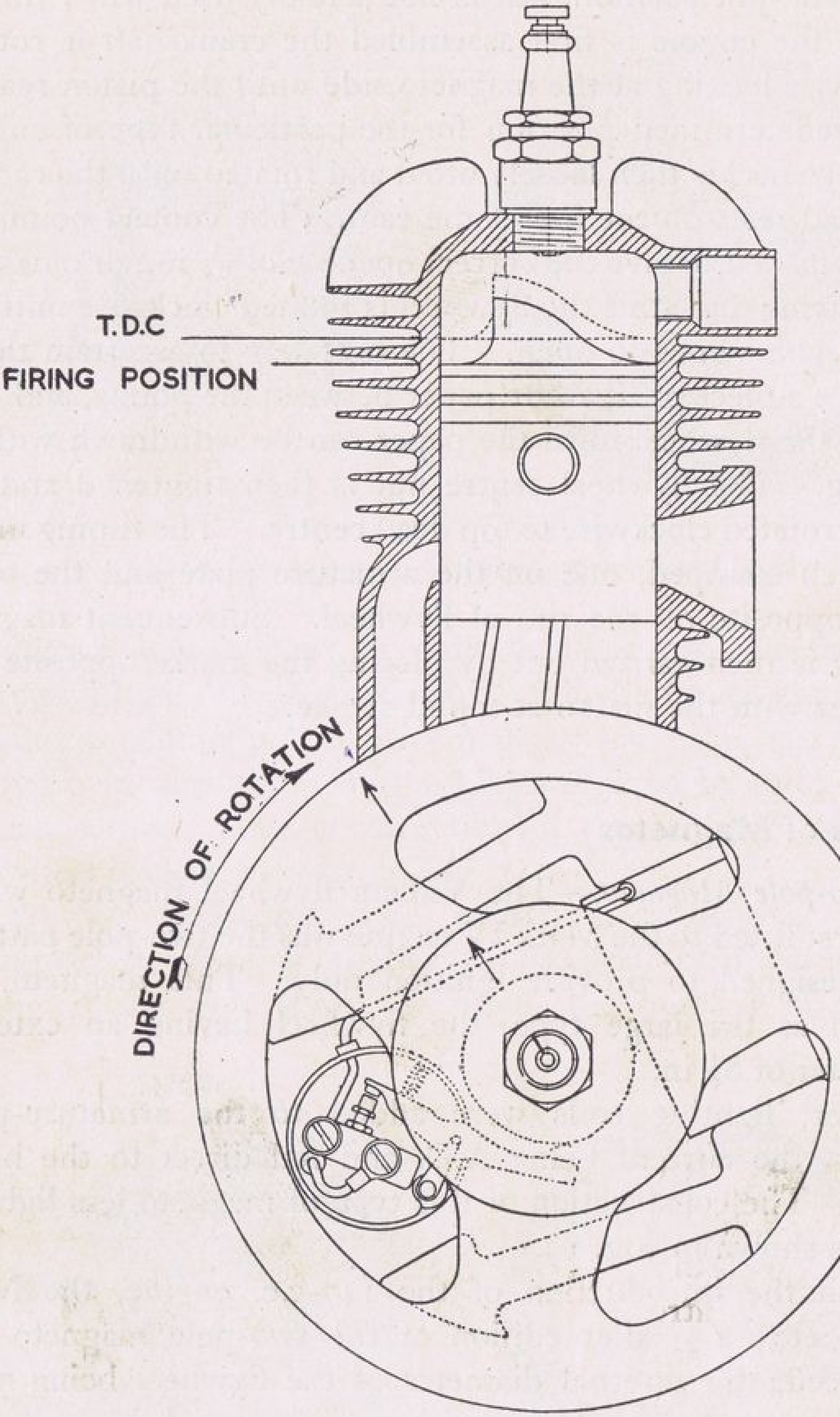


FIG. 18.—IGNITION TIMING DIAGRAM.
See page 62 for details of piston-firing position.

the crank-pin position, but is not actually used when timing. When the engine is first assembled the crankshaft is rotated clockwise looking at the magneto side until the piston reaches the predetermined position for the particular type of engine. The flywheel is then loosely fitted and rotated until the rocker-arm pad rests on the top of the cam. The contact points are now adjusted to give the correct opening of $\frac{1}{64}$ in., or 0·015 in., and having done this the flywheel is rotated clockwise until the points commence to open. The best way to ascertain this is to place a piece of cigarette paper between the points, and then rotate the flywheel until the paper can be withdrawn without tearing. The flywheel centre nut is then tightened and the wheel rotated clockwise to top dead centre. The timing marks are then stamped, one on the armature plate and the other dead opposite on the rim of flywheel. Subsequent magneto timing is then carried out by placing the marks opposite one another with the piston at top of stroke.

Types of Magnetos

Two-pole Magneto.—The Villiers flywheel magneto which was first fitted to the Mark IV engine was the two-pole pattern, and designed to provide ignition only. This magneto was known as the large type, the flywheel having an external diameter of $8\frac{1}{4}$ in.

Later, lighting coils were added to the armature-plate cheeks, the current being A.C. and fed direct to the head-lamp. The construction of this type of magneto less lighting coils is shown in Fig. 19.

With the introduction of the 147-c.c. engine, the Mark VI-C, etc., a smaller edition of the two-pole magneto was produced, the external diameter of the flywheel being 7 in. This magneto was available with or without lighting coils, the later type being illustrated in Fig. 20.

Four-pole Magneto.—During 1932 the four-pole magneto was introduced. The armature plate had two lighting coils in addition to the ignition coil, the method of fixing to the

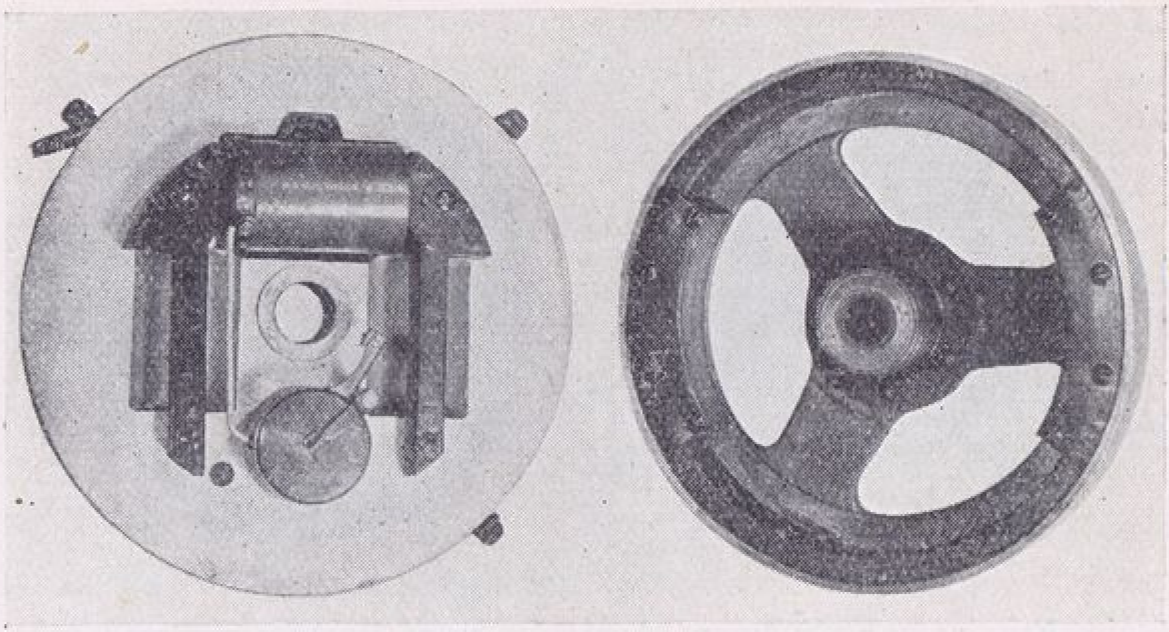


FIG. 19.—LARGE TWO-POLE MAGNETO WITHOUT LIGHTING COILS.

crankcase being either by split bush or two cheese-headed screws as described previously. The flywheel assembly is made up of four pole shoes equally spaced, the four magnets being held in position by top plates secured by the pole-shoe fixing screws. The construction of the armature plate and flywheel is clearly shown in Fig. 21.

Six-pole Magneto.—The construction of the six-pole magneto flywheel is similar to the four-pole pattern, but although six pole shoes are fitted, the number of magnets

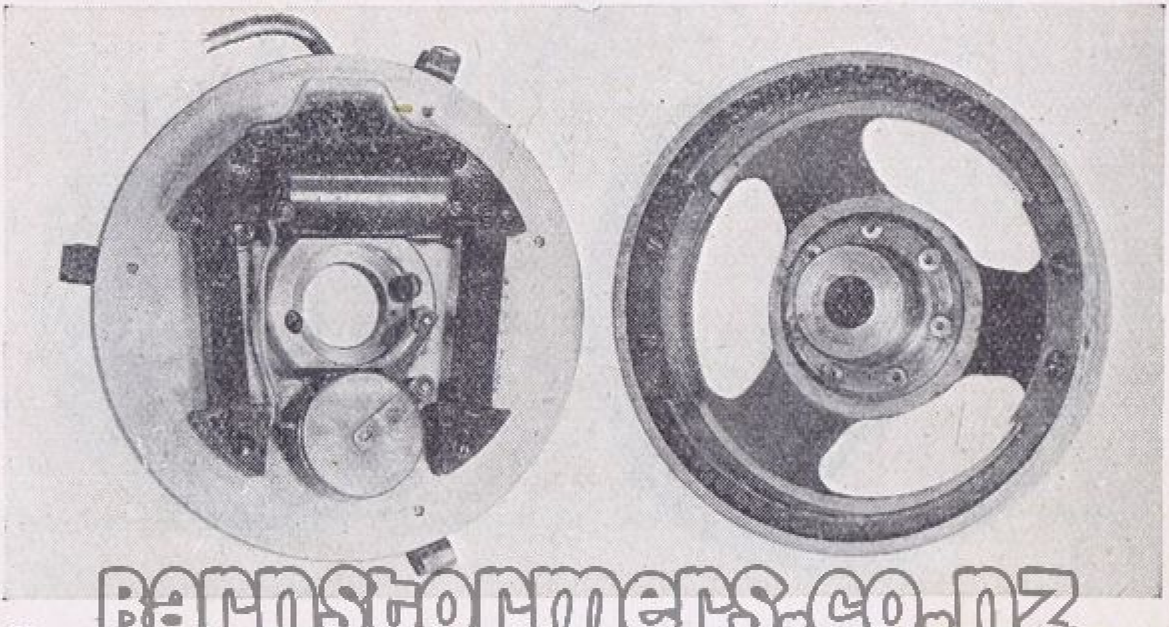


FIG. 20.—SMALL TWO-POLE MAGNETO WITHOUT LIGHTING COILS.

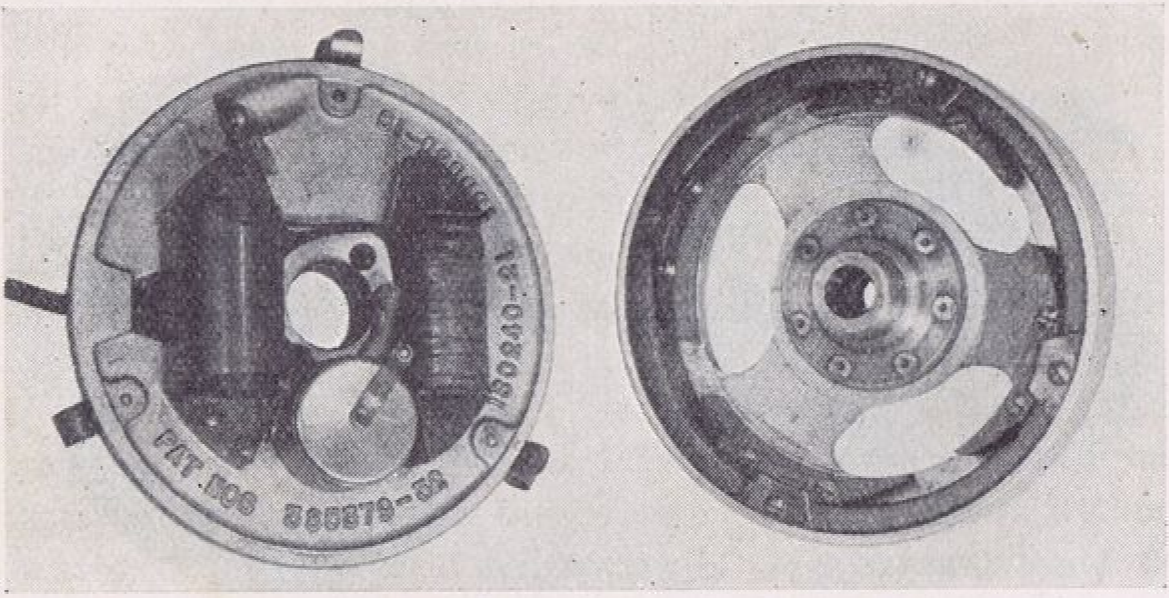


FIG. 21.—FOUR-POLE MAGNETO WITH LIGHTING COILS.

varies according to the requirements. The armature-plate assembly includes both lighting and ignition coils, and in the case of the former, separate coils for the head and tail lamps are fitted, the lighting cable from the magneto consisting of twin leads, coloured red and black.

