LUCAS

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EQUIPMENT

VOLUME 2

WORKSHOP INSTRUCTIONS

MOTOR CYCLE GENERATORS

MODELS E3L, E3LM and E3N

JOSEPH LUCAS LTD · BIRMINGHAM 19 · ENGLAND

Printed in England

GENERATORS

MODELS E3L, E3LM and E3N

1. GENERAL

The generator is a shunt-wound two pole machine, arranged to work in conjunction with a regulator unit (see SECTION L-3) to give an output which is dependent on the state of charge of the battery and the loading of the electrical equipment in use. When the battery is in a low state of charge, the generator gives a high output, whereas if the battery is fully charged the generator gives only a trickle charge to keep the battery in a good condition without overcharging. In addition, an increase of output is given to balance the current taken by the lamps when in use. Models E3L and E3LM are similar in construction and both have a 60 watt output. The constructional difference between the two models is in the shape of the drive-end bearing retaining plate; Model E3L is designed to fit on to the engine crankcase and Model E3LM to be the upper portion of the 'Magdyno'.

Model E3N is identical in diameter and construction to the two previously mentioned models, but differs in overall length and output. The output is 45 watts and the overall length is ⅞" less than that of Models E3L and E3LM.

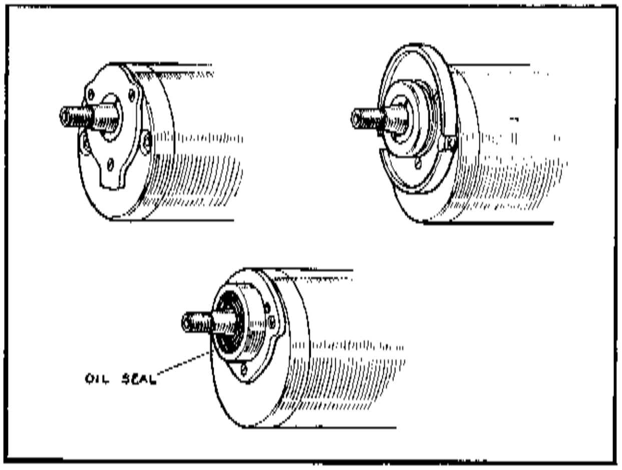

Fig. 1
Various drive-end bearing retaining plates

2. TEST DATA

Models	Cutting in Speed (generator cold)	Output Test	Field Resistance	Brush Spring Tension
E3L / E3LM	1050-1200 r.p.m. at 7 volts	8.5 amps. at 1850-2000 r.p.m. at 7 volts. *	2.8 ohms	16-20 oz.
E3N ...	1250-1500 r.p.m. at 7 volts	5 amps at 2100-2300 r.p.m. at 7 volts. †	3.2 ohms	16-20 oz.

* On resistance load of 0.82 ohm. † On resistance load of 1.4 ohms.

3. ROUTINE MAINTENANCE

(a) Lubrication
No lubrication is necessary as the ball bearings are packed with H.M.P. grease which will last until the machine is taken down for a general overhaul, when the bearings should be repacked. Thin lubricating oil, if allowed to reach the bearings, will soften the grease and eventually cause the bearings to run hot.

(b) Inspection of Commutator and Brushgear
About once every six months remove the cover band for inspection of commutator and brushes. The brushes are held in contact with the commutator by means of springs. Move each brush to see that it is free to slide in its holder; if it sticks, remove it and clean with a cloth moistened with petrol. Care must be taken to replace the brushes in their original positions, otherwise they will not 'bed' properly on the commutator. If, after long service, the brushes have become worn to such an extent that the brush flexible is exposed on the running face, or if the brushes do not make good contact with the commutator, they must be replaced by genuine Lucas brushes. The commutator should be free from any trace of oil or dirt and should have a highly polished appearance. Clean a dirty or blackened commutator by pressing a fine dry cloth against it while the engine is slowly turned over by means of the kick starter crank. (It is an advantage to remove the sparking plug before doing this.) If the commutator is very dirty, moisten the cloth with petrol.

4. SERVICING

(a) Testing in position to locate fault in charging circuit

In the event of a fault in the charging circuit, adopt the following procedure to locate the cause of trouble.

(i) Check that the generator and regulator unit are connected correctly. The generator terminal 'D' should be connected to the regulator unit terminal 'D' and generator terminal 'F' to regulator unit terminal 'F'.

(ii) Remove the cables from the generator terminals 'D' and 'F' and connect the two terminals with a short length of wire.

(iii) Start the engine and set to run at normal idling speed.

(iv) Connect the negative lead of a moving coil voltmeter, calibrated 0—10 volts, to one of the generator terminals and connect the positive lead to a good earthing point on the generator yoke or engine. Reverse voltmeter connections on negative earth machines.

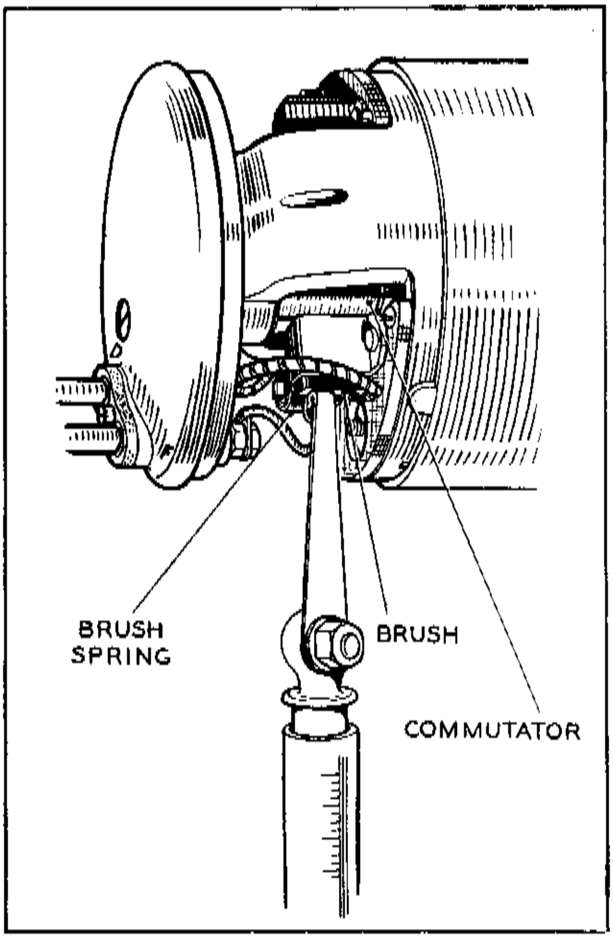

Fig. 2 Testing brush spring tension

(v) Gradually increase the engine speed, when the voltmeter reading should rise rapidly and without fluctuation. Do not allow the voltmeter reading to rise above 10 volts and do not race the engine in an attempt to increase the voltage. It is sufficient to run the generator up to a speed of 1,000 r.p.m. If there is no reading, check the brush gear, as described in (vi) below. If there is a low reading of approximately ½ volt, the field winding may be at fault (see Para. 4 (d). If there is a reading of approximately 1½ to 2 volts, the armature winding may be at fault (see Para. 4 (e).

(vi) Remove the cover band and examine the brushes and commutator. Hold back each of the brush springs and move the brush by pulling gently on its flexible connector. If the movement is sluggish, remove the brush from its holder and ease the sides by lightly polishing on a smooth file. Always replace brushes in their original positions. If the brushes are worn so that they do not bear on the commutator, or if the brush flexible is exposed on the running face, new brushes must be fitted.

Test the brush spring tension with a spring scale. The correct tension is 16—20 oz. and new springs must be fitted if the tension is low.

If the commutator is blackened or dirty, clean it by holding a petrol moistened cloth against it while the engine is turned slowly by means of the kick start (with sparking plug removed).

Re-test the generator as in (v) above. If there is still no reading on the voltmeter, there is an internal fault and the complete unit if a spare is available, should be replaced. Otherwise the unit must be dismantled (see Para. 4 (b) for internal examination.

(vii) If the generator is in good order, restore the original connections. Connect regulator unit terminal 'D' to generator terminal 'D', and regulator terminal 'F' to generator terminal 'F'. Proceed to test the regulator as described in SECTION L-3 Part A.

(b) To Dismantle

Remove the generator from the motorcycle. To detach the generator from a Magdyno, unscrew the hexagon-headed nut from the driving end cover and slacken the screws securing the band clip.

Proceed to dismantle as follows:—

(i) On models E3L and E3N, remove the securing nut from the drive end of the shaft, and withdraw the gear with the aid of an extractor. On model E3LM, bend back the tag on the washer 'B' locking the screw 'A'. Remove this screw, withdraw the gear 'C' from the shaft with the aid of an extractor and remove the key(s) 'D' from the shaft.

(ii) Remove the cover band 'H', hold back the brush springs and lift the brushes from their holders.

(iii) Take out the screw 'J' with spring washer, from the centre of the black moulded end cap 'G'. Draw the cap away from the end bracket, take off terminal nuts 'F', and spring washers, and lift the connections off the terminals.

(iv) Unscrew and remove from the drive end bracket, the two through bolts 'L' securing the drive end bracket 'N' and commutator end bracket 'Q' to the yoke 'M'. Hold the nuts 'K' at the commutator end while unscrewing the bolts, and take care not to lose the nuts.

(v) Draw the drive end bracket complete with armature 'E' out of the yoke.

(vi) Remove the nut 'R' and press the armature out of the drive end bracket by means of a hand press. When removing the armature from an E3L generator fitted with a rubber oil seal 'S' take great care not to damage the sealing lip.

(vii) Remove the bearing retaining plate 'P' from the drive end bracket (secured by three screws on E3L and E3N models, or two screws and long threaded bolt on E3LM models).

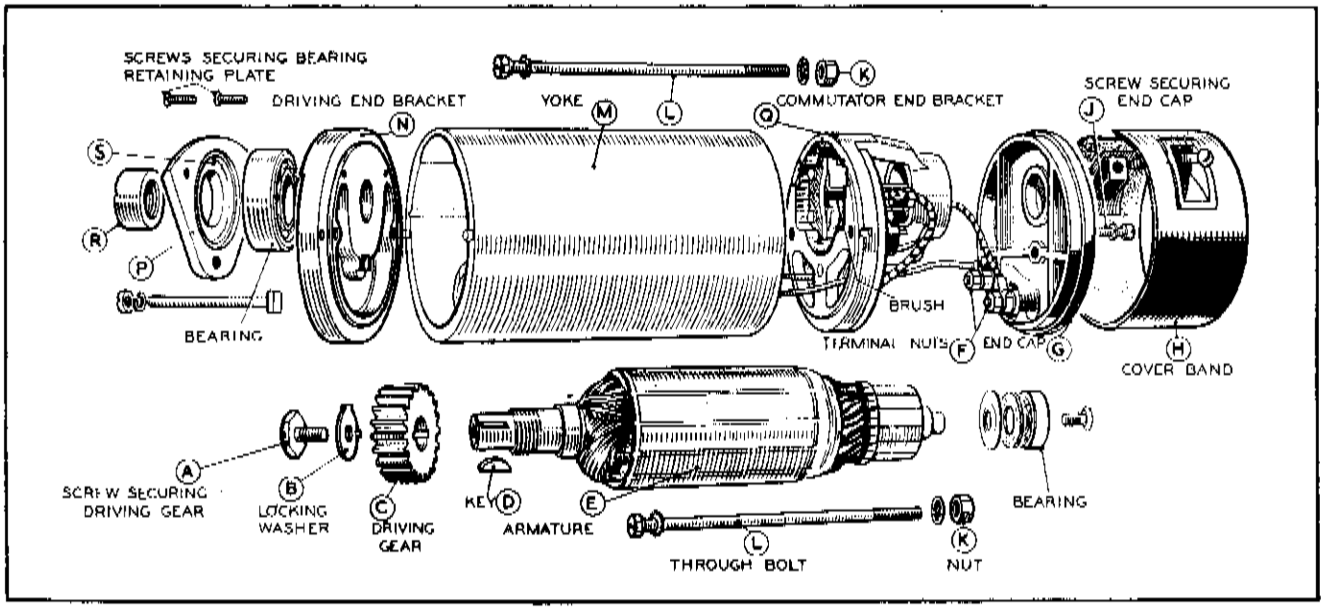

Fig. 3 Dismantled view of Model E3LM

(viii) Take out the screw securing the green field coil lead with the yellow sleeve to commutator end bracket and remove the end bracket 'Q' withdrawing the connectors through the slot in the insulating plate.

(ix) Unscrew the three screws securing the insulating plate to the commutator end bracket and remove the plate complete with brushgear.

(c) Commutator

Examine the commutator. If it is in good condition, it will be smooth and free from pits or burned spots. Clean with a petrol-moistened cloth. If this is ineffective, carefully polish with a strip of very fine glasspaper while rotating the armature. To remedy a badly worn commutator, mount the armature with or without the drive end bracket in a lathe, rotate at high speed and take a light cut with a very sharp tool. Do not remove more metal than is necessary. Polish the commutator with very fine glasspaper.

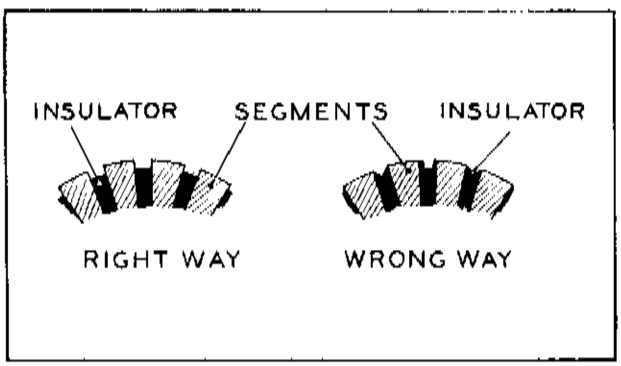

Fig. 4

Method of undercutting commutator insulation

Undercut the insulation between the segments to a depth of $\frac{1}{32}''$ with a hacksaw blade ground down until it is only slightly thicker than the insulation.

(d) Field Coil

Measure the resistance of the field winding by means of an ohm meter. If this is not available, connect a 6-volt D.C. supply with an ammeter in series across the coil. The ammeter reading should be approximately 2.1 amps. for models E3L and E3LM and 1.8 amps for E3N. No reading on the ammeter indicates an open circuit in the field winding.

To check for an earthed coil, connect a mains test lamp between one end of the coil and the yoke. If the bulb lights, there is an earth between coil and yoke.

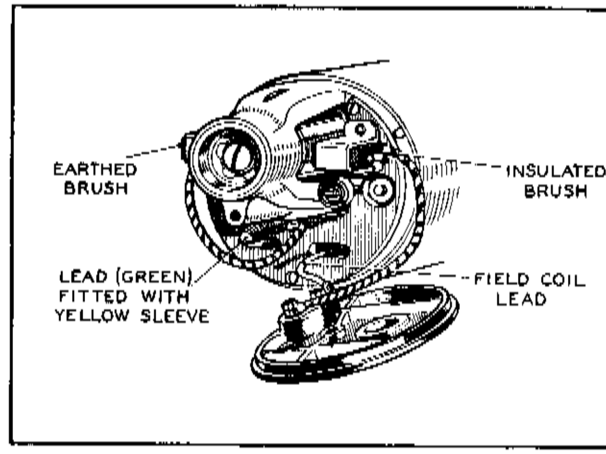

Fig. 5

Generator connections

In either case, unless a replacement generator is available, the field coil must be replaced, but this should only be attempted if a wheel-operated screwdriver and pole shoe expander are at hand, the latter being especially necessary to ensure that there will be no airgap between the pole shoe and the inner face of the yoke.

