LUCAS WORKSHOP INSTRUCTIONS

VOLUME 3

This Volume is divided into a number of Parts corresponding to the product groups shown in the Contents page. Each Part is sub-divided into Sections, the first of which is reserved for information of a general nature, while subsequent Sections deal with individual models of equipment. The composition of each Part is shown in its own Index.

It will frequently be found that several versions of a particular model may be in production, each version differing from the others in some design detail, and being identified by its individual part number. In general, the most commonly used version is described and illustrated in these workshop instructions.

LUCAS

Joseph Lucas (Sales & Service) Ltd · Birmingham 18 · England

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ALTERNATORS and DYNAMOS

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ALTERNATOR MODEL 11AC

1. DESCRIPTION

The alternator is shown dismantled in Fig. 1 (note that some machines are mounted by the drive end bracket only).

The stator comprises a 24-slot, 3-phase star-connected output winding on a ring-shaped lamination pack, housed between the slip-ring end and drive end brackets. The rotor is of 8-pole construction and carries a slip-ring fed rotor (field) winding. It is supported by a ball-bearing in the drive end bracket and a needle roller bearing in the slip-ring end bracket.

The brushgear for the field system is mounted on the slip-ring end bracket. Two carbon brushes bear against a pair of concentric brass slip-rings carried on a moulded disc attached to the end of the rotor.

The slip-ring end bracket also carries six silicon diodes connected in a 3-phase bridge circuit to give rectification of the generated a.c. output (see Fig. 2).

The diodes and stator windings are cooled by airflow through the alternator induced by a ventilating fan at the drive end.

A plastic strip — coloured either yellow, red or black — is attached to the output terminal of earth return machines and to each of the output terminals on insulated-return units. Each strip carries the polarity symbol or colour coding of its associated terminal. The strip was coloured yellow on all early production machines but units now being produced have a black-coloured strip to denote that the machine is to be employed on the positive-earth system only and a red strip for the negative earth system. There are one of each of these strips on insulated-return machines.

Output Control

The alternator output is controlled by an electronic voltage regulator unit (see Part B).

Field Isolating Device

The voltage regulator and the alternator rotor winding are isolated from the battery when the engine is stationary. With petrol-engined vehicles this is achieved either by a special double-pole ignition switch or by the normally-open contacts of a model 6RA relay whose operating coil is fed from a standard ignition switch. Low voltage relays, designed to operate at about 3 volts, are sometimes used with diesel-engined vehicles. In this application, the operating coil is energised from the mid-point of one pair of alternator diodes. With any arrangement the contacts are connected directly to the battery (or to the ammeter, when this is fitted) since the alternator output must respond to changes in battery voltage and not to conditions occurring elsewhere in the system.

Warning Light Control

A further terminal, marked 'AL', is provided for use with a warning light control (see Part K).

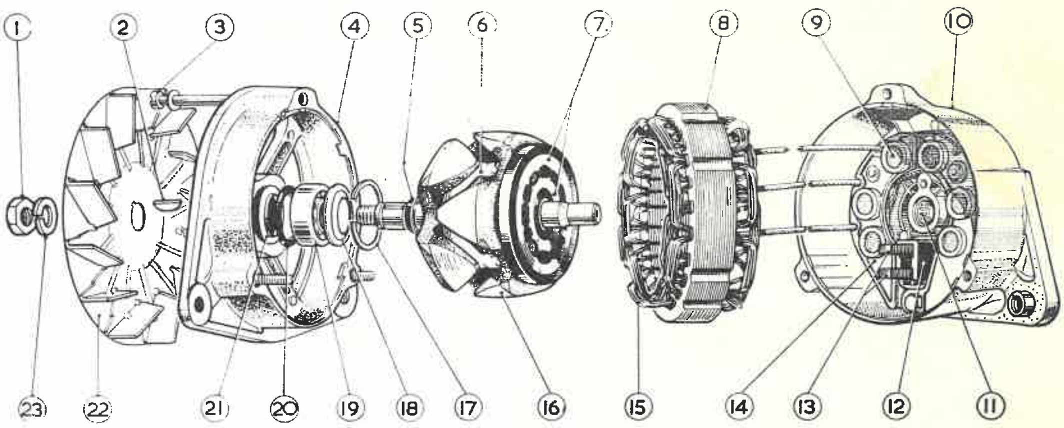

Fig. 1 Alternator model 11AC, dismantled

1 Shaft nut
2 Key
3 Through fixing bolts (3)
4 Drive end bracket
★ **5** Jump ring shroud (earlier models only)
6 Rotor (field) winding
7 Slip rings
8 Stator laminations
9 Silicon diodes (6)
10 Slip-ring end bracket
11 Needle roller bearing
12 Brush box moulding
13 Brushes
14 Diode heat sink
15 Stator winding
16 Rotor
17 Circlip
18 Bearing retaining plate
19 Ball bearing
20 'O' ring oil seal
21 'O' ring retaining washer
22 Fan
23 Shaft washer

★ *Amendment to previous issue*

Alternator Model 11AC

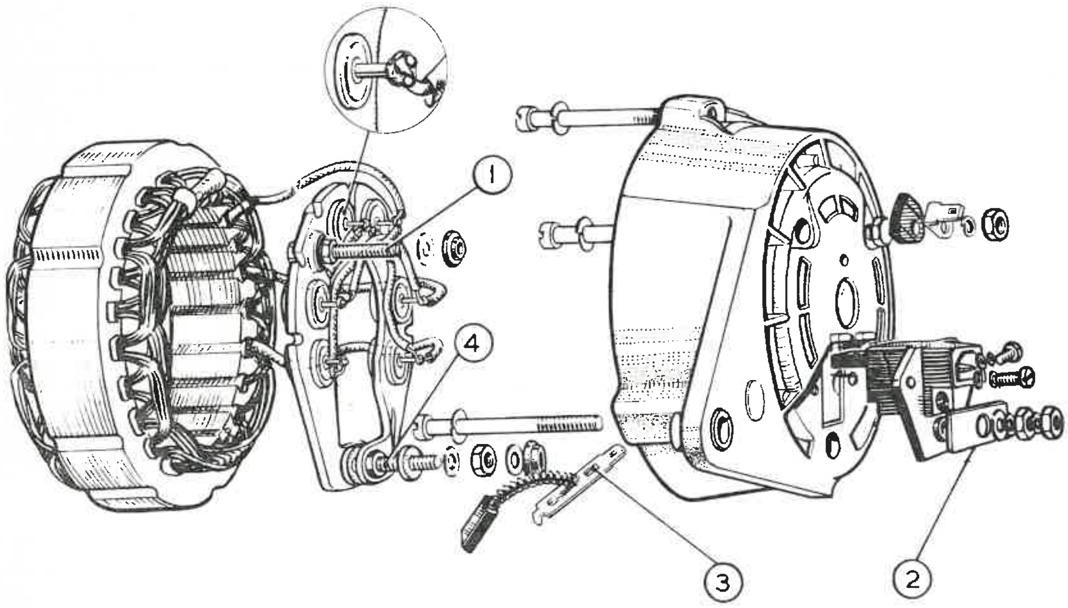

Fig. 2 Slip-ring end, showing heat sinks withdrawn

1 Warning light terminal 'AL'
2 Output terminal plastic strip
3 Terminal blade retaining tongue
4 Output terminal

2. ROUTINE MAINTENANCE

(a) Cleaning

Wipe away any dirt or oil which may collect around the slip-ring end cover ventilating apertures.

(b) Belt Adjustment

★ Occasionally inspect the driving belt, for wear and tension. Refer to the vehicle manufacturer's handbook for the correct method of adjusting belt tension.

Important. To avoid bearing damage when adjusting belt tension, apply leverage **only** on the alternator drive end bracket, **not** on any other part of the alternator. The lever should be a soft material preferably wood.

(c) Lubrication

The bearings are packed with grease during assembly and do not require periodic attention.

(d) Terminal Connexions

Make sure that all terminal connexions are tight.

3. TECHNICAL DATA

(i)	Nominal voltage	12	24
(ii)	Nominal d.c. output (hot) in amperes	43	23
(iii)	Resistance of rotor winding in ohms at 68°F (20°C)	3.8 ±5%	10.3 ±5%

Data Common to 12 and 24-volt alternators

(iv)	Maximum permissible rotor speed in rev/min	12,500
(v)	Rotation	Either, with suitable fan
(vi)	Stator phases	3
(vii)	Stator connexion	Star
(viii)	Number of rotor poles	8
(ix)	Number of rotor windings	1
(x)	Brush spring tension with brush face flush with brushbox housing	8–16 oz (227–454 g) ★

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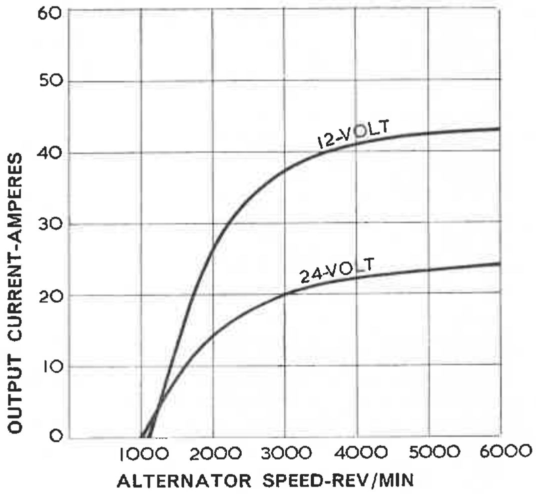

Fig. 3 Typical performance curve (alternator hot)

4. SERVICING

WARNING: The alternator must never be run on open circuit with the field winding energised, otherwise the rectifier diodes may be damaged.

(a) Testing the Alternator in Position

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

Inspect the driving belt for wear and tension.

Start the engine and check that battery voltage is being applied to the rotor winding by connecting a voltmeter between the cable ends normally attached to the field terminals. Stop the engine.

Disconnect the battery earth cable.

★ If an ammeter is not fitted to the vehicle, disconnect the cable(s) from the alternator output terminal including (when fitted) the suppression capacitor connexion. Connect a good-quality moving-coil ammeter of appropriate range between the output terminal and the disconnected cable(s) excluding the capacitor connexion.

Withdraw the cables from the alternator field terminals and, using a suitable pair of auxiliary cables, connect these terminals directly to the battery. For this test polarity matching is unimportant. Fig. 4 shows the alternator output test circuit.

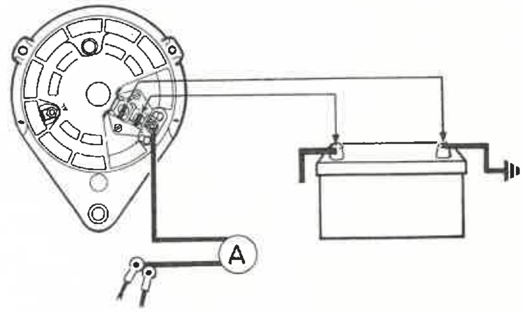

Fig. 4 Alternator output test-wiring connexions

Re-connect the battery earth lead. Start the engine and slowly open the throttle until the alternator speed is approximately 4,000 rev/min. At this speed the reading on the ammeter should be approximately 40 amperes (12-volt) or 22 amperes (24-volt).

If a zero reading results, stop the engine and disconnect the cables from the field terminals. Withdraw the two brushbox moulding retaining screws and remove the brushgear for examination as described in 4c. Fit new brush and spring assemblies if necessary and retest the alternator output. If the zero reading persists, the alternator must be removed from the engine and dismantled for detailed inspection (see 4b).

A low output current reading will indicate either a faulty alternator or poor circuit wiring connexions. Check the latter while keeping the

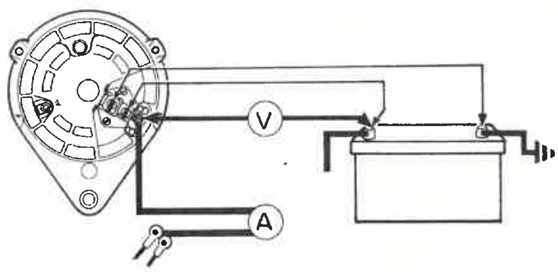

Fig. 5 Charging circuit voltage drop testing (insulated side)

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alternator connected and running as described above; connect a good-quality voltmeter — of low range if available — between the alternator output terminal and the battery insulated terminal (see Fig. 5) and note the voltmeter reading.

Now transfer the meter connexions to the alternator frame and battery earth terminal, Fig. 6, and again note the reading.

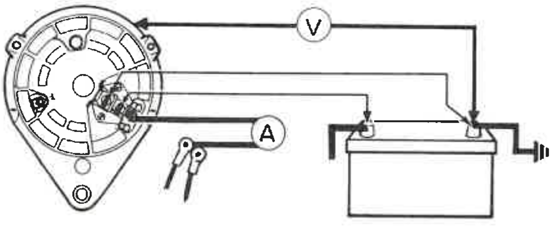

Fig. 6 Charging circuit voltage drop testing (earth side)

If either of these readings exceed 0.5 volt there is high resistance in the charging circuit which must be traced and remedied.

If, however, these tests show that there is no undue resistance in the charging circuit (although output is low) proceed to dismantle the alternator as described below.

(b) Dismantling the Alternator

Disconnect the battery and alternator cables and remove the alternator from the vehicle.

From the drive end remove the shaft nut, spring washer, pulley and fan.

Unscrew and withdraw the three 'through' bolts.

Mark the drive end bracket, lamination pack and slip-ring end bracket to facilitate reassembly in correct angular relation to each other.

Withdraw the drive end bracket and rotor from the stator. The drive end bracket and rotor need not be separated unless the drive end bearing requires examination or the rotor is to be replaced. In this event the rotor should be removed from the drive end bracket by means of a hand press, having first removed the shaft key.

From the slip-ring end bracket remove the terminal nuts, washers, insulating pieces, brushbox screws and the 2BA hexagon-headed bolt. With earlier units take care not to misplace the two washers fitted between the brushbox moulding and the end bracket.

Withdraw the stator and heat sink assemblies from the slip-ring end bracket.

Close up the retaining tongue at the root of each field terminal blade and withdraw the brush-spring-and-terminal assemblies from the moulded brushbox.

(c) Inspection of Brushgear

The brush length when new is ⅝″ (15.9 mm). The serviceability of the brushes may be gauged by measuring the amount by which they protrude beyond the brushbox moulding when in the free position. For a brush to remain serviceable the amount protruding should exceed 0.2″ (5 mm). Renew brush assemblies if the brushes are worn to or below this length. The new brush is supplied complete with brush spring and "Lucar" terminal blade and has merely to be pushed in until the tongue registers. To ensure that the terminal is properly retained, carefully lever up the retaining tongue with a fine screwdriver, so that the tongue makes an angle of about 30° with the terminal blade. ★

Check the brush spring pressures using a push-type spring gauge. Push each brush in turn back against its spring until the brush face is flush with the housing. The gauge should then indicate 8–16 oz. (227–454 g). Replace a brush assembly which gives a reading appreciably outside these limits where this is not due to the brush movement being impeded for any reason. ★

Check that the brushes move freely in their holders. If at all sluggish, clean the brush sides with a petrol-moistened cloth or, if this fails to effect a cure, lightly polish the brush sides on a smooth file. Remove all traces of brush dust before re-housing the brushes in their holders.

Note: The brush which bears on the inner slip-ring is always associated with the positive pole of the electrical system, since the lower linear speed of the inner ring results in reduced mechanical wear and helps to offset the higher rate of electrical wear peculiar to the positive-connected brush.

(d) Inspection of Slip-rings

The surfaces of the slip-rings should be smooth and uncontaminated by oil or other foreign matter. Clean the surfaces using a petrol-moistened cloth, or if there is any evidence of burning, very fine glass-paper. On no account must emery cloth or similar abrasives be used. No attempt should be made to machine the slip-rings, as any eccentricity in the machining may adversely affect the high speed

★ Amendment to previous issue

performance of the alternator. The small current carried by the rotor winding, and the unbroken surface of the slip-rings mean that the likelihood of scored or pitted slip-rings is almost negligible.

(e) Rotor

Test the rotor winding by connecting either an ohmmeter (Fig. 7) or the appropriate battery supply (Fig. 8) between the slip-rings.

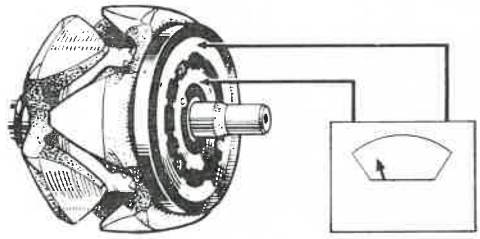

Fig. 7 Measuring rotor winding resistance with ohmmeter

The reading of resistance should be as given in 3(iii). If the alternative test has been made, the value of the current should be approximately 3.2 amperes (12-volt) or 2.3 amperes (24-volt).

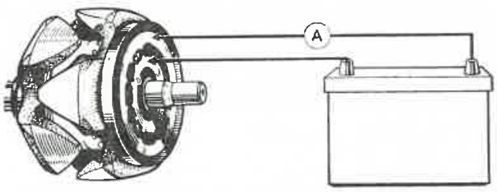

Fig. 8 Measuring rotor winding resistance with battery and ammeter

Test for defective insulation between one of the slip-rings and one of the rotor poles using a 110-volt a.c. mains supply and a 15-watt test lamp (Fig. 9). If the lamp lights, the coil is earthing and a replacement rotor/slip-ring assembly must be fitted.

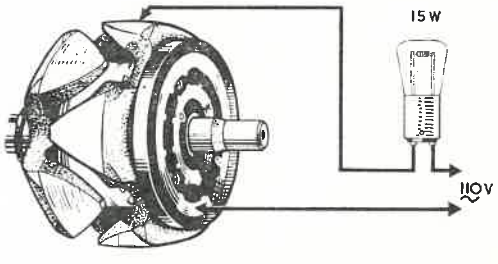

Fig. 9 Insulation test of rotor winding

No attempt should be made to machine the rotor poles or to straighten a distorted shaft.

(f) Stator

Unsolder the three stator cables from the heat sink assembly, taking care not to overheat the diodes — (see 4h page 6). Check the continuity of the stator windings by first connecting any two of the three stator cables in series with a test lamp of not less than 36 watts and a 12-volt battery as shown in Fig. 10. Repeat the test, replacing one of the two cables by the third cable. Failure of the test lamp to light on either occasion means that part of the stator winding is open-circuit and a replacement stator must be fitted.

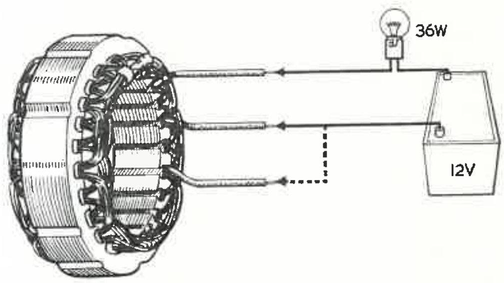

Fig. 10 Stator winding continuity test

Test for defective insulation between stator coils and lamination pack with the mains test lamp (see

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Fig. 11). Connect the test probes between any one of the three cable ends and the lamination pack. If the lamp lights, the stator coils are earthing and a replacement stator must be fitted.

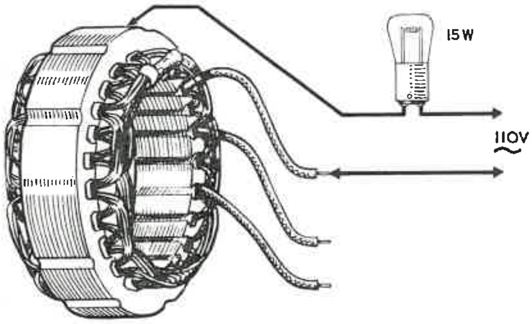

Fig. 11 Insulation test of stator windings

Before re-soldering the stator cable ends to the diode pins carry out the following test.

(g) Diodes

Each diode (whether on a 12-volt or 24-volt system) can be checked by connecting it in series with the 1.5-watt test bulb across a 12-volt d.c. supply and then reversing the connections (Fig. 12).

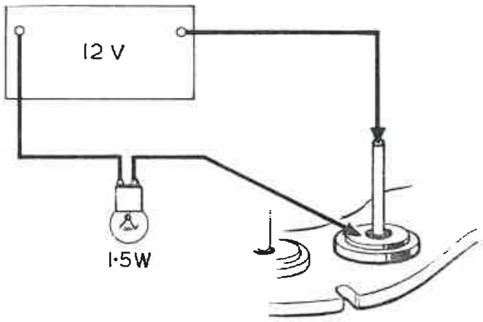

Fig. 12 Simple test for diodes

Current should flow, and the bulb light, in one direction only. Should the bulb light up in both tests or not light up in either, the diode is defective and the appropriate heat sink assembly must be replaced.

The above procedure is adequate for service purposes. Any accurate measurement of diode resistance requires factory equipment. Since the forward resistance of a diode varies with the voltage applied, no realistic readings can be obtained with battery-powered ohmmeters. However, should a battery-ohmmeter be used, a good diode will yield 'Infinity' in one direction, and some indefinite but much lower reading in the other.

WARNING: **Ohmmeters of the type incorporating a hand-driven generator must never be used for checking diodes.**

(h) Alternator Diode Heat Sink Replacement

The alternator heat sink assembly consists of two parts, one of positive polarity and the other negative (see Fig. 2). The positive portion carries three cathode base diodes marked red, and the negative portion three anode base diodes marked black. The diodes are not individually replaceable, but, for service purposes, are supplied already pressed into the appropriate heat sink portion.

When soldering the interconnexions, 'M' grade 45–55 tin-lead solder should be used.

Great care must be taken to avoid overheating the diodes or bending the diode pins. The diode pins should be lightly gripped with a pair of suitable long-nosed pliers (which act as a thermal shunt) and soldering must be carried out as quickly as possible. The operation is shown in Fig. 13. To facilitate cable positioning and the soldering operation the diode pins are bifurcated in later units. ★

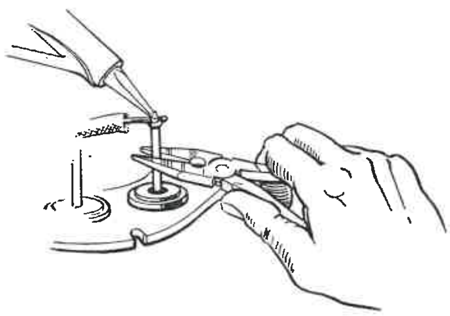

Fig. 13 Use of thermal shunt when soldering diode connexions

★ *Amendment to previous issue*

After soldering, the connexions must be neatly arranged around the heat sinks, to ensure adequate clearance for the rotor, and be tacked down with 'MMM' EC1099 adhesive where indicated in Fig. 14. The stator connexions must pass through the appropriate notches at the edge of the heat sink.

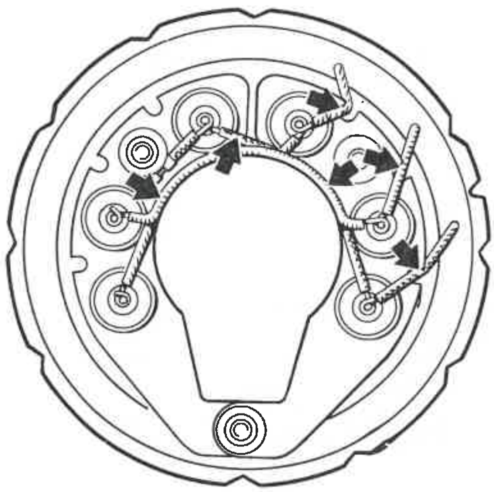

Fig. 14 Heat sink cable securing points

★ (j) Bearings

Bearings which are worn to the extent of allowing excessive side-movement of the rotor shaft must be renewed (Service replacement bearings are pre-packed with grease ready for use).

During reconditioning of the alternator, check the bearing lubricant and if necessary re-pack the original bearings with Shell Alvania 'RA' grease, or an equivalent lubricant.

Renewing the Bearings

The drive end ball-bearing is a press fit in the bracket and can be renewed by means of a wheel-operated, or power-assisted press. To renew the bearing, it will first be necessary to dismantle the bearing retaining plate which will be secured by screws, a circlip, or rivets. According to the method of fixing, remove the screws, file away the rivet heads, or insert the tip of a small screwdriver in the extractor notch and prise free the circlip from its groove. Assembling a new bearing into the bracket is simply a reversal of the dismantling procedure involved in removing the original bearing.

If the needle roller bearing in the slip ring end bracket needs to be renewed, first inspect the inside of the bracket and determine whether the bearing-housing incorporates a felt seal. If not, it is advisable to renew the bracket complete with bearing so that a bracket of improved design incorporating a felt seal is fitted. If the original bracket incorporates a felt seal, either the bracket complete with bearing can be renewed, or the bearing can be serviced separately. The bearing can be serviced by using a needle roller bearing kit (Lucas Pt. No. 54219553), comprising bearing, felt seal and associated assembly washers, as illustrated in Fig. 16.

In the case of brackets incorporating a felt seal, renewing the needle roller bearing is facilitated by using a specially designed and recommended jig and tool (Hartridge Cat. No. 99–70), manufactured and supplied by Leslie Hartridge Ltd., Buckingham, Bucks., England. The jig and tool (see Fig. 15 and 16) is used in conjunction with a wheel-operated, or power-assisted, press.

With the stator and heat sinks removed from the bracket, and using the recommended jig and tool, procedure for renewing the bearing is as follows:—

(i) Place the new felt seal in light oil and leave to soak.

(ii) Press out the old bearing assembly, using the smaller diameter of the punch supplied with the jig.

(iii) Locate the bracket on the jig and fit the new bearing on the spring loaded insert, as shown in Fig. 15.

(iv) Using the larger diameter of the punch, press the bearing into the housing. Ensure that the bearing is inserted to the full depth allowed by the jig, but avoid excessive pressure.

(v) Invert the bracket and place on the the jig, using the two small lugs for locating, as shown in Fig. 16.

(vi) Remove the felt seal from the oil.

(vii) Place felt seal and washers on bracket, as shown in Fig. 16.

(viii) Press the retaining washer into the housing, using the smaller diameter of the punch.

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Alternator Model 11AC

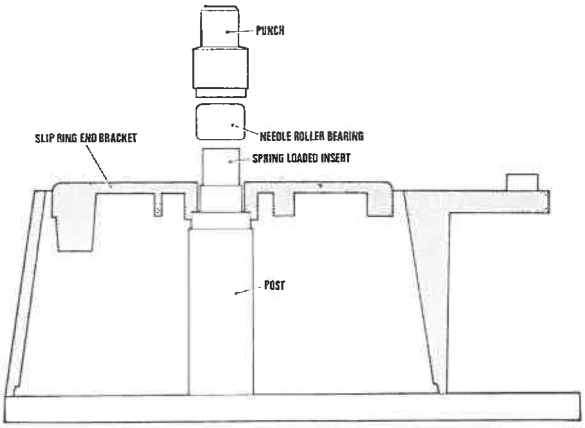


Fig. 15 Fitting the needle roller bearing in the slip ring end bracket

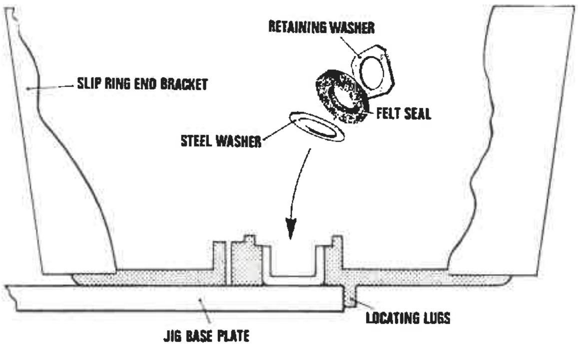


Fig. 16 Method of assembling the felt seal in the slip ring end bracket

(k) Reassembly

Reassembly of the alternator is the reversal of the dismantling procedure given in 4(b). Take care to align the drive-end bracket, lamination pack and slip-ring end bracket properly. Tighten the three 'through' bolts evenly. If the rotor and drive-end bracket have been separated, the inner journal of the drive-end bearing must be supported by a suitably-dimensioned tube for the re-assembling operation. Do not use the drive-end bracket as a support for the bearing while fitting the rotor.

ALTERNATOR MODEL 10AC

Alternator model 10AC is constructionally similar to model 11AC, but incorporates a shorter stator assembly which decreases by $\frac{3}{16}$" the overall length of this machine compared to model 11AC.

At present, model 10AC is manufactured for use with 12-volt systems only, this machine having a nominal d.c. output (hot) of 33 amperes.

The description and servicing information given for Alternator model 11AC in PART A, Section 2 of this Manual is wholly applicable to model 10AC except for the following:

3. TECHNICAL DATA

(ii) Nominal d.c. output (hot) in amperes 33

(iii) Resistance of rotor winding in ohms at 68°F (20°C) 3.47±5%

4. SERVICING

(a) (vi) 32 amperes (approx.).

(e) (i) 3.5 amperes (approx.).

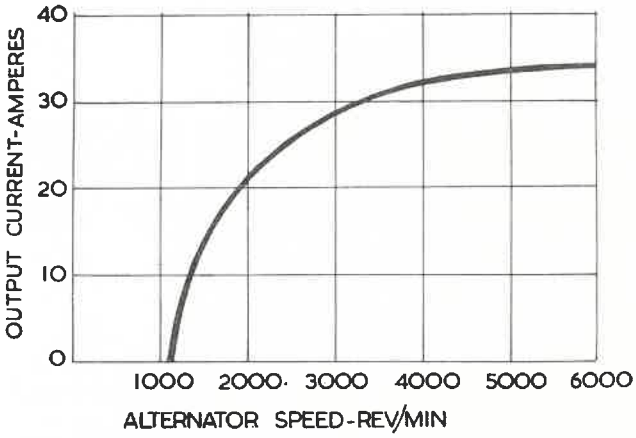


Fig. 1 Typical performance curve (alternator hot)

ALTERNATOR MODELS 15AC AND 16AC

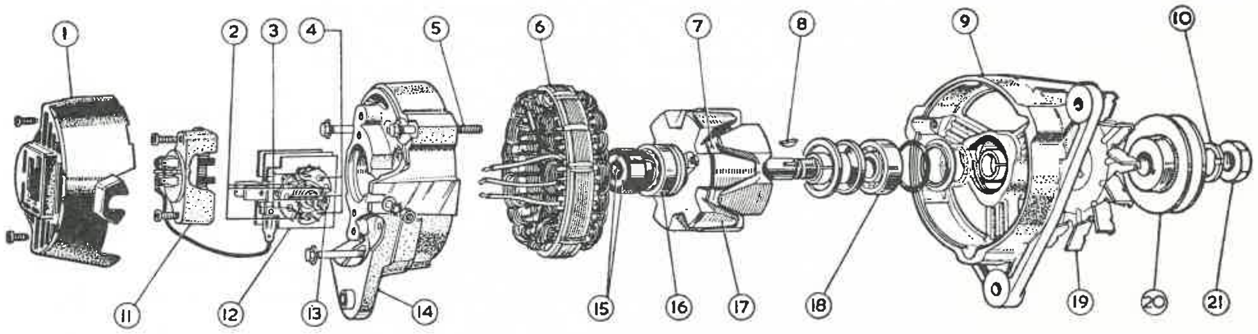


Fig. 1 Alternator Models 15AC & 16AC dismantled

1 Cover
2 Live side output diodes
3 Earth side output diodes
4 Field diodes
5 Through Bolts
6 Stator
7 Field winding
8 Shaft key
9 Drive end bracket
10 Spring washer
11 Brush box moulding
12 Rectifier pack
13 Rectifier assembly bolt
14 Slip ring end bracket
15 Slip rings
16 Slip ring bearing
17 Rotor
18 Drive end bearing
19 Fan
20 Pulley
21 nut

1. DESCRIPTION

These alternators are identical in mechanical construction, differing only in the number of turns and the wire gauge on the stator winding which result in alternative electrical performance characteristics (Fig. 3).

The construction is shown in Fig. 1. The laminated stator carries a 3-phase star-connected output winding. A 12-pole rotor carries the field winding, the rotor shaft running in ball-race bearings in die-cast end brackets.

Rectification of alternator output is achieved by six silicon diodes housed in a rectifier pack and connected as a 3-phase full wave bridge circuit. The rectifier pack is attached to the outer face of the slip-ring end bracket, and contains also three 'field' diodes. At normal operating speeds, rectified current from the stator output windings flows through these diodes to provide self-excitation of the rotor field, via brushes bearing on face type slip-rings, the latter being carried on a small diameter moulded drum attached to the rotor shaft outboard of the slip-ring end bearing.

Electrical connexions to external circuits are brought out to 'Lucar' connector blades, grouped in a manner suitable to accept a two-piece non-reversible moulded connector socket.

Early production model 15AC and 16AC alternators incorporate a rectifier pack of a different pattern to that shown in Fig. 1. The earlier unit is mounted partly on the brushbox moulding and partly on the slip-ring end bracket. The dismantling instructions in 4b refer to the later pattern rectifier pack only.

Diode testing procedure (see 4g) is the same for both types of rectifier.

When checking the field diodes on the earlier unit note that the insulating mounting bracket is positioned between the diodes and their heat sink.

Output Control

The alternator output is controlled by an electronic voltage regulator unit (see Part B).

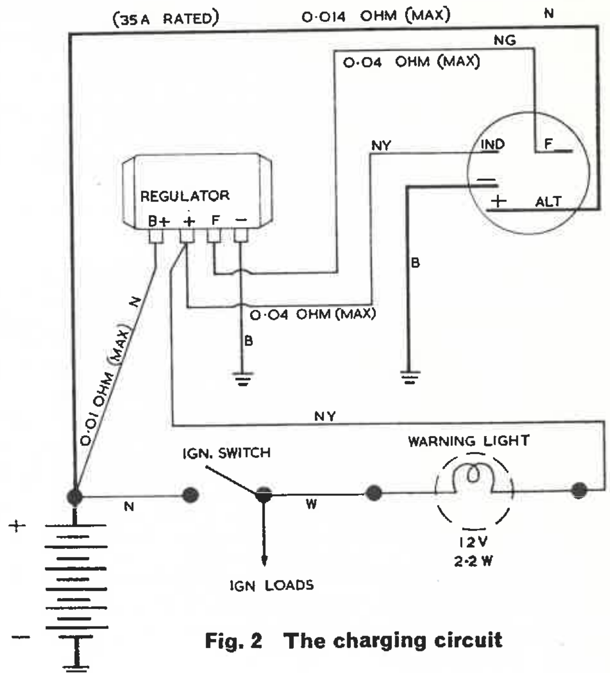


Fig. 2 The charging circuit

Warning Light

The additional 'field' diodes enable a simple charge-indicator warning light to be used (Fig. 2). When the ignition is switched on, the warning light is connected to the battery, the circuit being completed by way of the alternator field winding and the regulator. The bulb is then lit fully. This small current, flowing in the field winding, sets up a flux which supplements the residual flux in the rotor and aids the initial build-up of stator voltage as the rotor begins to rotate when the engine is started.

As rotor speed and generated voltage increases, the field current supplied by the stator winding through the 'field' diodes increases correspondingly until finally the alternator becomes self-excited. During the rise in stator generated voltage (reflected at terminal IND) the brilliance of the warning light is gradually reduced. At approximately the speed at which the alternator commences to charge, the voltage at the IND terminal equals that at the battery side of the warning light, and the latter is extinguished. Thus, illumination of the warning light under normal running conditions indicates that the alternator is not functioning correctly.

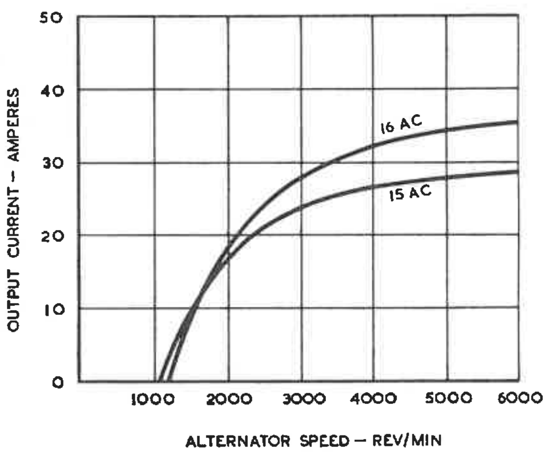


Fig. 3 Typical performance curve (alternator hot)

2. ROUTINE MAINTENANCE

(a) Cleaning

Wipe away any dirt or oil which may have collected around the apertures in the slip-ring end bracket and moulded cover.

(b) Belt Adjustment

Occasionally inspect the driving belt for wear and tension. Refer to the vehicle manufacturer's handbook for the correct method of adjusting belt tension.

Important. To avoid bearing damage when adjusting belt tension, apply leverage **only** on the alternator drive end bracket, **not** on any other part of the alternator. The lever should be of a soft material, preferably wood.

(c) Lubrication

The bearings are packed with grease during assembly, and will normally require no further lubrication during their service life.

(d) Connexions

All electrical connexions in the charging circuit (including those at the battery) must be maintained tight at all times.

3. TECHNICAL DATA

Earth polarity of system	NEGATIVE only
Nominal voltage	12
Nominal d.c. output (hot) at 14.0V and 6,000 rev/min.	28 amp. (15AC) 34 amp. (16AC)
Max. permissible rotor speed	12,500 rev/min
Stator phases	3
Stator winding connexion	Star
Number of rotor poles	12
Resistance of rotor winding	4.33 ±5% ohms at 20°C.
Brush spring tension	7–10 oz (198–283 g) with brush face flush with brushbox housing

1 Live side output diodes (3)
2 Earth side output diodes (3)
3 Field feed diodes (3)
4 Stator winding
5 Field winding
6 Slip rings
7 12 volt battery
8 0-40 or 0-60 ammeter
9 12 volt 2·2 watt bulb
10 0-20 voltmeter
11 0-15Ω, 35 amp variable resistor

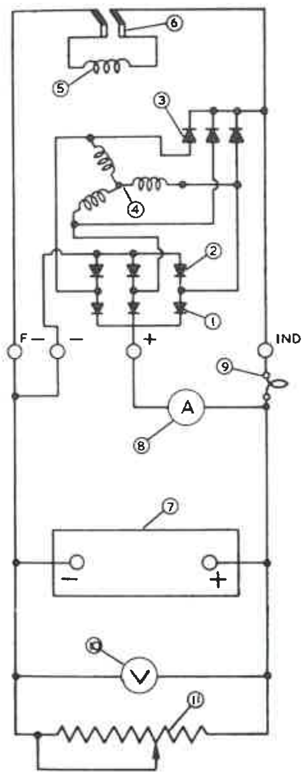


Fig. 4 Alternator output test circuit

4. SERVICING

Battery cables must not be disconnected while the engine is running or damage to semiconductor devices may occur. It is also inadvisable to break or make any other connexions in the alternator circuit while the engine is running.

(a) Testing the Alternator in Position

First check the driving belt for wear and tension. Also ensure that all connexions in the charging circuit are tight.

The nominal hot output ratings are given in para. 3. These figures may be exceeded slightly when the alternator is running cold. To avoid misleading results, the following test procedure should therefore be carried out with the alternator running as near to its normal operating temperature as possible.

Withdraw the moulded terminal connector from the alternator, and connect a test circuit as shown in Fig. 4. **Observe carefully the polarity of battery and alternator terminals – reversed connexions will damage the alternator diodes.**

The resistor across the battery terminals must not be left connected for longer than is necessary to carry out the following test.

Start the engine. At 1,500 alternator rev/min, the test circuit bulb should be extinguished. Increase engine speed until the alternator is running at 6,000 rev/min approximately, and adjust the variable resistance until the voltmeter reads 14.0 volts. The ammeter reading should then be approximately equal to the rated output (para. 3). Any appreciable deviation from this figure will necessitate the alternator being removed from the engine for further examination (para. 4b).

Failure of one or more of the diodes will be indicated in the above test by the effect on alternator output, and also in some instances by abnormally high alternator temperature and noise level. The table shows how diode failure will influence test results, and para. 4g gives information on testing the diodes.

SYMPTOMS				
	Alternator			
Warning light	Temperature	Noise	Output	Probable fault and associated damage
Normal at stand-still, goes out at cut-in speed but then glows progressively brighter as speed increases	High	Normal	Higher than normal at 6,000 rev/min. 15AC. 35 amp. approx. 16AC. 40 amp. approx.	Live side output diode open-circuit. (May damage rotor winding and reg. output stage, overheat brushboxes and blow warning light)
Light out under all conditions	High	Excessive	Very low at 6,000 rev/min. 10 amp. approx.	Live side output diode short-circuit. (May cause failure of associated 'field' diode)
Normal at stand-still, dims appreciably at cut-in and gets progressively dimmer at higher speeds	Normal	Excessive	Poor at low speed. Slightly below normal at 6,000 rev/min. 15AC. 26 amp. approx. 16AC. 32 amp. approx.	Earth side output diode open-circuit.
Normal at stand-still, dims slightly at cut-in and remains so throughout speed range	Normal	Excessive	Very low at all speeds above cut-in. 7 amp. approx.	Earth side output diode short-circuit. (The same symptoms would be apparent if one phase winding was shorted to earth)
Normal at stand-still, dims slightly at cut-in and remains so throughout speed range	Normal	Normal	Lower than normal at 6,000 rev/min. 15AC. 23 amp. approx. 16AC. 29 amp. approx.	'Field' diode open-circuit
Normal at stand-still, dims appreciably at cut-in and remains so at higher speeds	Normal	Excessive	Very low at 6,000 rev/min. 7 amp. approx.	'Field' diode short-circuit

Alternator Models 15AC and 16AC

If the foregoing test shows the alternator to be giving satisfactory performance, disconnect the test circuit and reconnect the alternator terminal connector. Now connect a low-range voltmeter (Fig. 5) between the positive terminal of the alternator (the moulded terminal connector is open ended to facilitate this) and the positive terminal of the battery.

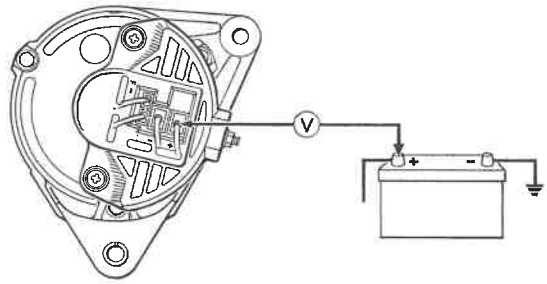


Fig. 5 Charging circuit voltage drop testing (insulated side)

Switch on the headlamps, start the engine and increase speed until the alternator runs at approximately 6,000 rev/min. The voltmeter reading should not exceed 0.5 volt. Transfer the voltmeter connexions to the negative terminals (Fig. 6) of alternator and battery. The meter reading should not exceed 0.25 volt.

If either reading is in excess of the value quoted, a high resistance in that portion of the charging circuit is indicated, which must be traced and remedied.

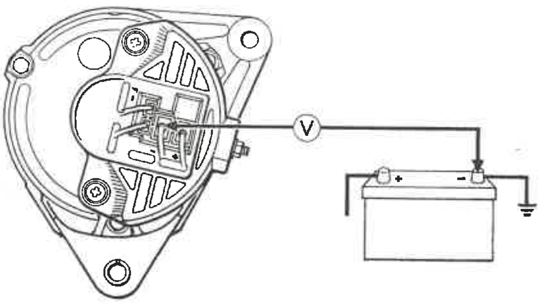


Fig. 6 Charging circuit voltage drop testing (earth side)

(b) Electrical Test Procedure

The following instructions cover the dismantling required to enable the alternator to be tested electrically. If, as a result of these tests (or because the rotor bearings are to be replaced) further dismantling becomes necessary, proceed as described in 4(h).

Disconnect the battery and alternator cables and remove the alternator from the vehicle.

Withdraw the two moulded cover securing screws and remove the cover.

Unsolder the three stator connexions to the rectifier assembly noting the order of connexion. (See para. 4g for soldering procedure).

Withdraw the two brush moulding securing screws and slacken the nut on the rectifier assembly bolt, allowing the brush moulding and rectifier assembly to be withdrawn together with the short cable which joins them.

(c) Inspection of Brushgear

The brush length when new is ½″ (12.6 mm). The serviceability of a brush may be gauged by measuring the amount by which it protrudes beyond the brush-box moulding when in the free position. For a brush to remain serviceable the amount protruding should exceed 0.2″ (5 mm). Renew the brush assemblies if the brushes are worn to or below this amount.

Check the brush spring pressures using a push-type spring gauge. This should indicate 7–10 oz (198–283 g) when the brush is pushed back against the spring until the brush face is flush with the housing. Replace a brush assembly which gives a reading appreciably outside these limits where this is not due to the brush movement being impeded for any reason. Clean a sticking brush with a petrol-moistened cloth or, if necessary, by lightly polishing the brush sides on a smooth file.

(d) Inspection of Slip-rings

The surfaces of the slip-rings should be smooth and uncontaminated by oil or other foreign matter. Clean the surfaces using a petrol-moistened cloth, or if there is evidence of burning, very fine glasspaper. On no account must emery cloth or similar abrasive be used. No attempt must be made to machine the slip-rings as any eccentricity in the machining may adversely affect the high-speed performance of the alternator.

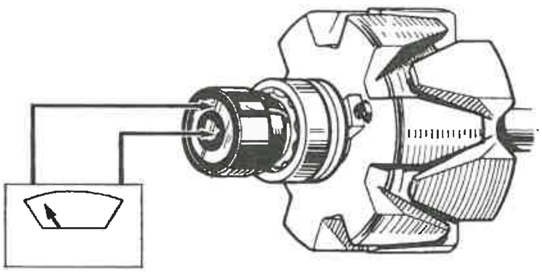


Fig. 7 Measuring rotor winding resistance with ohmmeter

(e) Rotor

Note: For clarity, the illustration of the electrical testing of the rotor and stator show these components isolated from the remainder of the alternator.

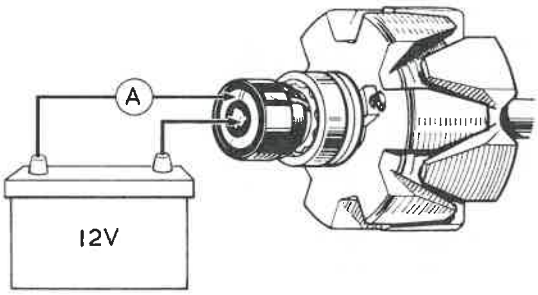


Fig. 8 Measuring rotor winding resistance with battery and ammeter

Test the rotor winding by connecting either an ohmmeter (Fig. 7) or a 12-volt battery and ammeter (Fig. 8) between the slip-rings. The resistance should be approximately 4.3 ohms, or the value of current approximately 3 amperes.

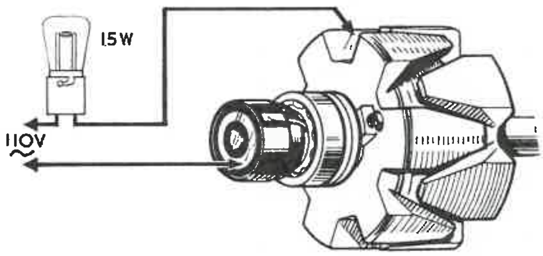


Fig. 9 Insulation test of rotor winding

Test for defective insulation between one of the slip-rings and one of the rotor poles using a 110-volt a.c. mains supply and a 15-watt test lamp (Fig. 9). If the lamp lights, the coil is earthed to the rotor core and a replacement rotor/slip-ring assembly must be fitted.

No attempt must be made to machine the rotor poles or to straighten a distorted shaft.

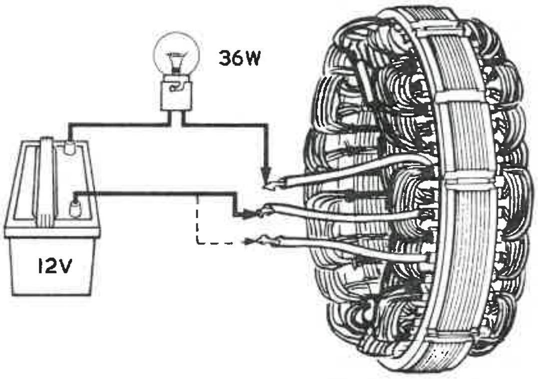


Fig. 10 Stator winding continuity test

(f) Stator

Check the continuity of the stator windings by first connecting any two of the three stator cables in series with a 12-volt battery and test lamp of not less than 36-watts (Fig. 10). Repeat the test, replacing one of the two cables by the third cable. Failure of the test lamp to light on either occasion means that part of the stator winding is open-circuit and a replacement stator must be fitted.

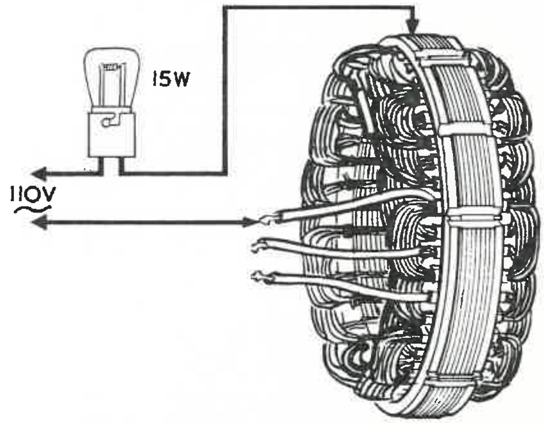


Fig. 11 Insulation test of stator windings

Test for defective insulation between stator coils and the lamination pack with the mains test lamp (Fig. 11). Connect the test probes between any one of the three cable ends and the lamination pack. If the lamp lights, the stator coils are earthing and a replacement stator must be fitted.

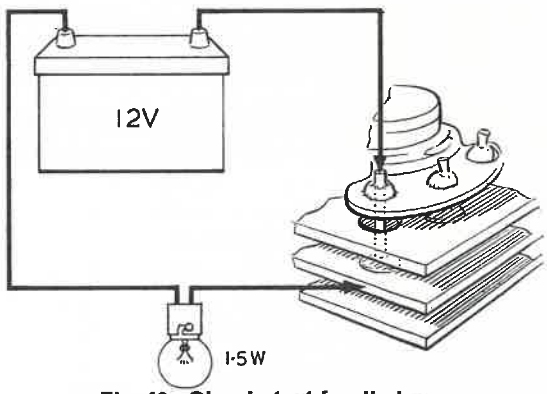


Fig. 12 Simple test for diodes

(g) Diodes

In the event of a fault in one or more of the diodes being indicated by the alternator output test (para. 4a), the stator winding connexions to the rectifier pack must be unsoldered (para. 4b).

Connect each of the nine diode pins in turn in series with a 1.5 watt test bulb and one terminal of a

12-volt battery (Fig. 12). Connect the other battery terminal to the particular heat sink on the rectifier pack into which the diode under test is soldered. Next, reverse the connexions to diode pin and heat sink. The bulb should light in one direction only. Should the bulb light in both tests, or not light in either, the diode is defective and a new rectifier pack must be fitted.

When re-soldering the stator cables to the diode pins use only 'M' grade 45-55 tin-lead solder. Take great care to avoid overheating the diodes or bending the diode pins. The diode pins should be lightly gripped with a pair of long-nosed pliers (which act as a thermal shunt) and soldering must be carried out as quickly as possible. The operation is shown in Fig. 13.

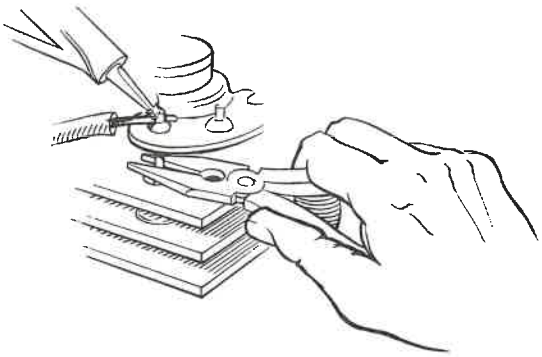


Fig. 13 Use of thermal shunt when soldering diode connexions

(h) Further Dismantling

If as a result of the foregoing electrical tests further dismantling is necessary proceed as follows:

Withdraw the three through bolts. Separate the slip-ring end bracket and stator assembly from the rotor and drive-end bracket — preferably by sleeving a metal tube about 3″ long over the slip-ring moulding so as to engage with the outer ring of the slip-ring end bearing and then carefully driving the bearing from its housing with the alternator positioned vertically, fan lowermost. The tube should be 1.320″ (33.53 mm) outside diameter and bored out to 1.240″ (31.5 mm) for about half of its length. Carefully file away any surplus solder from the field winding terminals which may prevent the tubing from sleeving over the slip-ring moulding. The less preferred method of separating the slip-ring end bracket and stator assembly from the rotor and drive-end bracket is to insert a lever between the stator and the drive-end bracket and carefully prise the two apart until the slip-ring end bearing is clear of its housing.

If necessary, the rotor shaft can be pressed out from the drive-end bracket having first removed the shaft nut, washers, pulley, fan and shaft key.

(j) Bearings

The need for bearing replacement during the service life of the alternator is extremely unlikely provided the alternator is mounted correctly and belt tension maintained as recommended. However, should bearing replacement become necessary, proceed as follows:

Drive-end Bearing

Dismantle the alternator as described in 4b (it is not necessary to unsolder the rectifier assembly) and also as in 4h including the separation of the rotor from the drive-end bracket.

The drive-end bearing assembly can be withdrawn following removal of the circlip — see Fig. 1 for details of the bearing assembly.

Slip-ring End Bearing

Dismantle the alternator as described for the drive-end bearing. Unsolder the field winding connexions to the slip-ring moulding assembly which can then be withdrawn from the rotor shaft. Extract the bearing from the shaft, noting that the shielded side of the bearing faces the slip-ring end moulding. Fit the new bearing and re-engage the slip-ring moulding with the slot in the rotor shaft. Finally, remake the field-to-slip-ring connexions using Fry's H.T.3 solder.

When required, the correct lubricant for the alternator bearings is Shell Alvania 'RA'.

(k) Reassembly

Reassembly of the alternator is a reversal of the dismantling procedure given in 4b and h. Ensure that the slip-ring end bearing is positioned as far as it will go along the rotor shaft in the direction of the field assembly. Ensure that the brushes are entered in their housing before refitting the brush moulding. Tighten the through bolts evenly. If the rotor and drive-end bracket have been separated, support the inner ring of the drive-end bearing with a suitably-dimensioned tube for the re-assembling operation. Do not use the drive-end as a support for the bearing while fitting the rotor.

5. PRECAUTIONS

It is important to observe the following precautions when servicing vehicles fitted with alternator charging systems:

(a) Battery cables must not be disconnected while the engine is running, or damage to semiconductor devices may occur. Do not break or make any other connexions in the charging circuit while the engine is running.

(b) All electrical connexions in the charging circuit must be maintained tight at all times.

(c) Care must be taken when connecting the battery, either on the vehicle or in a test circuit, to ensure the correct polarity.

(d) If electric arc welding is being carried out on any part of the vehicle, the connectors should be removed from the alternator and regulator to avoid possibility of damage to semiconductor devices.

ALTERNATOR MODELS 15ACR, 16ACR, 17ACR & 18ACR

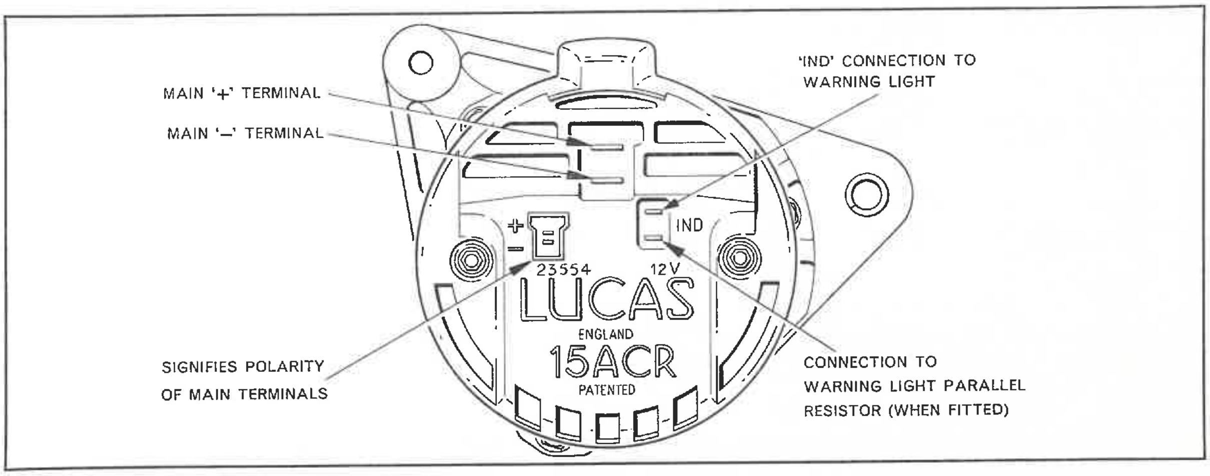


Fig. 1 Early production 15ACR alternator (machine-sensed)

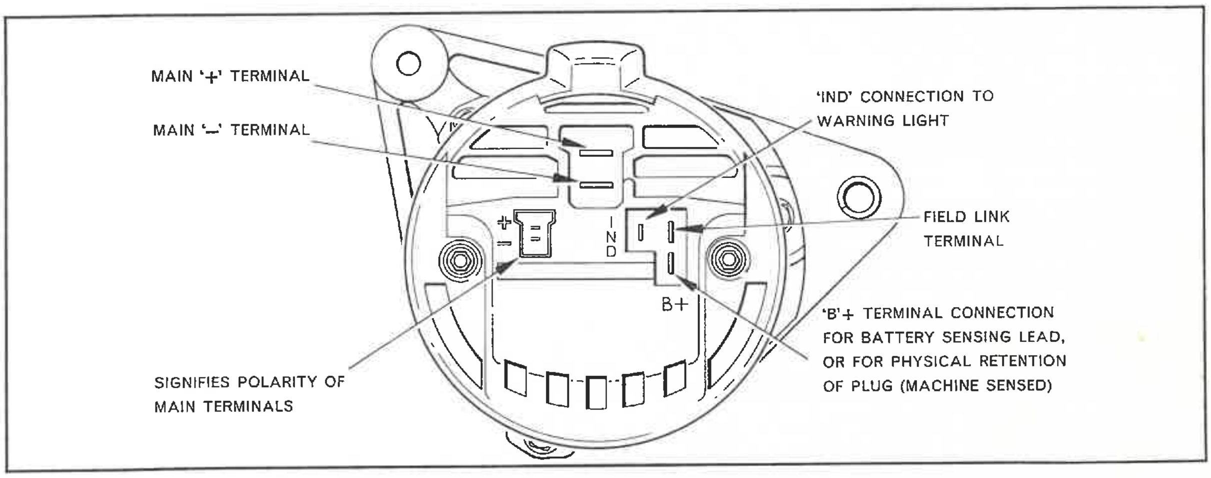


Fig. 2 15ACR, 16ACR and 17ACR alternators (machine-sensed or battery-sensed with standard terminations)

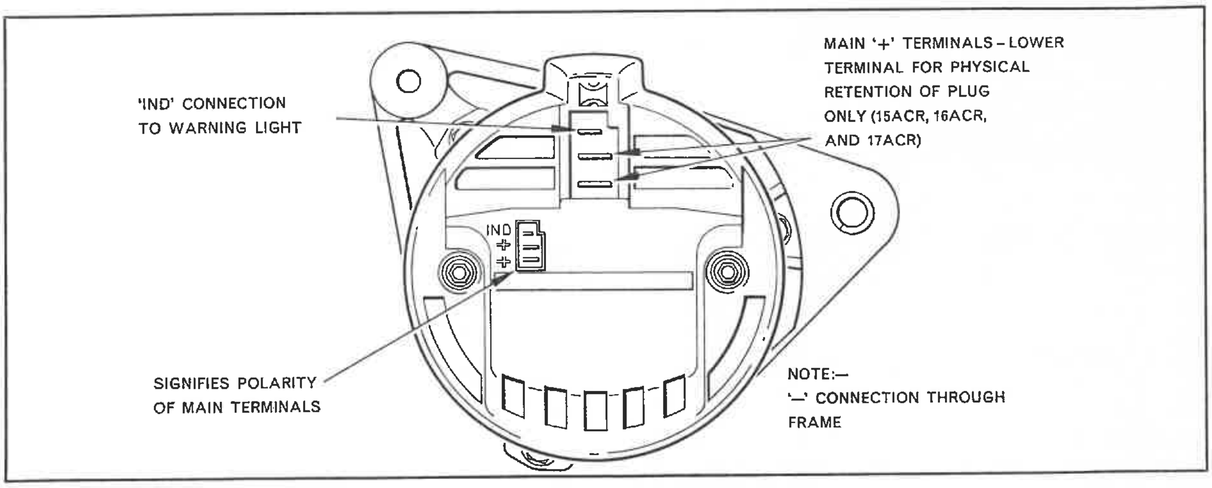


Fig. 3 15ACR, 16ACR, 17ACR and 18ACR alternators (machine-sensed European terminations)

Alternator Models 15ACR, 16ACR, 17ACR & 18ACR

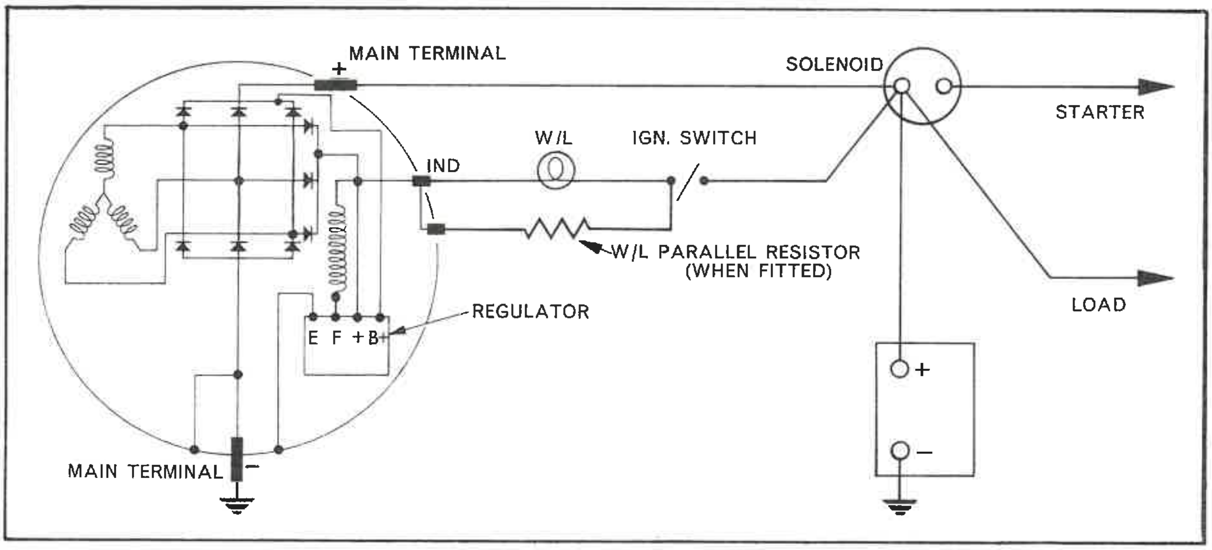


Fig. 4 Machine-sensing system, early production 15ACR alternators (terminal arrangement Fig. 1)

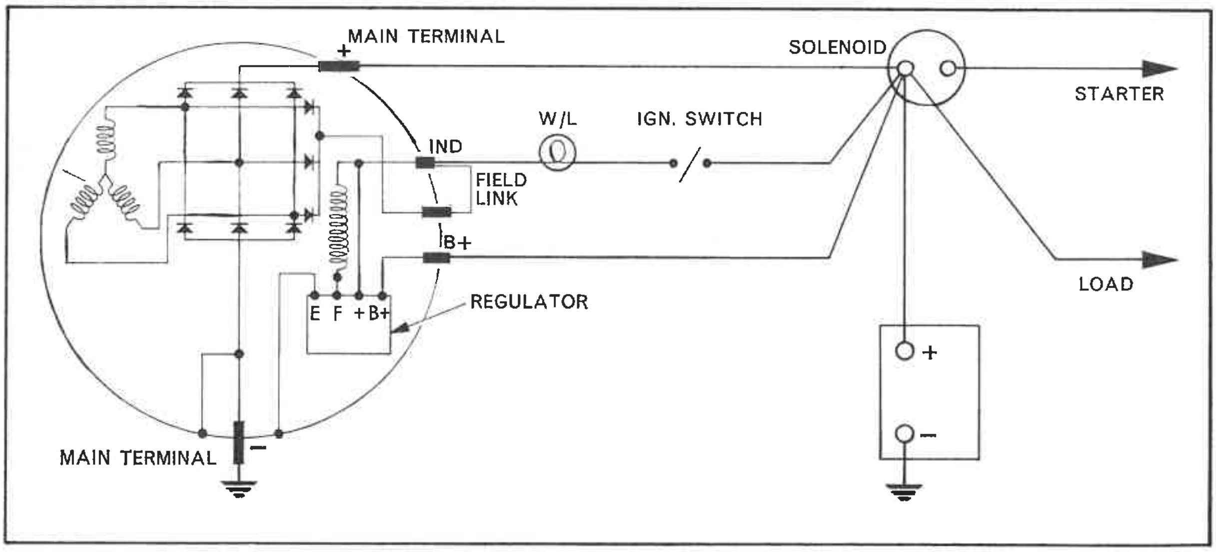


Fig. 5 Battery-sensing system, 15ACR, 16ACR and 17ACR alternators (standard terminations Fig. 2)

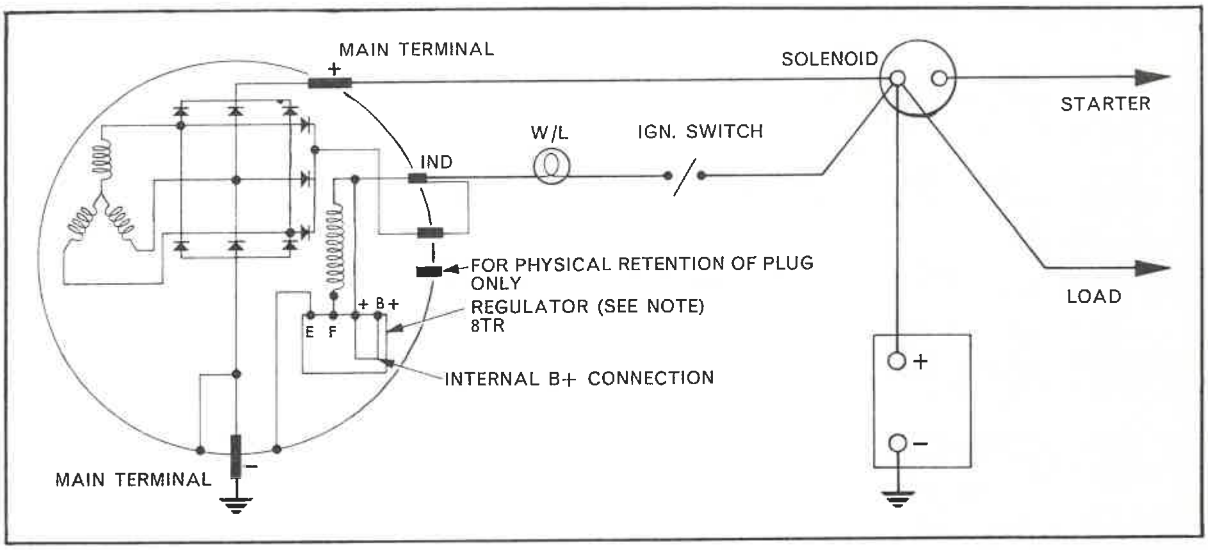


Fig. 6 Machine-sensing system, 15ACR, 16ACR and 17ACR alternators (standard terminations Fig. 2)

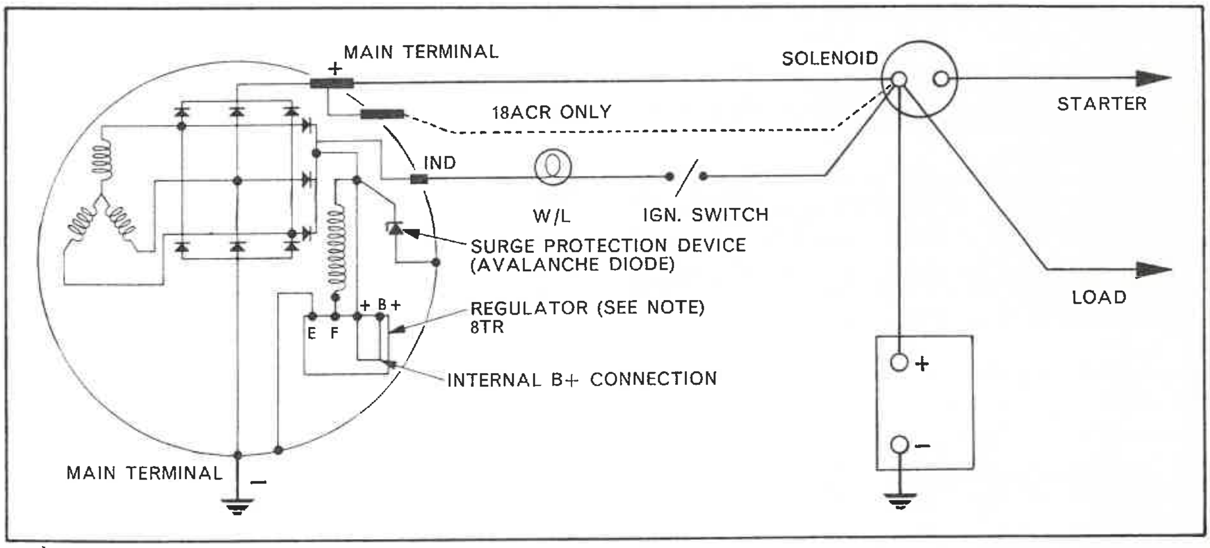


Fig. 7 Machine-sensing system, 15ACR, 16ACR, 17ACR and 18ACR alternators (European terminations Fig. 3)

Note:

If a 3-lead model 11TR regulator is fitted, the 'B+' terminal and internal link will not apply.

If a 2-lead model 8TRD regulator is fitted, the earth-connection will be via the regulator case.

If a later production 2-lead model 14TR regulator is fitted, the 'F' connection will be via the regulator case (connected to the brush box via a metal connector link) and the 'B+' terminal and internal link will not apply.