To the leads are attached similarly coloured rubber-covered connectors, the red one being the head circuit and the black for the tail circuit, the two circuits being entirely independent. There are in service a number of six-pole magnetos having head coils only, in which case a single output lead is fitted.

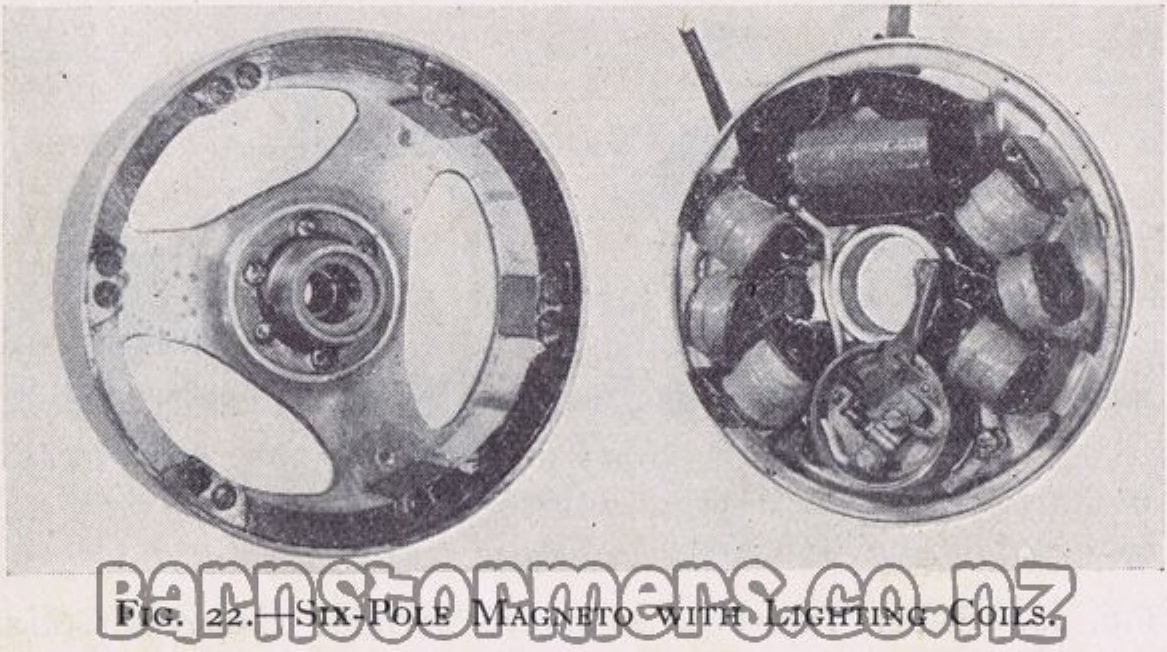


FIG. 22.—SIX-POLE MAGNETO WITH LIGHTING COILS.

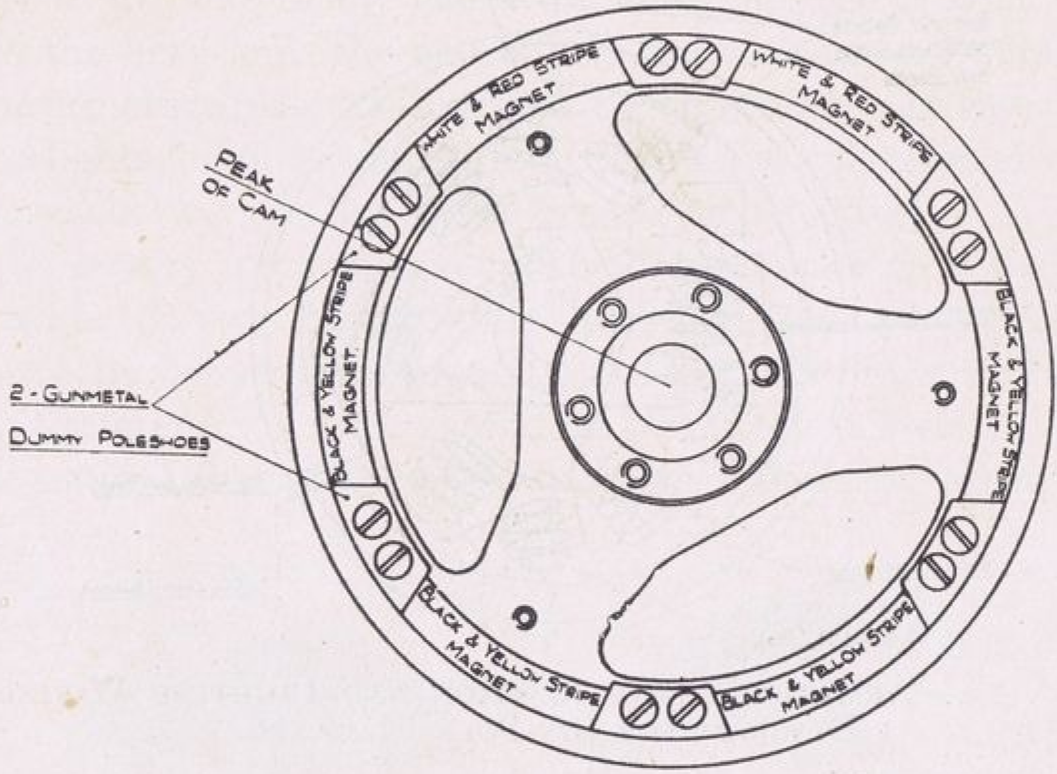


FIG. 23.—FLYWHEEL ASSEMBLY OF SIX-POLE 18-WATT MAGNETO.

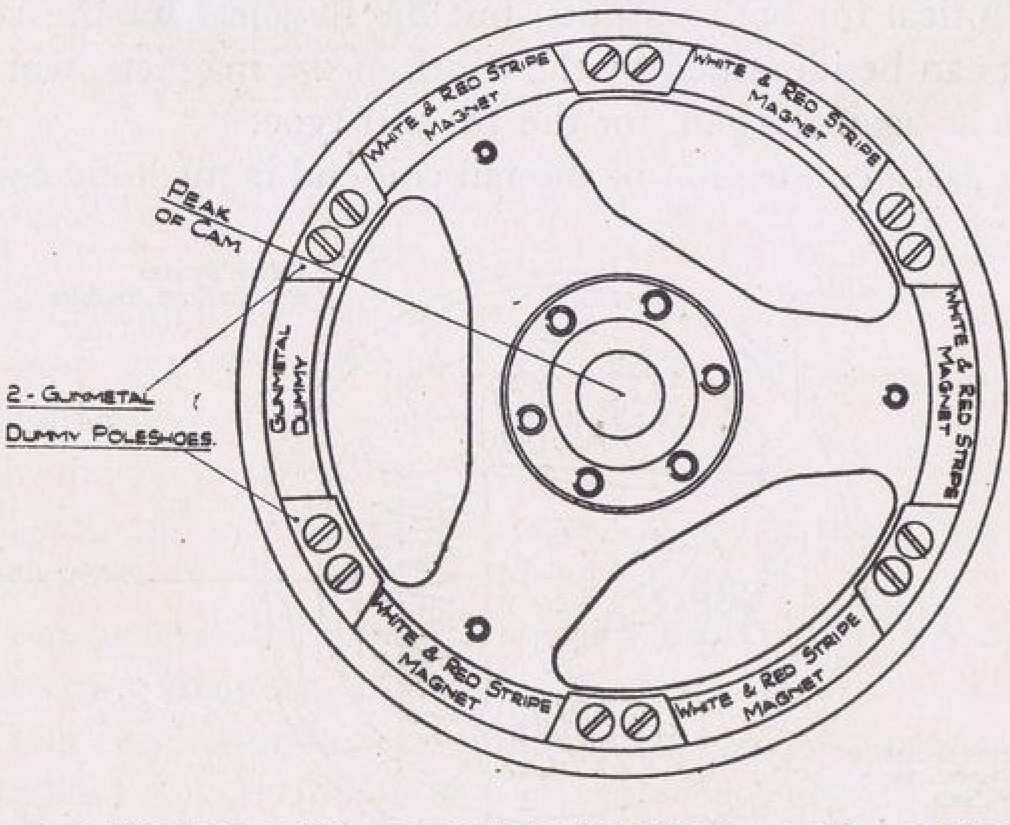


FIG. 24.—FLYWHEEL ASSEMBLY OF SIX-POLE 24-WATT MAGNETO.

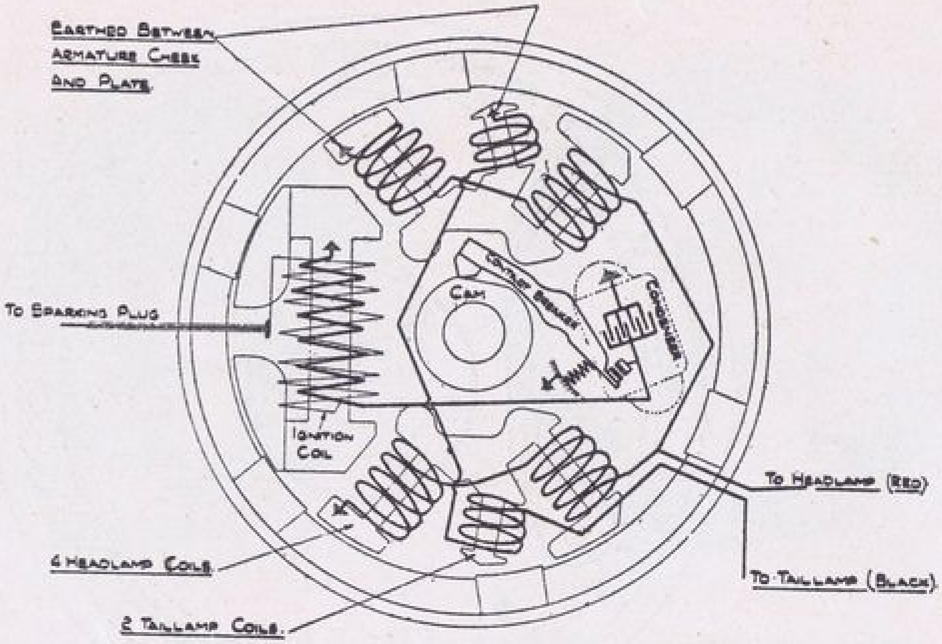


FIG. 25.—ARMATURE PLATE IGNITION AND LIGHTING WIRING DIAGRAM FOR SIX-POLE MAGNETO.

Magnetos are available giving A.C. lighting current of either 18 or 24 watts at 6 volts from the head coils, the output from the tail coils being 6 watts at 6 volts. The armature assemblies are identical for both outputs, but the flywheel for the larger output can be identified by the width of the magnets, which is $1\frac{7}{16}$ in. as against $1\frac{1}{8}$ in. for the 18-watt type.