To replace the field coil, proceed as follows:–

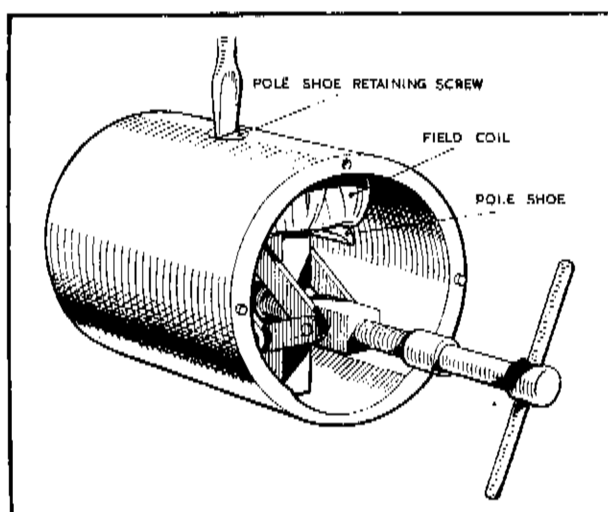

Fig. 6

Pole shoe expander

(i) Unscrew the pole shoe retaining screw(s) (Fig. 6) by means of the wheel-operated screwdriver.

(ii) Draw the pole shoe and field coil out of the yoke and lift off the coil.

(iii) Fit the new field coil over the pole shoe and place it in position inside the yoke. Take care to ensure that the taping of the field coil is not trapped between the pole shoe and the yoke.

(iv) Locate the pole shoe and field coil by lightly tightening the fixing screw(s), insert the pole shoe expander, open to its fullest extent and tighten the screw(s). Remove the expander and give the screw(s) a final tightening with the wheel-operated screwdriver. Lock the screw(s) in position by caulking, that is, by tapping some of the metal of the yoke into the slot in the head of the screw(s).

(e) Armature

The testing of the armature winding requires the use of a voltdrop test or a growler. If these are not available, the armature should be checked by substitution. No attempt should be made to machine the armature core or to true a distorted armature shaft.

(f) Bearings

Ball bearings are fitted to both the commutator and drive end brackets. When the bearings become worn to such an extent that they allow side movement of the armature shaft, they must be replaced. To replace the ball bearing at the commutator end, proceed as follows:—

(i) Remove the screw from the end of the armature shaft and using a calliper type extractor, draw the bearing off the shaft.

(ii) Wipe out the bearing housing and pack the new bearing with H.M.P. grease.

(iii) Position the bearing on the end of the shaft and press it squarely home, applying pressure on the inner journal of the bearing.

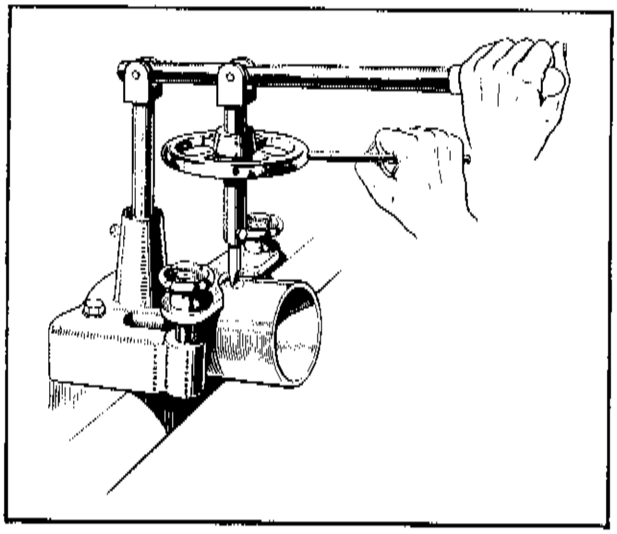

Fig. 7 Wheel-operated screwdriver

To replace the ball bearing at the drive end, proceed as follows:

(i) Remove the bearing retaining plate from the drive end bracket as previously described.

(ii) Press the bearing out of the end bracket, using a metal drift locating on the inner journal of the bearing. Wipe out the bearing housing and pack the new bearing with H.M.P. grease.

(iv) Position the bearing in its housing and press it squarely home, applying pressure on the outer journal of the bearing.

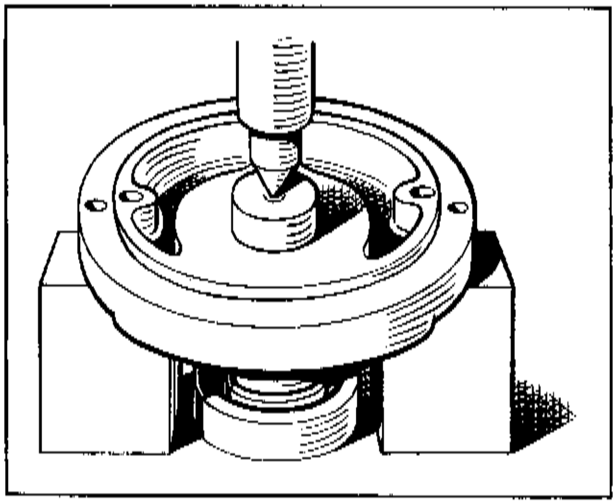

Fig. 8 Removing the ball race

(g) Reassembly

In the main, the reassembly of the generator is a reversal of the operations described in paragraph 4 (b), bearing in mind the following points:—

(i) The field coil lead fitted with the short length of yellow tubing must be connected together with the eyelet of the earthed brush to the commutator end bracket by means of the screw provided.

(ii) The second field coil lead must be connected to terminal 'F' on the moulded cap.

(iii) The unearthed brush flexible lead must be connected direct to terminal 'D' on the moulded end cap.

(iv) Take care to refit cover band in original position and make sure that the securing screw, when of flush-fitting pattern, does not short on brushgear.

(v) On E3L generators with oil seal, ensure that no damage has been caused to the seal, otherwise replacement must be made. To remove the oil seal from the bearing retaining plate, use a metal drift locating on the outer edge of the rubber seal. Insert a new seal using a mandrel to press it squarely home.

5. GENERATOR POLARITY

All replacement motor cycle generators are despatched from the Works suitable for immediate use on positive earth systems. If the negative terminal of the battery is earthed on the machine for which the replacement generator is intended, it will be necessary to re-polarize the generator before use to make it suitable for negative earth.

Similarly, if a generator has been incorrectly connected on the motorcycle and its polarity has become reversed, then it must be re-polarized.

To do this, fit the generator to the motor cycle but do not at this stage connect the cables to the D and F terminals. Temporarily connect a length of wire to the battery positive terminal and hold the other end of this wire in contact with generator terminal F for a few seconds only. This serves to re-polarize the generator; the temporary connection can now be removed and the original cables connected to D and F terminals.

The practice of closing the cut-out points to reverse the generator polarity is not recommended as this method allows a high initial surge of current from the battery to pass through the armature, which can damage the windings, insulation, etc., and result in a decreased service life of the machine.

Generally speaking, the majority of motor-cycles manufactured up to and including 1951 had the negative terminal of the battery connected to the frame. The majority of machines in current production have the positive terminal earthed.

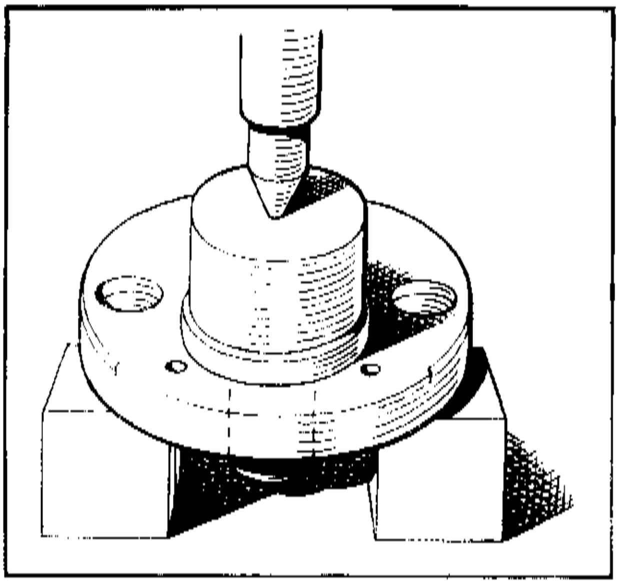

Fig. 9

Replacing the ball race

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WORKSHOP INSTRUCTIONS

MOTOR CYCLE GENERATOR

MODEL MC45L

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MOTOR CYCLE GENERATOR

MODEL MC45L

1. GENERAL

Model MC45L generator is designed for building directly into the engine crankcase. Of four-pole four-brush shunt wound design, this generator is arranged to operate in conjunction with the standard motorcycle control box. (See SECTION L-3, Part A.). As compared with other motorcycle generators, the yoke is of greater overall diameter (4½ in.) but is very much shorter, the length being 2¾ in.

Two different methods of mounting have been devised for supporting and driving the armature. On Sunbeam S7 and S8 models the armature is mounted on a sleeve which fits over the end of the crankshaft and is secured by a bolt passing axially through the armature and sleeve. On Scott 'Flying Squirrel' models the armature is supported by ball bearings at both ends. The ball bearing at the drive end is clamped in position by the driving flange, which is secured to the armature shaft by a bolt. The ball bearing at the commutator end is secured to the armature shaft by a countersunk screw.

Both methods of mounting incorporate a rubber oil seal at the drive end of the generator, to prevent the ingress of oil to the generator from the engine.

The yoke, pole shoe and field coil assembly which is of conventional design, is spigoted directly into the engine crankcase and secured by countersunk-headed bolts on Sunbeam motorcycles. On Scott motorcycles, two through bolts secure the commutator end bracket and yoke on the drive housing which in turn is clamped to the engine crankcase.

The brushgear is carried on a plate fitted to the commutator end of the yoke assembly. The polished commutator end cover (Sunbeam) or bracket (Scott), has a rubber sealing ring to prevent the entry of dirt and water into the generator.

2. TEST DATA

(*a*) Cutting-in speed: 750 — 850 r.p.m. at 6.5 volts.

(*b*) Output test: 10 amps. at 1,250 — 1,400 r.p.m. at 7 generator volts taken without regulator, on a calibrated resistance load capable of carrying 12 amps. without overheating.

(c) Total field resistance: 2.5 — 2.7 ohms.

3. ROUTINE MAINTENANCE

Inspection of Commutator and Brushgear

Every 12,000 miles remove the commutator end cover (or bracket) and check that the brushes move freely in their holders, cleaning if necessary. The commutator must be clean and free from oil or dirt, and should have a polished appearance. If it is dirty, clean it with a dry fluff-free cloth. If the commutator is very dirty, moisten the cloth with petrol. Be careful to refit the brushes in their original positions in order to retain their bedding.

When reassembling, position the rubber seal between the cover and the yoke and carefully tighten the fixing screws.

4. SERVICING

(a) Testing in position to locate fault in charging circuit.

In the event of a fault in the charging circuit, adopt the following procedure to locate the cause of trouble.

(i) Check that the generator and regulator unit are connected correctly. The generator terminal 'D' should be connected to the control box terminal 'D' and generator terminal 'F' to control box terminal 'F'.

(ii) Remove the cables from the generator terminals 'D' and 'F' and connect the two terminals with a short length of wire.

(iii) Start the engine and set to run at normal idling speed.

(iv) Connect the negative lead of a moving coil voltmeter, calibrated 0 --10 volts, to one of the generator terminals and connect the positive lead to a good earthing point on the generator yoke or engine. Reverse voltmeter connections on negative earth machines.

(v) Gradually increase the engine speed, when the voltmeter reading should rise rapidly and without fluctuation. Do not allow the voltmeter reading to rise above 10 volts and do not race the engine in an attempt to increase the voltage. It is sufficient to run the generator up to a speed of 1,000 r.p.m. If there is no reading, check the brush gear, as described in (vi) below. If there is a low reading of approximately ½ volt, the field winding may be at fault, see Para. 4 (d). If there is a reading of approximately 1½ to 2 volts, the armature winding may be at fault, see Para. 4 (e).

(vi) Remove the commutator end cover (or bracket) and examine the brushes and commutator. Hold back each of the brush springs and move the brush by pulling gently on its flexible connector. If the movement is sluggish, remove the brush from its holder and ease the sides by lightly polishing on a smooth file. Always replace brushes in their original positions. If the brushes are worn so that they do not bear on the commutator, or if the brush flexible is exposed on the running face, new brushes must be fitted.

Test the brush spring tension with a spring scale. The correct tension is 12 –15 oz. and new springs must be fitted if the tension is low.

If the commutator is blackened or dirty, clean it by holding a petrol-moistened cloth against it whilst the armature is slowly rotated.

Re-test the generator as in (v) above. If there is still no reading on the voltmeter, an internal fault is indicated and the complete unit should be replaced. Alternately the unit can be dismantled, see Para. 4 (b) for internal examination.

(vii) If the generator is in good order, restore the original connections. Connect control box terminal 'D' to generator terminal 'D' and control box terminal 'F' to generator terminal 'F'. Proceed to test the control box as described in SECTION L-3 Part A.

(b) To Dismantle

When fitted to Sunbeam motor cycles:

(i) Disconnect the generator connections.

(ii) Unscrew the two cover securing screws and remove the cover and sealing ring.

(iii) Lift the brushes and wedge them in the raised position by means of the springs.

(iv) Unscrew the two countersunk headed bolts. The complete yoke assembly can now be withdrawn, leaving the armature in position.

(v) To remove the brushgear plate from the yoke, remove the two insulated brushes from their holders and unscrew the two earthing screws.

(vi) Take out the armature fixing bolt (left hand thread), and withdraw the armature. Be careful not to damage the machined surface on which the oil seal rests.

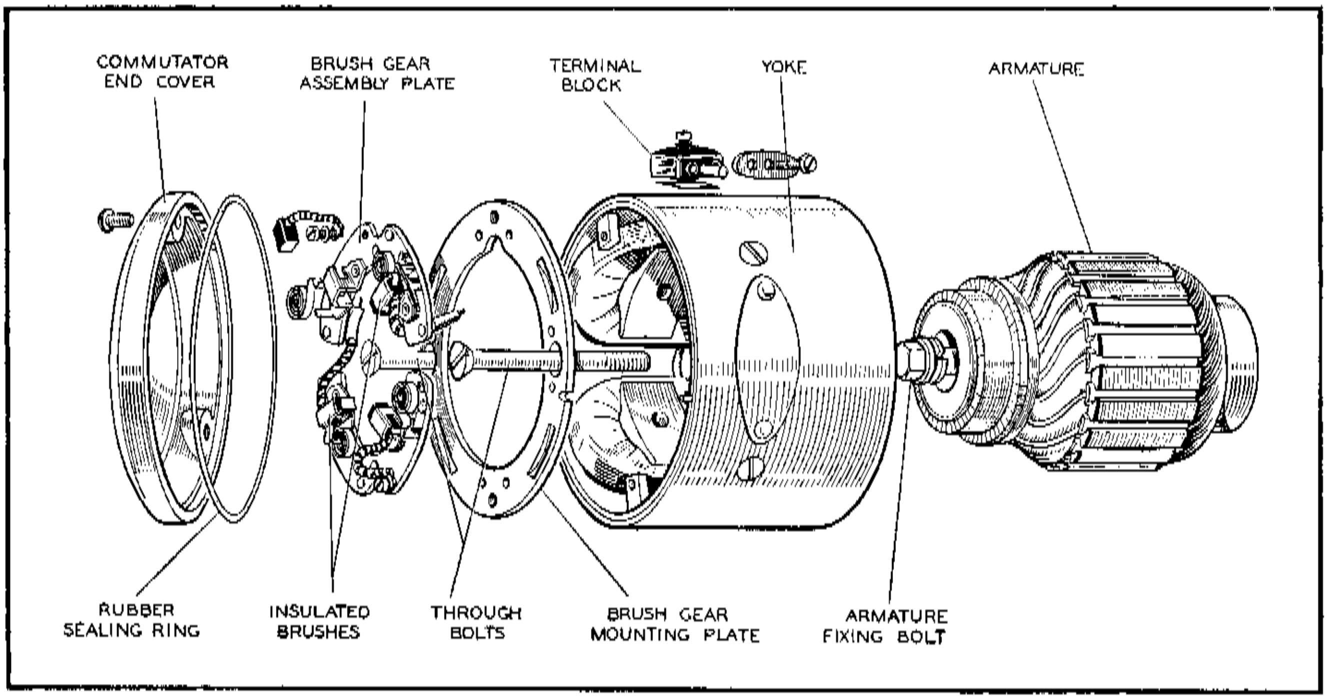

Fig. 1
Dismantled view of generator (Sunbeam type)