Alternator Models 15ACR, 16ACR, 17ACR & 18ACR

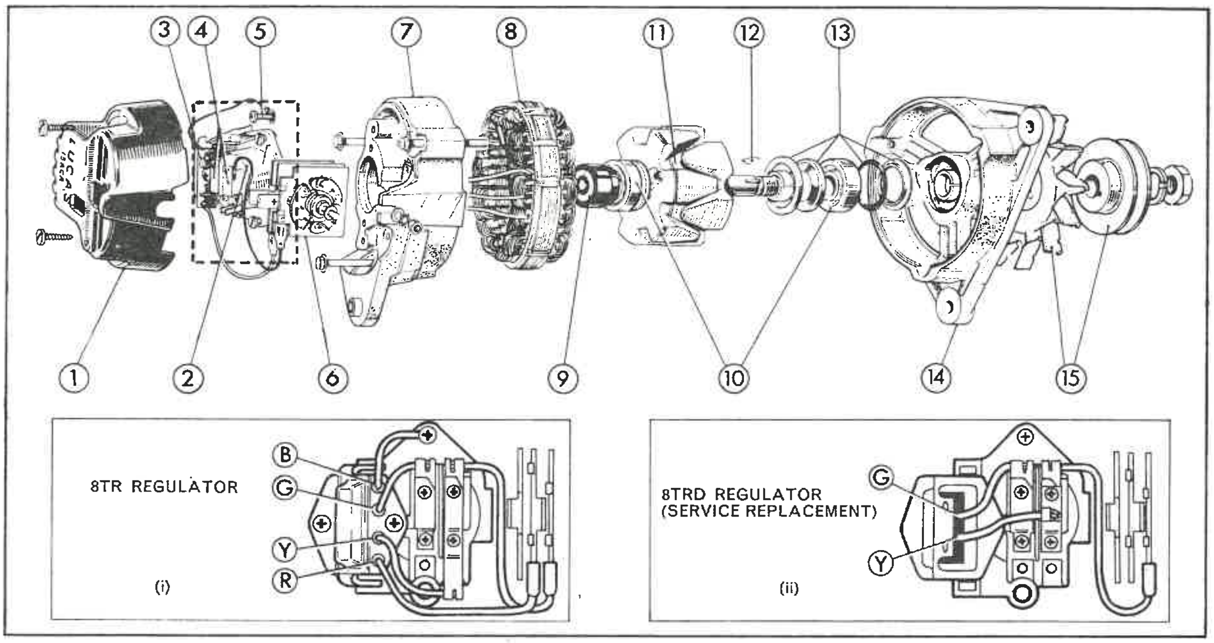


Fig. 8(a) Machine-sensing system, early production 15ACR alternators (reference Fig. 1 and 4)

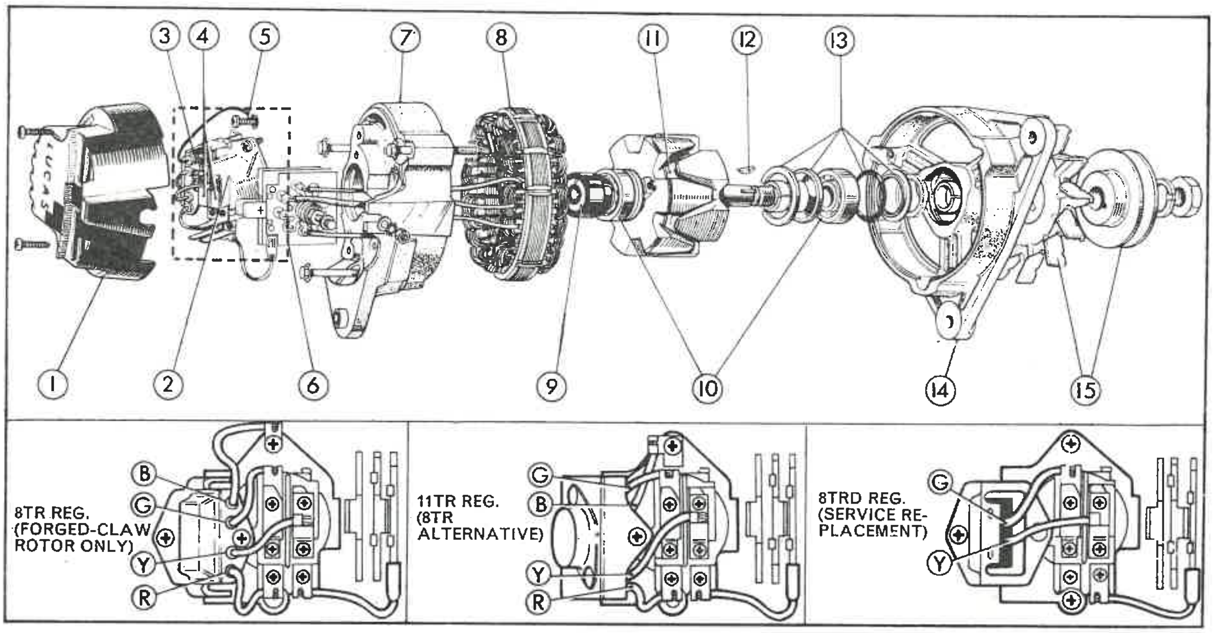


Fig. 8(b) Battery-sensing system, 15ACR, 16ACR and 17ACR alternators (reference Fig. 2 and 5)

Wiring Colour Code:
B — Black
G — Green
Y — Yellow
R — Red

1 Moulded cover (two fixing screws)
2 Brush box assembly, comprising item (4), (two fixing screws)
3 Regulator (two fixing screws)
4 Brush and spring assemblies (2)
5 Regulator earthing screw
6 Rectifier (fixing nut and washers)
7 Slip ring end bracket (three fixing bolts)

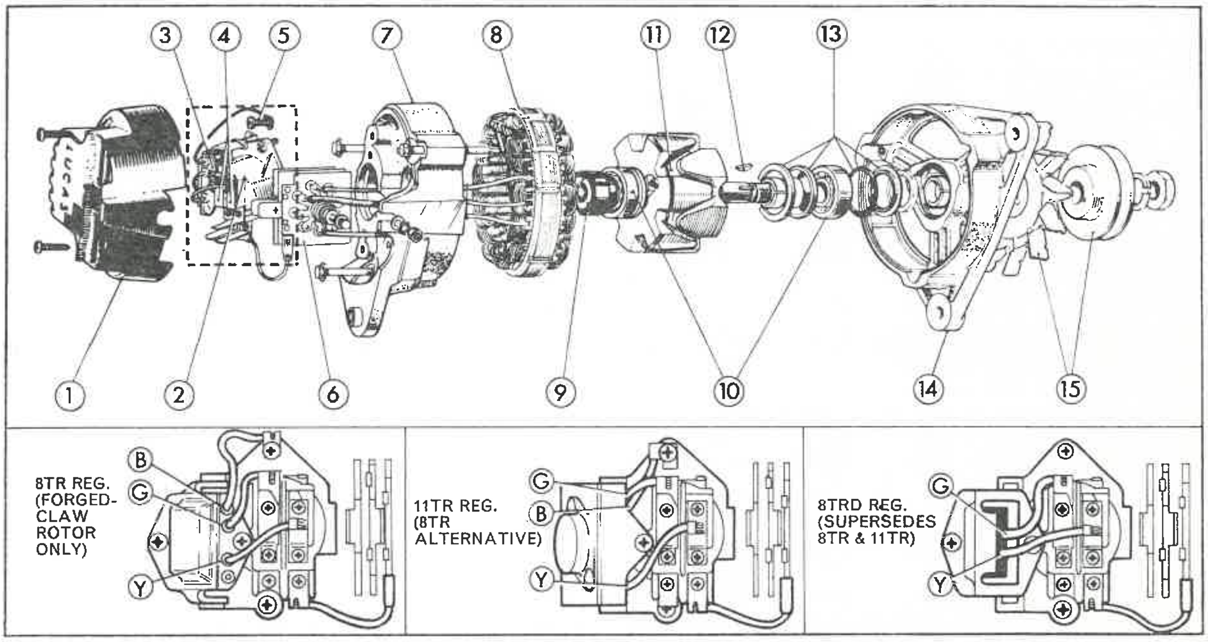


Fig. 8(c) Machine-sensing system, 15ACR, 16ACR and 17ACR alternators (reference Fig. 2 and 6)

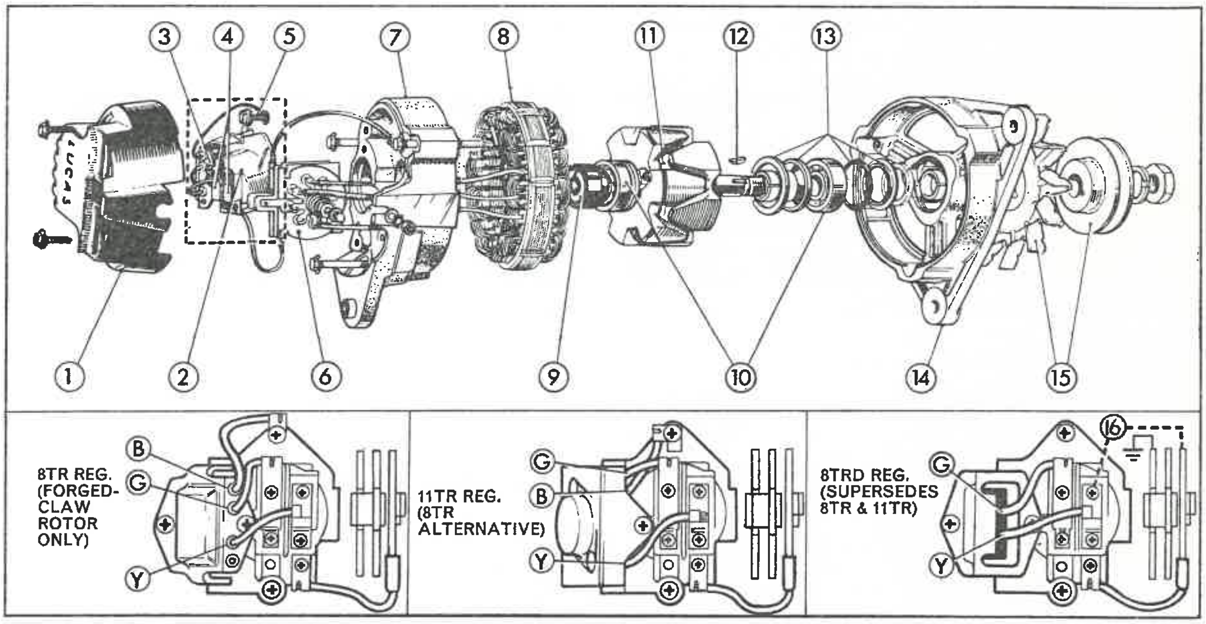


Fig. 8(d) Machine-sensing system, 15ACR, 16ACR, 17ACR and 18ACR alternators (reference Fig. 3 and 7)

8 Stator winding assembly
9 Slip ring moulding
10 Ball bearing(s)
11 Rotor and field winding
12 Woodruffe shaft key (fan and pulley fixing)
13 Bearing assembly parts
14 Drive-end bracket
15 Fan and pulley (fixing nut and spring washer)
16 Alternative connections for surge protection device (when fitted)

Wiring Colour Code:

B — Black
G — Green
Y — Yellow
R — Red

Alternator Models 15ACR, 16ACR, 17ACR & 18ACR

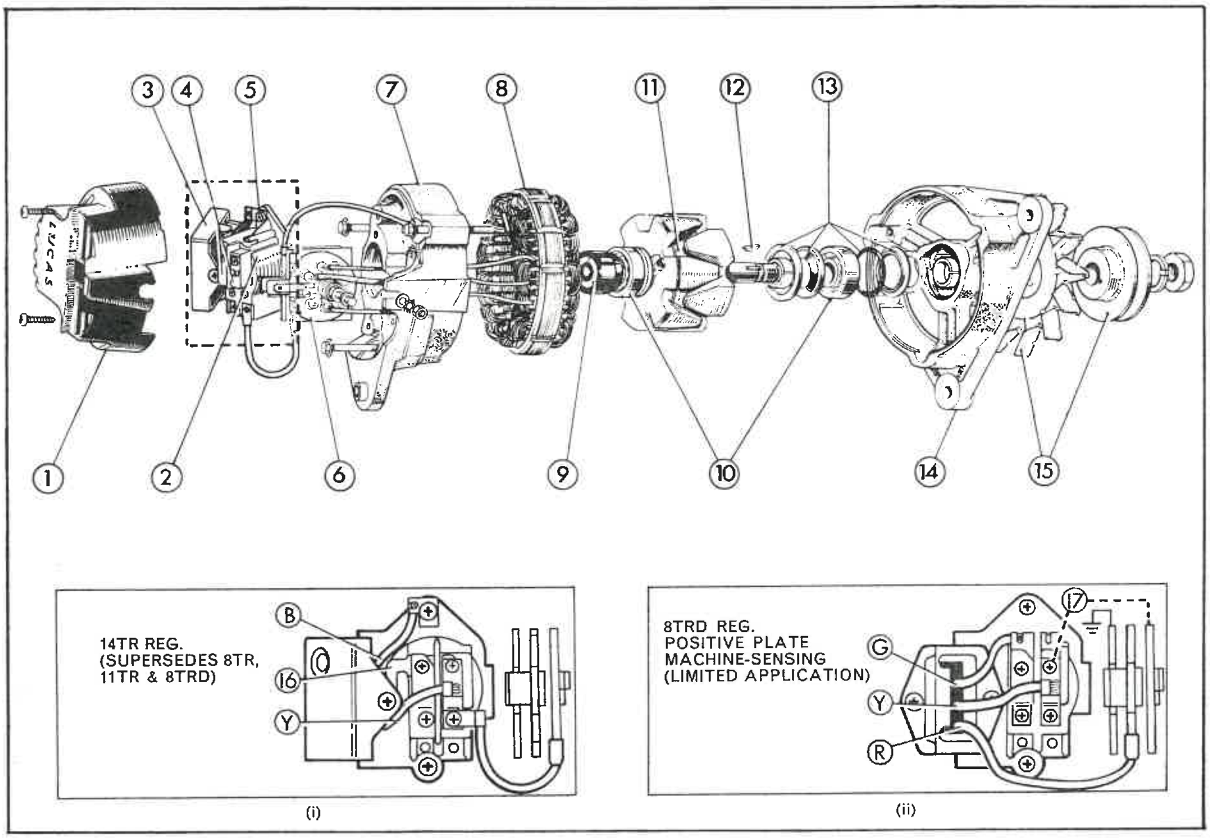


Fig. 8(e) Machine-sensing system

14TR regulator, 15, 16, 17 and 18ACR (reference Fig. 3 and 7)

8TRD regulator, 16, 17 and 18ACR (reference Fig. 3 and 7, but with regulator connections as Fig. 4, except for the earth connection 'E' which is via the regulator case)

1 Moulded cover (two fixing screws)
2 Brush box assembly
3 Regulator (two fixing screws)
4 Brush and spring assemblies (2)
5 Regulator earthing screw and brush box fixing screws (2)
6 Rectifier (fixing nut and washers)
7 Slip ring end bracket (three fixing bolts)
8 Stator winding assembly
9 Slip ring moulding
10 Ball bearing(s)
11 Rotor and field winding
12 Woodruffe shaft key (fan and pulley fixing)
13 Bearing assembly parts
14 Drive-end bracket
15 Fan and pulley (fixing nut and spring washer)
16 'F' terminal connector strip
17 Alternative connections for surge protection device (when fitted)

Wiring Colour Code: B — Black G — Green Y — Yellow R — Red

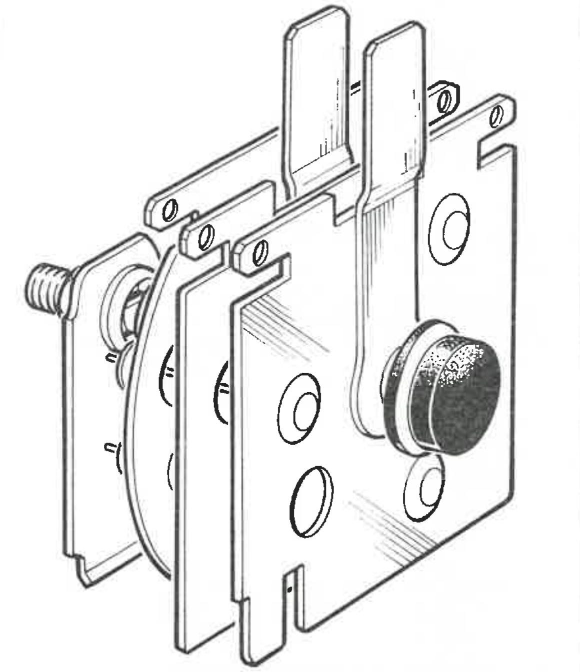
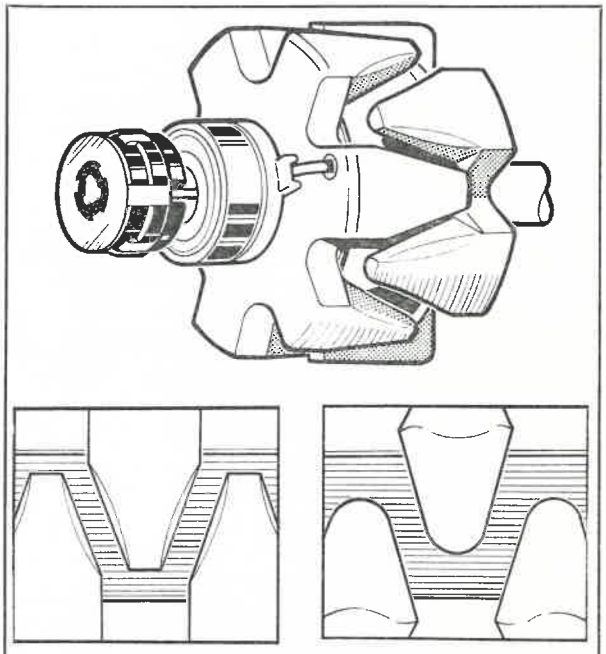


Fig. 9 Model 4DS5 rectifier 83192
15ACR early-production and standard terminations (battery-sensed or machine-sensed)



(a)
Forged-claw
(early production)

(b)
Pressed-claw
(later production)

Fig. 11 Rotor assembly

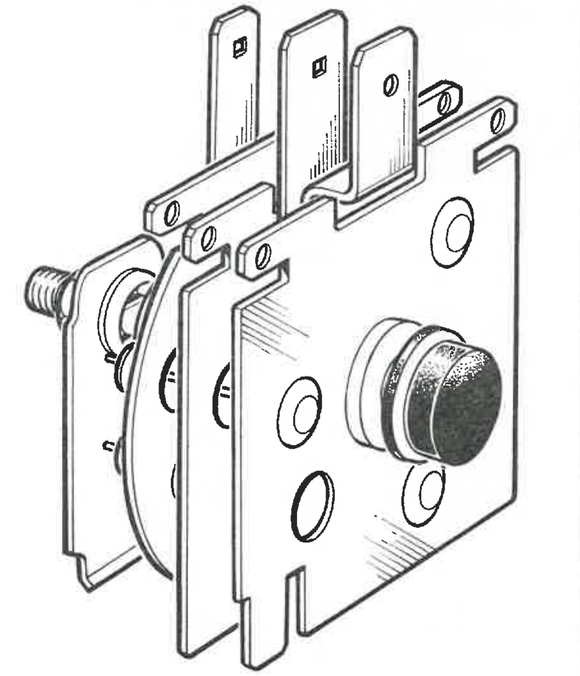


Fig. 10 Model 4DS5 rectifier 83166
(European terminations, machine-sensed)

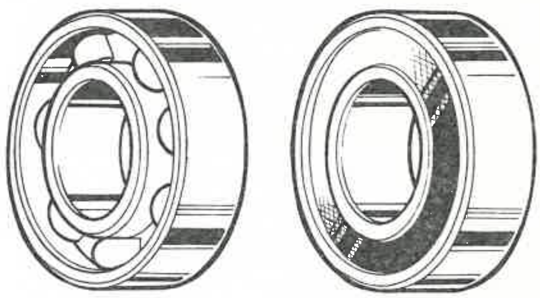


Fig. 12(a)
Standard bearing
(fitted to drive-end and slip-ring end; slip-ring end bearing shielded one side, facing slip-ring)

Fig. 12(b)
Fully-sealed bearing
(heavy-duty applications)
(fitted to drive-end and slip-ring end)

Alternator Models 15ACR, 16ACR, 17ACR & 18ACR

1. GENERAL

(a) Variations in Alternator Design

The 15, 16, 17 and 18ACR range of alternators are similar in mechanical construction (see Figs. 8a to e). Overall length and end-bracket fixing centre dimensions of the 15ACR and 16ACR are approximately ¼" (0·25 in. or 6 mm) smaller than the 17ACR and 18ACR. Differences in rotor and stator windings provide alternative electrical performance characteristics (refer 3. TECHNICAL DATA).

Terminal Arrangement

(i) Early-Production 15ACR (see Fig. 1).
(ii) Standard Terminations (see Fig. 2).
(iii) European Terminations (see Fig. 3).

Alternator Output Control

Integral electronic voltage regulator unit of micro-circuit construction.

(i) 8TR or 11TR 4-lead regulator (see Figs. 8a & b).
(ii) „ „ „ 3-lead „ (see Figs. 8c & d).
(iii) 8TRD 2-lead regulator (see Figs. 8a to d).
(iv) „ 3-lead „ (see Fig. 8e ii).
(v) 14TR 2-lead „ (see Fig. 8e i).

Rectifier

Plate-type rectifier pack comprising nine silicon diodes, three field diodes and six main output diodes.

(i) Standard termination rectifier model 4DS5 Pt. No. 83192 (see Fig. 9).
(ii) European termination rectifier model 4DS5 Pt. No. 83166 (see Fig. 10).

Rotor

Forged-claw or pressed-claw types (see Figs. 11a & b).

(i) Forged-claw rotor: 18ACR alternators and other early-production alternators.
(ii) Pressed-claw rotor: Later-production alternators.
(iii) Pressed-claw rotor (de-rated): 17ACR alternators fitted to 'Combine Harvesters'.

Note: Combine Harvesters work under adverse conditions of excess dust, chaff etc., which enters the alternator via the ventilating slots in the slip-ring end cover moulding. Over a period of time this foreign matter builds up inside the alternator and around the ventilating slots in the end brackets and if the alternator were of standard specification it would overheat and eventually fail. Overheating of the 17ACR alternator fitted to Combine Harvesters is avoided by using a de-rated rotor (fewer windings than a standard rotor) which limits the 17ACR alternator output to 25A (normally 36A). This reduces the working temperature of the alternator below the normal limit, so providing a tolerance to counteract any adverse increase in heat due to restricted air-flow through the alternator.

Surge Protection Device

The surge protection device is a special avalanche-diode, fitted to the outer-face of the slip-ring end bracket (not to be confused with a suppression capacitor, similarly fitted in the end bracket). The avalanche-diode is connected between terminal 'IND' and frame and its purpose is to protect the regulator from damage by absorbing high transient voltages which occur in the charging system due to faulty cable connections, or if the cables are temporarily disconnected at the battery whilst the engine is running. (The surge protection device is intended to provide limited protection for the regulator under normal working conditions and therefore the service precaution not to disconnect any of the charging system cables, particularly those at the battery, while the engine is running, should still be observed).

(b) Operation of the Alternator

When the ignition switch (or the equivalent control switch for diesel engines) is switched 'ON', a small current flows from the battery and through the rotor field winding, the circuit being completed via the warning light, alternator terminal(s) 'IND' and the carbon brushes contacting the rotor slip-rings, the alternator regulator and earth. At this stage, the warning light is illuminated and the rotor is partially-magnetised.

When the engine is started and the partially-magnetised rotor rotates within the stator windings, 3-phase alternating current (a.c.) and rapidly rising voltage is generated.

A small portion of generated alternating current (a.c.) is rectified to direct current (d.c.) by the three field diodes incorporated in the rectifier pack. Output current from the field diodes supplements the initial current flowing through the rotor field winding from the battery, causing an increase in the magnetic influence of the rotor and resulting in self-excitation of the alternator. As rotor speed and generated current and voltage increases, the rotor field current increases correspondingly until the alternator becomes fully-excited.

During the rise in generated output voltage (reflected at terminal 'IND') the rising voltage influences the warning light so that it functions as a 'Charge-Indicator Warning Light', as follows: When the generated voltage applied to one side of the warning light (via the 'IND' terminal) rises above the battery voltage applied to the other side of the warning light, the warning light is extinguished and this normally indicates that the alternator is developing its main battery-charging current.

The main battery-charging current is rectified from a.c. to d.c. by the other six diodes in the rectifier pack (main output diodes) which function in a full-wave bridge rectifier circuit.

Alternator output is controlled by a voltage-sensing regulator unit, attached to the brushbox moulding and the outer-face of the slip-ring end bracket. The regulator functions as an electronic control switch in the earth-side of the rotor field winding circuit, switching the circuit 'OFF' and 'ON' at very high frequency to maintain the alternator output voltage (and so the current) at a predetermined and safe working limit. The alternator-controlled voltage, measured at the battery terminals, is normally 13·6–14·4V. There are two systems of alternator output control (i) Battery-Sensing and (ii) Machine-Sensing.

(i) Battery-Sensing: The regulator senses the system voltage, direct from the battery, via a battery-sensing cable connected between the 'B+' terminal of the alternator and the insulated side of the battery (see Fig. 5).

(ii) Machine-Sensing: The regulator senses the alternator generated output voltage, via the regulator connections inside the alternator.

(a) Terminal 'IND' machine-sensing: See Figs. 6 and 7.

(b) Positive plate machine-sensing: See Fig. 4. Also later-production alternators, similar to Fig. 4 except European terminations and the regulator earth-connection is via the case (see also Fig. 8e ii). Later-production alternators with positive plate machine-sensing can be identified by the regulator, model 8TRD 3-lead marked 37587.

(c) Service Precautions

(i) Ensure that no connection in the charging circuit, including the battery, is made or broken while the engine is running.

(ii) Observe correct polarity when refitting the vehicle battery, using a slave battery to start the engine, or when using a battery charger (connect positive to positive, negative to negative).

2. ROUTINE MAINTENANCE

Occasionally check the general condition and tightness of the fan belt. If necessary, the fan belt tension should be adjusted to obtain approximately ⅝" (0·6 in. or 16 mm) deflection of the belt when pressed at the longest point between pulleys.

Note: When adjusting the fan belt, leverage must only be applied to the alternator drive-end bracket and the lever should preferably be wood.

3. TECHNICAL DATA

(i) Earth polarity: Negative

(ii) Nominal voltage: 12V

(iii) Nominal d.c. output (hot, at 14V and 6,000 rev/min.):

15 ACR	*16 ACR*	*17 ACR*	*18 ACR*
28A	34A	36A	45A

Combine Harvesters 25A (*17ACR*)

(iv) Alternator controlled voltage (measured across the battery terminals with alternator current stabilised below 10A): 13·6–14·4V

(v) Max. permissible speed: 15,000 rev/min.

(vi) Rotor field winding resistance (approx.):
4·3 ohms (15ACR & 16ACR rotors with PINK windings).
3·3 ohms (15ACR & 16ACR rotors with PURPLE windings).
4·2 ohms (17ACR rotors with PINK windings).
3·2 ohms (17ACR rotors with GREEN windings).
3·3 ohms (17ACR de-rated rotors with GOLD windings).
3·2 ohms (18ACR rotors with GREEN windings).

(vii) Brush spring pressure (measured with brush depressed flush with brushbox moulding): 9–13 ozf (255–368 g or 2·5–3·3N)

(viii) New brush length: ½" (0·5 in. or 12 mm)
Renew when worn to: $\frac{5}{16}$" (0·3 in. or 8 mm)

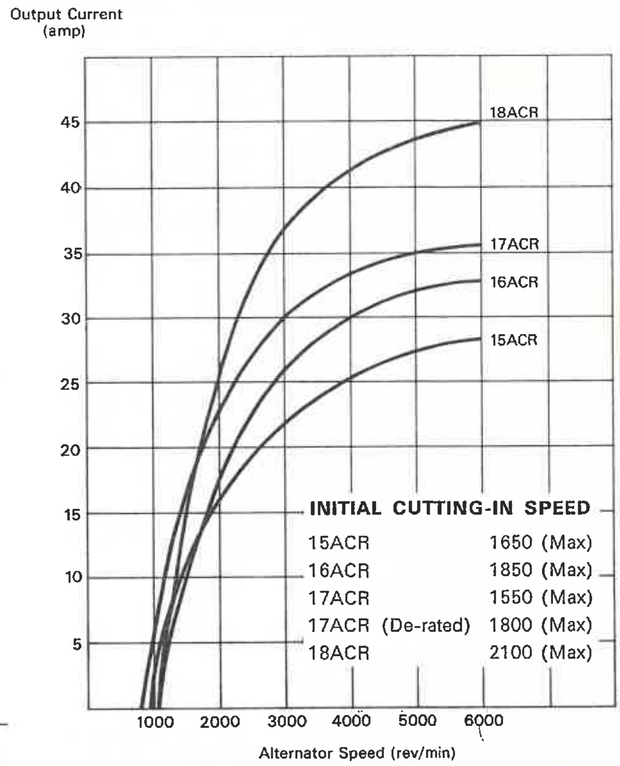


Fig. 13 Typical performance curve (alternator hot)

4. SERVICING

(a) Checking the Charging System

(i) Eliminate the Battery

Check with a hydrometer the specific gravity of the electrolyte in each of the battery cells. If the cell readings vary by more than 40 points (0.040), the battery is suspect. Specific gravity readings should be:

State of charge	Specific gravity readings correct to 15°C (60°F)	
	Climates normally below 25°C (77°F)	Climates normally above 25°C (77°F)
Fully-charged	1.270 – 1.290	1.210 – 1.230
70% charged	1.230 – 1.250	1.170 – 1.190
Discharged	1.100 – 1.120	1.050 – 1.070

Electrolyte Temperature Correction

For every 10°C (18°F) *below* 15°C (60°F) *subtract* 0.007.
For every 10°C (18°F) *above* 15°C (60°F) *add* 0.007.

If the battery is found to be discharged it should be independently recharged, renewed, or substituted for the following tests. If the battery is found to be satisfactory, check for tightness of its terminal connections.

(ii) Observe Operation of the Warning Light

Switch on the ignition switch, or equivalent control switch for diesel engines (do not at this stage start the engine). **The warning light should be fully illuminated.** If the warning light is not illuminated, check the bulb. If the bulb is not the cause of the fault, proceed direct to para. iv.

If the warning light is illuminated, start the engine and run above idling speed. **The warning light should be extinguished.** If the warning light is not extinguished, the driving belt may be broken or slipping (refer para. iii). If the driving belt is not the cause of the fault, remove the alternator 'IND' field-terminal connector plug, or 'IND'/MAIN terminal connector plug (European termination alternators). If warning light remains illuminated, check for short-circuit to frame between the 'IND' cable-end and warning light. If warning light is now extinguished, refit alternator connector plug and proceed direct to para. v.

(iii) Check the Driving Belt

Check whether the driving belt is broken or slipping. With the driving belt depressed by hand at the longest point between pulleys, deflection of the belt should be approximately ⅝″ (0·6 in. or 16 mm).

(iv) Check the Alternator Plug Connections

Note: A moving-coil voltmeter 0–20V range is required.

Alternators with either Fig. 1 or Fig. 2 terminal arrangements

Move ignition switch or equivalent control switch to 'ON'.

Remove rotor field-winding connector plug from alternator terminals marked 'IND', or 'IND B+', and connect voltmeter between each cable-end in turn and the frame (negative-side of voltmeter to frame). **Battery voltage should be registered.**

Remove main connector plug from alternator terminals marked '+' and '—' and connect voltmeter between cable-ends (negative side of voltmeter to cable-end coloured BLACK). **Battery voltage should be registered.**

If the test is unsatisfactory, in either case, the continuity fault in the external cable circuit(s) must be traced and remedied (refer circuit diagrams Figs. 4, 5 & 6).

If the test is satisfactory, in both cases, refit connector plugs to the alternator and proceed direct to next test para. v.

Alternators with Fig. 3 terminal arrangements

Move ignition switch or equivalent control switch to 'ON'.

Remove connector plug from alternator and connect voltmeter between each cable-end in turn and the frame (negative-side of voltmeter to frame). **Battery voltage should be registered.**

If the test is unsatisfactory, the continuity fault in the external cable circuit(s) must be traced and remedied (refer circuit diagram Fig. 7).

If the test is satisfactory, refit connector plug to the alternator and proceed to next test para. v.

(v) Check Alternator Charging Current, and Alternator Controlled Voltage at the Battery Terminals

Note: In addition to the voltmeter used in the previous test (para. iv), unless the vehicle is fitted with an ammeter, it will be necessary to connect a test-ammeter, 0–60A range, in series with the cable(s) connected to the main output '+' terminal of the alternator. (This can be achieved by connecting the ammeter in series with the brown-coloured 'eyeleted' alternator cable(s) attached to the main input terminal of the starter solenoid. Connect ammeter negative-side to solenoid terminal and positive-side to cable eyelet).

Connect the voltmeter across the battery terminals, so that battery voltage is registered.

Start engine, increase speed (ignore voltmeter at this stage) and observe the ammeter reading.

If ammeter registers zero amps, the alternator is faulty and must be removed from the vehicle for individual testing (proceed to 4(b) 'Bench Testing').

If ammeter registers a charging current in excess of 10A continue running the engine until ammeter reading falls below 10A, and observe the voltmeter reading. **13·6–14·4V should be registered** (alternator-controlled voltage), in which case the charging system is working normally.

If the voltmeter reading exceeds 14·4V, the alternator should be removed from the vehicle and the regulator renewed, otherwise the battery will be subjected to overcharging and the alternator will be overworked and damaged.

If voltmeter reading is below 13·6V, a faulty alternator (regulator) or a high-resistance fault in the external connections of the charging system is indicated. Proceed to para. (vi) 'Charging Circuit Volt Drop Testing'. If the volt drop tests are satisfactory, remove the alternator from the vehicle and proceed to 4(b) 'Bench Testing'.

(vi) Charging Circuit Volt Drop Testing

Check for a high resistance fault in the charging system, by carrying out two separate volt drop tests on the insulated-side and earth-side of the charging circuit. The tests must be carried out with all the alternator cables connected. (The connector plug is open-ended to facilitate testing). Switch on the headlamps to load the charging system and run the engine at a fairly high speed (simulating normal working speed), and connect the voltmeter as follows:

Insulated-side volt drop test

Connect voltmeter between the alternator main output '+' terminal(s) and the '+' terminal of the battery. (Voltmeter red lead to alternator and black lead to battery). **The test is satisfactory if the voltmeter registers 0–0·5V.**

If the test is unsatisfactory, a high-resistance fault between the positive side of the battery and the alternator '+' terminal(s) must be traced and remedied.

Earth-side volt drop test

European termination alternators (Fig. 3):

Connect voltmeter between the alternator frame and the '—' (earth) terminal of the battery. (Voltmeter black lead to alternator and red lead to battery).

Other alternators (Figs. 1 & 2):

Connect voltmeter between the alternator main output '—' terminal and the '—' (earth) terminal of the battery. (Voltmeter black lead to alternator and red lead to battery).

In either case the test is satisfactory if the voltmeter registers 0–0·25V.

If the test is unsatisfactory, a high-resistance fault on the earth-side of the charging circuit must be traced and remedied.

(b) Bench Testing

Note: The test rig must be capable of varying the alternator speed from zero to 6,000 rev/min. To avoid overheating of the alternator it should be fitted with a fan and driven in the correct direction-of-rotation. (Correct rotation of the alternator can be determined by an arrow marking on the face of the fan or, alternatively, by the angle of the fan blades which are inclined in the opposite direction to that in which the alternator must be rotated when viewed from the drive-end). Wiring used in the test circuit must be of equivalent grade to that used in vehicle alternator installations, 14/010 (14/0·25 mm) grade for the 'IND' field circuit cables and 120/012 (120/0·30 mm) grade for the main terminal(s) and earth cables. Connect two 120/012 grade cables to the main output '+' terminals of 18ACR alternators with European terminations (Fig. 7).

Clamp the alternator in the test rig, with the alternator moulded slip-ring end cover removed to expose the regulator connections. Connect a test circuit, similar to one of the applicable circuits shown in Figs. 4, 5, 6 & 7 (depending on alternator terminal arrangement) but using direct connections between the alternator, warning light (12V 2·2W), and the test battery.

Include in the test circuit: a 0–60A moving-coil ammeter in series with the alternator main output '+' cable(s) and connect in parallel across the battery terminals a 0–20V moving-coil voltmeter and a 15 ohm 35A variable load resistor. **The warning light should be illuminated,** in which case proceed direct to first test para. (i) 'Alternator Output Test with Regulator Inoperative'.

If the warning light is not illuminated (providing the warning light bulb is known to be good), non-continuity of the rotor field winding circuit is indicated. Check in the following order: regulator, brushes-and-springs and rotor slip-rings, rotor field-winding continuity.

Regulator

Connect the regulator 'F' terminal to alternator frame. If this results in the warning light now being illuminated, the regulator is faulty and it must be renewed.

In all cases except a model 14TR regulator, the regulator 'F' terminal is a green coloured lead. In the case of a 14TR regulator, the 'F' terminal connection is via the regulator case, connected to the brushbox by a metal connecting strip (see Fig. 8e (i), item 16).

Brushes-and-springs and rotor slip-rings

Remove the brushbox moulding. Check whether brushes and slip-rings are free of oil or grease. If necessary, the brushes and springs can be cleaned with a petrol-moistened cloth. Check brush-and-spring assemblies for freedom-of-movement in the brushbox moulding. If the visible length of the brushes in the free position is less than ¼″ (0·25 in. or 6 mm), this is the probable cause of non-continuity of the field circuit. In any case, the brush-and-spring assemblies should now be renewed if the overall length of the brushes has become worn to 5/16″ (0·3 in. or 8 mm).

While the brushbox moulding is removed, check rotor field winding continuity.

Rotor field winding continuity

Check the rotor field winding continuity, by connecting a battery-operated ohmmeter or a 12V battery test-lamp between each of the rotor slip-rings. **The ohmmeter should register a reading or the test lamp should light.**

If the test is unsatisfactory, renew the rotor (refer 4(c) 'Dismantling') and then proceed to para. (i) 'Alternator Output Test with Regulator Inoperative'.

(i) **Alternator Output Test with Regulator Inoperative**

Make the regulator inoperative, by linking its green lead ('F' terminal) to alternator frame. A

FAULT SYMPTOMS

Warning Light	Alternator: Temperature	Alternator: Noise	Alternator: Output	Probable Fault (Associated Damage)
Illuminated at stand-still, extinguished at cut-in speed (1,500 rev/min) but at higher speeds becomes partially illuminated again and gets progressively brighter.	High	Normal	Higher than normal at 6,000 rev/min. Approximately: 35A 15ACR 40A 16ACR 38A 17ACR 50A 18ACR	Live-side main output diode open-circuit. (May damage rotor field winding and regulator, overheat brushboxes, and fuse warning light bulb).
Not illuminated between zero and 1,500 rev/min.	High	Excessive	Very low at 6,000 rev/min. Approximately: 10A (all models).	Live-side main output diode short-circuit. (May damage associated 'field' diode).
Illuminated at stand-still, dims appreciably at cut-in speed (1,500 rev/min) and gets progressively dimmer or may be extinguished at higher speeds.	Normal	Excessive	Poor at low speed. Slightly below normal at 6,000 rev/min. Approximately: 26A 15ACR 32A 16ACR 30A 17ACR 40A 18ACR	Earth-side main output diode open-circuit.
Illuminated at stand-still, dims appreciably at cut-in speed (1,500 rev/min) and gets progressively dimmer or may be extinguished at higher speeds.	Normal	Normal	Lower than normal at 6,000 rev/min. Approximately: 23A 15ACR 29A 16ACR 29A 17ACR 35A 18ACR	'Field' diode open-circuit.
Illuminated at stand-still, dims at cut-in speed (1,500 rev/min) and remains dim, but may be extinguished at very high speeds.	Normal	Excessive	Very low at all speeds above cut-in (1,500 rev/min). Approximately: 7A (all models).	Earth-side main output diode short-circuit, or stator winding short-circuit to earth.
Illuminated at stand-still, dims at cut-in speed (1,500 rev/min) and remains dim, but may be extinguished at very high speeds.	Normal	Excessive	Very low at 6,000 rev/min. Approximately: 7A (all models).	'Field' diode short-circuit.

model 14TR regulator does not incorporate a green lead (the 'F' terminal being via the regulator case), in which case connect the regulator case to alternator frame.

Run the alternator in the test rig at a slowly-increasing speed. **At the cutting-in speeds indicated in Fig. 13, the warning light should be extinguished.**

If the warning light is not extinguished, the suppression capacitor and/or surge protection device (when fitted) should be proved by repeating the test with each of these items disconnected in turn.

If the result is still unsatisfactory, the alternator is faulty and must be dismantled for detailed inspection to determine and rectify the fault. (Proceed to 4(c) 'Dismantling, Inspection and Electrical Testing of Components').

Providing the first half of the test is satisfactory (warning light extinguished), increase alternator speed to 6,000 rev/min and adjust the variable load resistor until the voltmeter registers 13·6V. **The ammeter should register the maximum rated output of the alternator.** (Refer 3. TECHNICAL DATA).

If this second half of the test is unsatisfactory, the suppression capacitor and/or surge protection device (when fitted) should be proved by repeating the test with each of these items disconnected in turn.

If the result is still unsatisfactory, the alternator is faulty and it must be dismantled for detailed inspection to determine and rectify the fault. (Refer 4(c) 'Dismantling, Inspection and Electrical Testing of Components').

Note: Failure of one or more of the diodes will be indicated by the effect on alternator output, and in some instances by abnormally high alternator temperature and noise level. The fault symptom table shows how diode failure will influence alternator output test results, and para. c (iii) gives information on testing the diodes.

(ii) Regulator Test (in situ)

Note: This test assumes the alternator output test (para. i) has previously been carried out and found to be satisfactory.

Remove the variable load resistor from the battery terminals and also the test link connecting the regulator 'F' terminal connection to alternator frame.

Run the alternator at 6,000 rev/min, until the ammeter registers less than 10A. **If the voltmeter registers 13·6–14·4V,** the regulator is working normally. If the voltmeter reading is outside the limits specified, the regulator must be renewed.

(c) Dismantling, Inspection and Electrical Testing of Components

(i) Preliminary dismantling

The following information covers minimum dismantling of the alternator to enable the brushgear and slip-rings to be inspected, and the rotor and stator-windings and rectifier diodes to be electrically tested. If inspection and testing determines the need to extend dismantling in order to renew a faulty part, refer (c) iv 'Further Dismantling'.

Remove the moulded slip-ring end cover (if not already removed).

Note the arrangement of the stator winding connections to the rectifier diode connecting pins, and then using a thermal shunt (see Fig. 20) and a light-weight soldering iron (e.g. 25-watt) unsolder the connections to the rectifier.

Refer to Figs. 8a to e and identify the arrangement of the cable connections to the rectifier plates. (This ensures correct refitting of the rectifier cables during reassembly). These cables can now be disconnected from the rectifier.

Remove the three hexagon-headed screws, securing the brushbox moulding and regulator to the end-face of the slip-ring end bracket. The brushgear-and-regulator sub-assembly can now be detached from the rest of the alternator.

Slacken the rectifier securing nut and detach the rectifier from the rest of the alternator.

The alternator is now sufficiently dismantled to allow inspection and electrical testing of components as detailed in the following paras. (ii) and (iii).

(ii) Inspection of brushgear and rotor slip-rings

Brushgear

Renew the brush-and-spring assemblies if the overall length of the brushes are worn to, or approaching, $\frac{5}{16}$" (0·3 in. or 8 mm). If the brushes are satisfactory but require cleaning, use a petrol-moistened cloth.

Check the brush spring pressure. With the brush-and-spring assemblies fitted in the brushbox moulding, apply a push-type spring gauge to the end-face of each brush in turn until the end-face of the brush is flush with the moulding. The spring pressure should then be 9–13 ozf (255–368 g or 2·5–3·6 N).

Rotor slip-rings

The slip-rings should be clean and smooth. If necessary, clean the slip-rings with a petrol-moistened cloth. If the slip-rings are burnt and require refinishing, use very fine glass paper (not emery cloth, or similar abrasives) and afterwards wipe clean with a petrol-moistened cloth.

NOTE: It is essential that the refinishing glass paper is sufficiently fine to produce a highly-polished slip-ring surface, otherwise excessive brush wear will occur.

(iii) Electrical testing of components

Note: For clarity, illustrations of electrical testing show the components separated from the rest of the alternator.

Rotor field winding

Check field winding continuity and resistance simultaneously, by connecting either a battery-operated ohmmeter (see Fig. 14) or a 12V battery and moving-coil ammeter (see Fig. 15) between the slip-rings. **The ohmmeter should indicate the appropriate resistance given in 3. TECHNICAL DATA, or the ammeter should indicate a current approximate to the figure obtained by dividing the appropriate resistance of the rotor into the battery voltage (12).**

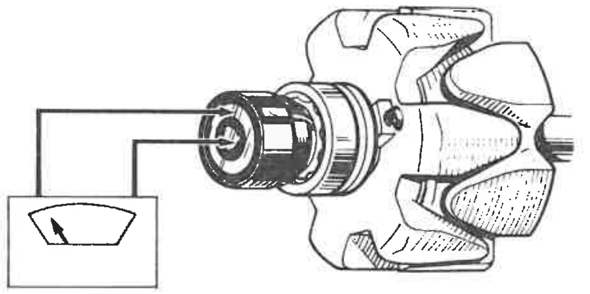


Fig. 14 Measuring rotor winding resistance with ohmmeter

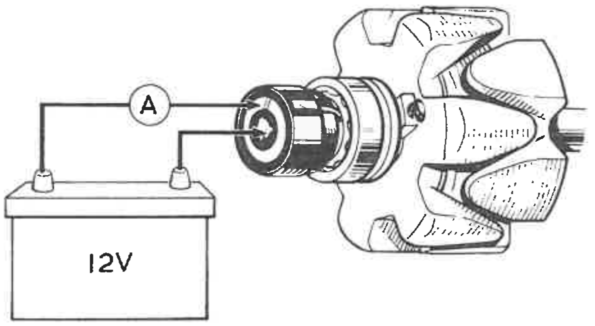


Fig. 15 Measuring rotor winding resistance with battery and ammeter

Check for satisfactory field winding insulation, by connecting a 110V a.c. 15-watt test lamp (see Fig. 16) between either of the slip-rings and the rotor body. **The lamp should not light.**

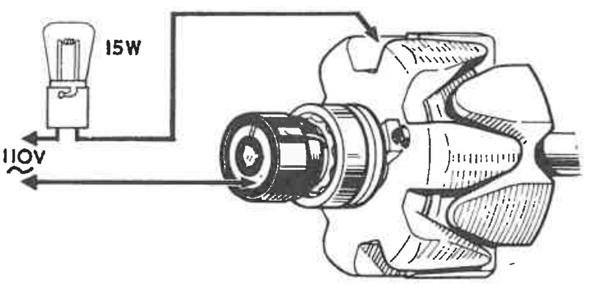


Fig. 16 Insulation test of rotor winding

Stator windings

Due to the very low resistance of the stator windings, a practical test to determine the presence of short-circuited turns cannot be carried out without the use of special instruments. However, in practice inter-winding short-circuiting is usually indicated by obvious signs of burning of the insulating varnish covering the windings. If this is the case, renew the stator assembly without the need for further testing.

Check continuity of stator windings, by first connecting any two of the three stator winding connecting cables in series with a 12V battery-operated test lamp, of not less than 36-watts (see Fig. 17). **The test lamp should light.** If not, renew the stator assembly. Providing the first part of the test is satisfactory, transfer one of the test lamp leads to the other (third) cable. **Again the test lamp should light.** If so, proceed to insulation test.

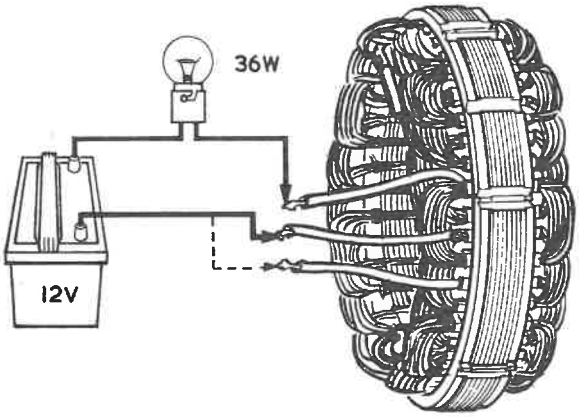


Fig. 17 Stator winding continuity test

Check insulation of stator windings, by connecting a 110V a.c. 15-watt test lamp between the stator laminations and any one of the three connecting cables (see Fig. 18). **The lamp should not light.**

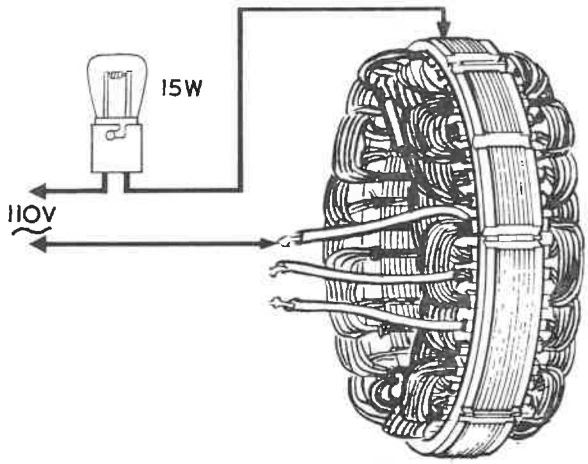


Fig. 18 Stator winding insulation test

Rectifier diodes

Test each of the nine diodes separately, as follows.

Connect a 12V battery and a 1·5-watt bulb in series with one of the diodes, one test lead being applied to the diode connecting pin and the other to the particular heat sink plate in which the diode undergoing test is soldered (see Fig. 19). Note whether lamp lights, then reverse the test lead connections. **The lamp should light during one half of the test only.** If any one diode test is unsatisfactory, renew the rectifier assembly.

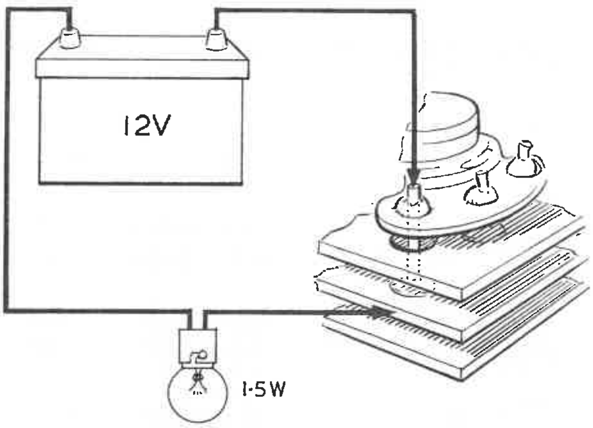


Fig. 19 Simple test for diodes

Note: During reassembly of the alternator, use only 'M' grade 45–55 resin-cored solder to attach the stator cables to the diode connecting pins. Carry out the operation as quickly as possible, using a thermal shunt to avoid damaging the diode(s). (Long-nosed pliers are suitable as a thermal shunt, see Fig. 20).

Fig. 20 Use of thermal shunt when soldering diode connections

Regulator

Individual testing of the regulator can only be carried out with special test equipment and unless this is available the regulator must be proved by substitution.

Surge protection device (avalanche diode) and suppression capacitor, (when fitted)

Both these components should be proved by disconnecting them in turn during bench testing. If the alternator then performs satisfactorily, the component should be renewed.

(iv) Further dismantling

In reference to preliminary dismantling para. (i), if it is necessary to extend dismantling to enable the bearings or other faulty parts to be renewed, proceed as follows:

Remove the three through bolts.

Grip both ends of the alternator in the hands, pull apart the end brackets from the stator laminations and separate the alternator into three major parts.

Slip-ring end bracket
Stator laminations-and-windings
Sub-assembly comprising:

Fan and pulley
Drive-end bracket and bearing
Rotor complete with slip-ring end bearing

If difficulty is experienced in separating the above parts, suspend the alternator gripped by the pulley in one hand and apply a series of light blows with a hide, plastic, or wooden mallet in turn to the shoulders of the through bolt housings of the slip-ring end bracket.

Separate the rotor assembly from the drive-end bracket. First remove the driving pulley, fan and shaft key, then press the rotor shaft from the bearing in the bracket. Alternatively, use the open jaws of a vice to support the bracket and carefully drive the rotor shaft from the bearing by a series of light blows applied to the end of the shaft with a hide, plastic, or wooden mallet. (Open the jaws of the vice sufficient only to clear the rotor poles, position the bracket off-set to the centre of the top of the vice to avoid the slip-ring moulding fouling the bottom of the vice, and temporarily fit the shaft nut flush with the end of the shaft to avoid damage to the shaft threads by the mallet).

If it is necessary to renew either the slip-ring moulding assembly or slip-ring end bearing, the slip-ring moulding assembly can be withdrawn from the keyway in the rotor shaft after the field winding connections have been unsoldered. (Use a light-weight soldering iron, e.g. 25-watt, and for re-soldering the connections use only resin-cored solder).

Bearings

Check whether the bearings need renewing. Determine this by first inspecting the rotor and stator poles for signs of rubbing. If so, excessively worn bearings are indicated and both should be renewed. If there is no visible evidence of worn bearings, check whether the bearings are worn to the extent of allowing perceptible side movement of the rotor shaft and if so the bearing(s) should be renewed.

Renewing the bearings

After removing the slip-ring moulding from the rotor shaft (refer para. prior to the heading 'Bearings'), the slip-ring end bearing can be removed from the rotor shaft and then either renewed or if otherwise satisfactory re-packed with grease lubricant (refer 'Lubrication of bearings'). Position the two halves of the support plate of a hand-operated power press beneath the shoulder of the nylon distance-piece and press the rotor shaft from the bearing. Alternatively, use a suitably-sized claw-type bearing extractor tool (position claws behind the shoulder of the nylon distance-piece) and pull the bearing from the shaft. **NOTE: When refitting the bearing, ensure the shielded side of the bearing faces the slip-ring moulding.**

After removing the bearing retaining circlip and plate, the drive-end bearing can either be pressed or carefully tapped from the bracket with a suitably-sized mandrel inserted in the outer-face aperture of the bearing housing. **NOTE: When refitting the bearing, ensure correct sequence of assembly of sundry parts associated with the bearing.** (See Figs. 8a to e, Alternator dismantled).

Lubrication of bearings

During major overhaul of the alternator, providing the bearings have been checked and found not to be excessively worn, 'standard-type' bearings (see Fig. 12a) can be serviced by re-packing with Shell Alvania 'RA' grease lubricant, or equivalent.

To re-pack the slip-ring end bearing with grease it will be necessary to gain access to the unshielded (open) side of the bearing, by removing first the slip-ring moulding and then the bearing from the rotor shaft (slip-ring moulding removal is dealt with in the paragraph prior to the heading 'Bearings' and bearing removal is dealt with under the heading 'Renewing the bearings').

Note: Heavy-duty alternators are fitted with fully-sealed bearings (see Fig. 12b). This type of bearing cannot be serviced by re-packing with grease but providing the bearing is not worn to the extent of allowing perceptible side movement of the rotor shaft, and providing also the bearing rotates smoothly, it should be allowed to continue in use, (except when the alternator has been dismantled for the purpose of fully-reconditioning it for a further period of long service, in which case it is then advisable to renew the bearings).

A fully-sealed bearing should not be confused with a 'standard-type' shielded bearing fitted to the slip-ring end of alternators of standard specification. A standard-type shielded bearing incorporates a metal shield in one side of the bearing only (facing slip-ring moulding), whereas a fully-sealed bearing incorporates a plastic shield in both sides of the bearing.

(d) Reassembly

Reassembly of the alternator is simply a reversal of the dismantling procedure.

However, it should be noted that the sub-assembly comprising rotor and drive-end bracket, stator assembly and slip-ring end bracket (secured by three through bolts) can be incorrectly assembled in two of three alternative ways which causes mis-alignment of the alternator fixing lugs of each end bracket.

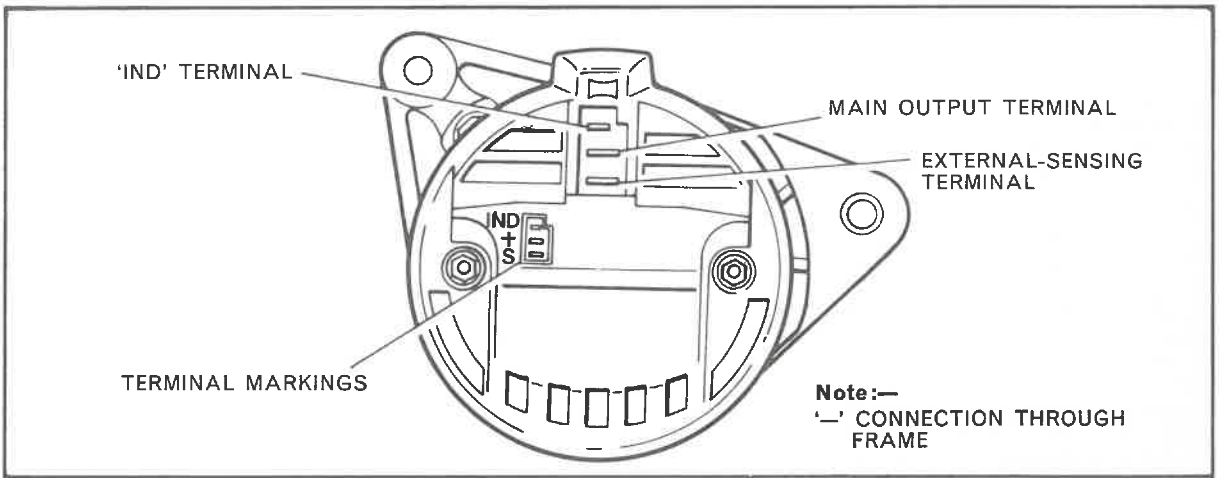
Assuming the rotor assembly to be already fitted in the drive-end bracket, mis-alignment of the end brackets previously referred to can be avoided by first fitting the stator assembly correctly in the drive-end bracket. (In preference to first fitting the stator assembly in the slip-ring end bracket).

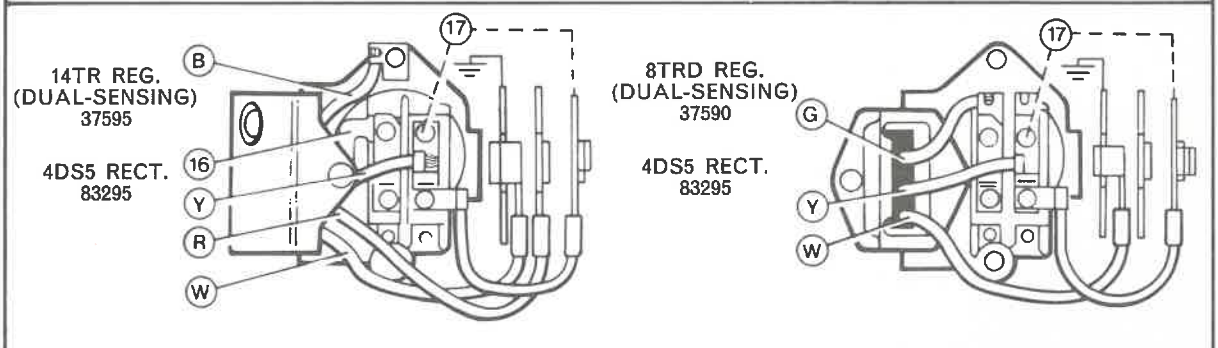
Fit the stator assembly in the drive-end bracket so that the stator connecting leads are positioned between and in line with the alternator fixing lugs, then assemble the slip-ring end bracket to the stator laminations and finally secure into a sub-assembly by fitting the through bolts.

Avoid overtightening the through bolts, the maximum tightening torque is 55 lbf in (6·215 Nm).

ALTERNATOR MODELS 16ACR & 17ACR, EXTERNAL-SENSED, AND B.S.E. TERMINATIONS

(INCORPORATING DUAL-SENSING 'FAIL-SAFE' FEATURE)

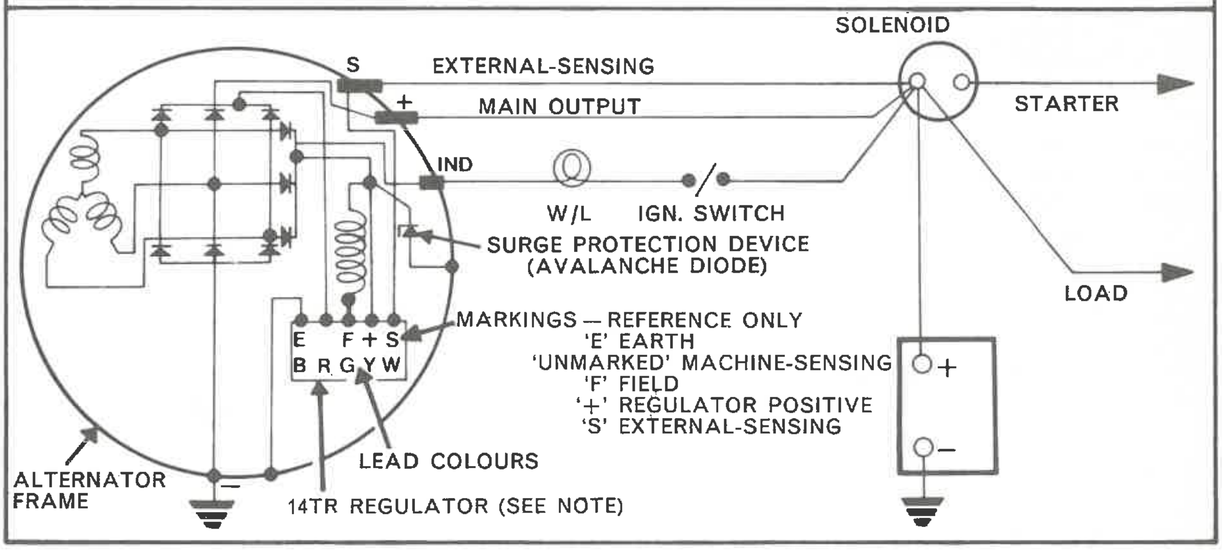




WIRING COLOUR CODE: B — BLACK Y — YELLOW W — WHITE G — GREEN R — RED

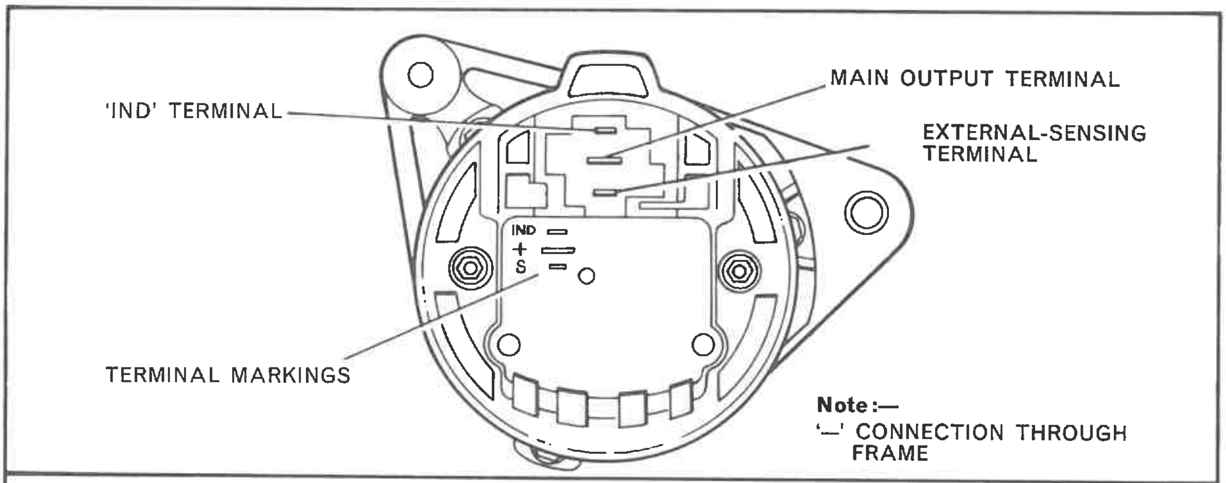
16 — METAL CONNECTOR LINK ('F' TERMINAL)

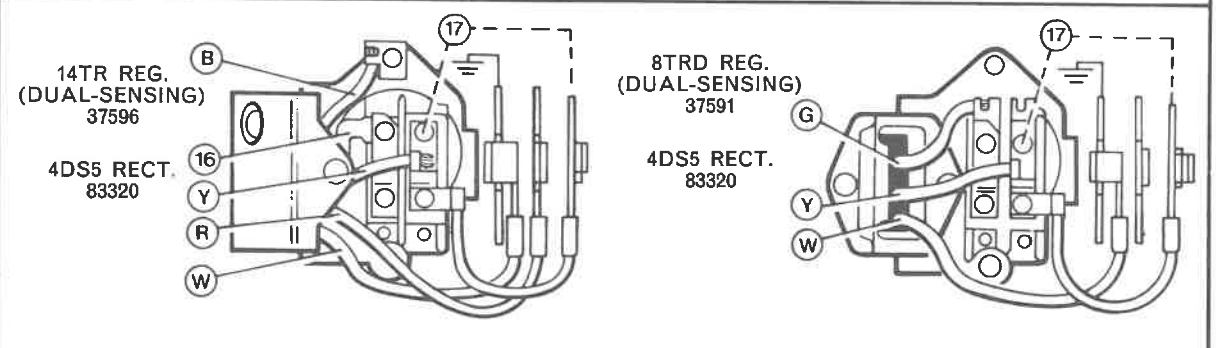
17 — ALTERNATIVE CONNECTIONS FOR SURGE PROTECTION DEVICE



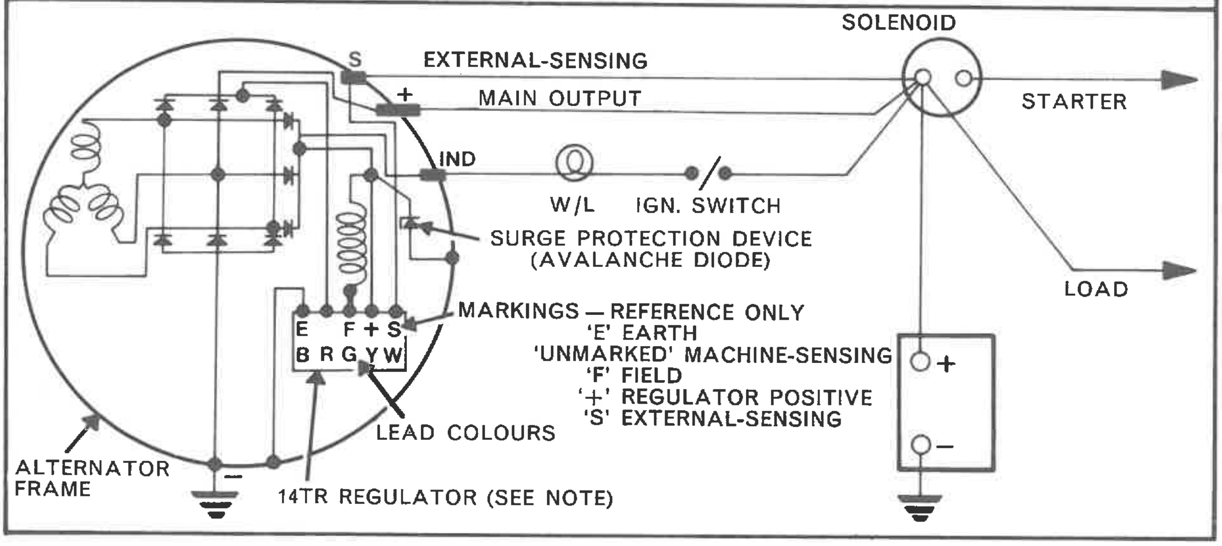
Note: If an 8TRD regulator is fitted:— earth lead 'E' will be a connection via the regulator case, machine-sensing lead 'unmarked' will not apply (its function being catered for in the regulator design), and field connector link 'F' will be a green lead.

ALTERNATOR MODEL 18ACR, EXTERNAL-SENSED, AND B.S.H. TERMINATIONS
(INCORPORATING DUAL-SENSING 'FAIL-SAFE' FEATURE)





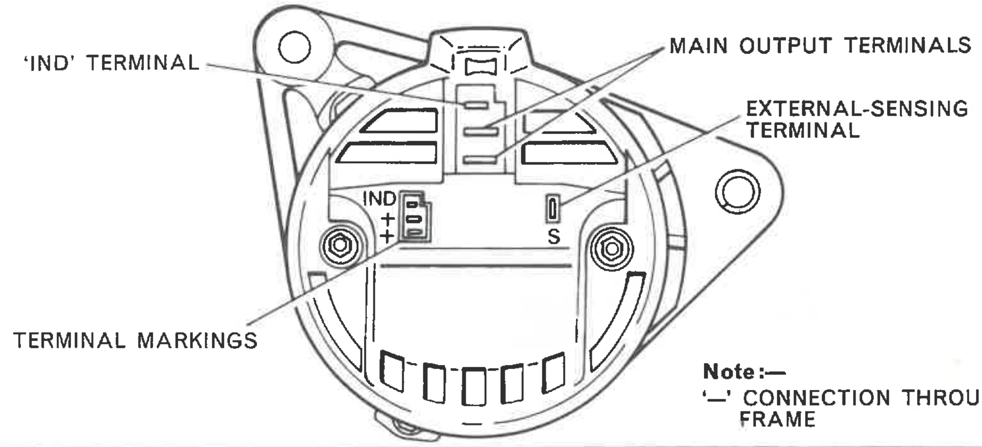
WIRING COLOUR CODE: B — BLACK Y — YELLOW W — WHITE G — GREEN R — RED
16 — METAL CONNECTOR LINK ('F' TERMINAL)
17 — ALTERNATIVE CONNECTIONS FOR SURGE PROTECTION DEVICE



Note: If an 8TRD regulator is fitted:— earth lead 'E' will be a connection via the regulator case, machine-sensing lead 'unmarked' will not apply (its function being catered for in the regulator design), and field connector link 'F' will be a green lead.

