

# LUCAS

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## EQUIPMENT

VOLUME 2

### WORKSHOP INSTRUCTIONS

#### MOTOR CYCLE ALTERNATORS

**MODELS RM13, 14, 13/15, 15 AND 5AF**  
(With Notes on the Energy Transfer System)



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# LUCAS WORKSHOP INSTRUCTIONS

## MOTOR CYCLE ALTERNATORS

MODELS RM13, 14, 13/15, 15 AND 5AF

(With Notes on the Energy Transfer System)

### 1. GENERAL

#### (a) SIZES OF ALTERNATOR

Motor cycle alternators comprise a six-pole permanent magnet rotor and a six-limbed laminated iron stator. The rotor is driven by an extension of the engine crankshaft while the stator is located in the crankcase or chain case. The rotor has an hexagonal steel centre, each face of which carries a high-energy magnet keyed to a laminated pole tip, as shown in Fig. 1. The six pole tips are riveted to brass end plates. This assembly is cast in aluminium and then machined to give a smooth external finish. Five-inch diameter stators, of differing thicknesses, have been used for all models except RM14, for which thick, intermediate and thin hexagonal stator packs of  $5\frac{7}{8}$ " A/F ( $5\frac{7}{8}$ " spigot dia.) were used. Two rotor lengths are used. Alternator, model RM13/15 utilises the RM13 stator pack with the longer rotor as fitted in model RM15, in order to obtain output characteristics intermediate between these two.

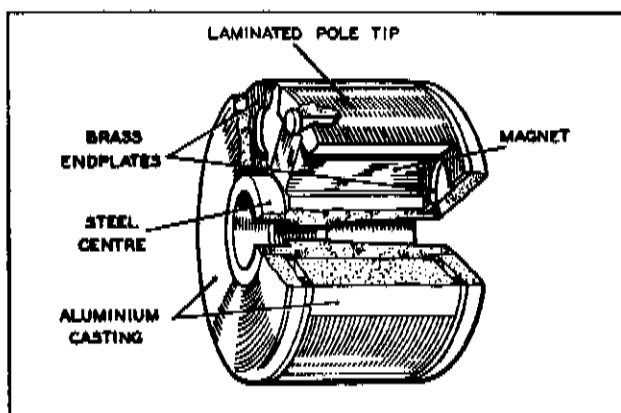


Fig. 1 View of rotor, sectioned

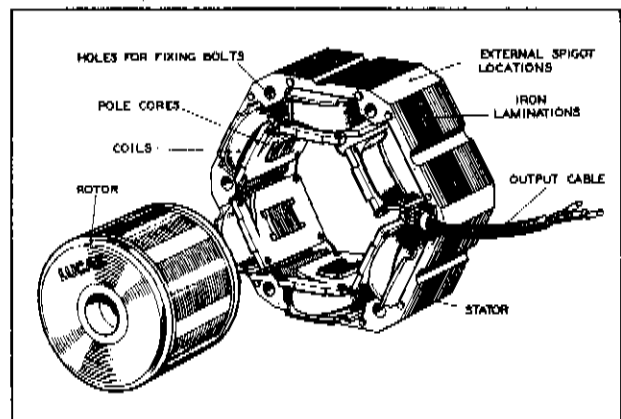


Fig. 2 Alternator model RM14, with rotor withdrawn

The same rotor and stator sizes are used in model 5AF scooter alternator but, in this case, the rotor is cast integral with the engine flywheel and cooling fins. This flywheel, when fitted to 6-volt units, carries an inertia ring while, in 12-volt units, a ring gear is fitted for engagement with the starting motor, model M3. Models RM14 and RM15 (Figs. 2 and 3) are fitted to large capacity machines having high top gear ratios while the remainder are fitted to small capacity machines having low top gear ratios.

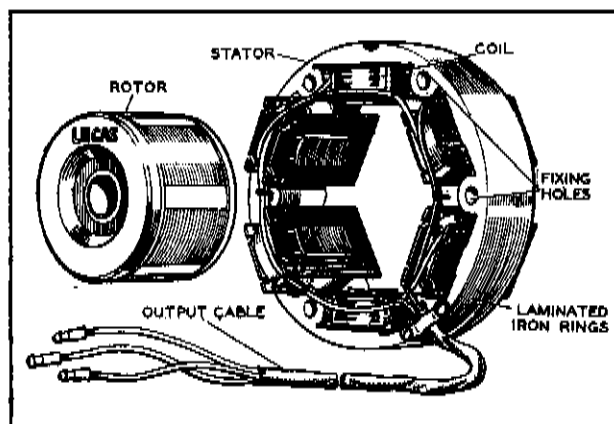


Fig. 3 Alternator model RM15, with rotor withdrawn

#### (b) FUNCTIONS

Today, motor cycle alternators are designed, either, to provide battery charging through a full-wave bridge-connected rectifier, in conjunction with magneto or coil ignition—when (with coil ignition) provision is also made for emergency starting in the event of a flat battery and even for restricted running without a battery—or to provide an energy transfer ("E.T.") ignition system with direct lighting. Alternators for battery lighting, with magneto or coil ignition (the latter being originally known as Lucas A.C. Lighting-ignition Units), are normally specified for Roadsters, while alternators for direct lighting and energy transfer ignition are normally specified for Competition machines. A few alternator equipped machines were made in which both battery lighting and energy transfer ignition were combined. However, this practice was discontinued due, mainly, to the problem that the then existing sizes of alternators presented of providing adequate ignition timing ranges with ample capacity for battery charging.