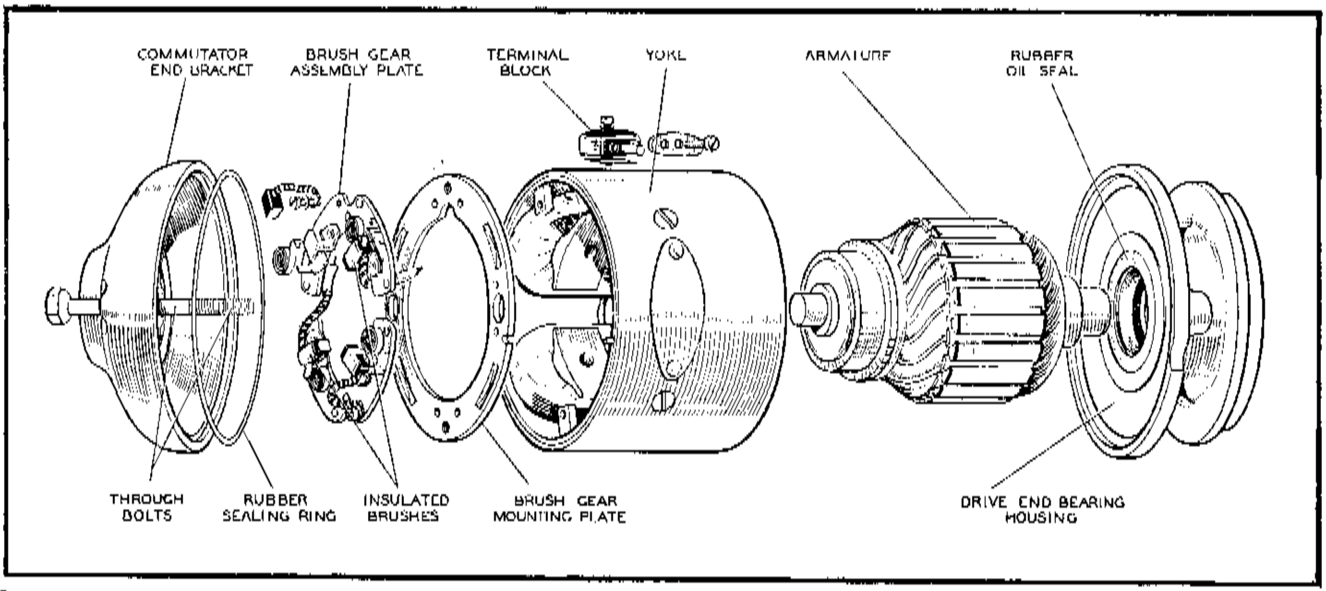

Fig. 2
Dismantled view of generator (Scott type)

When fitted to Scott motor cycles:

(i) Disconnect the generator connections.

(ii) Unscrew the two through bolts and gently pull the commutator end bracket away from the yoke.

(iii) Lift the brushes and wedge them in the raised position by means of the springs. The yoke assembly can now be removed from the drive housing.

(iv) To remove the brushgear plate from the yoke, remove the two insulated brushes from their holders and unscrew the two earthing screws.

(v) To remove the armature from the machine, the drive housing must be removed from the engine. When the drive housing has been removed, the driving flange will be exposed. Unscrew the armature fixing bolt from the centre of the driving flange and press the armature out of the ball bearing.

(vi) The commutator and drive end brackets are not of Lucas manufacture and for information regarding oil seal and bearing replacement, refer to the manufacturer's instruction book.

(c) Commutator

Examine the commutator. If it is in good condition, it will be smooth and free from pits or burned spots. Clean with a petrol-moistened cloth. If this is ineffective, carefully polish with a strip of very fine glass paper while rotating the armature. To remedy a badly worn commutator, mount the armature in a lathe, rotate at high speed and take a light cut with a very sharp tool. Do not remove any more metal than is necessary. For the purpose of skimming the commutator on Sunbeam armatures it will be necessary to use a mandrel to ensure concentricity. On no account must the machined oil-sealing face be gripped in the chuck of the lathe.

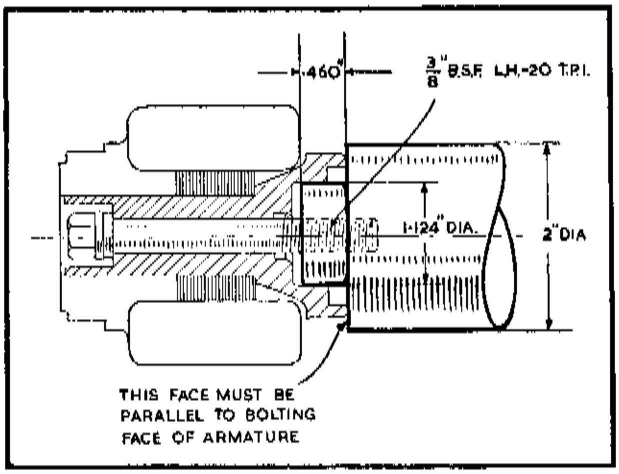

Fig. 3
Mandrel for skimming commutator

(d) Field Coils

Remove the nut securing the end of the field coil lead to the yoke, and measure the resistance of the field coils by means of an ohm-meter. If this is not available, connect a 6-volt battery and an ammeter in series with the field coils by connecting to the 'F' terminal and the end of the field coil lead. The ammeter reading should be approximately 2.3 amperes. No reading on the ammeter indicates an open circuit in the field winding.

To check for earthed coils, connect a mains test lamp between the 'F' terminal and the yoke, with the end of the field coil lead removed from the yoke. If the bulb lights, there is an earth fault occurring in the field winding.

In either case it will be necessary, by checking the field coils individually, to determine which is the faulty coil.

Unless a replacement generator is available, a faulty field coil must be replaced, but this should only be attempted if a wheel-operated screwdriver and pole shoe expander are available. The pole shoe expander is especially necessary to ensure that there will not be any air gap between the pole shoe and the inner face of the yoke.

To replace the field coils, proceed as follows:

(i) Loosen the grub screw at the back of the terminal marked 'F' on the terminal block and pull the coil lead clear of the yoke.

(ii) Unscrew the pole shoe retaining screws by means of the wheel-operated screwdriver.

(iii) Draw the pole shoes and field coils out of the yoke and lift off the coils.

(iv) Fit the new coils over the pole shoes and place them in position inside the yoke. Take care to ensure that the taping of the field coil is not trapped between the pole shoe and the yoke.

(v) Locate the pole shoes and field coils by lightly tightening the pole shoe retaining screws. Insert the pole shoe expander, open to its fullest extent and tighten the screws. Remove the expander and give the screws a final tightening with the wheel-operated screwdriver. Lock the screw in position by caulking.

(e) Armature

The testing of the armature winding requires the use of a volt drop test or a growler. If these are not available, the armature should be checked by substitution. No attempt should be made to machine the armature core or to true a distorted armature shaft.

(f) Reassembly

Reassembly of the generator is a reversal of the operations described in paragraph 4 (b).

5. GENERATOR POLARITY

All replacement generators are despatched from the Works suitable for immediate use on positive earth systems.

If a generator has been incorrectly connected on the motor cycle and its polarity has become reversed, then it must be re-polarized.

To do this, fit the generator to the motor cycle but do not at this stage connect the cables to the 'D' and 'F' terminals. Temporarily connect a length of wire to the battery positive terminal and hold the other end of this wire in contact with generator terminal 'F' for a few seconds only. This serves to re-polarize the generator; the temporary connection can now be removed and the original cables connected to 'D' and 'F' terminals.

The practice of closing the cut-out points to reverse the generator polarity is not recommended as this method allows a high initial surge of current from the battery to pass through the armature, which can damage the windings, insulation, etc., and result in a decreased service life of the machine.

Note: When fitting a replacement coil set ensure that the coils are arranged in the yoke as shown in Fig. 4 below.

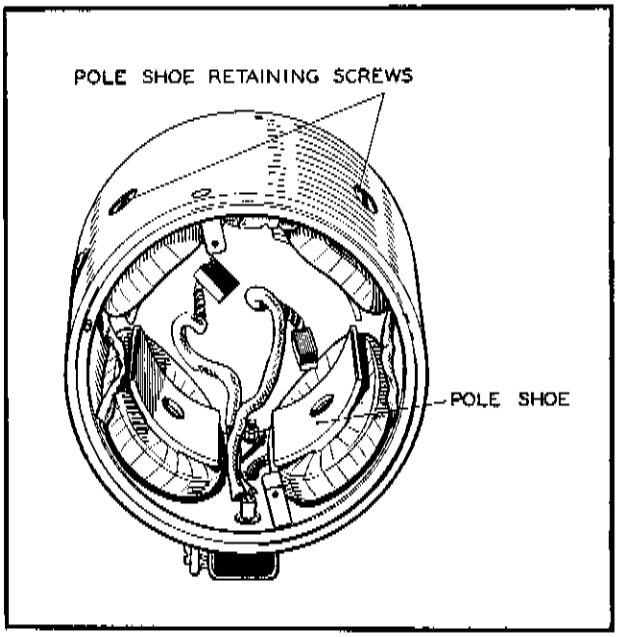

Fig 4

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MOTOR CYCLE GENERATOR

MODEL C35SD

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Printed in England

MOTOR CYCLE GENERATOR

MODEL C35SD

1. GENERAL

Model C35SD generators are shunt-wound two-pole two-brush machines designed to operate in conjunction with a standard motor cycle control box. (See SECTION L-3 Part A).

Both the drive and commutator ends of the armature are supported in ball bearings. The arrangement of the commutator end bearing has been modified on later machines. On earlier machines a thrust spring was fitted between the commutator and the inner journal of the bearing. On later machines the bearing is secured to the armature shaft by a screw and the thrust spring, now loading the outer journal of the bearing, is fitted in the bearing housing in the commutator end bracket. The differences between the two methods of construction will be made clear by reference to Figs. 1 and 2.

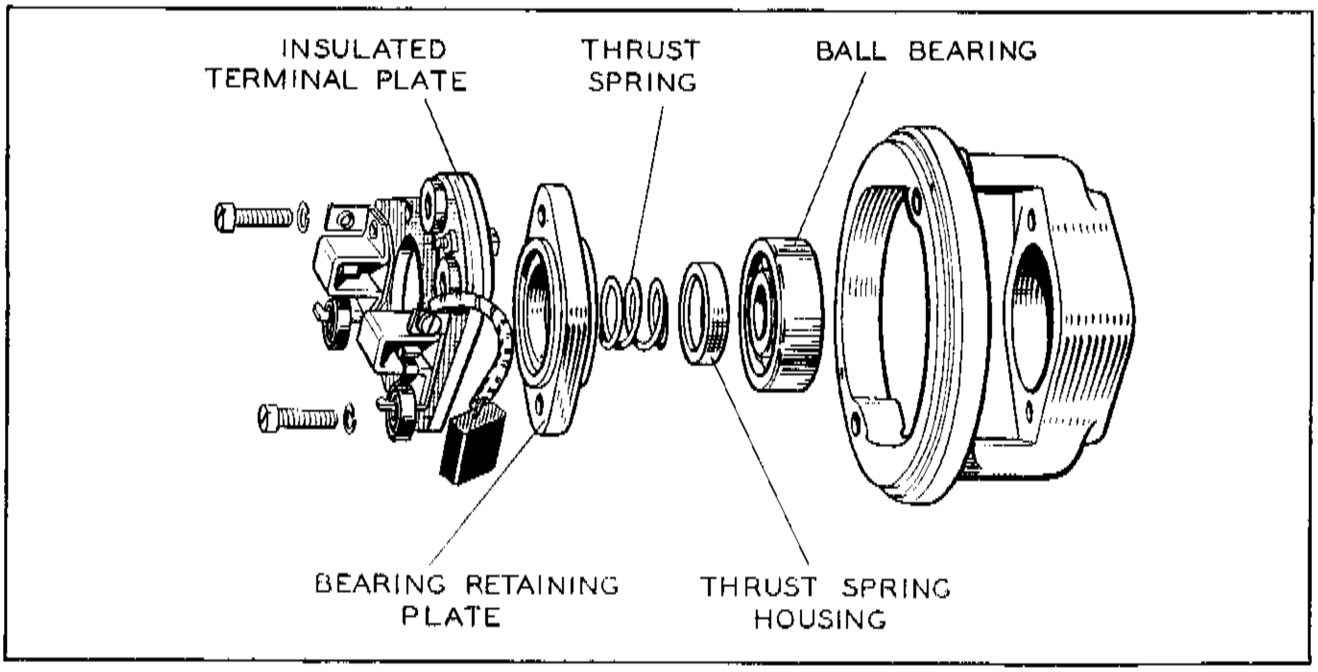


Fig. 1
Dismantled view of earlier type commutator end bracket

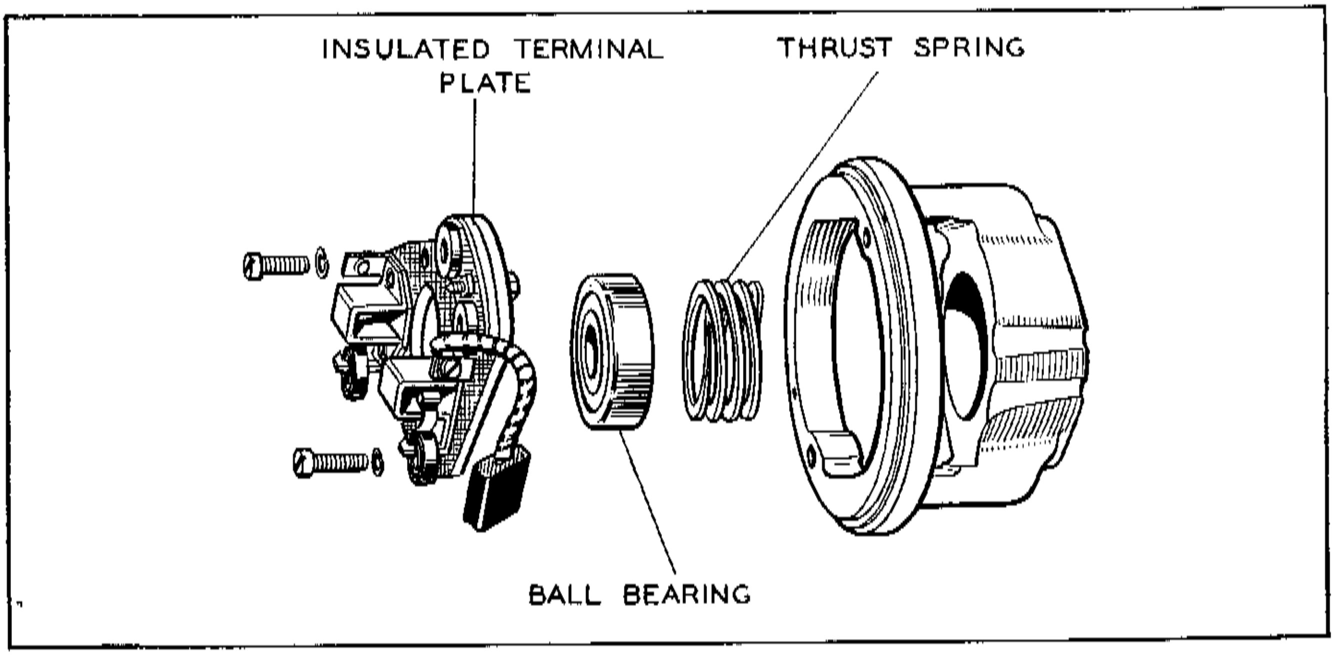


Fig. 2
Dismantled view of later type commutator and bracket

Mounted on the drive end bracket of the generator is a distributor, driven via a worm gear and pinion from the armature shaft. Workshop instructions to cover the distributors are in SECTION L-5 Part C.