ALTERNATOR MODEL 18ACR, EXTERNAL-SENSED, EUROPEAN TERMINATIONS AND ADDITIONAL 'S' TERMINAL

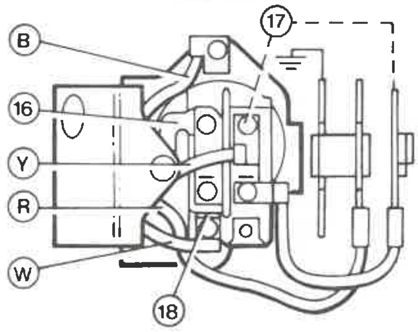
(INCORPORATING DUAL-SENSING 'FAIL-SAFE' FEATURE)



Note:—
'—' CONNECTION THROUGH FRAME

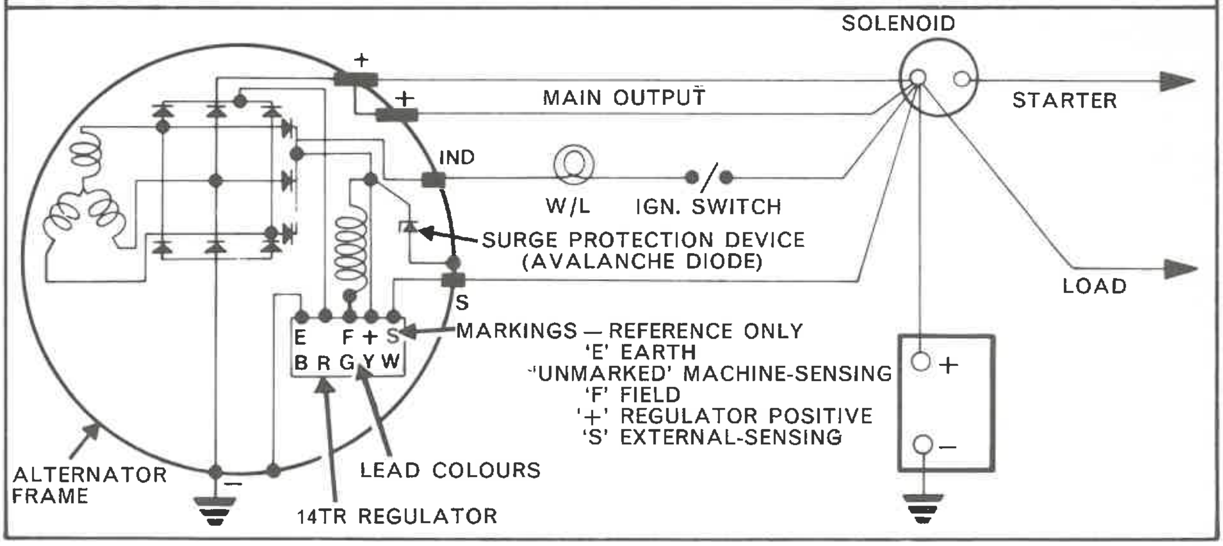
14TR REG.
(DUAL-SENSING)
37582

4DS5 RECT.
83166

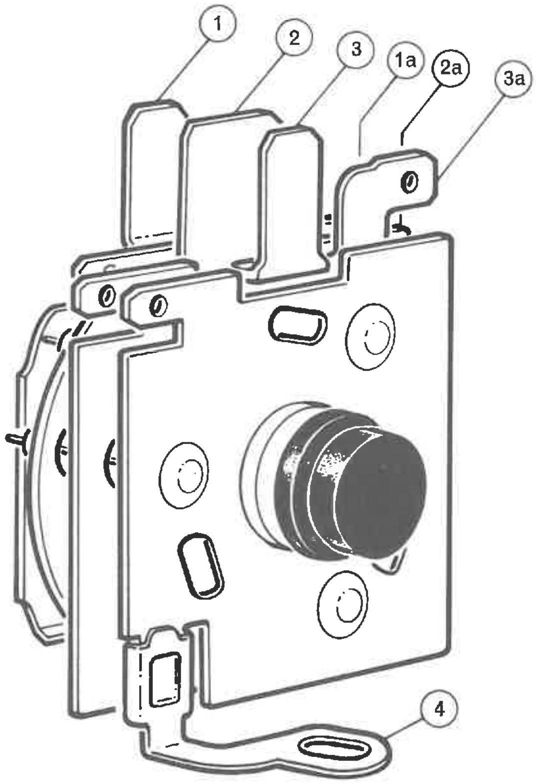


WIRING COLOUR CODE: B — BLACK Y — YELLOW W — WHITE G — GREEN R — RED

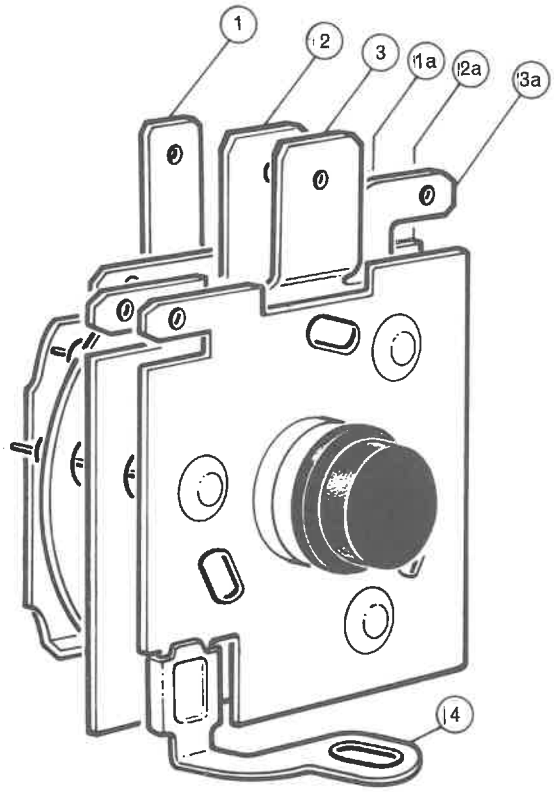
16 — METAL CONNECTOR LINK ('F' TERMINAL)
17 — ALTERNATIVE CONNECTIONS FOR SURGE PROTECTION DEVICE
18 — LUCAR 'S' TERMINAL



MODEL 4DS5 RECTIFIERS
(ALTERNATOR MODELS 16ACR, 17ACR & 18ACR, EXTERNAL-SENSED)



PT. No. 83320
(B.S.H. TERMINATIONS)
18ACR



PT. No. 83295
(B.S.E. TERMINATIONS)
16ACR & 17ACR

Note: PT. No. 83166 (EUROPEAN TERMINATIONS), AS FIG. 10, PAGE 7, MAIN ISSUE. APPLICABLE TO 18ACR WITH ADDITIONAL 'S' TERMINAL.

1. Field Terminal 'IND'
(a) Associated rectifier plate take-off terminal (internal connections to brushbox and regulator '+', via orange and yellow leads, respectively).

2. Main Output Terminal '+'
(a) Associated rectifier plate take-off terminal (internal connection for positive plate machine-sensing, regulator 'unmarked connection' red lead). Reference dual-sensing 'fail-safe' feature.

3. External-Sensing Terminal 'S'
(a) Associated rectifier plate take-off terminal (internal connection for external-sensing, regulator 'S' connection white lead).

4. Rectifier Earth Connection

12-VOLT DYNAMOS

(Models C39PV, C39P, C40, C40/1, C40A, C40L, C40LA, C40T, C42, C45PV, C45P, C47 and C48)

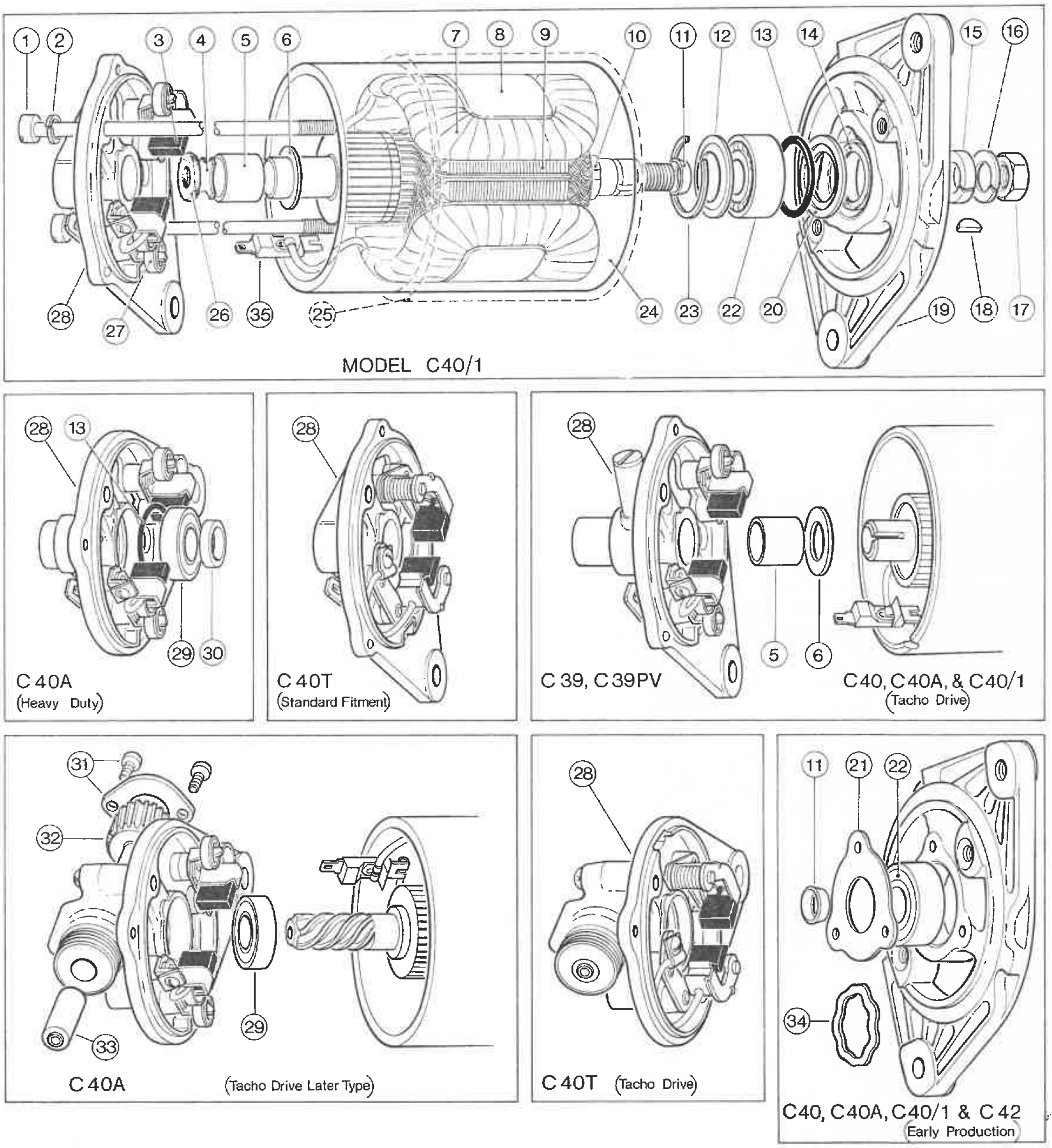


Fig. 1 Typical generator dismantled (showing alternative fittings)

1 Through bolts
2 Spring washer
3 Carbon brushes
4 Felt-oiler retainer
5 Bearing bush
6 Thrust washer
7 Field coils
8 Pole shoes
9 Armature
10 Bearing collar
11 Bearing collar thrust cup
12 Retaining plate
13 O'ring seal
14 Felt ring
15 Pulley spacer
16 Spring washer
17 Pulley fixing nut
18 Woodruffe key (pulley fixing)
19 Bracket, drive-end
20 Felt ring retainer
21 Bearing plate
22 Bearing, drive-end
23 Circlip, bearing retaining
24 Yoke, non-stepped
25 Yoke, stepped
26 Felt oiler
27 Brush springs
28 Bracket, commutator-end
29 Ball bearing (heavy duty)
30 Distance collar
31 Plate and screws
32 Worm wheel
33 Porous bronze bush
34 Corrugated washer
35 Field terminal

12-Volt Dynamos

(Models C39PV, C39P, C40, C40/1, C40A, C40L, C40LA, C40T, C42, C45PV, C45P, C47 and C48)

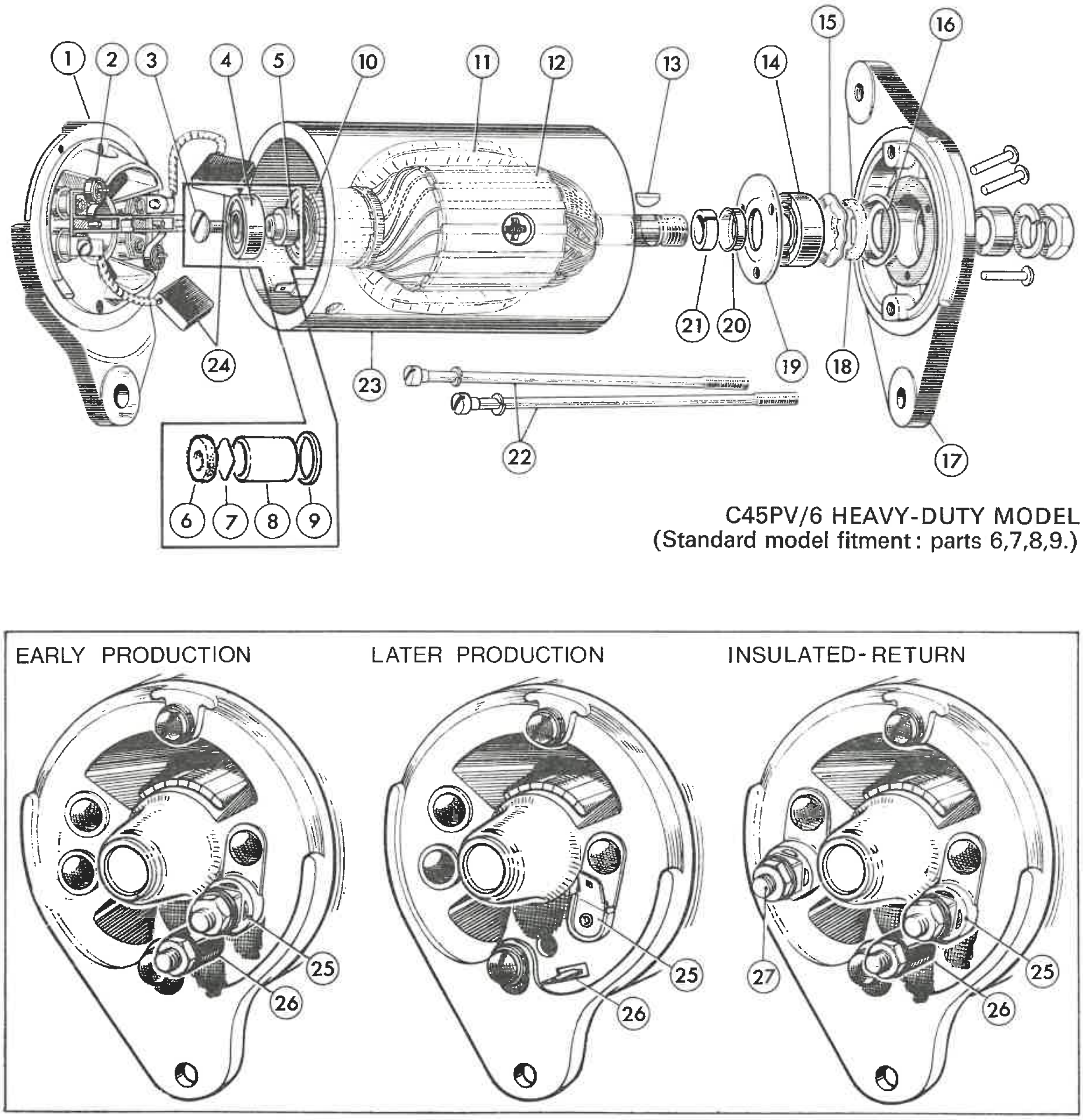


Fig. 2 Dynamo Model C45PV/6

1 Bracket assembly, commutator-end
2 Brush springs
3 Bearing retaining screw
4 C.E. bearing
5 Bearing collar
6 Felt-oiler
7 Felt-oiler retainer
8 Bearing bush
9 Thrust washer
10 Commutator
11 Field coils
12 Armature
13 Woodruffe key
14 Bearing, drive-end
15 Corrugated washer
16 Retaining cup
17 Bracket, drive-end
18 Felt ring
19 Bearing retaining plate
20 Bearing collar thrust cup
21 Bearing collar
22 Through bolts
23 Yoke
24 Carbon brushes
25 Main output terminal 'D'
26 Field terminal 'F' (small)
27 Insulated-return terminal

12-Volt Dynamos

(Models C39PV, C39P, C40, C40/1, C40A, C40L, C40LA, C40T, C42, C45PV, C45P, C47 and C48)

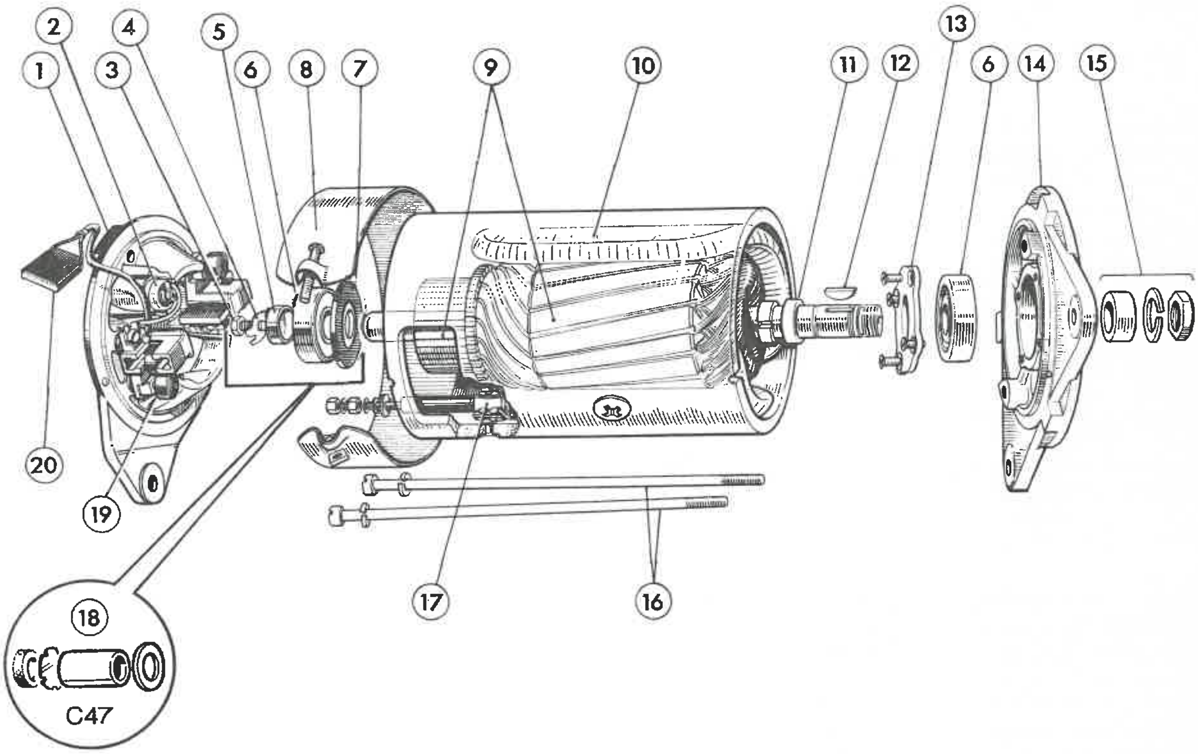


Fig. 3 Heavy-duty dynamos, Models C47 and C48

1 Bracket assembly, commutator-end
2 Radio suppression capacitor
3 Bearing retaining screw
4 Locking plate
5 Locking cup
6 Ball bearing(s)
7 Thrust washer
8 Bandcover, fixing screw and nut
9 Commutator/armature
10 Field coils
11 Bearing spacing collar
12 Woodruffe key (pulley fixing)
13 Bearing retaining plate with screws
14 Bracket, drive-end
15 Spacing collar, spring washer and nut (pulley fixing)
16 Through bolts
17 Field coil terminal
18 Felt-oiler, retainer, bush and thrust washer
19 Springs
20 Brushes

1. GENERAL

These dynamos are two-pole two-brush machines and the field circuit is shunt-connected and controlled by a separate control box.

Two types of control boxes are used in conjunction with these dynamos:

(i) Compensated Voltage Control. (See PART B, SECTION 4).

(ii) Current Voltage Control. (See PART B, SECTION 5).

The use of either type of control box depends on the vehicle application and the electrical loading likely to be imposed on the dynamo and battery. Current Voltage Control is superior to Compensated Voltage Control.

Model Interpretation

Prefix C: Concentrically mounted armature.
39: 3.9 in. dia. yoke
40: 4.0 ,, ,, ,,
42: 4.2 ,, ,, ,,
45: 4.5 ,, ,, ,,
47: 4.7 ,, ,, ,,
48: 4.8 ,, ,, ,,

Suffix P : Two-pole field.
,, PV : Two-pole field and ventilated end brackets.
,, A : Non-ventilated end brackets.
,, L : Long yoke.
,, LA : Long yoke and non-ventilated end brackets.
,, T : Trigger-type brushgear.
,, /1 : Extruded (non-welded) stepped yoke.

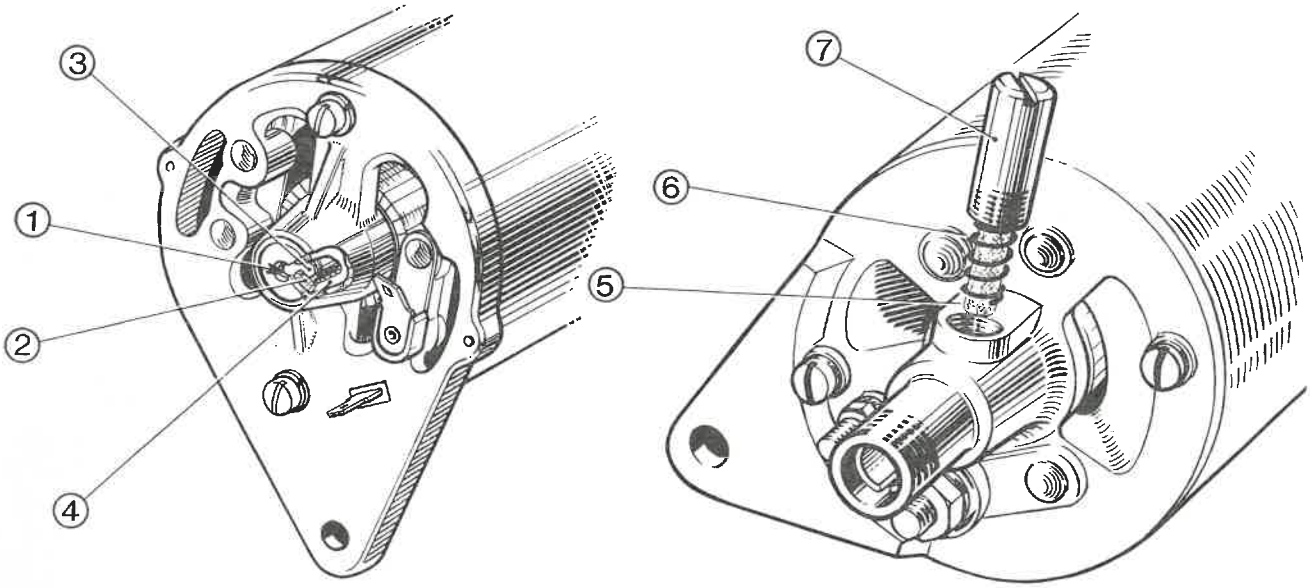
2. ROUTINE MAINTENANCE

(a) Driving Belt Adjustment

Occasionally check the general condition and tightness of the fan belt. If the dynamo driving pulley can be made to slip when turned by hand, the belt needs adjusting. Adjust the tension of the belt by first slackening the dynamo fixing bolts and strap, then swivel the dynamo to obtain approximately $\frac{5}{8}''$ (0.62″ or 16 mm) movement of the belt when pressed with the thumb at the longest point between pulleys.

(b) Lubrication

In the majority of cases, the armature shaft bearings comprise a ball bearing at the drive-end and a bearing bush at the commutator-end. Other generators (tachometer and heavy-duty applications) incorporate a ball bearing at the commutator-end as well as at the drive-end.



(a) (b)

Fig. 4 Lubricator in commutator-end bracket

1 Oil injection hole
2 Felt-oiler
3 Felt-oiler retainer
4 Bearing bush
5 Felt pad
6 Spring
7 Lubricator cap

No routine lubrication of ball bearings is necessary, since these are packed with sufficient grease to provide adequate lubrication of the bearing until major overhaul of the dynamo becomes necessary.

In the case of the commutator-end, a bearing bush is incorporated which needs routine lubrication every 6 months or, alternatively, 6,000 miles cars and light commercial vehicles and 700 running hours tractors and industrial engine applications. Use a force-feed oil can and inject clean engine oil sparingly in the small hole marked 'OIL' incorporated in the end-face of the bearing bush housing of the commutator-end bracket (see Fig. 4a). Alternatively, when a screw-type lubricator is incorporated (see Fig. 4b), unscrew the lubricator assembly from the bracket, remove the felt pad and spring from the lubricator cap, half fill the lubricator cap with high melting point grease and, after replacing the felt pad and spring, refit the lubricator assembly to the bracket.

(c) Inspection of Brushgear and Commutator

To avoid unnecessary failure of the dynamo due to normal wearing of the brushes, the brushgear and commutator should be inspected every 2 years or, alternatively every 24,000 miles cars and light commercial vehicles and 2,800 running hours tractors and industrial engine applications. (Servicing the brushgear and commutator is dealt with in 4c, paras. i, ii and iii. Recommended procedure for engaging the brushes on the commutator, when re-fitting the commutator-end bracket, is dealt with in 5c Reassembly.)

3. TEST DATA (Ambient temperature 20°C, 68°F)

Model	Nominal Voltage	Cut-in Speed (r.p.m.) (max.)	At Dynamo (volts)	Max. Cont. Output (amps)	At r.p.m. (max.)	At Dynamo (volts)	Field Resistance (ohms)
C39PV	12	1200	13	17	2100	13.5	6.1
C39PV/2	12	1200	13	19	2150	13.5	6.1
C39P and C39P/2	12	1200	13	11	1700	13.5	6.1
C40 and C40/1	12	1525	13	22	2335	13.5	6.0
★ C40A — 22755, 22757, 22772	12	1525	13	11	2000	13.5	6.0
★ C40A — others	12	1100	13	11	1700	13.5	6.0
C40L	12	1350	13	25	2275	13.5	5.8
C40LA	12	1320	13	13	1740	13.5	5.9
C40T — 22762, 22769	12	1100	13	18	2050	13.5	6.0
C40T — others	12	1525	13	22	2400	13.5	6.0
C42 — 22900	12	1360	13	30	2330	13.5	5.25
C42 — 22901	12	1750	13	35	2750	13.5	4.5
C45PV/4	12	1050	13	20	1700	13.5	6.0
C45PV/5	12	1250	13	22	1900	13.5	6.0
C45PV/6	12	1300	13	25	2050	13.5	5.3
C45P/4	12	1050	13	13	1350	13.5	6.0
C45P/5	12	1250	13	13	1650	13.5	6.0
C45P/6	12	1300	13	13	2050	13.5	5.3
C47	12	1050	13	30	1750	13.5	5.9
C48	12	850	13	35	1650	13.5	3.0

4. SERVICING

If a fault develops in the charging system, before removing the dynamo from the vehicle, check whether the dynamo is the cause of the fault.

(a) Testing the Dynamo in Situ

A moving-coil voltmeter (0–20V range) and a moving-coil ammeter (0–5A range) are required in the following tests.

(i) Disconnect 'D' and 'F' cables at the control box.

(ii) Connect voltmeter between 'D' cable and earth (in the case of insulated-return vehicles, connect earth side of voltmeter to control box terminal 'E').

(iii) Run engine at approximately 1500 rev/min. **Voltmeter should read 1.5 – 3V.**

(iv) Connect ammeter between 'D' and 'F' cables, leaving voltmeter still connected.

★ *Amendment to previous issue*

(v) Run engine and slowly increase speed until voltmeter reads approximately 12V. **Ammeter should read 2 – 3A.**

If voltmeter and ammeter readings are unsatisfactory, repeat the tests at the dynamo terminals. (In the case of insulated-return, the voltmeter connection to control box terminal 'E' must be transferred to the dynamo insul-return terminal, which is separately positioned on the commutator-end bracket.) If satisfactory voltmeter and ammeter readings are now obtained, a fault exists in the wiring or connections. If the voltmeter and ammeter readings are still unsatisfactory, the dynamo must be removed from the vehicle for dismantling and inspection.

(b) Dismantling

(i) If the commutator-end bracket incorporates screw-type terminals, it will be necessary to remove sundry parts from the small field coil terminal 'F' but do not disturb the larger adjacent terminal 'D'.

(ii) Unscrew and withdraw the two through bolts.

Note: Model C42 dynamos have non-magnetic through bolts. Ensure replacement bolts are those specified for that machine.

(iii) Separate from the yoke: The commutator-end bracket and the sub-assembly comprising armature, drive-end bracket and the fan-and-pulley. Take care of the thrust washer (when fitted) on the commutator-end of the armature shaft.

Note: In the case of insulated-return dynamos, one end of the field coils must be disconnected from one of the brushboxes, or brush arms, before the commutator-end bracket can be detached from the yoke.

Do not at this stage unnecessarily dismantle the sub-assembly comprising armature, drive-end bracket and the fan-and-pulley, unless it is obvious that one of the parts needs renewing. If so, proceed as follows:—

Remove fan-and-pulley and then the woodruff key from the armature shaft. Separate the armature from the drive-end bracket. To do this, carefully support the bracket and then press the armature shaft from the inner race of the ball bearing, using a wheel-operated (or lever-operated) power press. If the bearing in the bracket needs renewing, refer (c) Bench Inspection, para. (v).

(c) Bench Inspection

(i) Check the Brushes

The brushes should be renewed when worn to approximately $\frac{5}{16}''$ (0.31″ or 8 mm) in length.

Note: In the case of brushes fitted to model C40T dynamos and later fitment brushes with twin-flexibles fitted to models C47 and C48 dynamos, measure the length of the brush from the shoulder and not the overall length.

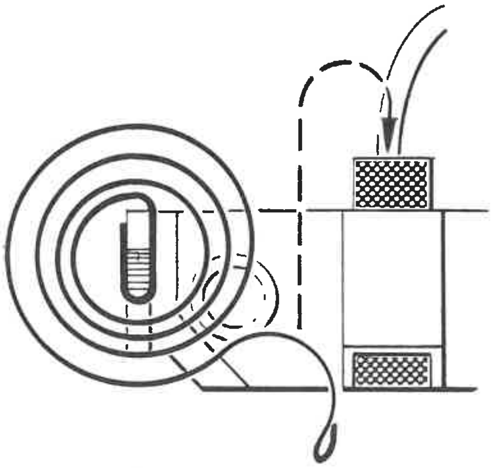
If it should be necessary to renew the brushes, use the correct brush set.

Check the brushes for freedom of movement. If brushes stick in the brushboxes, the brushes and brushboxes should be cleaned with a petrol-moistened cloth or brush. In the case of model C40T dynamos, with pivoted-arm type brushgear, after cleaning, apply clean engine oil sparingly (e.g. one or two drops) to the pivot of the brush arms.

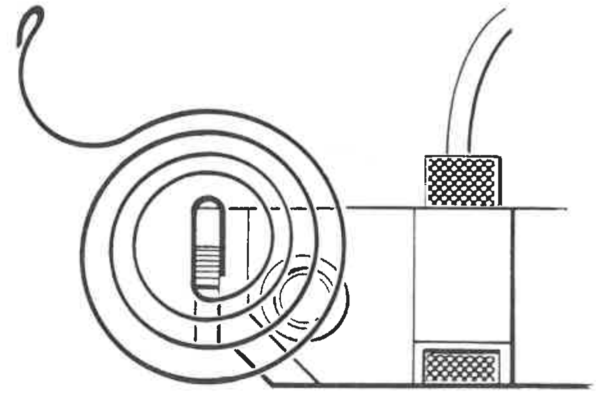
(ii) Brush Spring Pressure

Fit the commutator-end bracket assembly to the armature, with the brushes (not less than the renewable length) contacting the armature in the simulated working position, then with a pull-type spring gauge, check the spring pressure.

Note: Ensure the brush springs are correctly fitted (see Fig. 5). Incorrect fitting causes excessive spring pressure, resulting in premature brush wear and damage to the commutator.



CORRECT



INCORRECT

Fig. 5 Correct fitting of brush spring, in free position on post

Dynamo Model	*Brush Spring Pressure*	
C39 (Types PV and P)	25–15 ozf (7.0–4.0 N)	New brush varying to fully-worn brush
C40 (All types except C40T)	30–13 ozf (8.5–3.5 N)	,,
C40T	24–20 ozf (6.5–5.5 N)	,,
C42	33–16 ozf (9.0–4.5 N)	,,
C45 (Types PV and P)	44–30 ozf (12.0–8.5 N)	,,
C47 and C48	25–15 ozf (7.0–4.0 N)	,,

(iii) Armature

First, inspect the armature for obvious signs of a fault.

If the armature has markings indicating that it has fouled the pole shoes, first check that the pole shoes are tight in the yoke and, if so, suspect excessively worn bearings. (Renewing the bearings is dealt with in para. v.)

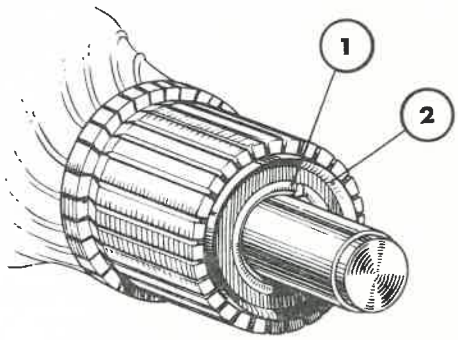
If the armature shows signs of 'thrown' solder, or lifted conductors, the armature should be renewed. (In this case the cause of armature failure should be investigated. When the dynamo has been re-fitted to the vehicle, the charging circuit wiring should be checked to ensure that it is correctly connected and the control box should also be checked for satisfactory operation as detailed in PART B, SECTION 4 or 5, of this manual.)

If the working surface of the commutator is in good condition but needs cleaning, use a petrol-moistened cloth. If necessary, rectify slight imperfections with very fine glass paper, prior to wiping the commutator clean with the petrol-moistened cloth. If the commutator is excessively worn, pitted or burnt, it will need skimming in a lathe. (Before skimming the commutator, refer 'Note.)

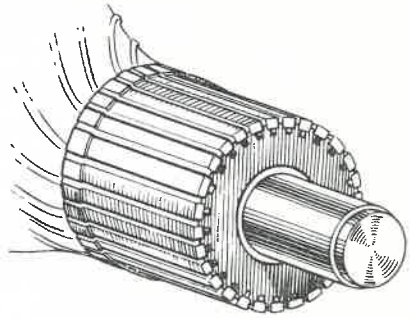
Note: (1) If the dynamo has been dismantled for inspection to determine and rectify an electrical fault, before skimming the commutator, check whether the armature requires renewing. (See later para. 'Checking the armature insulation and windings'.)

Note: (2) If the dynamo is model C40, C40/1, C40A, C40L or C40T, inspect the armature at the commutator-end and determine whether the commutator is a 'fabricated' or 'moulded' type (see Fig. 6).

Fabricated commutators: Can be skimmed providing the thickness of copper is not reduced to less than $\frac{1}{16}''$ (0.06″ or 1.5 mm). After skimming the commutator, the insulation between the segments must be undercut (see Fig. 7) to a depth of $\frac{1}{32}''$ (0.03″ or 0.80 mm) approx.



Fabricated Commutator



Moulded Commutator

Fig. 6 Identification of fabricated and moulded commutators
1 Metal roll-over 2 Insulating cone

After undercutting the commutator, rotate the armature again in the lathe and polish the surface of the commutator with very fine glass paper. Finally, use a compressed air line to clean the commutator, or wipe clean with a cloth.

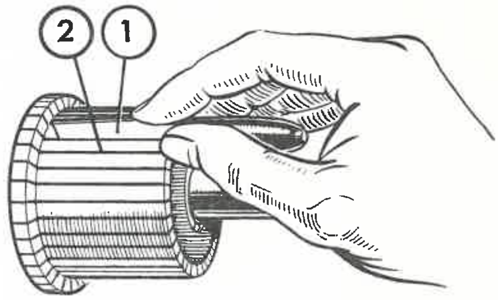


Fig. 7 Undercutting the commutator
1 Portion of standard size (12″) hacksaw blade (approx. 7″ long with both sides of teeth ground to thickness of commutator slots).
2 Slot depth $\frac{1}{32}''$ (.03″ or .80 mm) approx.

Moulded commutators: Can be skimmed providing this does not result in the diameter being reduced to less than $1\frac{29}{64}''$ (1.45″ or 37 mm). It is not necessary to undercut the commutator. During manufacture of the armature, sufficient undercut is provided to last the maximum number of skimming operations on the commutator, or to last the expected service life of the armature. After skimming the commutator, remove copper swarf from between segments and then polish and clean the commutator as described for the fabricated type.

Check the armature insulation and windings: Check the armature insulation by connecting a 110-volt a.c. 15-watt test lamp between one of the commutator segments and the shaft. **The lamp should not light.** If the lamp lights, the armature must be renewed.

Check continuity and resistance of the armature windings, by connecting a good quality battery-operated ohmmeter alternately between adjacent commutator segments. **The ohmmeter should register the same resistance in every case.** If the ohmmeter does not register a reading (no continuity), or the ohmmeter registers either a full-scale needle deflection or a variation in resistance readings (short-circuited windings), the armature must be renewed.

Note: Interwinding short-circuits can sometimes only be detected with specialised armature testing 'Growler' equipment. If this equipment is not available, and all other components are eliminated as the cause of dynamo failure, check the armature by substitution.

(iv) Field Coils

Inspect the inside of the yoke for obvious signs of a fault. Check the tightness of the pole shoes and closely inspect the field coils. Inspect continuity of the interconnecting wire between the field coils, and check the field coil insulation. If the interconnecting wire is bare, an insulation piece should either be folded over the wire or positioned between the wire and the yoke to provide extra protection against the possibility of short circuits. If the protective covering of the field coil windings is discoloured or damaged due to overheating or burning, the field coil assembly should be renewed without the need for testing. Although there may not be any visible sign of a field coil fault, the field coils should be tested in situ, as follows:–

Checking the field coils of earth-return dynamos: Field coil continuity resistance and insulation can be checked simultaneously, by connecting a good quality ohmmeter between the field coil terminal and a clean and unpainted part of the yoke. **The ohmmeter should register the field coil resistance given in '3. Test Data'.**

Note: Alternative to using an ohmmeter, connect a 12V battery and a moving-coil ammeter (e.g. 0–5A range, or 0–10A range in the case of a C48 dynamo) in series with the field coil terminal and the yoke. **The ammeter should read approximately, 2A for C39, C40, C47 and C45 range of dynamos (excepting C45P/6 and C45PV/6), 2.5A for C42, C45P/6 and C45PV/6 dynamos and 4A for a C48 dynamo.**

If the ohmmeter or ammeter does not register a reading, or either a low resistance or high current reading is obtained, renew the field coils.

If either a high resistance or low current reading is obtained, check the terminal assembly riveted to the yoke.

Checking the field coils of insulated-return dynamos: Carry out two separate tests, with the field coils in situ as, follows:—

Test 1. Check field coil continuity and resistance, by connecting the ohmmeter between the main field coil terminal and the insulated-return terminal eyelet on the other end of the windings. **The ohmmeter should register the field coil resistance given in '3. Test Data'.** Providing the test is satisfactory, proceed to test 2, otherwise renew the field coils.

Test 2. Check the insulation between field coils and yoke, by connecting a 110V a.c. 15-watt test lamp between either of the field coil terminal connections and the yoke. **The lamp should not light.** If the lamp lights, renew the field coils.

Renewing the field coils: Using a suitably-sized drill, remove the riveted end of the rivet securing the field coil terminal to the yoke. Next, tap the rivet out of the yoke with a pin-punch or, alternatively, prise the terminal assembly away from the yoke with the blade of a medium-sized screwdriver.

With a power-operated screwdriver, remove the pole shoe fixing screws and then withdraw the field coil assembly from the yoke.

Before discarding the faulty field coils, clean and transfer the pole shoes to the new part. Also, if the faulty field coils incorporate a screw-type terminal, the terminal and a terminal eyelet in the case of insulated-return will need to be transferred to the service replacement field coils (see 'Note').

Note: Prior to unsoldering and transferring the terminal fitting(s) from the faulty field coils to the new part, note the arrangement and colour of the leads soldered to the appropriate eyelets. This eliminates the possibility of soldering the leads of the new field coils to the wrong terminal eyelets, causing the normal rotation of the dynamo to be reversed and making the dynamo unsuitable for the vehicle application for which it was intended.

Fitting the new field coils in the yoke is facilitated, if pole shoe expanding equipment is available to press the pole shoes tight to the yoke while the pole shoe screws are tightened to a torque of 30 lbf.ft. (40.70 Nm). Ensure the interconnecting link insulation piece is correctly positioned before tightening the pole-shoe screws. (See Fig. 8). Finally, rivet the field coil terminal to the yoke.

(v) Bearings

If the armature shows signs of having fouled the pole shoes, the bearings must be renewed. This is likely to occur when the bearings become worn and allow excessive side movement of the armature shaft. If there is no visible indication of worn bearings, each bearing should be checked separately with the bracket-and-bearing assembled to the armature shaft. Grasp the armature in one hand and each bracket in turn in the other hand and if there is appreciable side movement of the armature shaft, the bearing should be renewed. In the case of a ball bearing, extend the testing by grasping each bracket in turn in the one hand, and spin the armature sharply with the palm of the other hand. If the armature rotates smoothly and without noise in a horizontal and vertical position, the bearing is satisfactory.

If the bearings are satisfactory, they should be re-lubricated before reassembly of the dynamo.

A bearing bush should be lubricated with clean engine oil (e.g. S.A.E. 30 grade).

A ball bearing should be re-packed with high-melting point grease unless the bearing is a shielded (heavy-duty) type, which cannot be re-lubricated in service, in which case the bearing will initially have been packed with sufficient grease to last the life of the bearing.

Renewing a bearing bush in the commutator-end bracket: If the bearing housing is open-ended, support the bracket around the bearing housing and press the worn bush out of the bracket with a suitably-sized mandrel used in conjunction with a wheel-operated (or lever-operated) press. Alternatively, if a hand-operated power press is not available, after carefully supporting the bracket around the bearing housing, use a hammer and tap the bush out of the bracket with a mandrel.

If the bearing housing has an enclosed end, the worn bush must be extracted from the bracket with a special tool or, alternatively, if a suitably-sized thread tap is screwed a few turns into the bush, the bush can then be extracted from the bracket with the thread tap. For C39 and C40 range of dynamos (all types), and also C42 dynamos, use a thread tap $\frac{5}{8}''$ (0.62″ or 15.9 mm). For C45 range of dynamos (all types), and also C47 dynamos, use a thread tap $\frac{11}{16}''$ (0.68″ or 17.4 mm). After removing the worn bush, remove the metal disc and felt-oiler from the bearing housing.

Note: A new felt-oiler should be soaked in clean engine oil before being put into service and it must be placed in the bearing housing prior to the metal disc which contacts the bearing.

A new bush must be soaked in clean engine oil for 24 hours at room temperature before being fitted. Alternatively, if the lubricant is heated to a temperature of 100°C, 2 hours immersion of the bush is sufficient providing the lubricant is allowed to cool before the bush is removed. The bush must not be reamed after fitting, otherwise the self-lubricating qualities will be impaired.

Carefully support the bracket around the bearing housing and press or drive the bush squarely into the bracket until the edge of the bush is level with the top of the bearing housing, using a shouldered highly-polished mandrel with the fitting pin diameter 0.002″ (0.05 mm) larger than the armature shaft which is to fit into the bearing.

Renewing the drive-end ball bearing, and the commutator-end ball bearing (when fitted).

Note: Service replacement ball bearings are packed with grease ready for use.

The ball bearing at the drive-end can be renewed after separating the bracket from the armature.

Support the bracket, and use a wheel-operated (or lever-operated) press to extract the armature shaft from the bearing.

Remove the rivets or screws securing the bearing retaining plate to the bracket or, in the case of a circlip-retained bearing, lever the circlip from its groove with the blade of a screwdriver. In the case of a bearing retaining plate secured by rivets, use a drill to remove the riveted end of the rivets and then either tap the rivets from the bracket or lever the bearing retaining plate from the bracket with the blade of a screwdriver.

Fit new bearing, taking care to fit associated parts of the bearing assembly in the correct sequence (see Figs. 1 and 2), and ensure circlip is fully located in the groove.

5. REASSEMBLY

Dynamo reassembly is facilitated by cradling the yoke in the jaws of a vice. This will ensure the dynamo being held sufficiently firm for the purpose of reassembly but will also enable the dynamo to be easily repositioned to facilitate certain operations during the various stages of reassembly.

Reassembling the dynamo is simply a reversal of the dismantling procedure. The following information is of special interest.

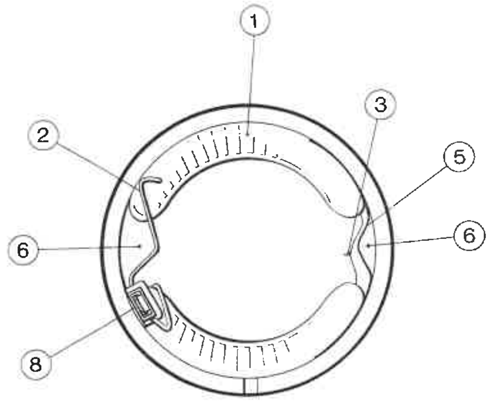
(a) Tightening Torques

Through bolts: 72 lbf.in. (8.13 Nm) max.
Driving pulley: 25 lbf.in. (2.82 Nm) max.

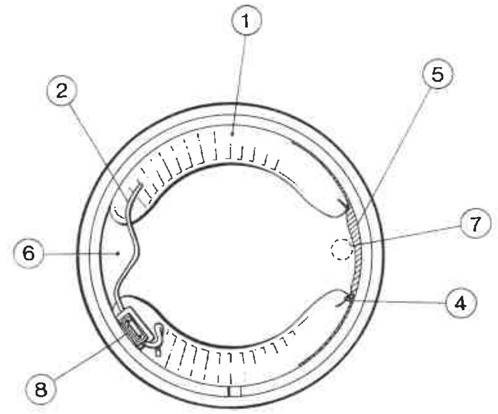
(b) Correct Positioning of the Through Bolts in Relation to the Field Coil Connections

When fitting the commutator-end bracket, carefully position the through bolts so as to avoid fouling the field coil connections. This is particularly important in the case of the through bolt which fits adjacent to the interconnecting link, which in some cases is a bare wire.

Before fitting the commutator-end bracket, inspect the inside of the yoke and check for satisfactory insulation and positioning of the field coil connections (see Fig. 8).



(a) Early type



(b) Later type

Fig. 8 Insulating and positioning of field coil connections

1 Field coils
2 Earth lead
3 Interconnecting link (centre joint)
4 Interconnecting link (offset joint)
5 Insulation piece (folded over wire, later type)
6 Through bolt entry point – ½" (0.5" or 12 mm)
7 Position of through bolt
8 Field ('F') terminal

The method of insulating and positioning the field coil interconnecting link may vary, according to the type of field coil assembly fitted, as follows:—

(i) If the interconnecting link is covered with insulated sleeving, it should be positioned the same as the field coil earth-lead (see Fig. 8, item 2).

(ii) If the interconnecting link is a bare wire, joined at the centre, position the interconnecting link and insulation piece as shown in Fig. 8 (a), items 3, 5 and 6.

(iii) If the interconnecting link is a bare wire, with an offset joint adjacent one of the field coils and an insulation-piece folded over the wire, position the interconnecting link and insulation-piece flat to the yoke as shown in Fig. 8 (b), items 5 and 4.

(c) Recommended Procedure for Engaging the Brushes on the Commutator

To fit the commutator-end bracket to a model C40T dynamo, engage the brushes on the commutator by manipulating the brushgear pivoted arms with the fingers inserted between the bracket and the edge of the yoke.

The majority of dynamos will have a commutator-end bracket incorporating the usual type of brushgear with brushboxes. In such cases, before the bracket can be fitted, it will be necessary to wedge the brushes in a fully lifted position in the brushboxes. The working surface of each brush should be positioned in turn level with the edge of the brushbox, the brush should then be wedged in this position by applying the brushspring pressure to the side of the brush (see Fig. 9).

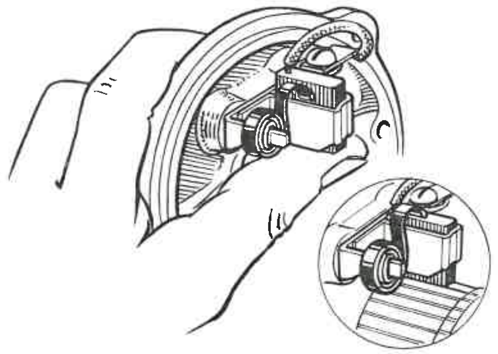


Fig. 9 Wedging the brushes with the brush springs, prior to fitting the commutator-end bracket

After the brushes have been wedged in the brushboxes, the bracket is prepared for fitting in accordance with one of the following paras. (i), (ii), (iii).

(i) Bandcover type dynamo with windows in the yoke

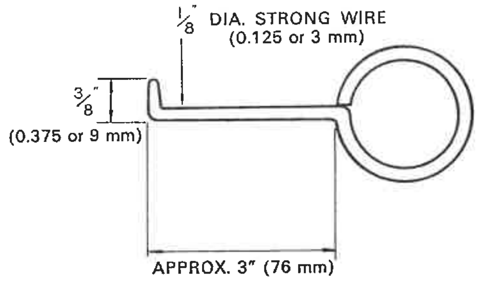


Fig. 10 Brush spring hooking tool

Assemble the commutator-end bracket on the armature shaft and secure the bracket with the through bolts. Next, insert a hook tool (see Fig. 10), through one of the appropriate windows in the yoke and release each brush in turn on the commutator, by hooking and transferring the brush spring from the side of the brush to its normal position on top of the brush (see Fig. 11).

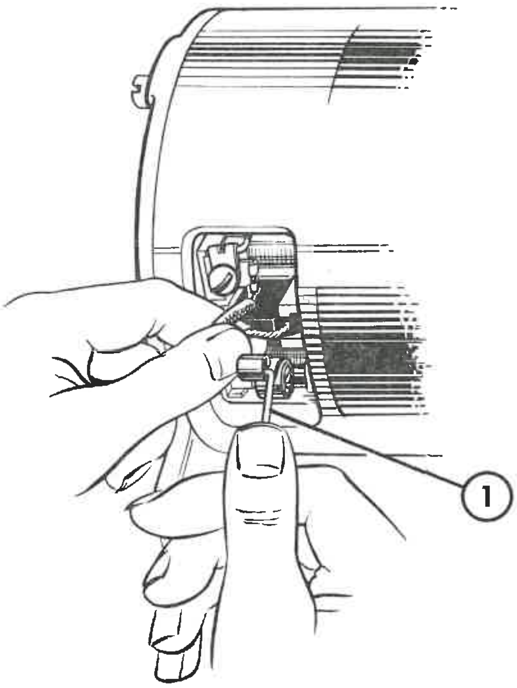


Fig. 11 Engaging the brushes on the commutator (Bandcover type dynamos)
1 Brush spring hooking tool (see Fig. 10)

(ii) Windowless-yoke type dynamos with ventilated end brackets

Assemble the commutator-end bracket on the armature shaft and secure the bracket with the

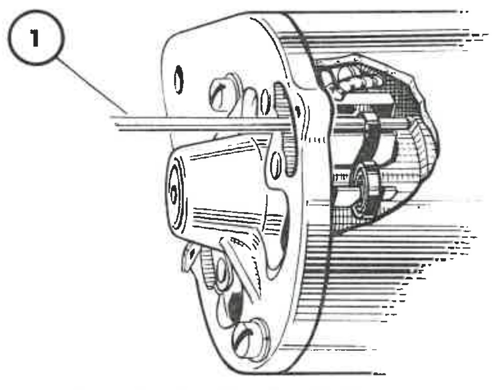


Fig. 12 Engaging the brushes on the commutator (windowless-yoke dynamo with ventilated end-brackets)
1 Steel rod – ⅛″ (.125″ or 3 mm dia.) approx.

through bolts. Next, use a six inch length of steel rod, approx. ⅛″ (0.125″ or 3 mm) diameter (a small electricians type screwdriver is suitable), and insert the end of the rod, or the shaft of the screwdriver, through one of the ventilating slots in the bracket (see Fig. 12). Release each brush in turn on the commutator, by transferring the brush spring from the side of the brush to its normal position on top of the brush.

(iii) Windowless-yoke type dynamos with non-ventilated end brackets

Assemble the commutator-end bracket on the armature shaft, with the field coil terminal partially engaged in the bracket and the brushboxes just overlapping the edge of the commutator. Next, insert a hook tool (see Fig. 10) between the bracket and the edge of the yoke and release each brush in turn onto the commutator, by hooking and transferring the brush spring from the side of the brush to its normal position on top of the brush.

(d) Testing the Dynamo Following Reassembly

Rotate the driving pulley by hand and check that the armature is free to rotate and does not foul the pole shoes.

(i) Preliminary test, dynamo functioning as a motor

Note: For the purpose of this test it is advisable to observe correct polarity when connecting the battery to the dynamo, otherwise it may be necessary to repolarise the dynamo to suit the polarity of the vehicle electrical system (see following para. iii).

Cradle the dynamo in the jaws of a vice.

Connect a test link between the two adjacent terminals 'D' and 'F' on the commutator-end bracket.

Using a 12V battery, connect one side of the battery to the dynamo frame (earth-return), or alternatively connect one side of the battery to the large individual terminal on the commutator-end bracket (insulated-return), and in both cases connect the other side of the battery to either the dynamo 'D' or 'F' terminals (terminals connected together with a test link). **The dynamo should function as a motor.**

(ii) Dynamo performance test

The dynamo performance should be checked with a calibrated resistance load (provided by a variable resistor connected across the dynamo) instead of a battery. Using a variable resistor (instead of a fixed value resistor) enables the circuit load to be adjusted to suit any particular type of dynamo.

A suitable circuit for testing earth-return dynamos is shown in Fig. 13, which comprises a moving-coil voltmeter (V) 0–20V range, a moving-

12-Volt Dynamos

(Models C39PV, C39P, C40, C40/1, C40A, C40L, C40LA, C40T, C42, C45PV, C45P, C47 and C48)

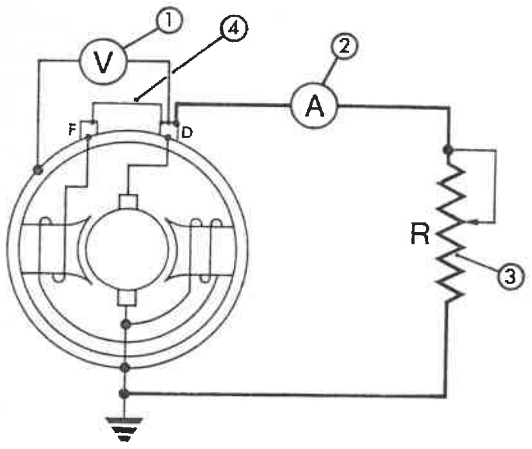


Fig. 13 Test circuit for checking the performance of earth-return dynamos

(For insulated-return refer text, section 5(d) para. ii)

1 Moving-coil voltmeter (0–20V range)
2 Moving-coil ammeter (0–50A range)
3 Variable resistor (500-watt)
4 Test link

coil ammeter (A) 0–50A range and a variable resistor (R) 500-watt, with the dynamo terminals 'D' and 'F' linked to provide full output.

In the case of insulated-return, the voltmeter connection to the yoke, and the variable resistor connection to the yoke-and-earth, should be connected instead to the insul-return terminal individually positioned on the commutator-end bracket.

The value of the load resistance can be calculated by dividing the maximum continuous output current figure of the dynamo (refer 3. TEST DATA) into 13.5.

Note: The connecting leads must be capable of carrying the maximum output current of the dynamo without overheating.

Dynamo testing speed and performance details are given in 3. TEST DATA.

Run the dynamo in the normal direction of rotation at a progressively increasing speed and when the voltmeter registers 13.0V, check the cutting-in speed (refer 3. TEST DATA, column 3).

Increase the dynamo speed and adjust the variable load resistor to give a voltmeter reading of 13.5V with the dynamo running at its maximum output speed (refer 3. TEST DATA, column 6), the maximum continuous rated output current of the dynamo should then be as detailed in 3. TEST DATA, column 5.

(iii) Repolarising the dynamo in situ

If the dynamo fails to function when fitted to the vehicle, it may require repolarising to suit the polarity of the vehicle electrical system.

To repolarise the dynamo in situ: Insulated-return dynamos, first check that the insul-return terminal on the dynamo commutator-end bracket is connected to the vehicle wiring, then repolarise the dynamo in the same way as for earth-return dynamos, as follows:—

Attach a suitable length of cable to the insulated terminal side of the battery (or main supply terminal of the battery in the case of insulated-return) and 'flick' the other end of the cable two or three times to the small 'F' (field) terminal of the dynamo.

OUTPUT CONTROL UNITS

INDEX

Section	Subject
1	General Information
2	Model 4TR
3	Model 6GC
4	Model RB 106/2 and RB 108
5	Model RB 340

Issue 3 July 1971
Supersedes Issue 2 October 1966

ALTERNATOR OUTPUT CONTROL MODEL 4TR

1. DESCRIPTION

Model 4TR is an electronic control unit. In effect its action is similar to that of the vibrating contact type of voltage control unit, but switching of the field circuit is achieved by transistors instead of vibrating contacts, while a Zener diode provides the voltage reference in place of the voltage coil and tension spring system. No cut-out is required since the diodes incorporated in the alternator prevent reverse currents from flowing. No current regulator is required as the inherent self-regulating properties of the alternator limit the output current to a safe value.

The control unit and the alternator field windings are isolated from the battery when the engine is stationary, usually either by a special double-pole ignition switch or by means of an isolating relay.

When a temperature compensation device is fitted this takes the form of a thermistor connected in parallel with one of the Zener-biasing resistors. The thermistor is a device whose resistance increases as the temperature falls and vice-versa. Any alteration in its ohmic value will cause the Zener diode to begin to conduct at a modified value of alternator output voltage, so matching the changes which take place in "on charge" battery terminal voltage due to temperature change.

WARNING: **The battery must never be disconnected while the alternator is running. Failure to observe this ruling will cause the control unit to be irreparably damaged.**

Care must be taken at all times to ensure that the battery, alternator and control unit are correctly connected. Reversed connexions will damage the semi-conductor devices employed in the alternator and control unit.

2. ROUTINE MAINTENANCE

The output control unit does not require any regular maintenance but the moulded cover, can be occasionally be wiped clean and a check made that the terminal connector is secure.

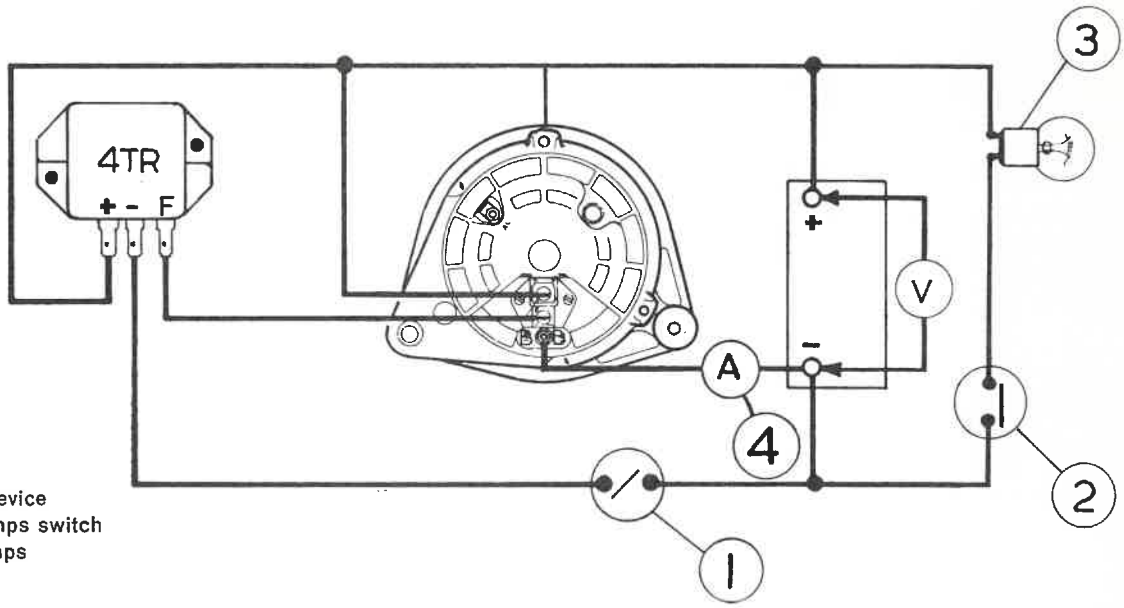
3. CHECKING AND ADJUSTING

Before checking and adjusting the control unit it must be established that the alternator and the charging circuit wiring are in good order (see PART A). Check also the battery-to-control unit wiring which incorporates the field isolating device. To ensure proper working of the control unit, the resistance of this complete circuit — including the isolating device — must not exceed 0.1 ohm. Any unduly high resistance must be traced and remedied.

Checking

Leave the existing connexions to the alternator and control unit undisturbed. Connect a voltmeter of 1% or better accuracy and appropriate range between the battery terminals and note the reading with all electrical equipment switched off. If available, use a voltmeter of the suppressed-zero type, reading 12–15 volts (12-volt installations) or 24–30 volts (24-volt installations).

Unless an ammeter is fitted to the vehicle, insert one, of suitable range, in series with the alternator main output cable.



1. Field isolating device
2. Side and tail lamps switch
3. Side and tail lamps
4. Ammeter

Fig. 1 4TR Control test circuit

Alternator Output Control Model 4TR

Switch on an electrical load of approximately 2 amperes, e.g. side and tail lighting. The test circuit is shown in Fig. 1.

Ascertain the Part Number of the control unit — this is marked on the upper edge of the moulded cover.

Start the engine and run the alternator at approximately 3,000 rev/min for at least eight minutes. (This will ensure that the system voltage has stabilised.) If the charging current is still greater than 10 amperes, continue to run the engine until this figure is reached. Now compare the voltmeter reading with the appropriate setting limits given in the following table.

Part No.	*Voltage Setting Limits*
*37423, *37449	13.9 – 14.3
37429	13.7 – 14.1
*37444, *37502	27.9 – 28.3

*Fitted with thermistor.

If the reading obtained is stable but outside the appropriate limits the unit can be adjusted to control at the correct voltage (see **'Adjusting'**).

If, however, the voltmeter reading remains unchanged (at open-circuit battery terminal voltage) or, conversely, increases in an uncontrolled manner, then the control unit is faulty and a replacement must be fitted. Component parts are not serviced individually.

Adjusting

Stop the engine and withdraw the control unit mounting screws. Invert the unit and carefully scrape away the sealing compound which conceals the potentiometer adjuster (see Fig. 2). Check that the voltmeter is still firmly connected between the battery terminals. Start the engine and, while running the alternator at 3,000 rev/min, turn the potentiometer adjuster slot — clockwise to increase the setting or anti-clockwise to decrease it — until the required setting is obtained. Use care in making this adjustment — a small amount of adjuster movement causes an appreciable difference in the voltage reading.

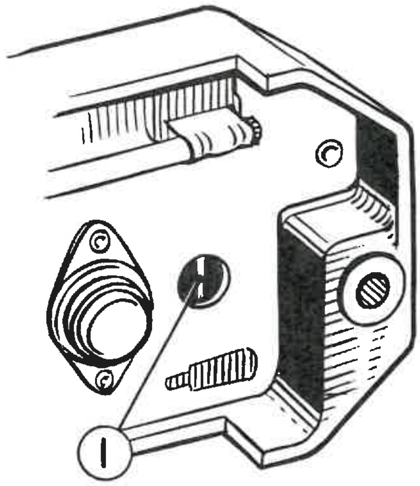


Fig. 2 4TR Control rear view
1 Potentiometer adjuster

Re-check the setting by first stopping the engine, then again starting and running the alternator at 3,000 rev/min.

Refit the control unit and disconnect the voltmeter.

IMPORTANT

Precaution to be observed when using a fast-charger

Before using a fast-charger, either to boost the battery or to start the engine, first withdraw the three-way connector from the control unit terminals. Do not re-connect the terminals until the charger has been disconnected and, in the case of assisted starting, the engine speed reduced to tick-over.

Failure to observe this precaution may result in irreparable damage of the semiconductors in the control unit.

Note: Originally, three separate connectors were used at the control unit. When disconnecting these, make sure that

(i) the disconnected ends do not contact either each other or any other part, and

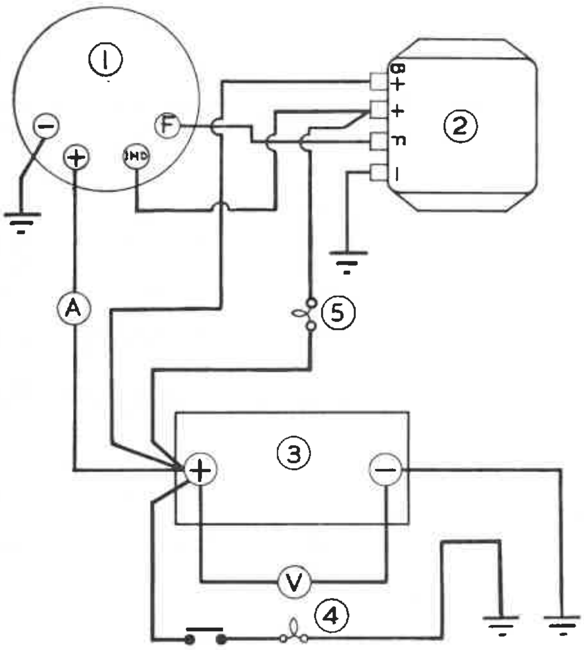
(ii) are correctly re-connected subsequently.

ALTERNATOR OUTPUT CONTROL MODEL 4TR

PART NO. 37527

1. DESCRIPTION

This addition to the range of 4TR output control units is designed for use with '9-diode' alternators, e.g. models 15AC and 16AC. The unit is similar to previous 4TR units, described earlier in this section, except that the thermistor is omitted and the unit is not adjustable. In addition, it carries a fourth terminal by means of which battery voltage is sensed directly from the battery connection at the starter solenoid. This avoids the necessity for an external relay or separate contacts on the ignition switch, and ensures more accurate sensing of battery voltage. The drain on the battery created by the permanent connection is negligible.



1 Alternator
2 Output control unit
3 12 V 9-plate battery
4 Side and tail lighting (if required)
5 Warning light

Fig. 1 4-terminal 4TR Control test circuit

2. CHECKING THE VOLTAGE SETTING

Before checking the voltage setting of the control unit it must be established that the alternator and the charging circuit wiring are in good order (see Part A). In particular the circuit resistance must not exceed 0.04 ohm between regulator '—' terminal and battery '—' terminal or 0.003 ohm between alternator '—' terminal and battery '—' terminal.

For the following test the vehicle battery must be in a well-charged condition, or temporarily replaced by a 9-plate battery that is well charged.

Leave the existing connections to the alternator and control unit undisturbed. Connect a voltmeter of 1% or better accuracy and appropriate range between the battery terminals. If available, use a voltmeter of the suppressed-zero type, reading 12–15 volts. Unless an ammeter is fitted to the vehicle, insert an ammeter of 0–40 range in series with the alternator main output (+) cable at its connection with the starter solenoid. Make the ammeter connections firmly so that, when at charging speed, there is no risk of disconnection taking place due to vibration. See 'PRECAUTIONS' in Section A-4.

Start the engine and run the alternator at approximately 5,000 rev/min until the ammeter shows an output current of 5 amperes. If, on starting the engine, the charging rate is already below this value, switch on a light external load, e.g. side and tail lamps. The test circuit is shown in Fig. 1.

The voltmeter should now give a reading of 14.3–14.7 volts. If the reading obtained is unstable or is outside these limits, the control unit is faulty and a replacement unit must be fitted.

The control unit is not adjustable and its component parts are not serviced individually.

OUTPUT CONTROL UNIT MODEL 6GC

1. GENERAL

Model 6GC Output Control Unit has now superseded model RB310 both for use as initial equipment with some C.A.V. generators and also as a replacement for Lucas and C.A.V. RB310 units already in service. Units are identified as 'Lucas' or 'C.A.V.' by their cover marking.

Internally, model 6GC retains the same regulator and cut-out assembly as RB310, but this assembly is mounted on an RB340 type baseplate.

An extension foot enables model 6GC to be used as a direct replacement for RB310. Terminals are normally of 'Lucar' pattern, although certain units supplied as service replacements have screw terminals for direct interchangeability.

2. TECHNICAL DATA

From the foregoing it will be seen that existing RB310 servicing instructions remain generally applicable to 6GC. However, to obviate the need for referring to earlier Workshop Manual sections statistical information covering the present range of 6GC units is given overleaf.

Notes concerning the use of the tables overleaf:

1. The electrical checking and setting of all Lucas 6GC units and C.A.V. units with Part Numbers 37506-8-9-10-11-15 must be carried out with their terminals uppermost. All remaining 'C.A.V.' units with terminals lowermost.
2. Some units have voltage-regulator open-circuit voltage reset limits which differ from the checking limit figures given in the preceding column. Adjust these units to the closer (reset) limits **only if the open circuit voltage is found to be outside the checking limits.** Units that are satisfactorily controlling the output voltage **within** the checking limits MUST NOT BE DISTURBED.