The earth connection of the tail coil end is made by solder-

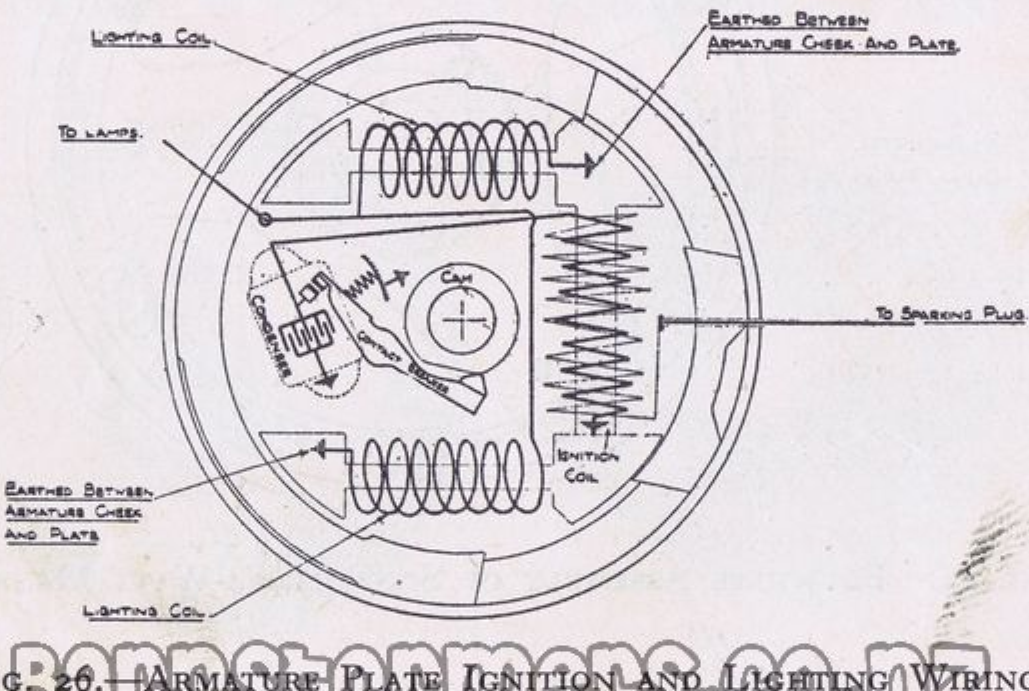


FIG. 26.—ARMATURE PLATE IGNITION AND LIGHTING WIRING DIAGRAM FOR THREE-POLE MAGNETO.

ing to the side of the cheek on which the coil is wound, and for the head coils the end is held between the coil cheek and the armature plate by the cheek-fixing screws. In cases where the lights fail or become dim, examination will often show that these connections are either broken or defective.

It is very important should it be necessary to entirely dismantle the magnets and pole shoes that these components are correctly reassembled in relation to the peak of the centre cam, and reference to Figs. 23 and 24 will make this clear. It will be noticed that in the 18-watt flywheel there are six magnets,

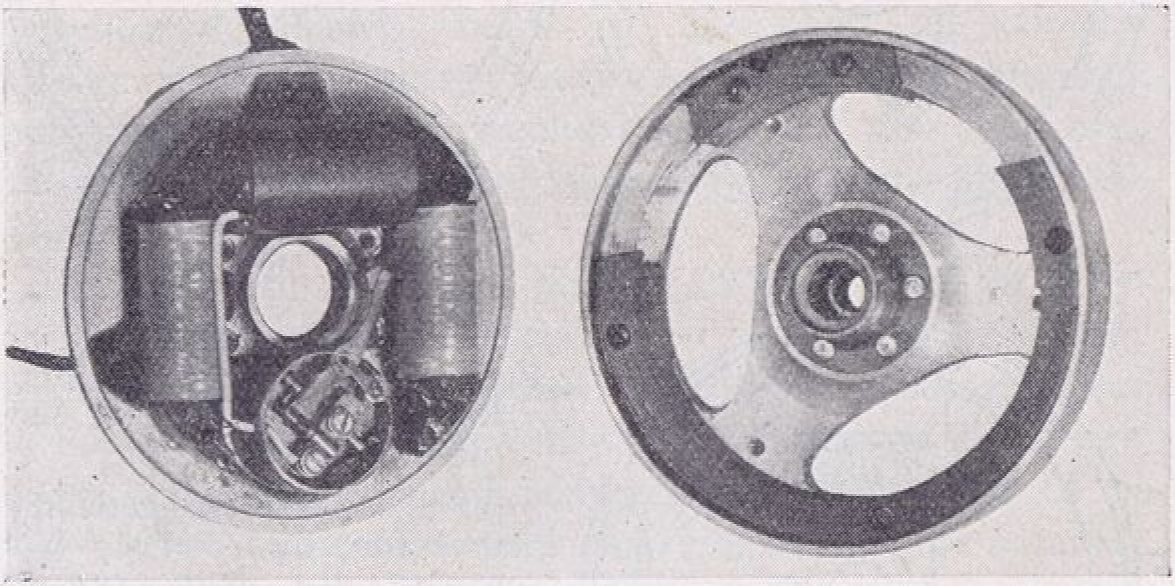


Fig. 27.—Three-Pole Magneto with Lighting Coils.

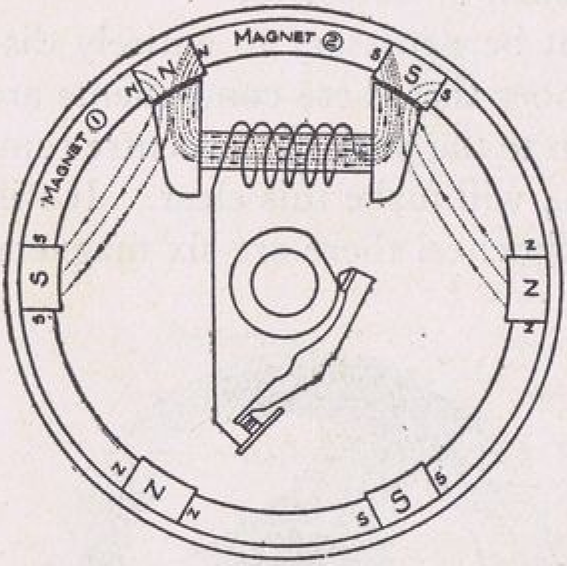
four of which are painted with a black and yellow stripe, the remaining two magnets having white and red stripes. Note the position of the two dummy pole shoes.

In the 24-watt flywheel there are five magnets, painted white and red, and one dummy magnet. Two of the pole shoes are dummies.

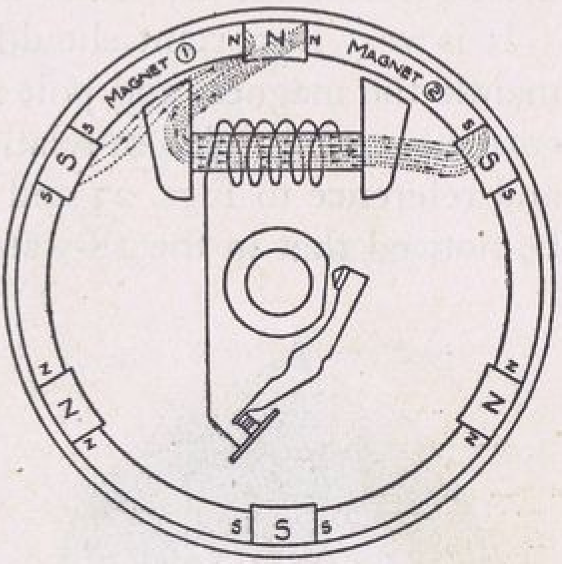
The separate circuits of the head and tail coils are shown in the wiring diagram, Fig. 25.

The condenser-box assembly fitted to all six-pole magnetos is the old type as shown in Fig. 15 on page 48.

New Six-pole Magneto.—For the new range of engines introduced at the end of 1948 entirely new six-pole magnetos are fitted. The construction of the flywheel is somewhat similar to the one shown in Fig. 22, page 56, but the armature-plate assembly is entirely different. A much greater output in lighting current is given which enables a 30-watt headlamp bulb to be used with the *direct* lighting set for the Mark



(*a*)



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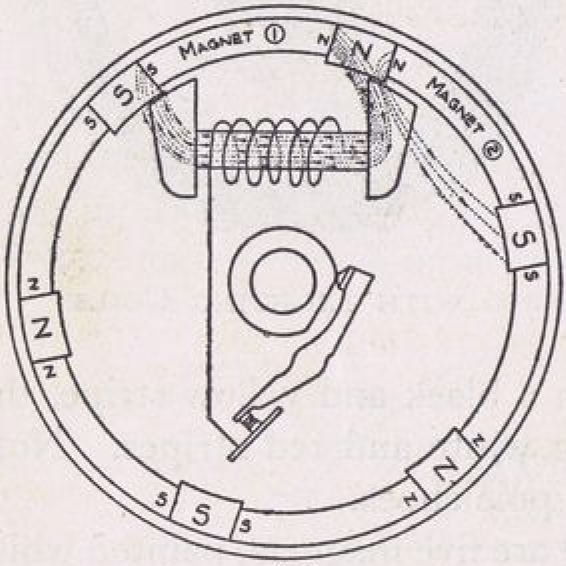

(*c*)

FIG. 27A.—METHOD OF FLUX REVERSAL USED IN THE NEW SIX-POLE MAGNETO.

(*a*) Shows the magnetic flux path before the reversal which generates the high primary current required.

(*b*) Shows the flux path just before the actual point of reversal and

(*c*) Shows the path immediately after the reversal.

10D and Mark 6E engine-gear units described in later chapters.

At the beginning of this chapter, the method of producing the electric spark is explained, and the method of flux reversal used in the new six-pole magneto for obtaining the high primary current required is shown in the three diagrams, Fig. 27A. In (*a*) the flux from magnet 2 is seen to be passing through the coil core from left to right, and being more or less unchanging is generating no current in the primary winding. In (*b*) the flux of magnets 1 and 2 is seen to be drawn out to breaking point at the left-hand coil end. In (*c*) we see where the flux has broken away from the attraction of the iron mass of the left-hand coil end and jumped with extreme rapidity to the iron right-hand coil end, where it passes through the coil core from right to left.

The rapid movement of the flux across the primary wires thus generates a high voltage in the primary winding, making a powerful electro-magnet of the ignition coil and causing the fine high-tension winding to be enclosed in a highly concentrated magnetic field. At this point the contact-breaker opens and causes very rapid collapse of this field, generating in this fine secondary winding the very high voltage required to jump the points of the sparking plug in the cylinder.

This magneto comprises rotating magnets fixed in a fly-wheel, and the coil and contact-breaker mechanism are secured to a stationary aluminium plate, and the fine windings of coil do not, therefore, have to withstand the effect of centrifugal force. The stationary coil enables a direct connection to the plug wire to be made instead of having to provide a carbon brush and slip ring, as with a rotating armature. All parts are very robust, and the flywheel is secured to the crankshaft so that there is no possibility of wear or noise which is present when a chain or gear drive is used.

The number of magnets in the flywheel and the lighting-coil assemblies vary according to the engine to which the magneto is fitted, and details are given in the chapters dealing with each model.

The condenser-box assembly for the new six-pole magneto is as illustrated in Fig. 16, needing only a screwdriver for point adjustment. It should be noted that the rocker arm itself is earthed, but that every care must be taken to see that the adjustable point plate is properly protected from the contact-breaker box itself, by: (1) the large circular insulating washer under the plate; (2) the small insulating washer under the clamp screw brass washer; (3) the small black insulating bush in which the point plate pivots.

Three-pole Magneto.—This type of magneto providing both ignition and lighting is fitted to the Junior-de-Luxe autocycle engine, and, being mounted on the driving or near side of engine, the direction of rotation is anti-clockwise. A single lead from the magneto conveys the A.C. current direct to the

MAGNETO SPARK TIMING

Engine.	Capacity, c.c.	Timing in ins.
Midget	98	$\frac{11}{64}$
Junior	98	$\frac{7}{32}$
Junior-de-Luxe	98	$\frac{1}{4}$
Mk. VIII-D	125	$\frac{5}{16}$
Mk. 9D	125	$\frac{5}{16}$
Mk. VI-C	147	$\frac{5}{32}$
Mk. VII-C	147	$\frac{7}{32}$
Mk. VIII-C	147	$\frac{1}{4}$
Mk. XII-C	148	$\frac{1}{4}$
Mk. XV-C	148	$\frac{7}{32}$
Sports	172	$\frac{5}{16}$
Super Sports	172	$\frac{11}{32}$
S.S.T.T.	172	$\frac{11}{32}$
196 Super Sports	196	$\frac{5}{16}$
Mk. 1E	196	$\frac{7}{32}$
Mk. 2E	196	$\frac{7}{32}$
Mk. 3E	196	$\frac{3}{8}$
Mk. VI-A	247	$\frac{3}{16}$
Mk. IX-A	247	$\frac{5}{16}$
Mk. X-A	247	$\frac{5}{16}$
Mk. XVI-A	247	$\frac{5}{16}$
Mk. XIV-A	249	$\frac{3}{8}$
Mk. XVII-A	249	$\frac{7}{16}$
Mk. XVIII-A	249	$\frac{7}{16}$
Mk. IX-B	342	$\frac{5}{16}$
Mk. IX-BA	342	$\frac{5}{16}$
Mk. X-B	342	$\frac{5}{16}$
Mk. XIV-B	346	$\frac{3}{8}$
Mk. 1F	98	$\frac{1}{8}$
Mk. 2F	98	$\frac{1}{8}$
Mk. 10D	122	$\frac{5}{32}$
Mk. 6E	196	$\frac{5}{32}$

The timing dimension is in all engines measured *before* top dead centre and, with the piston so positioned, the magneto contact points should be just about to open.

headlamp, the current for the tail lamp being controlled by the switch through a resistance so that the single-filament bulb can be fed by a dry battery for parking purposes. The new type of condenser-box assembly described on page 49, Fig. 16, is now fitted as standard, and is interchangeable with the old type as a complete assembly. A wiring diagram is shown in Fig. 26 and it should be noted that the one end of the lighting coils is earthed by being held underneath one of the coil cheeks, thus making contact with the armature-plate casting.