2. TEST DATA

Cutting in speed: 1000—1150 r.p.m. at 6.5 generator volts.

Output test: 10 amps at 1700—1850 r.p.m. at 7 volts.

Total field resistance: 2.6—2.8 ohms.

Brush spring tension: 16—20 oz.

3. ROUTINE MAINTENANCE

LUBRICATION

No lubrication is necessary as the ball bearings are packed with H.M.P. grease, which will last until the machine is taken down for a general overhaul, when the bearings should be repacked. Thin lubricating oil, if allowed to reach the bearings, will soften the grease and eventually cause the bearings to run hot.

INSPECTION OF COMMUTATOR AND BRUSH-GEAR

About once every six months remove the commutator end cover for inspection of commutator and brushes. The brushes are held in contact with the commutator by means of springs. Move each brush to see that it is free to slide in its holder; if it sticks, remove it and clean with a cloth moistened with petrol. Care must be taken to replace the brushes in their original positions, otherwise they will not 'bed' properly on the commutator. If, after long service, the brushes have become worn to such an extent that the brush flexible is exposed on the running face, or if the brushes do not make good contact with the commutator, they must be replaced by genuine Lucas brushes. The commutator should be free from any trace of oil or dirt and should have a highly polished appearance. Clean a dirty or blackened commutator by pressing a fine dry cloth against it while the engine is slowly turned over by means of the kick starter crank. (It is an advantage to remove the sparking plug before doing this). If the commutator is very dirty, moisten the cloth with petrol.

4. SERVICING

(a) TESTING IN POSITION TO LOCATE FAULT IN CHARGING CIRCUIT

In the event of a fault in the charging circuit, adopt the following procedure to locate the cause of trouble.

(i) Check that the generator and regulator unit

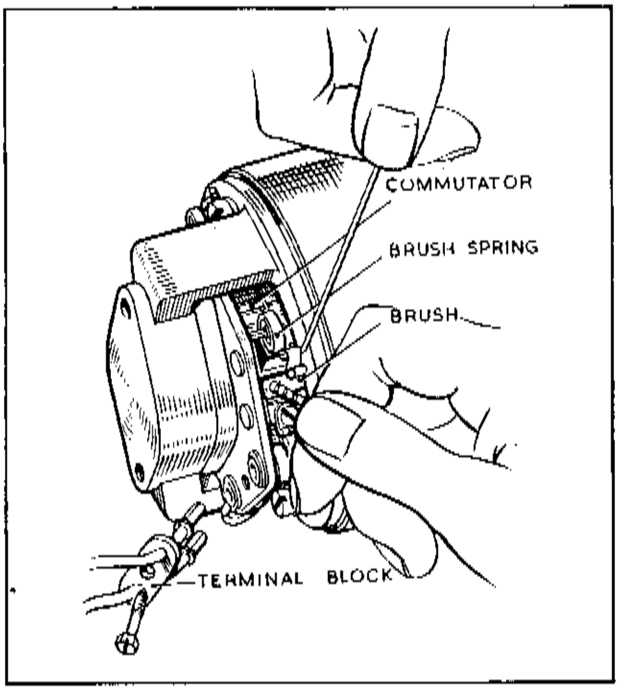


Fig. 3
Checking brushgear

are connected correctly. The generator terminal 'D' should be connected to the control box terminal 'D' and generator terminal 'F' to control box terminal 'F'. Check the earthing cable connected to control box terminal 'E'.

(ii) Remove the cables from the generator terminals 'D' and 'F' and connect the two terminals with a short length of wire.

(iii) Start the engine and set to run at normal idling speed.

(iv) Connect the negative lead of a moving coil voltmeter, calibrated 0—10 volts, to one of the generator terminals and connect the positive lead to a good earthing point on the generator yoke or engine. Reverse voltmeter connections on negative earth machines.

(v) Gradually increase the engine speed, when the voltmeter reading should rise rapidly and without fluctuation. Do not allow the voltmeter reading to rise above 10 volts and do not race the engine in an attempt to increase the voltage. It is sufficient to run the generator up to a speed of 1,000 r.p.m. If there is no reading, check the brush gear, as described in (vi) below. If there is a low reading of approximately ½ volt, the field winding may be at fault (see para. 4e). If there is a reading of approximately 1½ to 2 volts, the armature winding may be at fault (see para. 4f).

(vi) Remove the commutator end cover and examine the brushes and commutator. Hold back each of the brush springs and move the brush by pulling gently on its flexible connector. If the movement is sluggish, remove the brush from its holder and ease the sides by lightly polishing on a smooth file. Always replace brushes in their original positions. If the brushes are worn so that they do not bear on the commutator, or if the brush flexible is exposed on the running face, new brushes must be fitted.

Test the brush spring tension with a spring scale. The correct tension is 16—20 oz. and new springs must be fitted if the tension is low.

If the commutator is blackened or dirty, clean it by holding a petrol moistened cloth against it while the engine is turned slowly by means of the kick start (with sparking plug removed).

Re-test the generator as in (v) above. If there is still no reading on the voltmeter, there is an internal fault and the complete unit if a spare is available, should be replaced. Otherwise the unit must be dismantled (see para. 4b) for internal examination.

(vii) If the generator is in good order, restore the original connections. Connect regulator unit terminal 'D' to generator terminal 'D' and regulator terminal 'F' to generator terminal 'F'. Proceed to test the regulator as described in SECTION L-3 Part A.

(b) TO DISMANTLE

Remove the generator and distributor from the motorcycle. To detach the distributor from the generator drive end bracket, loosen the distributor shank clamping bolt and withdraw the complete unit from the bracket. On earlier models an additional securing bolt is located in the drive end bracket and must be loosened a few turns to allow the distributor to be withdrawn from the bracket. Proceed to dismantle as follows:—

(i) Remove the securing nut from the drive end of the armature shaft, and withdraw the gear with the aid of an extractor. Knock out the key from the armature shaft.

(ii) Unscrew the two commutator end cover securing screws and remove the cover. Hold

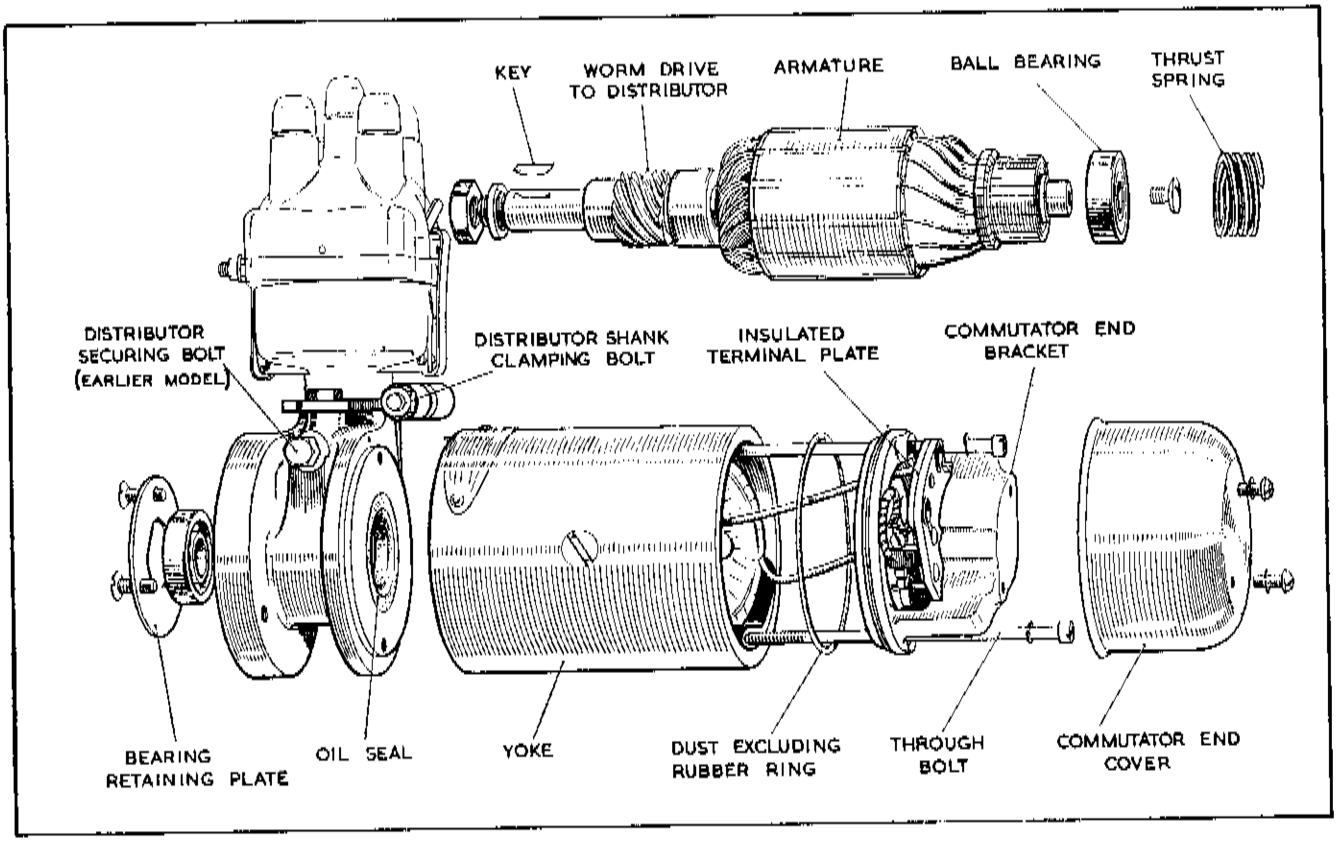


Fig. 4
Dismantled view of later type generator

back the brush springs and lift the brushes from their holders.

(iii) Disconnect the earthed field connection and unsolder the field connection to terminal 'F' on the terminal strip.

(iv) Unscrew and remove from the commutator end bracket, the two through bolts securing the end bracket and yoke to the drive end bracket.

(v) Draw the commutator end bracket away from the armature and separate the yoke from the drive end bracket. On earlier models a thrust spring will be found around the armature shaft (on later models it is located between the ball bearing and the housing); take care not to lose this.

(vi) The armature can now be pressed out of the drive end bearing, taking great care not to damage the sealing lip of the rubber oil seal.

(vii) Unscrew the two screws on the inner side of the commutator end bracket which secure the insulated terminal plate carrying the terminals and brushgear. On earlier models removal of the insulating plate will reveal the bearing retaining plate and thrust spring housing.

(c) BEARINGS

Ball bearings are fitted to both the commutator and drive end brackets. When the bearings become worn to such an extent that they allow side movement of the armature shaft, they must be replaced. The bearings should not be disturbed, except for the purpose of replacement. To replace the ball bearing at the drive end, proceed as follows:—

(i) Remove the bearing retaining plate from the drive end bracket by unscrewing the three countersunk screws.

(ii) Press the defective bearing out of the end bracket. Wipe out the bearing housing and pack the new bearing with H.M.P. grease.

(iii) Position the bearing in its housing and press it squarely home, applying pressure on the outer journal of the bearing.

To replace the ball bearing at the commutator end, proceed as follows:—

Earlier Type

(i) Using an expanding calliper type extractor, draw the bearing from its housing in the commutator end bracket.

(ii) Wipe out the bearing housing and pack the new bearing with H.M.P. grease.

(iii) Position the new bearing in its housing and press it squarely home, applying pressure on the outer journal of the bearing.

Later Types

(i) To remove the bearing slacken and withdraw the thrust screw and pull the bearing off the armature shaft with an extractor.

(ii) Wipe out the bearing housing and pack the new bearing with H.M.P. grease.

(iii) Force the new bearing home against the shoulder on the armature shaft. Insert and tighten the thrust screw.

(d) COMMUTATOR

Examine the commutator. If it is in good condition, it will be smooth and free from pits or burned spots. Clean with a petrol-moistened cloth. If this is ineffective, carefully polish with a strip of very fine glasspaper while rotating the armature. To remedy a badly worn commutator, mount the armature (with or without the drive end bracket) in a lathe, rotate at high speed and take a light cut with a very sharp tool. Do not remove more metal than is necessary. Polish the commutator with very fine glasspaper.

Undercut the insulation between the segments to a depth of $\frac{1}{32}$" with a hacksaw blade ground down until it is only slightly thicker than the insulation.

(e) FIELD COILS

Measure the resistance of the field coils by means of an ohm meter (see para. 2). If an ohm meter is not available, connect a 6 volt D.C. supply with an ammeter in series across the coils. The ammeter reading should be approximately 2.2 amps. No reading on the ammeter indicates an open circuit in the field coils.

To check for an earthed coil, connect a 110 volt mains test lamp between one end of the field coils and the yoke. If the bulb lights, there is a short circuit between the coils and the yoke.

In either case, unless a replacement generator is available, the field coils must be replaced, but this should only be attempted if a wheel-operated screwdriver is available.

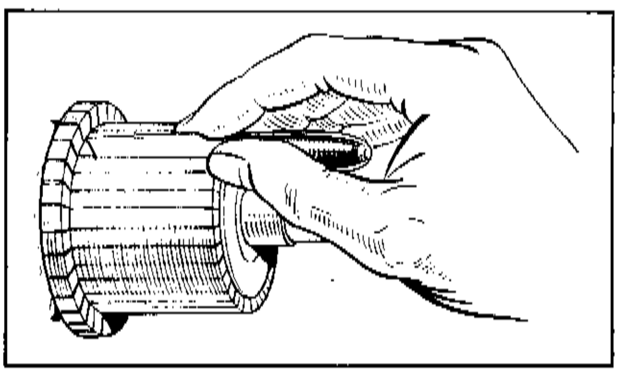
To replace the field coils, proceed as follows:—

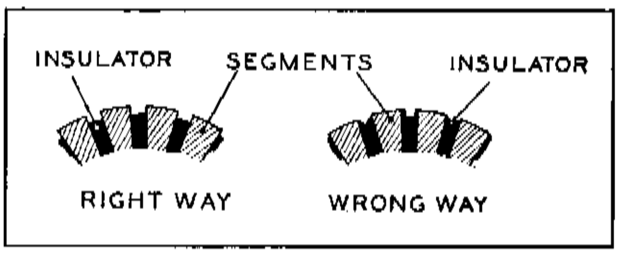
(i) Unscrew the pole shoe retaining screws by means of a wheel-operated screwdriver.

(ii) Draw the pole shoes and field coils out of the yoke and lift off the coils.

(iii) Fit the new field coils over the pole shoes and place in position inside the yoke. Take care to ensure that the taping of the field coils is not trapped between the pole shoes and the yoke.

(iv) Locate the pole shoes and field coils by lightly tightening the fixing screws with a screwdriver. Give the screws a final tightening with the wheel-operated screwdriver. Lock the screws in position by caulking, that is, by tapping some of the metal of the yoke into the slot in the head of the screw.





(a) Fig. 5 (b)

Method of under cutting commutator insulation

(f) ARMATURE

Indication of an open-circuited armature will be given by burnt commutator segments. If armature testing facilities are not available, an armature can be checked by substitution. No attempt should be made to machine the armature core or to true a distorted armature shaft.