   When electrically resetting ANY unit, aim for the mean voltage of the limits given.
3. For ease of identification resistors are painted at one end with a particular colour.

   The colours, nominal values and duties of the resistors employed with 6GC units are:

Blue	...	240 ohms	Contact resistors.
Orange	...	100 „	Contact resistors.
Red	...	60 „	Contact resistors.
Green	...	30 „	Swamp resistor. ★
Yellow	...	40 „	Field parallel resistor. ★

★ *Amendment to previous issue ('Swamp' and 'Field Parallel' resistor figures and colouring reversed.)*

Output Control Unit Model 6GC

Part No.	Voltage	VOLTAGE REGULATOR OPEN-CIRCUIT VOLTAGE (AT 20°C)			CURRENT REGULATOR		CUT-OUT		ARMATURE-TO-CORE AIRGAP SETTING		RESISTOR VALUE (Ohms)		
		Checking Limits	Reset To	Generator Rev/Min	Setting Amperes	Generator Rev/Min	Cut-In Voltage	Drop-Off Voltage	Voltage Regulator	Current Regulator	Contacts Resistor	Swamp ★	Field Parallel ★
37433, 37434, 37453, 37454, 37455, 37465, 37506, 37511, 37513, 37515	24	28.0–28.5	28.0–28.5	3000	14–15	3000	26.5–27.0	19.0–23.0	0.025″–0.028″	0.025″–0.028″	240	30	40
37435, 37436, 37456, 37457, 37507	24	28.0–28.5	28.0–28.5	3000	17–18	3000	26.5–27.0	19.0–23.0	0.025″–0.028″	0.025″–0.028″	240	30	40
37437, 37458, 37459	24	28.0–28.5	28.0–28.5	3000	21–22	3000	26.5–27.0	19.0–23.0	0.025″–0.028″	0.025″–0.028″	240	30	40
37441, 37462, 37492	12	14.1–14.5	14.1–14.5	3000	19–20	3000	13.0–13.5	9.5–11.0	0.017″–0.020″	0.020″–0.023″	100	—	—
37442, 37463, 37466	12	14.1–14.5	14.1–14.5	3000	24–25	3000	13.0–13.5	9.5–11.0	0.017″–0.020″	0.020″–0.023″	100	—	—
37469	12	14.8–15.1	14.8–15.1	1500	29–31	4000	12.7–13.3	9.5–11.0	0.019″–0.022″	0.019″–0.022″	60	—	40
37470	12	14.8–15.1	14.8–15.1	1500	35–36	4000	12.7–13.3	9.5–11.0	0.019″–0.022″	0.019″–0.022″	60	—	40
37471, 37477	12	14.6–15.8	14.9–15.5	3000	24–26	4000	12.7–13.3	9.5–11.0	0.017″–0.020″	0.017″–0.020″	60	—	—
37472, 37475, 37483	12	14.6–15.8	14.9–15.5	3000	21–23	4000	12.7–13.3	9.5–11.0	0.017″–0.020″	0.017″–0.020″	60	—	—
37473, 37485	12	14.2–14.8	14.2–14.8	1500	33–35	4000	12.7–13.3	9.5–11.0	0.019″–0.022″	0.019″–0.022″	60	—	40
37474, 37478	12	14.6–15.8	14.9–15.5	3000	18–20	4000	12.7–13.3	9.5–11.0	0.017″–0.020″	0.017″–0.020″	60	—	—
37476, 37481	12	14.4–15.0	14.4–15.0	3000	28.5–31.5	4000	12.7–13.3	9.5–11.0	0.019″–0.022″	0.019″–0.022″	60	—	40
37490	12	14.6–15.8	14.9–15.5	3000	10.5–11.5	4000	12.7–13.3	9.5–11.0	0.019″–0.022″	0.019″–0.022″	60	—	—
37504	12	14.6–15.8	14.9–15.5	3000	19–21	4000	12.7–13.3	9.5–11.0	0.017″–0.020″	0.017″–0.020″	60	—	—
37505	12	14.2–14.8	14.2–14.8	1500	33–34	3000	12.7–13.3	9.5–11.0	0.019″–0.023″	0.019″–0.022″	60	—	40
37508, 37510	24	28.0–28.5	28.0–28.5	3000	11–12	3000	26.5–27.0	19.0–23.0	0.025″–0.028″	0.025″–0.028″	240	30	40
37509	24	28.0–28.5	28.0–28.5	3000	13–14	3000	26.5–27.0	19.0–23.0	0.025″–0.028″	0.025″–0.028″	240	30	40

★ *Amendment to previous issue ('Field Parallel' and 'Swamp' headings reversed.)*

DYNAMO OUTPUT CONTROL UNITS

Models RB106/2 and RB108

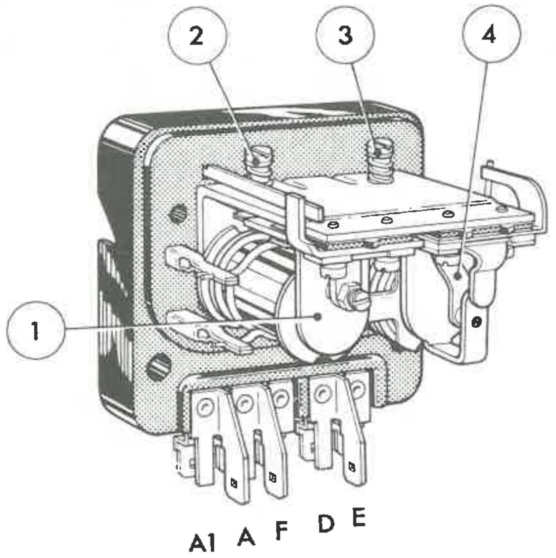


Fig. 1a Model RB106/2

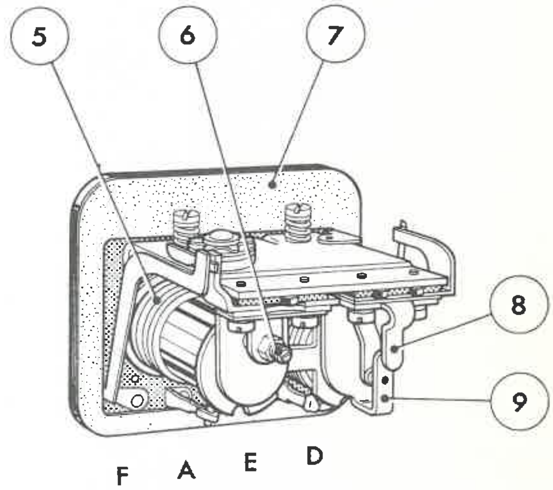


Fig. 1b Model RB108

1 Regulator moving contact
2 Regulator adjustment screw
3 Cut-out adjustment screw
4 Fixed contact blade
5 Regulator series windings
6 Regulator fixed contact screw
7 Gasket
8 Stop-arm
9 Armature tongue and moving contact

1. DESCRIPTION

These two control units are of the two-bobbin, compensated voltage control design and differ only in their base assembly and terminal arrangement. The RB106/2 is normally fitted to cars and light commercial vehicles to control the C40 dynamo. The RB108 is fitted to earlier motor cycles in 6 volt form, and tractors and stationary engines in 12 volt form. It is used to control lower output dynamos, i.e. E3 (motor cycle) and C40A (tractors etc.).

The regulator automatically controls the dynamo output to safe limits by varying the strength of the field circuit. This is effected by the action of opening and closing a pair of contacts to insert a resistance in the field circuit.

The voltage regulator has two regulating windings (one shunt and one series) wound on the voltage regulator bobbin. The shunt (or voltage) winding is connected directly across the dynamo armature (between terminal 'D' and earth). The series winding which carries dynamo output (battery charge and any load current), is wound on the bobbin in the same direction as the 'shunt' winding. Compensation is by means of the series winding which assists the shunt winding to make and break the regulator contacts.

The cut-out is an automatic switch which disconnects the dynamo from the battery when the dynamo terminal voltage is lower than that of the battery.

2. SERVICING

(a) Preliminary Check of Charging Circuit

Before disturbing any electrical adjustments, examine as follows to ensure that the fault does not lie outside the control box:

Check the battery by substitution or with a hydrometer.

Check the condition and tension of the dynamo driving belt.

Check the dynamo by disconnecting the cables from the two terminals on the commutator end bracket and, using an ammeter, link the large terminal 'D' to the small terminal 'F'. Connect a voltmeter between terminal 'D' and earth. Run engine, slowly increasing speed until the voltmeter reads battery volts. Ammeter should read 2–3A.

Inspect the wiring of the charging circuit and carry out continuity tests. Check the control box earth connections.

In the event of reported undercharging, ascertain that this is not due to low mileage.

(b) Checking the Regulator Electrical Setting

Connect a first-grade 0–20V moving coil voltmeter between control box terminals 'D' and 'E'.

Dynamo Output Control Units

Models RB106/2 and RB108

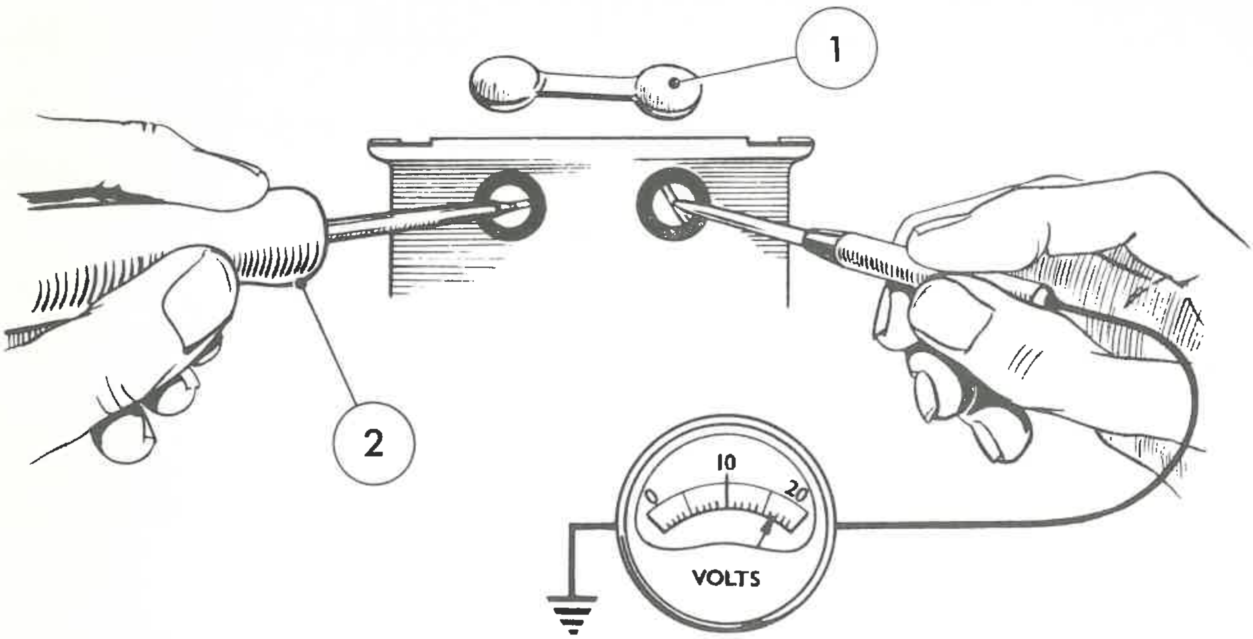


Fig. 2 Adjustment for RB108 Regulator

1 Linked rubber blanks
2 Screwdriver with insulated blade

Disconnect the cables from control box terminals 'A' and 'A1' and join them together. With model RB108 disconnect the cable from the 'A' terminal and ensure that the end of the cable does not contact any earthed parts of the vehicle.

Start and run the engine so that the dynamo is driven at 3,000 rev/min. Observe the voltmeter reading. This should lie between the following limits:

12V Units	16.0–16.5 volts
6V Units	8.0– 8.5 volts

NOTE 1. Refer to table on page 4 for special settings.

NOTE 2. Earlier RB108's (plug-in terminals) — remove the linked rubber blanks from the control box cover, and use test prods to measure the voltage between the exposed head of one of the adjustment screws and a good earth (see Fig. 2).

An unsteady reading may be due to dirty contacts (see 'Cleaning Contacts', para. 2f), but if the reading is outside the appropriate limits an adjustment must be made. Stop the engine.

(c) Regulator — Electrical Adjustment

Remove the control box cover (RB106/2).

With the voltmeter still connected as in the previous paragraph, re-start the engine and run the dynamo at 3,000 rev/min.

Turn the voltage regulator adjustment screw (clockwise to raise the setting or anti-clockwise to lower it), until the correct setting is obtained. Check the setting by reducing the dynamo speed (engine at tickover), and then again raising it to 3,000 rev/min.

NOTE. When the model RB108 is in an upright position, the right-hand hole gives access to the voltage regulator adjustment screw.

Restore the original connections and refit the cover (RB106/2) or rubber blanks (RB108).

(d) Checking Cut-out Relay Electrical Setting

Connect a first-grade 0–20V moving coil voltmeter between control box terminals 'D' and 'E'.

NOTE. Earlier RB108's (plug-in terminals) — remove the linked rubber blanks from the control box cover, and use test prods to measure the voltage between the exposed head of one of the adjustment screws and a good earth.

Switch on the headlamps to load the charging system, and to give a more easily recognisable flick back of the voltmeter pointer at the instant of contact closure.

Dynamo Output Control Units

Models RB106/2 and RB108

Start the engine and while slowly increasing its speed observe the voltmeter pointer. The flick back should occur within the limits 12.75–13.25 volts, or 6.3–6.7 volts (6 volt units). If it does not an adjustment must be made.

Stop the engine.

(e) Cut-out Relay Electrical Adjustments

(i) Method of Cut-in Voltage Adjustment

Remove the control box cover (RB106/2) or remove the rubber blanks (RB108). Keep the voltmeter connected as in the previous paragraph. Turn the cut-out relay adjustment screw (clockwise to raise the setting or anti-clockwise to lower it) until the correct setting is obtained.

Recheck the setting by increasing the engine speed slowly from zero.

Stop the engine, disconnect the voltmeter and either refit the cover (RB106/2) or the rubber blanks (RB108).

(ii) Method of Drop-off Adjustment

RB106/2 — Disconnect the cables from the control box terminal 'A' and 'A1' and join the cables together. RB108 — Remove cable to terminal 'A'.

Connect the voltmeter between terminal 'A' and earth.

Start the engine and run up to charging speed.

Slowly decelerate and observe the voltmeter pointer. Opening of the contacts, indicated by the voltmeter pointer dropping to zero should occur between the limits 8.5–11.0 volts, 4.8–5.5 volts (6 volt units).

If the voltmeter reading is within the limits, stop the engine and restore the original connections. If the drop-off occurs outside these limits, remove the control box cover and adjust the contact pressure as follows:

Stop the engine, RB106/2 — Remove the control box cover. RB108 — Remove the control box from its mounting and remove the cover, secured to the base by a rolled-over edge.

Adjust the height of the fixed contact by carefully bending the fixed contact blade towards the bobbin to reduce the drop-off voltage or away from it to raise the drop-off voltage.

Recheck the setting and if necessary, re-adjust until the correct drop-off voltage setting is obtained.

Restore the original connections and refit the cover. With the RB108, refit the cover, bending back the rolled-over edge into its former position round the base.

(f) Cleaning Contacts

(i) Regulator Contacts

To clean the voltage regulator contacts, use fine carborundum stone or silicon carbide paper.

(ii) Cut-out Relay Contacts

To clean the cut-out relay contacts use a strip of fine glass-paper, never carborundum stone or emery cloth.

(g) Adjustment of Air Gap Settings

Air gap settings are accurately adjusted during assembly and do not normally require any further attention. If, however, an armature is removed for any reason (e.g. contact renewal) care must be taken to obtain the correct setting on re-assembly.

(i) Voltage Regulator (Fig. 3)

Slacken the two armature securing screws and screw back the voltage adjustment screw until it is clear of the armature tension spring. Unlock the fixed contact until it is clear of the armature contact. Insert a 0.021″ (0.533 mm) feeler gauge between the armature and the core face. Press the armature down squarely on to the gauge and re-tighten the armature securing screws. Keeping the gauge in position and the armature pressed down, screw in the adjustable contact until it just touches the armature contact and lock it in this position.

Finally, re-adjust the voltage regulator electrical setting as described in para. 2(c).

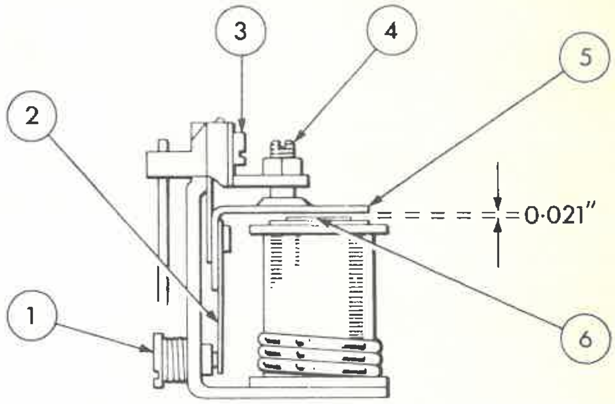


Fig. 3 Voltage Regulator Adjustment

1 Voltage adjustment screw
2 Armature tension spring
3 Armature securing screws
4 Fixed contact adjustment screw
5 Armature
6 Core face and shim

(ii) Cut-out Relay (Fig. 4)

Slacken the two armature securing screws and screw back the adjustment screw until it is clear of the armature tension spring. Press the armature squarely down against the core face (no gauge required) and re-tighten the armature securing screws. With the armature pressed down against the core face, adjust the gap between the armature stop arm and the armature tongue to 0.025″–0.040″ (0.63–1.02 mm). The gap is adjusted by bending the stop arm. Release the armature and screw in the voltage adjustment screw until the armature tongue contacts the stop arm.

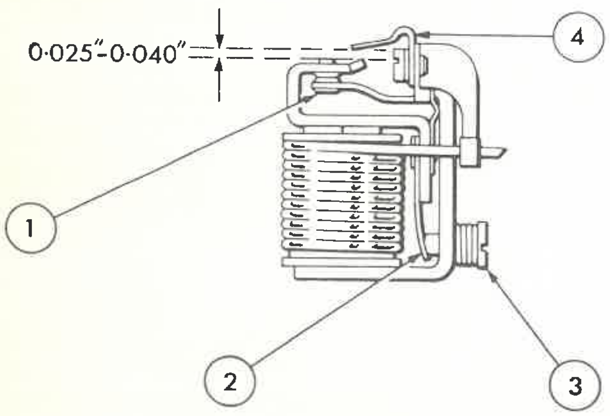


Fig. 4 Cut-out Adjustment

1 'Follow-through' 0.010″–0.020″
2 Armature tension spring
3 Cut-out adjustment screw
4 Stop arm

Adjust the fixed contact blade to give a 'follow-through' or blade deflection, of 0.010″–0.020″ (0.25–0.51 mm) when the armature is pressed squarely down against the core face.

Finally, re-adjust the cut-out relay electrical settings as described in para. 2(e).

3. TECHNICAL DATA

Resistance Values at 20°C (68°F)

Carbon Resistors

6 volt units	36–45 ohms
12 volt units	60–75 ohms

Wire Wound Resistors

6 volt units	27–33 ohms
12 volt units	55–65 ohms

Shunt Winding Resistance

Check between terminals 'D' and 'E'

6 volt units	13–15 ohms
12 volt units	50–56 ohms

Special Settings

Part No.	*Associated Dynamo*	*Regulator O/C voltage at 20°C 3,000 rev/min*
37272	C45P5	17.2–17.8
37274	C45P5	17.0–17.4
37381	C45P6	16.0–16.3

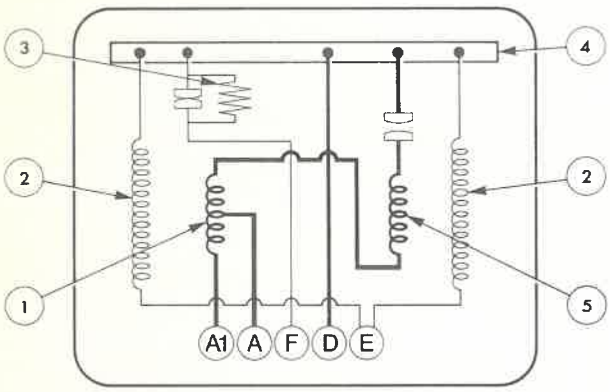


Fig. 5 Regulator Internal Connections Model RB106/2

1 Regulator tapped series coil
2 Shunt coils
3 Field resistance
4 Regulator and cut-out frame
5 Cut-out series coil

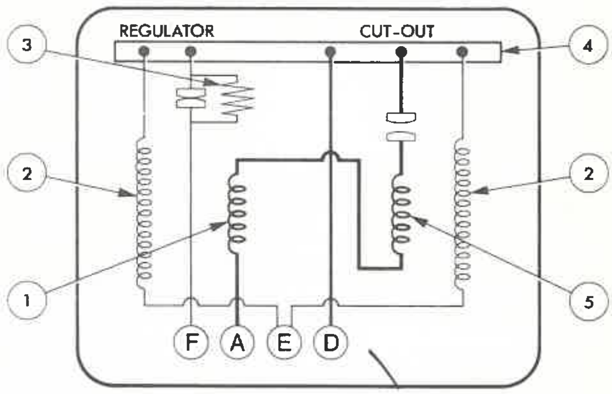


Fig. 6 Regulator Internal Connections Model RB108

1 Regulator series coil
2 Shunt coils
3 Field resistance
4 Regulator and cut-out frame
5 Cut-out series coil

PART
C

STARTERS

INDEX

Issue 7 January 1972
Supersedes Issue 6 July 1971

PRE-ENGAGED STARTER MODEL M50

(With Actuating Solenoid Model 14S or 18S and Roller Clutch Drive Model 9SD)

1. DESCRIPTION

(a) Two-stage Switching

(i) Except for the actuating solenoid, which is described below, this is a conventional four-brush four-pole starter motor of 5″ diameter with a pre-engaging push-screw roller clutch drive. The solenoid is arranged to provide two stage switching on occasions of tooth-to-tooth abutment. As described page 2 this ensures that the starter pinion is always fully meshed with the engine ring gear before full cranking torque is developed. A dismantled view of the complete machine is shown in Fig. 1 and of the solenoid unit in Fig. 2.

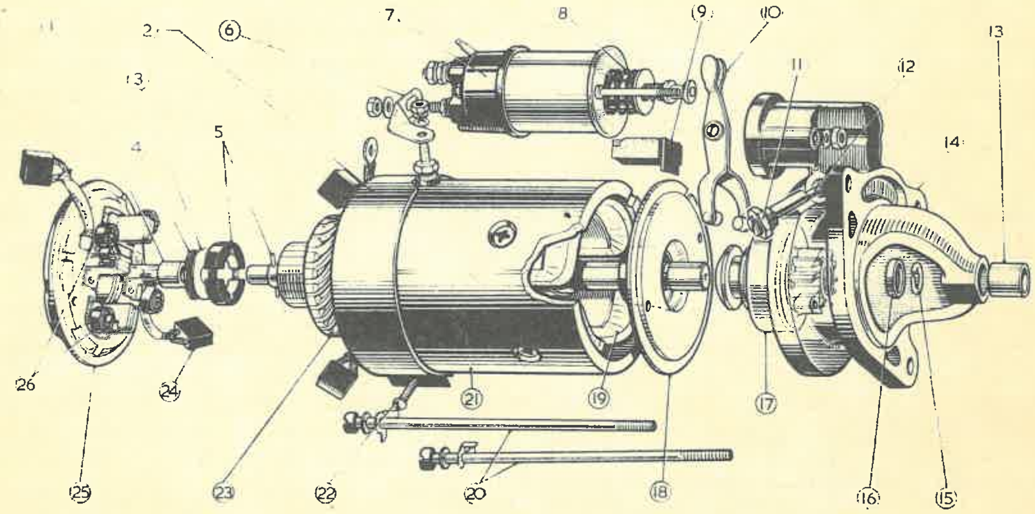


Fig. 1 Pre-engaged Starter Model M 50 with 14S solenoid

1 Bearing Bush
2 Cover Band
3 Steel Thrust Washer
4 Fibre Washer
5 Brake Shoes & Cross Peg
6 Copper Link
7 Solenoid Unit
8 Return Spring
9 Rubber Seal
10 Engagement Lever
11 Pivot Pin Locking Nut
12 Eccentric Pivot Pin
13 Bearing Bush
14 Drive End Bracket
15 Jump Ring
16 Thrust Washer
17 Drive Assembly
18 Intermediate Bracket
19 Field Coils
20 Through Bolts
21 Yoke
22 Cover Band Screw
23 Armature
24 Brushes
25 Commutator End Bracket
26 Brush Springs

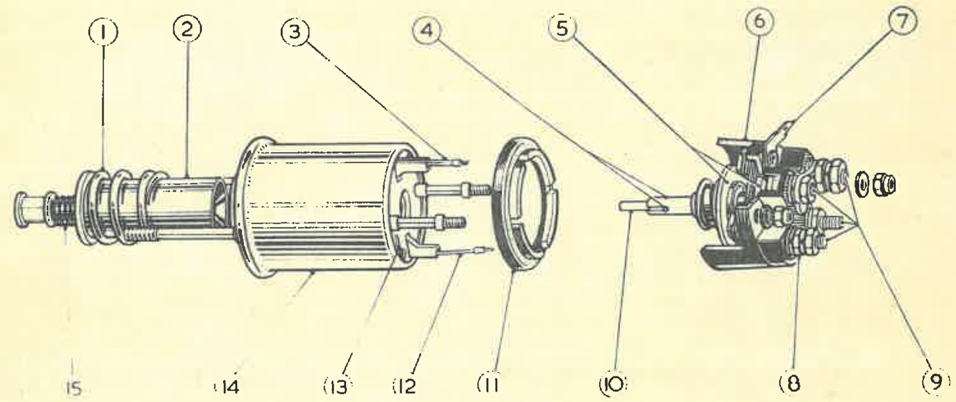
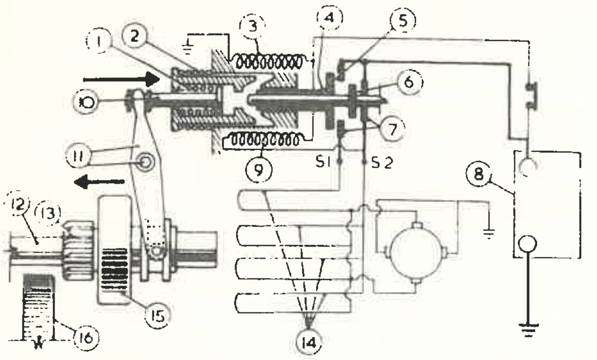


Fig. 2 Solenoid Model 14S (18S alternative, refer page 8)

1 Plunger Return Spring
2 Plunger
3 Start of Shunt & Series Windings
4 Brass Sleeve & Cross Pin
5 Moving Contacts
6 Moulded Cover
7 Lucar Terminal Blade
8 Soldered Terminal Strip
9 Terminal Studs (Fixed Contacts)
10 Spindle
11 Sealing Rubber Washer
12 End of Series Winding
13 End of Shunt Winding
14 Solenoid Body
15 Lost Motion Spring

(ii) The solenoid contains two pairs of starter switch contacts. When the solenoid is operated and the pinion moves towards the engine flywheel, its teeth will either mesh immediately with the engine ring gear or will meet the ring gear in tooth-to-tooth abutment. On occasions of immediate meshing, both pairs of contacts close simultaneously when the position of full drive engagement is reached.

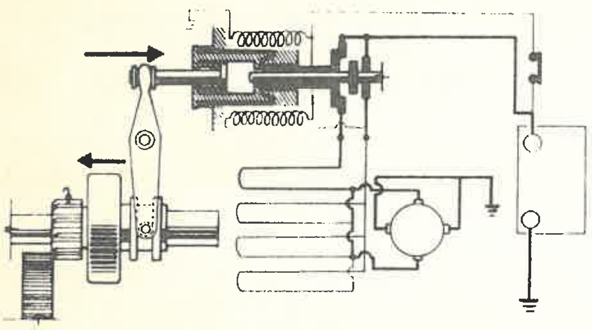
(iii) However, on occasions of tooth-to-tooth abutment, one pair only of the contacts closes initially to energise one of the four field coils. This



(Fig. 3a)

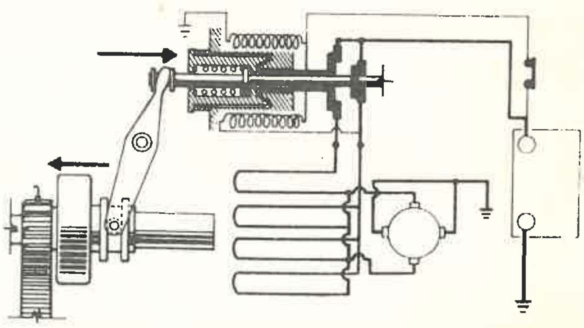
THE SOLENOID IS ENERGISED IN THE CONVENTIONAL MANNER TO MOVE THE PINION TOWARDS THE GEAR RING ON THE VEHICLE FLYWHEEL.

1 Engagement spring
2 Return spring
3 Solenoid hold-on winding
4 Switch operating spindles (concentric)
5 First switch contacts
6 Second switch contacts
7 Fixed contacts
8 Battery
9 Solenoid operating winding
10 Plunger
11 Operating lever and pivot
12 Armature shaft
13 Pinion
14 Field system: Four field coils in parallel
15 Roller clutch
16 Gear ring



(Fig. 3b)

IF TOOTH-TO-TOOTH ABUTMENT OCCURS, THE FIRST SET OF SOLENOID CONTACTS CLOSE AND ENERGISE ONE FIELD COIL ONLY, THUS GIVING LOW POWER INDEXING TO MOVE THE PINION TEETH INTO A MESHING POSITION.



(Fig. 3c)

ON FULL DRIVE ENGAGEMENT, THE SECOND SET OF SOLENOID CONTACTS CLOSE GIVING FULL CRANKING POWER.

IF THE PINION TEETH, ON MOVING FORWARD, CAN MESH IMMEDIATELY WITH THE GEAR RING, FULL DRIVE ENGAGEMENT TAKES PLACE WITH THE SIMULTANEOUS CLOSING OF BOTH CONTACTS IN THE FINAL STAGE.

Fig. 3 Explanation of Two-Stage Switching

results in partial torque being exerted by the armature with consequent indexing of the pinion. As soon as the position of alignment is reached and the pinion meshes with the flywheel, the second pair of contacts closes to connect the remaining field coils in parallel with the first. Full cranking power is then exerted. Two-stage switching is shown schematically in Fig. 3.

(iv) The solenoid also carries the drive engagement spring. This is located within the plunger, thus enabling the drive mechanism (and therefore the overall length of the machine) to be made shorter. On occasions of tooth-to-tooth abutment, axial movement of the drive and pivoting of the engaging lever is stopped, but the solenoid plunger can continue its travel by compressing the engaging spring within it. When the first pair of contacts closes, the pinion clears the abutment and moves into mesh under pressure from the engagement spring and with push-screw assistance from the drive sleeve helix.

(v) In other respects, the solenoid is of conventional design, having two windings — a series pull-in and shunt hold-on windings, the former being shorted out by the second pair of contacts in the fully engaged pinion position.

When the solenoid is switched off, the drive is retracted in the normal manner by a return spring sleeved over the plunger.

(b) Standard and Sealed Versions

For applications where the starter motor is liable to be splashed with water or fuel oil, a sealed version is used (see Part C, Section 6). This differs from the standard version in the following ways:—

(i) It has a modified commutator-end bracket and brushgear assembly which is completely enclosed by a zinc-base die-cast cover. This cover is secured by screws to the commutator-end bracket and carries a rubber compression seal in contact with the end of the yoke.

(ii) A sealing ring is fitted between the intermediate bracket and the yoke.

(iii) A sealing gasket is fitted between the solenoid body and the drive end bracket.

(iv) The through bolt threads are sealed.

(v) The nuts of the studs securing the solenoid are sealed.

(vi) The heads of the screws securing the commutator end cover are sealed.

2. ROUTINE MAINTENANCE

Routine maintenance is not necessary, although an occasional check should be made on the tightness of the electrical connections and the starter fixing bolts.

The starter motor should be dismantled for detailed inspection on the occasion of major engine overhaul. At this time the brushes, bushes and roller clutch drive should be renewed and, if necessary, the commutator skimmed as described in "Servicing".

3. TECHNICAL DATA

(i)	Lock torque:	33·5 lbf ft (4·6 kgf m) with 1165 amperes at 5.0 terminal volts.
(ii)	Torque at 1000 rev/min:	15·4 lbf ft (2·1 kgf m) with 670 amperes and 8·0 terminal volts.
(iii)	Light running current:	115 amperes at 5500–8000 rev/min.

These are typical performance characteristics obtained with a 12 volt, 120 A.H. (20-hour rate) battery in a well-charged condition. All current figures are inclusive of the solenoid hold-on current.

4. SERVICING

(a) Testing in Position

Connect a voltmeter (0-20 range) between the battery terminals and then operate the starter switch. If the voltmeter reading falls appreciably but the starter does not crank the engine, check that the battery is sufficiently well charged. If however, the voltmeter reading remains unaffected and the starter does not crank the engine, check the terminal connections at the battery, operating switch and starter motor.

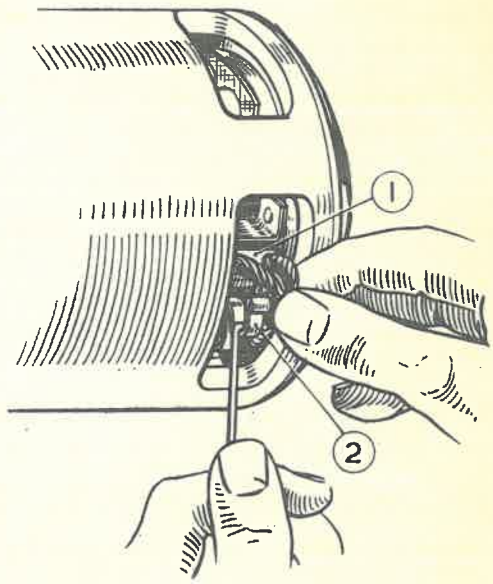
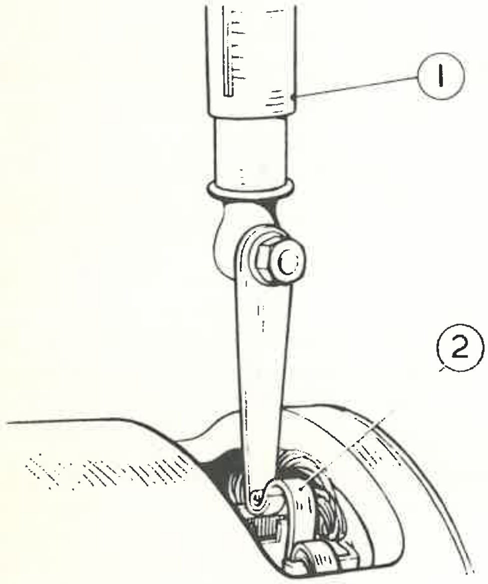


Fig. 4 Checking brushgear
1 Brush 2 Brush Spring

(b) Bench Testing

(i) Checking the brushgear

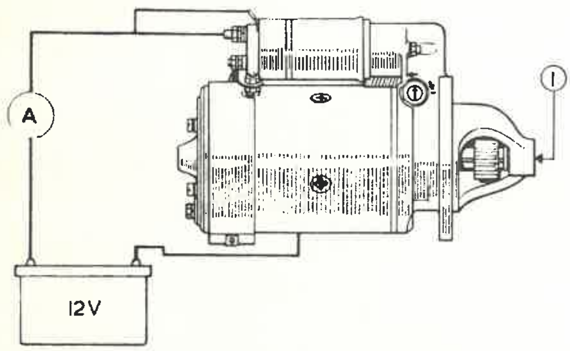
Slacken the cover band pinch bolt and slide the band off the yoke. Check that the brushes are free to move in their holders as shown in Fig. 4. If necessary, remove the brushes and clean with a fluffless petrol-moistened cloth. Refit cleaned brushes in original positions. Renew brushes when worn to (or approaching) $\frac{5}{16}$" (8 mm.) in length — see 4 (d) (i) for brush replacement procedure.



1 Spring Balance **2** Brush Spring

Fig. 5 Checking brush spring pressure

Check brush spring pressures as shown in Fig. 5. The minimum pressure exerted by a good spring on a new brush is 42 ozf. (1.2 kgf.). To check pressures, use a new brush and insert it in each brush holder in turn.



1 Apply tachometer here

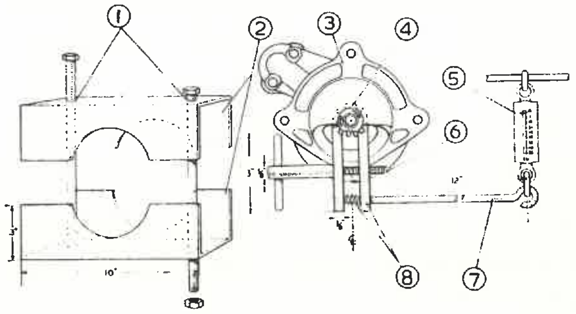
Fig. 6 Measuring the light running current and speed

(ii) Measuring light running current and speed

With the starter motor securely clamped in a vice and using a 12 volt battery and suitable ammeter, check the light running current and armature speed and compare the results with 3. Technical Data. Connect one terminal of the battery, via the ammeter, to either of the solenoid terminals that are linked with the copper strap and from this connection make a short link to the "Lucar" blade terminal. Connect the remaining battery terminal to the yoke of the motor. (Fig. 6).

(iii) Measuring lock torque and current

Keeping the same electrical connections, carry out a lock torque test as shown in Fig. 7 and compare results with 3. Technical Data. If a constant voltage supply is used, it is important to adjust this to be 5-volts at the starter motor terminal when testing.



1 Holes for ½" dia. Clamping Bolts
2 Yoke Clamp made from 3" Channel iron machined to suit Yoke
3 D.E. Bracket
4 Driving Pinion
5 Spring Scale
6 $\frac{3}{8}$" B.S.F. thread
7 $\frac{3}{8}$" M.S. Rod
8 $\frac{13}{32}$" dia. hole spring

Fig. 7 Measuring lock torque

If the starter motor fails to perform satisfactorily in either or both of these tests it must be replaced with another machine of the same model and part number, or dismantled for more detailed examination.

(iv) Fault diagnosis

An indication of the nature of the fault, or faults, may be deduced from the results of the light running and lock torque tests.

Symptom	*Probable Fault*
Speed, torque and current consumption low.	High resistance in starter motor circuit, *e.g.* faulty internal or external connections, dirty or burned commutator, burned contacts in solenoid starter switch.
Speed and torque low, current consumption high.	Tight or worn bearings, bent shaft, insufficient end play, armature foul-

	ing a pole shoe, or cracked spigot on drive-end bracket. Short-circuited armature, earthed armature or field coils.
Speed and current consumption high, torque low.	Short-circuited windings in field coils.
Armature does not rotate, low current consumption.	Open-circuited armature, field coils, or solenoid unit. If the commutator is badly burned, there may be poor contact between brushes and commutator.
Armature does not rotate, high current consumption.	Earthed field winding or short-circuited solenoid unit. Armature physically prevented from rotating.
Excessive brush movement.	Low brush spring tension, worn or out-of-round commutator. "Thrown" or high segment on commutator.
Excessive arcing at the commutator.	Defective armature windings, sticking brushes or dirty commutator.

(c) Dismantling

(i) Disconnect the copper link and eyeletted cable from solenoid terminals S1 and S2.

(ii) Remove the two solenoid unit securing nuts. Withdraw the solenoid from the drive end bracket casting, carefully disengaging the solenoid plunger from the starter drive engagement lever.

(iii) Remove the cover band and lift the brushes from their holders.

(iv) Unscrew and withdraw the two through bolts from the commutator-end bracket. The commutator-end bracket and yoke can now be removed from the intermediate and drive-end brackets.

(v) Extract the rubber seal from the drive-end bracket.

(vi) Slacken the nut securing the eccentric pin on which the drive engagement lever pivots, and unscrew and withdraw the pin.

(vii) Displace the thrust washer from the jump ring at the end of the armature shaft using a mild steel tube of suitable bore. Prise the jump ring from its groove and slide the drive assembly and intermediate bracket from the shaft. Take care not to lose any shims which may be fitted between the intermediate bracket and the armature core.

(d) Bench Inspection

Solenoid (refer subsequent main heading 5.)

(i) Replacement of brushes

The two earth brush flexible connectors are soldered to terminal plates secured by brush box rivets, and the two insulated brush flexible connectors are hot pressed to free ends of the field coils. Unsolder the earth brush flexibles and solder the connectors of the new brush set in their place.

To replace the insulated brushes, cut off their flexibles $\frac{1}{8}$" (approx. 3 mm.) from the hot-pressed joint. Open out and tin the loop of the replacement brush. Place the tinned loop over the stub of flexible; squeeze up and solder.

The brushes are pre-formed so that "bedding" to the commutator is unnecessary.

Check that the new brushes move freely in their boxes.

(ii) Armature

The surface of the commutator should be clean and free from burnt spots. Clean the commutator with a petrol-moistened cloth. If necessary, use very fine glass paper or emery cloth, prior to using the petrol-moistened cloth.

The commutator may be skimmed to a minimum diameter of 1.5" (38 mm) before a replacement armature becomes necessary. The commutator surface should then be polished with very fine glass paper or emery cloth. THE INSULATION SLOTS MUST NOT BE UNDERCUT.

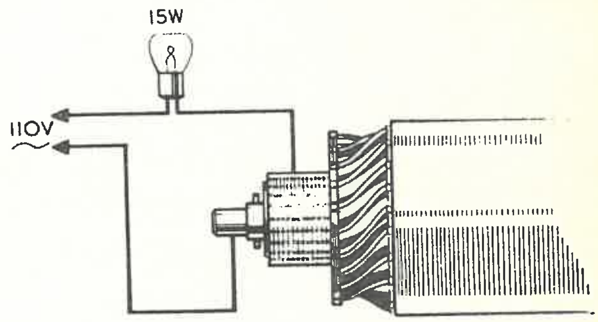


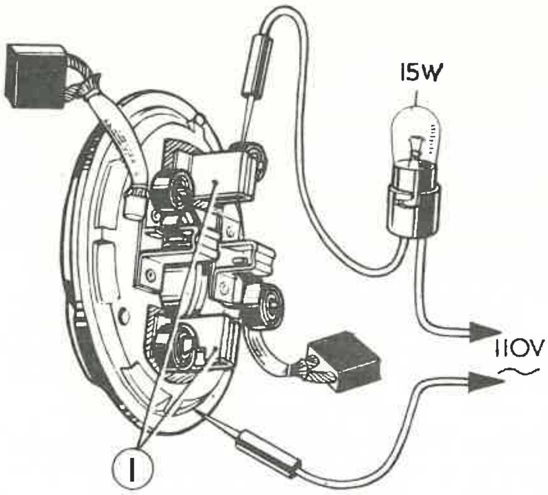
Fig. 8 Armature winding insulation test

If there are signs of thrown solder or the conductors have lifted from the commutator segments, the motor has probably been overspeeding. Check the operation of the roller clutch drive. Refer para. (v).

If the armature fouls the pole-shoes, it indicates worn bearings, loose pole-shoes, or the armature shaft is distorted. Check the armature in a lathe. If it is out of true, it should be renewed. If the armature is satisfactory, renew the bearings in both end brackets. Refer para. (iv).

Check armature insulation with a 110V a.c. 15W test lamp connected between one of the commutator segments and the armature shaft (Fig. 8). If the lamp lights the insulation is unsatisfactory.

Check armature for short-circuited windings, using 'GROWLER' equipment.



1 Insulated Brush Boxes

Fig. 10 Brush-box insulation test using low voltage a.c. mains

(iii) Insulation test of field coils and brushgear

Ensure that both brushes are clear of the yoke and connect a 110-volt a.c. test lamp between the field coil eyelet and a clean part of the yoke (Fig. 9). If the test lamp lights it indicates that the field coils are earthed to the yoke and must be replaced.

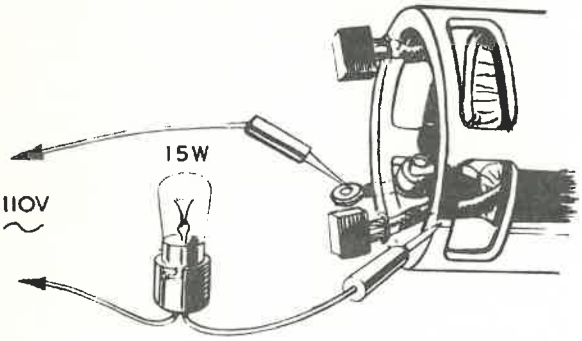


Fig. 9 Field coil insulation test using low voltage a.c. mains

Using the same equipment, check also the insulated pair of brush boxes on the commutator-end bracket. Clean off all traces of brush deposit before testing. Connect the test lamp between each insulated brush box and the bracket (Fig. 10).

If the lamp lights, this indicates faulty insulation and the end bracket must be replaced.

Renewing the Field Coil Assembly

Remove the nuts, washers and insulation pieces to free the yoke-mounted terminal stud.

Unscrew the four pole shoe retaining screws, using a wheel-operated screwdriver. Remove the insulation piece which is fitted to prevent the inter-coil connectors from contacting with the yoke.

Draw the pole shoes and coils out of the yoke and lift off the coils. Fit the new field coils over the pole shoes and place them in position inside the yoke. Ensure that the taping of the field coils is not trapped between the mating surfaces of the pole shoes and the yoke. Locate the pole shoes and field coils by lightly tightening the retaining screws.

Replace the insulation piece between the field coil connections and the yoke. Tighten the screws by means of the wheel-operated screwdriver while the pole pieces are held in position by a poleshoe expander or a mandrel of suitable size.

(iv) Bearing replacement

Bushes must be replaced when there is excessive side-play of the armature shaft. Fouling of the pole-shoes by the armature, or inefficient operation of the starter, is likely to occur when the inner diameter of the bushes exceeds the following dimensions:—

Commutator-end cover bush 0.505″ (12.82 mm), intermediate bracket bush 1.127″ (28.62 mm), and drive-end fixing bracket bush 0.675″ (17.14 mm).

The bushes in the intermediate and drive-end brackets can be pressed out, while that in the commutator-end bracket is best removed by inserting a $\frac{9}{16}$″ tap squarely into the bearing and withdrawing the bush with the tap. New bushes must be completely immersed in Shell 'Turbo 41' oil, or clean engine oil, for at least 20 min. before being fitted.

Press each new bush into position with a shouldered, highly-polished fitting pin of the correct diameter, namely:—

Commutator-end cover bush 0.5005″ (12.712 mm), intermediate bracket bush 1.1226″ (31.054 mm), and drive-end fixing bracket bush 0.6705″ (17.030 mm).

Porous bronze bushes must not be reamed out after fitting or the porosity of the bush will be impaired.

(v) The Roller Clutch Drive Assembly

Check the clutch action. The pinion should have instantaneous take-up of the drive in one direction and be free to rotate in the other.

Check that the assembly moves freely along the armature shaft splines. The armature shaft splines and moving parts of the engagement lever should be liberally smeared with Shell SB.2628 (home market and cold climates); Retinax 'A' (hot climates). The roller clutch mechanism is a sealed unit, which is pre-packed with sufficient grease to last the life of the starting motor. In the unlikely event of the clutch action becoming faulty, it will not be possible to rectify the fault and the whole of the drive assembly will have to be renewed.

(e) Reassembly

After cleaning all parts, reassembly of the starter motor is the reversal of the dismantling procedure given in 4 (c) but the following special points should be noted:

The thrust shims must be refitted between the intermediate bracket and the armature, see 4 (c) (vii). These shims are provided to limit the end float to 0.005″—0.020″. It is important that after re-assembly the end float be checked and if necessary, a further shim added. Shims are available under Part Numbers 54140213 (0.010″ thick) and 54148522 (0.018″ thick). The following parts should be tightened to the maximum torques indicated:

Nuts on solenoid terminals:
 24 lbf in (0.28 kgf m)
Solenoid fixing nuts:
 4.5 lbf ft (0.62 kgf m)
Starter motor through bolts (¼″ diameter):
 8.0 lbf ft (1.1 kgf m)
Starter motor through bolts (5/16″ diameter):
 10.0 lbf ft (1.38 kgf m)

When refitting the commutator-end bracket see that the fibre and steel thrust washers are fitted in the correct order (see Fig. 1) beneath the moulded brake shoes. Then turn the armature shaft so that the cross peg engages correctly with the slots in the shoes.

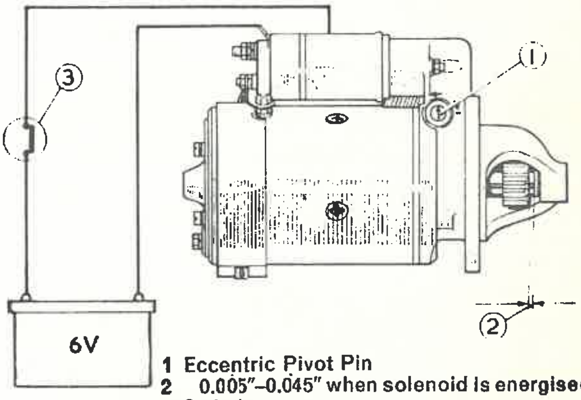
(f) Setting Pinion Movement

After complete assembly of the starter motor, connect the "Lucar" terminal on the solenoid unit by way of a switch to a 6-volt supply.

Connect the other side of the supply to the starter motor yoke.

Close the switch (this throws the drive assembly forward into the engaged position) and measure the distance between the front edge of the pinion and the thrust washer on the armature shaft extension. Make this measurement with **the pinion lightly pressed towards the armature** to take up any slack in the engagement linkage.

For correct setting this distance should be 0.005″ – 0.045″.



1 Eccentric Pivot Pin
2 0.005″–0.045″ when solenoid is energised
3 Switch

Fig. 11 Setting pinion movement

To adjust the setting, slacken the eccentric pivot pin securing nut and turn the pin until the correct setting is obtained. Note that the arc of adjustment is 180° and that the head of the arrow marked on the pivot should be set between the arrows on the arc described on the drive end bracket casting. After setting, tighten the securing nut to retain the pin in position and recheck the setting.

Finally, lock the securing nut in position by applying gold size to the pivot pin threads.

5. SOLENOID

Check for satisfactory closing of the first and second-stage contacts associated with terminals S1 and S2. Disconnect terminal S1 and apply a 12V battery supply between the solenoid 'Lucar' terminal and a clean part of the solenoid body or starter frame. Using a battery-operated ohmmeter or battery-operated test lamp, connect one lead to the solenoid main (largest) terminal and connect the other lead alternately to the terminals S1 and S2. If there is a zero reading on the ohmmeter or the test lamp lights, it proves that the solenoid contacts are satisfactory.

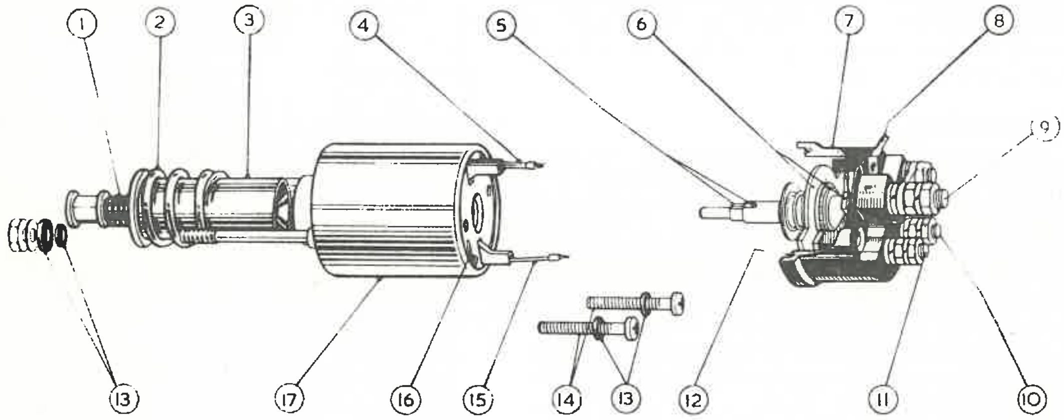
If there is no contact continuity in the foregoing test, the cause may be either faulty operating windings or faulty contacts. To check the windings, disconnect the solenoid terminal S2 and use a good quality ohmmeter capable of measuring 0–1 ohm (e.g. Universal Avo-meter No. 8 Mk. II) to measure the resistance between the solenoid terminal S2 and the solenoid body or starter frame. This should be 0.76–0.88 ohm. If a suitable instrument for measuring resistance is not available, connect a 0–20A moving-coil ammeter in series with a 12V battery, solenoid terminal S2, and the solenoid body or starter frame. If the solenoid operating windings are satisfactory, a reading of 13.5–15.75A will be obtained.

Replacement of terminal base and contacts assembly

If, as an alternative to replacing the solenoid completely, it is decided to renew the terminal base and contacts assembly only, proceed as follows:

Remove the two nuts (or screws) securing the moulded cover, together with the rubberised spring washers.

Unsolder the ends of the windings from the soldered connections at the inner end of the "Lucar" terminal blade and at the terminal strip positioned 180° away. Pull the moulded cover gently away from the body of the solenoid during the unsoldering operation — it can be withdrawn, complete with the contacts assembly, once unsoldering is completed.



1 Lost motion spring
2 Plunger return spring
3 Plunger
4 Start of shunt & series windings ('Lucar' terminal)
5 Brass sleeve & cross pin
6 Moving contacts
7 Moulded cover
8 'Lucar' terminal blade
9 Main input terminal(s) with copper strap marked 'BAT'
10 Terminal S2
11 Terminal S1
12 Sealing ring
13 Sealing washer(s)
14 Fixing screw (moulded cover)
15 End of series winding (S2)
16 End of shunt winding
17 Solenoid body

Fig. 12 Solenoid Model 18S (*Supersedes* **14S**, Fig. 2)

SOLENOID MODEL 15S

1. DESCRIPTION

Solenoid model 15S has been developed for general fitment to M418 and M45 machines.

Electrically, model 15S is identical to model 14S (described in Part C, Section 2 of this Manual) except that it is fitted with one pair of contacts only.

2. SERVICING

(a) Current Check of Solenoid Windings

This is carried out exactly as described for model 14S (see page 7 in Part C, Section 2) except that, when checking the closing winding, the 4-volt supply must be connected between terminal 'STA' and the 'Lucar' terminal.

(b) Contact Replacement

If, as an alternative to replacing the solenoid completely, it is required to renew the contact assembly only, proceed as follows:

(i) Withdraw the screws which secure the moulded base assembly to the solenoid body.

(ii) Remove all nuts and washers from main terminal 'STA'.

(iii) Unsolder the wires connected to the 'Lucar' terminal and withdraw the base moulding from the body leaving terminal bolt 'STA' attached to one end of the pull-in winding. In production this connexion is made by hot-pressing the wire to the terminal bolt, the wire being looped between the solenoid body and bolt. Using long-nosed pliers grip the exposed portion of the pull-in winding as close as possible to the junction with the bolt. Twist the bolt until the joint is broken. Silver-solder the replacement terminal bolt to the pull-in winding using 'Easi-flo No. 2' or an equivalent solder. (Use asbestos sheeting to protect the solenoid body if this is liable to be exposed to excessive heat).

Clean off any excessive flux deposit which may remain on the bolt after the joint is made.

Fig. 1 shows the solenoid, before and after replacement of the terminal bolt.

(iv) Replace the second terminal bolt and moving contact assembly and re-assemble the base moulding to the solenoid body.

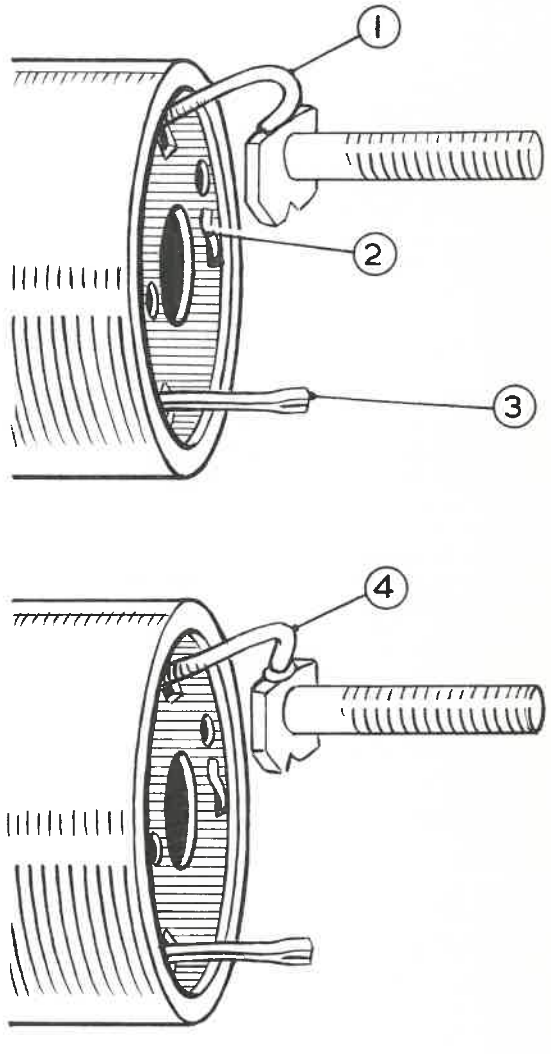


Fig. 1 Fixed contact replacement

1 Existing contact welded to pull-in winding

2 Earthed end of hold-on winding

3 Wires normally soldered to 'Lucar' terminal

4 Replacement contact silver-soldered to pull-in winding

PRE-ENGAGED STARTER MODELS M35J PE AND 5M90 PE

(INCORPORATING ACTUATING SOLENOID MODEL 17S AND ROLLER CLUTCH DRIVE MODEL 7SD)

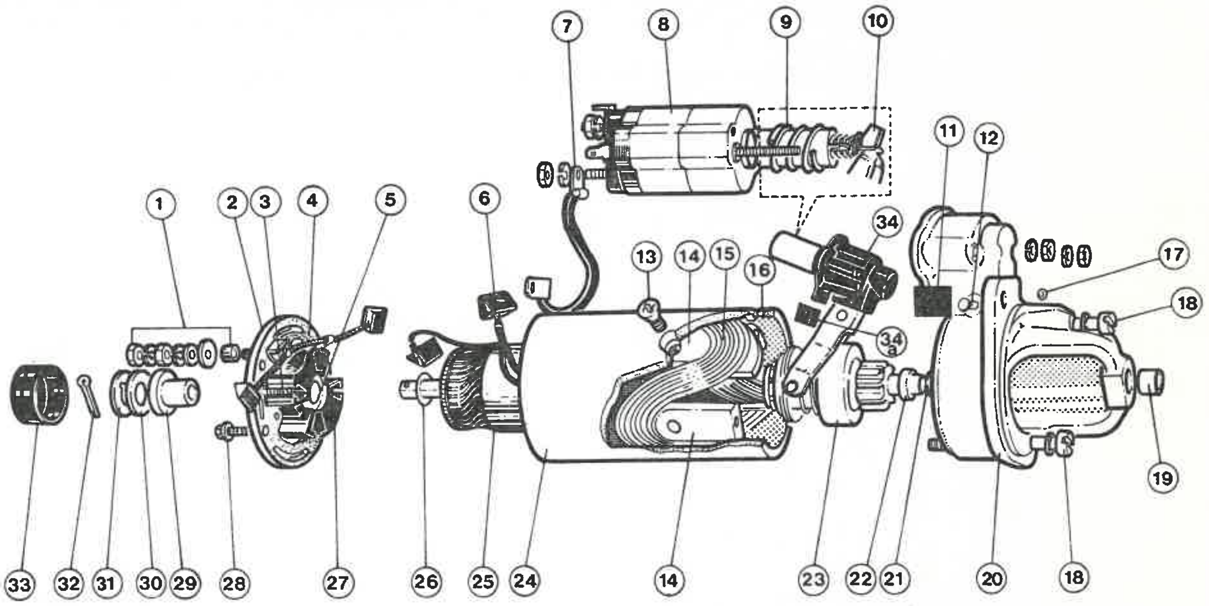


Fig. 1 Typical Starter, Models M35J and 5M90

1 Terminal nuts and washers
2 Commutator end bracket
3 Brush springs
4 Sealing washer (when fitted)
5 Bush housing
6 Brushes
7 Connector link (Solenoid to starter)
8 Solenoid unit (see fig.7)
9 Return spring
10 Engagement lever
11 Sealing grommet (brkt. sealing)
12 Pivot pin
13 Pole screws
14 Pole shoes
15 Field coils
16 Field to earth connection
17 Retaining ring (when fitted)
18 Fixing bolts (studs & nuts, early M35J)
19 Bearing bush
20 Drive end bracket
21 Jump ring
22 Thrust collar
23 Drive assembly
24 Yoke
25 Armature
26 Thrust washer
27 Brush box moulding
28 C.E. bracket fixing screws (4), early M35J (2)
29 Bearing bush
30 Thrust plate
31 Shim washers
32 Cotter pin
33 Plastic sealing cap
34 Sealing cover (when fitted)
34a Sealing cover grommet

1. GENERAL

Starter models M35J PE and 5M90 PE are of similar construction but the 5M90 has a slightly higher performance (refer 3. TECHNICAL DATA). Compared with the M35J, the 5M90 incorporates larger field windings and pole-shoes.

The starters have a yoke diameter 90 mm (3.5 in) and incorporate a series wave-wound field winding face-type commutator and fully-insulated brushgear. Other features include:— non-adjustable drive engagement lever, independently fixed end-brackets and a windowless yoke, and end-float externally controlled at the commutator end.

The wave-wound field winding has no interconnecting joints. One end of the continuously wound winding is earthed to the yoke and the other end terminates at a pair of brushes (see Fig. 2).

The face-type moulded commutator forms the end-face of the armature (see Fig. 5) and the fully-insulated brush-gear comprises a plastic brushbox moulding with wedge-shaped brushes and coil type springs (see Fig. 3).

The non-adjustable drive engagement lever eliminates the need for setting the pinion position, a procedure necessary with earlier design pre-engaged starters.

Independently fixed end-brackets and a windowless yoke eliminates conventional through bolts and the bandcover. The drive end bracket is secured by bolts, or studs, locating in threaded holes in two diametrically opposite pole-shoes and the commutator end bracket is secured by screws locating in threaded holes in the edge of the yoke (see Fig. 1, items 18 & 28). Deletion of the bandcover is due to the fact that routine inspection and servicing of the commutator and brushgear, is unnecessary.

Brushgear axial thrust and armature end-flloat is controlled at the commutator end by a thrust plate and a required number of packing shims, assembled on the armature shaft extension and retained by a cotter pin

Pre-Engaged Starter Models M35J PE and 5M90 PE

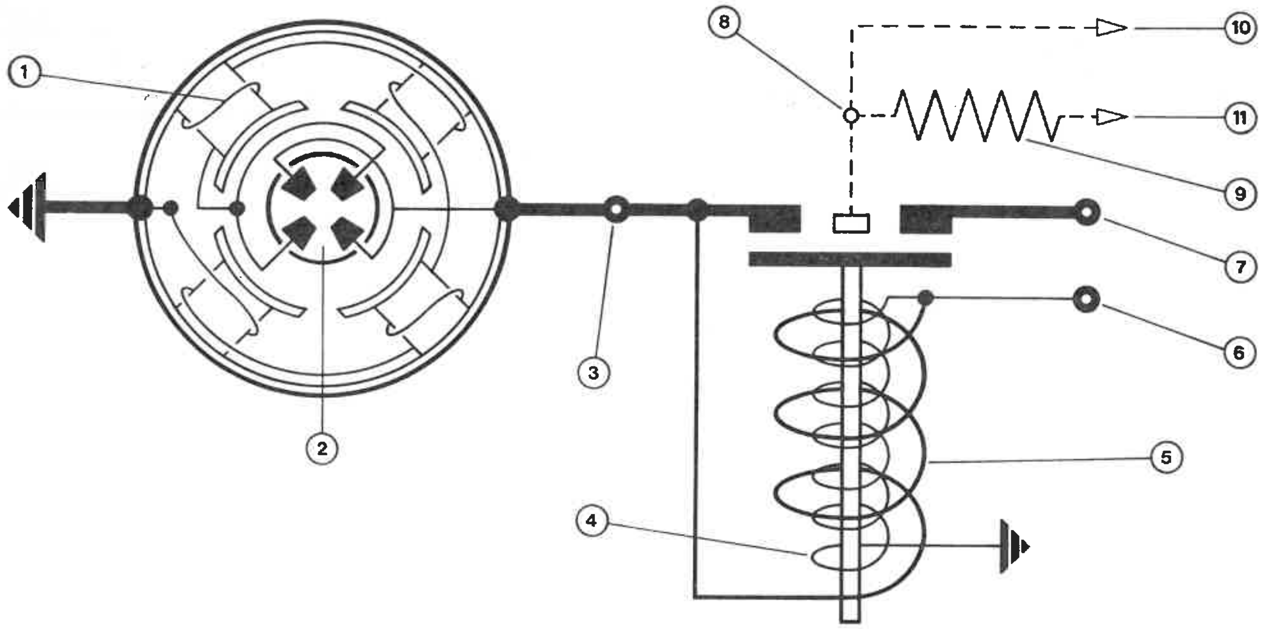


Fig.2 Internal connections of starter and solenoid
(Broken lines applicable only when ballast ignition coil is used)

1 Field
2 Armature
3 Terminal 'STA'
4 Hold-on winding
5 Closing winding
6 Small (unmarked) terminal on solenoid
7 Battery supply terminal
8 Terminal 'IGN'
9 Ballast resistor
10 To ignition coil
11 To ignition switch

secured through the end of the shaft (see Fig. 1, items 30, 31, 32). The cotter pin also serves to lock the thrust plate and packing shims together so that they rotate with the armature shaft and this limits the thrust wear to the bearing surfaces of the thrust plate and the external shoulder of the bearing bush.

The solenoid is a dual-purpose unit, serving as a relay to apply battery voltage to the starter motor and actuating its pre-engaged drive mechanism. The solenoid plunger is fitted with a 'lost-motion' spring (see Fig. 6, item 10) which provides a measure of lost motion in the drive operating mechanism. The measure of lost motion takes place at the commencement of disengaging the drive, its purpose being to ensure that the main solenoid contacts will always open (to switch off the starter) prior to pinion retraction.

The roller clutch, incorporated in the drive assembly, is an over-running or free-wheeling device. For a limited period it prevents the armature from being rotated at an excessive speed if an excess throttle opening is used during the starting period or, if due to a fault, the drive is held in engagement after the engine has started.

Note: The 5M90 PE range of starters include Part No. 25264 which incorporates a non-standard 17S solenoid Part No. 76971. This starter is specified for vehicles which have the starter system wiring-connections standardised, to enable either a pre-engaged or inertia-type starter to be fitted. The non-standard solenoid fitted to this starter incorporates a permanent connector-link between its main input terminal and operating windings (see Fig. 2, items 6 & 7), enabling the solenoid to function as a 'slave solenoid' controlled by a remotely-fitted starter solenoid relay (Starter control being similar to inertia-starter systems, but with advantage of pre-engaged drive). The starter solenoid incorporates an auxiliary feed 'Lucar' terminal blade, positioned where the operating winding terminal would normally be, and this should not be mistaken for the conventional solenoid operating winding terminal. Care must be taken to ensure that this particular starter is only fitted to vehicles for which it is normally specified, since application of the supply voltage direct from the battery to the starter solenoid main input terminal (as in the case of basic pre-engaged starter systems) would in this case cause uncontrolled operation of the starter, resulting in cranking of the engine and movement of the vehicle if it should be in gear. Starter motors, and service replacement solenoid units, leave the factory with an adhesive label stating:

WARNING: This starter must be operated via a LUCAS 4ST or equivalent relay.

2. TECHNICAL DATA

(a) Starter Performance

Starter performance is dependent on the capacity and state of charge of the associated battery. The figures given are typical performance characteristics obtained with a 12V 43Ah (20 h. rate) battery in a good state of charge.

M35J PE

Lock torque: 9.5 Nm (7.0 lbf ft) (0.97 kgf m) with 390A max. at 7V.

Torque at 1,000 rev/min: 6.0 Nm (4.4 lbf ft.) (0.61 kgf m) with 280A max. at 8.5V.

Light running current:- 65A at 8000-11500 rev/min.

5M90 PE

Lock torque: 10.8 Nm (8.0 lbf ft) (1.11 kgf m) with 370A max. at 7V.

Torque at 1,000 rev/min: 6.5 Nm (4.8 lbf ft) (0.66 kgf m) with 257A max. at 8.6V.

Light running current: 65A at 8000-11500 rev/min.

(b) Solenoid

Closing (or series) winding resistance: 0.21–0.25 ohm. (measured between the small unmarked 'Lucar' terminal and the main terminal marked STA).

Hold on (or shunt) winding resistance: 0.9–1.1 ohm. (measured between the small unmarked 'Lucar' terminal and a good earth point on the solenoid body).

3. SERVICING

No routine maintenance is necessary. The armature bearings are porous-bronze bushes, initially impregnated with sufficient oil lubricant to provide self-lubrication until major overhaul of the starter becomes necessary. The starter should be dismantled for detailed inspection during major engine overhaul, when the commutator should be serviced if necessary and the brushes and armature bearings renewed.

For satisfactory starter performance, the battery must be in good condition and at least 70% charged. Check with a hydrometer the specific gravity of the electrolyte in each of the battery cells. If there is a variation of more than 40 points (0.040) in any cell reading, the battery is suspect and should be given a heavy-discharge test. Alternatively, prove the battery by substitution.

Specific gravity readings should be:

	Specific gravity readings correct to 15°C (60°F)	
State of charge	Climates normally below 25°C (77°F)	Climates normally above 25°C (77;F)
Fully charged	1.270–1.290	1.210–1.230
70% charged	1.230–1.250	1.170–1.190
Discharged	1.100–1.120	1.050–1.070

(a) Bench Testing

Clamp the starter in a vice.

If starter testing equipment is available, first check the starter light running current and speed and, if the test is satisfactory, proceed to check lock torque performance (refer 2, TECHNICAL DATA).