The assembly of the magneto components is clearly shown in Fig. 27.

The three-pole magneto as described above can be fitted to the original Junior autocycle engine, but as the output from the lighting coils is double that of the original two-pole magneto, it is necessary to change the bulbs as recommended on page 73.

SPARKING PLUG CHART

Recommended "Lodge" Types for Villiers Engines

Engine.	Capacity, c.c.	Plug.
Midget	98	C3
Junior	98	C14
Junior-de-Luxe	98	CB3
Mk. 1F and 2F	98	H14
VIIID and 9D	122	H3 or H1
10D	122	H14
VIIIC	147	C3
XIIC	148	CB3
Sports	172	CB3
Super Sports	172	HLS
1E and 2E	197	CB3
3E	197	CB3
5E	197	HLS
6E	197	HHN or HH14
XIVA	249	CB3
XVIIA	249	CB3
XVIII-A	249	CB3
XIV-B	346	CB3

CHAPTER VI

ELECTRIC LIGHTING SYSTEMS

SINCE about the year 1930 all lighting sets supplied with the Villiers engine have been the *direct* type. The term *direct* indicates that the alternating current from the magneto is taken direct to the head and tail lamps, the lamp bulbs being fed, therefore, only whilst the engine is running. With the introduction of the Mark 1F, 10D and 6E engines, both *direct* and *rectifier* sets are available, details being given in later chapters, but before describing the earlier types of *direct* lighting sets it may be of interest to riders of old machines to have details of the dynamo charging set in production prior to 1930.

Dynamo Charging Set

This lighting set consists of a flywheel magneto having two lighting coils and twin leads which are connected to the A.C. terminals of a Westinghouse metal-plate rectifier having special end brackets for attachment to the frame of the motor

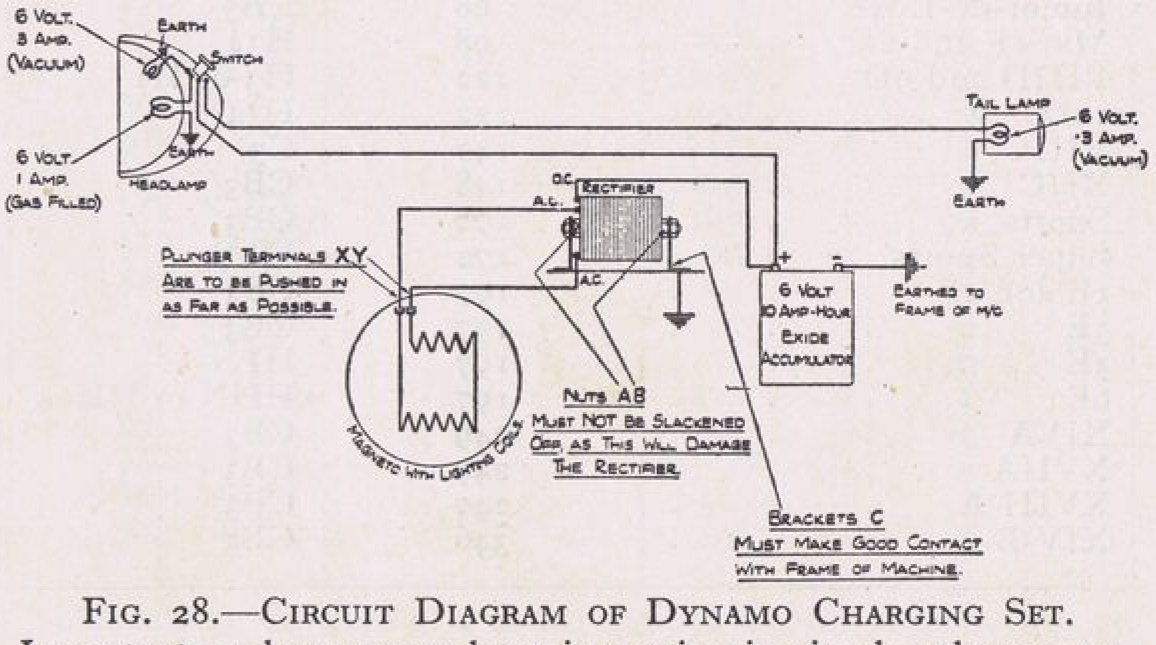

FIG. 28.—CIRCUIT DIAGRAM OF DYNAMO CHARGING SET.
Important: when accumulator is not in circuit, the plunger terminals should be disconnected.

cycle. The wiring diagram together with particulars of the correct bulbs to be used is given in Fig. 28.

A large number of these sets are still in use, and it may be of interest to owners to enumerate the necessary precautions to be taken to ensure satisfactory service :—

(1) Do not attempt to dismantle the rectifier; the nuts A and B must on no occasion be loosened or removed.

(2) Should it be necessary to remove the rectifier from the machine, the positive (+) terminal should be disconnected from the accumulator, and the plunger terminals X and Y should be pulled out of the armature plate.

(3) On no account should the engine be run when the accumulator is removed and the rectifier still in circuit; to prevent damage pull out the terminals X and Y.

(4) Make sure that the plunger terminals really make contact in their sockets.

(5) The brackets C of the rectifier must make metal-to-metal contact with frame of motor cycle.

(6) The rectifier must not be subjected to heat from the engine, but must be kept dry, as oil or water entering the rectifier casing will cause a short-circuit.

For details of bulbs to be used with this set see page 72.

Direct Lighting Sets

Two-pole Magneto without Parking Light.—This set was used with both the original large two-pole and small two-pole magnetos as already described, no provision being made for parking lights in head or tail lamps. The current was taken from the magneto direct to the headlamp switch which controlled both lamps, these being wired in series. The correct bulbs to use with these two magnetos are included in the list on page 72.

Two-pole Magneto with Parking Light.—With the improved small two-pole magneto, direct lighting sets having either a 5-in. or 7-in. headlamp were available, a dry battery for parking light being carried in a separate container fixed to the frame when the 7-in. lamp was used. The correct bulbs are listed on page 72.

Four-pole Magneto.—Similar lamps to those described above were available for use with the four-pole magneto, but owing to the greater output it was necessary to use a headlamp bulb of greater wattage. A single-filament tail bulb is used, the current from magneto passing through a resistance situated in the headlamp; this is necessary to prevent blowing of the filament, which is fed from the dry battery when parking. Later 7-in. pattern headlamps had double-filament bulbs fitted, control being by dipswitch on the handlebar. See page 72 for correct bulbs.

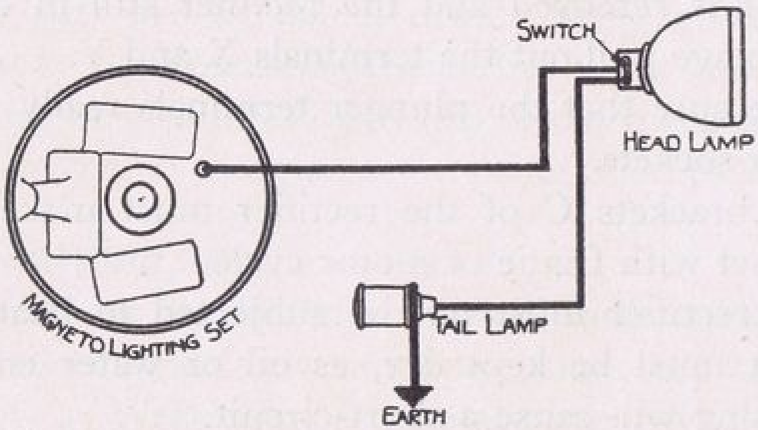

FIG. 29.—WIRING DIAGRAM FOR DIRECT LIGHTING SET—TWO-POLE MAGNETO WITHOUT PARKING LIGHT.

Direct Lighting Set with Six-pole Magneto.—This set when using a 24-watt bulb gives a driving light equal to the present-day light car, the output remaining practically constant at all engine speeds. Double-filament bulbs are fitted in head and tail lamps which, in the case of the tail light, eliminates the necessity for a resistance being provided in the wiring. As previously explained, magnetos giving 18 watts and 6 watts or, alternatively, 24 watts and 6 watts outputs are in use, but the lighting sets are identical except for the headlamp bulbs.

Before the war, headlamps of 5½ in. or 7 in. diameter were available together with the alternative bulbs mentioned above, but since 1940 only engines having the 5½-in. set have been in

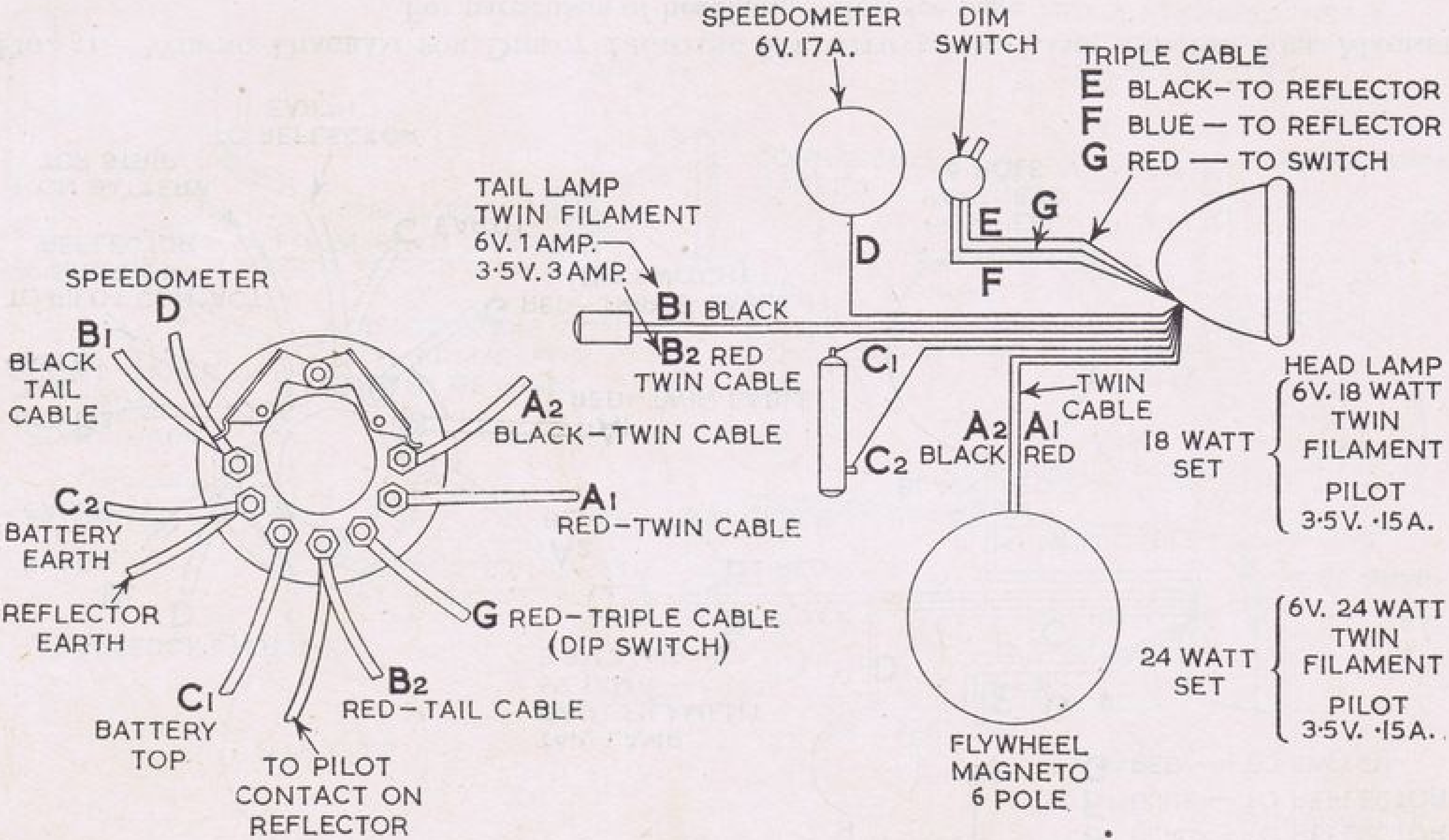

Fig. 30.—Wiring Diagram for Direct Lighting Set with 7-in. Lamp and Six-Pole Magneto.