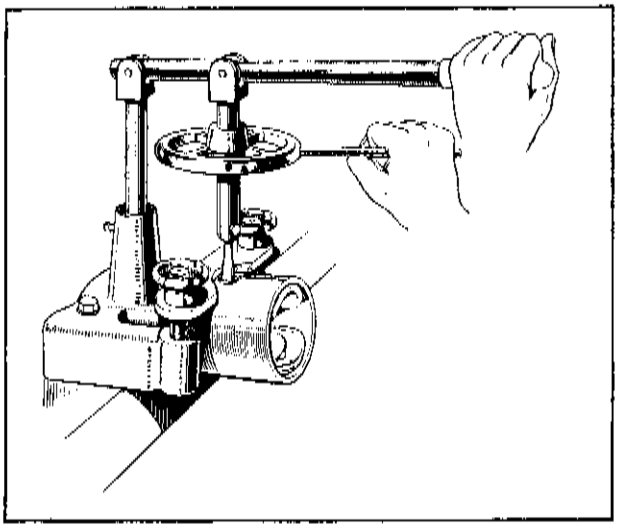


Fig. 6
Tightening pole shoe retaining screw

(g) REASSEMBLY

In the main the reassembly of the generator is a reversal of the operations described in para. 4(b), bearing in mind the following points:—

(i) The field coil lead fitted with a terminal eyelet must be connected, together with the eyelet of the earthed brush flexible, to the commutator end bracket by means of the screw provided.

(ii) The second field coil lead must be resoldered to terminal 'F' on the insulated terminal strip.

(iii) The unearthed brush flexible lead must be connected direct to terminal 'D' on the insulated terminal strip.

(iv) When refitting the commutator end cover, do not forget to refit the dust excluding rubber ring.

(v) If the oil seal in the drive end bracket has been damaged a replacement seal must be fitted during reassembly. To remove the oil seal from the end bracket, use a metal drift locating on the outer edge of the rubber seal. Insert a new seal using a mandrel to press it squarely home.

5. GENERATOR POLARITY

All replacement motor cycle generators are despatched from the Works suitable for immediate use on positive earth systems. If the negative terminal of the battery is earthed on the machine for which the replacement generator is intended, it will be necessary to re-polarize the generator before use to make it suitable for negative earth.

To do this, fit the generator to the motor cycle but do not at this stage connect the cables to the 'D' and 'F' terminals. Temporarily connect a length of wire to the battery positive terminal and hold the other end of this wire in contact with generator terminal 'F' for a few seconds only. This serves to re-polarize the generator; the temporary connection can now be removed and the original cables connected to 'D' and 'F' terminals.

The practice of closing the cut-out points to reverse the generator polarity is not recommended as this method allows a high initial surge of current from the battery to pass through the armature, which can damage the windings, insulation, etc., and result in a decreased service life of the machine.

If a generator has been incorrectly connected on the motor cycle and its polarity has become reversed, then it must be re-polarized to suit the system in use.

Para. (g) REASSEMBLY (*continued*)

(vi) Before refitting the drive end bracket, pack the distributor drive housing with Duckham's H.B.B. Grease.

LUCAS

Quality

EQUIPMENT

WORKSHOP INSTRUCTIONS

INDUCTOR-GENERATORS

MODEL IA45

JOSEPH LUCAS LTD · BIRMINGHAM 19 · ENGLAND

Printed in England

INDUCTOR-GENERATORS

MODEL IA45

1. GENERAL

Model IA45 Inductor-Generator comprises two main components, a stator and a rotor. The stator carries two coils wound on laminated steel cores, and two magnets cast integral with an aluminium shell. An output similar to that given by a twelve pole rotating magnet alternator is obtained by using a six-toothed rotor, also of laminated steel. Thus, as the rotor turns, rapid and repeated reversals of flux take place in the coil cores, to induce alternating e.m.f.'s in the coils.

Connections from the ends of the coils are taken to a terminal board and thence, through multi-cored cable, to a separately mounted control switch.

A contact-breaker mechanism is included in the design for use with coil ignition. The cam is carried by an extension to the rotor core, whilst the contact-breaker plate is carried by an extension to the stator casting.

Three basically similar designs are produced and can be identified as follows:

One design includes an auto-advance mechanism fitted to the rotor extension; on another, the rotor extension is partially supported or steadied by a roller bearing mounted behind the contact-breaker assembly; whilst a third design, usually fitted to light delivery vans, carries neither an auto-advance mechanism nor a steady bearing.

The rotor is taper-coupled with, and driven by, an extension to the crankshaft. It is important, therefore, that excessive wear in the engine bearings is not allowed to develop. In the event of such wear developing and resulting in a badly scored rotor and stator, the complete unit should be returned to the Works for repair or replacement.

Warning : To prevent the magnets from becoming de-energised, avoid unnecessary removal of the rotor. When such removal is unavoidable, special keepers must be fitted to the stator and the precautions recommended in Section D-6, page 7, observed. The dimensions and method of fitting the keepers is shown in Section D-6, Fig. 8a.

If the rotor is removed, and these precautions are not observed, it will be necessary to return the complete unit to the Works for re-magnetisation.

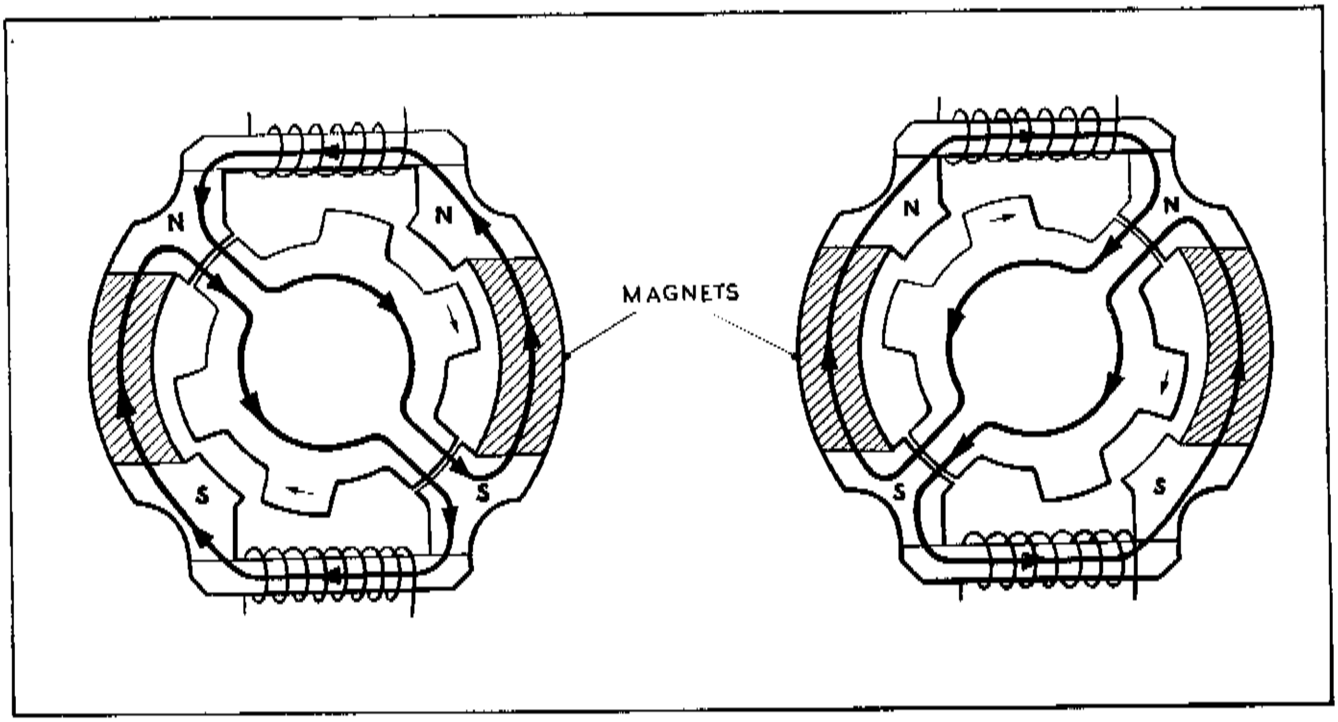


Fig.1.
Inductor-generator, principle of operation

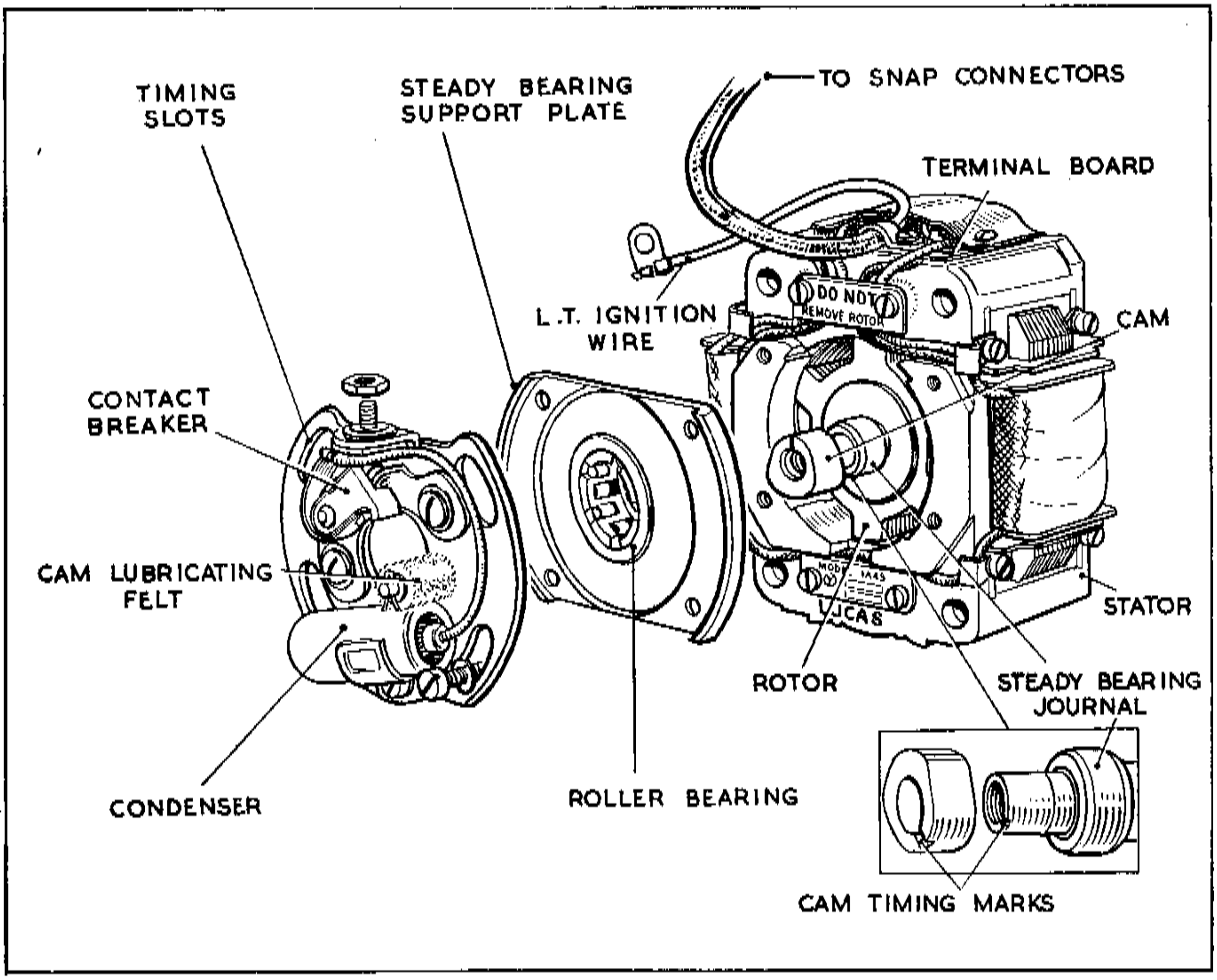


Fig. 2.
Exploded view of an inductor-generator fitted with a steady bearing

GENERAL PRECAUTIONS

The inductor-generator set is designed for working with a 'positive earth' system. Should the battery be connected with its negative terminal to earth, the rectifier will be burnt out when the ignition is switched on.

Since it is not possible to repair a burnt out or badly damaged rectifier, a defective unit must be replaced. It is important to fit the new rectifier in the manner specified by the makers, i.e. spacer bushes to be used to allow free ventilation to both sides of the rectifier, and the unit to be mounted vertically with the cables emerging from its lower edge.

The set has an ample margin of safety. Nevertheless, it should not be run with the battery disconnected for longer than is necessary - whether or not the ignition switch is in the Emergency position. The higher operating voltage generated under these conditions can cause overheating of the ignition coil and burning of the contact-breaker points.

2. MAINTENANCE

In general, the only maintenance required is to lubricate and clean the contact-breaker assembly as described below. This procedure should be carried out every 3,000 miles.

When lubricating take great care to prevent oil or grease from getting on or near the contact-breaker points.

(*a*) LUBRICATION

The Cam:

The contact-breaker cam is lubricated by an impregnated felt pad, which should not need renewing during the normal service life of the generator. Occasionally, bend out the pad securing tag and turn the pad to expose a fresh rubbing surface to the cam. Bend in the tag to prevent the pad from rotating in service. Do not apply oil or grease to this lubricator, even if the felt seems dry to the touch.

Automatic Advance Mechanism:

To lubricate this mechanism (when fitted) the contact-breaker plate must be removed. The plate is secured by two screws which pass through slotted holes. It is important therefore to mark both plate and body before separating and thus avoid alteration to the ignition timing during reassembly. Apply a *trace* of thin machine oil to the spindle and moving parts. Refit the contact-breaker plate.

Roller Bearings:

The roller bearings (when fitted) are housed in a dished plate which together with the contact-breaker plate, is secured by four screws. Again, before removing, mark both contact-breaker plate and body, to avoid altering the ignition timing during reassembly.
Lift off the contact-breaker plate, and carefully lever off the bearing plate. Lightly smear cage and rollers with a *small quantity* of high melting point grease. Refit the bearing and contact-breaker plates.

(*b*) CLEANING

Examine the contact-breaker. The contacts must be quite free from grease or oil. If they are burned or blackened, clean them with very fine carborundum stone or emery cloth, afterwards wiping with a clean petrol-moistened cloth.
Cleaning is facilitated if the contact-breaker is removed. To do this, slacken the nut or nuts on the low tension terminal post to release the slotted end of the contact-breaker spring, and lift the contact-breaker lever off its pivot. Note that the contact-breaker spring is sandwiched between the tag of the condenser connection and a fibre washer.
After cleaning, smear the contact-breaker pivot with a *trace* of Mobilgrease No. 2 or clean engine oil. Replace the contact-breaker lever and tighten the low tension terminal.

3. DESIGN DATA

(*a*) Rotation: Anti-clockwise when viewed from contact-breaker end.
Direct Current Output: Should exceed 7 amperes at 2,200 r.p.m and be less than 10 amperes at 4,000 r.p.m.
(*b*) Contact Gap: 0.010 – 0.012 in.
(*c*) Spring Tension at Contacts: 18 — 24 oz.
(*d*) Condenser Capacity: 0.2 microfarad.
(*e*) Automatic Timing Control:
(The following characteristics apply only to machines bearing the Service No. 47 069 and are quoted from ECM 457):

Accelerating

Speed (r.p.m)	Cam Advance (degrees)
up to 500	Zero
4000	28 — 32

Decelerating

Speed (r.p.m.)	Cam Advance (degrees)
3000	20 — 24
2000	6 — 10
1600	0 – 5

4. SERVICING

(*a*) TESTING IN POSITION

The following tests are designed to check performance and to assist in tracing faults.
Test (i) is suitable for use when a simple and rapid check is required.
Tests (ii) (iii) and (iv) provide miscellaneous checks on the equipment.
Test (v) is the recommended method of checking performance in which the voltage drop across a one-ohm resistance is measured using an a.c. voltmeter.
Test (vi), using a d.c. voltmeter, is an alternative to Test (v) and may be used when an a.c. voltmeter is not available.
For constructional details of the one-ohm resistance used in Tests (iv), (v) and (vi), see para. 5 (*a*) and 5 (*b*).