The tests should first be carried out with the solenoid energised and the supply voltage applied to the main input terminal of the solenoid.

If either the light running or lock torque tests are unsatisfactory, the tests should be carried out with the supply voltage transferred from the solenoid main input terminal to the starter motor terminal.

If the test is now satisfactory, the solenoid is proved faulty.

If the test is still unsatisfactory, the starter motor is proved faulty.

If starter testing equipment is not available, or previous testing establishes that dismantling is necessary, proceed to following sub-heading (b).

(b) Dismantling

(i) Solenoid

Unless previous testing has already established the solenoid is faulty, it can be tested in-situ (refer following sub-heading (c), para. vi).

After removing the solenoid-to-starter connecting link and the solenoid securing nuts and washers, the main part of the solenoid can be removed from the starter motor. The solenoid plunger, complete with drive return spring, can then be lifted from the top of the drive engagement lever and withdrawn from the bracket.

Note: The solenoid plunger is individually suited to the main part of the solenoid and is not interchangeable separately.

(ii) Starter Motor

Unless the starter is being reconditioned, in which case full dismantling will be necessary and the solenoid unit should first be removed (previous para. refers), remove the plastic sealing cap, cotter pin, thrust-plate and packing shims from the commutator-end and then remove the commutator end bracket to enable the inside of the starter to be inspected (It may be possible to rectify the fault without the need for full-dismantling).

Inspect the brushgear and commutator, and inside the yoke (refer following sub-heading (c), para's i, ii & iii) and determine whether further dismantling is necessary.

Dismantling continued.

With the commutator end bracket already removed, now remove:— solenoid unit (unless already removed), pivot-pin (supporting the drive engagement lever), drive end bracket securing bolts (or nuts), and finally separate major components (drive end bracket, drive engagement lever, armature and drive assembly and yoke and field winding assembly). Do not unnecessarily dismantle either the armature or yoke sub-assemblies, the roller clutch drive and the field winding can be checked in-situ (following sub-heading (c), para's iii & iv refer).

(c) Bench Inspection and Testing of Components

(i) Brushgear

Check for sticking brushes. If necessary, clean brushes and brushbox moulding with a petrol-moistened cloth.

Check whether the brushes need renewing. Brushes worn to approximately 8 mm (5/16 in) must be renewed, as a set.

Two of the brushes are serviced complete with the commutator end bracket terminal but the field winding brushes will need soldering to the original brush-flexibles, which should be cut about 6 mm (¼ in) from the field winding conductor. Note arrangement of the short and long brush-flexibles (see Fig. 3) and ensure a perfect soldered joint.

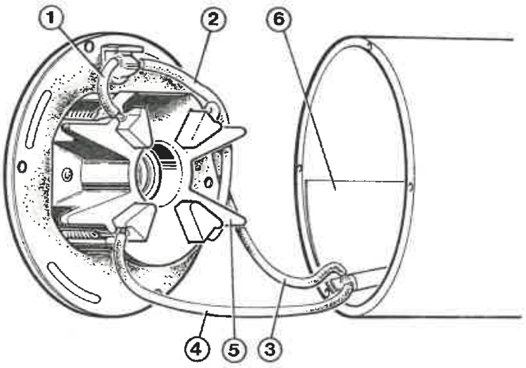


Fig. 3 Brushgear arrangement
1 Short brush-flexible, C/E bracket
2 Long brush-flexible, C/E bracket
3 Long brush-flexible, field winding
4 Short brush-flexible, field winding
5 Brush-flexible retaining lugs
6 Yoke insulation piece

Check the brush spring pressure, with a push-type spring gauge (see Fig. 4). Spring pressure should be 7.80 N (28 ozf or 0.8 kgf) approx.

Note: The brush springs are not serviced individually. If an incorrect spring pressure reading is obtained, the bracket assembly must be renewed.

Check insulation of the brush springs and the terminal post. Connect a 110V a.c. 15-watt test lamp, between a clean unpainted part of the bracket and each of the springs in turn and then between the bracket and the terminal post. **The test lamp should not light.**

(ii) Armature

The face of the commutator should be clean and free from burnt spots. Clean the commutator with a petrol-moistened cloth and, if it should be necessary, use fine emery cloth to rectify burnt spots, prior to using the petrol-moistened cloth.

In some cases it may be necessary to skim the commutator. The minimum thickness to which the commutator copper may be skimmed, before a replacement armature becomes necessary, is 2 mm approx. (0·080 in.).

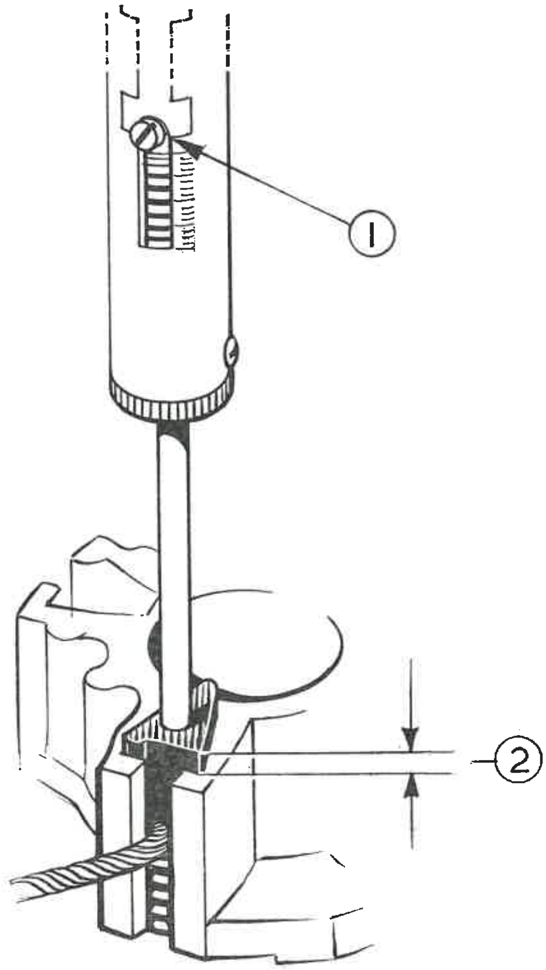


Fig. 4 Checking brush spring pressure
1 Push type spring gauge with sliding marker indicating reading where 'arrowed' (Alternatively, the gauge could be dial-type)
2 1.5 mm (0·062 in.) approx.

Note: Later design brush-boxes incorporate lugs for retaining the brush-flexibles (see Fig. 3, item 5).

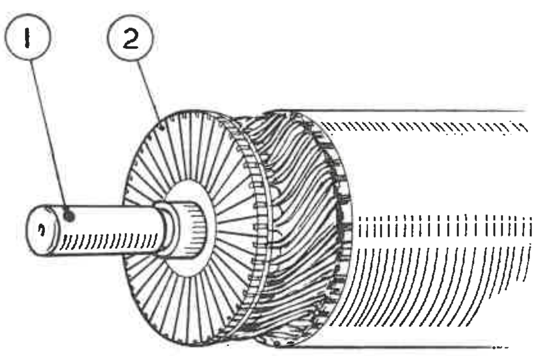


Fig.5 Armature with face-type commutator
1 Cotter pin hole (end-float and thrust)
2 Face-type commutator

The skimming operation should be terminated by polishing the commutator surface with fine emery cloth, then wipe clean with a petrol-moistened cloth. DO NOT UNDER-CUT THE INSULATION SLOTS.

If the armature shows signs of 'thrown' solder, or lifted conductors, overspeeding of the armature is indicated (Check the operation of the roller clutch drive, refer subsequent para. iv).

The armature insulation can be checked by connecting a 110V a.c. 15-watt test lamp between a commutator segment and the shaft. **The lamp should not light.**

Short-circuited armature windings (indicated by a high current consumption, low light running speed and low lock torque performance) can only be detected by the use of specialised armature testing 'Growler' equipment. If this equipment is not available, the only alternative is to check the armature by substitution.

If the armature laminations have been in contact with the pole-shoes, the armature bearings are probably excessively worn. First check that the pole-shoes are tight and that the armature runs true in a lathe. Then, if necessary, renew the armature bearings (refer subsequent para. v).

(iii) Yoke and Field Winding Assembly

Inspect the field windings in-situ for obvious signs of a fault. A visual indication of a breakdown in field winding insulation will eliminate the need for testing and the field winding must be renewed.

Providing field winding insulation appears to be satisfactory, and providing the starter has been sufficiently dismantled to enable the earthed-end of the field winding to be inspected, check continuity between field winding conductor and flexible link connection to the yoke. In the case of early-production M35J starters, check for a good soldered joint between flexible link and yoke. In other cases, check for a firmly riveted connection between flexible link and yoke.

If there are no obvious signs of a field winding fault, providing the armature has previously been tested (para. ii) and found to be satisfactory, consider the results of starter performance tests which should previously have been carried out if the equipment was available. If light running speed and torque tests were unsatisfactory, then disconnecting the earthed-end of the field winding to enable a positive field winding insulation test to be carried out, is justified.

After disconnecting the earthed-end of the field winding at the yoke (not the hot-pressed joint between field winding and flexible link), carry out a positive test of the field winding insulation by connecting a 110V a.c. 15-watt test lamp between the disconnected end of the winding and a clean unpainted part of the yoke. **The test lamp should not light.** Ensure neither of the brushes or bare part of their flexibles are contacting the yoke during the test.

A field winding continuity test is unnecessary in the case of full-dismantling, where it is possible to inspect the joints at both ends of the field winding. In the case of partial-dismantling (commutator end bracket only removed), field winding continuity can be checked by connecting a 12V battery-operated test lamp between either of the brushes and a clean unpainted part of the yoke. **The test lamp should light.**

If field winding insulation and continuity are found to be satisfactory, wipe clean the inside and outside of the yoke before reassembling the starter.

Field winding replacement

Disconnect the earthed-end of the winding at the yoke. Drill out the soldered connection (early-production M35J starters) or riveted connection in other cases. Alternatively, the end of the rivet can either be filed or ground away and the rivet then tapped from the yoke.

Slacken the four pole-shoe retaining screws with a power-operated screwdriver. Remove two of these screws from a diametrically opposite pair of pole-shoes and remove the two pole shoes from the yoke. Providing the remaining pair of pole-shoes are sufficiently slackened, the field winding can be slid out from beneath the shoulders of the in-situ pole-shoes and withdrawn from the yoke.

Wipe clean the yoke and the insulating piece which separates the field winding brush-joint from the yoke. Loosely fit the new field winding and the four pole-shoes in the yoke and position the insulation piece between brush-joint and yoke. Tighten the pole-shoes screws evenly to a torque of 40.70 Nm (30 lbf ft) and make a good riveted connection between the earth-end of the winding and the yoke.

(iv) Roller Clutch and Drive Operating Mechanism

Check the clutch action. The pinion should have instantaneous take-up of the drive in one direction and be free to rotate in the other. Check that the drive sub-assembly moves freely along the armature shaft splines. The armature shaft splines and corresponding splines in the drive sub-assembly, and all moving parts of the drive operating mechanism, should be liberally smeared with Shell SB2628 (home market and cold climates); Retinax 'A' (hot climates). The roller clutch mechanism is a sealed unit, pre-packed with sufficient grease to last the life of the starter. In the unlikely event of the clutch action becoming faulty, the drive sub-assembly will need renewing.

Note: The service replacement drive assembly (complete with engagement lever) must be fitted to the armature shaft with the bevelled tip of the lever facing the commutator-end (see Fig. 1, item 10).

Pre-Engaged Starter Models M35J PE and 5M90 PE

(v) Bearings

The bearings in both end brackets are self-lubricating porous bronze bushes.

New bushes must be completely immersed in Shell 'Turbo 41' oil, or clean engine oil, for at least 20 min. before being fitted.

The bushes must not be reamed after fitting, otherwise the self-lubricating qualities will be impaired (A special fitting mandrel is required, refer last para.).

Renew the bushes when there is excessive side-play of the armature shaft. Fouling of the pole-shoes by the armature, or inefficient operation of the starter, is likely to occur when the inner diameter of the bushes exceeds the following dimensions:— commutator end bracket bush 11.20 mm (0.441 in), drive end bracket bush 12.09 mm (0.476 in).

The bush in the commutator end bracket should be removed by first inserting a 12 mm (15/32 in) thread tap into the bush and then after clamping the shank of the thread tap in a wheel-operated (or lever-operated) power press, withdraw the bush from the bracket.

The bush in the drive end bracket should be pressed out with a wheel-operated (or lever-operated) power press. Alternatively, the bush can be tapped out with a suitably-sized mandrel.

New bushes should preferably be pressed into position, but alternatively can be tapped into position, using a shouldered mandrel with the fitting pin dimension polished to the following diameters:— commutator end bracket bush 11.117 mm (0.4377 in), drive end bracket bush 12.011 mm (0.4729 in).

(vi) Solenoid

Note: If the solenoid is checked in-situ on the motor, first disconnect the solenoid-to-motor connecting link at the 'STA' terminal of the solenoid.

Continuity of the two solenoid operating windings can be checked simultaneously by connecting a 12V battery-operated test lamp (of low wattage) between the solenoid main terminal marked 'STA' and a good earth point on the solenoid body. **The lamp should light.** If test is unsatisfactory, the solenoid must be renewed. If test is satisfactory, check the resistance of each of the windings. Refer 2. TECHNICAL DATA, sub-heading (b).

Check for satisfactory opening and closing of the solenoid contacts. First check opening of the main contacts by connecting a 12V battery-operated test lamp of high wattage (e.g. 60-watt) between the main terminals. **The lamp should not light.** If this test is satisfactory, leave the test lamp connected and check closing of the main contacts by energising the solenoid, with a separate 12V circuit connected between the small unmarked 'Lucar' blade and a good earth point on the solenoid body. **The solenoid should be heard to operate and the lamp should light.**

Note: The solenoid may incorporate an additional small 'Lucar' terminal blade (marked 'IGN'), which is for use in conjunction with a ballast ignition system. It is sufficient to ensure that this terminal becomes electrically connected to the solenoid main input terminal, when the solenoid is energised.

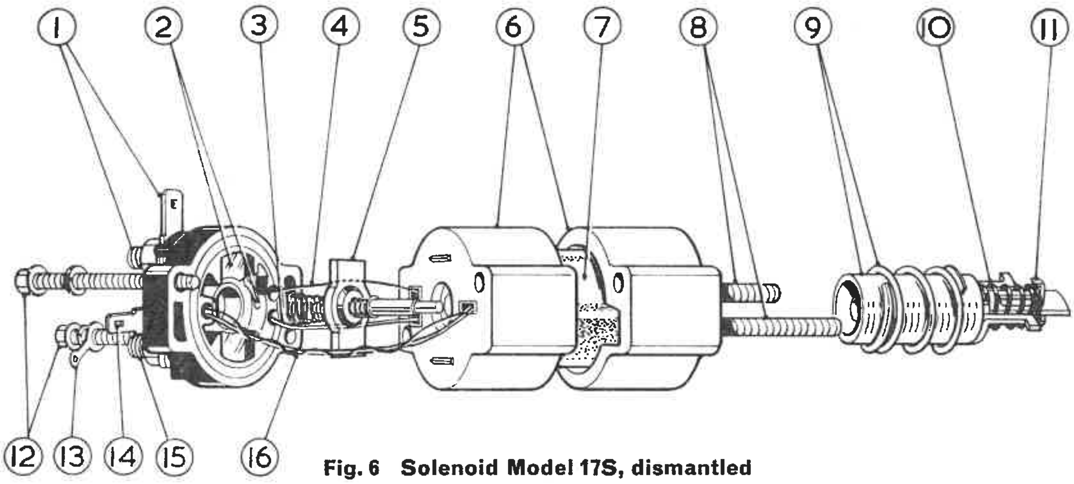


Fig. 6 Solenoid Model 17S, dismantled

1 Main input terminal and 'Lucar' terminal (main external circuits)
2 Base assy. comprising: fixed 'main contacts and ballast ignition (IGN) contact
3 Closing coil connection to 'STA' terminal
4 Hold-on coil connection to earth strip
5 Moving spindle and contact assy.
6 Solenoid body
7 Coil or winding assy.
8 Solenoid fixing studs
9 Plunger and drive return spring
10 'Lost motion' spring
11 Spring retaining-plate
12 Solenoid assy. screws
13 Earth strip, hold-on coil
14 Small unmarked 'Lucar' terminal (solenoid operating)
15 Main 'STA' terminal
16 Closing and hold-on coil connections to small (unmarked) 'Lucar' blade terminal

If previous testing confirms that the solenoid contacts are unsatisfactory, the solenoid unit can either be renewed or repaired.

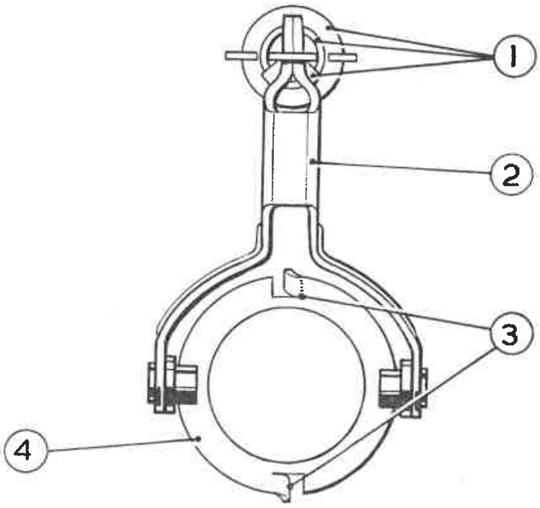


Fig. 7 Method of assembling engagement lever and solenoid plunger (refer 'NOTE')

1 { Plunger, Lost-motion spring, Retaining plate
2 Drive engagement lever
3 Locking shoulders
4 Drive operating plate (viewed from pinion end)

Note: In the case of later-production M35J starters, and all 5M90 starters, individual items 2 & 4 are manufactured as a sub-assembly.

Renewing the solenoid contacts.

Remove the two screws securing the terminal and base assembly to the solenoid body. Apply a hot soldering iron alternately to the three winding connections in the moulded cover (The small unmarked 'Lucar' terminal, the main terminal marked 'STA' and the earth connector strip which fits beneath one of the securing screws). When the solder runs free, shake most of the melted solder out of the joints by tapping the solenoid terminal ends sharply down on the bench. Now clamp the solenoid body in a vice (terminals uppermost) and while applying a constant pull on the moulded cover, apply the soldering iron alternately to the soldered connections until the terminal and base assembly is freed. When re-making the soldered connections, avoid dry-soldered joints by ensuring the terminal connections are adequately heated before applying the solder. Tighten the terminal and base assembly securing screws to a torque of 2.033 Nm. (1.5 lbf ft).

Note: (1) Ensure connections of the two windings are re-soldered to the correct terminals (See Fig. 6, items 3, 4 & 16).

Note: (2) If the joint between the two halves of the solenoid body becomes inadvertently disturbed during repair of the solenoid, a sealing compound resistant to petrol and oil must be applied to the joint during reassembly of the solenoid.

(d) Reassembly

Assembling the starter is simply a reversal of the dismantling procedure. Sequence of assembling components is illustrated in Fig. 1.

When assembling the commutator end bracket to the yoke, it is important to position the brushes and their flexibles correctly (see Fig. 3).

In the case of early-production M35J starters, the drive engagement lever and the drive operating plate are separate components. During reassembly of the starter, slotted bushes in the drive engagement lever must be correctly engaged with the operating plate incorporated in the drive sub-assembly (see Fig. 7). Bevelled tip of lever must face the commutator-end see Fig. 1, item 10).

Fitting the solenoid plunger to the drive engagement lever is facilitated by positioning the broad section of the spring retaining plate at 6 o'clock (see Fig. 7, item 1). A new design 'H' type retaining plate supersedes the inverted 'Y' type (λ) and eliminates the need for special positioning of the retaining plate when fitting the solenoid plunger to the drive engagement lever.

Discard the original 'spire nut' retaining ring, which secured the drive engagement lever pivot-pin (see Fig. 1, items 12 & 17), and fit a new one.

Note: Later-production starters may not incorporate a pivot-pin retaining ring, in which case the pivot-pin should be renewed and stake-riveted in about four places between pin and bracket.

Take care to re-fit the internal thrust washer on the armature shaft at the commutator end (see Fig.1, item 26).

Armature end float is 0.25 mm (0.010 in), controlled at the commutator end by fitting the required number of shims (usually one or two). Assemble the parts in the sequence illustrated in Fig. 1 and ensure they are locked together and prevented from rotating separately by the cotter pin, which should engage with the locking piece on the thrust plate.

Tightening torques

Commutator end bracket securing screws	4.52 Nm (40 lbf in)
Drive end bracket securing bolts, or nuts	10.84 Nm (8 lbf ft)
Solenoid unit securing nuts	6.10 Nm (4.5 lbf ft)

Other tightening torques are quoted elsewhere if associated with a particular fitting operation.

INERTIA DRIVE STARTER, MODEL M35J

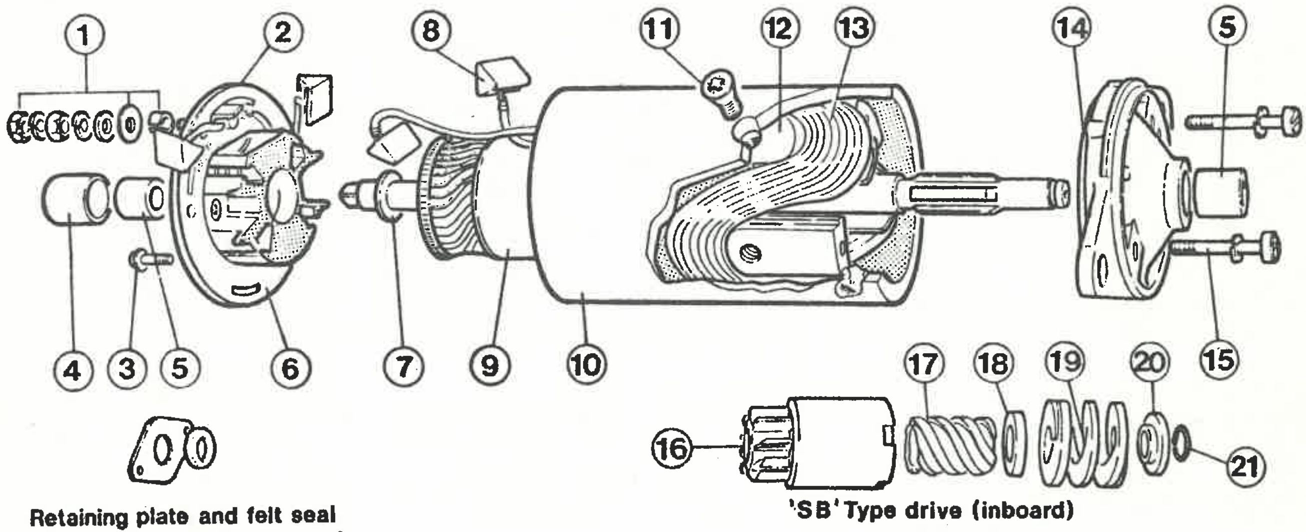


Fig. 1 Typical Starter, Model M35J

1 Terminal nuts and washers, bush
2 Commutator end bracket
3 C.E. bracket fixing screws (4), early M35J (2)
4 Plastic sealing cap (when fitted)
5 Bearing bush (self-lubricating)
6 Sealing washer (when fitted)
7 Thrust washer
8 Brushes
9 Armature
10 Yoke
11 Pole-shoe retaining screws (4)
12 Pole-shoes (4)
13 Field coil assembly
14 Drive end bracket
15 Fixing bolts (studs & nuts, early M35J)
16 Pinion and barrel
17 Screwed sleeve
18 Thrust collar
19 Main spring
20 Shroud washer (circlip retaining)
21 Circlip (retaining drive parts on armature shaft)

1. GENERAL

The starter has a yoke diameter 90 mm (3.5 in) and incorporates a series wave-wound field winding face-type commutator and fully-insulated brushgear.

The wave-wound field winding has no interconnecting joints. One end of the continuously wound winding is earthed to the yoke and the other end terminates at a pair of brushes (see Fig. 1).

The face-type moulded commutator forms the end-face of the armature (see Fig. 5) and the fully-insulated brushgear comprises a plastic brushbox moulding with wedge-shaped brushes and coil type springs (see Fig. 3).

Independently fixed end-brackets and a windowless yoke eliminates conventional through bolts and the bandcover. The drive end bracket is secured by bolts, or studs, locating in threaded holes in two diametrically opposite pole-shoes and the commutator end bracket is secured by screws locating in threaded holes in the edge of the yoke (see Fig. 1, items 3 & 15). Deletion of the bandcover is due to the fact that routine inspection and servicing of the commutator and brushgear, is unnecessary.

2. TECHNICAL DATA

Lock torque: 9.1 Nm (6.7 lbf ft) (0.92 kgf m) with 365A max. at 7V.

Torque at 1,000 rev/min: 5.4 Nm (4.0 lbf ft) (0.55 kgf m) with 265A max. at 8.5V.

Light running current: 50A at 8000-11500 rev/min.

Starter performance is dependent on the capacity and state of charge of the associated battery. The figures given are typical performance characteristics obtained with a 12V 43Ah (20 h. rate) battery in a good state of charge.

3. SERVICING

No routine maintenance is necessary. The armature bearings are porous-bronze bushes, initially impregnated with sufficient oil lubricant to provide self-lubrication until major overhaul of the starter becomes necessary. The starter should be dismantled for detailed inspection during major engine overhaul, when the commutator should be serviced if necessary and the brushes and armature bearings renewed.

Inertia Drive Starter, Model M35J

(a) Starter in Situ

If the starter fails to crank the engine, or cranks the engine at a low speed, consider the fault symptoms. It may be possible to rectify the fault without removing the starter from the engine.

(i) Starter operates and runs freely as a motor, but engine is not cranked

Starter pinion not engaging with engine flywheel. Probably due to:

The battery (Extremely low state of charge). Refer subsequent para. (iv).

Faulty starter drive (Faulty component(s), or sticking pinion). Remove starter from engine and inspect the drive. Renew faulty part(s). Check whether the pinion is sticking, as follows:

Rotate pinion into engaged position and then release it. The pinion restraining spring should return the pinion smartly to the disengaged out-of-mesh position. If the pinion sticks, lubricate the helical splines of pinion and sleeve with machine oil and activate the pinion until it moves freely.

(ii) Starter does not operate

Check and eliminate in the following order:

Battery terminal connections (Must be clean and tight).

Battery condition (Check for sufficient charge and internal fault). Refer subsequent para. (iv).

Heavy-duty cable connections (Check tightness).

Earth connections (Check tightness). Check battery earth connection to frame, and check engine/gearbox earth connection to frame.

Starter switch or solenoid (Check continuity).

Starter pinion jammed in engine flywheel (Refer following sub-headings).

Cars and light commercial vehicles: Switch on the headlamps. Operate the starter control switch and observe whether headlamp brilliance dims.

If headlamp brilliance is unaffected, it proves that the pinion is not jammed. (Starter internal fault).

If headlamp brilliance dims, either the pinion is jammed or there is an internal fault in the starter. (Proceed as follows). Ensure either the ignition switch or fuel control switch is OFF. Engage top gear and rock the vehicle forward and backward, several times. This normally results in a jammed pinion being freed and is usually confirmed by the audible return of the pinion to the disengaged out-of-mesh position. Disengage gear and check whether starter now operates. If not, carry out the alternative method of freeing a jammed pinion as detailed for industrial engines.

Industrial engines: Use the blade of a screwdriver and prise a cylindrical dust cover (when fitted) from the end-face of the starter, to expose a square end of the starter shaft. Check that the engine or vehicle is in neutral gear. Apply a spanner to the square end of the shaft and determine whether the shaft can be turned in both directions. If so, it proves that the pinion is not jammed. (Starter internal fault).

If the shaft can only be turned in one direction, it confirms that the pinion is jammed. Continue turning the shaft by repositioning the spanner at least three times on the square end of the shaft, and the pinion should then be freed.

Note: Frequent jamming of the starter pinion is usually caused by the pinion teeth being excessively worn. The fault can usually be rectified by renewing the starter pinion only but if the flywheel teeth are excessively worn, the flywheel must also be renewed.

(iii) Starter cranks engine at a low speed

Check and eliminate in the following order:

Battery condition (Check for sufficient charge and internal fault). Refer following para. (iv).

Battery terminal connections (Must be clean and tight).

Heavy-duty cable connections (Check tightness).

Earth connections (Check tightness). Check battery earth connection to frame, and check engine/gearbox earth connection to frame.

(iv) The Battery

For satisfactory starter performance, the battery should be at least 70% charged and must be free of internal faults.

Check, with a hydrometer, the specific gravity of the electrolyte in each of the battery cells.

If there is a variation of more than 40 points (0.040) between any cell readings, the battery is faulty and must be renewed.

	Specific gravity readings corrected to 15°C (60°F)	
State of charge	*Climates normally below 25°C (77°F)*	*Climates normally above 25°C (77°F)*
Fully charged	1.270 – 1.290	1.210 – 1.230
70% charged	1.230 – 1.250	1.170 – 1.190
Discharged	1.100 – 1.120	1.050 – 1.070

Electrolyte Temperature Correction

For every 10°C (18°F) below 15°C (60°F) subtract 0.007

„ „ „ „ above „ „ add 0.007

(b) Bench Testing

Clamp the starter in a vice.

If starter testing equipment is available, first check the starter light running current and speed and, if the test is satisfactory, proceed to check lock torque performance (refer 2, TECHNICAL DATA)

If starter testing equipment is not available, or previous testing establishes that dismantling is necessary, proceed to following sub-heading (c).

(c) Dismantling

(i) Dismantling (renewing) the drive assembly

M35J 'SB' type drive assemblies are retained on the armature shaft by a circlip, enclosed by a shroud washer which in turn retains the circlip in its groove in the shaft (see Fig. 1, items 20 and 21). In this case, to dismantle the drive, it will be necessary to use a special tool to compress the main spring and press the shroud washer away from the circlip, so exposing the circlip and enabling it to be removed from its groove in the shaft (see Fig. 2). The drive parts can then be renewed.

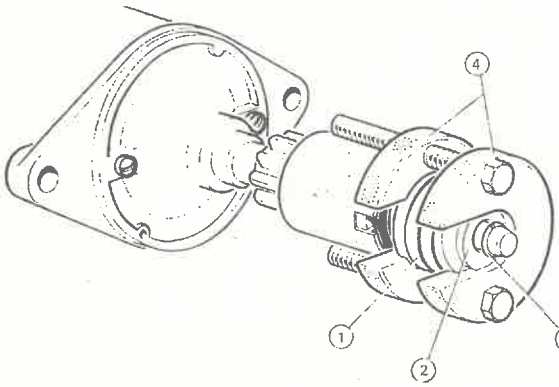


Fig. 2 Using main spring compressing tool to dismantle circlip-retained 'SB' type drive

1 Main spring 2 Shroud washer 3 Circlip

4 Main spring compressing tool for exposing circlip (the tool illustrated is manufactured by J. W. Pickavent & Co. Ltd., Kilnhouse Lane, St. Annes, England, and is obtainable from most major suppliers of motor spares).

(ii) Further dismantling

Remove the commutator end bracket securing screws and the drive end bracket securing bolts (or nuts), then separate the major parts of the starter.

Note: Unless the starter is being reconditioned, full dismantling may not be necessary. Providing the drive is satisfactory, remove the commutator end bracket and then inspect the brushgear and commutator. and inside the yoke.

(d) Bench Inspection and Testing of Components

(i) Brushgear

Check for sticking brushes. If necessary, clean brushes and brushbox moulding with a petrol-moistened cloth.

Check whether the brushes need renewing. Brushes worn to approximately 8 mm (5/16 in) must be renewed, as a set.

Two of the brushes are serviced complete with the commutator end bracket terminal but the field winding brushes will need soldering to the original brush-flexibles, which should be cut about 6 mm (¼ in) from the field winding conductor. Note arrangement of the short and long brush-flexibles (see Fig. 3) and ensure a perfect soldered joint.

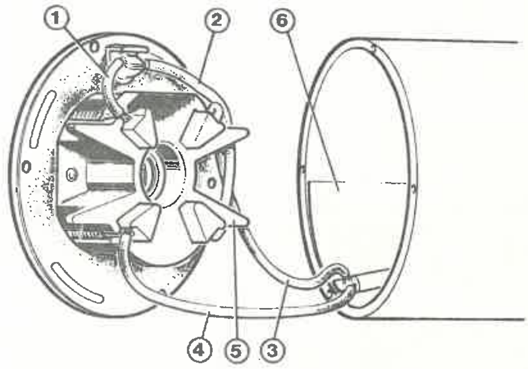


Fig. 3 Brushgear arrangement

1 Short brush-flexible, C/E bracket
2 Long brush-flexible, C/E bracket
3 Long brush-flexible, field winding
4 Short brush-flexible, field winding
5 Brush-flexible retaining lugs
6 Yoke insulation piece

Check the brush spring pressure, with a push-type spring gauge (see Fig. 4). Spring pressure should be 7.80 N (28 ozf or 0.8 kgf) approx.

Note: The brush springs are not serviced individually. If an incorrect spring pressure reading is obtained, the bracket assembly must be renewed.

Check insulation of the brush springs and the terminal post. Connect a 110V a.c. 15-watt test lamp, between a clean unpainted part of the bracket and each of the springs in turn and then between the bracket and the terminal post. **The test lamp should not light.**

(ii) Armature

The face of the commutator should be clean and free from burnt spots. Clean the commutator with a petrol-moistened cloth and, if it should be necessary, use fine emery cloth to rectify burnt spots, prior to using the petrol-moistened cloth.

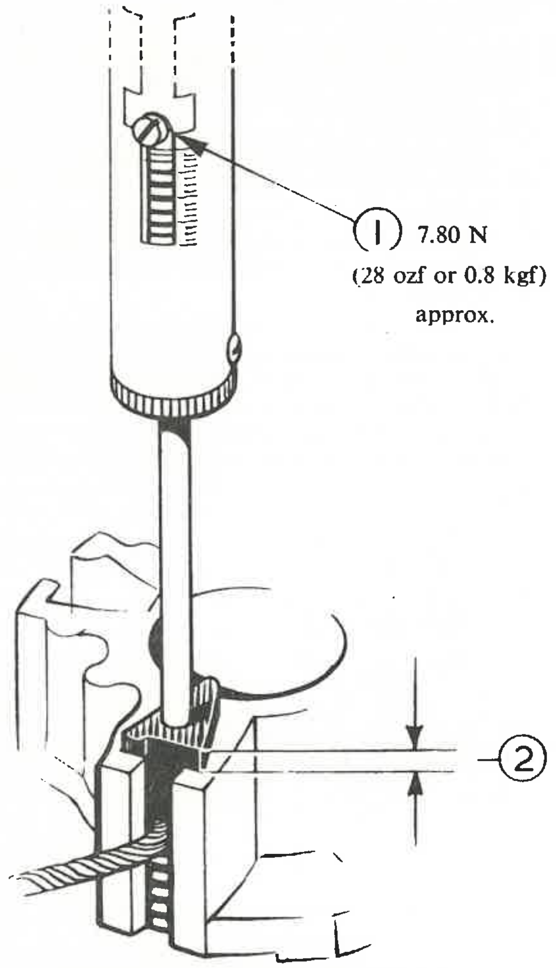


Fig. 4 Checking brush spring pressure

1 Push type spring gauge with sliding marker indicating reading where 'arrowed' (Alternatively, the gauge could be dial-type)
2 1.5 mm (0·062 in.) approx.

Note: Later design brush-boxes incorporate lugs for retaining the brush-flexibles (see Fig. 3, item 5).

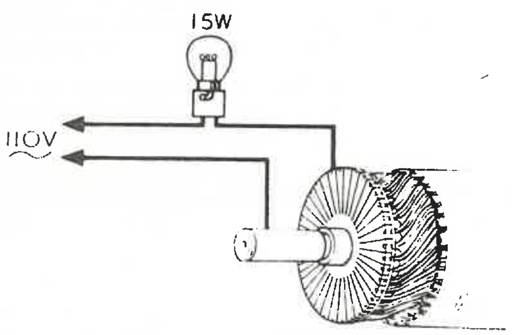


Fig. 5 Armature insulation test

In some cases it may be necessary to skim the commutator. The minimum thickness to which the commutator copper may be skimmed, before a replacement armature becomes necessary, is 2 mm approx. (0·080 in.).

The skimming operation should be terminated by polishing the commutator surface with fine emery cloth, then wipe clean with a petrol-moistened cloth. DO NOT UNDER-CUT THE INSULATION SLOTS.

The armature insulation can be checked by connecting a 110V a.c. 15-watt test lamp between a commutator segment and the shaft. **The lamp should not light.** (see Fig. 5)

Short-circuited armature windings (indicated by a high current consumption, low light running speed and low lock torque performance) can only be detected by the use of specialised armature testing 'Growler' equipment. If this equipment is not available, the only alternative is to check the armature by substitution.

If the armature laminations have been in contact with the pole-shoes, the armature bearings are probably excessively worn. First check that the pole-shoes are tight and that the armature runs true in a lathe. Then, if necessary, renew the armature bearings (refer subsequent para. iv).

(iii) Yoke and Field Winding Assembly

Inspect the field windings in-situ for obvious signs of a fault. A visual indication of a breakdown in field winding insulation will eliminate the need for testing and the field winding must be renewed.

Providing field winding insulation appears to be satisfactory, and providing the starter has been sufficiently dismantled to enable the earthed-end of the field winding to be inspected, check continuity between field winding conductor and flexible link connection to the yoke. In the case of early-production M35J starters, check for a good soldered joint between flexible link and yoke. In other cases, check for a firmly riveted connection between flexible link and yoke.

If there are no obvious signs of a field winding fault, providing the armature has previously been tested (para. ii) and found to be satisfactory, consider the results of starter performance tests which should previously have been carried out if the equipment was available. If light running speed and torque tests were unsatisfactory, then disconnecting the earthed-end of the field winding to enable a positive field winding insulation test to be carried out, is justified.

After disconnecting the earthed-end of the field winding at the yoke (not the hot-pressed joint between field winding and flexible link), carry out a positive test of the field winding insulation by connecting a 110V a.c. 15-watt test lamp between the disconnected end of the winding and a clean unpainted part of the yoke. **The test lamp should not light.** Ensure neither of the brushes or bare part of their flexibles are contacting the yoke during the test.

A field winding continuity test is unnecessary in the case of full-dismantling, where it is possible to inspect the joints at both ends of the field winding. In the case of partial-dismantling (commutator end bracket only removed), field winding continuity can be checked by connecting a 12V battery-operated test lamp between either of the brushes and a clean unpainted part of the yoke. **The test lamp should light.** (see Fig. 6)

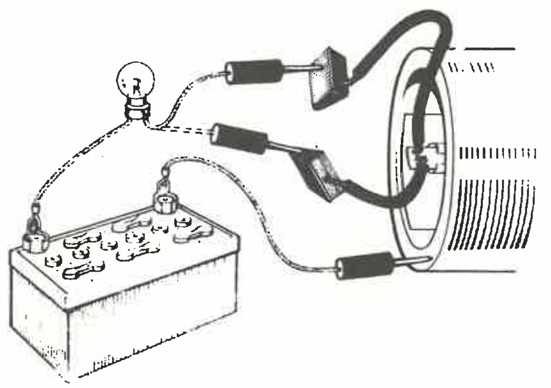


Fig. 6 Field winding continuity test

If field winding insulation and continuity are found to be satisfactory, wipe clean the inside and outside of the yoke before reassembling the starter.

Field winding replacement

Disconnect the earthed-end of the winding at the yoke. Drill out the soldered connection (early-production M35J starters) or riveted connection in other cases. Alternatively, the end of the rivet can either be filed or ground away and the rivet then tapped from the yoke.

Slacken the four pole-shoe retaining screws with a power-operated screwdriver. Remove two of these screws from a diametrically opposite pair of pole-shoes and remove the two pole shoes from the yoke. Providing the remaining pair of pole-shoes are sufficiently slackened, the field winding can be slid out from beneath the shoulders of the in-situ pole-shoes and withdrawn from the yoke.

Wipe clean the yoke and the insulating piece which separates the field winding brush-joint from the yoke. Loosely fit the new field winding and the four pole-shoes in the yoke and position the insulation piece between brush-joint and yoke. Tighten the pole-shoes screws evenly to a torque of 40.70 Nm (30 lbf ft) and make a good riveted connection between the earth-end of the winding and the yoke.

(iv) Bearings

The bearings in both end brackets are self-lubricating porous bronze bushes.

New bushes must be completely immersed in Shell 'Turbo 41' oil, or clean engine oil, for at least 20 min. before being fitted.

The bushes must not be reamed after fitting, otherwise the self-lubricating qualities will be impaired (A special fitting mandrel is required, refer last para.).

Renew the bushes when there is excessive side-play of the armature shaft. Fouling of the pole-shoes by the armature, or inefficient operation of the starter, is likely to occur when the inner diameter of the bushes exceeds the following dimensions:-
commutator end bracket bush 11.20 mm (0.441 in),
drive end bracket bush 19.15 mm (0.754 in).

The bush in the commutator end bracket should be removed by first inserting a 12 mm (15/32 in) thread tap into the bush and then after clamping the shank of the thread tap in a wheel-operated (or lever-operated) power press, withdraw the bush from the bracket.

Note: The commutator end bracket may incorporate a bearing felt seal and retaining plate (see Fig. 1) in which case it will be necessary to remove two rivets securing these parts to the bracket, before the bearing bush can be renewed. A service replacement bearing kit, includes new rivets.

The bush in the drive end bracket should be pressed out with a wheel-operated (or lever-operated) power press. Alternatively, the bush can be tapped out with a suitably-sized mandrel.

New bushes should preferably be pressed into position, but alternatively can be tapped into position, using a shouldered mandrel with the fitting pin dimension polished to the following diameters:—
commutator end bracket bush 11.117 mm (0.4377 in),
drive end bracket bush 19.042 mm (0.7497 in).

(d) Reassembly

Assembling the starter is simply a reversal of the dismantling procedure. Sequence of assembling components is illustrated in Fig. 1.

Take care to re-fit the internal thrust washer on the armature shaft at the commutator end (see Fig. 1, item 7).

When assembling the commutator end bracket to the yoke, it is important to position the brushes and their flexibles correctly (see Fig. 3).

Tightening torques

Commutator end bracket securing screws	4.52 Nm (40 lbf in)
Drive end bracket securing bolts, or nuts	10.84 Nm (8 lbf ft)

PRE-ENGAGED STARTER MODEL M50

"OIL-AND-WATER-PROOF FROM SPLASH" AND "STANDARD WINDOWLESS" VERSIONS

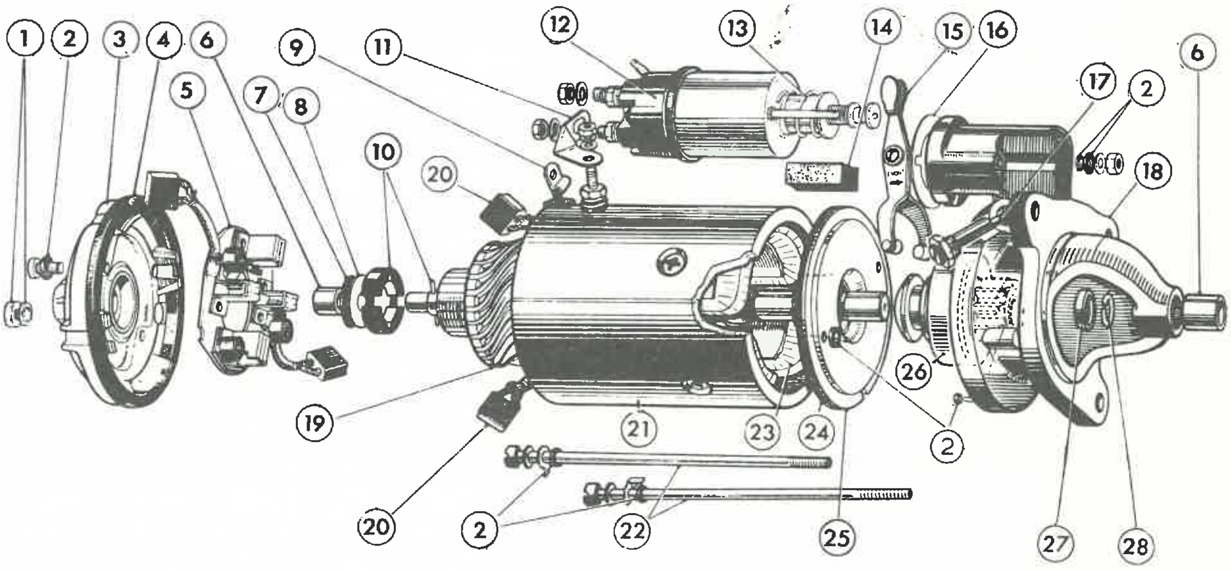


Fig. 1 Starter, dismantled

1 Nut & spring washer (C/E cover earth stud)
2 Sealing washers (when fitted)
3 Commutator end cover
4 Sealing ring
5 Brushgear assembly comprising, earth brushes and springs
6 Bearing bush
7 Fibre washer
8 Steel thrust washer
9 Flexible link
10 Brake shoes and cross peg
11 Copper link
12 Solenoid unit
13 Return spring
14 Sealing grommet
15 Engagement lever
16 Gasket
17 Eccentric pivot pin
18 Drive end fixing bracket
19 Armature
20 Insulated brushes (field coils)
21 Yoke
22 Through bolts
23 Field coils
24 Sealing ring (when fitted)
25 Intermediate bracket
26 Drive assembly
27 Thrust collar
28 Jump ring

1. DESCRIPTION

This pre-engaged starter is a four-pole four-brush machine, 5 in. (127 mm) diameter and having a solenoid-operated roller clutch drive. The solenoid incorporates two sets of contacts which provide two-stage switching. Normally, when the starter is operated the pinion moves into full engagement with the engine flywheel ring-gear and the first and second-stage contacts of the solenoid close simultaneously connecting all four field coils of the starter to the battery, and full cranking torque then develops. On occasions when tooth-to-tooth abutment occurs, the solenoid plunger continues to move by compressing a drive engagement spring inside the plunger. This plunger movement causes the first-stage contacts to close, connecting one of the field coils to the battery. The starter armature now turns at low speed and the pressure of the drive engagement spring, combined with push screw assistance from the drive helix, causes the pinion to move into mesh. When the pinion is fully engaged, the solenoid second-stage contacts close and the remaining three field coils are connected to the battery (Refer Fig. 2a, b & c).

The roller clutch prevents the armature from rotating excessively if the drive remains in mesh with the flywheel after the engine has started.

The starter is oil-and-water-proof from splash, when fitted with the full complement of seals as follows:

(i) Between commutator end cover and yoke.

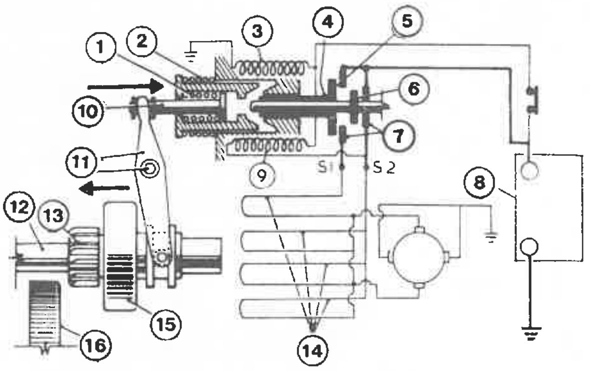
(ii) Between intermediate bracket and yoke.

(iii) Between solenoid and drive-end bracket.

(iv) At both ends of the through bolts, at the earthing stud, at the solenoid fixing studs and brushgear plate securing screws in the outer face of the commutator end cover.

Note: When the starter is manufactured for the purpose of superseding the earlier production non-sealed basic M50 starter (see Part C, Section 2), the specification for oil-and-water-proof sealing is limited to (i) and (iii). The starter will then be known as Model M50 "Standard Windowless".

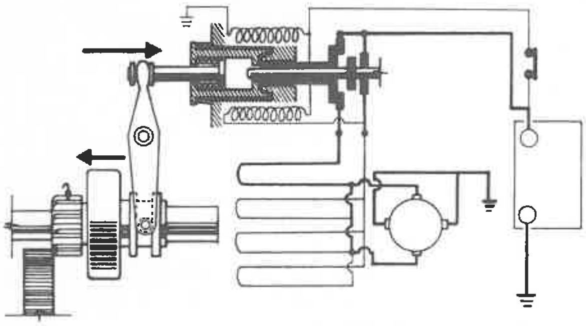
Pre-engaged Starter Model M50
"Oil-and-Water-Proof from Splash" and "Standard Windowless" Versions



Explanation of two-stage switching (Fig. 2a)

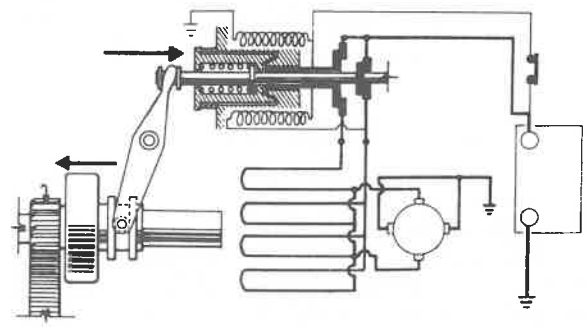
THE SOLENOID IS ENERGISED IN THE CONVENTIONAL MANNER TO MOVE THE PINION TOWARDS THE GEAR RING ON THE VEHICLE FLYWHEEL.

1 Engagement spring
2 Return spring
3 Solenoid hold-on winding
4 Switch operating spindles (concentric)
5 First switch contacts
6 Second switch contacts
7 Fixed contacts
8 Battery
9 Solenoid operating winding
10 Plunger
11 Operating lever and pivot
12 Armature shaft
13 Pinion
14 Field system: Four field coils in parallel
15 Roller clutch
16 Gear ring



(Fig. 2b)

IF TOOTH-TO-TOOTH ABUTMENT OCCURS, THE FIRST SET OF SOLENOID CONTACTS CLOSE AND ENERGISE ONE FIELD COIL ONLY, THUS GIVING LOW POWER INDEXING TO MOVE THE PINION TEETH INTO A MESHING POSITION.



(Fig. 2c)

ON FULL DRIVE ENGAGEMENT, THE SECOND SET OF SOLENOID CONTACTS CLOSE GIVING FULL CRANKING POWER.

IF THE PINION TEETH, ON MOVING FORWARD, CAN MESH IMMEDIATELY WITH THE GEAR RING, FULL DRIVE ENGAGEMENT TAKES PLACE WITH THE SIMULTANEOUS CLOSING OF BOTH CONTACTS IN THE FINAL STAGE.

2. ROUTINE MAINTENANCE

Routine maintenance is not necessary, although an occasional check should be made on the tightness of the electrical connections and the starter fixing bolts.

The starter should be dismantled for detailed inspection during major engine overhaul. The commutator should then be examined and the brushes and bearing bushes renewed (see 4 (d) i, ii & v).

3. TECHNICAL DATA

The starter performance is dependent on the capacity and state of charge of the associated battery. The following are typical performance figures obtained with a 12V 128 Ah (20h rate) battery in a 70% charged condition, at 20°C (68°F).

(i) Lock torque: 33·5 lbf ft (45·4 Nm) with 1165 A at 5·0 V.
(ii) Torque at 1,000 rev/min: 15·4 lbf ft (20·9 Nm) with 670 A at 8·0 V.
(iii) Light running current approx.: 115 A at 5500– 8000 rev/min.

4. SERVICING

(a) Testing in Position :– refer appropriate sub-heading ★

★ Starter cranks engine, but at reduced speed.

(i) **Check the Battery.**

Ensure that the battery is in a good state of charge. S.G. readings should be

State of Charge	Specific Gravity Readings Corrected to 15°C (60°F)	
	Climates normally below 25°C (77°F)	Climates normally above 25°C (77°F)
Fully Charged	1.270 – 1.290	1.210 – 1.230
70% Charged	1.230 – 1.250	1.170 – 1.190
Discharged	1.100 – 1.120	1.050 – 1.070

Electrolyte Temperature Correction

For every 10°C (18°F) below 15°C (60°F), subtract 0.007, and for every 10°C (18°F) above 15°C (60°F), add 0.007.

If there is a variation of more than 40 points (0.040) between any cell readings, the battery is suspect and should be removed for testing by a battery agent.

(ii) **Check that the battery and starter connections are tight.**

Particular attention should be paid to the battery terminal connections and earth connections to the vehicle frame. Do not overlook the engine earth cable (or flexible strap), usually fitted between the engine and the vehicle frame.

If the wiring connections appear to be satisfactory, but the fault persists, check with a moving-coil voltmeter (0–20V range) to ascertain whether sufficient voltage is being applied to the starter under load conditions.

Note: During the voltmeter checks, the starter must be made to crank the engine without actually starting it. In the case of petrol engines, if necessary disconnect the low-tension circuit of the ignition coil between the coil and the distributor, and in the case of diesel engines, switch off the fuel supply.

(iii) **Check the battery terminal voltage under load conditions.**

Connect the voltmeter across the battery terminals, and operate the starter switch. The test is satisfactory if the voltage now registered is approximately 10.5-volts (petrol engines) or 10-volts (diesel engines), in which case proceed direct to para. (v).

If the voltmeter reading is appreciably lower than previously stated, the starter should be removed from the engine for testing and examination.

If a higher voltage reading is obtained, there is a high resistance in the starter circuit or the starter solenoid, or the starter motor is faulty. Do not remove the starter from the engine at this stage, proceed to further testing (para. iv).

(iv) **Check battery earth and starter earth.**

Carry out two separate tests. First connect the voltmeter between the battery earth terminal and a good earth point on the vehicle frame, and then between the earth terminal stud on the starter end bracket and a good earth point on the vehicle frame. In each case the starter control switch must be operated. If the voltmeter registers not more than 0.5-volt, the battery earth and starter earth connections are satisfactory.

Note: If the starter earth test is unsatisfactory and no earth cable is fitted between the starter and the vehicle frame, check the engine earth cable, or strap, usually fitted between engine and frame.

(v) **Check the voltage at the solenoid main input terminal, under load conditions.**

Note: The solenoid main input terminal is linked to a smaller terminal by a copper strap marked 'BAT'.

Connect the voltmeter between the solenoid main input terminal and a good earth point on the starter or vehicle frame, then operate the starter switch. The voltmeter should register not more than 0.5-volt lower than that obtained at the battery terminals during the test in para. (iii). Approximately 10-volts (petrol engines) and 9.5-volts (diesel engines) should therefore be registered in this test.

If a lower reading is obtained, the heavy-duty cable connecting the battery to the starter is unsatisfactory.

If a higher-than-normal reading, previously obtained during the test carried out in para. (iii), is also obtained in this test, the solenoid contacts may be faulty or the starter has an internal fault.

In either case, the starter should be removed from the vehicle to rectify the fault. Refer to Bench Testing 4 (b).

★ Starter does not crank engine.

(i) **Repeat the checks detailed in para. (i) and para. (ii) of the previous heading.**

Using a moving-coil voltmeter (0–20V range), carry out the following tests:

(ii) **Check that there is battery voltage at the solenoid main input terminal.**

Note: The solenoid main input terminal is linked to a smaller terminal by a copper strap marked 'BAT'.

Connect the voltmeter between the solenoid main input terminal and a good earth point on the starter or vehicle frame. Battery voltage should be registered, indicating that the heavy-duty cable between the battery and the starter, the battery terminal connections, and the battery earth connections, are all satisfactory.

If this test is satisfactory, do not disconnect the voltmeter but proceed to further testing (para. iii).

(iii) **Check the voltage at the solenoid main input terminal, with the starter switch operated (voltmeter connected as in the previous test).**

If the starter fails to crank the engine and the voltage falls appreciably, or falls to zero, the starter has an internal fault and must be removed from the vehicle for detailed examination.

If the starter fails to crank the engine and the voltage remains unaltered, the failure is probably due to one of the following causes:— faulty control switch circuit, or solenoid unit, or there is an internal fault in the starter. Proceed to further testing (para. iv).

(iv) **Check the starter control switch circuit.**

Connect the voltmeter between the solenoid operating-winding terminal (small 'Lucar' blade) and a good earth point on the starter or vehicle frame, and operate the starter control switch. Battery voltage should be registered and the solenoid should be heard to operate, proving that the control switch circuit is satisfactory.

If this test proves to be satisfactory, the failure must be due to a faulty solenoid unit or a fault inside the starter. In either case the starter should be removed from the vehicle for more detailed testing and examination (refer 4 b).

If the test is unsatisfactory, first check the wiring associated with the switch and then prove the switch by making a temporary but direct connection between a convenient battery supply point and the solenoid operating-winding terminal. The solenoid and starter should now operate, indicating that the starter control switch is faulty and must be renewed.

(b) Bench Testing

Before dismantling completely, check the solenoid. Check for satisfactory closing of the first and second-stage contacts associated with terminals S1 and S2. Disconnect terminal S1 and apply a 12V battery supply between the solenoid 'Lucar' terminal and a clean part of the solenoid body or starter frame. Using a battery-operated ohmmeter or battery-operated test lamp, connect one lead to the solenoid main (largest) terminal and connect the other lead alternately to the terminals S1 and S2. If there is a zero reading on the ohmmeter or the test lamp lights, it proves that the solenoid contacts are satisfactory.

(i) If the solenoid contacts are satisfactory, the cause of starter failure can only be determined by dismantling the unit for detailed inspection. Proceed to 4 (c) and dismantle the unit to the stage noted for checking the commutator and brushgear.

(ii) If there is no contact continuity in the foregoing test, the cause may be either faulty operating windings or faulty contacts. To check the windings, disconnect the solenoid terminal S2 and use a good quality ohmmeter capable of measuring 0–1 ohm (e.g. Universal Avo-meter No. 8 Mk. II) to measure the resistance between the solenoid terminal S2 and the solenoid body or starter frame. This should be 0.76–0.88 ohm. If a suitable instrument for measuring resistance is not available, connect a 0–20A moving-coil ammeter in series with a 12V battery, solenoid terminal S2, and the solenoid body or starter frame. If the solenoid operating windings are satisfactory, a reading of 13.5–15.75A will be obtained.

(c) Dismantling

Remove copper link, which connects solenoid terminal S2 to yoke terminal.

Disconnect the flexible link connecting solenoid terminal S1 to the first-stage field coil inside yoke.

Remove solenoid securing nuts. Take from the fixing studs a spring washer, or a metal washer and a sealing washer of similar size (when fitted).

Withdraw solenoid unit complete with gasket from drive-end fixing bracket, retrieving at the same time a small sealing washer (when fitted) which seals the threads of the solenoid fixing studs. Note that the solenoid plunger will be left attached to the starter when the main part of the solenoid is withdrawn.

To remove the solenoid plunger, grip plunger by hand, and lift up the front end of the plunger. Withdraw plunger from the fork in which it pivots at the top of the drive engagement lever.

Remove sealing grommet which is wedged between fixing bracket and yoke, where the solenoid attaches to the bracket.

Remove through bolts complete with spring washer, locking washer, and sealing washer (when fitted).

Remove two Phillips-recess screws from outer face of commutator end cover. (These screws, complete with sealing washers if the unit is fully-sealed, secure the brushgear assembly to the inner face of the end cover).

The commutator end cover assembly comprising sealing ring, brake shoe assembly, steel thrust washer, fibre packing washer and bearing bush can now be removed, leaving the brushgear still in its working position on the commutator.

Note: At this stage of dismantling, inspect brushes and commutator to see if these are the cause of starter failure. Information regarding inspecting and servicing commutator and brushgear is given in 4 (d) i & ii.

To remove brushgear assembly, grip the commutator end of the armature shaft and pull the armature forward so as to fully expose commutator and brushgear. Use a wire hook, or alternatively a small screwdriver on the edge of the brushgear plate, to lever up the brush springs so that the brushes can be disengaged from their brushboxes. The whole of the brushgear assembly can now be removed from the commutator and detached from the insulated brushes of the yoke assembly.

Withdraw yoke assembly from armature and drive-end bracket.

The sealing ring (when fitted) between yoke and intermediate bracket should now be removed from its retaining groove in the bracket.

Unscrew eccentric pivot pin from the side of fixing bracket.

The assembly comprising drive-end fixing bracket, drive engagement lever, and armature complete with roller clutch drive and intermediate bracket can now be dismantled. In the case of fully-sealed units, separation of the fixing bracket and intermediate bracket may cause two small sealing washers to become dislodged from a recess in the through bolt holes of the fixing bracket. Make a special point of retrieving these seals.

The armature assembly comprising roller clutch drive and intermediate bracket can now be dismantled. The drive assembly and intermediate bracket are retained on the armature shaft by a jump ring, locating in a groove in the armature shaft and retained by a thrust collar. By using a tubular tool (e.g. a box-spanner) the thrust collar can be driven squarely off the jump ring, which can then be removed from its groove. Make a special point of retrieving any packing shim(s), which may be assembled on the armature shaft between the intermediate bracket and the armature core. These control the armature end float to 0.025″ (0.63 mm) max.

(d) Bench Inspection

(i) Armature

The surface of the commutator should be clean and free from burnt spots. Clean the commutator with a petrol-moistened cloth. If necessary, use very fine glass paper or emery cloth, prior to using the petrol-moistened cloth.

The commutator may be skimmed to a minimum diameter of 1.5″ (38 mm) before a replacement armature becomes necessary. The commutator surface should then be polished with very fine glass paper or emery cloth. THE INSULATION SLOTS MUST NOT BE UNDERCUT.

If there are signs of thrown solder or the conductors have lifted from the commutator segments, the motor has probably been overspeeding. Check the operation of the roller clutch drive (4 (d) vi).

If the armature fouls the pole-shoes, it indicates worn bearings, loose pole-shoes, or the armature shaft is distorted. Check the armature in a lathe. If it is out of true, it should be renewed. If the armature is satisfactory, renew the bearings in both end brackets (4 (d) v).

Check armature insulation with a 110V a.c. 15W test lamp connected between one of the commutator segments and the armature shaft (Fig. 3). If the lamp lights the insulation is unsatisfactory.

Check armature for short-circuited windings, using 'GROWLER' equipment.

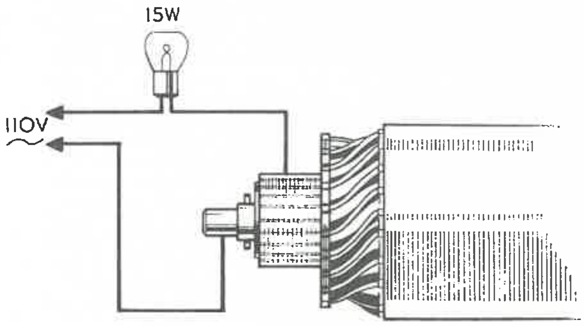


Fig. 3 Armature insulation test

(ii) Brushgear

Brushes should move freely in the brushboxes. Sticking brushes should be cleaned with a petrol-moistened cloth.

Brushes which are worn to approximately 0.313″ (8 mm) in length must be renewed. Service replacement brushes are preformed and do not require 'bedding' to the commutator.

Renewing the Brushes.

Insulated brushes (field coil): Place the yoke assembly on its end, with brush and terminal arrangement uppermost (Fig. 4). Cut the worn brush flexibles as near as possible to the field coil conductor. Carefully prise the brush flexible joining-part of the conductors away from the yoke, to provide sufficient space for soldering new brushes in position. Separate the ends of the two brush flexibles and position one each side of the conductor. Pinch the ends of the flexibles and conductor together with long-nosed pliers and bend the brush and flexibles firmly down over the edge and outside of the yoke (as illustrated in Fig. 4). This will help to retain the brush and its flexibles in position during the soldering operation and also prevent solder from running too far down the flexibles.

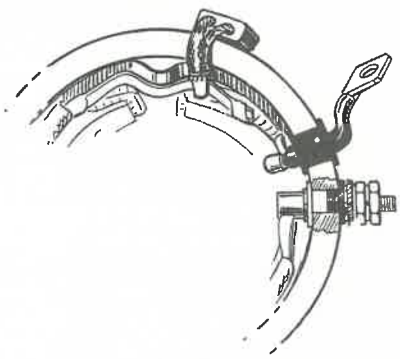


Fig. 4 Brush and terminal arrangement

Earth brushes (brushgear plate): Place the hot soldering iron on the rolled-over portion of the brush flexible joint. When the solder inside the joint is sufficiently heated, use a screwdriver and lever up the roller-over portion enough to enable the worn brush flexible to be pulled clear of the joint.

Checking the Spring Pressure.

Brush spring pressure should be checked with the whole of the brushgear loosely assembled to the commutator (i.e. all four brushes assembled in their working position). Hold the brushgear assembly firmly centralised on the commutator and apply a pull-type spring gauge to each spring in turn (Fig. 5). The spring pressure reading should be 42 ozf (11.70 N).

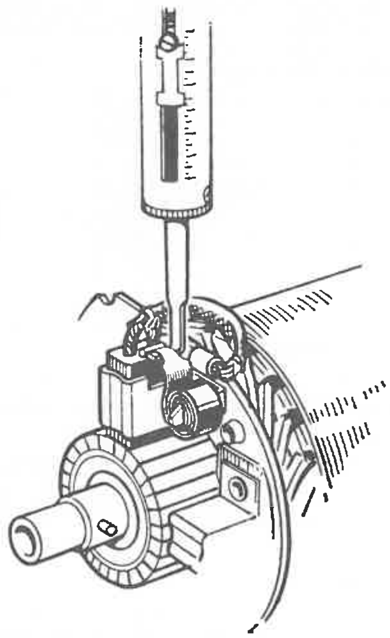


Fig. 5 Checking brush spring pressure

Checking the Brushgear Insulation.

Connect a 110V a.c. 15 watt test lamp between a clean part of the brushgear plate and each of the two insulated brushboxes in turn.

If the lamp lights, the insulation between the brushboxes and the brushgear plate is unsatisfactory and the brushgear assembly must be renewed.

(iii) Checking Field Coil Insulation.

Ensure that both insulated brushes are clear of the yoke and connect a 110V a.c. 15 watt test lamp between the eyelet of the flexible link and a clean part of the yoke. If the lamp lights, there is a short circuit between the field coils and the yoke. The field coil assembly must therefore be renewed.

(iv) Field Coil Continuity and Inter-winding Insulation.

Due to the very low resistance of the field coils and the method of interconnecting the conductors, the continuity of the field coils and the presence of a short-circuit between windings can only be determined by using special equipment. The field coils should be visually inspected *in situ* for signs of obvious fault(s). Check the various joints of the field coil assembly and look for discoloration (due to burning) of the winding insulation tape, which could indicate short-circuited windings. If in doubt, the field coil assembly should be proved by substitution.

Renewing the Field Coil Assembly.

Before disturbing the original fitting of the field coils in the yoke, pay particular attention to the following:—

The close-forming of the field coil conductors to the yoke to ensure adequate clearance for the armature.

A minimum clearance of 0.406" (10.32 mm) between the edge of the field coil assembly and the end face of the yoke.

The forming of the conductors around the two through bolt entry points.

The build-up of the insulators and washers associated with the yoke terminal (Fig. 4).

Use a wheel-operated or power-assisted screwdriver to unscrew and refit the pole-shoe retaining screws. The fitting operation will be facilitated by using pole-shoe expanding equipment and the screws should be progressively tightened. Tighten pole-shoe screws to a torque of 20 lbf ft (27.11 Nm), and yoke terminal lower fixing nut to 3.0 lbf ft (4.1 Nm)

(v) Bearings

The commutator-end cover, intermediate bracket and drive-end fixing bracket are fitted with self-lubricating porous bronze bearing bushes. New bushes should be allowed to stand for 24 hours at room temperature completely immersed in clean light engine oil. Alternatively the bush may be immersed in the above lubricant at 100°C for two hours and allowed to cool before removal. Bushes must not be reamed after fitting otherwise the self-lubricating qualities will be impaired.

Bushes must be replaced when there is excessive side-play of the armature shaft. Fouling of the pole-shoes by the armature, or inefficient operation of the starter, is likely to occur when the inner diameter of the bushes exceeds the following dimensions:—

Commutator-end cover bush 0.505" (12.82 mm), intermediate bracket bush 1.127" (28.62 mm), and drive-end fixing bracket bush 0.675" (17.14 mm).

The bush in the commutator end cover can be removed by inserting a 0.563" (14.30 mm) thread tap and then withdrawing the tap complete with the bush.

The bushes in the intermediate bracket and drive-end fixing bracket can be removed by using a press, or by supporting the bracket and carefully tapping the bush out with a mandrel.

New bushes should be pressed or carefully driven squarely into position using a shouldered polished mandrel with a bush fitting dimension as follows:—

Commutator-end cover bush 0.5005" (12.712 mm), intermediate bracket bush 1.1226" (31.054 mm), and drive-end fixing bracket bush 0.6705" (17.030 mm).

(vi) Roller Clutch and Drive Operating Mechanism.

The roller clutch is an over-running device which prevents the armature from rotating at excessive speed if the drive is held in engagement, after the engine has started.

A roller clutch drive assembly in good condition provides instantaneous take-up of the drive in one direction while it is free to rotate in the other. The assembly should move freely along the armature shaft splines without roughness or tendency to bind. All moving parts should be smeared liberally with Shell SB2628 (home market and cold climate): Retinax 'A' (hot climate).

(vii) Solenoid

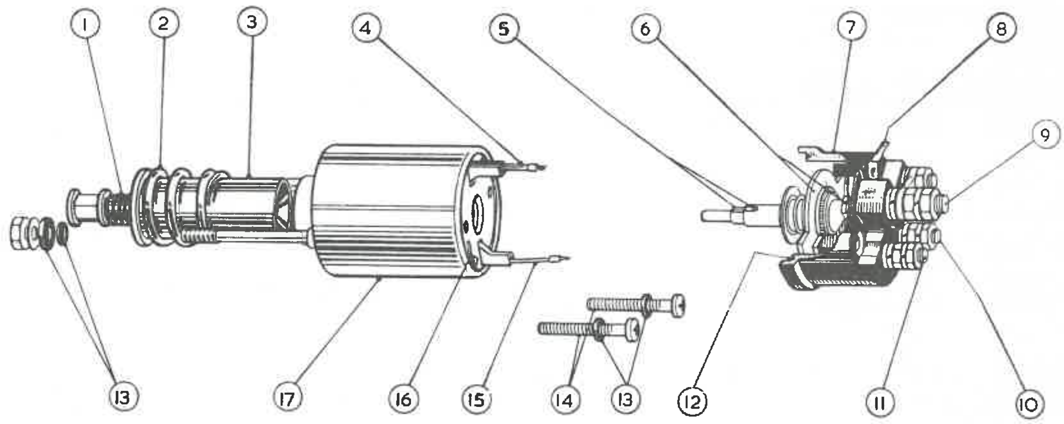
In addition to the engagement spring inside the plunger, and the return spring outside the plunger, the solenoid plunger is also fitted with a lost-motion spring (Fig. 6) which provides a measure of lost motion as the drive commences to disengage, ensuring that the solenoid contacts are open before the pinion retracts. This also takes effect if the pinion remains engaged with the flywheel ring gear when the solenoid switch is released.