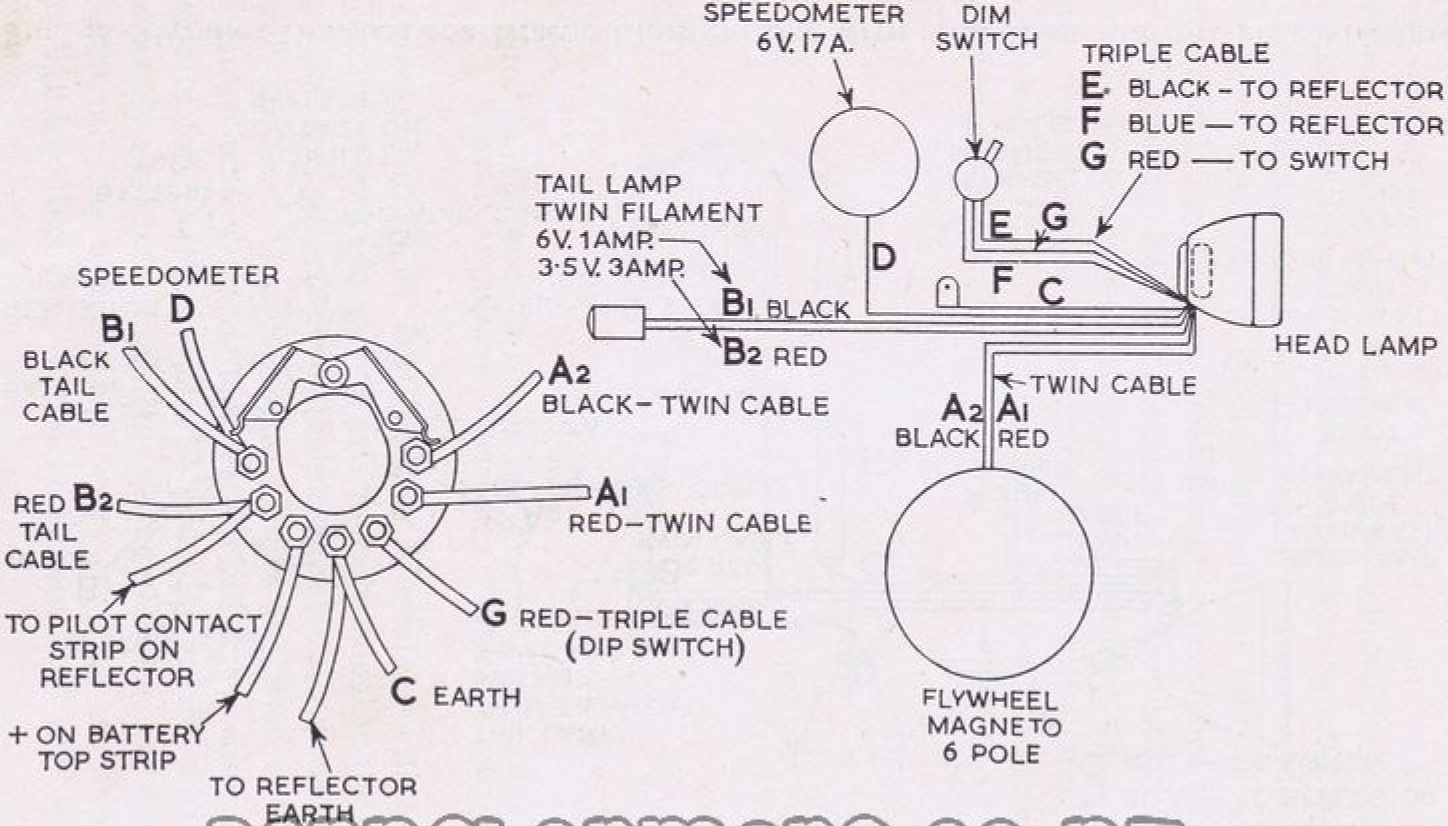

Fig. 31.—Wiring Diagram for Direct Lighting Set with 5½-in. Lamp and Six-Pole Magneto.
For particulars of headlamp bulbs, see page 72.

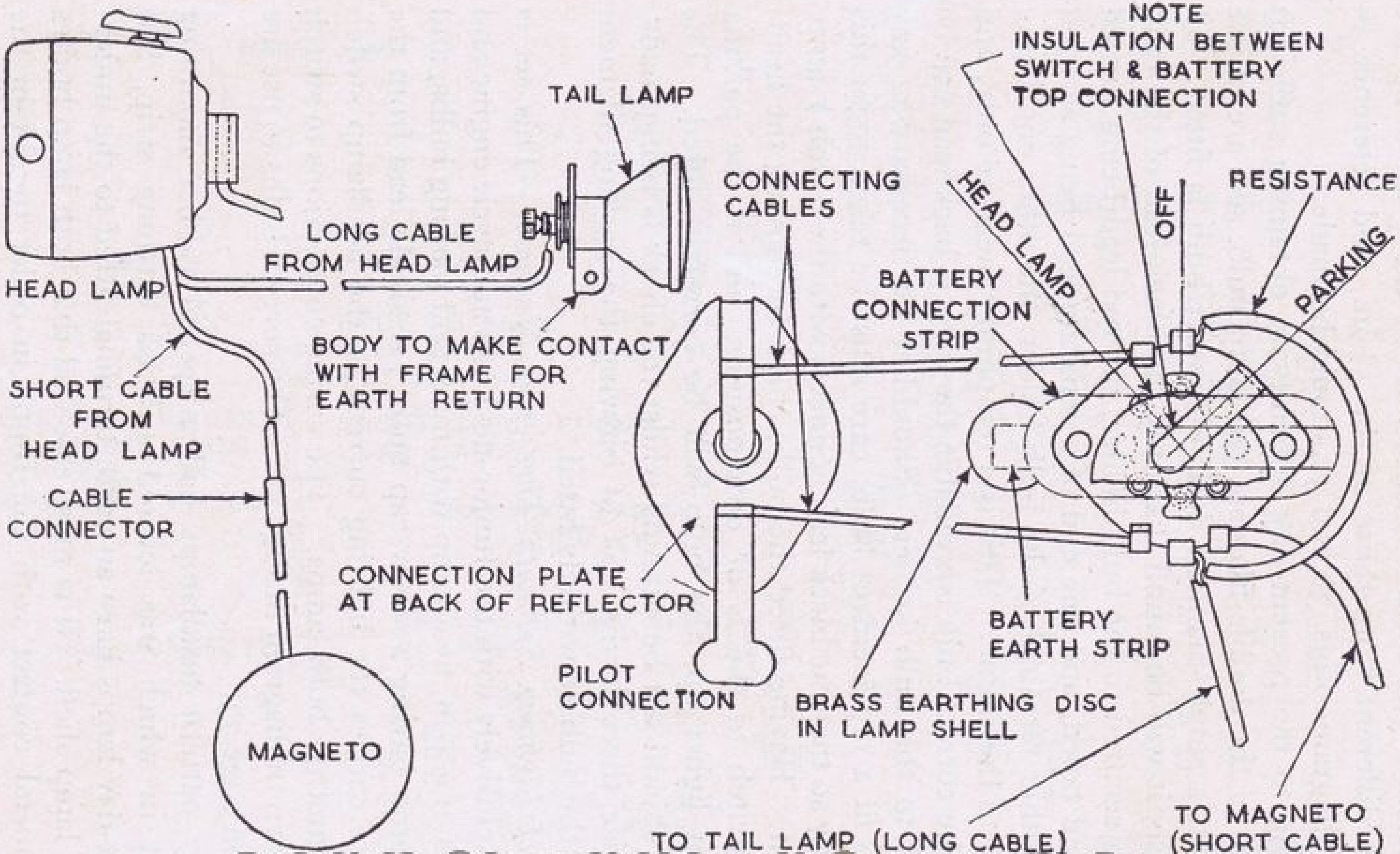

FIG. 32.—WIRING DIAGRAM FOR DIRECT LIGHTING SET WITH 4-IN. HEADLAMP AND THREE-POLE MAGNETO.

production. The switch connections in the 7-in. lamp are slightly different from those of the 5½-in., and reference to wiring diagrams Figs. 30 and 31 should be made.

Owing to the present-day difficulty in obtaining sufficient supplies of the double-filament tail-lamp bulb, sets are in use in which a single-filament double-contact bulb is fitted. In this case, it will be found that only the black lead of the twin cable is secured to the bulb holder, the red lead being turned back and taped, and one end of a separate lead being secured to the other terminal of the bulb holder, the other end being earthed to the frame. This is a temporary measure only, and when the correct bulb is available the turned-back lead can be refitted to the bulb holder. Should it be necessary at any time to fit a replacement bulb, care must be taken to fit this correctly so that the black lead connects with the 6-volt 1-amp. filament. Having fitted the bulb, check by moving the head-lamp switch to the L or dim position, and if the parking filament lights up, the bulb will be correctly fitted. The engine should not be running whilst the check is being made, otherwise there is the risk of blowing the parking filament should the bulb be wrongly fitted.

Direct Lighting Set with Three-pole Magneto.—This set is used exclusively with the Junior-de-Luxe autocycle engine and consists of a 4-in. headlamp with main and parking bulbs, and a tail lamp having a screw-cap bulb. A single lead from the magneto carries the lighting current to the headlamp switch which controls both lamps. The wiring connections to switch are shown in diagram in Fig. 32. The correct bulbs to use are given on page 73.

Early pattern headlamps had a special rubber mounting bracket in which was located a brass earthing strip, but present-day lamps have an earth terminal fitted to the under-side of lamp shell. It is most essential that both lamp bodies make metal contact with the frame in order to obtain the maximum light.

There are probably still in use a number of headlamps in which is fitted a single bulb which did duty for the main and

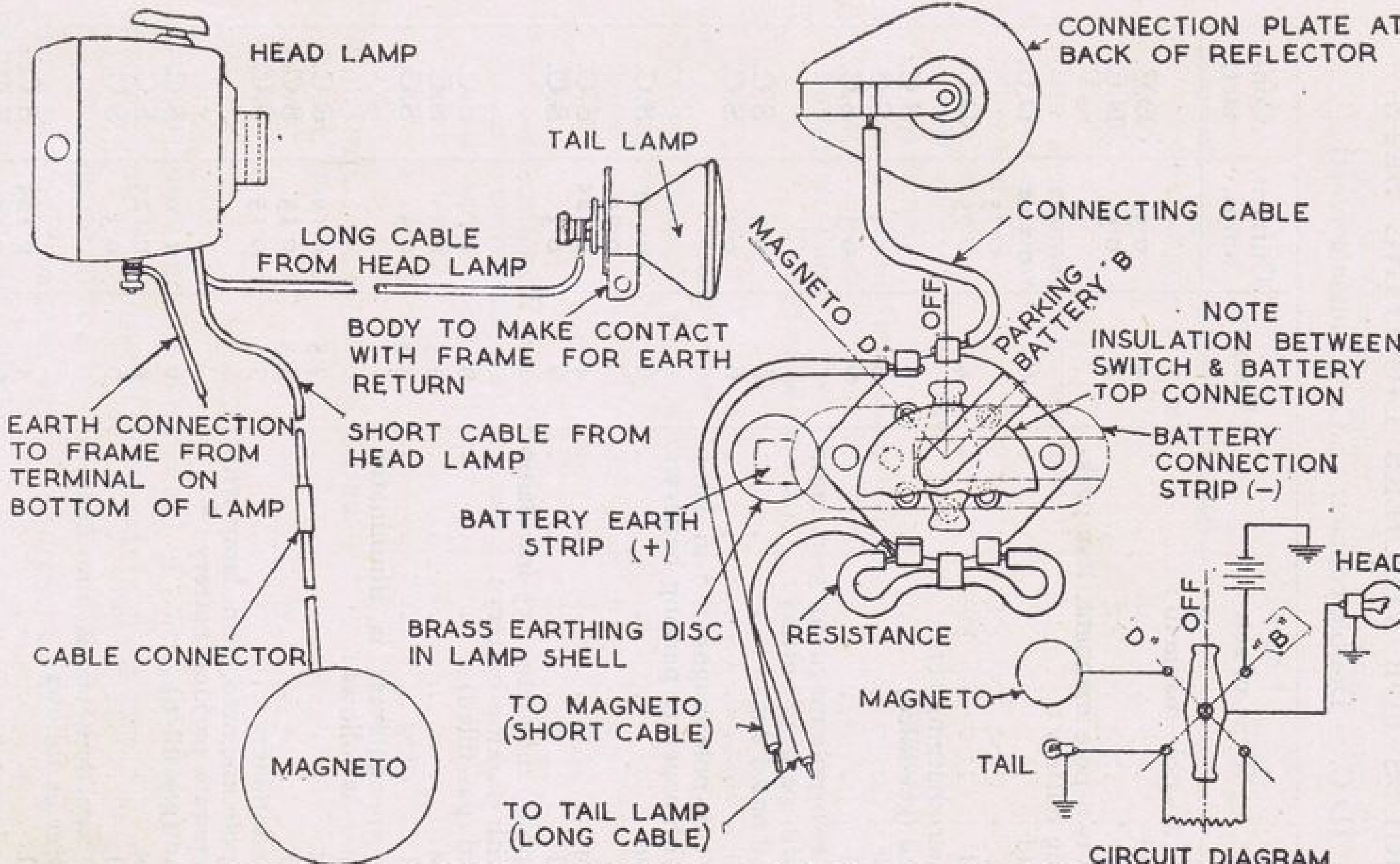

FIG. 33.—WIRING DIAGRAM FOR LIGHTING SET WITH HEADLAMP HAVING SINGLE BULB FOR MAIN AND PARKING.