Internal connections of the Inductor-Generator are brought out in multi-core cable and coloured Purple, Yellow and Green. A fourth wire coloured White is connected to the contact breaker terminal. The ends are fitted with snap connectors.
When carrying out tests (i), (iii), (v) and (vi), disconnect the Purple, Yellow or Green wires as required at the snap connector, but leave the White or Black and White ignition wire connected in order that the engine may be run

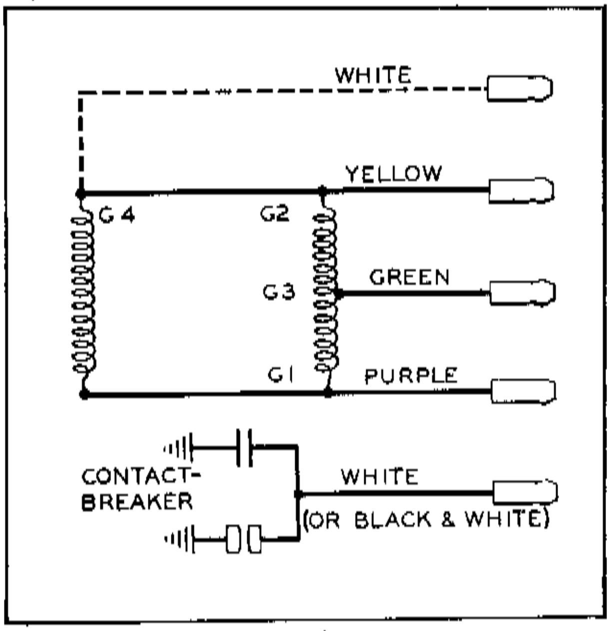


Fig. 3.
Terminal arrangement and internal connections of Model IA45 inductor-generator

The most usual terminal arrangement is shown diagramatically in Fig. 3. However, in the case of Inductor-Generators fitted to light delivery vans, terminals G4 and G2 are not connected internally. Instead, the connection to G4 (shown in broken line) is brought out, using the white core normally connected to the contact-breaker. A separate wire, run outside the four-core cable, is connected to the contact-breaker.

(i) **Bulb Tests.** Using a 6-volt 36-watt test lamp, connect one test lead to snap connector G3 (Green) and the other to snap connector G1 (Purple). Start the engine and run it at about 2,000 r.p.m. The bulb should light to full brilliance.

Stop the engine and disconnect the test lead from G1. Connect it to snap connector G2 (Yellow) and re-test. The bulb should again light to full brilliance.

Note: In the case of light delivery vans, snap connectors G2 (yellow) and G4 (white) must be joined together.

(ii) **Insulation Test.** Using a 500-volt insulation tester, test between the coloured connectors (G1, G2 and G3 bunched together) and the stator casting. A reading of not less than 10MΩ should be obtained.

(iii) **Battery Input Tests.** Connect an ammeter calibrated 0– 10 amps. in series with the battery cable. Turn the lighting switch to OFF. Start the engine and accelerate until the ammeter needle steadies.

This should indicate 3.0 to 3.5 amperes.

A reading of approximately 7 amps would indicate an open circuit. Check therefore at the following points:

For vehicles fitted with half-charge resistance (B.S.A. 'Bantam' and Brockhouse Motor-Cycles) refer to Fig. 10.

Check resistance for continuity (6.5 ohms.).

Check switch contacts connecting G1 to R.

Check wiring between the switch and the resistance, and from the snap connectors to the switch and to the resistance.

Turn the lighting switch to position 'P'. The ammeter needle should indicate 5.5 - 6.0 amperes.

For vehicles not fitted with half-charge resistance (light delivery vans) refer to Fig. 11.

Check the switch rocker arms. The left-hand rocker arm should be in contact with switch terminal '7', and the right-hand arm should be lifted clear of terminal '1'.

Turn the lighting switch to the Headlamp position. The ampere output should now increase. If it does not:—Check that the right-hand rocker arm has contacted terminal '1'; check wiring for continuity between generator terminal G4 (yellow) and the rocker arms, and between generator terminal G2 and switch terminal '1'.

In the event of zero output in all positions of the lighting switch check the rocker arms—these may be contacting terminals '1' and '7' simultaneously.

(iv) **Rectifier Tests.** The rectifier is designed for use with a Positive Earth Battery. It must not be connected to a negatively earthed battery.

Remove the rectifier from the machine. Connect it in series with a 6-volt battery, ammeter, and loading resistance, using a centre (0.5 ohm.) tapping of the one-ohm resistance, as shown in Fig. 4.

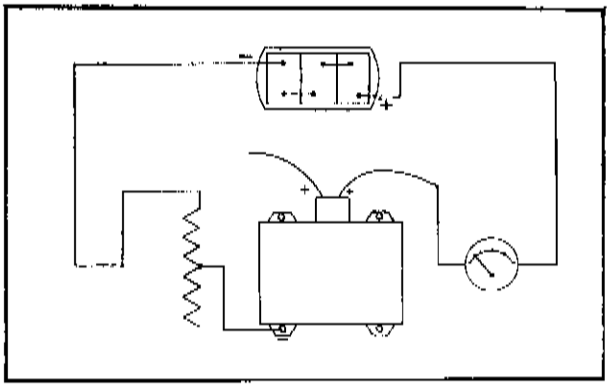


Fig. 4.
Circuit diagram for rectifier test

The ammeter should indicate a current of not more than 10 amperes when either of the two rectifier cables are connected to it.

If the current flows freely, then reverse the battery connections and measure the back current through each rectifier cable. This current should not exceed 100 milli-amps. If a current greatly in excess of 100 milli-amps is measured, then the rectifier plates are shorted and a replacement rectifier must be fitted.

If the above tests show the rectifier to be sound, refit it to the machine, taking care to see that the rectifier-to-machine contact is good. A faulty earthing contact will cause erratic or zero generator output.

If Tests (i) to (iv) suggest demagnetisation or a faulty stator coil, proceed with Test (v); or if an A.C. voltmeter is not available, with Test (vi).

(v) **A.C. Voltmeter Tests.** Tests (a), (b) and (c) below require points G2 and G4 to be connected. On the majority of machines these points are joined internally by a soldered connector at the terminal board, but with light delivery vehicles snap-connectors G2 (Yellow cable) and G4 (White cable) must be wired together externally.

Tests (d) and (e) require points G2 and G4 to be isolated. It will be necessary with some machines, therefore, to remove the generator in order to unsolder the link G2-G4. Great care must be taken to ensure that stator and rotor are removed simultaneously and that the rotor is not allowed, even momentarily, to leave the stator. See Warning, page (1) and para. 4 (*e*) and 4 (*g*).

Using the one-ohm loading resistance with an a.c. voltmeter connected in parallel make the following tests, and note the voltage reading when the engine runs at 4000 — 5000 r.p.m.

		One-ohm Resistance Connected between:	Voltmeter Reading:
(*a*)	...	G1 and G2 - - G4	4.7 to 5.7
(*b*)	...	G3 ,, G1	8.5 ,, 10.3
(*c*)	...	G3 ,, G2	8.5 ,, 10.3
(*d*)	...	G1 ,, G4	2.35 ,, 2.85
(*e*)	...	G1 ,, G2	2.35 ,, 2.85

Analysis of Tests (*a*) to (*e*):

Test(s):	Result:	Conclusion:	Action:
(*a*)	Reading of 3.0 to 3.8 volts.	Rotor has been withdrawn and replaced.	If tests (*b*) and (*c*), and (*d*) and (*e*), give pairs of identical but low readings, return generator to Works for remagnetisation.
(*b*) & (*c*)	Low reading.	An internally shorted coil.	Identify faulty coil from Tests (*d*) and (*e*).
(*d*) & (*e*)	Low reading.	As above.	Replace faulty coil, see page 6, para. (*c*).
	Zero reading.	Open circuited coil.	As above.

(vi) **D.C. Voltmeter Test.** Disconnect snap connectors G1, G2, G3 (Purple, Yellow, Green) and, in the case of light delivery vans, also G4 (White) and join it to G2 (Yellow).

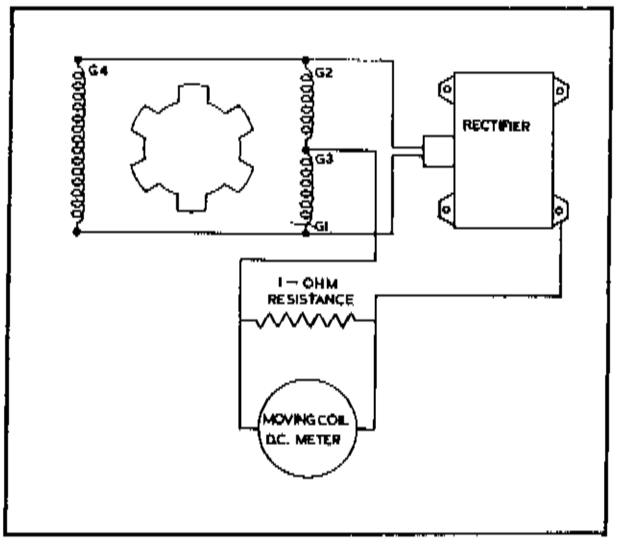


Fig. 5.
Circuit diagram for D.C. voltmeter test

Connect the rectifier, one-ohm loading resistance, and D.C. voltmeter as shown in Fig. (5). Start the engine and run it at 4000 — 5000 r.p.m. when the voltmeter should show 8.5 to 10.3 volts.

A low reading can be caused by: a faulty coil or defective insulation; a defective rectifier; loss of magnetism.

If the generator insulation and the rectifier are shown to be sound by Tests (ii) and (iv), then either check the coils by substitution, para. (*c*), or return the complete unit to the Works for repair or remagnetisation.

(b) IGNITION TESTS

To carry out the following ignition tests, the generator must be removed from the machine, as described in para. 4 (*e*) or 4 (*g*).

A special bench fixture to support the generator is required, equipped with a variable-speed electric motor to drive the rotor. In addition, a Type CQ ignition coil and a contact-breaker set in accordance with Design Data 3 (*b*) and 3 (*c*) are also required.

(1) **High Speed Test.** Connect the plug cable to an 8 kV rotary gap (see Section C8, Fig. 2) and turn the ignition switch to IGN., i.e. with coil terminal SW, and battery negative, connected to G3, see Fig. 6 (*a*). Regular sparking should occur up to 5000 r.p.m.

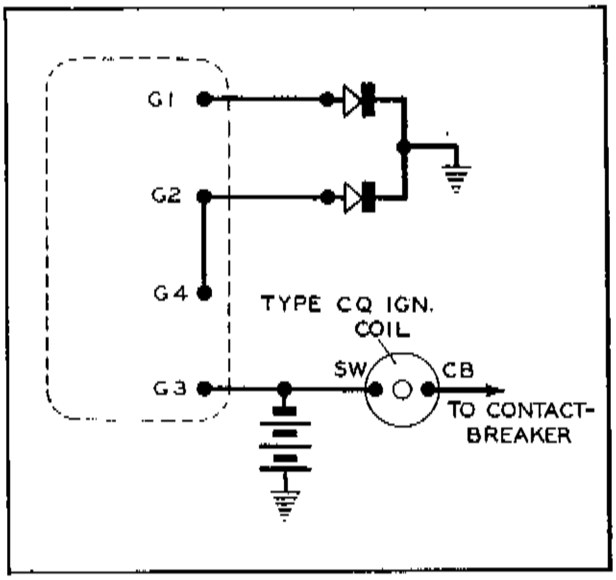


Fig. 6 (*a*).
High speed sparking test

(2) **Low Speed Test.** Connect the plug cable to an 8kV rotary gap or an equivalent (4½ milli-metres) 3-point stationary gap. Turn the ignition switch to the Emergency Start position, i.e., with battery disconnected and coil terminal SW connected to G1, see Fig. 6 (*b*).

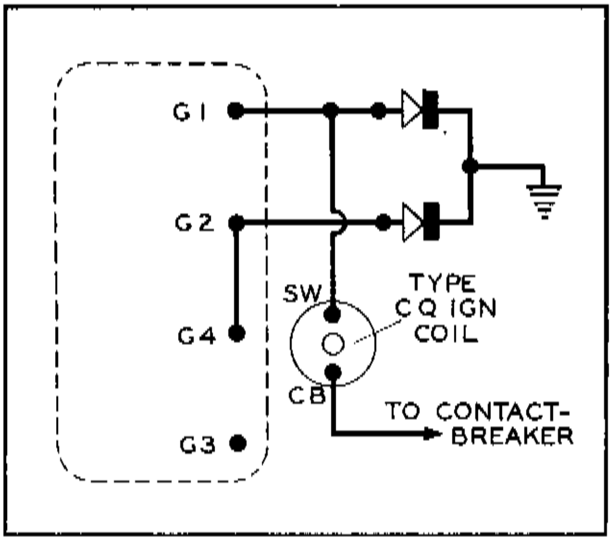


Fig. 6 (*b*).
Low speed sparking test

Regular sparking should occur, at a speed less than 550 r.p.m., through a range of ± 5° with respect to a pre-set nominal firing position of the contact-breaker base plate.

To obtain this position, face the drive end and turn the rotor so that a centre-line drawn through the rotor keyway is displaced with respect to a vertical centre-line drawn through the stator. This displacement is 25° to the **right** of bottom with models stamped 47 068 or 47 077, or 34° to the **left** with models stamped 47 069, as shown in Fig. 7. With the rotor in this position, set the contact-breaker base plate so that the contacts are just separating. The contact-breaker base plate is now in the nominal firing position.

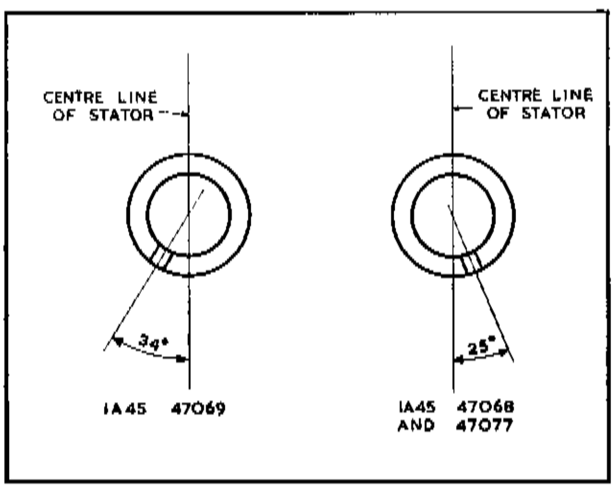


Fig. 7.
Location of rotor keyway for nominal firing point

(c) COIL REPLACEMENT

A stator coil is classified as right-hand or left-hand when viewed from the drive side of the rotor. There are two coils which, with the terminal plate and cable, form a soldered assembly that can be removed as follows:—

Remove the two terminal plate retaining screws and the cable clamping screws. Remove the labels and insulating strips from the front of the stator. Release the four coil retaining clamps and lift the coil assembly from the generator.

Before fitting new coils, check that the contacting surfaces of the laminations are perfectly clean and free of grease or magnetically attracted particles such as swarf and filings.

(*d*) CONTACT-BREAKER REMOVAL

The base plate fixing holes are slotted. It is therefore important to mark both plate and stator before separation in order that the manufacturers' ignition setting shall not be altered when reassembling.

Remove the low tension ignition cable (white, or white with a black tracer) from the contact-breaker terminal. Withdraw the base plate fixing screws and lift off the plate complete with contact-breaker and condenser.

(e) REMOVAL OF GENERATORS NOT FITTED WITH STEADY BEARING

Remove the generator cover and disconnect all cables from the machine. Withdraw the rotor retaining bolt and insert the special extracting bolt shown in Fig. 8. Turn the extracting bolt until the rotor is just free of the crankshaft.

Withdraw the stator securing bolts and lift the *complete* generator away from the crankcase. See Warning, on page 1.