Checking the operation of the solenoid is dealt with in 4 (b).

Renewing Contacts.

After being in service for long periods, the contacts may require renewing. If this is necessary the major part of the solenoid can be retained and the solenoid repaired by fitting a service replacement contact set comprising terminal-and-base assembly (refer Fig. 6).

Remove the two screws securing the terminal-and-base assembly to the solenoid body. Apply a hot soldering iron alternately to each of the two soldered terminal connections and wait for the solder to run free. Shake most of the melted solder out of the joint(s) by tapping the solenoid terminal ends sharply down on the bench. Now clamp the solenoid body in a vice and while continually pulling on the moulded cover, apply the soldering iron alternately to the two soldered connections until terminal-and-base assembly is freed. When re-making soldered connections, avoid dry-soldered joints by ensuring that the parts are clean and adequately heated before applying solder. Tighten the terminal-and-base assembly fixing screws to a torque of 1.8 lbf ft (2.44 Nm).



1 Lost motion spring
2 Plunger return spring
3 Plunger
4 Start of shunt & series windings ('Lucar' terminal)
5 Brass sleeve & cross pin
6 Moving contacts
7 Moulded cover
8 'Lucar' terminal blade
9 Main input terminal(s) with copper strap marked 'BAT'
10 Terminal S2
11 Terminal S1
12 Sealing ring
13 Sealing washer(s)
14 Fixing screw (moulded cover)
15 End of series winding (S2)
16 End of shunt winding
17 Solenoid body

Fig. 6 Solenoid Model 18S, dismantled

(e) Reassembly

Sequence of assembling components is illustrated in Fig. 1.

The following tightening torques apply to general assembly of the starter. (Other tightening torques are quoted elsewhere if associated with a particular fitting operation.)

Through bolts	8.0 lbf ft (10.84 Nm)
Brushgear securing screws in commutator end cover...	2.5 lbf ft (3.40 Nm)
Solenoid-unit fixing stud nuts	4.5 lbf ft (6.10 Nm)
Solenoid terminals S1 and S2 and yoke terminal upper- nuts	4.0 lbf ft (5.42 Nm)
Solenoid main battery terminal nut (when con- (12–14 mm)	4.0 lbf ft (5.42 Nm)
necting the cable) (16–17 mm)	8.0 lbf ft (10.84 Nm)
Starter earthing stud nut in commutator end cover (when connecting the cable) ...	6.0 lbf ft (8.13 Nm)

The following method of reassembly is recommended:—

Fit intermediate bracket and drive assembly to the armature. (Check that the shims have been included between armature core and intermediate bracket.)

Fully-sealed starters: Fit sealing ring to groove in intermediate bracket. Also, fit sealing washers to fixing bracket, one at each through bolt entry point and one on dowel peg (Fig. 1).

Assemble the armature sub-assembly to fixing bracket, locating intermediate bracket with dowel peg in fixing bracket.

Slide yoke assembly over armature and locate yoke with dowel peg protruding through edge of intermediate bracket.

At this stage, check for sufficient clearance between armature and field coil conductors, particularly at through bolt entry points.

Locate partially in their holders the two earth brushes and then the two insulated brushes. The springs should be wedged against the sides of the brushes to hold them temporarily in the lifted position for reassembly purposes.

Place brushgear assembly partially over the commutator (as far as brush flexibles will allow). Locate the two through bolts in the half-holes of the brushgear plate and screw the bolts a few threads into the fixing bracket to position the brushgear plate in its correct assembly position.

Now press the brushes on the commutator and check that the springs are properly located before manipulating the brushgear assembly further on the commutator and into its approximate working position.

Position the armature with brake-shoe cross peg in line with the two threaded holes in the brushgear plate.

Remove the two through bolts, but do not disturb the positioning of brushgear plate.

Assemble the fibre washer, steel washer and brake-shoe parts into the commutator end cover (refer to Fig. 1 to ensure correct sequence of assembly).

Position brake shoes in commutator end cover with cross peg slot in line with the two smallest of the four holes in the cover. (This will correspond with previous lining up of the armature shaft cross peg with the threaded holes in the brushgear plate, so ensuring approximate engagement of the cross peg with the brake shoes when fitting the end cover.)

Fit sealing ring to the commutator end cover.

Locate dowel peg in end cover approximately in line with dowel hole in the end face of the yoke and loosely assemble the end cover on the armature shaft and to the yoke.

Fix first the two through bolts and then the two brushgear securing screws. (Difficulty in locating the threads of the brushgear securing screws is avoided by fixing the through bolts prior to the brushgear securing screws.)

Loosely fit the eccentric pivot pin through the drive engagement lever and into the fixing bracket. (The pivot pin lock nut should not be tightened at this stage, as the pinion position must be set by adjusting the pivot pin when the starter is fully reassembled.)

Fit the block-shaped sealing grommet between the yoke and solenoid mounting portion of the fixing bracket. (Fitting the grommet is facilitated by soaping the grommet before assembly.)

Fit the solenoid plunger to the drive engagement lever. Fit the solenoid unit ('Lucar' terminal uppermost) complete with gasket and sealing washers.

Connect solenoid terminals S1 and S2 to the starter flexible link and yoke terminal, respectively.

(f) Pinion Setting

The position of the pinion must be set after reassembling the starter.

The amount of adjustment of the eccentric pivot pin for setting the pinion is 180°, and the centre of this limit is denoted by an arrow-head marking on the fixing bracket. When adjusting the pinion position, first apply gold size to the threads of the pivot pin, then turn the pivot pin until correct adjustment of the pinion is obtained with the arrow-head marking on the end face of the pivot pin within the 180° limit of the fixing bracket marking. After adjustment, secure the pinion setting by tightening the pivot pin lock nut to a torque of 16.0 lbf ft (21.70 Nm).

To check or carry out the adjustment, connect a 6V supply between the solenoid 'Lucar' terminal and the starter frame. (This will move the drive forward to the fully-engaged position.) With the pinion pressed lightly back, measure the space between the front of the pinion and the thrust collar on the armature shaft. This should be 0.005″–0.045″ (0.127—1.143 mm).

PRE-ENGAGED STARTING MOTOR MODEL M35K PE
(WITH ACTUATING SOLENOID MODEL 17S AND ROLLER CLUTCH DRIVE MODEL 7SD)

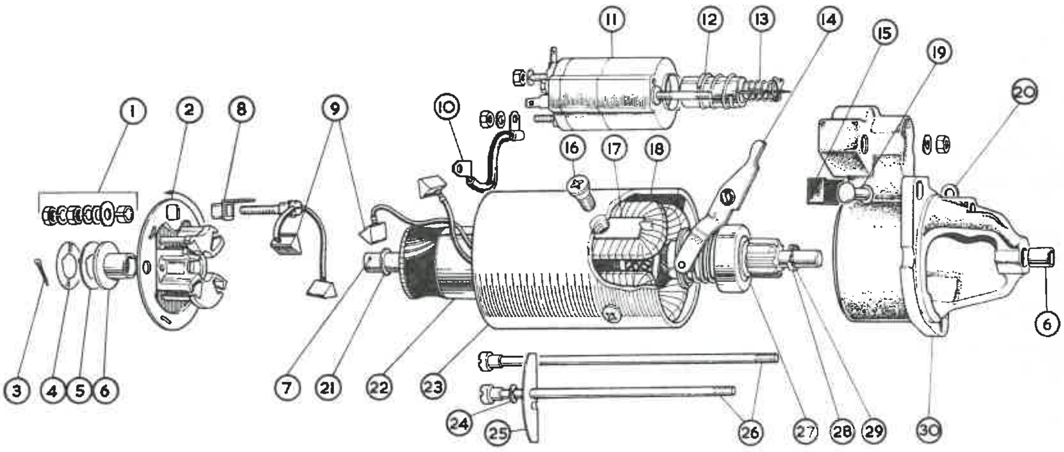


Fig. 1 Starting motor, dismantled

1 Terminal nuts and washers
2 Commutator end bracket assy. comprising: brush box moulding, springs and bearing bush
3 Cotter pin
4 Shim washer(s)
5 Thrust plate
6 Bearing bush
7 Cotter pin hole
8 Terminal insulator
9 Brush set
10 Connector link, solenoid to starting motor
11 Solenoid unit
12 Return spring
13 Lost motion spring
14 Engagement lever
15 Grommet
16 Pole screw(s)
17 Pole shoe(s)
18 Field coils
19 Pivot pin
20 Retaining ring
21 Thrust washer
22 Armature
23 Yoke
24 Spring washer
25 Chord plate
26 Through bolts
27 Drive assembly
28 Thrust collar
29 Jump ring
30 Drive-end fixing bracket

1. DESCRIPTION

The model M35K pre-engaged starting motor is a four-pole four-brush machine 3.5 in. (88.9 mm) diameter, with a series-parallel field, an armature with a face-type commutator and a solenoid-operated roller clutch drive.

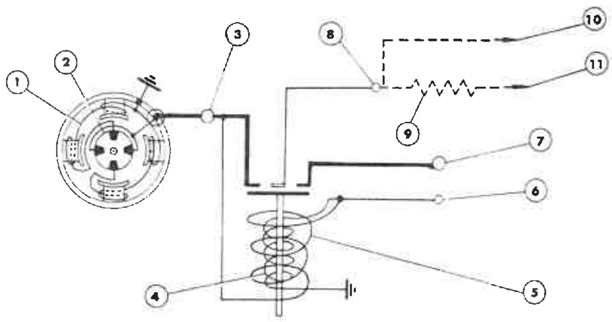


Fig. 2 Internal connections of starting motor and solenoid. (Broken lines applicable only when ballast ignition coil is used)

1 Field
2 Armature
3 Terminal 'STA'
4 Hold-on winding
5 Closing winding
6 Small (unmarked) terminal on solenoid
7 Battery supply terminal
8 Terminal 'IGN'
9 Ballast resistor
10 To ignition coil
11 To ignition switch

It is the same as starting motor model M35J PE except for the use of conventional field coils and through bolts. The M35K PE starting motor is shown dismantled in Fig. 1 and the internal connections of the starting motor and solenoid are shown in Fig. 2.

The face-type commutator on the end face of the armature works in conjunction with a fully-insulated brushgear assembly, comprising two pairs of wedge-shaped brushes and coil-type springs assembled into a brushbox moulding, which is riveted to the inside of the commutator end cover. The brushes are provided with a keyway to ensure correct fitting and the springs are held captive in the brushbox moulding. Access to the brushgear is obtained by removing the commutator end cover.

The supply voltage to the starting motor is applied (via the solenoid) direct to a pair of brushes. The four field coils are manufactured in series, with the start and finish of the windings terminating at a brush, and the centre point between two pairs of the coils is earthed direct to the frame of the starting motor by a riveted connection to the yoke. This method of connecting the field coils provides a series-parallel field circuit (see Fig. 2).

End float and axial movement of the armature is controlled at the commutator end by a thrust plate and a required number of packing shims (usually two), which are assembled on the armature shaft where it extends through the commutator end bracket. The parts are retained by a cotter pin secured through the end of the armature shaft (see Fig. 1).

The need for setting the pinion, to obtain correct operation of the solenoid, has been eliminated. The operating position of the drive engagement lever is therefore non-adjustable and the plain type pivot pin on which the lever swivels is retained in the fixing bracket by a special type of 'Spire' retaining ring, which fits into a groove in the pin.

A feature of a pre-engaged starting motor is that the pinion is fully-engaged with the engine flywheel before cranking torque is developed. Normally, when the starting motor is operated, the pinion moves into full engagement with the engine flywheel and the solenoid contacts close to connect the starting motor to the battery. Full cranking torque is then developed. On occasions when tooth-to-tooth abutment occurs, the solenoid plunger continues to move by compressing a drive engagement spring inside the plunger. This plunger movement causes the solenoid contacts to close, connecting the starting motor to the battery. The starter armature now commences to rotate and the pressure of the drive engagement spring, combined with push screw assistance from the drive helix, causes the pinion to move into mesh. Full cranking torque is then developed.

The roller clutch prevents the armature from rotating excessively if the drive remains in mesh after the engine has started.

2. ROUTINE MAINTENANCE

No routine maintenance is necessary, but occasionally check the tightness of the electrical connections.

The starting motor should be dismantled for detailed inspection during major engine overhaul. The commutator should then be serviced, if necessary, and the brushes and armature bearings renewed (refer 4 (d), paras i, ii and v).

3. TECHNICAL DATA

(a) Starting Motor

Lock torque (approx.): 8.0 lbf ft (10.85 Nm) with 375–400 A at 7.0 V.

Torque at 1,000 rev/min.: 5.5 lbf ft (7.46 Nm) current not greater than 290 A at 8.3 V.

Light running current: 70 A at 8,000–11,500 rev/min.

The performance of the starting motor depends on the capacity and state of charge of the associated battery. The figures quoted are typical performance characteristics obtained with a 12-volt 43 Ah (20 hr. rate) battery in a 70% charged condition at 20°C (68°F).

(b) Solenoid

Closing (or series) winding resistance: 0.21–0.25 ohm (measured between the small unmarked 'Lucar' terminal blade and the main output terminal marked 'STA').

Hold-on (or shunt) winding resistance: 0.9–1.1 ohm (measured between the small unmarked 'Lucar' terminal blade and a good earth point on the solenoid body).

4. SERVICING

If the starting motor fails to crank the engine, or cranks the engine at a low speed, the cause of the fault could be due to:—

(i) The battery, or faulty terminal connections.

(ii) The starter control switch, or its associated circuit.

(iii) The heavy-duty wiring, or connections, associated with the battery and starting motor.

(iv) The starting motor, or solenoid unit.

(a) Check the Battery and Terminal Connections

First, check that the battery terminal connections are clean and tight. If the fault still persists, check with a hydrometer the specific gravity in each of the battery cells. For satisfactory operation of the starting motor, the battery should be at least 70% charged.

	Specific gravity readings corrected to 15°C (60°F)	
State of charge	Climates normally below 25°C (77°F)	Climates normally above 25°C (77°F)
Fully charged	1.270–1.290	1.210–1.230
70% charged	1.230–1.250	1.170–1.190
Discharged	1.100–1.120	1.050–1.070

If there is a variation of more than 40 points (0.040) between any cell readings, the battery is suspect and should be removed from the vehicle for testing by a battery agent.

Electrolyte Temperature Correction

For every 10°C (18°F) below 15°C (60°F) subtract 0.007 and

For every 10°C (18°F) above 15°C (60°F) add 0.007.

(b) Check the Starting Motor in-situ

If previous testing has confirmed that the battery and the battery connections are satisfactory, it will be necessary to use a moving-coil voltmeter (0–20V range) to determine whether the fault requires the starting motor to be removed from the vehicle.

Note: During the voltmeter checks, the starting motor should crank the engine without actually starting it. In the case of petrol engines, if the starter switch is controlled via the ignition switch, the low-tension circuit of the ignition coil should be disconnected between the coil and distributor. In the case of diesel engines, switch off the fuel supply.

(i) Check the Battery Terminal Voltage under Load Conditions

Connect the voltmeter across the battery terminals, and operate the starter control switch. The starting motor should crank the engine and the voltmeter reading, which was originally battery voltage, should now be 10.5V (petrol engines) or 10.0V (diesel engines). If the test is unsatisfactory, one of the following conditions will apply:—

The voltmeter reading remains unaltered, the solenoid is not heard to operate and the engine is not cranked. This fault could be due to the starter control switch circuit, or the solenoid unit. To prove the starter control switch circuit, detach the cable from the solenoid-operating small (unmarked) 'Lucar' terminal blade on the solenoid and check that battery voltage is available at the terminal on the end of the cable when the starter control switch is operated. If satisfactory, proceed direct to further testing (para. iv) and prove the solenoid unit.

If the starter control switch test was unsatisfactory, the switch and associated wiring must be individually checked.

The voltmeter reading remains unaltered, the solenoid is heard to operate but the engine is not cranked or is cranked at a low speed. Either of these faults could be due to a high resistance in the heavy-duty wiring installation between the battery and starting motor, or a faulty solenoid or starting motor. Proceed to further testing (para. ii).

The voltmeter reading falls rapidly to a reading appreciably lower than quoted at the beginning of para. (i), irrespective of whether the engine is cranked. This indicates a fault in the starting motor, necessitating its removal from the vehicle for detailed testing and examination. After removing the starting motor from the vehicle, dismantle the starting motor in accordance with 4(c) and then refer to 4(d).

(ii) Check the Battery Earth and Starting Motor Earth

Carry out two separate tests. First connect the voltmeter between the battery earth terminal and a good earth point on the vehicle frame, and then between the frame of the starting motor and a good earth point on the vehicle frame. In each case operate the starter control switch. If the voltmeter registers no more than 0.5V, the battery and the starting motor earth connections are satisfactory. If the starting motor earth test is unsatisfactory and no earth cable is fitted between the starting motor and frame, check the engine earth cable (or flexible strap) usually fitted between the engine and the vehicle frame.

(iii) Check the Voltage at the Solenoid Main Input Terminal, under Load Conditions

Connect the voltmeter between the main input terminal of the solenoid and a good earth point on the vehicle frame, and then operate the starter control switch. The voltmeter should register the same or no more than 0.5V lower than that registered during the battery terminal voltage test (para. i), in which case the heavy-duty cable connection between the battery and starting motor is satisfactory.

(iv) Check the Voltage at the Starting Motor Terminal

Before checking the voltage at the starting motor terminal, check the tightness of the flexible link connections between solenoid and starting motor.

Check the voltage at the starting motor terminal on the commutator end bracket by connecting the voltmeter between this terminal and a good earth point on the vehicle frame, then operate the starter control switch.

If the voltmeter does not register, or the reading is less than 9.5V (petrol engines) or 9.0V (diesel engines), a faulty solenoid unit is indicated. The fault in the solenoid could be due to open-circuit or high resistance contacts, or open-circuit or short-circuited solenoid-operating windings. The solenoid windings should be checked, and providing they are satisfactory the solenoid unit can be repaired by renewing the terminal-and-base assembly which comprises new contacts (refer 4(d), para. vi). If the solenoid operating windings are open-circuit, or have an appreciably incorrect resistance value, the solenoid unit must be renewed.

If the voltage at the starter motor terminal was satisfactory, but the engine was not cranked, or was cranked at a low speed, a fault in the starting motor is indicated and it must be removed from the vehicle for individual testing and examination. Before proceeding to full dismantling (4c), remove only the commutator end cover and inspect the commutator and brushgear (refer 4(d), paras i and ii).

(c) Dismantling

(i) Removing the Solenoid

Remove the flexible link from between the solenoid 'STA' terminal and the motor terminal. Remove the nuts and washers which fix the solenoid to the drive-end bracket. Withdraw and remove the main part of the solenoid, the plunger and its drive-return spring remaining coupled to the drive engagement lever.

Remove the plunger and return spring assembly by lifting it from the top of the engagement lever.

Note : The solenoid plunger is individually suited to the main part of the solenoid and is not interchangeable separately.

(ii) Dismantling the Motor

Remove the rubber sealing block from between the drive-end bracket and yoke.

Remove the cotter pin, shim washers and thrust plate from the armature shaft extension at the commutator-end.

Remove the two through bolts and part the commutator-end bracket from the yoke. Disengage the field winding brushes from the brushbox moulding and then completely remove the bracket.

Remove the thrust washer from the commutator end of the armature shaft.

Remove the yoke but do not at this stage dismantle the field coil assembly from the yoke. The field coils can be tested in-situ (refer 4(d), para. iii).

Remove the retaining ring from the groove in the engaging lever pivot-pin and withdraw the pin.

Remove the armature, complete with drive assembly, from the drive end fixing bracket.

The drive assembly is removable from the armature as a complete unit. Remove the thrust collar from the jump ring by using a mild steel tube with a suitable bore, remove the jump ring from its groove and then slide the drive assembly off the end of the armature shaft. Do not at this stage dismantle the drive assembly (refer 4(d), para. iv).

(d) Bench Inspection

After dismantling the motor, examine the individual items, as follows:—

(i) Armature

A commutator in good condition will be burnished and free from pits or burned spots. The surface of the commutator can be cleaned with a petrol-moistened cloth. Skimming the commutator will not normally be required, but if the surface is badly worn the armature must be removed and the commutator serviced. The minimum thickness to which the commutator copper may be skimmed before a replacement armature assembly becomes necessary, is 0.08 in. (2.05 mm). The commutator surface should be finally polished with very fine glass paper. The insulation slots MUST NOT BE UNDERCUT.

If the solder appears to have 'thrown', or the conductors to have 'lifted' from the commutator segments, overspeeding of the motor is indicated and, besides repairing or renewing the armature, the operation of the roller clutch drive should be checked (refer para. iv).

Check the armature insulation, between windings and shaft. To do this, connect a 110V a.c. 15-watt test lamp between any of the commutator segments and the shaft (refer Fig. 3). If the lamp lights, renew the armature.

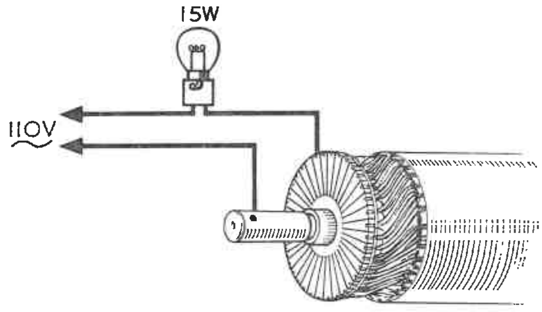


Fig. 3 Armature insulation test

Armature interwinding short circuits can only be detected by using specialised 'Growler' equipment. Alternatively, checking the armature by substitution would be justified providing short-circuited field windings and restricted movement of the armature (e.g. worn bearings, or out-of-true armature shaft, causing fouling of the pole shoes) has been eliminated as other possible causes of the fault symptom, and particularly if also light running and torque tests carried out previous to dismantling indicated a high current consumption with a low speed and torque.

(ii) Brushgear

Each of the four brushes must move freely in the brushboxes. Sticking brushes can usually be rectified by cleaning brushes and moulding with a petrol-moistened cloth.

Renewing the Brushes

Brushes worn to or approaching 0.375 in. (9.50 mm) should be renewed as a set.

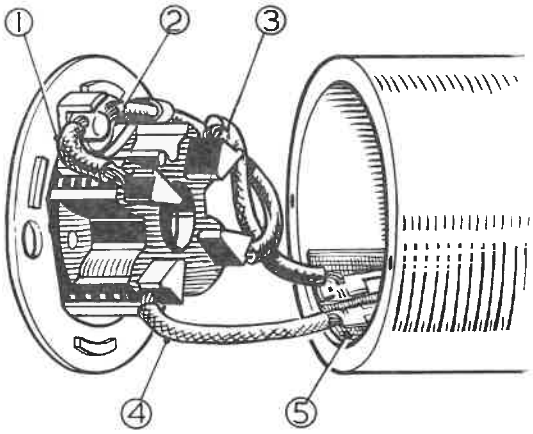


Fig. 4 Brushgear and terminal arrangement

1 Short brush flexible, C/E bracket
2 Long brush flexible, C/E bracket
3 Long brush flexible, field winding
4 Short brush flexible, field winding
5 Yoke insulation piece

When renewing the assembly of terminal and brushes in the commutator end bracket, it is necessary to locate the shoulders of the terminal and the terminal insulator in the correct one of four possible assembling positions of the square hole in the bracket. It is also necessary to assemble the terminal fixing parts in the correct sequence. (In both cases, refer to Fig. 1 and Fig. 4).

To renew the field coil brushes, it will be necessary to carry out a soldering operation. After removing the worn brush flexibles from the two ends of the field windings, prepare the ends of the field windings for soldering (by cleaning and tinning), and then solder the new brushes in position, referring to Fig. 4 to ensure correct arrangement of the long and short brush-flexibles.

Brush Springs

To measure the spring pressure press on top of a new brush with a push-type spring gauge (refer Fig. 5) until the top of the brush protrudes about 0.062 in. (1.50 mm) from the brushbox moulding, the spring pressure should then be approximately 28 ozf (7.80 N).

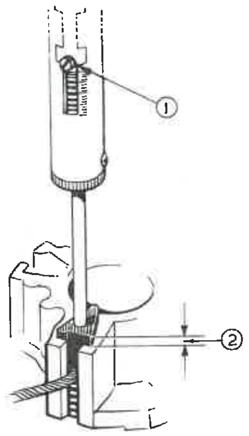


Fig. 5 Checking brush spring pressure

1 Push type spring gauge, with sliding marker indicating reading where 'arrowed'
2 0.062 in. (1.50 mm) approx.

If the spring pressure is appreciably incorrect, the spring(s) must be renewed. To remove an unsatisfactory spring:— grip the top of the spring with snipe-nosed pliers and tilt the spring to release one side of the top of the spring from either of the locating shoulders in the brushbox moulding, then pull the spring from the moulding. To fit a new spring:— compress the spring tightly between the first finger and thumb, then place the spring in the brushbox moulding. When the spring is released, it will partially locate itself in the brushbox moulding and it is then only necessary to use a small screwdriver (or other suitable tool) to finally manipulate the spring into its working position.

Check the insulation of the springs and terminal post by connecting a 110V a.c. 15-watt test lamp between a clean part of the bracket and each of the springs in turn and then between the bracket and the terminal post (refer Fig. 6). The lamp will light if the insulation is not satisfactory.

Note: The brushes and flexibles (where bared) must not come in contact with the bracket during the test.

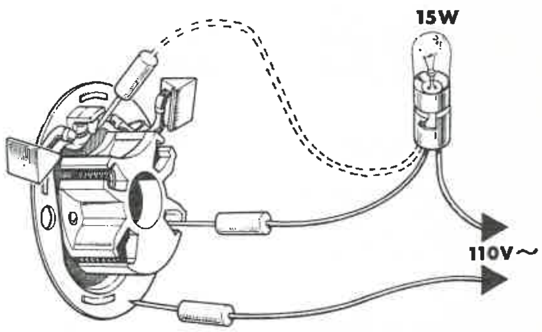


Fig. 6 Brush springs and terminal insulation test

(iii) Field Coils

Inspect the inside of the yoke for obvious signs of a field winding fault. If the winding insulation tape is discoloured (due to burning), this indicates short-circuited windings, or a short-circuit between the windings and the yoke. Visible signs of a fault affecting the field coils will eliminate the need for testing, but otherwise the continuity and insulation of the field coils should be checked with the field coil assembly in-situ.

Field Coil Continuity

Check by connecting a 12V battery-operated test lamp between each of the brushes in turn and a clean part of the yoke. The lamp should light.

Field Coil Insulation

To check the insulation between field coils and yoke, it will be necessary to first disconnect the earthed end of the windings at the yoke. Before disturbing the riveted connection unnecessarily, determine whether it is justified by considering the results of light running or lock torque tests, or alternatively consider the fault symptoms. If the speed and torque were low, and the current consumption high, or the fault symptom was low cranking speed, faulty field winding insulation could be the cause and this interpretation of the starting motor performance would justify disconnecting the earthed end of the field windings to enable an insulation test to be carried out. The field coil insulation can be checked (after disconnecting the windings at the yoke) by connecting a 110V a.c. 15-watt test lamp between the disconnected end of the windings and a clean and unpainted part of the yoke. Ensure that neither of the brushes nor bared part of their flexibles contact the yoke during the test. An insulation breakdown will be indicated by the lamp lighting, in which case the field coil assembly must be removed from the yoke and the fault rectified, or the field coil assembly renewed.

Note: Due to the very low resistance of the field coil conductors (or windings), the presence of a short circuit between the windings can only be determined by using specialised equipment. If the results of all previous testing has been satisfactory, short-circuited field coil windings could be the cause of the fault and the field coil assembly must be proved by substitution.

Renewing the Field Coil Assembly

Disconnect the end of the field winding where it is riveted to the yoke. To do this, file away the riveted-over end of the connecting-eyelet securing rivet, sufficient to enable the rivet to be tapped out of the yoke. Remove the four pole-shoe screws with a wheel-operated or power-operated screwdriver and withdraw the field coil assembly from the yoke. Wipe clean the inside of the yoke and the insulating piece through which the through bolts locate. Loosely fit the new field coil assembly (with pole-shoes) into the yoke, with the threads of the pole-shoe fixing screws only partially engaged. Slide the insulating piece between the field coils and yoke, the extended portion of the insulating piece preventing the brush connections from contacting the yoke (refer Fig. 3). Now tighten the pole-shoe screws progressively to a torque of 30 lbf ft (40.70 Nm). Finally, make a good earth connection between the end of the field winding and the yoke.

(iv) Roller Clutch and Drive Operating Mechanism

A roller clutch drive assembly in good condition will provide instantaneous take-up of the drive in one direction and rotate smoothly and easily in the other. The assembly should move freely round and along the armature shaft splines without roughness or tendency to bind. Should the assembly not meet these requirements, a replacement unit must be fitted.

If it is necessary to dismantle the drive assembly, remove the jump ring from its groove in the end of the drive sleeve.

All moving parts of the drive should be smeared liberally with grease. Shell SB.2628 (Home and cold climates): Retinax 'A' (Hot climates).

The setting of the pinion and satisfactory operation of the solenoid and the drive are dependent on the condition or amount of wear between the moving parts associated with the drive operating mechanism. For this reason, it is important to replace any part which shows signs of wear. The solenoid plunger is individually suited to the main part of the solenoid and is not interchangeable separately. For this reason, wear to the solenoid plunger stirrup linkage will necessitate a new solenoid unit being fitted.

(v) Bearings

Both end brackets are fitted with self-lubricating porous bronze bearing bushes. New bushes must be immersed in clean engine oil (S.A.E. 30/40 grade) for a minimum of 24 hours before fitting. Alternatively, if the lubricant is heated to a temperature of 100°C, 2-hours immersion of the bushes is sufficient, providing the lubricant is allowed to cool before the bushes are removed, The bushes must not be reamed after fitting otherwise the self-lubricating qualities will be impaired.

Renew the bushes when there is excessive side-play of the armature shaft. Fouling of the pole-shoes by the armature, or inefficient operation of the starting motor, is likely to occur when the inner diameter of the bushes exceeds the following dimensions:— commutator end bracket bush 0.442 in. (11.22 mm) and the drive end bracket bush 0.477 in. (12.11 mm).

Remove worn bushes with a press or, alternatively, support the bracket and carefully drive out the bush with a suitable mandrel.

New bushes should be pressed or carefully driven squarely into position, using a shouldered polished mandrel with bush fitting dimensions as follows:— commutator end bracket bush 0.4377 in. (11.117 mm) and drive end bracket bush 0.4729 in. (12.011 mm).

Note: Because the armature axial thrust and end float is controlled at the commutator end, when fitting a new bush in the commutator end bracket, ensure that the shoulder of the bush is fitted tight up to the outer face of the bracket.

(vi) Solenoid

The solenoid plunger is fitted with a 'lost-motion' spring which provides a measure of lost motion in the drive operating mechanism. The measure of lost motion takes place at the commencement of disengaging the drive, its purpose being to ensure that the main solenoid contacts will always open prior to pinion retraction. This will also take effect if, for other reasons, the pinion fails to become disengaged from the flywheel ring gear when the solenoid switch is released. In the case of the drive engagement spring (inside the plunger), to check the spring, grip the plunger body in the hand and pull hard on the connecting part of the plunger. A spring-loaded pull action should exist between the plunger body and the connecting part of the plunger.

Pre-engaged Starting Motor Model M35K PE

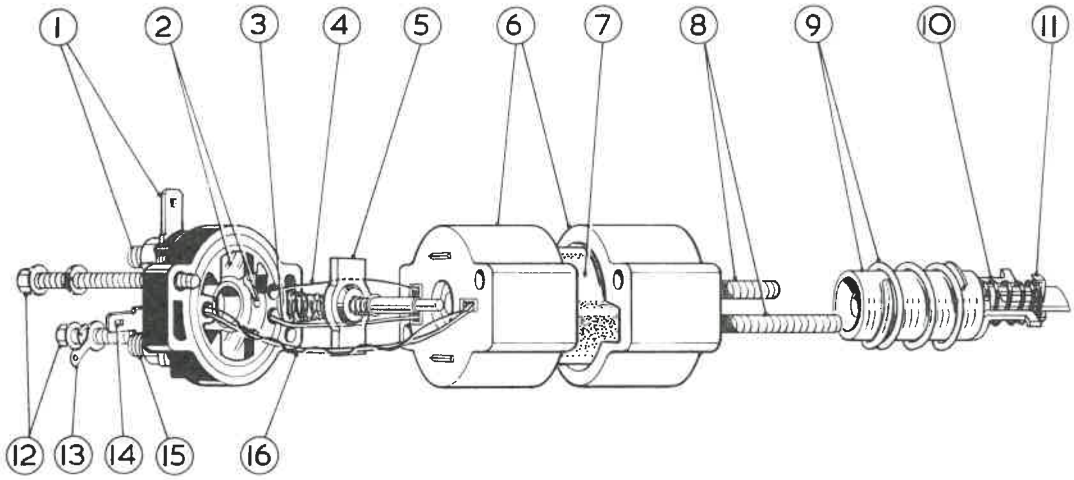


Fig. 7 Solenoid Model 17S, dismantled

- ★1 Main input terminal and 'Lucar' terminal (main external circuits)
- 2 Base assy. comprising: fixed 'main' contacts and ballast ignition (IGN) contact
- 3 Closing coil connection to 'STA' terminal
- 4 Hold-on coil connection to earth strip
- 5 Moving spindle and contact assy.
- 6 Solenoid body
- 7 Coil or winding assy.
- 8 Solenoid fixing studs
- 9 Plunger and drive return spring
- 10 'Lost motion' spring
- 11 Spring retaining-plate
- 12 Solenoid assy, screws
- 13 Earth strip, hold-on coil
- ★14 Small unmarked 'Lucar' terminal (solenoid operating)
- 15 Main 'STA' terminal
- 16 Closing and hold-on coil connections to small (unmarked) 'Lucar' blade terminal

Checking the Solenoid Windings

If the solenoid unit is fitted to the starting motor, to check the solenoid closing and hold-on windings it will be necessary to disconnect the solenoid-to-starting motor flexible link at the solenoid terminal marked, STA'.

The continuity and resistance of both the solenoid windings can be checked simultaneously, by connecting a good quality ohmmeter between the solenoid terminal 'STA' and a good earth point on the solenoid body. A reading of 1.11–1.35 ohm should be obtained. If no reading is obtained, at least one winding is open-circuit and the solenoid unit must be renewed.

Note: Alternative to using an ohmmeter, connect a 0–20A moving-coil ammeter in series with a 12V battery, solenoid terminal 'STA' and a good earth point on the solenoid body. A reading of 9.0–11.0A should be obtained. If neither an ohmmeter or ammeter are available, continuity of the windings only may be checked with a battery-operated test lamp of low wattage, connected as detailed for the ohmmeter. The lamp should light.

Checking the Solenoid Contacts

After long service the contacts may require renewing. Check for satisfactory opening and closing of the contacts, by connecting a circuit comprising a 12V battery and a high wattage (e.g. 60 watt) test lamp between the solenoid main terminals. The lamp should not light. Leave the test lamp connected and now energise the solenoid by connecting another circuit, comprising a 12V battery supply, between the solenoid small unmarked 'Lucar' terminal blade and a good earth point on the solenoid body. The solenoid should be heard to operate and the lamp should light with full brilliance, indicating satisfactory closing of the contacts.

Note: The solenoid may incorporate a very small additional 'Lucar' terminal blade (marked 'IGN'), which is for use in conjunction with ballast ignition systems. It is sufficient to check that this terminal becomes electrically connected to the solenoid main input terminal, when the solenoid is energised.

Renewing the Solenoid Contacts

To gain access to the contacts, withdraw the two screws which fix the moulded cover and the two halves of the solenoid body together. Unsolder the three winding connections in the moulded cover (the small unmarked 'Lucar' terminal, the 'STA' terminal and the earth connector strip which fits beneath one of the assembly screws) and at the same time carefully pull the moulded cover away from the ends of the windings and the solenoid body.

If the two halves of the body are separated for any purpose, e.g. coil renewal, a petrol-resistant sealing compound must be used between the joint

★ *Amendment to previous issue*

when reassembling. Also, when reassembling, ensure that the separated ends of the windings protrude through the insulated body slot which is parallel to the body shoulder. The thicker of the two wires (closing coil winding) goes into the 'STA' terminal, and the thin one (hold-on coil winding) into the earth connector-strip. The internal connections of the solenoid are illustrated in Fig. 2.

5. REASSEMBLY

Reassembling the starting motor and solenoid is in general a reversal of the dismantling procedure, but the following special points should be considered.

When assembling the commutator-end bracket to the yoke, it is important to position the brushes and their flexibles correctly (see Fig. 4).

Discard the original 'spire nut' retaining-ring which secures the drive engaging lever pivot pin and fit a new one.

Take care to re-fit the internal thrust washer which goes on the armature shaft at the commutator end.

When assembling the parts to the armature shaft extension at the commutator end, note that the end-float is 0.010 in. (0.25 mm) max., which is obtained by fitting the required number of shims (usually one or two). Assemble the parts in the sequence illustrated in Fig. 1 and ensure that they are locked together and prevented from rotating separately by the cotter-pin, which should engage with the locking piece on the thrust plate.

PRE-ENGAGED STARTING MOTOR MODEL 2M100PE

(With Actuating Solenoid Model 19S and Roller Clutch Drive Model 7SD)

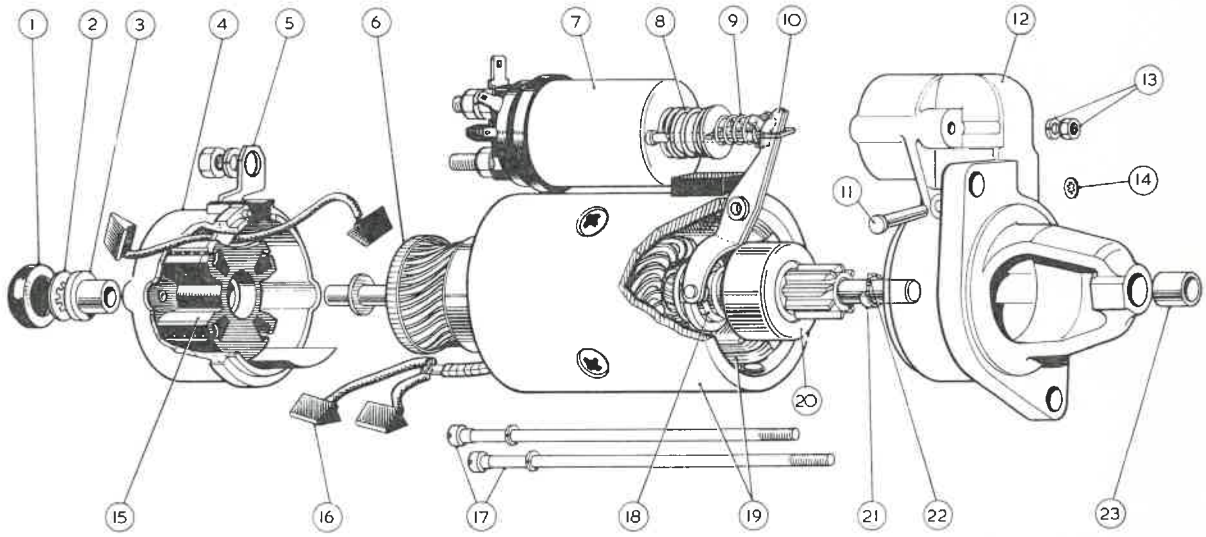


Fig. 1 Starting motor, dismantled

1 End cap
2 Retaining ring
3 Bearing bush
4 Commutator end cover
5 Connector link (solenoid to starter)
6 Armature
7 Solenoid unit 19S
8 Return spring
9 Lost motion spring
10 Drive engagement lever
11 Pivot pin
12 Drive end bracket
13 Solenoid fixing nut and washer (2 off)
14 Pivot pin retaining ring
15 Brush box moulding
16 Brushes
17 Through bolts
18 Spacing spring
19 Yoke and field coil assembly
20 Drive assembly
21 Thrust collar
22 Jump ring
23 Bearing bush

1. DESCRIPTION

The model 2M100PE pre-engaged starting motor is a four-pole four-brush machine, 4 in. (100 mm) diameter, with a series-connected field, an armature with a face-type commutator and a solenoid-operated roller clutch drive.

The face-type commutator on the end face of the armature works in conjunction with a fully-insulated brushgear assembly, comprising two pairs of wedge-shaped brushes and coil type springs assembled into a brushbox moulding, which is riveted to the inside of the commutator end cover. The brushes are provided with a keyway to ensure correct fitting and the springs are held captive in the brush-box moulding.

The field coils are of conventional design, but the method of connection is different to that usually employed. The supply voltage to the starting motor is applied via the solenoid direct to one pair of brushes, the start of the field winding is connected to the other pair of brushes and the terminating end of the field winding is earthed direct to the frame of the starting motor by a riveted connection to the yoke (refer Fig. 2).

End-float and axial movement of the armature is determined by the position in which a special type of 'Spire' retaining ring is fixed to the armature shaft, where it extends through the commutator end bracket (refer Fig. 1, item No. 2).

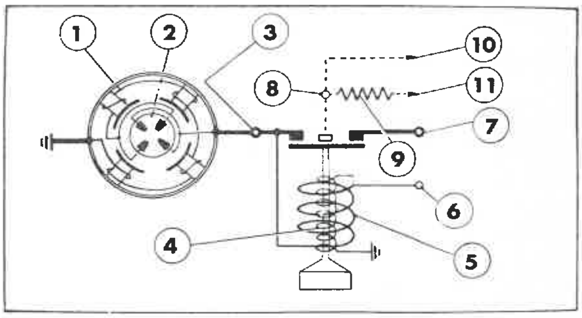


Fig. 2 Internal connections of starting motor and solenoid. (Broken lines applicable only when ballast ignition coil is used)

1 Field
2 Armature
3 Terminal 'STA'
4 Hold-on winding
5 Closing winding
6 Small (unmarked) terminal on solenoid
7 Battery supply terminal
8 Terminal 'IGN'
9 Ballast resistor
10 To ignition coil
11 To ignition switch

There is no need to set the drive pinion and therefore the operating position of the drive engagement lever is non-adjustable. The plain-type pivot pin on which the lever swivels is retained in the fixing bracket by a small special type of 'Spire' retaining ring (refer Fig. 1, item 14).

Pre-engaged Starting Motor Model 2M100PE

A feature of a pre-engaged starting motor is that the pinion is fully-engaged with the engine flywheel before cranking torque is developed. Normally, when the starting motor is operated, the pinion moves into full engagement with the engine flywheel and the solenoid contacts close to connect the starting motor to the battery. Full cranking torque is then developed. On occasions when tooth-to-tooth abutment occurs, the solenoid plunger continues to move by compressing a drive engagement spring inside the plunger. This plunger movement causes the solenoid contacts to close, connecting the starting motor to the battery. The starter armature now commences to rotate and the pressure of the drive engagement spring, combined with push-screw assistance from the drive helix, causes the pinion to move into mesh. Full cranking torque is then developed.

The roller clutch prevents the armature from rotating excessively if the drive remains in mesh after the engine has started.

Note: Oil and water-tight versions of this starting motor will include special sealing features. Particularly in the case of the solenoid plunger and drive operating mechanism, which will be effectively sealed from the bell housing.

2. ROUTINE MAINTENANCE

No routine maintenance is necessary, but the tightness of the electrical connections should be checked periodically.

The starting motor should be dismantled for detailed inspection during major engine overhaul. The commutator should then be serviced if necessary and the brushes and armature bearings renewed (refer 4 (c) i, ii, and iv).

3. TECHNICAL DATA

The performance of the starting motor depends on the capacity and state of charge of the associated battery. The following are typical performance figures obtained with a 12-volt 60 Ah (20 hr. rate) battery in a 70% charged condition at 20°C (68°F).

Lock torque:	14.4 lbf ft (19.52 Nm) with 463 A.
Torque at 1000 rev/min:	7.3 lbf ft (9.9 Nm) with 300 A.
Light running current:	40A at 6000 rev/min (approx).

Solenoid

Closing (or series) winding resistance (measured between the small unmarked 'Lucar' terminal and the main terminal marked 'STA':	0.25–0.27 ohm
Hold-on (or shunt) winding resistance (measured between the small unmarked 'Lucar' terminal and a good earth point on the solenoid body:	0.76–0.80 ohm

4. SERVICING

For satisfactory starting performance, the battery must be in good condition and at least 70% charged. Check with a hydrometer the specific gravity of the electrolyte in each of the battery cells. If there is a variation of more than 40 points (0.040) in any cell readings, the battery is suspect and should be removed for testing by a battery agent.

Specific gravity readings should be:

	Specific gravity readings correct to 15°C (60°F)	
State of charge	*Climates normally below 25°C (77°F)*	*Climates normally above 25°C (77°F)*
Fully charged	1.270–1.290	1.210–1.230
70% charged	1.230–1.250	1.170–1.190
Discharged	1.100–1.120	1.050–1.070

Electrolyte Temperature Correction

For every 10°C (18°F) below 15°C (60°F), subtract 0.007
„ „ „ „ above „ „ , add 0.007

If the battery is in good condition and sufficiently charged, and the wiring associated with the battery, starting motor and operating switch, and the switch itself, is satisfactory, a low cranking speed or failure of the starting motor to crank the engine means that the starting motor must be removed from the engine for detailed testing and examination. (Proceed to bench testing 4 a).

(a) Bench Testing

Determine if the Solenoid is the Cause of the Fault

(i) Using heavy-duty battery cable and a 0–50A range moving-coil ammeter in series with a 12-volt battery, connect one side of the supply voltage direct to the solenoid-to-starter connecting link and connect the other side of the supply voltage to the starting motor frame.

The starting motor should now run under light running conditions, independent of the solenoid unit.

If the starting motor does not run, or it runs but the light running current and speed are unsatisfactory (refer 3, Technical Data), proceed to 4 (b) and dismantle the starting motor sufficiently to enable the commutator and brushgear to be inspected.

If the starting motor runs and the light running current and speed are satisfactory, the fault could be due to the solenoid unit or the starting motor. Proceed to further testing (para. ii).

(ii) Transfer the previous test-circuit connection (from the solenoid-to-starter connecting link) to the solenoid main input terminal. Now connect a temporary link between this terminal and the small (unmarked) 'Lucar' terminal blade, to energise the solenoid operating winding.

The solenoid should operate and the starting motor should run under light running conditions.

If the starting motor runs and the light running current and speed are still satisfactory (as well as in the previous test, para. i), check that there is not a high resistance at the solenoid contacts, which would cause a low cranking speed. Proceed direct to para. iii.

If the starting motor does not run when supply voltage is applied between solenoid main input terminal and frame, and between solenoid operating winding terminal and frame, the solenoid unit is faulty. Proceed direct to para. iv.

(iii) Check that the solenoid contacts close satisfactorily, under load conditions. Connect a low-range moving-coil voltmeter between the solenoid main terminals, and perform lock torque test.

If voltmeter registers practically zero, the solenoid is satisfactory. In that case, a low cranking speed and an unsatisfactory lock torque performance indicate that the starting motor is faulty, Proceed to 4 (b) and dismantle the starting motor sufficiently to enable the commutator and brushgear to be inspected.

Note: If lock torque equipment is not available, check the solenoid by substitution, and, if necessary dismantle the starting motor for inspection.

(iv) In reference to previous testing (para. ii), a solenoid fault could be due to open-circuit contacts (in which case a satisfactory repair can be carried out by renewing the terminal-and-base assembly complete with new contacts), or the operating windings may be faulty (in which case the solenoid unit must be renewed).

Providing the solenoid-to-starter connecting link is first disconnected from the solenoid terminal 'STA', both solenoid windings can be simultaneously checked (in series) as follows:

Connect a good quality ohmmeter between solenoid terminal 'STA' and a good earth point on the solenoid body or starting motor frame. **A reading of 1.01–1.07 ohms should be obtained.**

Note: Alternative to using an ohmmeter, connect a 0–20A range moving-coil ammeter in series with a 12-volt battery, solenoid terminal 'STA' and a good earth point on the solenoid body or starting motor frame. **A reading of 11.2–11.8A should be obtained.**

If the solenoid operating windings are satisfactory, it confirms that the solenoid failure is due to faulty contacts. The solenoid unit should therefore be repaired or renewed.

(b) Dismantling

If access to the commutator and brushgear only is required, proceed direct to para. (ii) which deals with removing the commutator end cover.

(i) Removing the Solenoid

Remove the nut and washer which secures the solenoid-to-starter connecting link to solenoid terminal 'STA'.

Remove the nuts and washers which secure the solenoid unit to the fixing bracket. Pull back the connecting link from the solenoid terminal, and at the same time lift the terminal end of the solenoid clear of the connecting link, then withdraw the major part of the solenoid from the fixing bracket. Remove the plunger from the drive engagement lever, by gripping the plunger in the hand and applying an upward lift at the front end of the plunger.

(ii) Removing the Commutator End Cover

Before removing the commutator end cover, ensure that a service replacement 'Spire' retaining ring is available as a new fitment for use during re-assembly of the starting motor. This is necessary because this type of retaining ring is a press fit (or drive fit) on the armature shaft and if the original fitting of the retaining ring is disturbed, it becomes unsatisfactory for further use.

Remove the end cap seal to gain access to the 'Spire' retaining ring.

Remove the retaining ring before unscrewing the through bolts. Using an engineers chisel, cut through a number of the retaining ring claws until the grip on the armature shaft is sufficiently relieved to allow the retaining ring to be removed.

Remove the nut and washer which secures the solenoid-to-starter connecting link to solenoid terminal 'STA'. (This will already have been done, if the solenoid has previously been removed as a preliminary to complete dismantling).

Remove the two through bolts.

After removing the through bolts, the commutator end cover can be removed from the rest of the starting motor by partially withdrawing the cover from the yoke and then disengaging the two field coil brushes from the brush box moulding.

Note: At this stage of dismantling, check the commutator and brushgear (refer 4 c, para. i and ii).

(iii)

After removing the commutator end cover, continue dismantling by withdrawing the yoke and field-coil assembly from the armature and fixing bracket sub-assembly. Do not disturb the field-coil assembly in the yoke (refer to 4 c, para. iii).

(iv)

If the 'Spire' retaining ring is removed from the drive engagement lever pivot-pin and the pivot-pin is then withdrawn from the fixing bracket, the armature assembly comprising roller clutch drive and lever assembly can then be separated from the fixing bracket.

Note: The pivot-pin retaining ring, similar to the one at the commutator end (except for size), must be renewed if the original fitting is disturbed.

(v)

The roller clutch drive and lever assembly is removable from the armature shaft as a complete unit. Using a tubular tool (e.g. a box spanner) drive the thrust collar squarely off the jump ring and then after removing the jump ring from the groove in the armature shaft, slide the thrust collar and the roller clutch drive and lever assembly off the shaft. It is unnecessary to dismantle the drive engagement lever from the roller clutch drive, since both these parts are serviced as a complete assembly. (The operation of the roller clutch drive should be checked as detailed in 4 c, para. v).

(c) Bench Inspection

After dismantling the starting motor, examine the individual items as follows:

(i) Armature

The face of the commutator should be clean and free from burnt spots. Clean the commutator with a petrol-moistened cloth and, if it should be necessary, use a flat surface of very fine glass paper to rectify burnt spots, or grooving, prior to using the petrol-moistened cloth.

In some cases it may be necessary to skim the commutator. The minimum thickness to which the commutator copper may be skimmed, before a replacement armature becomes necessary, is 0.140 in. (3.5 mm). The skimming operation should be terminated by polishing the commutator surface with a flat pad of very fine glass paper or emery cloth, then wipe clean with a petrol-moistened cloth. DO NOT UNDERCUT THE INSULATION SLOTS.

If the armature shows signs of 'thrown' solder, or lifted conductors, over-speeding of the armature is indicated. (Check the operation of the roller clutch drive, 4 c, para. v).

The armature insulation can be checked by connecting a 110-volt a.c. 15-watt test lamp between a commutator segment and the shaft (refer Fig. 3). **The lamp should not light.**

Short-circuited armature windings (indicated by a high current consumption, low light running speed and low lock torque performance) can only be detected by the use of specialised armature testing 'Growler' equipment. If this equipment is not available, the only alternative is to check the armature by substitution.

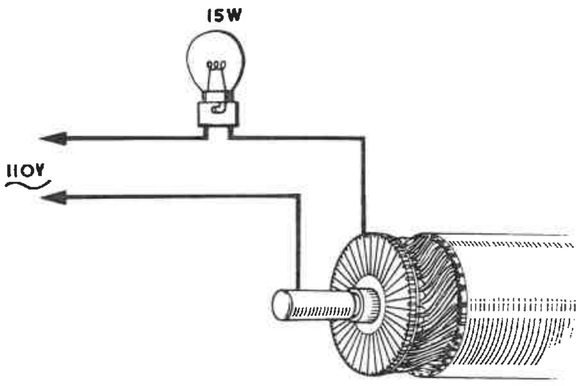


Fig. 3 Armature insulation test

If the armature laminations have been in contact with the pole-shoes, the armature bearings are probably excessively worn. First, check that the pole-shoes are tight and that the armature runs true in a lathe. Then, if necessary, renew the armature bearings (refer 4 c, para. iv).

(ii) Brushgear

Check that the brushes move freely in the brush box moulding. Sticking brushes should be cleaned with a petrol-moistened cloth. Brushes which are worn to approximately 0.375 in. (9.5 mm) in length, must be renewed.

Renewing the brushes: Cut the worn brush flexibles from the field coil, leaving approximately 0.25 in. (6 mm) of flexible each side of the coil end. Solder the new brushes to the remaining ends of the old flexibles. Replace the other two brushes complete with terminal link and moulded rubber grommet. Ensure the new brush set is correctly fitted in accordance with Fig. 4.

Note: Use only resin-cored type solder.

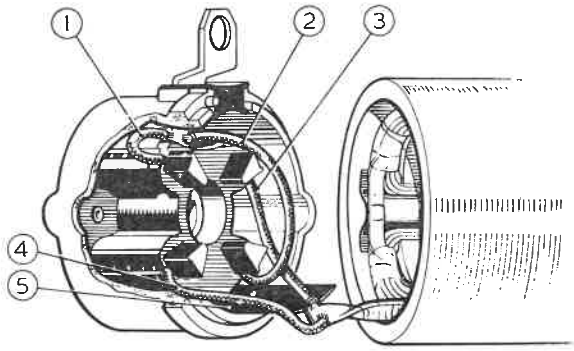


Fig. 4 Brushgear and terminal arrangement

1 Short brush-flexible, C/E cover
2 Long brush-flexible, ,,
3 Long brush-flexible, field winding
4 Short brush-flexible, ,,
5 Insulation piece

Brush spring pressure: To measure the brush spring pressure, position a new brush in each of the brush boxes in turn and then press on top of the brush with a push-type spring gauge (refer Fig. 5) until the top of the brush protrudes about 0.062 in. (1.5 mm) from the brush box moulding, when the spring pressure reading should be 36 ozf (10.0 N).

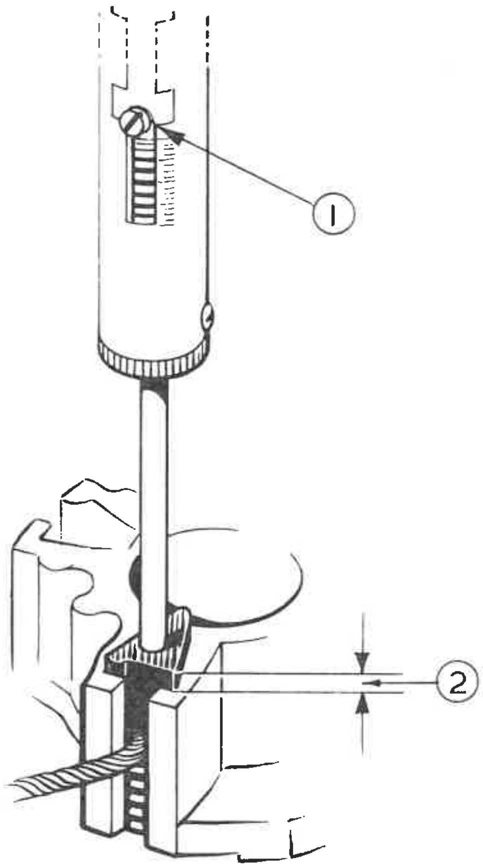


Fig. 5 Checking brush spring pressure

1 Push type spring gauge, with sliding marker indicating reading where 'arrowed'
2 0.062 in. (1.50 mm) approx.

Check the insulation of the brush springs by connecting a 110-volt a.c. 15-watt test lamp between a clean part of the commutator end cover and each of the springs in turn. The lamp should not light.

Check that the connecting link grommet is in good condition.

(iii) Yoke and Field Coil Assembly

The field coils should be visually inspected in-situ for signs of obvious fault(s). Check the inter-connecting joints between coils, the earthed connection of the field winding where it is riveted to the yoke, and look for discolouration (due to burning) of the winding insulation tape, which could indicate short-circuited windings or a short-circuit between the windings and the yoke. A visible fault will eliminate the need for testing and in such cases if necessary the field coil assembly should be removed from the yoke to enable it to be repaired or renewed.

If there are no obvious signs of a fault, the field coil continuity and the insulation between the field coils and yoke can be checked without removing the field coil assembly from the yoke.

Field coil continuity: Check by connecting a 12-volt battery-operated test lamp between either of the brushes and a clean part of the yoke. **The lamp should light.**

Field coil insulation: Before being able to check the insulation between the field coils and yoke, it will first be necessary to disconnect the earthed end of the winding from the yoke. Before disconnecting the winding (refer to the heading 'Renewing the field coils'), determine whether it is justified. Consider the results of the light running and lock torque tests, or alternatively consider the fault symptoms. If the speed and torque were low, and the current consumption high, or the fault symptom was low cranking speed, faulty field winding insulation could be the cause and this interpretation of the starting motor performance would justify disconnecting the earthed end of the field winding to enable a positive check to be carried out.

The field winding insulation can be checked (after disconnecting the winding at the yoke) by connecting a 110-volt a.c. 15-watt test lamp between the disconnected end of the winding and a clean part of the yoke. **The lamp should not light.** Ensure that neither of the brushes, or bare parts of their flexibles, contact the yoke during the test.

Note: Due to the very low resistance of the field coil conductors, the presence of a short-circuit between the field coil windings can only be determined by specialised equipment. If the results of all previous testing has been satisfactory, short-circuited field coil windings could be the cause of the fault and the field coil assembly should now be further proved by substitution.

Renewing the field coils: Disconnect the end of the field winding where it is riveted to the yoke. To do this, file away the riveted-over end of the connecting-eyelet securing rivet, sufficient to enable the rivet to be tapped out of the yoke. Remove the four pole-shoe screws with a wheel-operated or power-operated screwdriver and withdraw the field coil assembly from the yoke. Wipe clean the inside of the yoke, and the insulating pieces through which the through bolts locate.

Loosely fit the new field coil assembly (with pole-shoes) into the yoke, with the threads of the pole-shoe fixing screws only partially engaged. The through bolt insulating pieces should now be assembled into the yoke, by sliding the shoulders of the insulating pieces between the field coils and the yoke, in a position 180° apart and 90° each side of the field coil brush connection point (refer Fig. 4). Now tighten the pole-shoe screws progressively to a torque of 30 lbf ft (2.64 kgf m). Finally, make a good earth connection between the end of the field winding and the yoke.

(iv) Bearings

The armature bearings, fitted in the commutator end cover and the drive end fixing bracket, are self-lubricating porous-bronze bushes.

New bushes must be completely immersed in Shell 'Turbo 41' oil, or in clean engine oil, for 24 hours at room temperature, before they are fitted. Alternatively, if the lubricant is heated to a temperature of 100°C, 2-hours immersion of the bushes is sufficient, providing the lubricant is allowed to cool before the bushes are removed.

The bushes must **not** be reamed after fitting otherwise the self-lubricating qualities will be impaired.

The bushes must be renewed when there is excessive side-play of the armature shaft. Fouling of the pole-shoes by the armature, or inefficient operation of the starting motor, is likely to occur when the inner diameter of the bushes exceeds the following dimensions:– commutator end cover bush 0.441 in. (11.20 mm), drive end fixing bracket bush 0.476 in. (12.09 mm).

Worn bushes should be removed by using a wheel-operated press. Alternatively, support the bearing housing and then with a mandrel carefully tap the bush out of the cover or bracket.

New bushes should be pressed into position by means of a shouldered polished mandrel with dimensions as follows:– commutator end cover bush 0.4377 in. (11.117 mm), drive end fixing bracket bush 0.4729 in. (12.011 mm).

(v) The Roller Clutch Drive Assembly

Check the clutch action. The pinion should have instantaneous take-up of the drive in one direction and be free to rotate in the other.

Check that the assembly moves freely along the armature shaft splines. The armature shaft splines and moving parts of the engagement lever should be liberally smeared with Shell SB.2628 (home market and cold climates): Retinax 'A' (hot climates). The roller clutch mechanism is a sealed unit, which is pre-packed with sufficient grease to last the life of the starting motor. In the unlikely event of the clutch action becoming faulty, it will not be possible to rectify the fault and the whole of the drive assembly will have to be renewed.

(vi) The Solenoid Unit

Associated with the solenoid plunger are three springs: the plunger and drive return spring, the drive engagement spring which is incorporated inside the plunger to overcome the difficulty of engaging the pinion on occasions of tooth-to-tooth abutment, and the 'lost motion' spring which is assembled to the connecting part of the solenoid plunger to provide a measure of lost motion in the drive operating mechanism as the drive commences to disengage. It is sufficient to check only that the springs are not broken. In the case of the drive engagement spring (inside the plunger), to check the spring it will be necessary to ensure that a spring-loaded pull action exists between the plunger body and the connecting part of the plunger.

Checking the solenoid contacts and winding is dealt with in 4 (a), para. iii and iv.

Note: The solenoid incorporates a very small additional 'Lucar' terminal blade (marked 'IGN'), which is for use in conjunction with ballast ignition systems. It is sufficient to check that this terminal becomes electrically connected to the solenoid main input terminal, when the solenoid is energised.

Renewing the solenoid contacts: Remove the two screws securing the terminal and base assembly to the solenoid body. Apply a hot soldering iron alternately to each of the two soldered terminal connections and wait for the solder to run free. Shake most of the melted solder out of the joints, by tapping the solenoid terminal ends sharply down on the bench. Now clamp the solenoid body in a vice (terminals uppermost) and while applying a constant pull on the moulded cover, apply the soldering iron alternately to the two soldered connections until the terminal-and-base assembly is freed. When re-making the solenoid connections, avoid dry-soldered joints by ensuring that the parts are clean and adequately heated before applying the solder. Tighten the terminal-and-base assembly fixing screws to a torque of 1.8 lbf ft (2.44 Nm).

(d) Reassembly

Assembling the starting motor is simply a reversal of the dismantling procedure. Sequence of assembling components is illustrated in Fig. 1. Fitting the solenoid unit should take place after the commutator end cover has been fitted, otherwise it will be difficult to fit the block-shaped grommet which, when assembled, is compressed between the yoke, solenoid and fixing bracket.

Pre-engaged Starting Motor Model 2M100PE

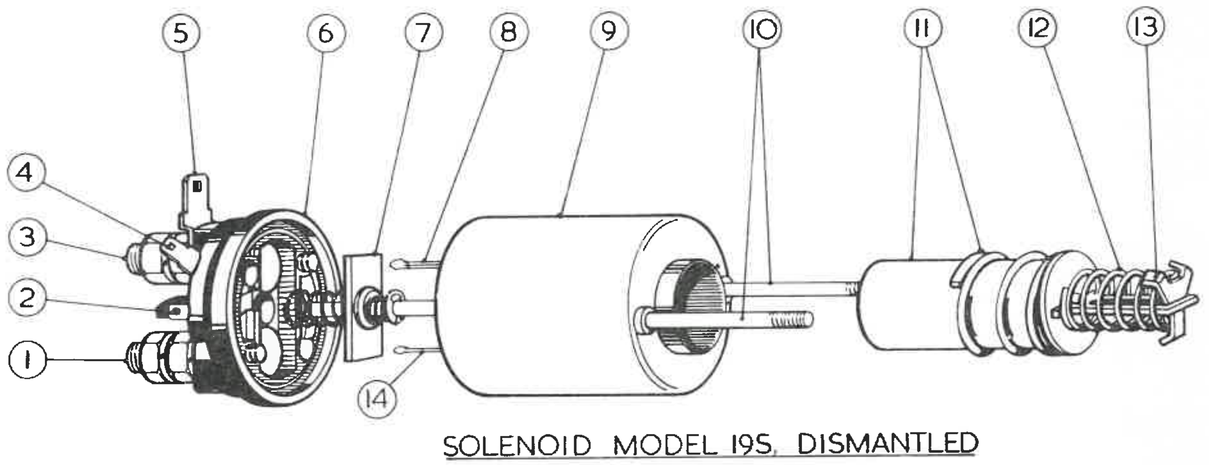


Fig. 6 Solenoid model 19S, dismantled

1 Main terminal 'STA'
2 Small 'Lucar' terminal 'IGN'
3 Main input terminal
4 'Lucar' terminal (solenoid operating)
5 'Lucar' terminal (main external circuits)
6 Base assembly, comprising, fixed main contacts and ballast ignition 'IGN' contact
7 Moving spindle and contact assembly
8 Start of shunt and series windings. ('Lucar' terminal solenoid operating)
9 Solenoid body
10 Solenoid fixing studs
11 Plunger and drive return spring
12 Lost motion spring
13 Spring retaining plate
14 End of series winding (main terminal 'STA')

Do not overlook refitting the internal thrust washer to the commutator end of the armature shaft (refer Fig. 1).

Tightening torques

Through bolts	8.0 lbf ft (10.84 Nm)
Solenoid-unit fixing stud nuts	4.5 lbf ft (6.10 Nm)
Solenoid upper-terminal nuts	3.0 lbf ft (4.1 Nm)

Other tightening torques are quoted elsewhere if associated with a particular fitting operation.

Armature end-float

After completing the assembly of the starting motor, drive the 'Spire' retaining ring on the armature shaft into a position which provides a maximum of 0.010 in. (0.25 mm) clearance between the retaining ring and the bearing bush shoulder.

Finally, fit the end cap seal to the commutator end cover.

PRE-ENGAGED STARTER MODEL 3M100PE

(With Actuating Solenoid Model 19S and Roller Clutch Drive Model 7SD)

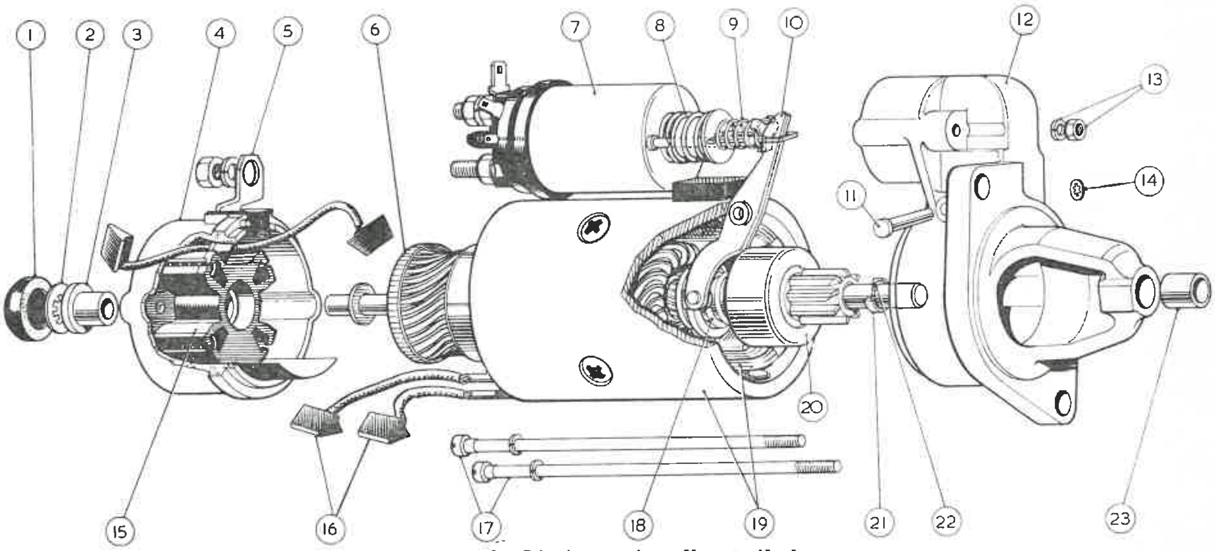


Fig. 1 Starter motor, dismantled

1 End cap
2 Retaining ring
3 Bearing bush
4 Commutator end cover
5 Connector link (solenoid to starter)
6 Armature
7 Solenoid unit 19S
8 Return spring
9 Lost motion spring
10 Drive engagement lever
11 Pivot pin
12 Drive end bracket
13 Solenoid fixing nut and washer (2 off)
14 Pivot pin retaining ring
15 Brush box moulding
16 Brushes
17 Through bolts
18 Spacing spring
19 Yoke and field coil assembly
20 Drive assembly
21 Thrust collar
22 Jump ring
23 Bearing bush

1. DESCRIPTION

The model 3M100PE pre-engaged starter is a four-pole four-brush machine, 4 in. (100 mm) diameter, with a series parallel field, an armature with a face-type commutator and a solenoid-operated roller clutch drive.

The face-type commutator on the end face of the armature works in conjunction with a fully-insulated brushgear assembly, comprising two pairs of wedge-shaped brushes and coil type springs assembled into a brushbox moulding, which is riveted to the inside of the commutator end cover. The brushes are provided with a keyway to ensure correct fitting and the springs are held captive in the brush-box moulding.