Two typical motor cycle rectifiers are shown in Fig. 4.

#### (c) ALTERNATORS FOR BATTERY CHARGING

When no lights are in use, the rectified output of the alternator is sufficient only to supply the ignition coil and to trickle charge the battery. On turning the



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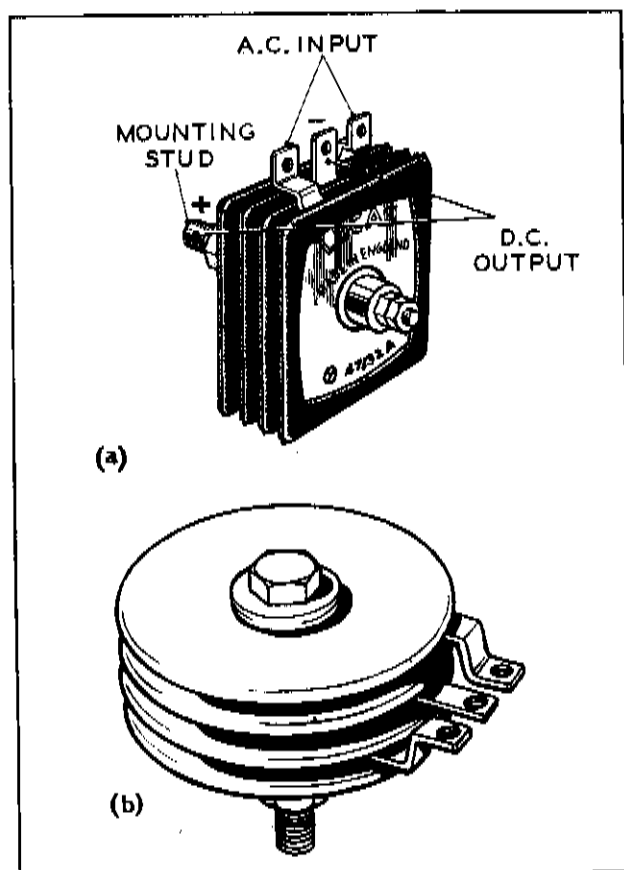


Fig. 4 Rectifiers, (a) new type (b) old type

lighting switch, the output is automatically increased to meet the additional load. On some machines (usually those fitted with RM14 or RM15 alternators or with magneto ignition) an increase occurs both when the parking light is switched on and again when the main bulb is brought into use. On other machines (usually of low capacity and with coil ignition, or with low speed engines and heavy electrical loading) an increase occurs only when the main bulb is switched on. Details of the alternative circuits involved are given in para. 4 (a).

## (d) ALTERNATORS FOR ENERGY TRANSFER IGNITION

Normally, alternator models RM13 and RM15 are used, together with a contact breaker unit and a special ignition coil, model 2ET—the four-limb stator winding of the alternator and the ignition coil primary winding being electrically matched. The alternator supplies a pulse of energy to the ignition coil primary winding each time the contact breaker contacts open. These low tension pulses are converted by the ignition coil to the high tension voltages required at the sparking plug. This form of ignition combines the good top speed characteristics of the magneto with the good low speed performance of the conventional ignition coil.

When required, the remaining stator limbs are wound to provide alternating current for a direct lighting set. Stop-lights are fed, either, from two coils of a four-coil ignition winding or from independent coils.

## 2. ROUTINE MAINTENANCE

### (a) ALTERNATOR

The alternator, having no rotating windings, commutator, brushgear, bearings or oil seals, requires no maintenance, apart from an occasional check of the snap-connectors in the three output cables to ensure that these are clean and secure.

To obviate metal contamination of the rotor, stator and windings, the chain case oil should be changed as regularly as is recommended by the motor cycle manufacturer. This procedure is particularly important if the stator carries ignition windings.

**Note:** If removal of the rotor becomes necessary for any reason, there will be no necessity to fit magnet keepers to the rotor poles. On removing a rotor, wipe off any metal swarf that may have been attracted to the pole tips and put the rotor in a clean place.

### (b) RECTIFIER (when fitted)

The rectifier requires no maintenance, apart from an occasional check of the cables and the securing nut.

**Note:** The nuts that clamp the rectifier plates together must never under any circumstances be turned, the clamping pressure having been carefully set during manufacture to give the correct rectifier characteristics.

When tightening rectifier fixing nuts, the plate assembly must never be gripped by hand in an attempt to prevent turning. Instead, two spanners must always be used—one being applied to the fixing nut and the other to the hexagonal part of the mounting stud or, in earlier types, to the backing nut.

The 2BA nuts shown in Fig. 4 (a) must never be disturbed.