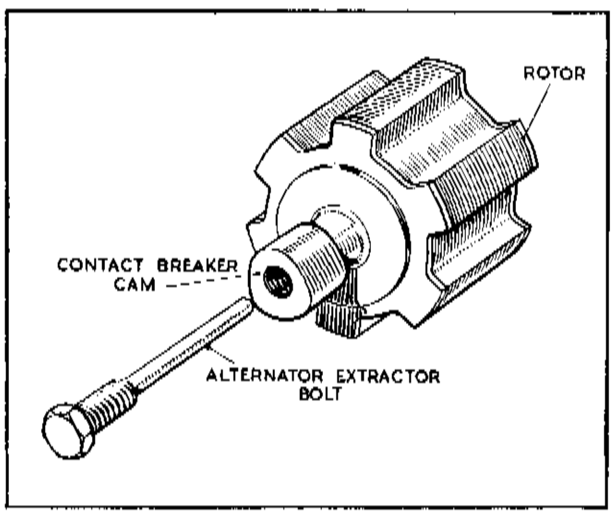


Fig. 8.
Extractor bolt

(*f*) REFITTING

Place the generator on the crankcase so that it locates with the register or spigot. Apply medium pressure to the rotor and turn it until it registers with the driving key on the engine crankshaft. Insert the centre bolt in the rotor and fully tighten. Replace the stator securing bolts and tighten evenly.

(*g*) REMOVAL OF GENERATORS FITTED WITH STEADY BEARING

Removal is generally as described in para. 4 (*e*). Provision is made for the easy removal and replacement of the steady bearing plate or bearings, see para. 2 (*a*). The cam and steady bearing journal are both press fits on the rotor shaft extension. These fitments can, if necessary, be withdrawn using a suitable extractor of standard pattern.

If a cam is removed for any reason, it is most important when reassembling to fit the cam in correct relation to the rotor shaft (see insert, Fig. 1), otherwise the engine performance, when the machine is run with the ignition switch in the Emergency Start position, will be affected adversely.

(*h*) REFITTING

Refitting is generally as para. 4 (*f*) except for the following additional procedure which must be observed to ensure correct alignment of the steady bearing: the contact plate securing screws must be left loose until the rotor and stator bolts have been fully tightened. The contact plate fixing holes are drilled to provide clearance and, providing the above method of refitting is followed, the plate and bearing will automatically align with the rotor shaft.

5. CONSTRUCTION

(*a*) CONSTRUCTION OF ONE-OHM TEST RESISTANCE

Material required:

(i) 12 feet of 18 SWG Nichrome resistance wire.
(ii) An asbestos former of approximately 2 in. dia.
(iii) Two terminals, test leads and crocodile clips.

Method of Winding:

In order to carry the normal test currents without overheating, the resistance wire should be wound on the former as follows:

Hold the ends of the wire together and fold it at the centre, to give a single six-foot length of double wire. Wind this double wire round the former and secure one end with a suitable terminal. The other end should not be permanently anchored until the resistance has been calibrated as described below.

(*b*) CALIBRATION OF ONE-OHM RESISTANCE

Apparatus required:

(i) A 6-volt battery.
(ii) A first grade 0–10 moving coil voltmeter.
(iii) A first grade 0–10 moving coil ammeter.
(iv) A test prod, and connecting cables.

The above items should be connected to the resistance as shown in Fig. 8. Apply the test prod firmly to the free end of the resistance and note the deflection thus caused to each meter pointer. If necessary, move the test prod along the resistance until the voltmeter and ammeter readings are numerically equal, i.e., the value of resistance between the first terminal and the prod is one ohm, and is the point at which the second terminal should be placed. Secure the end of the Nichrome wire to the terminal and cut off any surplus.

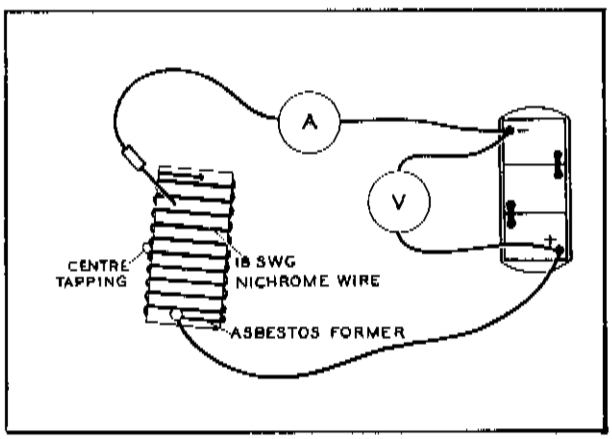


Fig. 9.
Circuit required to calibrate a one-ohm load resistance

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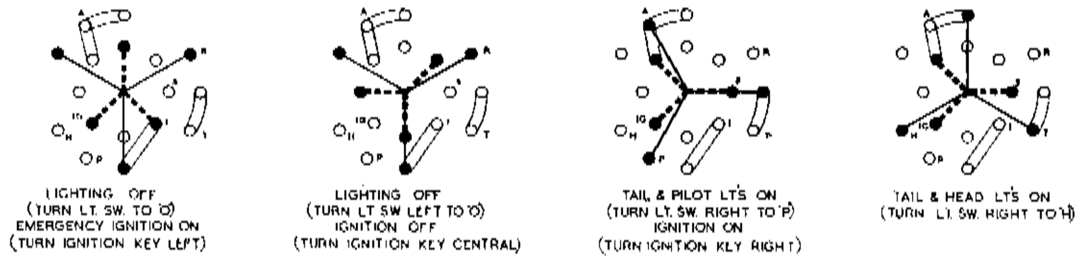

DIAGRAMS SHOWING SWITCH POSITIONS LOOKING ON TOP OF SWITCH

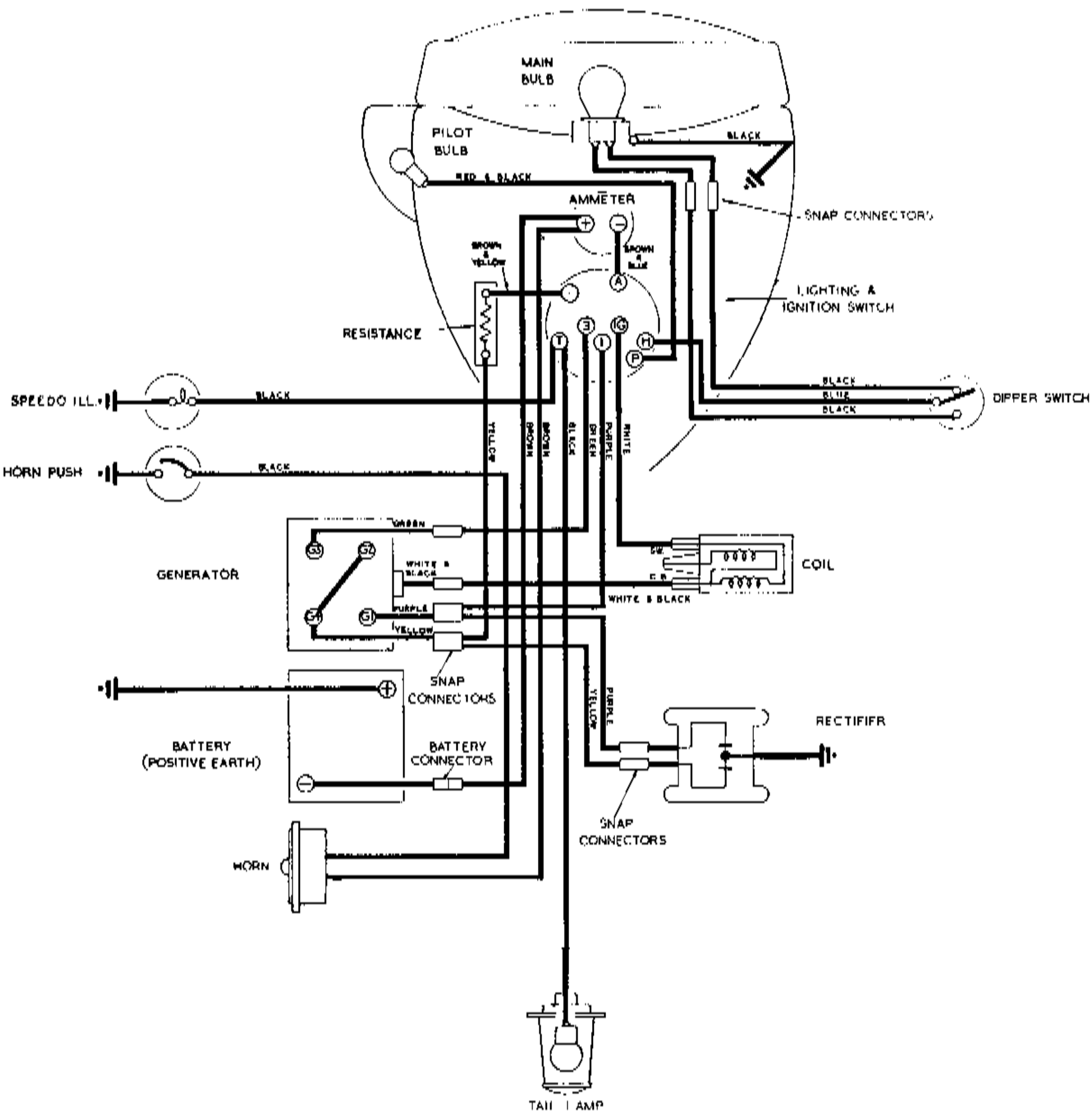

Fig. 10.
An inductor-generator circuit with half-charge resistance

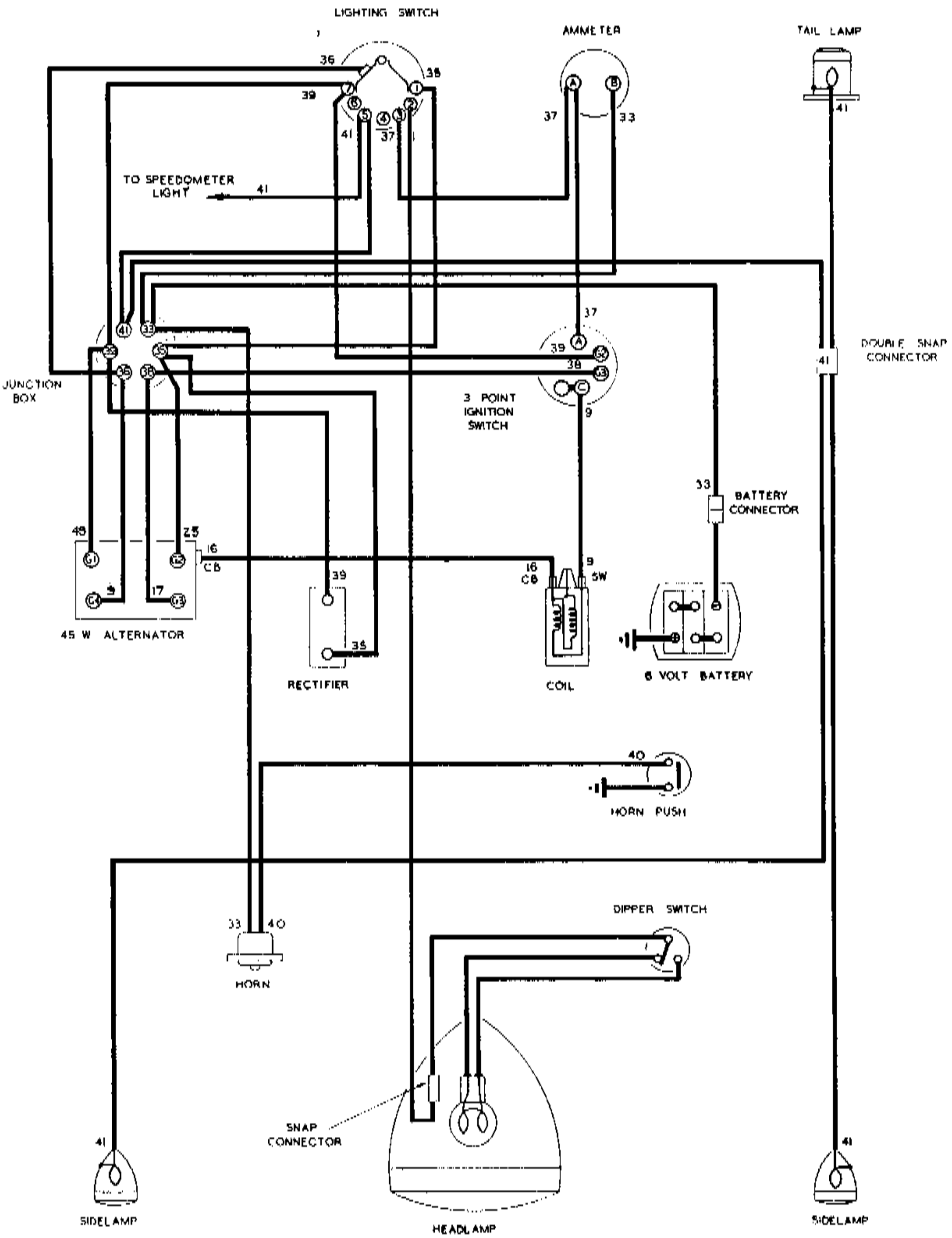

Fig. 11.
An inductor-generator circuit without half-charge resistance

SECTION L-2 Part E
ISSUE 1, NOVEMBER 1960

LUCAS

Quality

EQUIPMENT

VOLUME 2

WORKSHOP INSTRUCTIONS

MOTOR CYCLE ALTERNATORS

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

LUCAS

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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 $5\frac{7}{16}$" 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.

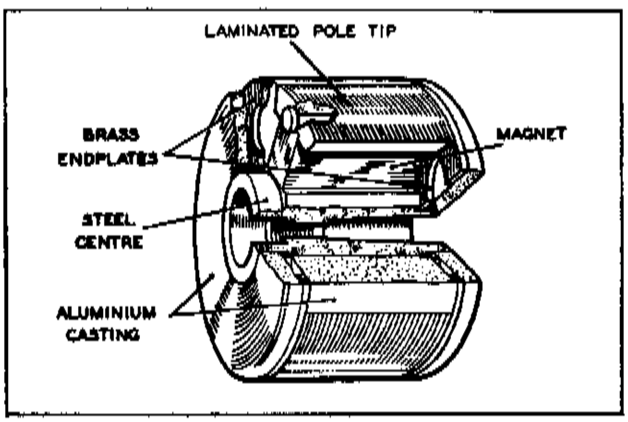


Fig. 1 View of rotor, sectioned

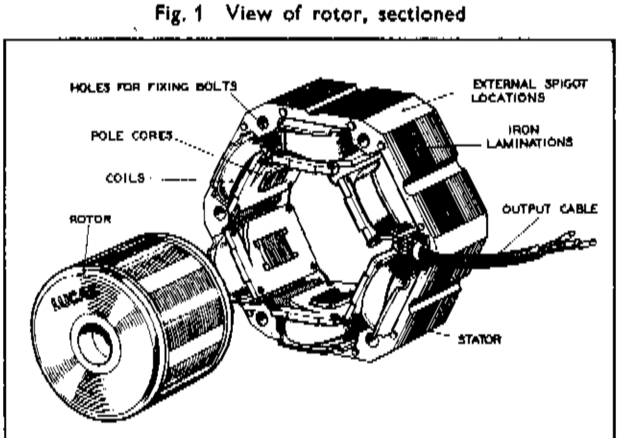


Fig. 2 Alternator model RM14, with rotor withdrawn

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.