The supply voltage to the starter is applied (via the solenoid) direct to a pair of brushes. The four field coils are manufactured in series, with the start and finish of the windings terminating at a brush, and the centre point between two pairs of the coils is earthed direct to the frame of the starter by a riveted connection to the yoke. This method of connecting the field coils provides a series-parallel field circuit (see Fig. 2).

End-float and axial movement of the armature is determined by the position in which a special type of 'Spire' retaining ring is fixed to the armature shaft, where it extends through the commutator end bracket (refer Fig. 1, item No. 2).

There is no need to set the drive pinion and therefore the operating position of the drive engagement lever is non-adjustable. The plain-type pivot pin on which the lever swivels is retained in the fixing bracket by a small special type of 'Spire' retaining ring (refer Fig 1, item 14).

A feature of a pre-engaged starter is that the pinion is fully-engaged with the engine flywheel before cranking torque is developed. Normally, when the starter is operated, the pinion moves into full engagement with the engine flywheel and the solenoid contacts close to connect the starter to the battery. Full cranking torque is then developed. On occasions when tooth-to-tooth abutment occurs, the solenoid plunger continues to move by compressing a drive engagement spring inside the plunger. This plunger movement causes the solenoid contacts to close, connecting the starter to the battery. The starter armature now commences to rotate and the pressure of the drive engagement spring, combined with push-screw assistance from the drive helix, causes the pinion to move into mesh. Full cranking torque is then developed.

The roller clutch prevents the armature from rotating excessively if the drive remains in mesh after the engine has started.

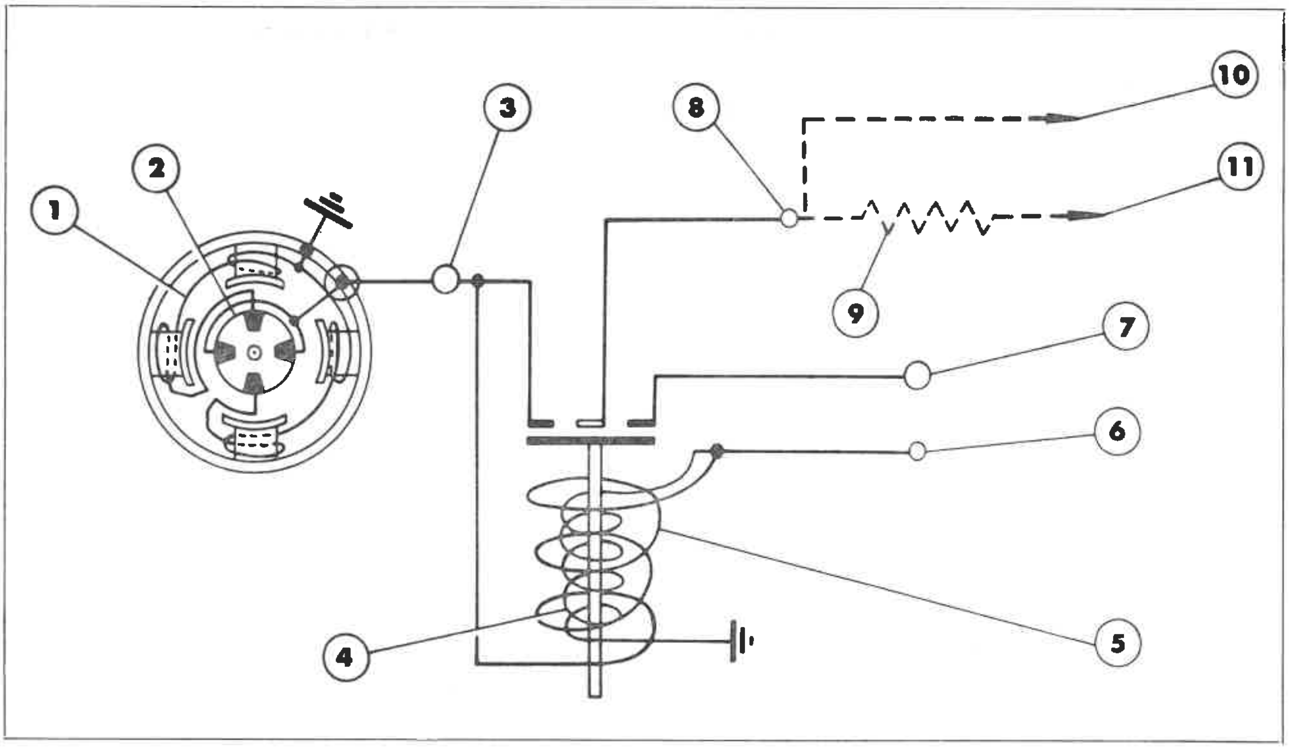


Fig. 2 Internal connections of starter and solenoid. (Broken lines applicable only when ballast ignition coil is used)

1 Field
2 Armature
3 Terminal 'STA'
4 Hold-on winding
5 Closing winding
6 Small (unmarked) terminal on solenoid
7 Battery supply terminal
8 Terminal 'IGN'
9 Ballast resistor
10 To ignition coil
11 To ignition switch

Note: Oil and water-tight versions of this starter will include special sealing features. Particularly in the case of the solenoid plunger and drive operating mechanism, which will be effectively sealed from the bell housing.

2. ROUTINE MAINTENANCE

No routine maintenance is necessary, but the tightness of the electrical connections should be checked periodically.

The starter should be dismantled for detailed inspection during major engine overhaul. The commutator should then be serviced if necessary and the brushes and armature bearings renewed (refer 4 (c) i, ii, and iv).

3. TECHNICAL DATA

The performance of the starter depends on the capacity and state of charge of the associated battery. The following are typical performance figures obtained with a 12-volt 60 Ah (20 hr. rate) battery in a 70% charged condition at 20°C (68°F).

Lock torque: 16.5 lbf ft (22.37 Nm) with 545 A (max).
Torque at 1000 rev/min: 9.0 lbf ft (12.20 Nm) with 365 A (max).
Light running current: 65A at 6000 rev/min (approx).

Solenoid

Closing (or series) winding resistance (measured between the small unmarked 'Lucar' terminal and the main terminal marked 'STA': 0.25–0.27 ohm

Hold-on (or shunt) winding resistance (measured between the small unmarked 'Lucar' terminal and a good earth point on the solenoid body: 0.76–0.80 ohm

4. SERVICING

For satisfactory starter performance, the battery must be in a good condition and at least 70% charged. Check with a hydrometer the specific gravity of the electrolyte in each of the battery cells. If there is a variation of more than 40 points (0.040) in any cell readings, the battery is suspect and should be removed for testing by a battery agent.

Specific gravity readings should be:

	Specific gravity readings correct to 15°C (60°F)	
State of charge	*Climates normally below 25°C (77°F)*	*Climates normally above 25°C (77°F)*
Fully charged	1.270–1.290	1.210–1.230
70% charged	1.230–1.250	1.170–1.190
Discharged	1.100–1.120	1.050–1.070

Electrolyte Temperature Correction

For every 10°C (18°F) below 15°C (60°F), subtract 0.007
,, ,, ,, ,, above ,, ,, , add 0.007

If the battery is in good condition and sufficiently charged, and the wiring associated with the battery, starter and operating switch, and the switch itself is satisfactory, a low cranking speed or failure of the starter to crank the engine means that the starter must be removed from the engine for detailed testing and examination. (Proceed to bench testing 4 a).

(a) Bench Testing

Determine if the Solenoid is the Cause of the Fault

(i) Using heavy-duty battery cable and a 0–70A range moving-coil ammeter in series with a 12-volt battery, connect one side of the supply voltage direct to the solenoid-to-starter connecting link and connect the other side of the supply voltage to the starter frame.

The starter should now run under light running conditions, independent of the solenoid unit.

If the starter does not run, or it runs but the light running current and speed are unsatisfactory (refer 3, Technical Data), proceed to 4 (b) and dismantle the starter sufficiently to enable the commutator and brushgear to be inspected.

If the starter runs and the light running current and speed are satisfactory, the fault could be due to the solenoid unit or the starter. Proceed to further testing (para. ii).

(ii) Transfer the previous test-circuit connection (from the solenoid-to-starter connecting link) to the solenoid main input terminal. Now connect a temporary link between this terminal and the small (unmarked) 'Lucar' terminal blade, to energise the solenoid operating winding.

The solenoid should operate and the starter should run under light running conditions.

If the starter runs and the light running current and speed are still satisfactory (as well as in the previous test, para. i), check that there is not a high resistance at the solenoid contacts, which would cause a low cranking speed. Proceed direct to para. iii.

If the starter does not run when supply voltage is applied between solenoid main input terminal and frame, and between solenoid operating winding terminal and frame, the solenoid unit is faulty. Proceed direct to para. iv.

(iii) Check that the solenoid contacts close satisfactorily, under load conditions. Connect a low-range moving-coil voltmeter between the solenoid main terminals, and perform lock torque test.

If voltmeter registers practically zero, the solenoid is satisfactory. In that case, a low cranking speed and an unsatisfactory lock torque performance indicate that the starter is faulty. Proceed to 4 (b) and dismantle the starter sufficiently to enable the commutator and brushgear to be inspected.

Note: If lock torque equipment is not available, check the solenoid by substitution, and, if necessary dismantle the starter for inspection.

(iv) In reference to previous testing (para. ii), a solenoid fault could be due to open-circuit contacts (in which case a satisfactory repair can be carried out by renewing the terminal-and-base assembly complete with new contacts), or the operating windings may be faulty (in which case the solenoid unit must be renewed).

Providing the solenoid-to-starter connecting link is first disconnected from the solenoid terminal 'STA', both solenoid windings can be simultaneously checked (in series) as follows:

Connect a good quality ohmmeter between solenoid terminal 'STA' and a good earth point on the solenoid body or starter frame. **A reading of 1.01–1.07 ohms should be obtained.**

Note: Alternative to using an ohmmeter, connect a 0–20A range moving-coil ammeter in series with a 12-volt battery, solenoid terminal 'STA' and a good earth point on the solenoid body or starter frame. **A reading of 11.2–11.8A should be obtained.**

If the solenoid operating windings are satisfactory, it confirms that the solenoid failure is due to faulty contacts. The solenoid unit should therefore be repaired or renewed.

(b) Dismantling

If access to the commutator and brushgear only is required, proceed direct to para. (ii) which deals with removing the commutator end cover.

(i) Removing the Solenoid

Remove the nut and washer which secures the solenoid-to-starter connecting link to solenoid terminal 'STA'.

Remove the nuts and washers which secure the solenoid unit to the fixing bracket. Pull back the connecting link from the solenoid terminal, and at the same time lift the terminal end of the solenoid clear of the connecting link, then withdraw the major part of the solenoid from the fixing bracket. Remove the plunger from the drive engagement lever, by gripping the plunger in the hand and applying an upward lift at the front end of the plunger.

(ii) Removing the Commutator End Cover

Before removing the commutator end cover, ensure that a service replacement 'Spire' retaining ring is available as a new fitment for use during re-assembly of the starter. This is necessary because this type of retaining ring is a press fit (or drive fit) on the armature shaft and if the original fitting of the retaining ring is disturbed, it becomes unsatisfactory for further use.

Remove the end cap seal to gain access to the 'Spire' retaining ring.

Remove the retaining ring before unscrewing the through bolts. Using an engineers chisel, cut through a number of the retaining ring claws until the grip on the armature shaft is sufficiently relieved to allow the retaining ring to be removed.

Remove the nut and washer which secures the solenoid-to-starter connecting link to solenoid terminal 'STA'. (This will already have been done, if the solenoid has previously been removed as a preliminary to complete dismantling).

Remove the two through bolts.

After removing the through bolts, the commutator end cover can be removed from the rest of the starter by partially withdrawing the cover from the yoke and then disengaging the two field coil brushes from the brush box moulding.

Note: At this stage of dismantling, check the commutator and brushgear (refer 4 c, para. i and ii).

(iii)

After removing the commutator end cover, continue dismantling by withdrawing the yoke and field-coil assembly from the armature and fixing bracket sub-assembly. Do not disturb the field-coil assembly in the yoke (refer to 4 c, para. iii).

(iv)

If the 'Spire' retaining ring is removed from the drive engagement lever pivot-pin and the pivot-pin is then withdrawn from the fixing bracket, the armature assembly comprising roller clutch drive and lever assembly can then be separated from the fixing bracket.

Note: The pivot-pin retaining ring, similar to the one at the commutator end (except for size), must be renewed if the original fitting is disturbed.

(v)

The roller clutch drive and lever assembly is removable from the armature shaft as a complete unit. Using a tubular tool (e.g. a box spanner) drive the thrust collar squarely off the jump ring and then after removing the jump ring from the groove in the armature shaft, slide the thrust collar and the roller clutch drive and lever assembly off the shaft. It is unnecessary to dismantle the drive engagement lever from the roller clutch drive, since both these parts are serviced as a complete assembly. (The operation of the roller clutch drive should be checked as detailed in 4 c, para. v).

(c) Bench Inspection

After dismantling the starter, examine the individual items as follows:

(i) Armature

The face of the commutator should be clean and free from burnt spots. Clean the commutator with a petrol-moistened cloth and, if it should be necessary, use a flat surface of very fine glass paper to rectify burnt spots, or grooving, prior to using the petrol-moistened cloth.

In some cases it may be necessary to skim the commutator. The minimum thickness to which the commutator copper may be skimmed, before a replacement armature becomes necessary, is 0.140 in. (3.5 mm). The skimming operation should be terminated by polishing the commutator surface with a flat pad of very fine glass paper or emery cloth, then wipe clean with a petrol-moistened cloth. DO NOT UNDERCUT THE INSULATION SLOTS.

If the armature shows signs of 'thrown' solder, or lifted conductors, over-speeding of the armature is indicated. (Check the operation of the roller clutch drive, 4 c, para. v).

The armature insulation can be checked by connecting a 110-volt a.c. 15-watt test lamp between a commutator segment and the shaft (refer Fig. 3). **The lamp should not light.**

Short-circuited armature windings (indicated by a high current consumption, low light running speed and low lock torque performance) can only be detected by the use of specialised armature testing 'Growler' equipment. If this equipment is not available, the only alternative is to check the armature by substitution.

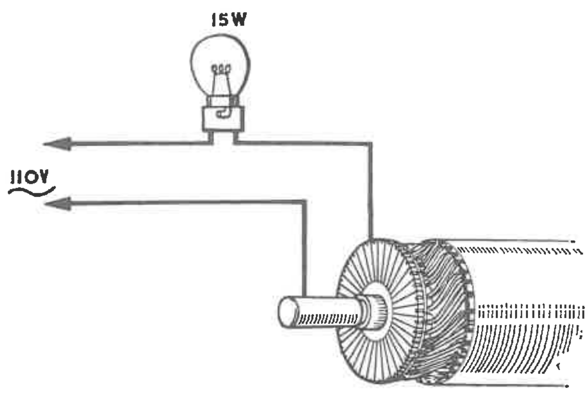


Fig. 3 Armature insulation test

If the armature laminations have been in contact with the pole-shoes, the armature bearings are probably excessively worn. First, check that the pole-shoes are tight and that the armature runs true in a lathe. Then, if necessary, renew the armature bearings (refer 4 c, para. iv).

(ii) Brushgear

Check that the brushes move freely in the brush box moulding. Sticking brushes should be cleaned with a petrol-moistened cloth. Brushes which are worn to approximately 0.375 in. (9.5 mm) in length, must be renewed.

Renewing the brushes: Note which of the two field coil conductors is fitted with the long and short brush-flexibles, then cut the worn brush-flexibles from the field coils and solder the new brushes in position. Replace the other two brushes complete with terminal link and moulded rubber grommet. Ensure the new brush set is correctly fitted in accordance with Fig. 4.

Note: Use only resin-cored type solder.

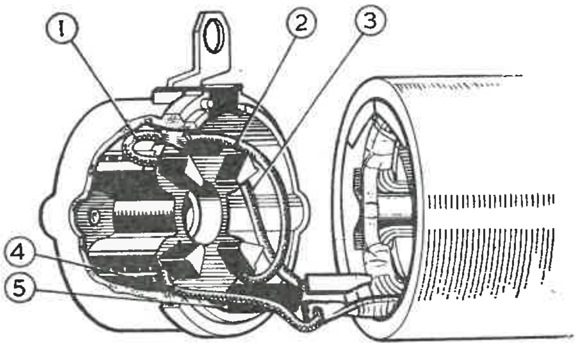


Fig. 4 Brushgear and terminal arrangement

1 Short brush-flexible, C/E cover
2 Long brush-flexible, ,,
3 Long brush-flexible, field winding
4 Short brush-flexible, ,,
5 Insulation piece

Brush spring pressure: To measure the brush spring pressure, position a new brush in each of the brush boxes in turn and then press on top of the brush with a push-type spring gauge (refer Fig. 5) until the top of the brush protrudes about 0.062 in. (1.5 mm) from the brush box moulding, when the spring pressure reading should be 36 ozf (10.0 N).

Check the insulation of the brush springs by connecting a 110-volt a.c. 15-watt test lamp between a clean part of the commutator end cover and each of the springs in turn. The lamp should not light.

Check that the connecting link grommet is in good condition.

(iii) Yoke and Field Coil Assembly

The field coils should be visually inspected in-situ for signs of obvious fault(s). Check the inter-

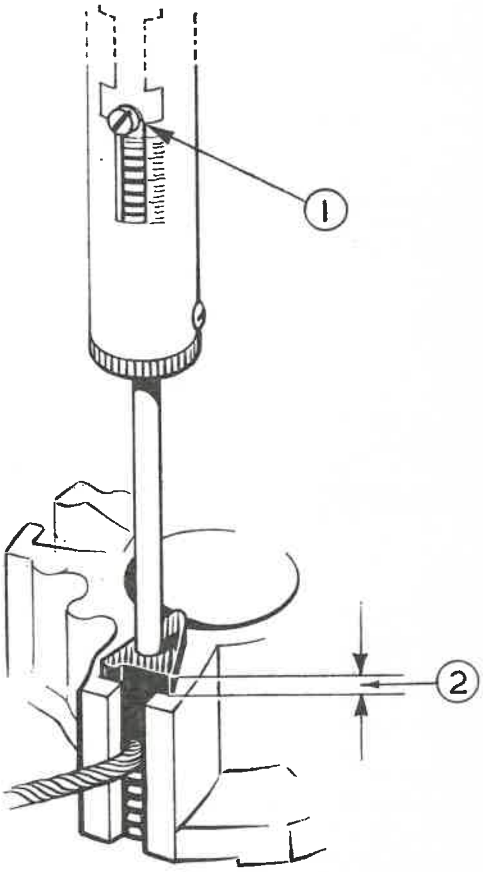


Fig. 5 Checking brush spring pressure

1 Push type spring gauge, with sliding marker indicating reading where 'arrowed'
2 0.062 in. (1.50 mm) approx.

connecting joints between coils, the earthed connection of the field winding where it is riveted to the yoke, and look for discolouration (due to burning) of the winding insulation tape, which could indicate short-circuited windings or a short-circuit between the windings and the yoke. A visible fault will eliminate the need for testing and in such cases if necessary the field coil assembly should be removed from the yoke to enable it to be repaired or renewed.

If there are no obvious signs of a fault, the field coil continuity and the insulation between the field coils and yoke can be checked without removing the field coil assembly from the yoke.

Field coil continuity: Check by connecting a 12-volt battery-operated test lamp between each of the brushes in turn and a clean part of the yoke. **The lamp should light.**

Field coil insulation: Before being able to check the insulation between the field coils and yoke, it will first be necessary to disconnect the earthed end of the winding from the yoke. Before disconnecting the winding (refer to the heading 'Renewing the field coils'), determine whether it is justified. Consider the results of the light running and lock torque tests, or alternatively consider the fault symptoms. If the speed and torque were low, and the current consumption high, or the fault symptom was low cranking speed, faulty field winding insulation could be the cause and this interpretation of the starting motor performance would justify disconnecting the earthed end of the field winding to enable a positive check to be carried out.

The field winding insulation can be checked (after disconnecting the winding at the yoke) by connecting a 110-volt a.c. 15-watt test lamp between the disconnected end of the winding and a clean part of the yoke. **The lamp should not light.** Ensure that neither of the brushes, or bare parts of their flexibles, contact the yoke during the test.

Note: Due to the very low resistance of the field coil conductors, the presence of a short-circuit between the field coil windings can only be determined by specialised equipment. If the results of all previous testing has been satisfactory, short-circuited field coil windings could be the cause of the fault and the field coil assembly should now be further proved by substitution.

Renewing the field coils: Disconnect the end of the field winding where it is riveted to the yoke. To do this, file away the riveted-over end of the connecting-eyelet securing rivet, sufficient to enable the rivet to be tapped out of the yoke. Remove the four pole-shoe screws with a wheel-operated or power-operated screwdriver and withdraw the field coil assembly from the yoke. Wipe clean the inside of the yoke, and the insulating pieces through which the through bolts locate.

Loosely fit the new field coil assembly (with pole-shoes) into the yoke, with the threads of the pole-shoe fixing screws only partially engaged. The through bolt insulating pieces should now be assembled into the yoke, by sliding the shoulders of the insulating pieces between the field coils and the yoke. in a position 180° apart and 90° each side of the field coil brush connection point (refer Fig. 4). Now tighten the pole-shoe screws progressively to a torque of 30 lbf ft (40.70 Nm). Finally, make a good earth connection between the end of the field winding and the yoke.

(iv) Bearings

The armature bearings, fitted in the commutator end cover and the drive end fixing bracket, are self-lubricating porous-bronze bushes.

New bushes must be completely immersed in Shell 'Turbo 41' oil, or in clean engine oil, for 24 hours at room temperature, before they are fitted. Alternatively, if the lubricant is heated to a temperature of 100°C, 2-hours immersion of the bushes is sufficient, providing the lubricant is allowed to cool before the bushes are removed.

The bushes must **not** be reamed after fitting otherwise the self-lubricating qualities will be impaired.

The bushes must be renewed when there is excessive side-play of the armature shaft. Fouling of the pole-shoes by the armature, or inefficient operation of the starter, is likely to occur when the inner diameter of the bushes exceeds the following dimensions:– commutator end cover bush 0.441 in. (11.20 mm), drive end fixing bracket bush 0.476 in. (12.09 mm).

Worn bushes should be removed by using a wheel-operated press. Alternatively, support the bearing housing and then with a mandrel carefully tap the bush out of the cover or bracket.

New bushes should be pressed into position by means of a shouldered polished mandrel with dimensions as follows:- commutator end cover bush 0.4377 in. (11.117 mm), drive end fixing bracket bush 0.4729 in. (12.011 mm).

(v) The Roller Clutch Drive Assembly

Check the clutch action. The pinion should have instantaneous take-up of the drive in one direction and be free to rotate in the other.

Check that the assembly moves freely along the armature shaft splines. The armature shaft splines and moving parts of the engagement lever should be liberally smeared with Shell SB.2628 (home market and cold climates); Retinax 'A' (hot climates). The roller clutch mechanism is a sealed unit, which is pre-packed with sufficient grease to last the life of the starting motor. In the unlikely event of the clutch action becoming faulty, it will not be possible to rectify the fault and the whole of the drive assembly will have to be renewed.

(vi) The Solenoid Unit

Associated with the solenoid plunger are three springs: the plunger and drive return spring, the drive engagement spring which is incorporated inside the plunger to overcome the difficulty of engaging the pinion on occasions of tooth-to-tooth abutment, and the 'lost motion' spring which is assembled to the connecting part of the solenoid plunger to provide a measure of lost motion in the drive operating mechanism as the drive commences to disengage. It is sufficient to check only that the springs are not broken. In the case of the drive engagement spring (inside the plunger), to check the spring it will be necessary to ensure that a spring-loaded pull action exists between the plunger body and the connecting part of the plunger.

Checking the solenoid contacts and winding is dealt with in 4 (a), para. iii and iv.

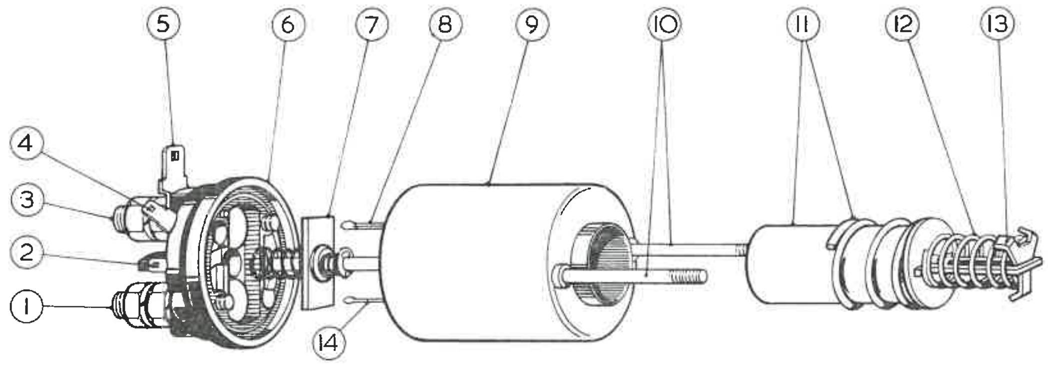


Fig. 6 Solenoid model 19S, dismantled

1 Main terminal 'STA'
2 Small 'Lucar' terminal
3 'IGN' Main input terminal
4 'Lucar' terminal (solenoid operating)
5 'Lucar' terminal (main external circuits)
6 Base assembly, comprising, fixed main contacts and ballast ignition 'IGN' contact
7 Moving spindle and contact assembly
8 Start of shunt and series windings ('Lucar' terminal solenoid operating)
9 Solenoid body
10 Solenoid fixing studs
11 Plunger and drive return spring
12 Lost motion spring
13 Spring retaining plate
14 End of series winding (main terminal 'STA')

Note: The solenoid may incorporate a very small additional 'Lucar' terminal blade (marked 'IGN'), which is for use in conjunction with ballast ignition systems. It is sufficient to check that this terminal becomes electrically connected to the solenoid main input terminal, when the solenoid is energised.

Renewing the solenoid contacts: Remove the two screws securing the terminal and base assembly to the solenoid body. Apply a hot soldering iron alternately to each of the two soldered terminal connections and wait for the solder to run free. Shake most of the melted solder out of the joints, by tapping the solenoid terminal ends sharply down on the bench. Now clamp the solenoid body in a vice (terminals uppermost) and while applying a constant pull on the moulded cover, apply the soldering iron alternately to the two soldered connections until the terminal-and-base assembly is freed. When re-making the solenoid connections, avoid dry-soldered joints by ensuring that the parts are clean and adequately heated before applying the solder. Tighten the terminal-and-base assembly fixing screws to a torque of 1.8 lbf ft (2.44 Nm).

(d) Reassembly

Assembling tbe starter is simply a reversal of the dismantling procedure. Sequence of assembling components is illustrated in Fig. 1. Fitting the solenoid unit should take place after the commutator end cover has been fitted, otherwise it will be difficult to fit the block-shaped grommet which, when assembled, is compressed between the yoke, solenoid and fixing bracket.

Do not overlook refitting the internal thrust washer to the commutator end of the armature shaft (refer Fig. 1).

Tightening torques

Through bolts	8.0 lbf ft (10.84 Nm)
Solenoid-unit fixing stud nuts	4.5 lbf ft (6.10 Nm)
Solenoid upper-terminal nuts	3.0 lbf ft (4.1 Nm)

Other tightening torques are quoted elsewhere if associated with a particular fitting operation.

Armature end-float

After completing the ssembly of the starter, drive the 'Spire' retaining ring on the armature shaft into a position which provides a maximum of 0.010 in. (0.25 mm) clearance between the retaining ring and the bearing bush shoulder.

Finally, fit the end cap seal to the commutator end cover.

12-VOLT INERTIA DRIVE STARTERS
(Models M35G, M418G and M45G)

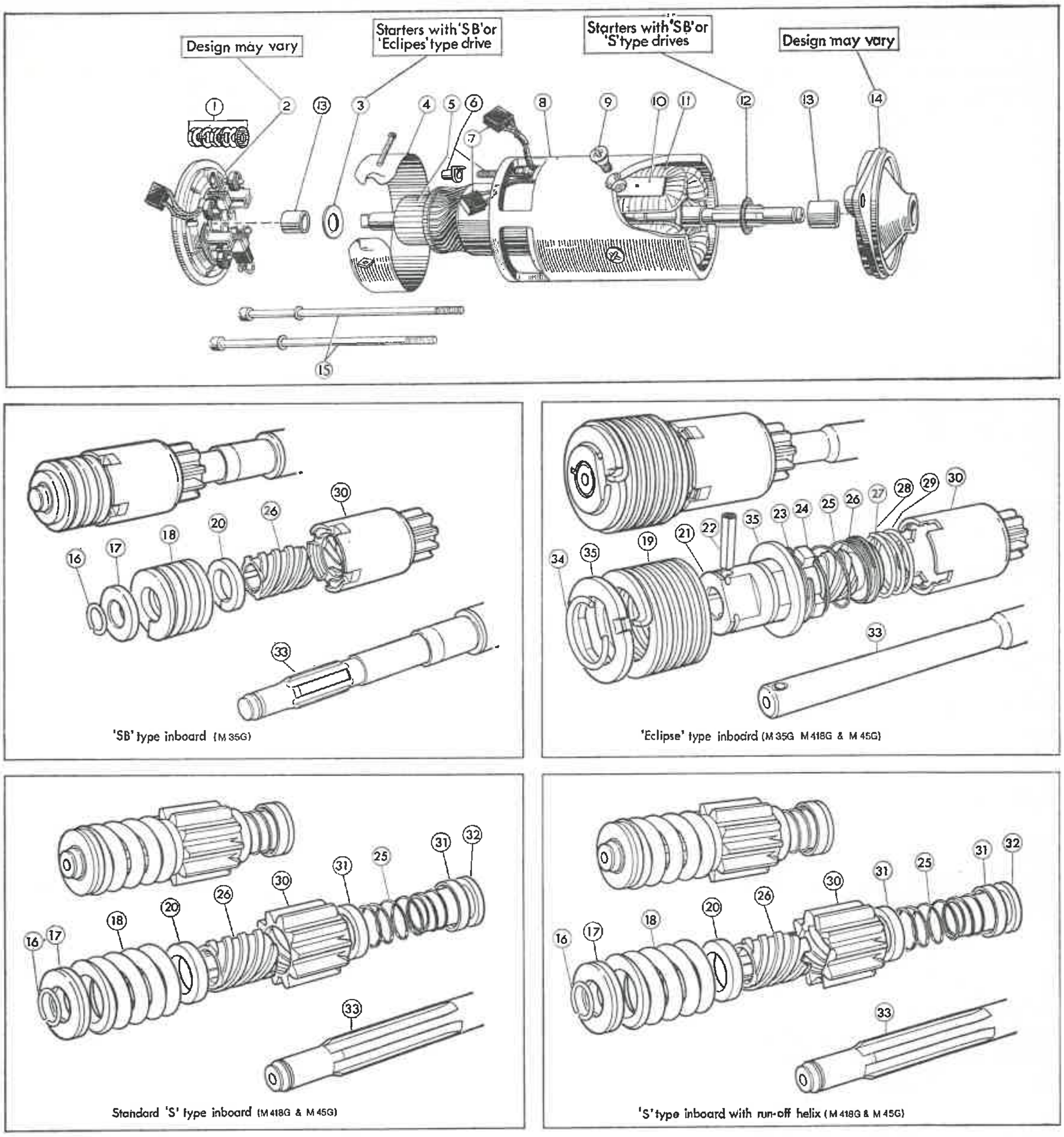


Fig. 1 Typical starter dismantled (showing alternative drive assemblies)

1 Terminal sundry parts, (note insul.-washer, extreme right)
2 Commutator end bracket assembly, (comprising bearing bush, earth brushes and springs)
3 Thrust washer(s)
4 Band cover, screw and nut
5 Commutator/Armature
6 Terminal and terminal insulator
7 Insulated brushes (attached to field coils)
8 Yoke assembly
9 Pole-shoe retaining screws (4)
10 Pole-shoes (4)
11 Field coil assembly (either series or series-parallel connected)
12 Thrust washer(s)
13 Bearing bush (porous-bronze, oil impregnated, self-lubricating)
14 Drive end bracket assembly (comprising bearing bush)
15 Through bolts
16 Circlip (retaining drive parts on armature shaft)
17 Shroud washer (circlip retaining)
18 Main 'compression' spring
19 Main 'tension' spring
20 Thrust collar
21 Drive shaft
22 Roll-type dowel pin (shouldered-type, earlier fitment)
23 Circlip (retaining pinion and barrel on drive shaft)
24 Control nut (circlip retained in pinion and barrel)
25 Pinion restraining spring (retains pinion in disengaged out-of-mesh position)
26 Screwed sleeve
27 Thrust washer, and shroud washer (circlip retaining)
28 Circlip (retains screwed sleeve etc. on drive shaft)
29 Run-off-helix operating spring
30 Pinion, or pinion and barrel ('SB' type pinion and barrel incorporates the screwed sleeve, pinion restraining spring and control nut)
31 Spring retaining cup (2)
32 Restraining spring sleeve
33 Armature shaft extension
34 Circlip (retains main spring on drive shaft)
35 Spring anchor plates

12-Volt Inertia Drive Starters
(Models M35G, M418G and M45G)

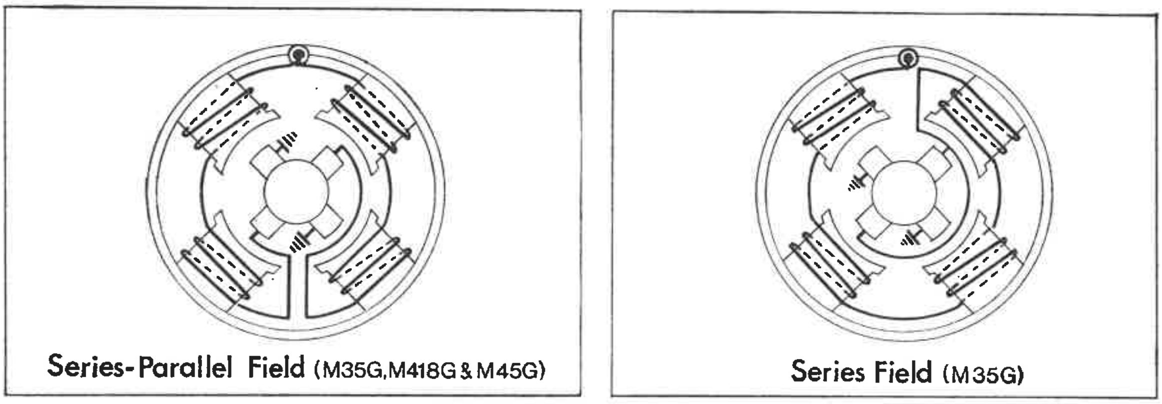


Fig. 2 Starter internal connections

1. GENERAL

Starter models M35G, M418G and M45G are four-pole, four-brush machines, similar in construction but different in size and electrical performance.

M35G

Yoke diameter 3.5 in. (89 mm), field windings either series-parallel or series connected (see Fig. 2). Small engine applications.

M418G

Yoke diameter 4.125 in. (105 mm), field winding series-parallel connected (see Fig. 2). Medium-sized engine applications.

M45G

Yoke diameter 4.5 in. (114 mm), field windings series-parallel connected (see Fig. 2). Larger engine applications requiring more cranking torque than the capabilities of the M35G and M418G starters.

The starters are used in conjunction with either a solenoid-operated or manually-operated switch, separately fixed to the engine, body or frame. The manually-operated switch will usually be Lucas Model ST19, either push or pull movement and rod or cable operated. The solenoid-operated switch may be one of the following: Lucas Models ST950, 2ST or 4ST, these being of different design but having the same function and completely interchangeable.

Note: Starters of standard specification are earth-return machines, the majority being clock rotation (viewed from the drive-end). Insulated-return starters (manufactured in small quantities) will have the two normally-earthed brushes insulated and connected to an additional terminal incorporated in the commutator end bracket.

Starter Operation

The moment the starter operates, pinion inertia overcomes the light pressure of the pinion restraining spring and the pinion moves along the screwed sleeve and into engagement with the engine flywheel. The engine is then cranked.

Pinion engagement is assisted by a chamfer on the engaging edges of both the pinion and flywheel teeth and engagement of the pinion and initial cranking torque is cushioned by the heavy-gauge main spring on the end of the drive shaft.

When the engine starts, the speed of the flywheel overcomes the cranking speed of the starter and the flywheel drives the pinion out of engagement and returns it along the screwed sleeve to the out-of-mesh stationary position, where it is retained until the next operation of the starter.

Explanation of Different Starter Drives

Four different types of starter drives are associated with M35G, M418G and M45G starters (refer Fig. 1 for design and starter applications).

'SB' and 'S' type drives

Both these drives have the same operation and are designed for small and larger engines respectively.

'S' type run-off-helix and 'Eclipse' type drives

These drives operate similarly to the other two types, but their design incorporates additional features which cater for adverse conditions of engine starting.

'S' type run-off-helix drive

In this case the run-off-helix protects the starter from overload and consequent damage if the engine backfires during starting. If this adverse condition of starting arises, the pinion forces the screwed sleeve along the straight splines of the shaft until the helical splines of pinion and sleeve disengage. A ratcheting free-wheeling action between pinion and drive then takes place, removing excess torque from the starter.

'Eclipse' type drive

This type of drive has two special features:

(i) A main tension spring (instead of a compression spring), which provides smoother engagement of the pinion with the engine flywheel and transmits the starter cranking torque through the drive to the engine.

(ii) Run-off-helix positive disengagement of pinion. (Not to be confused with the starter 'overload' feature of the 'S' type run-off-helix type drive). In this case the run-off-helix ratcheting free-wheeling action between pinion and drive, takes place after the engine has been started and when the flywheel has returned the pinion to the out-of-mesh position.

If an excess throttle-opening is used during the starting period, the flywheel will disengage the pinion at a faster speed than normal and the pinion will be driven along the screwed sleeve to the out-of-mesh position at considerable force. Under these conditions, the pinion of a standard-type drive would sometimes rebound from the out-of-mesh position (against the limited pressure of the pinion restraining spring) and foul the moving flywheel, causing damage to the pinion and flywheel teeth. The 'Eclipse' run-off-helix prevents this by allowing the pinion to rotate freely in the out-of-mesh position, independent of the rest of the drive, until excess inertia transmitted by the flywheel to the pinion has been safely dissipated. When the pinion stops rotating, the limited pressure of the pinion restraining spring is then sufficient to retain the pinion in the out-of-mesh stationary position.

2. ROUTINE MAINTENANCE

No routine maintenance is necessary. The porous-bronze bearing bushes are initially impregnated with sufficient oil lubricant to provide self-lubrication of the bushes until major overhaul of the starter becomes necessary, the bearing bushes and carbon brushes should then be renewed and the commutator inspected and serviced as required (refer 4b).

3. TEST DATA

The performance of the starter depends on the capacity, and state-of-charge of the associated battery. The figures given are typical performance characteristics obtained with a battery 70% charged at 20°C (68°F), using a 12V 43Ah (20hr. rate) battery in the case of an M35G starter and a 12V 60Ah (20hr. rate) battery in the case of M418G and M45G starters.

Starter M35G (12-volt)

Lock torque: 6.7 lbf ft MIN. (0.92 kgf m or 9.1 Nm) with 365A.

Torque at 1000 rev/min: 4.0 lbf ft MIN. (0.55 kgf m or 5.4 Nm) with 250A.

Light running current: 60A at 8,000–11,500 rev/min.

Starter M418G (12-volt)

Lock torque: 17.0 lbf ft MIN. (2.34 kgf m or 23.1 Nm) with 460A.

Torque at 1000 rev/min: 8.0 lbf ft MIN. (1.10 kgf m or 10.8 Nm) with 250A.

Light running current: 70A at 5,500–8,000 rev/min.

Starter M45G (12-volt)

Lock torque: 29.0 lbf ft MIN. (4.0 kgf m or 39.3 Nm) with 930A.

Torque at 1000 rev/min: 13.5 lbf ft MIN. (1.80 kgf m or 18.3 Nm) with 510A.

Light running current: 100A at 5,000–6,000 rev/min.

6.25 in. (159 mm) standard length yoke and 23-slot armature (refer 'Note').

Starter M45G (12-volt)

Lock torque: 18.5 lbf ft MIN. (2.50 kgf m or 25.1 Nm) with 450A.

Torque at 1000 rev/min: 7.8 lbf ft MIN. (1.07 kgf m or 10.6 Nm) with 235A.

Light running current: 70A at 5,800–6,500 rev/min.

6.25 in. (159 mm) standard length yoke and 37-slot armature (refer 'Note').

Note: In practice, to determine the test figures for a particular M45G starter, it will be necessary to know whether the starter incorporates either a 23-slot or 37-slot armature. This can be ascertained by first slackening the bandcover and sliding it along the yoke to expose the commutator, a light scratch mark should then be made on one of the commutator segments (outside the area which contacts the brushes), then rotate the drive shaft and count the commutator segments. The number of commutator segments corresponds with the number of winding slots.

4. SERVICING

(a) Starter in Situ

If the starter fails to crank the engine, or cranks the engine at a low speed, consider the fault symptoms. It may be possible to rectify the fault without removing the starter from the engine.

(i) Starter operates and runs freely as a motor, but engine is not cranked

Starter pinion not engaging with engine flywheel. Probably due to:

The battery (Extremely low state of charge). Refer 4(a), para. (iv).

Faulty starter drive (Faulty component(s), or sticking pinion). Remove starter from engine and inspect the drive. Renew faulty part(s). Check whether the pinion is sticking, as follows:

Rotate pinion into engaged position and then release it. The pinion restraining spring should return the pinion smartly to the disengaged out-of-mesh position. If the pinion sticks, lubricate the helical splines of pinion and sleeve with machine oil and activate the pinion until it moves freely.

(ii) Starter does not operate

Check and eliminate in the following order:

Battery terminal connections (Must be clean and tight).

Battery Condition (Check for sufficient charge and internal fault). Refer 4(a), para. (iv).

Heavy-duty cable connections (Check tightness).

Starter pinion jammed in engine flywheel (Refer following sub-headings).

Cars and light commercial vehicles: Switch on the headlamps. Operate the starter control switch and observe whether headlamp brilliance dims.

If headlamp brilliance is unaffected, it proves that the pinion is not jammed. (Proceed to volt drop testing, para. v).

If headlamp brilliance dims, either the pinion is jammed or there is an internal fault in the starter. (Proceed as follows). Ensure either the ignition switch or fuel control switch is OFF. Engage top gear and rock the vehicle forward and backward, several times. This normally results in a jammed pinion being freed and is usually confirmed by the audible return of the pinion to the disengaged out-of-mesh position. Disengage gear and check whether starter now operates. If not, carry out the alternative method of freeing a jammed pinion as detailed for industrial engines and heavy vehicles. If fault persists, remove the starter from the engine and proceed to 4(b), para.'s (ii) and (iii) 'Dismantling' and 'Bench Inspection'.

Industrial engines and heavy vehicles: Use the blade of a screwdriver and prise a cylindrical dust cover from the end-face of the starter, to expose a square end of the starter shaft. Check that the engine or vehicle is in neutral gear. Apply a spanner to the square end of the shaft and determine whether the shaft can be turned in both directions. If so, it proves that the pinion is not jammed. (Proceed to volt drop testing, para. v). If the shaft can only be turned in one direction, it confirms that the pinion is jammed. Continue turning the shaft by repositioning the spanner at least three times on the square end of the shaft, the pinion should then be freed.

Note: Frequent jamming of the starter pinion is usually caused by the pinion teeth being excessively worn. The fault can usually be rectified by renewing the starter pinion only, but if the pinion is renewed it should also be determined whether the teeth on the flywheel ring gear are excessively worn, in which case the flywheel must also be renewed.

(iii) Starter cranks engine at a low speed

Check and eliminate in the following order:

Battery condition (Check for sufficient charge and internal fault). Refer 4(a), para. iv.

Battery terminal connections (Must be clean and tight).

Heavy-duty cable connections (Check tightness).

If these preliminary checks do not result in locating the fault, proceed to volt drop testing, 4(a), para. v.

(iv) The Battery

For satisfactory starter performance, the battery should be at least 70% charged and must be free of internal faults.

Check, with a hydrometer, the specific gravity of the electrolyte in each of the battery cells.

If there is a variation of more than 40 points (0.040) between any cell readings, the battery is faulty and must be renewed.

	Specific gravity readings corrected to 15°C (60°F)	
State of charge	*Climates normally below 25°C (77°F)*	*Climates normally above 25°C (77°F)*
Fully charged	1.270 – 1.290	1.210 – 1.230
70% charged	1.230 – 1.250	1.170 – 1.190
Discharged	1.100 – 1.120	1.050 – 1.070

Electrolyte Temperature Correction

For every 10°C (18°F) below 15°C (60°F) subtract 0.007
,, ,, ,, ,, above ,, ,, add 0.007

(v) Volt drop testing

Note: A moving-coil voltmeter (0–20V range) is required in the following tests. In Figs. 3, 4, 5 and 6, the broken line indicates the voltage normally registered prior to the test.

If the starter is capable of cranking the engine, for the purpose of the following tests the engine must be prevented from starting.

Petrol engines: If the starter switch is controlled via the ignition switch, the low-tension circuit of the ignition coil should be disconnected between the coil and distributor.

Diesel engines: Switch off the fuel supply.

TEST 1.

Check the battery terminal voltage under load conditions.

Connect the voltmeter across the battery terminals (see Fig. 3), battery voltage (12V) should be registered.

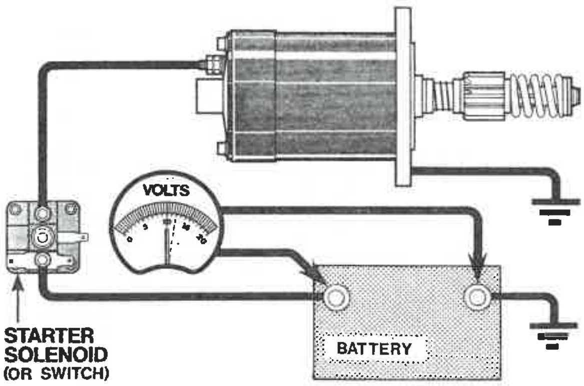


Fig. 3 Checking battery terminal voltage under load conditions. (Broken line indicates voltmeter reading prior to test)

Operate the starter control switch and observe the voltmeter reading.

If the starter cranks the engine and the voltmeter reading, initially 12V, falls to approximately 10V, testing so far is satisfactory. (Note actual voltage registered and proceed to TEST 2).

Irrespective of whether the starter operates, if the voltmeter reading falls appreciably below 10V then the starter must be faulty. (Remove starter from engine and proceed to 4(b), para's (ii) and (iii) 'Dismantling' and 'Bench Inspection').

Irrespective of whether the starter operates, if the voltmeter reading falls but registers more than 10.5V then suspect a high-resistance fault. (Proceed to TEST 3).

If the starter does not crank the engine and the voltmeter reading remains unaltered (12V) then either the starter is faulty or the starter circuit has an open-circuit fault. (Proceed to TEST 2).

TEST 2.

Check the starter terminal voltage under load conditions.

Connect the voltmeter between the starter terminal and either of the through bolts (see Fig. 4).

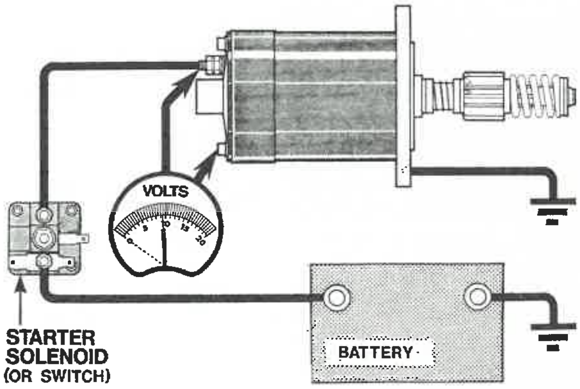


Fig. 4 Checking the starter terminal voltage under load conditions. (Broken line indicates voltmeter reading prior to test)

Operate the starter control switch and observe the voltmeter reading.

If the starter cranks the engine and the voltmeter reading is the same or not more than 0.5V below that registered in the previous test, the starter system is satisfactory and testing should be discontinued.

If the starter cranks the engine and the voltmeter reading is more than 0.5V below that registered in the previous test, the starter system has a high-resistance fault. (Proceed to TEST 3).

If the starter does not crank the engine and the voltmeter registers battery voltage (12V) then the starter is faulty. (Remove starter from engine and proceed to 4(b), para's (ii) and (iii) 'Dismantling' and 'Bench Inspection').

If the starter does not crank the engine and the voltmeter indicates zero volts, transfer the voltmeter connections to the main input terminal of the starter switch, or solenoid, and earth. Battery voltage (12V) should now be registered, otherwise continuity of the heavy-duty cable between the battery and the starter switch, or solenoid, must now be checked. Providing there is battery voltage at the main input terminal of the starter switch or solenoid: In the case of a manually-operated starter switch, it is now proved faulty, and should be renewed. In the case of a solenoid, audible operation of the solenoid would confirm the starter control switch to be satisfactory, in which case the solenoid is now proved faulty and should be renewed. If audible operation of the solenoid does not occur, detach the cable from the solenoid-operating (feed) terminal of the solenoid, connect the voltmeter between the cable-end and earth (frame), and check whether battery voltage is registered when the starter control switch is operated. If so, the solenoid is now proved faulty and should be renewed. If zero voltage is indicated, check continuity of the starter control switch and its associated circuit.

TEST 3.

Check for high-resistance fault on insul.-side of starter circuit.

Connect the voltmeter between the starter terminal and the insulated side of the battery (see Fig. 5), battery voltage (12V) should be registered.

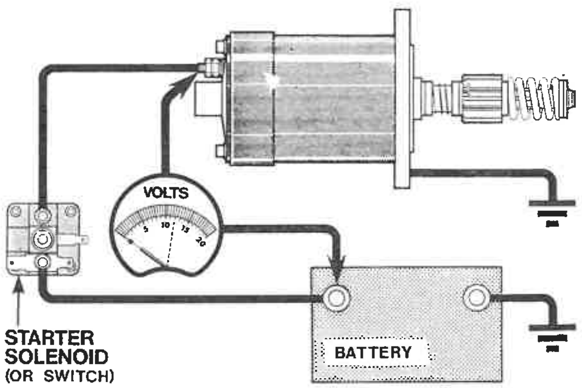


Fig. 5 Checking for high-resistance fault on insulated side of starter circuit. (Broken line indicates voltmeter reading prior to test)

Operate the starter control switch and observe the voltmeter reading. 0–0.25V is satisfactory. (Ignore Test 4 and proceed direct to TEST 5).

If more than 0.25V is registered, a high-resistance fault is confirmed. (Proceed to TEST 4).

TEST 4.

Check for high-resistance fault across the starter switch, or solenoid, contacts.

Connect the voltmeter between the two main terminals of the starter switch or solenoid (see Fig. 6), battery voltage (12V) should be registered.

Operate the starter control switch and observe the voltmeter reading.

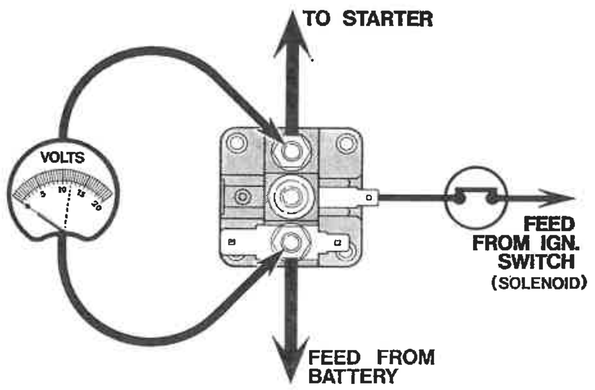


Fig. 6 Checking for high-resistance fault across the starter switch, or solenoid contacts. (Broken line indicates voltmeter reading prior to test)

Zero volts confirms the starter switch, or solenoid, is satisfactory, in which case the high-resistance fault detected in the previous test (TEST 3) must be due to unsatisfactory heavy-duty cable or connections.

If a voltage is registered, the starter switch, or solenoid, is faulty and should be renewed.

After rectifying either of the faults detected in this test proceed to TEST 5.

TEST 5.

Check for high-resistance fault on earth-side of starter circuit.

Connect the voltmeter between either of the starter through-bolts and the earth terminal of the battery (see Fig. 7).

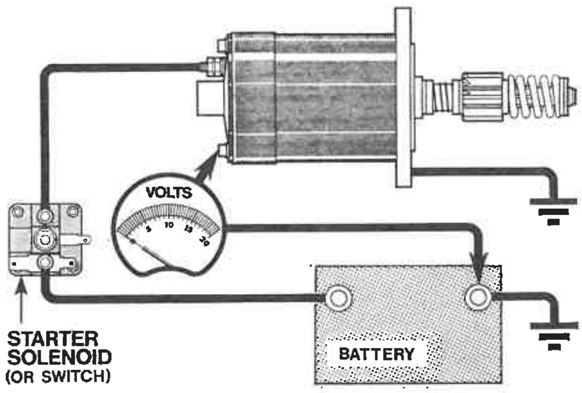


Fig. 7 Checking for high-resistance fault on earth-side of starter circuit

Operate the starter control switch and observe the voltmeter reading.

If 0–0.25V is registered, the starter system is satisfactory.

If more than 0.25V is registered, the earth-side of the starter circuit has a high-resistance fault. Check battery earth connection to frame, and check engine/gearbox earth connection to frame (see Fig. 8).

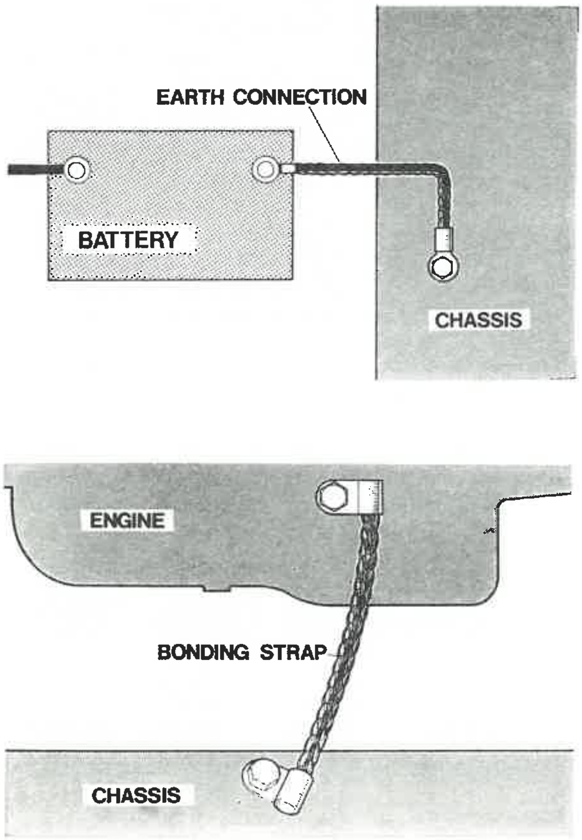


Fig. 8 Starter circuit earth connections

(b) Bench Testing, Dismantling and Bench Inspection

(i) Bench Testing

Ascertain whether the fault symptom 4(a) para. (i) applies, if so then refer sub-heading 'Faulty starter drive'.

Starter performance can only be determined by carrying out torque and light running tests. (Starter performance details are given in 3. TEST DATA).

(ii) Dismantling

Dismantling (renewing) the drive assembly

'SB' and 'S' type drives: Early-production drive assemblies are retained on the armature shaft by a round castle nut, locked in position by a cotter-pin inserted in the armature shaft (see Fig. 9). To dismantle the drive remove the cotter-pin from the shaft, prevent the armature from rotating by applying a spanner to the square end of the shaft at the commutator-end, then unscrew the castle nut.

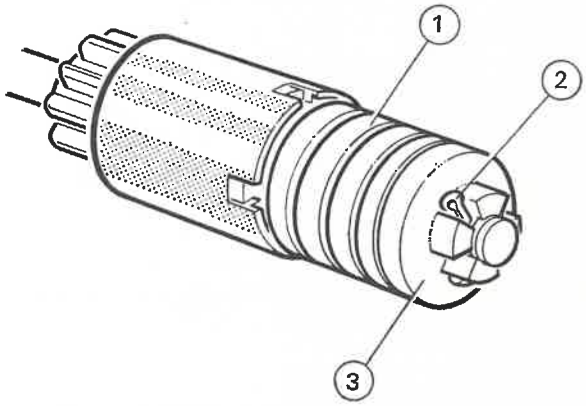


Fig. 9 Early-production cotter-pin-retained 'S' and 'SB' type drives ('SB' type illustrated)

1 Main spring **2** Cotter-pin **3** Castle nut

Note: 'S' and 'SB' type drives cotter-pin-retained can be dismantled and reassembled without the need for special tools (refer script)

Later-production drive assemblies are retained on the armature shaft by a circlip, enclosed by a shroud washer which in turn retains the circlip in its groove in the shaft (see Fig. 1, items 16 and 17). In this case, to dismantle the drive, it will be necessary to use a special tool to compress the main spring and press the shroud washer away from the circlip, so exposing the circlip and enabling it to be removed from its groove in the shaft (see Fig. 10).

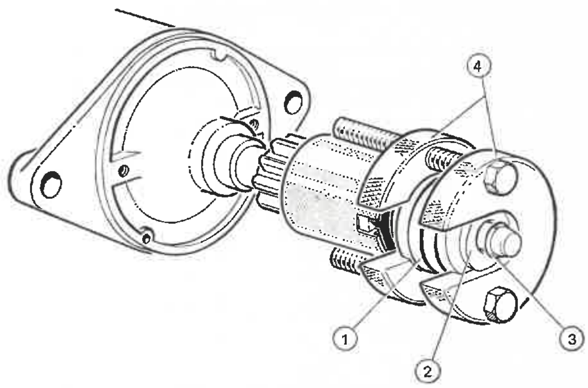


Fig. 10 Using main spring compressing tool to dismantle later-production circlip-retained 'S' and 'SB' type drives ('SB' type illustrated)

1 Main spring **2** Shroud washer **3** Circlip

4 Main spring compressing tool for exposing circlip (the tool illustrated is manufactured by J. W. Pickavent & Co. Ltd., Kilnhouse Lane, St. Annes, England, and is obtainable from most major suppliers of motor spares).

12-Volt Inertia Drive Starters
(Models M35G, M418G and M45G)

Eclipse type drive: The drive parts comprise a sub-assembly, retained on the armature shaft by a dowel pin. The dowel pin is recessed in the groove which accommodates the circlip that retains the main spring on the drive shaft.

Renewing the main spring: After removing the circlip from its groove, the anchor plate (see Fig. 1, item 35) and then the main spring can be withdrawn from the drive shaft. Removal of the circlip is facilitated by an assistant using the fingers of both hands to pull back the anchor plate against the pressure of the main spring, whilst a suitably-sized screwdriver is used to prise the circlip from its groove.

Note: Use a cloth pad to shield and restrain the spring energy of the circlip as it is prised from its groove, otherwise sudden and uncontrolled release of the circlip from its groove may cause personal injury and/or loss of the circlip.

When fitting the new main spring, ensure the anchor plate is assembled the correct way round on the drive shaft. The anchor plate is specially shaped where it engages the main spring and the correct method of assembly is with the best mating side of the anchor plate up against the main spring.

Renewing the complete drive sub-assembly: Inspect the circlip groove and determine which of two types of dowel pins is used to retain the drive sub-assembly on the armature shaft. (It may be necessary to reposition the circlip in its groove, to expose the dowel pin).

If a solid shouldered-type dowel pin is fitted, the drive assembly is early-production design and can be removed from the armature shaft as follows:– the anchor plate (see Fig. 1, item 35) should be pressed back against the pressure of the main spring, while long-nosed pliers are used to extract the dowel pin. Next, slide the drive assembly along the armature shaft to expose a woodruff key. After removing the woodruff key, the drive sub-assembly can be withdrawn from the armature shaft.

If a plain roll-type dowel pin is fitted, the drive assembly is later-production design and to remove the drive sub-assembly from the armature shaft it will be necessary to first carry out the procedure previously detailed for renewing the main spring. This will enable the dowel pin to be tapped from the drive-shaft and the armature shaft, using a $\frac{3}{16}$ in. (4 mm) pin punch, the drive sub-assembly can then be withdrawn from the armature shaft.

Renewing the pinion and barrel, pinion meshing spring, and pinion restraining spring: To enable these parts to be renewed, the drive assembly must be removed from the armature shaft. (Drive assembly removal procedure is detailed under the previous sub-heading).

Either the pinion and barrel or the pinion meshing spring can be renewed after the retaining circlip has been removed from the pinion barrel.

The pinion restraining spring can be renewed, following dismantling of the pinion and barrel and after a small round-sectioned circlip has been removed from the drive shaft.

The circlip can be removed from the pinion barrel as follows. First, position the drive assembly upright in a vice, with the pinion teeth lightly clamped between the jaws of the vice and the pinion barrel resting on top of the vice. Next, utilising four slots in the pinion barrel, which engage the lugs of the control nut, insert the blade of a suitably-sized screwdriver in each of these slots in turn and determine which slot facilitates the levering of one end of the circlip from its groove. After one end of the circlip has been removed from the groove, the remainder of the circlip can easily be levered from the groove.

Further dismantling

Remove the bandcover, relieve the brush spring pressure from the brushes and withdraw the brushes from the brushboxes (see Fig. 15).

Remove nuts and washers from terminal post.

Remove the two through-bolts, then separate the major parts of the starter.

(iii) Bench Inspection

Armature

Inspect the armature for obvious signs of a fault.

If the armature has markings indicating that it has fouled the pole-shoes, providing the pole-shoes are tight in the yoke, excessively worn bearings are indicated. (Renewing the bearings is dealt with under a later sub-heading).

If the armature shows signs of 'thrown' solder or lifted conductors, the armature must be renewed.

If the working surface of the commutator is in good condition but needs cleaning, use a petrol-moistened cloth. If necessary, rectify slight imperfections with either very fine glass paper or emery cloth, then wipe clean with the petrol-moistened cloth. If the commutator is excessively worn, pitted or burnt, it will need skimming in a lathe. Terminate skimming operations by polishing the commutator surface with either very fine glass paper or emery cloth, finally wiping clean with the petrol-moistened cloth. **Do not undercut the insulation slots.**

Note 1: The minimum diameter to which the commutator may be skimmed, before a replacement armature becomes necessary, is as follows: Model M35G 1.295 in. (33 mm), models M418G and M45G 1.545 in. (39 mm).

Note 2: Before skimming the commutator, determine whether faulty insulation or short-circuited windings necessitate renewing the armature.

Armature insulation can be checked with a 110-volt a.c. 15-watt test lamp, connected between one of the commutator segments and the shaft (see Fig. 11). **The lamp should not light.**

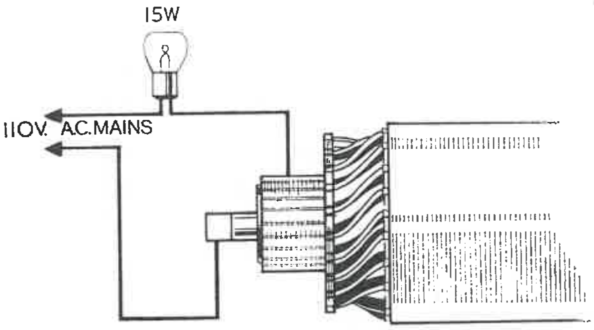


Fig. 11 Armature insulation test

Armature inter-winding short-circuiting can only be detected with specialised armature testing 'Growler' equipment. If this equipment is not available, the only alternative is to prove the armature by substitution. (This is justified if bench testing has previously been carried out and a fault symptom of high current consumption with low speed and torque was indicated).

Brushgear

Check the brushes for freedom-of-movement in the brushboxes. Sticking brushes can usually be rectified by wiping the brushes clean with a petrol-moistened cloth. Brushes should be renewed (as a set) when worn to approximately $\frac{5}{16}$ in. (0.3 in. or 8 mm) in length. If the starter has been dismantled for the purpose of being fully-reconditioned, renew the brushes in any case. Renewing the brushes requires an unsoldering and re-soldering operation. In the case of aluminium field coils (some M35G starters), the worn brush flexibles should be cut approximately $\frac{1}{4}$ in. (0.25 in. or 6 mm) from the junction with the field coil windings. The ends of the original brush flexibles can then be used as a soldering medium between the new brush flexibles and the field windings.

Check the brush spring pressure, using a pull-type spring gauge and without the brush in the brushbox (see Fig. 12a). The spring pressure recorded by the spring gauge at the moment the spring pressure is relieved from the brushbox, should be as follows: M35G starter 34 ozf min. (0.96 kgf or 9.45 N), M418G and M45G starters 42 ozf min. (1.1 kgf or 11.70 N).

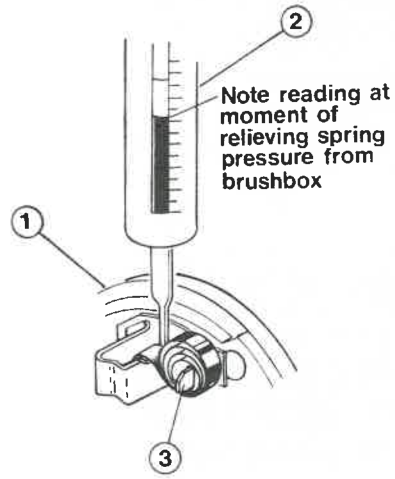
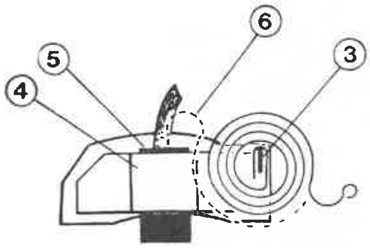
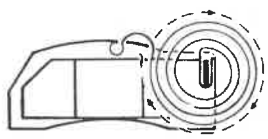


Fig. 12(a) Checking the brush spring pressure

Note: If the brush springs need renewing, ensure they are correctly fitted (see Fig. 12b). If the springs are incorrectly fitted there will be excessive pressure on the brushes, resulting in premature brush wear and damage to the commutator.



CORRECT (Spring tensioning half-turn)



INCORRECT (Spring tensioning full-turn)

Fig. 12(b) Correct fitting of brush spring in free position on post

1 Commutator end bracket assembly
2 Pull-type spring gauge
3 Spring anchor post
4 Brushbox
5 Brush (twin flexibles)
6 Normal working position of spring

Check the brushgear insulation, using a 110-volt a.c. 15-watt test lamp connected between each of the two insulated brushboxes in turn and a clean unpainted part of the bracket (see Fig. 13). **The lamp should not light.**

Note: In the case of insulated-return, the test applies to all four brushboxes.

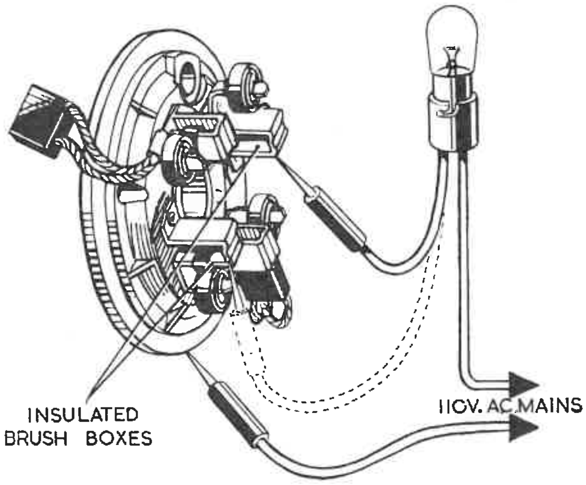


Fig. 13 Brushgear insulation test

Field Coils

Do not unnecessarily disturb the field coil assembly in the yoke. First inspect the inside of the yoke for obvious signs of a fault. Check the tightness of the pole-shoes and closely inspect the field coils. Check field coil continuity by inspecting the inter-connections between the field coils, and check that the terminal and brush-flexible joints are satisfactory. Inspect the protective covering on the field coil windings and if found to be discoloured or damaged, due to overheating or burning, renew the field coil assembly.

Although there may not be any visible signs of a field coil fault, the field coils should be tested *in situ* for satisfactory insulation between the windings and yoke. Ensure the brushes are not contacting the yoke,

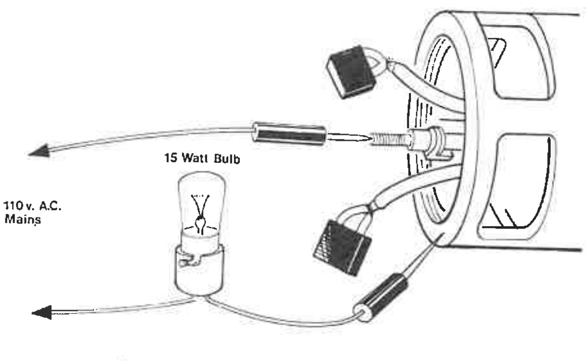


Fig. 14 Field coil insulation test

then connect a 110-volt a.c. 15-watt test lamp between the field coil terminal and the edge of the yoke (see Fig. 14). **The lamp should not light.**

To renew the field coil assembly, it is necessary to use a power-operated screwdriver to remove and refit the pole-shoe retaining screws.

Remove the faulty field coil assembly from the yoke and transfer the pole-shoes to the new part.

Loosely fit the new field coil assembly in the yoke (pole-shoe screws partially tightened). Now fit the insulation-piece between the field coil bare inter-connections and the yoke (at the window end of the yoke), so that the terminal and brush-flexible con-nection(s) are insulated from the yoke and the inter-connections between two field coils is insulated from the entry point of one of the through bolts. After fitting the insulation-piece, tighten the pole-shoe screws to a torque of 30 lbf ft (4 kgf m, or 40 Nm).

Note: Fitting the field coils in the yoke is facilitated by using pole-shoe expanding equipment.

After completing the fitting of the field coil assembly in the yoke: (1) Check that the field coil interconnecting link, at the window end of the yoke, is shaped to provide just sufficient space for the through bolt entry point, so ensuring adequate clear-ance for the armature; (2) Check that the field coil interconnecting links, at the drive-end of the yoke, are positioned clear of the yoke to avoid short-circuiting.