### (c) CONTACT BREAKER UNIT (or Distributor)

See SECTION L-5 PART C of this Manual, Paragraphs 2 (a) (b) (c) and (d).

## 3. SERVICING

### (a)

Service Testing Procedures, together with explanations of working principles, for these and earlier alternators are given in Publication No. SB519 and other associated service publications (such as Test Procedure Cards SB1004 and SB1005, and Service Bulletins for individual motor cycles) obtainable from the Sales and Service Company. It is not intended to duplicate that information here but only to supplement it.

The approximate winding resistances of model 2ET ignition coil, used in conjunction with the permanent (as opposed to 'Emergency') Energy Transfer Ignition



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System described on pages 7 and 8, are as follows :

Primary Winding 0.5—0.7 ohm ;  
Secondary Winding 6,000—7,000 ohms.

## 4. ALTERNATORS FOR BATTERY CHARGING

### (a) STANDARD STATOR CONNECTIONS

- (i) Alternator windings comprise three pairs of series-connected coils. In a standard installation, one pair is permanently connected across the rectifier to provide some degree of battery charging current whenever the engine is running. Connections to the remaining coils vary according to the positions of the lighting and ignition switch controls, as shown schematically in Fig. 5. Provided the ignition key is at 'Ign.', the basic circuits of a standard alternator installation providing three alternative outputs are as shown in Fig. 5 (a) (b) and (c) for lighting switch positions 'Off', 'Parking' and 'Head', respectively. In a standard installation providing two alternative outputs, as fitted to small coil ignition machines and others with low top gear ratios, the stator connections in both 'Off' and 'Parking' are as shown in Fig. 5 (b).
- (ii) The above alternative outputs are obtained by modifying the internal connections of the stator winding. In the lights 'Off' position, with an installation arranged to provide three alternative outputs, the alternator output is regulated to a minimum value by the interaction of a magnetic flux set up by the current flowing in the short-circuited coils with the magnetic flux of the rotor—the latter flux being distorted and therefore less effective. In the 'Parking' position, the short-circuit is removed and the regulating flux is consequently reduced. The alternator output therefore increases and balances the parking light load. In the 'Head' position, the alternator output is further increased by connecting all three pairs of coils in parallel.

**Note:** This latter condition, shown in Fig. 5 (c), is also obtained on operating the Maximum Charge

Rate Switch fitted to certain single-alternator motor cycles equipped with two-way radio. To avoid overcharging, such switches must only be operated with the radio load connected.

### (b) SPECIAL STATOR CONNECTIONS FOR RADIO EQUIPPED MOTOR CYCLES\*

- (i) When necessary, two further degrees of output can be obtained if, instead of only one pair of coils being permanently connected across the rectifier, two pairs are so connected—the remaining pair being either short-circuited or open-circuited as shown in Fig. 5 (d) and (e).
- (ii) The output into a battery held to its nominal voltage obtained with each of the five modes of connection is tabulated below for various alternators.

### (c) CABLE AND SWITCH CONNECTIONS

- (i) The circuits shown in Fig. 5 (a) and (b) obtain when the alternator cables are connected to the harness cables colour-to-colour as shown in Fig. 6 (a). The circuit shown in Fig. 5 (c) obtains (temporarily by switching, or permanently by snap-connector) when the green-with-black and the green-with-yellow cables are connected as shown in Fig. 6 (b). The circuits shown in Fig. 5 (d) and (e) obtain when the green-with-black (formerly dark green) and green-with-yellow (formerly mid-green) cables are transposed as shown in Fig. 6 (c).
- (ii) The method of obtaining the short-circuit conditions giving a reduced charge rate in the 'Off' position, shown in Fig. 5 (a) and (d), depends upon the design of lighting switch fitted to the machine, as follows :

#### Model PRS8 switch:

Green-with-white cable connected to terminal '4' and terminals '5' and '6' linked externally. (Removal of this link modifies the installation from a three-rate to a two-rate system).

\*Details, with wiring diagrams, of the Lucas Double Generator Charging System (Dynamo and Alternator in tandem) fitted to certain radio equipped motor cycles are contained in Publication No. 1463A and Supplement.

Schematic Diagram 1	Alternator Connections 2	Alternator Output (Rectified) in amperes at :									
		2,000 r.p.m. 3					5,000 r.p.m. 4				
		RM13	RM13/15 SAF (6v.)	SAF (12v.)	RM14	RM15	RM13	RM13/15 SAF (6v.)	SAF (12v.)	RM14	RM15
1 Fig. 5 (a)	As Fig. 6 (a)	1.75—2.0	2.25—2.5	1.25—1.5	2.4—2.9	2.25—2.5	2.75—3.25	2.75—3.25	2.5—3.0	2.75—3.25	3.0—3.5
2 Fig. 5 (b)	As Fig. 6 (a)	3.0—3.25	3.25—3.5	2.0—2.25	3.75—4.25	3.75—4.0	4.25—4.75	4.5—5.0	3.75—4.25	4.5—5.0	4.75—5.25
3 Fig. 5 (d)	As Fig. 6 (c)	3.25—3.5	4.5—4.75	3.0—3.25	5.25—5.75	5.0—5.25	5.75—6.25	6.0—6.5	5.25—5.75	6.25—6.75	6.0—6.5
4 Fig. 5 (e)	As Fig. 6 (c)	5.25—5.5	5.75—6.0	3.75—4.0	6.5—7.0	6.25—6.5	7.0—7.5	7.5—8.0	6.5—7.0	7.5—8.0	7.5—8.0
5 Fig. 5 (c)	As Fig. 6 (b)	7.0—7.25	7.75—8.0	5.0—5.25	8.5—9.0	8.25—8.5	9.0—9.5	9.5—10.0	8.0—8.5	9.5—10.0	9.5—10.0