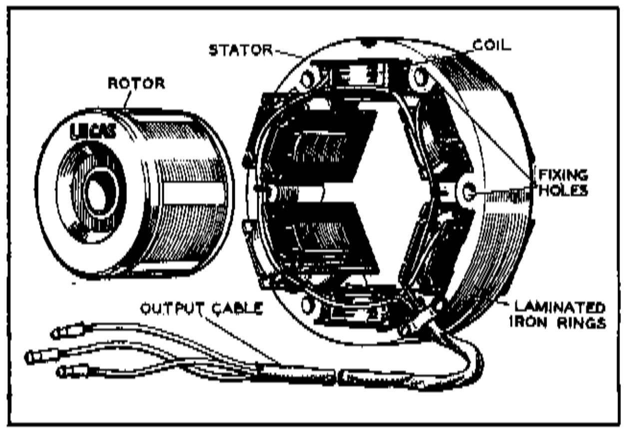


Fig. 3 Alternator model RM15, with rotor withdrawn

(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

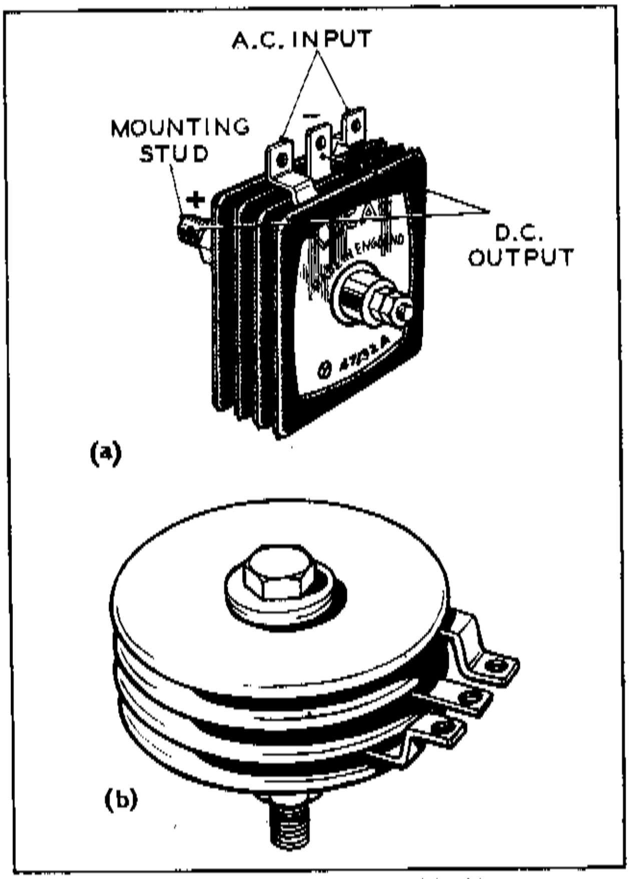


Fig. 4 Rectifiers, (a) new type (b) old type

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

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 5AF (6v.)	5AF (12v.)	RM14	RM15	RM13	RM13/15 5AF (6v.)	5AF (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

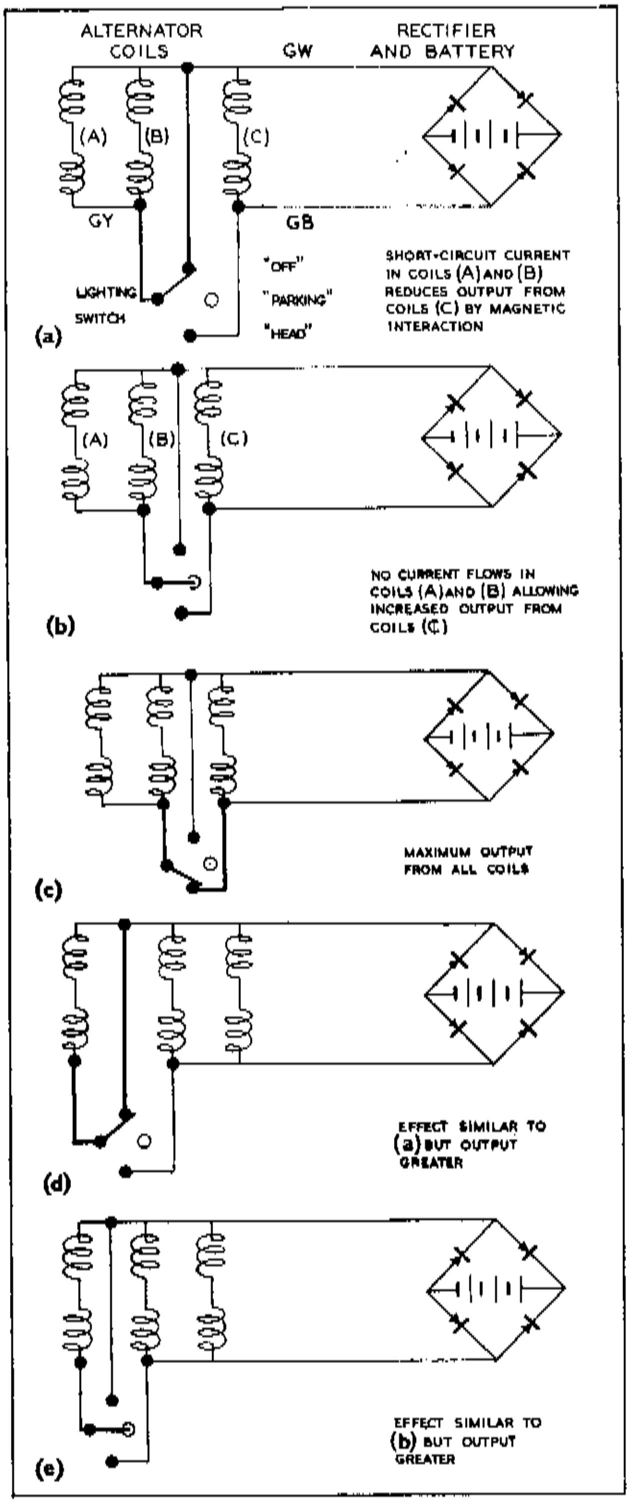


Fig. 5
Alternator, internal connections

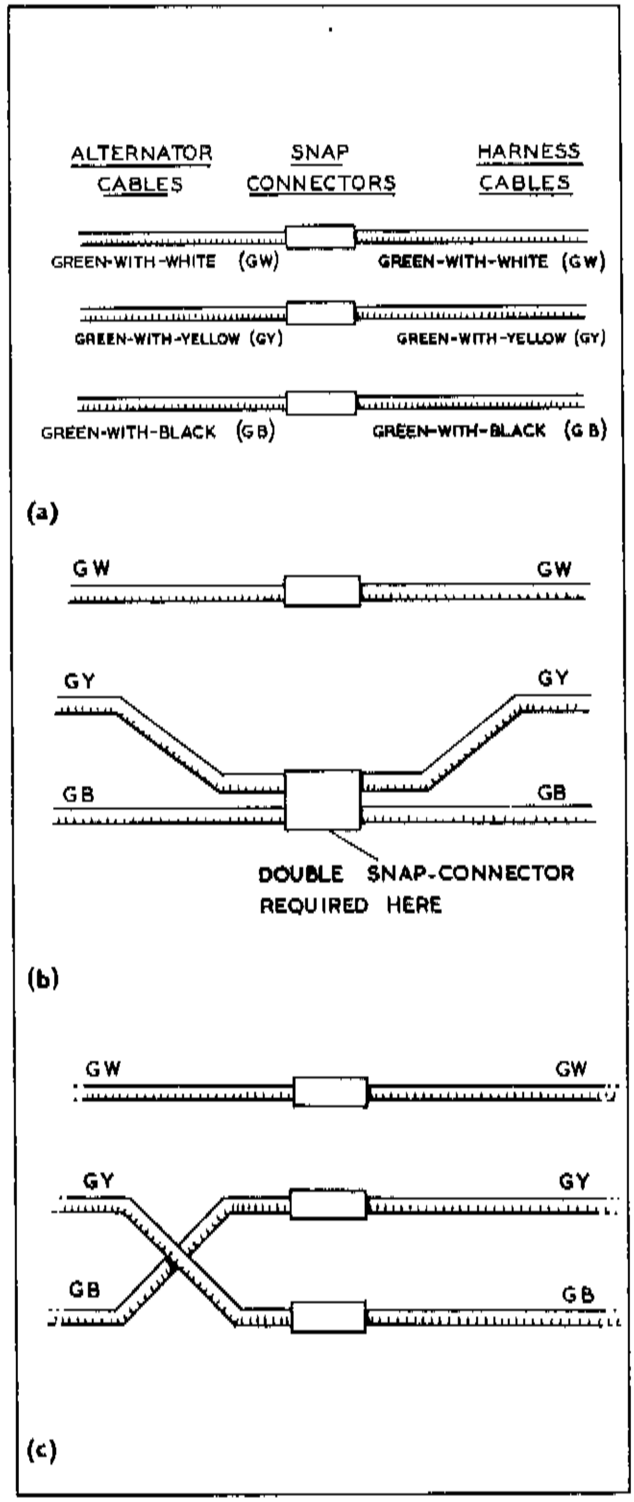


Fig. 6
Cable connections giving alternative outputs from alternator

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).

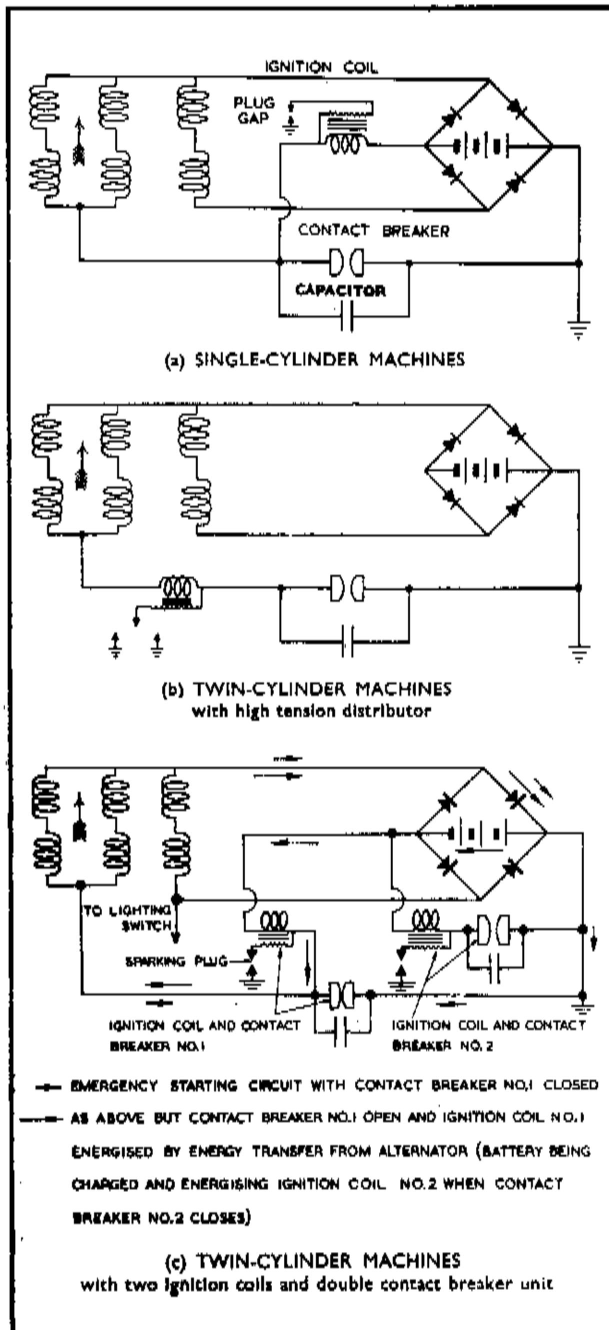
Note: Avoidance of overcharging: since, with the lighting switch in the 'Off' position, the output into the battery from a two-rate connected alternator is greater than that from the three-rate, the effect of removing the terminal link of model PRS8 switch, or the appropriate cable from models U39, 41SA, 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.



(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

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

(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
- Sparking plug needs cleaning
- Sparking 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.

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.

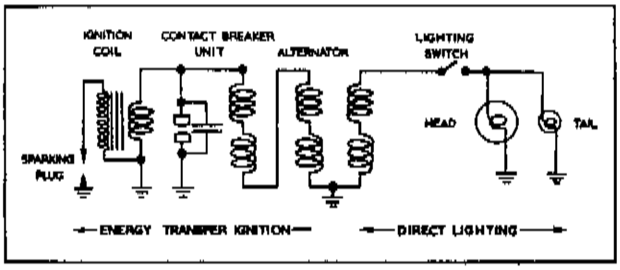


Fig. 8
Energy transfer ignition circuit with direct lighting, for Competition motor cycles

(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° past the Magnetic Neutral at 200 r.p.m., it changes to some 12° 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.

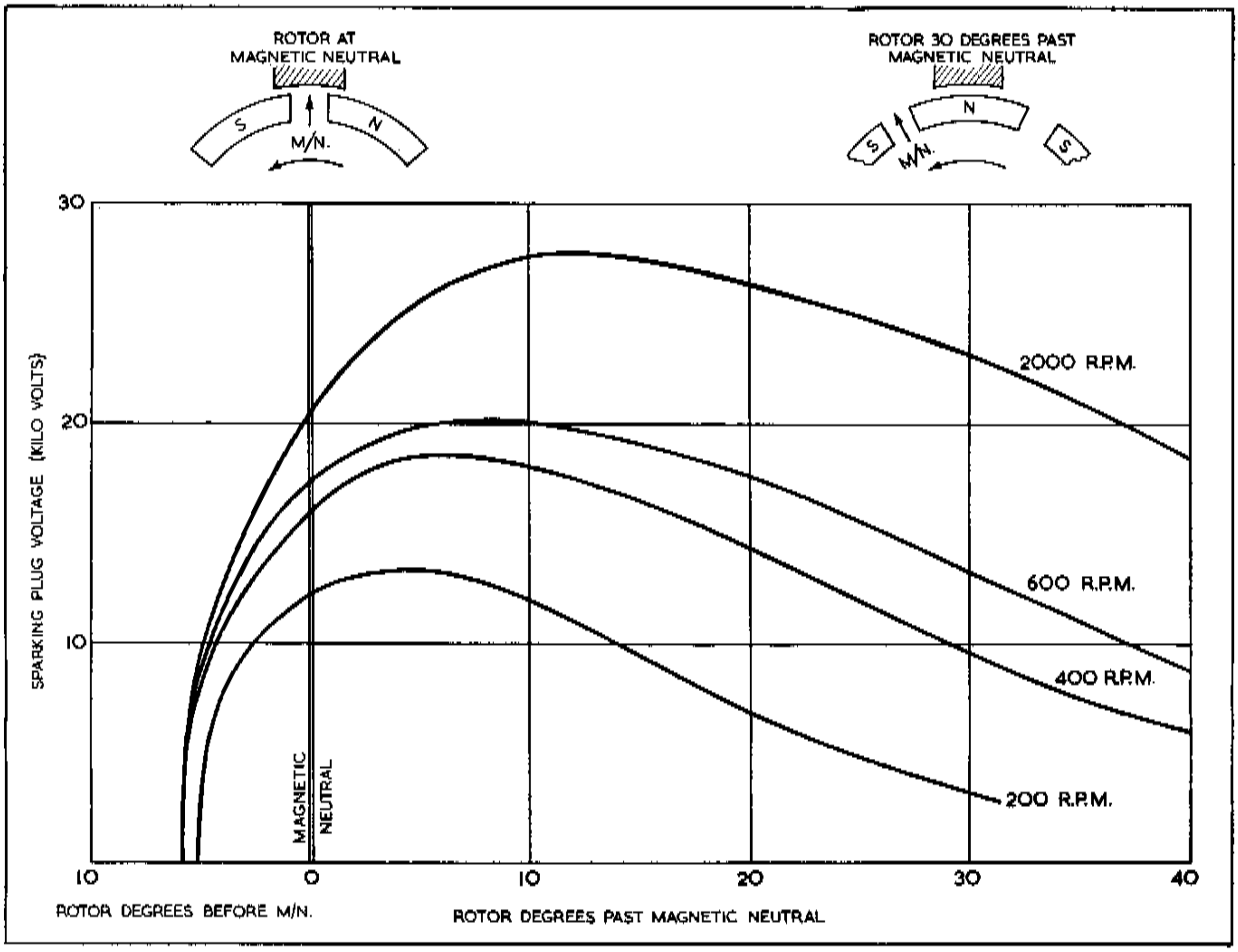


Fig. 9
Curves showing how sparking plug voltages depend on magnetic timing and kick-starting speeds

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.