BULBS FOR VILLIERS LIGHTING SETS

(D.C. = Double contact. S.C. = Single contact)

Type of set.	Voltage.	Current, amps.	Contact.
Large two-pole magneto :			
Head	4	0·5	D.C.
Tail	4	0·5	D.C.
Small two-pole magneto, less parking battery :			
Head	6	0·5 or 0·75	D.C.
Tail	4	0·75	D.C.
Rectifier charging set :			
Head (gas-filled)	6	1	S.C.
Pilot	6	0·3	S.C
Tail	6	0·3	S.C.
Small two-pole magneto, 5-in. lamp with parking battery :			
Head and Pilot	6	0·5	S.C.
Tail	6	0·3	S.C.
Small two-pole magneto, 7-in. lamp with separate parking battery :			
Head	6	0·5 or 0·75	S.C.
Pilot	4	0·125	S.C.
Tail	6	0·3	S.C.
Four-pole magneto, 5½-in. lamp with parking battery :			
Head (gas-filled)	6	1	S.C.
Pilot	3·5	0·3	S.C.
Tail	3·5	0·3	S.C.
When speedometer is illuminated alter as follows :			
Pilot	3·5	0·15	S.C.
Tail	3·5	0·15	S.C.
Speedometer	3·5	0·15	S.C.
Four-pole magneto, 7-in. lamp with separate parking battery : *			
Head (gas-filled)	6	1	S.C.
Pilot	4	0·125	S.C.
Tail	6	0·3	S.C.
When speedometer is illuminated alter as follows :			
Tail	4	0·125	S.C.
Speedometer	6	0·17	S.C.

* When a dip-switch is fitted, fit a 6-volt 6/6-watt double-filament bulb.

BULBS FOR VILLIERS LIGHTING SETS (*continued*)
(D.C. = Double contact. S.C. = Single contact)

Type of set.	Voltage.	Current, amps.	Contact.
Two-pole magneto fitted to original 125-c.c. engine–gear unit:			
Head	6	0·5	S.C.
Pilot	3·5	0·3	S.C.
Tail	3·5	0·3	S.C.
When speedometer is illuminated alter as follows:			
Pilot and Tail	3·5	0·15	S.C.
Speedometer	3·5	0·15	S.C.
Six-pole magneto, 5½- and 7-in. headlamps:		(watts)	
18-watt: Head (double-filament)	6	(18/18)	D.C.
24-watt: Head (double-filament)	6	(24/24)	D.C.
Both sets: Pilot	3½	0·15	S.C.
Tail (double-filament)	6	6-watt/ 3·5-volt 0·3 amp	D.C.
Speedometer	6	0·17	S.C.
Two-pole magneto, Junior autocycle engine:			
Head	6	0·5	S.C.
Pilot	4	0·3	S.C.
Tail	3·5	0·3	S.C.
Three-pole magneto, Junior-de-Luxe autocycle engine, with separate main and parking bulbs:			
Head	6	1	S.C.
Pilot	4	0·3	S.C.
Tail	4	0·3	S.C.
With single bulb for main and parking light:			
Head	6	1	S.C.
Tail	4	0·3	S.C.

parking lights, and for the benefit of owners a diagram of the wiring connections inside this lamp is given (see Fig. 33).

The magneto fitted to the original Junior autocycle engine was a two-pole pattern, and the correct bulbs to use with the lighting set are listed above.

The lighting sets used in post-war engines are described in later chapters.

CHAPTER VII

THE VILLIERS CARBURETTER

BEFORE giving details of the various types and models in use, it may be of interest, particularly to novices, to briefly describe the action of the carburetter.

The function of the carburetter is to supply the engine with a mixture of petrol and air which, when compressed by the piston of the engine, is ignited by the spark from the magneto.

Petrol-Air Mixture Supply

Liquid petrol issues through the jet orifice into a stream of rapidly moving air, by which process it is converted into a highly atomised vapour. The vacuum created in the crankcase sucks this vapour through the choke, or bore, of the carburetter, the amount passing into the crankcase being controlled by the throttle slide, the strength of the vapour or mixture depending on the proportion of petrol emerging from the jet and the air passing through the carburetter.

In most carburetters the size of the jet is fixed so that a set quantity of petrol with air is constantly fed to the engine. This proportion is determined for average running, but obviously it is desirable to vary this according to the engine requirements, because at times a much richer mixture, *i.e.*, a greater proportion of petrol to air, may be needed.

In the Villiers carburetter, the amount of petrol that is allowed to issue from the jet is automatically proportioned to the amount of air that is allowed to enter the crankcase, from which it follows that a wider range of engine conditions is covered than is the case in which the carburetter has a fixed jet.

The carburetter is entirely automatic in its operation, and gives a correctly adjusted mixture over the whole range of throttle opening. This is obtained by the taper needle attached to and working with the throttle, and to the special method of compensation employed.

Rich Mixture for Starting

An independent adjustment of the taper needle is provided on some models to give a specially rich mixture at times when required, such as when starting a cold engine, the methods employed to obtain the adjustment being as follows:—

(1) By a vertical rod engaging with a special quick-thread in the centre of the throttle, and which raises or lowers the taper needle $\frac{1}{4}$ in. for one complete turn. The bar is screwed right-hand so that turning anti-clockwise raises the needle, thereby richening the mixture. Should the throttle control cable restrict the required amount of turn, holes in the side of the bar give alternative positions for the operating rod (see Fig. 34).

(2) By a Bowden-operated control fitted to the handlebar. The nipple soldered to end of inner cable rests against the head of taper needle, which is kept in contact with the nipple by a spring, so that when the inner cable is moved up and down, the needle follows because of the spring pressure. The control is marked " rich " and " weak " to indicate the needle setting. On no account should the control lever be used as an ordinary " air-control lever " is used. It should remain stationary except when deliberately wishing to alter the size of the jet for starting from cold, or when an extra-rich mixture is required.

The carburetter described above is known as the " two-lever " pattern, and the construction, which is similar for Lightweight and Middleweight types, is shown in Fig. 35.

Action of the Carburetter

The action of the carburetter is very simple, and reference to the sectional drawings, Figs. 34 and 35, will make it clear.

Depressing the float by means of the tickler situated at the side of the body causes the petrol to rise and thereby creates a well of petrol at (*a*), which is sucked into the cylinder via the crankcase at the first kick of the starter. The size or area of the jet orifice (*b*) is controlled by the taper needle (*c*) with the opening and closing of the throttle, but for starting from cold

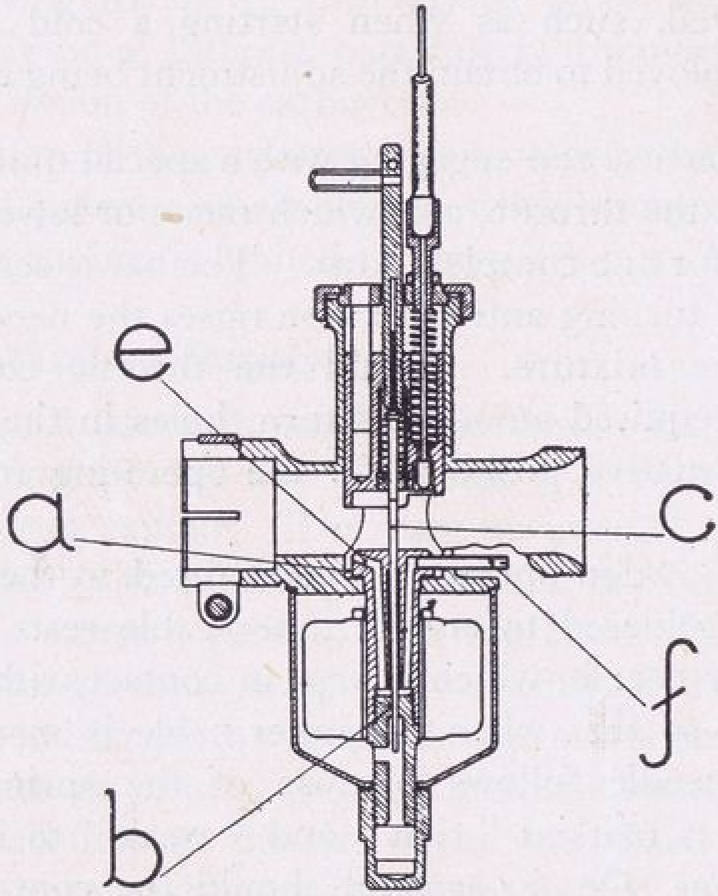

FIG. 34.—SECTIONAL ARRANGEMENT OF SINGLE-LEVER CARBURETTER.

the taper needle is raised in the jet independently of the throttle by means already explained. When the engine is warmed up the needle is lowered to weaken the mixture for normal running. The position of the needle relative to the throttle will then not be required to be altered until again starting from cold.

The automatic compensating action of the carburetter is now described. The mixture is supplied by the carburetter in two ways—first, by the suction of the piston on the orifice (*e*), and secondly, by the force of the head of petrol through the jet (*b*) which is always submerged.

The suction of the engine on the orifice (*e*) draws air through the compensating tubes (*f*) across the top of the jet (*b*), where it mixes with and breaks up the petrol, and so issues from (*e*) into the main air stream as a partially atomised vapour.

If the load on the engine is increased, so reducing the

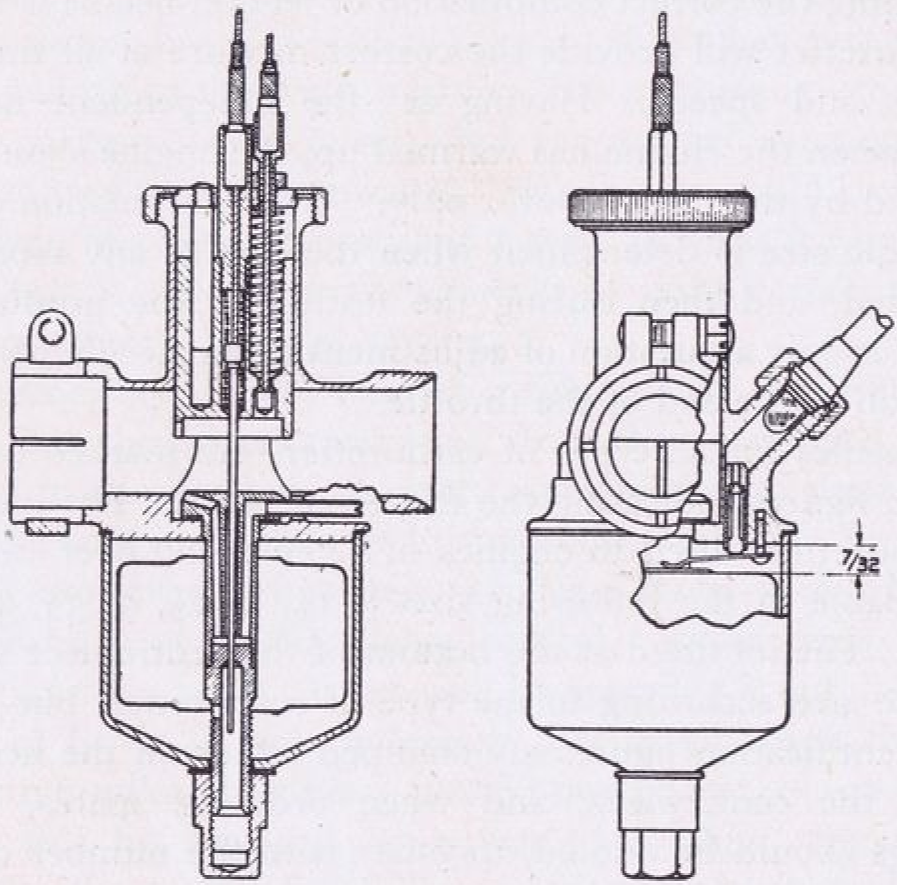

FIG. 35.—SECTIONAL ARRANGEMENTS OF TWO-LEVER CARBURETTER.

engine speed, as, for instance, when climbing, the suction on the orifice (*e*) is reduced. This would weaken the mixture but for the fact that the petrol issuing from the jet (*b*) is constant, thereby richening the partially atomised vapour coming through (*e*), the combined effect being that the mixture strength remains constant irrespective of engine speed or load. The main jet being in the centre of the float chamber, the mixture is not upset by the tilting of the machine. In the original Villiers carburetter, the needle controlling the entry of petrol into the carburetter rested directly on the float, but for some years a lever giving increased pressure on the needle seating has been interposed between the bottom end of needle and top of float. Should this lever become damaged or bent it should be reset to give a distance of $\frac{7}{32}$ in. between top of float and underside of carburetter body.