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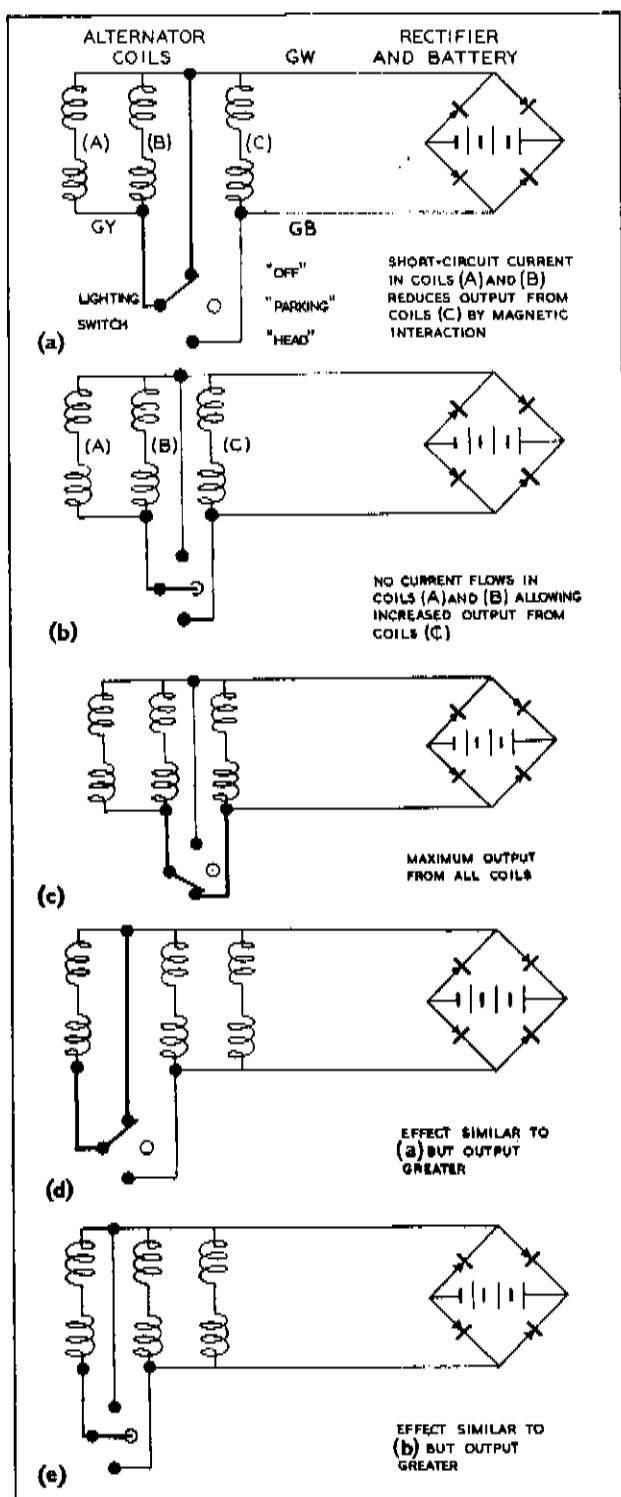