Tuning the Carburetter

Providing the correct combination of jet and needle is used, the carburetter will provide the correct mixture at all throttle positions and speeds. Having set the independent needle control when the engine has warmed up, the engine should be controlled by the throttle lever only. The combination of jet and needle size is determined when the first of any model is type-tested, and then during the testing of the production model it is only a question of adjustment to the needle position in relation to the end of the throttle.

All needles for all types of carburetters are marked on the side, the figures indicating the degree of taper. For most of the carburetters fitted to engines of 147 c.c. and over needles are available in the following sizes: $1\frac{1}{2}$, 2, $2\frac{1}{2}$, 3, $3\frac{1}{2}$, 4, $4\frac{1}{2}$, 5, 6, 7. The jet fitted at the bottom of the centrepiece varies in orifice size according to the type of carburetter, but in all cases identification figures are stamped either on the head or side of the centrepiece, and when ordering spares, these markings should be quoted, together with the number of the engine to which the carburetter is fitted. In no case should the jet be removed from the centrepiece, as this component cannot be supplied separately as a spare part.

To tune the carburetter, first obtain, by altering the jet-control lever, the most satisfactory position of the needle for slow running on the road when the engine is warm, and then open the throttle lever quickly. If the engine dies out it shows that the mixture is too weak, and a needle with a greater degree of taper should be fitted. If it is found possible to open it quickly and the engine is inclined to hunt, the mixture is obviously too "rich", and a needle with less taper should be fitted.

Again the mixture is shown to be too " rich " if when running at speed and the throttle is closed the engine hesitates or momentarily ceases to fire. When the needle best suited for speed is obtained, it will be the best one for economy and power.

Best Position for Jet Lever

There is no definite rule as to the best running position of the jet lever, but it is wise to set it so that when turned as far as it will go to the weak position, the mixture is actually too weak to run. This means that for normal running it will have to be a little way towards " rich ", and would always give a margin of safety, otherwise if it were as far as it would go in the weak position, one would never be quite certain that one was running on the best setting.

If necessary, in the case of a single-lever carburetter, the small bar should be unscrewed from the needle rod and replaced in another hole at right angles to the previous one, so that the needle rod may be turned round farther. In the case of the two-lever carburetter, there is a screw with a lock-nut on the body of the handlebar control. By screwing this in, the mixture is made weaker, and by screwing it out, it is made " richer ". It is very necessary that at all times the compensating tubes are clear. Should one be lost, on no account must this be replaced by a screw or plug. Should this be done the carburetter will not function satisfactorily.

TYPES OF CARBURETTER IN USE

Lightweight and Middleweight Carburetters

The types of carburetter previously described are known as the single-lever carburetter and the two-lever carburetter, and these are made in two sizes, namely, the Lightweight and Middleweight types.

The Lightweight is made to fit on a stub 1 in. in diameter and the Middleweight pattern is for a $1\frac{1}{8}$-in. stub; the other main differences are the diameters of the choke, throttle and float chamber. The construction of both types is generally as shown in Figs. 34 and 35.

To Change the Taper Needle—Single-lever Carburetter

In early pattern carburetters, the needle-adjuster rod, which is screwed in the centre of throttle, was split and bulged on the end to prevent rotation due to vibration. To change the needle, remove carburetter from inlet manifold or cylinder, and unscrew the knurled top ring, when the throttle with needle can be withdrawn from the carburetter body. Unscrew the rod in centre of throttle; the taper needle with spring can then be pushed out from underneath.

Nowadays a special S-shaped damper is fitted, having a centre lip extended to engage in the slot cut in the end of the adjuster rod, so that the taper needle has to be removed from the bottom of the throttle. Before this can be done, however, the slotted, screwed bush surrounding the needle has to be undone; this is best done by using a special screwdriver made from a piece of tube long enough to clear the needle end, and having two tongues on the end to engage in the slots in the bush.

To Change the Taper Needle—Two-lever Carburetter

Remove the throttle with needle from the carburetter body as explained for the single-lever model. The needle, however, has to be removed from the top of the throttle, but before this can be done the hexagon throttle extension which carries the needle control cable has to be unscrewed; the needle with the spring under the head can then be pushed up through throttle.

It is advisable to fit a new spring when replacing the needle, because the old one may have taken a set, and it is very essential that the head of needle is kept in contact with end of control cable. Fit the new spring with the small end-coil next to head of needle. Replace throttle and top ring exactly as for the single-lever carburetter.

Dismantling Carburetter

Remove from engine and withdraw throttle as already explained. Turn carburetter upside down and unscrew nut securing float chamber. Remove the fibre washer, then float cup and fibre joint washer between cup and body. On older type carburetters not having the fuel needle lever fitted, the fuel needle will now be exposed, and will drop out if the body is turned over. When it is required to remove the fuel needle where the lever is fitted, it is first necessary to remove the centrepiece, and before this can be done, the compensating tubes have to be unscrewed from the head of the centrepiece. Under the head of centrepiece is fitted a fibre washer, which must be in position when reassembling. Having pushed the centrepiece up through the throttle bore, the fuel-needle lever can be swung on one side to allow the needle to come out.

Carburetters having a nut-and-nipple connection for the fuel pipe have filter gauzes inside the screwed connection in the body. At one time a cup-shaped filter was fitted at the bottom of the hole in addition to the detachable visible filter at the top, but the top filter only is now fitted, and with this in position the bottom filter should be removed. The body is now ready for cleaning, which is best done with petrol and a brush, and compressed air where available.

Reassembling Carburetter

First examine the body, making sure that the two small vent holes in the circular-shaped flange are clear. (In later models air enters the float chamber via the tickler.) Before refitting the fuel needle examine the taper portion, and if found to have any ridges or to be pitted, a new needle should be used. Should flooding occur after assembly the seating in the fuel bush can be remade by gently tapping the exposed end of the needle whilst in position, the needle lever, of course, being swung round out of the way. Next fit the centrepiece with fibre washer in position under head, and shank of centrepiece between the fork of fuel-needle lever; then screw in compensating tubes, using just sufficient force to tighten without damaging the slotted end. Place float on centrepiece, and check distance between float and underside of body, which, with float resting on fuel-needle lever, should measure $\frac{7}{32}$ in. Correct, if necessary, by bending the lever.

Refit the fibre float-cup washer, then the cup after having examined the top face and removed any foreign matter, followed by the small fibre washer, and lastly the bottom nut, which should be tightened only sufficiently to secure a petrol-tight joint. If too much force is used there is the danger of stripping the thread on the centrepiece.

When refitting the carburetter to engine, make quite certain that the body is pushed on to the manifold or cylinder stub as far as possible. There are two or four narrow slots in the body to allow the securing clip to function, and if the stub does not extend past the end of the slots, air will be sucked in, causing hard starting and erratic running. This point can be checked whilst the engine is running by putting a drop of thin oil on each slot; if there is a leakage the oil will be sucked in. If the carburetter will not push farther along the stub, a cure can be effected by binding with insulating tape.

Air Cleaners

Most present-day motor-cycle engines have an efficient air filter fitted to the carburetter when sent out, this usually being an oil-wetted pattern which requires cleaning about every 2000 miles or even less if the weather is dry and dusty.

The filter should be cleaned by dousing in petrol and then, when dry, immersing in thin engine oil. Allow to drain before refitting. This type of filter with a screwed adaptor for fitting to carburetter intake can be supplied to suit any of the older types of carburetter.

Midget Carburetter

This model was introduced at the same time as the Midget engine, and for some time was fitted exclusively to this model. Later it was used with the original 125-c.c. (Mark VIII-D) engine-gear unit, and also for certain Mark 9D engines.

The carburetter body is made to fit on a stub $\frac{7}{8}$ in. diameter, and can be identified by the word Midget inscribed on the knurled top ring. Throttle control is by a single lever only, the adjuster to take up cable slack being screwed into the centre of the top ring. A single compensating tube is fitted to the head of the centrepiece, the slotted end of the tube being visible in the centre of the choke after removal of end-cap or filter.

To change or adjust the taper needle, remove the throttle

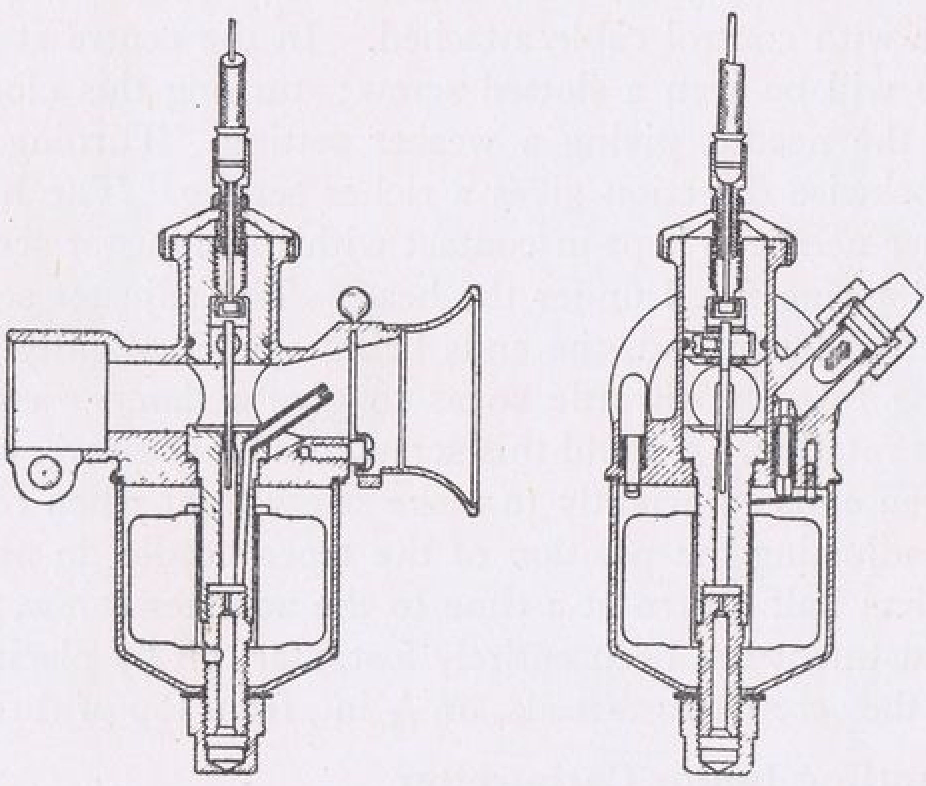

FIG. 36.—SECTIONAL ARRANGEMENTS OF MIDGET CARBURETTER.

with control cable after having unscrewed the top ring. In the side of the throttle will be seen the slotted head of a screw, but before this can be unscrewed, the retaining ring lying in the groove around the throttle must be removed. This retaining ring is fitted as a precaution against the screw entering the engine should it become detached from the centre sleeve. The taper needle is held by this screw in the sleeve, the adjustment being provided to obtain the initial setting to suit individual engines. The carburetter is dismantled as already described for the larger types, but to assist the user a sectional drawing, Fig. 36, showing the construction is reproduced. The fuel-needle lever, which is interposed between top of float and end of needle and is common to all carburetters, is clearly shown.

Junior Carburetter

This carburetter was originally made when the Junior autocycle engine was introduced, and whilst the action is similar to the Midget carburetter, the construction details vary in several respects.

Taper-needle Adjustment.—Unscrew top ring and remove throttle with control cable attached. In the centre at top of throttle will be seen a slotted screw; turning this clockwise lowers the needle, giving a weaker setting. Turning in an anti-clockwise direction gives a richer setting. The head of the taper needle is kept in contact with the adjuster screw by the coil spring fitted under the head. The adjuster screw is split at the lower end, the ends being opened slightly before screwing into the throttle so as to give a damper effect to prevent rotation. Should this screw lose its pressure, remove and open ends sufficiently to make screw tight when refitted. When adjusting the position of the taper needle do not give more than half a turn at a time to the adjuster screw, and if the adjustment has been entirely lost, start off by placing the end of the screw two threads, or $\frac{1}{16}$ in., from top of throttle.