Fig. 5  
Alternator, internal connections

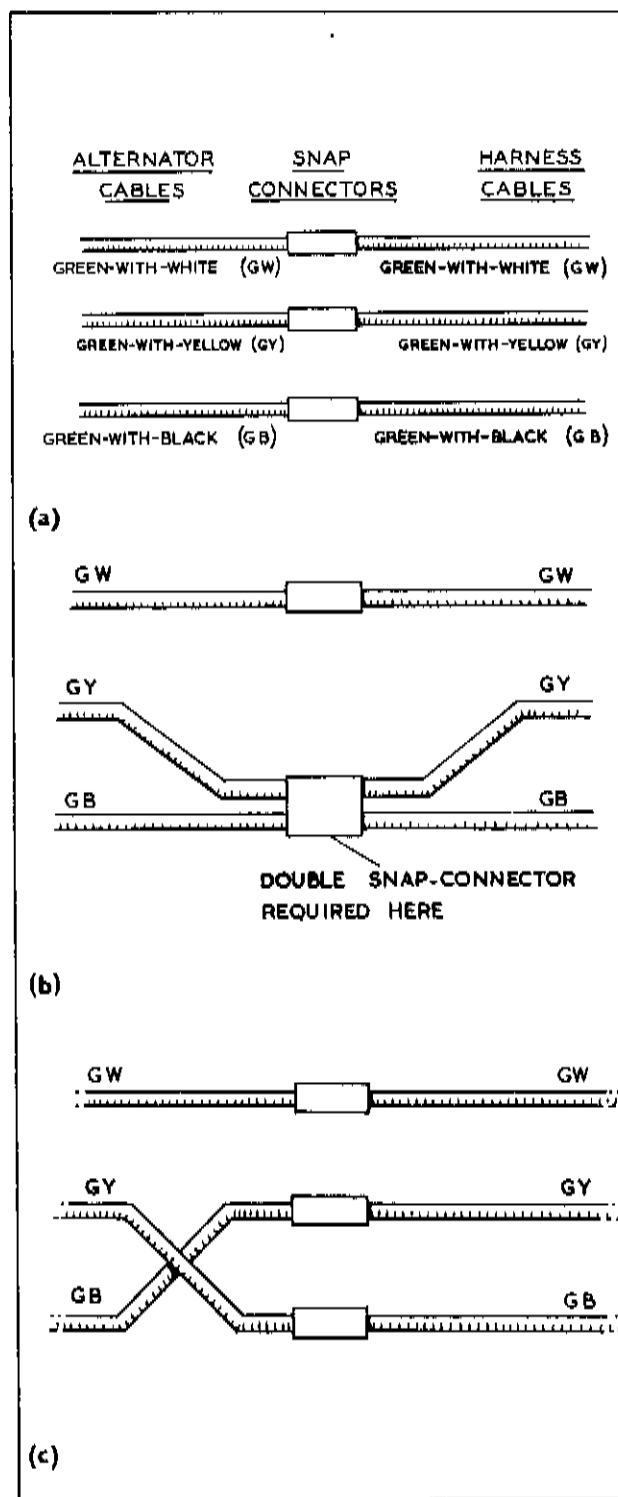


Fig. 6  
Cable connections giving alternative outputs from alternator



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## Models U39 and 41SA switches:

Green-with-white (formerly light green) cable connected to terminal '7'. (Disconnecting this cable modifies the installation from a three-rate to a two-rate system).

## Models 63SA and 88SA switches:

Green-with-white cable connected to terminal '4'. (Disconnecting this cable modifies the installation from a three-rate to a two-rate system).

**Note:** Avoidance of overcharging: since, with the lighting switch in the 'Off' position, the output into the battery from a two-rate connected alternator is greater than that from the three-rate, the effect of removing the terminal link of model PRS8 switch, or the appropriate cable from models U39, 41SA, 63SA and 88SA should (when applicable) first be ascertained before making the output boosting modifications shown in Fig. 6 (b) or (c).

## (d) EMERGENCY STARTING

- (i) Motor cycles fitted with the alternator-rectifier battery charging system are normally provided with a means of starting the engine in the event of an otherwise healthy battery becoming badly discharged. For this purpose, a three-position ignition switch is used, labelled 'Ign.', 'Off' and 'Emg.'. On switching to 'Emg.' and kick-starting the engine, the battery receives a charging current and, after a while, the ignition switch should be turned back to the normal running position 'Ign.'. (With the circuit as used on single-cylinder machines and on twins fitted with two ignition coils, the appropriate time to change back to normal Ignition is indicated by a tendency of the engine to misfire, due to the rising battery voltage being in opposition to the alternator voltage—thus a steadily reducing amount of energy is available for transfer to the ignition coil).
- (ii) The emergency starting feature also enables short journeys to be made (if absolutely unavoidable) without battery or lighting. This is done by connecting the cable normally attached to the battery negative terminal to an earthed point on the machine and kick-starting the engine with the Ignition switch in the 'Emg.' position. Thus, a rider can make for home even if his battery has failed completely or has been pilfered. It must be emphasised, however, that continuous running under these conditions will result in badly burnt contacts in the distributor or contact breaker unit and cannot therefore be recommended.
- (iii) The three circuits used for emergency starting are shown in Fig. 7 (a), (b) and (c). The first is applied to single-cylinder machines, and the second and third to twins. With each, the contact breaker is arranged to open at an instant when the alternating current in the stator windings reaches a

maximum in the direction shown by the feathered arrows.

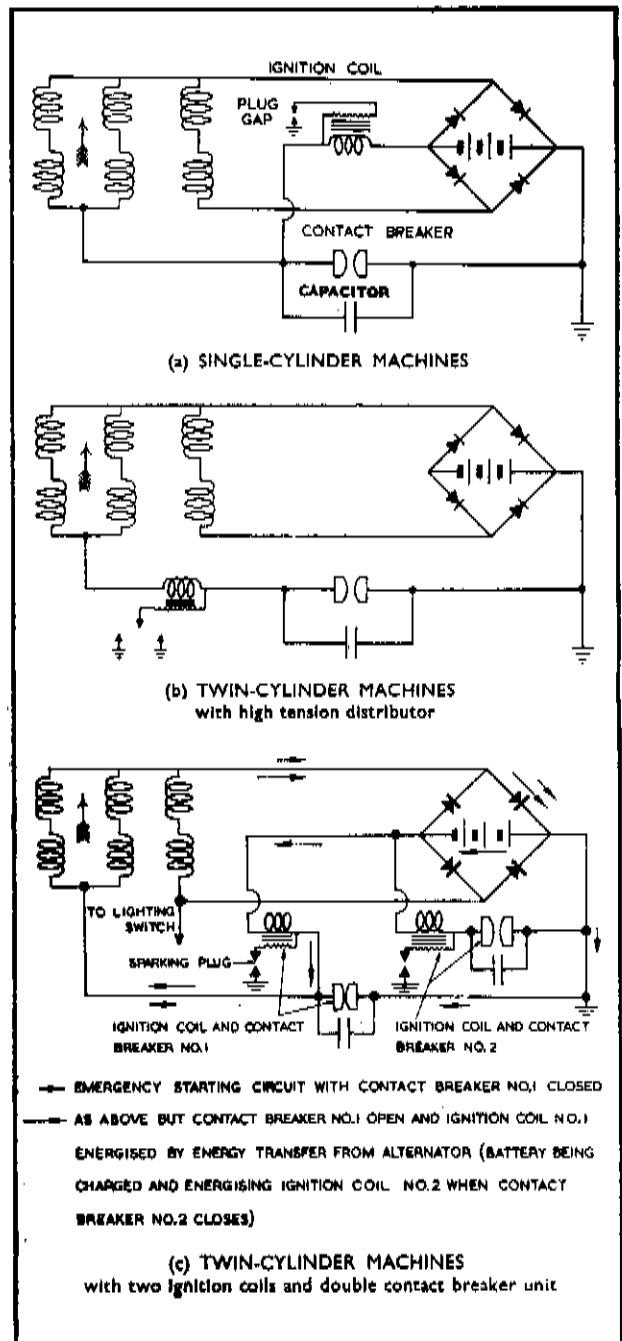


Fig. 7

Emergency starting circuits for battery ignition motor cycles, (a) single-cylinder machines, (b) twin-cylinder machines with high tension distributor, (c) twin-cylinder machines with two ignition coils and double contact breaker unit



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- (iv) When current flows through the windings in the direction indicated in Fig. 7 (a) and the contacts are closed, the main return circuit to the alternator is through one arm of the rectifier bridge. At the instant of contact separation, the built-up electro-magnetic energy of the alternator windings discharges through the alternative circuit consisting of the battery and the ignition coil primary winding. This rapid transfer of energy from the alternator to ignition coil primary winding causes a high tension voltage to be induced in the secondary winding and a spark to occur at the plug.
- (v) From Fig. 7 (b) it will be seen that when twin-cylinder machines are fitted with a distributor the ignition coil primary winding and the contact breaker are connected in series and not in parallel as for single-cylinder machines. The adoption of this more conventional practice permits a slightly more simple cable harness and switching system to be utilised. It is, however, unsuitable for use with single-cylinder machines due to the 'idle' sparking which occurs before the contacts separate. Twins, when fitted with distributor electrodes are unaffected by this premature sparking. With the circuit shown in Fig. 7 (a), 'idle' sparking occurs after the contacts separate, i.e. when the engine has fired. Thus single-cylinder engines are not affected by such sparking.
- (vi) It has recently become the practice to fit a pair of standard ignition coils and a double contact breaker unit in place of a distributor, as shown in Fig. 7 (c).  
With the ignition switch in the normal running position 'Ign.' each coil, with its associated pair of contact breaker contacts, serves one of the cylinders—each functioning as an ordinary battery ignition circuit. On switching to 'Emg.', however, one of the ignition coils functions on the energy transfer system described in para. 4 (d) (iv) for single-cylinder machines. The second coil is at first idle but, since the battery is receiving a charging current, this coil soon begins to develop secondary voltages, as in the normal running position 'Ign.'. As previously noted, the rising battery voltage causes misfiring to occur. This, incidentally, serves to remind the rider to switch back to the 'Ign.' position, when both coils will be operating under battery ignition and full power will be available.  
On referring to Fig. 7 (c), it will be noticed that during emergency starting, when one coil is operating under battery ignition and the other under energy transfer from the alternator, the primary currents are of opposite polarity—terminal 'CB' being positive on the former but negative on the latter. Also, it will be appreciated that energy pulses from the alternator are not passed through the primary winding of the coil

which is operating under battery ignition conditions, since the contacts of the contact breaker associated with this coil are open at the instants these pulses occur.