Dismantling Junior Carburetter

Dismantling is carried out in the same manner as with the Midget-type carburetter, with the exception that there is no compensating tube to be removed before the centrepiece can be taken out.

Reference to Fig. 37 will show that the air enters the centrepiece along a hole drilled in the body itself, but to ensure that this hole matches up with the hole in the centrepiece, the latter component has to be located correctly. This is done by a small screw situated below and at the left side of the petrol union. This screw has to be removed before the centrepiece can be raised, and of course replaced when the centrepiece is refitted.

The fuel-pipe connection to carburetter consists of a banjo sweated to the pipe and secured to the carburetter body by a bolt on which are fitted two fibre joint washers and a gauze filter. This filter should be cleaned occasionally in petrol, and when refitting, the fibre washer with the larger hole should be fitted next to the head of the bolt. Do not use excessive pressure when tightening the bolt, otherwise there is a danger of stripping the thread inside the body. Remove the air-

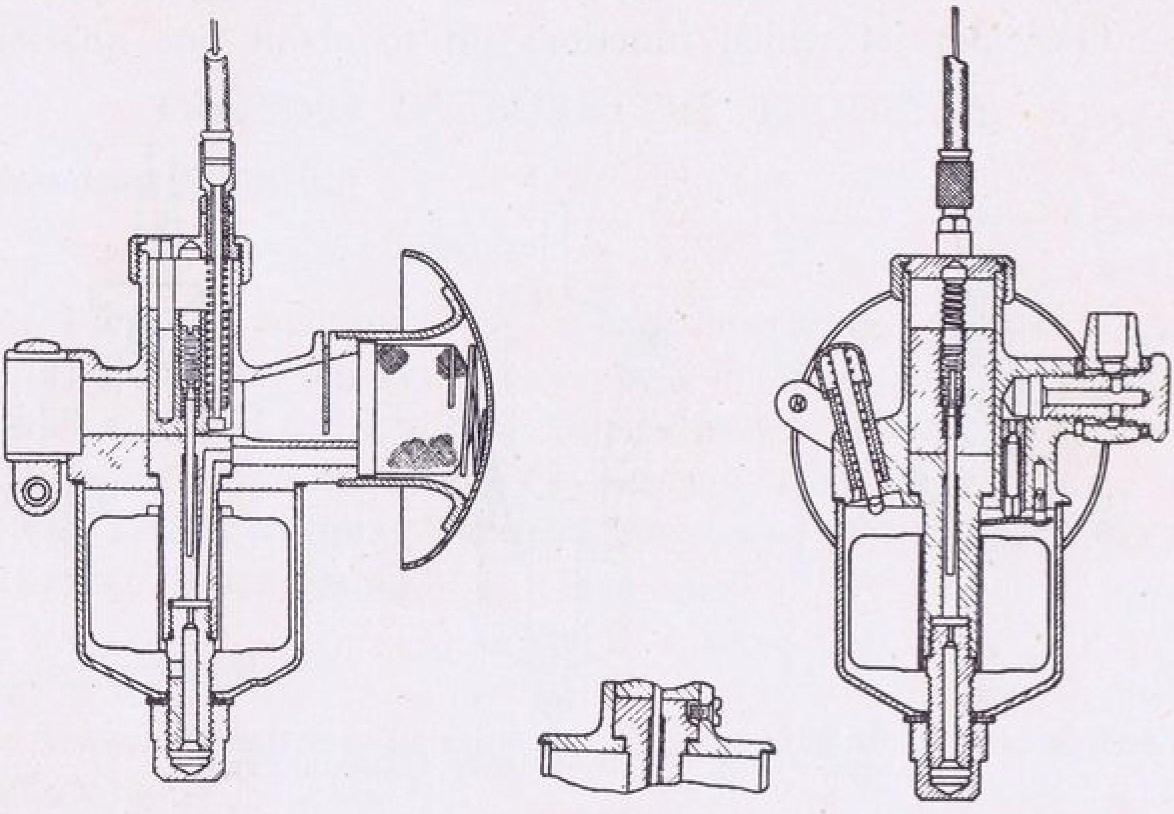

FIG. 37.—SECTIONAL ARRANGEMENTS OF JUNIOR CARBURETTER.

filter dome by unscrewing and clean the detachable filter by dipping in petrol.

The carburetter fitted to the Junior-de-Luxe engine has the petrol union on the opposite side to that of the original Junior-pattern carburetter, but apart from this feature the two carburetters are identical. The Junior-de-Luxe pattern can be used with the original Junior engine, but not vice versa.

Heavyweight Carburetter

This carburetter was made for and fitted only to the Mark XVIII-A engine, prefix letters UU, and as production of this engine as a motor-cycle power unit was discontinued early in the late war, the numbers in use are small compared with the other models already described.

One model only was made, having two-lever control, one to the taper needle (N) and the other to the throttle, but features such as pilot jet, inverted fuel needle (C) and a stub diameter of 1¼ in. were peculiar to this type only.

The sectional drawing, Fig. 38, shows the construction clearly.

The pilot jet which functions up to about one quarter

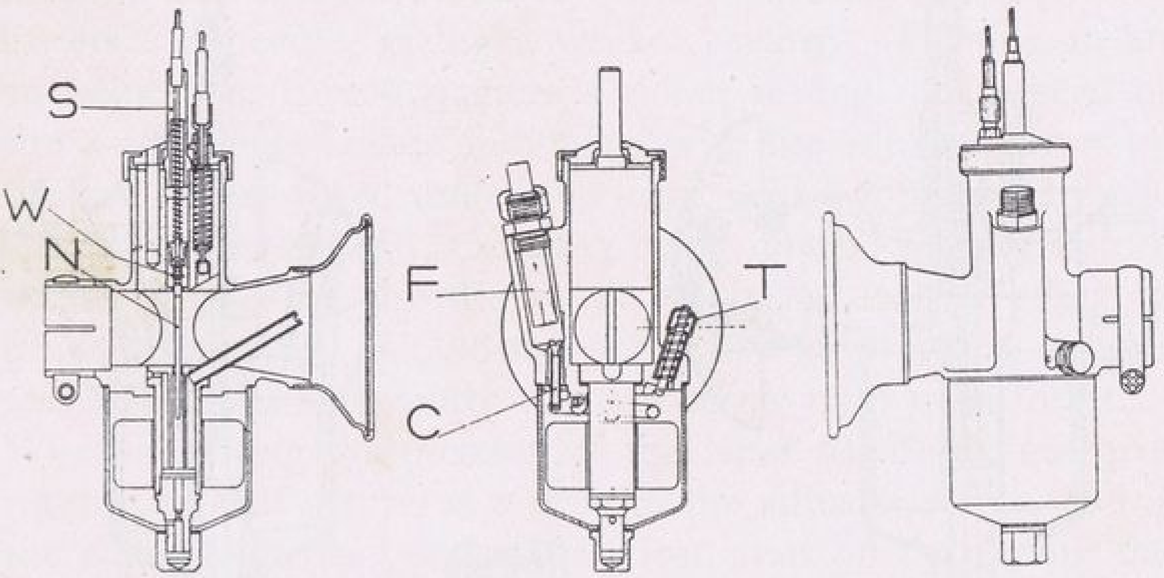

Fig. 38.—The Heavyweight Carburetter.

throttle opening is adjusted by a knurled screw situated at the base of the throttle chamber. To enrich the mixture, screw in clockwise, thereby reducing the air supply across the jet. A No. 2 needle is fitted as standard, and the position in relation to the end of throttle is adjustable irrespective of the lever control for raising the needle for cold starting. To adjust the needle unscrew the top sleeve (S) from the throttle, when the needle and holder will follow attached to the inner cable. The needle is held by a U-shaped wire (W) engaging with one of the several grooves in the needle. Extract the wire and reinsert in a higher or lower groove to give a richer or weaker mixture.

The fuel filter (F) is removable by unscrewing the hexagon union, and should be cleaned occasionally in petrol. Pressing the tickler (T) raises the fuel needle from the detachable seating, allowing fuel to enter the float chamber. The central compensating tube must be unscrewed before the centrepiece can be removed.

This carburetter was fitted to the first Mark 3E engines, prefix letters V.V., but later the Middleweight two-lever pattern of carburetter was used for these engines.

TRACING CARBURETTER TROUBLES

Constant Flooding

Flooding may be caused by :—

(1) Foreign matter on the fuel-needle seating.

(2) Dirt between centrepiece and float, causing jamming which prevents the float pressing against the fuel-needle lever.

(3) Punctured float made too heavy by entry of petrol.

(4) Tickler jamming when depressed, due to dirt or perhaps a broken return spring.

Spitting Back

A weak mixture is usually the cause and may be due to the following :—

(1) Incorrect setting of the taper needle control, which should be moved towards the " Rich " position.

(2) Restricted fuel supply to carburetter caused by :—

- (*a*) Dirty filter on petrol tap or in carburetter union.
- (*b*) Blocked petrol pipe.
- (*c*) Vent hole in filler cap of tank being partially obstructed.
- (*d*) Vent hole in carburetter body. In the Lightweight, Middleweight and Midget carburetters there are two vent holes in the base of the body, but in the Junior, Heavyweight and some of the later Lightweight models, the vent hole is in the tickler cap.

STANDARD CARBURETTER SETTINGS

Engine.	Capacity, c.c.	Carbu-retter.	No. of jet.	Taper needle.
Mk. VI-C . .	147	L/W	3	2½
Mk. VII-C . .	147	L/W	3	2½
Mk. VIII-C . .	147	L/W	3	2½
Mk. VI-A . .	247	M/W	3	2½
Mk. VII-A . .	247	M/W	3	2½
Mk. VIII-A . .	247	M/W	3	3
Mk. IX-A . .	247	M/W	3	4
Mk. IX-B . .	342	M/W	3	5
Sports . . .	172	M/W	3	3
T.T.S.S. . .	172	M/W	3	3½
Mk. 1E . .	196	M/W	3	3½
Mk. 2E . .	196	M/W	2	4
Mk. 3E . .	196	M/W	2	5
Super Sports .	196	M/W	2	4
Mk. IX-BA . .	342	M/W	2	5
Mk. X-A . .	247	M/W	2	5
Mk. XVI-A . .	247	M/W	2	5
Mk. IX-BA . .	247	M/W	2	5
Mk. XIV-A . .	249	M/W	2	5
Mk. XVII-A .	249	M/W	51	2 Special
Watercooled .	249	M/W	2	6
Mk. XII-C . .	148	M/W	2	4
Mk. XV-C . .	148	M/W	2	4
Mk. XIV-B . .	346	M/W	2	5
Midget . .	98	Midget	8	5½ Midget
Junior . . .	98	Junior	8J	2
Junior-de-Luxe .	98	Junior	7J	2
Mk. VIII-D .	125	Midget	8	6
Mk. 9D . .	125	Midget	8	6
Mk. 9D . .	125	L/W	3	3
Mk. 9D . .	125	L/W	3	3 Special
Mk. 1F . .	98	Type 3/1 Type 6/0	8 (Type 6/0)	20 (Type 6/0
Mk. 2F . .	98	Junior	8J	2½
Mk. 10D . .	122	Type 3/4	0·083	3
Mk. 6E . .	196	Type 4/5	0·081	4½

The L/W Type 3/1 carburetter has the internal adjustment to taper needle as shown in Fig. 60, p. 129.

(*e*) Water in petrol. This may only be in the carburetter, in which case remove the bottom nut of float cup and drain off, having first of all shut off the supply from tank.

(*f*) Fuel needle stuck in its seating, thus preventing fuel entering the float chamber.

(3) Air leaks where carburetter fits on to manifold or cylinder; the body must be a good fit, and pushed right on. A worn throttle slide will allow extra air to enter and thereby upset the mixture, and also allow the slide to flutter in the body, causing a rattle sometimes difficult to locate.

Engine Will Not Stop

When the throttle lever is in the closed position, the end of the throttle must rest on the top of the centrepiece, otherwise mixture will continue to be drawn into the crankcase. To check, remove the end-cap, or filter, and if the throttle is not right down, lower it by screwing in the cable adjuster at top of carburetter. If the full adjustment will not allow the throttle to fully close, the outer cable is probably trapped or has too many bends in it, which, in effect, shortens the inner cable, thus preventing the full movement. Another cause may be binding of the throttle due to dirt. The remedy is to remove throttle, clean and smear with a little thin oil before replacing.