- (vii) Ignition performance under emergency starting conditions should be equivalent to that of a magneto at kick-start speeds. However, any of the faults listed below can affect performance and may well be encountered in service :
- Engine wrongly timed
  - Contact breaker contacts need cleaning
  - Contact breaker gap needs setting
  - Spark plug needs cleaning
  - Spark plug gap needs setting
  - Wiring or connections defective
  - Rectifier defective
  - Battery terminals corroded
  - Battery sulphated
  - Capacitor defective

## (e) CORRECT METHOD OF CONNECTING A FOGLAMP

- (i) As previously explained, the alternator can only develop its maximum output when the lighting switch is turned to the 'H' position. This is because the alternator windings are switched to obtain the required charge rate by means of special contacts built into the lighting switch—the rate being least in the switch position 'Off' and most in 'H'.
- (ii) It follows that a foglamp and its associated control switch should never be directly connected across the battery, since the alternator output in lighting switch position 'P' would be insufficient to balance the additional load and the resulting drain on the battery would soon cause the light from the foglamp to dim.
- (iii) The correct method is to connect an additional dip switch (i.e., a single-pole, two-way switch) in series with the existing dip switch in order to be able to select for operation either the headlamp or the foglamp, when the main lighting switch is turned to position 'H'. To do this :

Disconnect the feed cable (normally blue) from the centre main terminal of the existing dip switch.

Connect this cable to the centre main terminal of the new switch.

Connect one of the two remaining terminals of the new switch to the centre main terminal of the existing switch.

Connect the third terminal of the new switch to one of the foglamp terminals.

Connect the other terminal of the foglamp to earth.



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## 5. ENERGY TRANSFER IGNITION

### (a) IGNITION CIRCUIT

- (i) In an alternator designed for energy transfer ignition, it is now customary to locate coils on four of the stator limbs for the purpose of generating the primary current. Exceptions to this practice were referred to in para. 1 (b). These stator coils are connected in series with each other and with the primary winding of the ignition coil, model 2ET.

The contacts of a contact breaker unit or distributor are connected in parallel with the ignition coil primary winding. Since one end of the stator winding, one end of the ignition coil primary winding and one side of the contact breaker is earthed, these three parts of the circuit are, in effect, connected in parallel, as shown in Fig. 8.

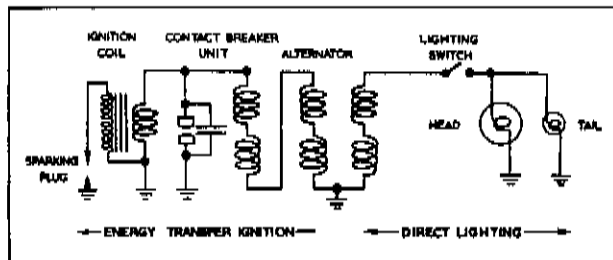


Fig. 8

Energy transfer ignition circuit with direct lighting, for Competition motor cycles

- (ii) Closure of the contact breaker contacts short-circuits the ignition coil primary winding and, at the same time, creates a closed circuit of the stator ignition windings. As the magnet rotor turns, voltages are induced in the stator coils giving rise to alternating currents during the period that the contacts are closed. At the instant of contact opening, however, a pulse of electromagnetic energy (developed in the stator during the contacts closed period) is discharged through the ignition coil primary winding. The effect of this energy pulse in the primary winding is to induce a high tension voltage in the ignition coil secondary winding which is then applied either directly or by way of a distributor to the appropriate sparking plug.

### (b) TIMING CONSIDERATIONS

- (i) Since the magnetic rotor of the alternator is keyed or otherwise located on the crankshaft, the magnetic pulse in the alternator stator, which produces the energy pulse to feed the ignition coil primary winding, must be timed to occur at the firing point of the engine.
- (ii) The magnetic pulse occupies several degrees of crankshaft (and therefore of rotor) rotation. A

fairly wide angular tolerance would thus be available for a fixed ignition engine.

- (iii) However, it is desirable with most four-stroke engines to incorporate an ignition timing control (usually centrifugally operated) giving a range of advanced and retarded sparking. The magnetic relationship of the alternator rotor to its stator must therefore be governed by this fact, namely, that the engine firing point will vary by several degrees between the fully retarded starting condition and the fully advanced running condition.
- (iv) This is exactly the same problem which obtains with a manually controlled magneto and gives rise to the same characteristics, i.e. the available sparking voltage for a given kick-start speed reduces progressively with the amount of retard angle. A magneto, however, is a self-contained unit and will produce a spark however grossly it may be mistimed to the engine. This is because a magneto contact breaker is always in correct relationship to the magnetic geometry of the unit. With an alternator, however, the position of the magnetic rotor with respect to the stator and to the engine piston at the instant of firing is pre-determined by its located position on the engine crankshaft.
- (v) The range of retarded magnetic timing that can be used with a particular engine depends in part on that engine's startability, since the required plug voltage is influenced by many factors of engine design. The speed at which it can be kicked over in attempting to reach this voltage will depend on piston and bearing friction, kick-starter ratio, etc.
- (vi) The characteristics reproduced in Fig. 9 show how the available plug voltage varies with different magnetic timing positions and for different speeds of rotation. The reference point is known as the Magnetic Neutral position, when the interpolar gaps of the rotor are situated on the centre-lines of the stator limbs.
- (vii) It will be seen that whilst the optimum magnetic position is some  $4^\circ$  past the Magnetic Neutral at 200 r.p.m., it changes to some  $12^\circ$  past at 2,000 r.p.m., due to distortion of the magnetic flux.
- (viii) It will also be seen that the sparking performance deteriorates rapidly a few degrees before the Magnetic Neutral position. Hence commercial tolerances on keyways etc., dictate the inadvisability of approaching too near to this critical point in the advanced or running position of engine timing.
- (ix) As stated in para. (v) above, the extent to which the retard timing can be used depends on plug voltage requirements at starting and on kick-starter speed.





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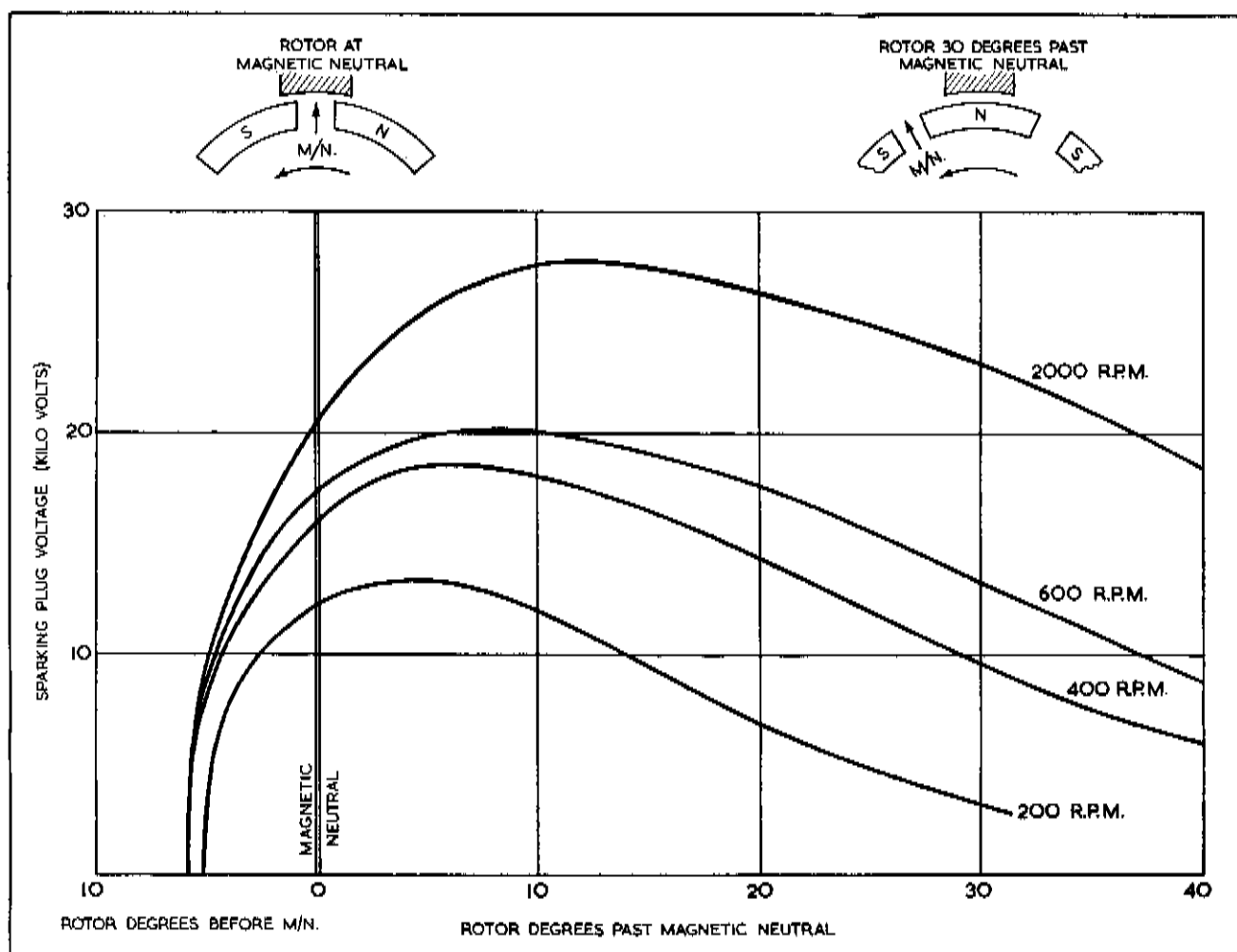


Fig. 9  
Curves showing how sparking plug voltages depend on magnetic timing and kick-starting speeds

For example, if the required plug voltage is 6 kilovolts, the retarded timing would be restricted to about 20° (engine) if the kick-starting speed was to be limited to 200 r.p.m.—in practice, a fairly low speed. On the other hand, at the fairly normal kick-starting speed of 400 r.p.m., a timing range of some 30° could be accommodated with plug voltages up to about 8 kilovolts.

- (x) It will be appreciated, therefore, that accurate ignition timing is an important requirement in the operation of an energy transfer system. The optimum conditions are determined by the engine

designers during the development stages and these conditions should always be maintained in order to ensure the highest performance, both from the engine and from the ignition system designed to work with it.

It will also be appreciated that amateur tuning, departing from the designers' recommendations, cannot be expected to improve a highly developed engine. Indeed, some harmful results may occur. For this reason, indifferent sparking outside the prescribed range will almost certainly indicate tampering and may well serve as a warning to the would-be tuner.