Bearings

The porous-bronze bearing bushes are initially oil-impregnated, self-lubricating, and do not require any attention until major overhaul of the starter.

Immerse new bushes in Shell 'Turbo 41' oil, or clean engine oil, for 24 hours at room temperature, before fitting. Alternatively, if the oil is heated to a temperature of 100°C, 2 hours' immersion of the bushes is sufficient, providing the oil is allowed to cool before removing the bushes.

The bushes must not be reamed after fitting, otherwise the self-lubrication qualities will be im-paired.

Renew the bushes if worn to the extent of allowing excessive side-movement of the armature shaft, otherwise fouling of the pole-shoes by the armature or inefficient operation of the starter is likely to occur. The bushes are excessively worn if they allow more than just perceptible side-movement of the armature shaft, or alternatively, if the inner diameter of the bushes exceeds the following dimen-sions:

Commutator end bracket bush: M35G 0.504 in. (12.80 mm), M418G and M45G 0.631 in. (16.09 mm). Drive end bracket bush: M35G 0.754 in.

(19.15 mm), M418G and M45G 0.879 in. (22.31 mm).

Remove worn brushes as follows:

In the case of the drive end bracket, and also the commutator end bracket if it is a type with an open-ended bearing housing, use a suitably-sized mandrel fitted in either a wheel-operated or lever-operated power press, and press the bush from the bracket. Alternatively, after carefully supporting the bearing housing, tap the bush from the bracket with the mandrel.

In the case of a commutator end bracket with an enclosed bearing housing, first screw a suitably-sized thread tap firmly in the bush and then with the thread tap fitted in either a wheel-operated or lever-operated power press, extract the bush from the bracket. Recommended thread tap sizes are as follows: M35G $\frac{17}{32}$ in. (13.5 mm), M418G and M45G $\frac{11}{16}$ in. (0.687 in. or 17.46 mm). Choose a thread tap with a fine thread.

Fit new bushes as follows:

Using a shouldered polished mandrel, fitted in either a wheel-operated or lever-operated power press, press the bush into the bracket or, alternatively, after carefully supporting the bearing housing, tap the bush into the bracket with the mandrel. The mandrel fitting pin diameter must be to the following dimensions: Commutator end bracket bush: M35G 0.5002 in. (12.705 mm), M418G and M45G 0.6263 in. (15.908 mm). Drive end bracket bush: M35G 0.750 in. (19.05 mm), M418G and M45G 0.8753 in. (32.231 mm).

(c) Reassembly

Assembling the starter is simply a reversal of the dismantling procedure, but the following points are of special interest.

While the yoke assembly is separated from the other major parts of the starter, loosely fit the commutator end bracket to the yoke and identify two of the four windows in the yoke which are adjacent to an insulated brushbox. Fitting the commutator end bracket, and fitting the brushes in the brushboxes, is facilitated if the two insulated brushes attached to the field coils are now threaded through the two appropriate windows in the yoke, previously identified. Later, when assembling the major parts of the starter and during final assembly of the commutator end bracket to the yoke, thread the two earth brushes through the remaining two vacant windows in the yoke. Each of the four brushes will now protrude through the appropriate windows in the yoke, ready for assembly into the brushboxes (see Fig. 15).

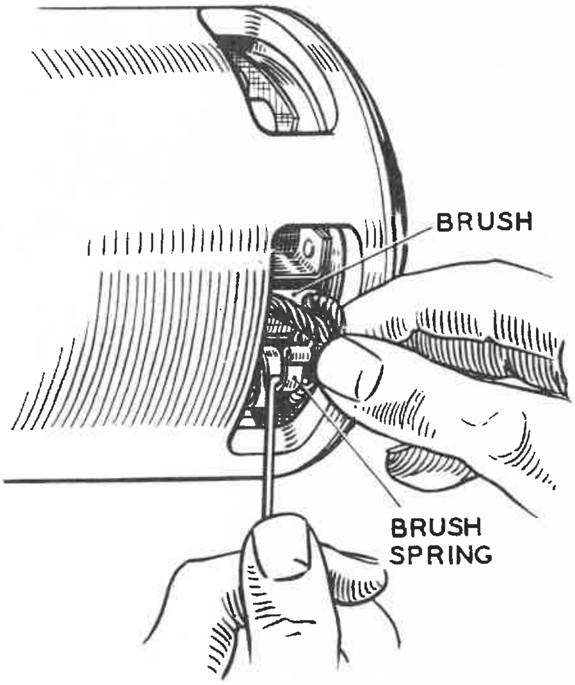


Fig. 15 Removing or refitting the brushes

Tighten the through bolts to a torque of 6 lbf ft (0.8 kgf m, or 8 Nm).

After final assembly, lubricate moving parts of the drive with machine oil and check that the pinion returns smoothly to the disengaged out-of-mesh position.

Following dismantling and reassembly of the starter, if lock torque testing equipment is available, check the performance of the starter.

IGNITION

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Issue 7 July 197
Supersedes Issue 6 November 197

T. A. C. IGNITION

INCORPORATING TRANSISTOR IGNITION UNIT MODEL TAC3

Important: Model TAC3 is intended for 12-VOLT POSITIVE EARTH vehicles only.

When a TAC3 ignition unit is used to replace a TAC2 unit, the external suppression capacitor, when fitted, must be removed.

1. DESCRIPTION

(a) Construction

The Lucas TAC3 ignition system comprises: Transistor Ignition Unit; Ballast Resistor Model 3BR; Ignition Coil Model BA12; and a conventional distributor, except that the contact breaker capacitor is not required.

The physical layout of these units is shown in Fig. 1.

Transistor Ignition Unit. The unit (see Figs. 2 and 3) is built-up on an aluminium extruded heat sink and incorporates a high voltage transistor, two capacitors and two printed circuit resistors. Although the transistor is capable of functioning at ambient temperatures up to 100°C, adequate for normal under-bonnet operation, both the transistor and printed circuit resistors are cooled by convection currents, the back compartment of the heat sink where they are sited being left open at both top and bottom. On the other hand, the front compartment of the heat sink which houses the two capacitors is enclosed by a pressed aluminium cover making the front compartment splash-proof.

The cover is attached to the heat sink base by four self-tapping screws, and the whole unit is secured to the vehicle through four $\frac{9}{32}$ in (7.14 mm) diameter flange fixing holes.

Electrical connexions to the ignition unit are made by a single shrouded plug comprising three 'Lucar' connectors to British Standard AU17.

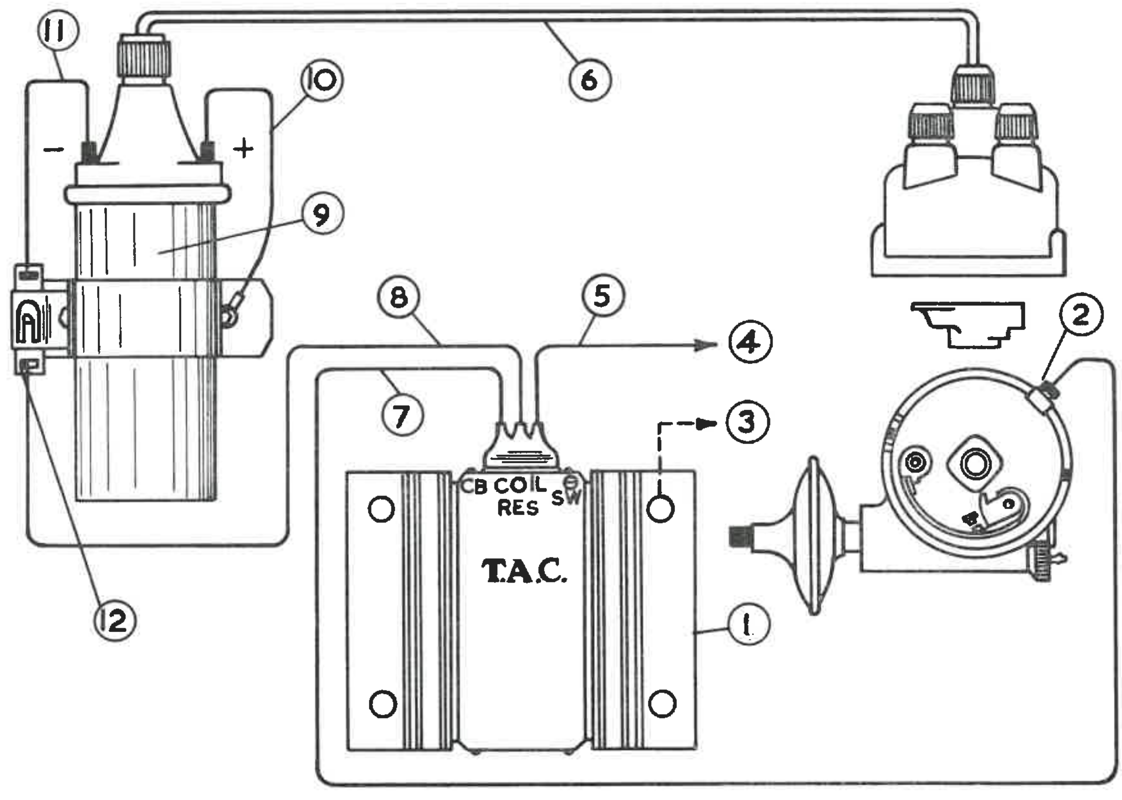


Fig. 1 Wiring Diagram

1. Transistor ignition unit
2. Distributor low tension terminal
3. To earth via fixing bolts
4. To ignition switch
5. Cable colour, white
6. High tension cable
7. Cable colours, white-with-black
8. Cable colours, white-with-blue
9. Ignition coil, model BA12
10. Earthing Cable, black
11. Cable colours, white-with-blue
12. Ballast resistor

TAC3 Ignition

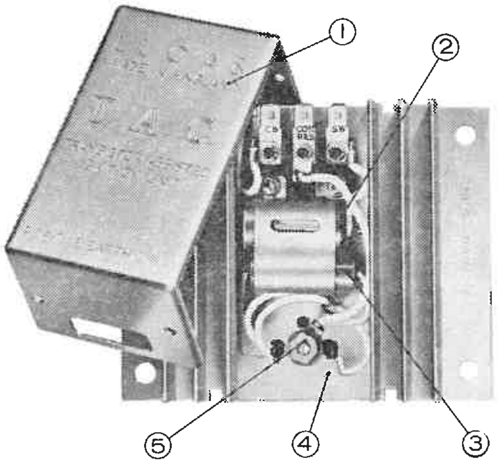


Fig. 2 Ignition Unit with cover withdrawn

1. Cover
2. Capacitor C2
3. Capacitor C
4. Heat sink
5. Transistor fixing stud

Ignition Coil Model BA12. This is a fluid-cooled coil with a high turns ratio and a lower primary inductance than that of the ignition coil used in a conventional system.

L.T. terminals are marked '+' and '—'.

It is important that the coil can is always earthed when in use.

Ballast Resistor Model 3BR. This is wired in series with the ignition coil primary winding and limits the voltage applied to the primary winding. Electrical connexions are made by two 'Lucar' connectors to British Standard AU17. The ballast resistor is secured by one of the ignition coil fixing bolts, usually on the coil negative side.

(b) Operation

The electrical circuit of TAC3 is shown in Fig. 4. It operates as follows:—

When the distributor contact breaker is closed, a current of about 1A flows from the battery positive, via the contacts, resistor R1, the base-emitter junction of the transistor and back to the battery via the ignition switch. With current flowing in the base circuit transistor T assumes a conductive state and, due to its current gain, a much larger current of about 5A flows in the collector-emitter circuit and the primary of the ignition coil. Energy is thus stored magnetically in the coil.

When the contacts open due to the rotation of the distributor cam, current ceases to flow in the base circuit and the transistor reverts to a non-conductive state. With no current in the primary of the ignition coil to sustain it, the magnetic flux in the coil core quickly collapses, inducing a high voltage across the coil secondary winding which in turn produces a spark at the plug in the normal manner. The self-induced voltage in the primary winding of the coil now appears across the collector to base and emitter of the transistor, the latter being designed to withstand this high voltage.

When the spark occurs, high frequency reverse voltage transients are produced at the collector of the transistor. Capacitor C absorbs these impulses and prevents transistor breakdown.

Capacitor C2 connected across the supply prevents radio interference currents being transmitted into vehicle low tension wiring.

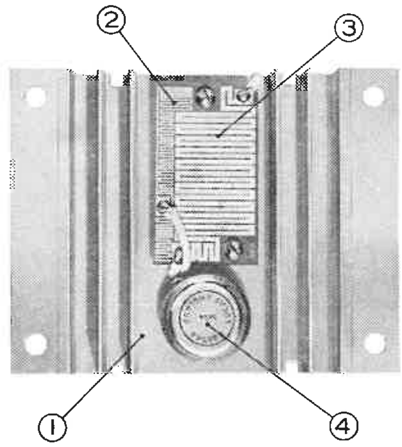


Fig. 3 Rear view of Ignition Unit

1. Heat sink
2. Printed circuit resistor R2
3. Printed circuit resistor R1
4. Transistor

2. ROUTINE MAINTENANCE

(a) After the first 500 miles

Distributor. To compensate for initial bedding-in of the fibre heel, adjust the contact breaker gap to measure 0.014–0.016 in (0.35–0.4 mm) when fully opened.

(b) Every 6,000 miles

Distributor. Carry out the usual lubrication and cleaning procedure for a conventional ignition distributor.

Transistor Ignition Unit. Wipe away any dirt, oil or grease which may have collected on the heat sink - otherwise its cooling efficiency will be impaired.

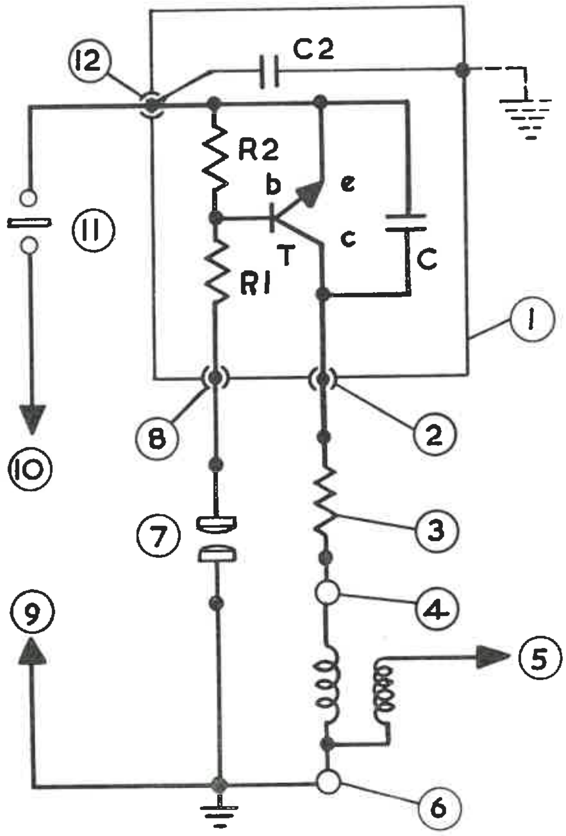


Fig. 4 Circuit Diagram

1. Transistor ignition unit
2. Terminal marked 'Coil Res'
3. Ballast resistor
4. Ignition coil terminal marked '—'
5. Ignition coil high tension
6. Ignition coil terminal marked '+'
7. Contact breaker
8. Terminal marked 'CB'
9. To battery positive
10. To battery negative
11. Ignition switch
12. Terminal marked 'SW'

Terminal Connexions. Make sure that all terminal connexions are secure.

(c) Every 25,000 miles

Distributor. Check the contact breaker gap and adjust if necessary.

3. TECHNICAL DATA

(a) Nominal voltage:	12V (Positive Earth)
(b) Stall current (battery voltage 12.0–12.5V):	4.8–6.5A
(c) Primary resistance of ignition coil:	1.3–1.5 ohm
(d) Resistance of ballast resistor:	1.0 ohm (0.5 ohm on earlier models)
(e) Contact breaker gap setting:	0.014–0.016 in (0.35–0.4 mm)

4. SERVICING

Should it be necessary during the following tests to disconnect and reconnect the transistor, it is extremely important to grip the transistor pins below the soldered joint with a pair of pointed-nose pliers. These act as a heat shunt and prevent damage to the transistor.

Testing the System in Position

In the event of a fault being suspected in the ignition circuit, confirm this by checking the high tension in the normal way, adopting the following procedure to locate the cause of trouble.

(i) Remove the transistor ignition unit cover and switch on the ignition.

Connect the negative lead of a d.c. voltmeter to the 'SW' terminal of the transistor ignition unit and the positive lead to the '+' terminal of the ignition coil. The voltmeter should read battery voltage.

Should a zero reading result, then there is an open circuit lead from the ignition switch to the 'SW' terminal or from the ignition coil to earth. This must be traced and remedied.

(ii) Transfer the voltmeter negative lead to the 'CB' terminal of the ignition unit. Having removed the distributor cover and ensured that the contacts are open, observe the voltmeter reading. It should be within 2 or 3 volts of that indicated in test (i).

If no reading is obtained, resistor R1 is open circuit and the printed circuit board will have to be replaced. This, however, is unlikely to occur.

(iii) With the voltmeter connected as in (ii) above, close the contacts. If the voltmeter reading does not fall to zero, remove and clean the contacts. Refit them after cleaning and set the contact breaker gap to 0.014–0.016 in (0.35-0.4 mm). If the voltmeter reading still does not fall back to zero with the contacts closed, then either the 'CB' lead from the ignition unit to the distributor (white-with-black lead), or the contact breaker earth lead in the distributor, is open circuit. This must be traced and remedied.

(iv) Transfer the voltmeter negative lead to the ignition unit 'Coil Res.' terminal. Close the contacts and observe the voltmeter reading which should be approximately battery voltage. If such a reading is obtained proceed to test (v).

If no reading is obtained then the transistor is faulty and will have to be replaced. To remove the transistor from the ignition unit proceed as follows.

Disconnect the voltmeter leads, switch off the ignition and remove the shrouded plug from the ignition unit. Unscrew the four fixing bolts and remove the ignition unit from the vehicle.

Having taken note of the appropriate connexions, unsolder the leads from the two transistor pins.

Unscrew the transistor securing nut and lift off the spring washer (when fitted), solder tag, metal washer and mica insulating washer. The transistor and second mica washer may now be removed from the heat sink.

To replace a transistor the above procedure should be reversed.

Note: When reassembling a transistor to the heat sink smear both sides of the mica washers with 484 silicone grease.

The transistor pins must be insulated with $\frac{3}{16}$ in (4.75 mm) lengths of pvc 2 mm bore tubing, and the fixing stud with an insulating bush.

Maximum torque to be applied to the transistor fixing nut is 12 lbf in (0.14 kgf m).

Secure the ignition unit to the vehicle and insert the shrouded plug.

(v) With the same voltmeter connexions as in test (iv) and the ignition switched on, open the contacts. If the voltmeter reading does not fall to zero either the transistor or capacitor C is faulty. To determine which should be replaced, proceed as follows.

Disconnect the voltmeter leads, switch off the ignition and remove the shrouded plug from the ignition unit. Unscrew the transistor securing nut and lift off the tag located under the nut. Replace the nut.

Important: Do not allow the tag to reconnect with the transistor stud or the heat sink during the subsequent test.

Connect a 500V megger between the ignition unit 'Coil Res.' and 'SW' terminals and check for a short circuit. If a short circuit is indicated the capacitor should be replaced.

If a short circuit is not indicated the transistor is faulty and should be replaced (see test iv).

(vi) While the solder tag is still removed check the two insulating mica washers. To do this transfer the megger leads to the transistor stud and the heat sink. A minimum reading of 50 megohms should be obtained. If such is the case, reconnect the solder tag to the transistor stud, the shrouded plug to the ignition unit and proceed to test (vii).

If less than 50 megohms is indicated remove the transistor securing nut, metal washer and transistor (see test iv), and examine the two insulating mica washers. If either of the mica washers is cracked or broken it should be replaced by another mica washer smeared on both sides with 484 silicone grease.

Reassemble the transistor to the heat sink, ensuring that both the mica washers and the metal washer are in their correct position. Repeat the test.

When a satisfactory reading has been obtained, reconnect the solder tag to the transistor stud and the shrouded plug to the ignition unit.

(vii) Switch on the ignition and connect the negative lead of the voltmeter to the ignition unit side of the ballast resistor, and the positive lead to earth. Close the contacts. The voltmeter should indicate the same as for test (iv).

If previously in test (iv) a reading approximately equal to the battery voltage was obtained, but now the voltmeter reads zero, this indicates an open circuit lead from the ballast resistor to the ignition unit. It should be traced and remedied.

(viii) Keeping the contacts closed, transfer the negative voltmeter lead to the coil side of the ballast resistor. The voltmeter should read about half that obtained in test (iv).

If no reading is obtained the ballast resistor is open circuit and should be replaced.

(ix) Transfer the voltmeter negative lead to the '—' terminal of the ignition coil. With the contacts closed the voltmeter should give the same reading as obtained in test (viii).

If previously a satisfactory reading was obtained for test (viii) but now the voltmeter reads zero, this indicates an open circuit lead from ballast resistor to ignition coil which should be replaced.

(x) Connect the voltmeter negative lead to the ignition unit side of the ballast resistor, and the positive lead to the other terminal of the ballast resistor. If the primary winding of the ignition coil is satisfactory approximately 5 volts will be indicated on the voltmeter.

If no reading is obtained, fit a replacement coil.

T. A. C. IGNITION

INCORPORATING EITHER NEGATIVE OR POSITIVE EARTH

TRANSISTOR IGNITION UNIT MODEL TAC4

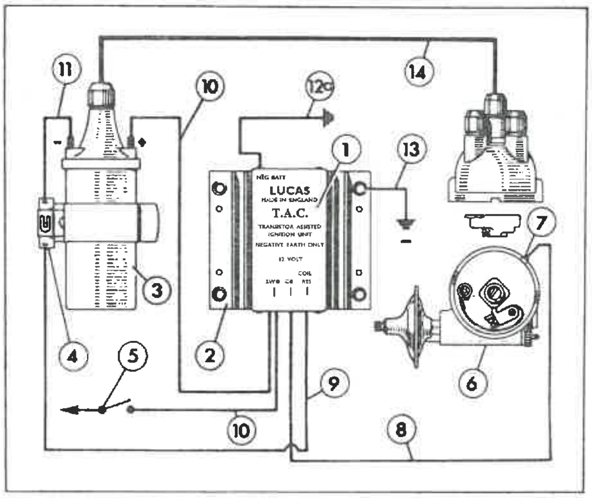


Fig. 1 (a) Negative earth wiring diagram

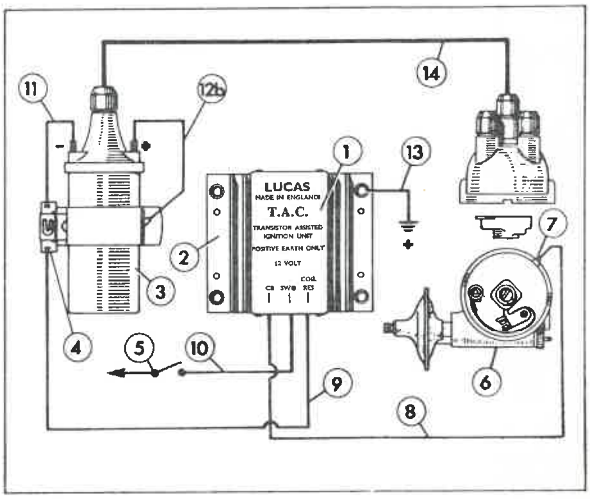


Fig. 1 (b) Positive earth wiring diagram

1 Transistor ignition unit (Front compartment cover)
2 Transistor ignition unit (heat sink)
3 Ignition coil (ballast ignition type)
4 Ballast resistor (3BR)
5 Ignition switch (battery supply)
6 Distributor
7 Distributor L.T. terminal
8 Cable (white with black)
9 Cable (white with blue)
10 Cable (white)
11 Cable (white with black)
12a Cable (black) earthed direct to distributor fixing bracket
12b Cable (black) earthed to ignition coil fixing bolt
13 Cable (black) earth
14 High tension (H.T.) cable

1. DESCRIPTION

(a) Construction

The Lucas TAC4 ignition system comprises: Transistor Ignition Unit (of suitable polarity); Ballast Resistor Model 3BR; Ignition Coil Model BA12; and a conventional distributor, except that the contact breaker capacitor is not required. Except for the transistor ignition unit, these components are the same as used in the TAC3 system, which is confined to positive earth applications.

TAC4 negative earth and positive earth wiring diagrams are illustrated in Fig. 1 (a) and 1 (b).

Transistor Ignition Unit. The unit comprises a black anodised aluminium heat sink assembly, with a natural finish aluminium cover. Incorporated in the heat sink are two compartments, known as the front and rear compartments (see Fig. 2 (a), 2 (b), and 2 (c)). The front compartment, normally enclosed by the cover, contains a power transistor and two capacitors. The rear compartment, which has no cover and is exposed for convection cooling, contains a printed circuit wiring board assembly, which incorporates resistors (plus a driver transistor and an additional resistor in the case of negative earth systems) and 'Lucar' terminal blades for connecting the external circuits. The 'CB' and 'SW' terminals have double-bladed connectors, so enabling additional wiring to be fitted. This would normally be connected to the ignition coil terminals in conventional ignition systems.

T. A. C. Ignition

Incorporating Either Negative or Positive Earth Transistor Ignition Unit Model TAC4

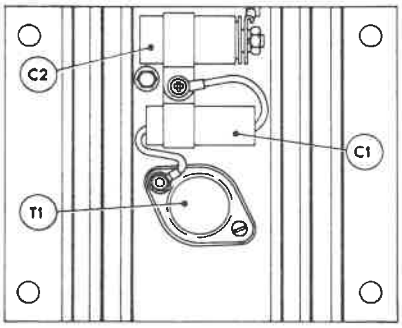


Fig. 2 (a) Front compartment of transistor ignition unit (negative and positive earth systems)

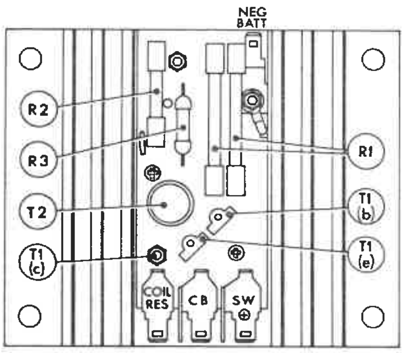


Fig. 2 (b) Rear compartment of transistor ignition unit (negative earth system)

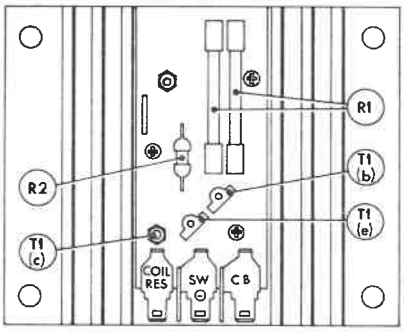


Fig. 2 (c) Rear compartment of transistor ignition unit (positive earth system)

T1 Power transistor
T1 (e) Emitter connection of power transistor
T1 (c) Collector connection of power transistor
T1 (b) Base connection of power transistor
T2 Driver transistor
C1 Capacitor (transient H.T. suppression)
C2 Capacitor (radio interference suppression)
R1 Resistor(s) 10 ohms (Fig. 2 b and 2 c)
R2 Resistor(s) 33 ohms (Fig. 2 b) 15 ohms (Fig. 2 c)
R3 Resistor 68 ohms

Ignition Coil Model BA12. This is a fluid cooled coil with a high turns ratio and a lower primary inductance than that of the ignition coil used in a conventional system. The coil low tension terminals are marked '+' and '—' and the primary winding resistance is 1.3–1.5 ohms. It is important to provide a good earth connection at the coil fixing bracket.

Ballast Resistor Model 3BR. This has a resistance value of 0.9–1.1 ohms and it is wired in series with the ignition coil primary winding to limit the voltage applied to the primary winding. Electrical connections are by means of two 'Lucar' connectors and the resistor is secured by one of the coil fixing bolts, or screws.

(b) Operation

Note: The contact breaker is called upon to handle only a relatively small current and since the contact breaker circuit is resistive only, instead of the highly inductive circuit with conventional ignition, the life of the contacts is greatly increased. Moreover, the transistor can handle a greater current and is a most efficient switch, which ensures more consistent firing at low engine speeds.

Negative Earth Systems

Refer Fig. 3 (a): The negative earth system employs two transistors, 'T1' and 'T2'. Transistor T1 is known as the power transistor and controls the current in the primary winding of the ignition coil. Transistor T2 is known as the driver transistor and controls the switching operation of transistor T1. When the distributor contacts close, the base of T2 is short-circuited to earth and a small current flows in the base of T1 by way of resistor R1. This allows a larger current to flow in the collector/emitter of T1 and the ballast resistor and coil. When the contacts open, the base of T2 is no longer short-circuited to earth and a current flows in the base by way of resistors R2 and R3. This permits a greater current to flow in the collector/emitter of T2 and effectively short-circuits the base of T1, which now switches off. Current in the coil now collapses and a high voltage is developed across the secondary winding to produce a spark at the plug in the normal manner. When the contact breaker closes, T2 is once again short-circuited and the cycle is repeated.

Positive Earth Systems

Refer Fig. 3 (b): The positive earth system employs a power transistor only, 'T1'. This controls the current in the primary winding of the ignition coil. The distributor contact breaker controls the base circuit, which influences the switching of the transistor. When the distributor contacts close, a small current flows in the base circuit, so switching on the transistor and allowing a much larger current to flow through the ignition coil primary winding,

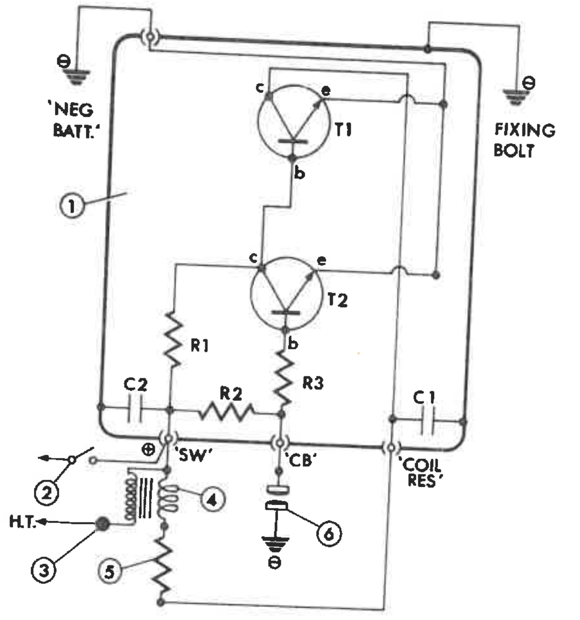


Fig. 3 (a) Negative earth circuit diagram

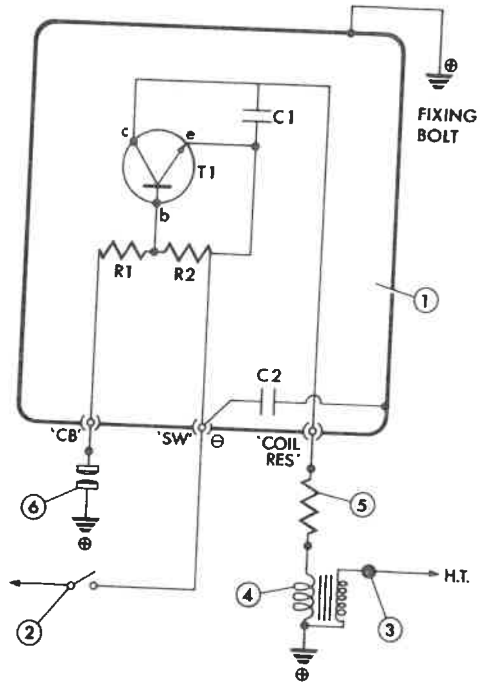


Fig. 3 (b) Positive earth circuit diagram

1 Transistor ignition (T.A.C.) unit
2 Ignition switch (battery supply)
3 Ignition coil secondary winding (H.T. terminal connection)
4 Ignition coil primary winding
5 Balast resistor
6 Distributor contact breaker

T1 Power transistor
T2 Driver transistor
(b) Base
(c) Collector
(e) Emitter

C1 Capacitor (transient H.T. suppression)
C2 Capacitor (radio interference suppression)
R1 Resistor(s) 10 ohms (Fig. 3 a and 3 b)
R2 Resistor(s) 33 ohms (Fig. 3 a) 15 ohms (Fig. 3 b)
R3 Resistor 68 ohms

via the collector and emitter electrodes of the transistor. When the contacts open, the base current is switched off and the transistor immediately becomes non-conductive. Current in the coil now collapses and a high voltage is developed across the secondary winding to produce a spark at the plug in the normal manner.

Note: Negative and positive earth systems. When the H.T. spark occurs, high-frequency reverse transients are produced at the collector of the power transistor. Capacitor 'C1' absorbs these impulses and prevents transistor breakdown. Capacitor 'C2', connected across the supply, prevents radio interference currents being transmitted into the vehicle low-tension wiring.

2. ROUTINE MAINTENANCE

No routine maintenance is necessary other than the usual periodic attention to the distributor.

3. SERVICING

Checking the Ignition System

Note: If a short-circuit is immediately obvious when the ignition is switched on, first check the wiring attached to the 'SW' terminal of the T.A.C. unit and ensure that a short-circuit does not exist between the wiring and frame. If the wiring is satisfactory, suspect a faulty capacitor 'C2' inside the T.A.C. unit (see Fig. 2 a).

(a) Check Whether a High Tension (H.T.) Spark is Available at the Centre Terminal of the Distributor

(i) Remove the distributor moulded cover and check the contact breaker.

If the contacts are dirty or contaminated with oil, clean them with a petrol-moistened cloth.

Crank the engine by hand and check that the contact breaker is functioning, then with the moving

T. A. C. Ignition

Incorporating Either Negative or Positive Earth Transistor Ignition Unit Model TAC4

contact on the highest part of the cam, check the contact gap. This should be 0.014″–0.016″ (0.35–0.40 mm).

(ii) Crank the engine so that the distributor contact breaker is in the fully closed position.

Remove the H.T. cable from the centre terminal of the distributor moulded cover and position the cable-end about $\frac{3}{16}$″ (0.187″) or (4.76 mm) from a clean and unpainted part of the engine. Switch on the ignition and open the contact breaker a few times. **A spark should regularly occur at the cable-end.**

If the test is satisfactory, proceed direct to 3 (c).

If the test is unsatisfactory, again carry out the same test but this time with the H.T. cable-end positioned near a good earth point on the vehicle frame, instead of the engine. If a spark now occurs (but a spark did not previously occur between H.T. cable and engine) the engine earth cable (or flexible strap) must be faulty. If a spark still does not occur, proceed to 3 (b).

(b) No H.T. Spark, or Weak H.T. Spark, at the Centre Terminal of the Distributor

Note: The H.T. spark is too weak if the test gap is less than that specified in the previous test (see 3 (a), para. ii). It is also assumed that the distributor contact breaker has already been checked, as detailed in 3 (a), para. 1.

A d.c. moving-coil low-range voltmeter (e.g. 0–20 V) is required in the following tests. The plastic protective sleeves usually fitted over the 'Lucar' female connectors at the cable-ends, must be pulled back along the cables to enable the voltmeter to be connected to the terminals of the T.A.C. unit.

(i) Check the Supply Voltage to the T.A.C. Unit:

Positive Earth Systems: Connect the negative lead of the voltmeter to the 'SW' terminal of the T.A.C. unit and the positive lead to the L.T. '+' terminal of the ignition coil.

Negative Earth Systems: Connect the positive lead of the voltmeter to the 'SW' terminal of the T.A.C. unit and the negative lead to a good earth point.

With the ignition switch ON: **The voltmeter should indicate battery terminal voltage.**

If the test is satisfactory, proceed to the next test (para. ii).

If the test is unsatisfactory, check the ignition switch and associated wiring, and, in the case of positive earth systems, check the cable and connections between the ignition coil L.T. '+' terminal and frame (earth).

(ii) Check for Satisfactory Operation of the T.A.C. Unit

Check the Switching Action of the T.A.C. Unit

Positive Earth Systems: Connect the negative lead of the voltmeter to the 'COIL RES' terminal of the T.A.C. unit and connect the positive lead of the voltmeter to a good earth point.

Negative Earth Systems: Connect the positive lead of the voltmeter to the 'SW' terminal of the T.A.C. unit and connect the negative lead of the voltmeter to the 'COIL RES' terminal of the T.A.C. unit.

With the distributor contact breaker closed and the ignition switched on, open the contact breaker points a few times and observe the voltmeter reading. **The opening and closing of the contact breaker points should cause the voltmeter needle to fluctuate between zero and battery voltage.**

If the test is satisfactory, the T.A.C. unit is working normally and this and the distributor contact breaker can be eliminated from further testing. Check the ballast resistor and ignition coil (para. vi).

If the test is unsatisfactory, proceed to the next test (para. iii).

(iii) Check for Satisfactory Opening and Closing of the Distributor Contact Breaker

Positive Earth Systems: Connect the negative lead of the voltmeter to the 'CB' terminal of the T.A.C. unit and connect the positive lead of the voltmeter to a good earth point.

Negative Earth Systems: Connect the positive lead of the voltmeter to the 'CB' terminal of the T.A.C. unit and connect the negative lead of the voltmeter to a good earth point.

With the distributor contact breaker closed and the ignition switched on: **The voltmeter should indicate zero voltage.**

If the test is unsatisfactory, the distributor contact breaker points are probably not making good electrical contact. If the fault is not due to the contact breaker, check the miniature wiring connections associated with the contact breaker. Finally, check the wiring between the 'CB' terminal of the T.A.C. unit and the L.T. terminal of the distributor.

If the test is satisfactory, carry out an extension to the original test by opening the distributor contact breaker points. **The voltmeter should now indicate 9 – 12 V (positive earth systems) or approximately 8 V (negative earth systems).**

If this second part of the test is unsatisfactory, a faulty base circuit resistor is indicated and the printed circuit wiring board assembly must be renewed (see para. v).

If this second part of the test is satisfactory and an earlier test (para. ii) was unsatisfactory (no switching action at the 'COIL RES' terminal of the T.A.C. unit), a faulty transistor action is indicated.

Positive Earth Systems: When the power transistor 'T1' is renewed (see para. v) it is advisable to check that the base circuit resistor 'R2' (see Fig. 2c) is not open-circuit. If this resistor is faulty the printed circuit wiring board assembly must be renewed, at the same time as the transistor, otherwise premature failure of the transistor will occur. Premature failure of the transistor could also occur due to partial failure of capacitor 'C1'. Therefore, if resistor 'R2' is found to be satisfactory, it is advisable when renewing the transistor to renew the capacitor 'C1' also (see Fig. 2a).

Negative Earth Systems: A faulty transistor action having been established, further testing is now necessary to determine whether it is the power transistor or the driver transistor which is associated with the fault. (Proceed to next test, para. iv).

(iv) Negative Earth Systems: Proving the Transistor Circuits (T.A.C. unit in-situ and normally connected)

The positive lead of the voltmeter is a common connection throughout the following tests.

Connect the positive lead of the voltmeter, either direct to the positive (insulated) terminal of the battery or a convenient battery supply terminal not controlled by the ignition switch.

Connect the negative lead of the voltmeter, as detailed in the following separate tests.

Check the Driver Transistor 'T2' for Short-circuit Fault between Collector and Emitter

First disconnect the cables from the 'NEG BATT' and 'COIL RES' terminals of the T.A.C. unit, then connect the negative lead of the voltmeter to the 'NEG BATT' terminal of the T.A.C. unit. With the distributor contact breaker closed, and the ignition switch OFF: **The voltmeter should indicate zero or a negligible voltage.**

If the test is unsatisfactory, the driver transistor is not serviced separately and the printed circuit wiring board assembly comprising resistors and transistor must be renewed (see appropriate heading, para. v).

If the test is satisfactory, disconnect the negative lead of the voltmeter and refit the cable to the 'NEG BATT' terminal of the T.A.C. unit, then proceed to the next test.

Prove the Power Transistor 'T1' Check for a Short-circuit Fault between Collector and Emitter:

With the cable disconnected from the 'COIL RES' terminal of the T.A.C. unit (reference previous test), connect the negative lead of the voltmeter to the disconnected terminal of the T.A.C. unit. With the ignition switch OFF: **The voltmeter should indicate either zero or a negligible voltage.**

If the test is unsatisfactory, either the transistor or the capacitor 'C1' has an internal short-circuit. Determine the fault by disconnecting one side of the capacitor (preferably the earth side by removing the screw from between capacitors 'C1' and 'C2', see Fig. 2a) and then carry out the test again. If this results in the test being satisfactory, renew the capacitor 'C1'. If the test is still unsatisfactory with the capacitor disconnected, renew the power transistor 'T1' (see para. v).

If the test is satisfactory, leave the voltmeter connected and proceed to the next test.

Check the Base Circuit and the Switching Action between Collector and Emitter:

With the cable disconnected from the 'COIL RES' terminal of the T.A.C. unit, and the negative lead of the voltmeter still connected to the disconnected terminal of the T.A.C. unit, with the distributor contact breaker closed and the ignition switch ON: **The voltmeter should indicate battery terminal voltage.**

If the test is unsatisfactory, either the power transistor 'T1' or its base circuit resistor is faulty. Determine the fault by checking resistor 'R1' (see Fig. 2b). If the resistor is faulty, the printed circuit wiring board assembly should be renewed (see para. v). If the resistor is found to be satisfactory, the power transistor 'T1' must be faulty and should be renewed (see para. v).

If the test is satisfactory, the power transistor 'T1' has now been eliminated as the cause of the fault (no transistor switching action at the 'COIL RES' terminal of the T.A.C. unit, reference previous testing 3 b ii). This means that the fault is now confined either to the driver transistor or its base circuit resistor 'R3' (base circuit resistor 'R2' having been previously proved satisfactory during the distributor contact breaker test 3 (b) iii).

In view of the fact that the driver transistor and resistor 'R3' are combined in one assembly, the printed circuit wiring board assembly must now be renewed (see para. v).

(v) Servicing the T.A.C. Unit Renewing the Power Transistor

The power transistor ('T1') is fitted in the front compartment of the heat sink, normally enclosed by the aluminium cover (see Fig. 2a). The base and emitter connecting pins of the transistor are soldered to connectors T1 (b) and T1 (e) on the printed circuit wiring board (see Fig. 2b, or 2c).

Note: The soldering iron required for un-soldering and re-soldering the transistor connections should be a type not exceeding 25-watt.

Remove the transistor fixing clip (an additional securing nut, sandwiched between the heat sink and the printed circuit wiring board, should be left in position).

Hold the T.A.C. unit in one hand, so that the printed circuit wiring board is facing the body with the main terminal arrangement at 6 o'clock, and then with the other hand apply the hot soldering iron alternately to each of the soldered connections. When the solder is fully-melted, shake from the connections by giving the T.A.C. unit a sharp tap on the top of the bench. Now lightly clamp the T.A.C. unit in a vice, with the main terminal arrangement at the top and leaving sufficient access to the transistor and its connections. Finally, melt the solder of both connections simultaneously, by applying the soldering iron across the gap between the two connections, and pull on the body of the transistor until it is freed from the T.A.C. unit.

After removing the faulty transistor, transfer the insulating sleeves of the connecting pins and also the mica insulating washer from the original transistor. Keep the mica washer clean and do not wipe the greasy film from the washer. This is silicone grease to ensure efficient heat transfer between the transistor, mica washer, and heat sink. If the original mica washer requires a fresh application of silicone grease, or if the mica washer is renewed, smear both sides of the washer with No. 484 silicone grease.

Before commencing to fit the new transistor, ensure that the transistor connecting pins are adjusted to the correct width and that they engage easily in the connector holes of the printed circuit wiring board. If necessary wipe the holes clear of solder with the hot soldering iron, or clear the solder from the holes with a small drill.

Note: The transistor base-and-emitter connecting pins do not have any identification marks. However, if the transistor connecting pins are accidentally engaged in the wrong connectors of the printed circuit wiring board, the transistor fixing clip will be prevented from being fitted until the transistor has been correctly repositioned. Incorrect assembly of the transistor can be avoided by ensuring that an imaginary line, drawn through the centre of the top of the transistor, coincides with the position in the heat sink of the two screw holes which fix the transistor fixing clip.

Engage the transistor connecting pins in the connector holes of the printed circuit wiring board and then secure the transistor with the fixing clip before soldering the connections. (Connect the capacitor to the clip, and assemble the non-captive clip fixing screw the correct way round, as illustrated in Fig. 2a).

Finally, place the T.A.C. unit flat on the bench with the printed circuit wiring board uppermost and (using only resin-cored solder) solder the transistor connections as quickly as possible. Avoid making dry-soldered joints, by ensuring that the soldering iron is clean and sufficiently heated and do not allow excess solder to bridge the gap between the two connections.

Renewing the Printed Circuit Wiring Board Assembly

Disconnect capacitor 'C2' from the lead connecting it to the printed circuit wiring board. (To achieve this it will be necessary to remove the capacitor clip securing screw from between the two capacitors 'C1' and 'C2').

Remove nut(s) and screws which secure the printed circuit wiring board to the T.A.C. unit. (It is not necessary to remove one particular nut, shown unmarked in Fig. 2 (b) and 2 (c), but excluding the 'NEG BATT' terminal nut in Fig. 2 (c), which needs to be removed).

In the case only of negative earth systems, remove also a shakeproof washer, connecting lead and 'Lucar' terminal blade ('NEG BATT' terminal) from one of the screws which fix the printed circuit wiring board assembly.

Hold the T.A.C. unit in one hand, so that the printed circuit wiring board is facing the body with the main terminal arrangement at 6 o'clock, and then with the other hand apply a hot soldering iron (25-watt max) alternately to each of the soldered connections. When the solder is fully-melted, shake most of the solder from the connections by quickly giving the T.A.C. unit a sharp tap on the top of the bench. Now lightly clamp the T.A.C. unit in a vice, with the printed circuit wiring board uppermost and the main terminal arrangement facing the body. Finally melt the solder of both connections simultaneously, by applying the soldering iron across the gap between the two connections, and pull the printed circuit wiring board upwards until it is freed from the T.A.C. unit.

After removing the printed circuit wiring board assembly, remove excess solder from the connecting pins of the power transistor so that the connecting pins will engage easily in the connectors of the new printed circuit wiring board assembly. Also, check that the insulating sleeves are still fitted to the transistor connecting pins.

Fitting a new printed circuit wiring board assembly, is simply a reversal of the procedure detailed for removing the original part. Solder the transistor connections as quickly as possible and use only resin-cored solder. Avoid making dry-soldered joints, by ensuring that the soldering iron is clean and sufficiently heated and do not allow excess solder to bridge the gap between the two connections.

(vi) Checking Ballast Resistor and Ignition Coil

Measure the Volt-Drop Across the Ballast Resistor

Connect the negative lead of the voltmeter to the 'COIL RES' terminal of the T.A.C. unit (cable connected) and connect the positive lead of the voltmeter to the ignition coil L.T. terminal marked '—'. With the distributor contact breaker closed, switch on the ignition. **The voltmeter should indicate approximately 5 V.**

If the test is satisfactory, the correct amount of current must be flowing in the ballast resistor and ignition coil primary winding circuit and the ballast resistor and ignition coil primary winding must therefore be satisfactory. Finally, check the ignition coil secondary winding by carrying out the H.T. spark test detailed in the second para 3 (a) ii. If this test is unsatisfactory, renew the ignition coil.

If the test is unsatisfactory, one of the following conditions will apply:–

(1) **The voltmeter indicates a voltage appreciably different to that stated:** Check the resistance of the ignition coil primary winding (1.3–1.5 ohms) and the ballast resistor (0.9–1.1 ohms), using a good quality ohmmeter. If the resistance check confirms the fault, renew the ballast resistor or ignition coil.

(2) **The voltmeter indicates zero voltage:** Check the continuity of the ignition coil primary winding, using a battery-operated test lamp, or an ohmmeter, connected between the coil L.T. terminals marked '+' and '—'. **The lamp should light, or the ohmmeter should indicate a reading.** If the continuity check confirms the fault, renew the ignition coil.

(3) **The voltmeter indicates battery terminal voltage:** An open-circuit ballast resistor is indicated and this must be renewed.

(c) Check for Satisfactory Distribution of the High Tension Voltage from Ignition Coil to Sparking Plugs

(i) Check the Distributor Rotor

Providing a satisfactory spark is available at the centre terminal of the distributor (previous testing 3 (a), para. ii refers), the ignition coil high-tension voltage can be utilised for testing the insulation of the rotor arm electrode.

With the contact breaker closed and the rotor fitted to the distributor shaft, position the cable-end of the H.T. cable (taken from the centre terminal of the distributor) close to the rotor arm electrode. Switch on the ignition and open the contact breaker a few times. **If a spark occurs (except a very faint trace of a spark), the rotor must be renewed.**

(ii) Check the Distributor Moulded Cover

The inside and outside of the distributor moulded cover should be reasonably clean, dry, and free from contamination by oil. Closely inspect the inside of the cover. 'Tracking' of the H.T. spark will be indicated by a thin greyish-white line or, sometimes more obviously, by signs of charring of the moulding. In such cases the fault can normally only be rectified by renewing the moulded cover. Check the carbon brush and spring for freedom of movement in the moulding. Check whether the spring is making electrical contact with the bottom of the brush-and-spring housing. Check whether the brush needs renewing. Inspect the contact tip of the brush, which should be bevelled. If the bevelled (hardened) tip of the brush has worn away, the brush-and-spring should be renewed. If the centre of the moulding around the brush-and-spring housing shows signs of damage, check that the rotor is fully-located on the distributor shaft.

(iii) Check the High Tension Cables

The general condition of the H.T. cables can be considered satisfactory, if the cables are clean and dry, free from contamination by oil and the insulation shows no sign of cracks.

If the engine fails to start, or misfires, the H.T. cables may previously have been removed and then accidentally refitted to the sparking plugs in the incorrect firing order. If this is not the cause of the fault, check whether a satisfactory spark occurs at the sparking plug end of each of the H.T. cables. First prevent the engine from starting by disconnecting the H.T. cables from the sparking plugs . (Ensure that the H.T. cable connectors are not adjacent to the carburetter or petrol pipes during the following test). Remove each of the H.T. cable connector/suppressors in turn, then position the cable-end about $\frac{3}{16}''$ (0.187") or (4.76 mm) from a clean and unpainted part of the engine. Switch on the ignition and crank the engine. **A spark should regularly occur.**

If the test is satisfactory, the fault must be due to one of the following causes:– H.T. cable connectors/suppressors, sparking plugs, carburation (or fuel supply), or an engine fault.

If the test is unsatisfactory,

(1) A spark is absent from the cable-end of all the H.T. cables. **Check the centre terminal connection in the distributor cover.**

(2) A weak spark occurs. **Check the connections in the distributor cover.**

(3) A satisfactory spark occurs, but is absent from one or more H.T. cable(s). **Check the connection of the faulty cable(s) in the distributor cover.**

LUCAS 'OPUS' 3 (MK II) ELECTRONIC IGNITION SYSTEM

(Fitted to Jaguar "E" Type Series III)

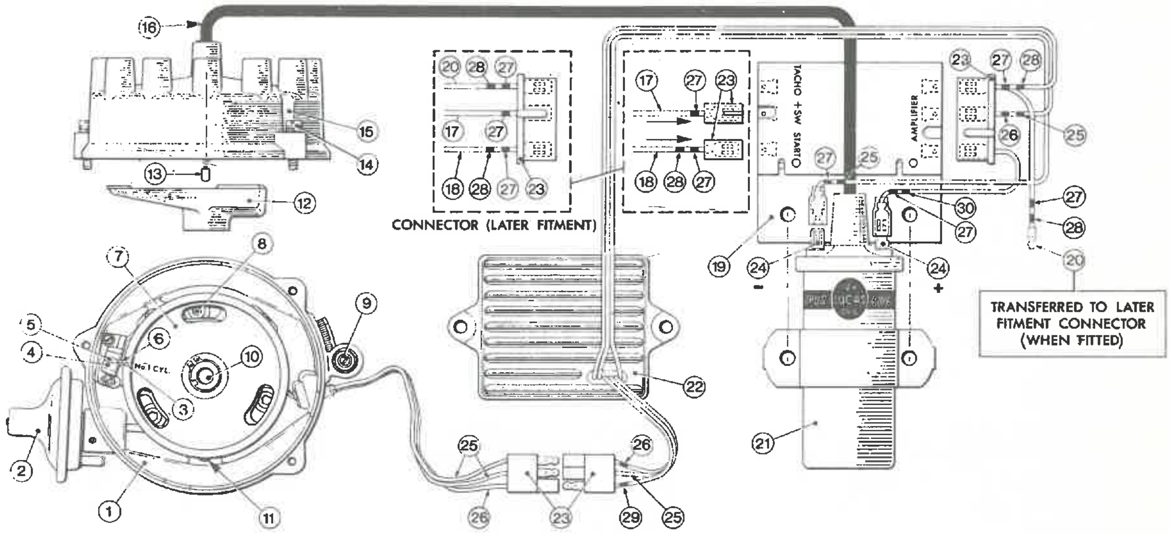


Fig. 1 Lucas 'Opus' 3 (Mk. II) electronic ignition system

1 Distributor (model 36DE12)
2 Vacuum unit (retard-type)
3 Timing mark No. 1 cylinder
4 Pick-up module
5 Timing mark groove
6 Air gap
7 Timing rotor
8 Allen screw(s) (static ignition timing and distributor fixing)
9 Vernier timing control screw
10 Felt lubrication pad in top of distributor shaft
11 Screw(s) (micro-housing fixing and tensioning)
12 H.T. rotor arm
13 Brush and spring
14 Screw(s), washers (spring and plain)
15 Moulded cover
16 Centre high-tension (H.T.) cable
17 Ignition switch feed
18 Ballast ignition supply voltage, via relay contacts when ignition switch is in 'start position'
19 Ballast resistance unit (model 9BR)
20 Tachometer connection
21 Ignition coil (model 13C12)
22 Amplifier unit (model AB3)
23 Inhibited (non-reversible) moulded connector(s)
24 Inhibited (non-reversible) 'lucar' connector(s)

Cable identification
25 Black
26 Red
27 White
28 Blue
29 Yellow
30 Green

1. DESCRIPTION

The 'Opus' electronic ignition system comprises: Distributor model 36DE12, Amplifier Unit model AB3, Ballast Resistance Unit model 9BR, and a conventional high-performance Ignition Coil model 13C12 (see Fig. 1).

The Distributor: In addition to the usual conventional centrifugal auto-advance mechanism, retard-type vacuum unit and high-tension (H.T.) rotor arm, the distributor also incorporates an electronic timing rotor and a pick-up module assembly (see Fig. 2). The timing rotor and pick-up module (in conjunction with a separate amplifier unit) replaces the conventional contact breaker and cam.

The timing rotor is a glass-filled nylon disc with small ferrite rods embedded in its outer edge and the number of ferrite rods, and the spacing of the rods, corresponds with the number of cylinders and firing angles of the engine. The timing rotor and the H.T. rotor arm rotate together, with an air-gap (adjustable to specified limits) existing between the outside edge of the timing rotor and the ferrite core of the stationary pick-up module.

The pick-up module assembly comprises a specially manufactured magnetically-balanced small transformer, with primary (input) and secondary (output) windings. Specialised magnetic balancing of the pick-up module 'E' shaped ferrite core is carried out at the factory by adjusting a small ferrite screw near the bottom limb of the core. **NOTE: Magnetic balancing of the pick-up module cannot alter in service and the ferrite adjusting screw must not be disturbed.**

Automatic control of retard-ignition timing is provided by the vacuum unit which varies the static timing position of the pick-up module in relation to the position of a ferrite rod in the timing rotor. This operates as part of the emission control system that prevents air pollution by eliminating obnoxious fumes from the engine during idling and over-run conditions.

Lucas 'Opus' 3 (Mk II) Electronic Ignition System
(Fitted to Jaguar "E" Type Series III)

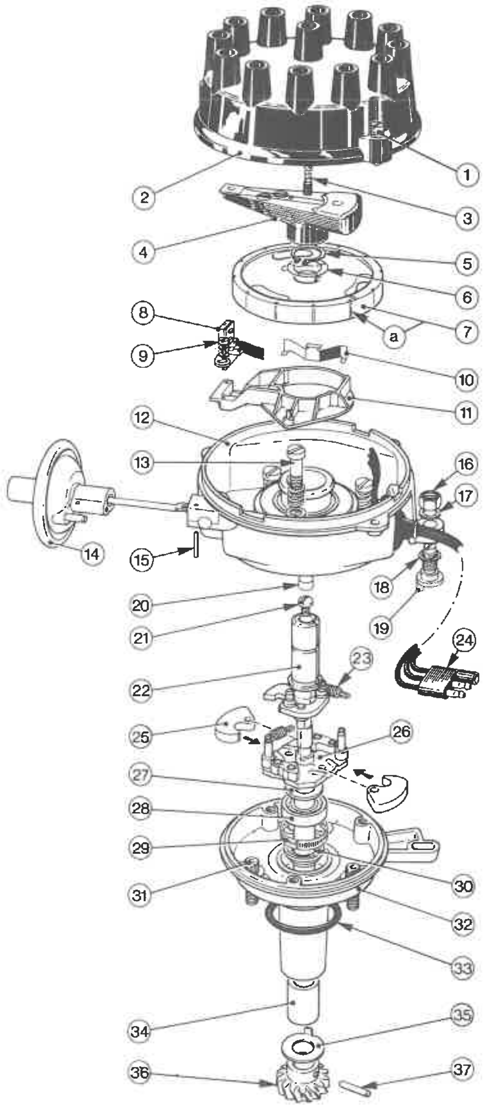


Fig. 2 Distributor model 36DE12

1 Cover fixing screw(s)
2 Moulded cover
3 Brush and spring
4 H.T. rotor arm
5 Circlip
6 Corrugated spring washer
7 Timing rotor, (a) ferrite rod(s)
8 Pick-up module
9 Fixing screw(s)
10 Bearing spring
11 Pick-up arm
12 Micro-housing
13 Screw(s) (micro-housing fixing and tensioning)
14 Vacuum unit (retard-type)
15 Roll pin
16 Locknut
17 Plain washer
18 Spring washer
19 Vernier timing control screw
20 Felt lubrication pad
21 Rotor carrier fixing screw
22 Rotor carrier assembly
23 Auto-advance spring(s)
24 Inhibited connector (distributor to amplifier)
25 Auto-advance weight(s)
26 Action plate
27 Distance collar
28 Ball bearing
29 Retaining ring
30 Oil seal
31 Allen screw(s) (static ignition timing and distributor fixing)
32 Distributor body
33 'O' ring oil seal
34 Bearing bush
35 Thrust washer
36 Driving gear
37 Driving gear pin

The distributor timing rotor and pick-up module generate an electronic timing signal, which activates the amplifier unit via external cables of a specified type and length. **NOTE: The length of this triple-core extruded type cable must not be altered and the cables must not be separated or replaced by loose individual cables.**

Amplifier Unit: This is a die-cast aluminium heat sink with cooling fins. Inside a compartment at the back of the heat sink (enclosed by a cover secured by four

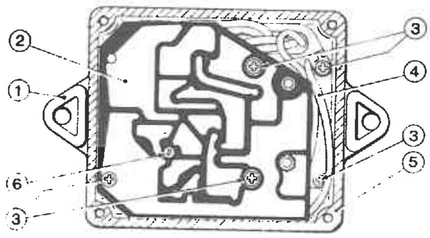


Fig. 3(a) Amplifier unit with cover removed

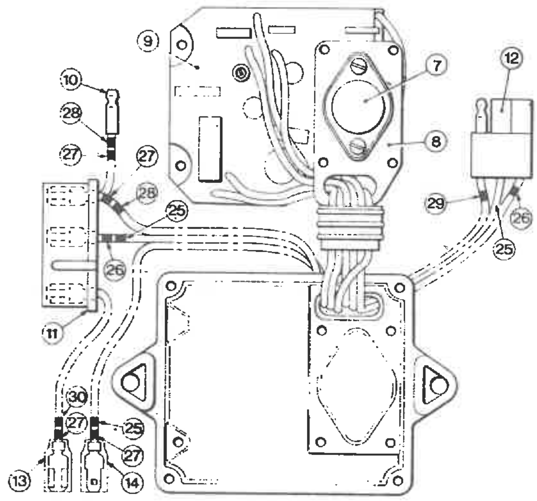


Fig. 3(b) Amplifier unit with printed circuit wiring board assembly partially removed

1 Amplifier unit body (heat sink)
2 Printed circuit wiring board assembly
3 Printed circuit wiring board assembly fixing screws (must not be disturbed)
4 Earth cable
5 Sealing gasket
6 Oscillator adjusting screw (must not be disturbed)
7 Power transistor
8 Power transistor fixing plate
9 Encapsulated area covering components
10 Tachometer connection (transferred to later fitment connector, when fitted, on 'SW' side of ballast resistance unit see Fig. 1
11 Connection to ballast resistance unit
12 Connection to distributor pick-up module
13 Connection to coil L.T. '+' terminal
14 Connection to coil L.T. '—' terminal

Cable identification

25 Black	26 Red	27 White
28 Blue	29 Yellow	30 Green

screws) is a printed circuit wiring board assembly, comprising four transistors, a diode and other associated electronic components (see Fig. 3). One transistor is an oscillator, two are amplifiers, and one is a power transistor which functions as an electronic switch to control the primary circuit of the ignition coil. NOTE: **A small ferrite trimmer screw (oscillator adjusting) is visible in the printed circuit wiring board when the heat sink cover is removed (see Fig. 3a, item 6). This trimmer screw tunes the coupling transformer of the oscillator transistor circuit and the original setting of the trimmer screw must not be disturbed. Also, do not disturb the printed circuit wiring board assembly fixing screws (refer para. (b), page 7).**

The amplifier unit interprets the electronic timing signals from the distributor and the power transistor in the amplifier unit then functions as an electronic switch in the primary circuit of the ignition coil.

The amplifier unit is connected to the ignition coil via a separate ballast resistance unit and external connecting cables.

Ballast Resistance Unit: An encapsulated assembly comprising resistors and 'Lucar' terminal connectors is a fixed part inside an aluminium heat-sink fixing

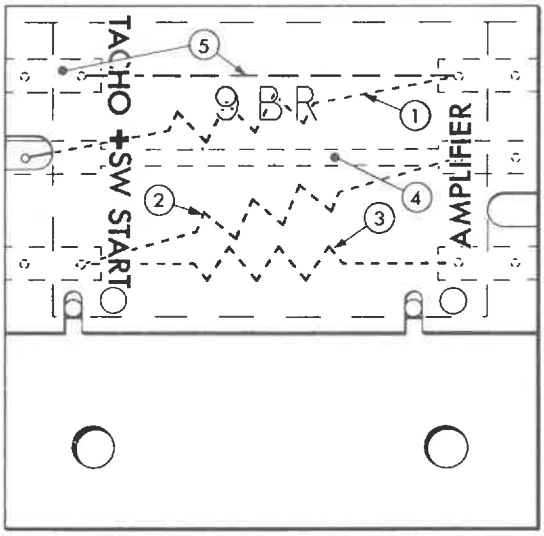


Fig. 4 Internal connections of ballast resistance unit

1 Amplifier unit drive resistor 7.6 -9.2 ohms
2 Ballast ignition resistor 0.72–0.80 ohms
(shorted during starting period only)
3 Ballast ignition resistor 0.9 -1.0 ohms
4 Straight-through internal connection
5 Tachometer terminal and straight-through internal connection (incorporated in later units marked 47227)

★47227 is superseded by 47229 which has a tachometer internal connection resistance 100 ohms.

Note: External cable connections are shown in Fig. 1

bracket (see Fig. 4). If the ballast resistance unit develops a fault, it cannot be repaired and must therefore be renewed.

External wiring connects two resistors (items 2 & 3, Fig. 4) in series with the ignition coil primary winding, this comprising a ballast ignition system which ensures that a satisfactory voltage is applied to the primary winding of the coil at all times, particularly during the period of starting motor operation when the battery terminal voltage is temporarily lowered below normal. At such times, an additional set of contacts inside the starting motor operating-solenoid (small 'Lucar' terminal marked 'IGN') automatically short-circuits one of the two series-connected resistors and this ensures that a satisfactory operating voltage is applied to the ignition coil primary winding '+' terminal during the period of starting motor operation.

Note: Ballast ignition is particularly beneficial during cold weather conditions, when adverse engine-starting conditions prevail.

A third resistor in the ballast resistance unit (item 1, Fig. 4) is also connected by external wiring to the amplifier unit, this resistor being associated with the function of one of the transistors.

Ignition Coil: This is a specially designed fluid-cooled high-performance ballast-ignition type ignition coil, for use only with the 'Opus' ignition system to which it is particularly suited. NOTE: **Other ballast-ignition type H.T. coils are not suitable as a service replacement for the original unit.** This is due to the very high ratio of turns between primary and secondary windings and low primary winding resistance of the 'Opus' ignition coil (0.8–1.0 ohms at 20°C) which is matched to the electronic amplifier unit.

The ignition coil primary winding low-tension (L.T.) 'Lucar' terminal connections are marked '+' and '—' and, in addition to these polarity markings, each terminal is a different type, which prevents incorrect fitting of the external connecting cables.

It is recommended that a satisfactory earth connection is made between the ignition coil fixing bracket and the vehicle frame. This will ensure that the coil metal casing 'fails safe', in the unlikely event of an insulation breakdown causing a leakage of H.T. voltage to the coil casing.

NOTE: **Performance testing of the ignition coil must only be carried out in conjunction with the ballast resistance unit normally used with the coil in the 'Opus' ignition system, or alternatively by using a suitable resistance of equal value to the total of the two series-connected resistors in the 'Opus' 9BR ballast-resistance unit, which is 1.62–1.80 ohms.**

Operation of the 'Opus' Ignition System

Normally, when the engine is stationary, prior to starting, the distributor timing rotor will be in a position where none of its ferrite rods is in close proximity with the ferrite core of the distributor pick-up module.

When the ignition is switched on, to start, a power transistor in the amplifier unit is in a conductive state and the ignition coil primary winding circuit is completed via the emitter/collector electrodes of the power transistor. At the same time, a sinusoidal (pulsating a.c.) voltage is applied by the amplifier unit to the distributor pick-up

★ *Amendment to previous issue*

module primary (input) windings and a small residual a.c. voltage is produced at the secondary (output) winding terminals of the pick-up module, which at this stage is 'magnetically balanced'. The voltage at the pick-up module output terminals is applied to the amplifier unit, but the residual voltage at this stage is insufficient to have any effect on transistor circuits which control the switching off of the power transistor in the output stage of the amplifier unit.

When the engine is cranked, to start, one of the ferrite rods in the distributor timing rotor being brought into close proximity with the ferrite core of the distributor pick-up module causes 'magnetic unbalancing' of the pick-up module core and this results in an increase in the voltage at the pick-up module output terminals. When the timing rotor ferrite rod traverses and magnetically bridges the faces of the centre and upper limbs of the pick-up module 'E'-shaped core, maximum magnetic unbalancing of the core of the pick-up module occurs and this results in a maximum voltage being developed at the pick-up module output terminals. Maximum a.c. voltage at the pick-up module output terminals is applied to the amplifier unit, where it is first rectified, and then the resulting direct (d.c.) current is used to operate the transistor circuits which control the switching off of the power transistor in the output stage of the amplifier unit. When the power transistor is switched off, its emitter/collector electrodes cease to conduct and the ignition coil primary winding circuit is disconnected. Disconnecting the ignition coil primary winding circuit causes a rapid collapse of the primary winding magnetic field through the secondary windings of the ignition coil and this results in a high-tension (H.T.) voltage being produced at the H.T. terminal of the ignition coil.

2. ROUTINE MAINTENANCE

No routine maintenance is necessary, but occasionally remove the distributor moulded cover and H.T. rotor arm and then add a few drops of machine oil to the felt lubricating pad in the top of the distributor shaft. At the same time inspect the H.T. carbon brush-and-spring inside the moulded cover and if necessary wipe clean the inside of the cover.

3. TECHNICAL DATA

(i)	Firing angles	0°, −30°, −60°, etc. ±1°
(ii)	Nominal voltage	12V (negative earth)
(iii)	Stall current (measured with ammeter in series with 'SW' terminal of ballast resistance unit)	5.0–6.5A
(iv)	Ignition coil primary winding resistance (measured between L.T. terminals marked '+' and '—',)	0.8–1.0 ohm at 20°C
(v)	Ballast resistance unit	Refer Fig. 4
(vi)	Distributor pickup module:	
	Primary (input) winding resistance (measured between centre terminal and outer terminal with red cable)	2.5 ohms nominal at 20°C
	Secondary (output) winding resistance (measured between centre terminal and outer terminal with black cable)	0.9 ohm nominal at 20°C
	Gap between pick-up module 'E' core faces and timing rotor outer edge	0.020″–0.022″ (0.50–0.55 mm)

(vii) Centrifugal auto-advance details:
(Distributor reference number 41321A-B)
Run up to 100 distributor rev/min and set gauge to read zero degrees. Check at the following increasing speeds:

Distributor rev/min	*Distributor advance degrees*
350	No advance
550	1.0– 3.5
750	5.5– 7.5
950	6.0– 8.0
1750	8.0–10.0
2900	11.0–13.0
3500	11.5–13.5

(viii) Vacuum retard details:
(Vacuum marking 2-7-8R part number 54422166)

	Distributor retard degrees
With rising vacuum	
At 7 in. Hg and up to 13 in. Hg	7–9
With falling vacuum	
At 1 in. Hg	No retard

4. SERVICING

(a) Testing in Situ

(i) Check the Battery Terminal Voltage and Battery Earth Connection

Connect a moving-coil voltmeter (e.g. 0–20V range) between the battery terminals. **12V or more should be registered.**

Connect the voltmeter between the earth terminal of the battery and a good earth point on the vehicle frame and disconnect the ignition coil L.T. terminal marked '—' to prevent the engine from starting. Operate the starting motor. **Not more than 0.5V should be registered.** If so, refit cable to ignition coil L.T. terminal and proceed to next test (para. ii).

If the test was unsatisfactory, rectify faulty connection between battery and frame.

(ii) Check Voltage Applied to Ignition Coil Primary Winding

Connect the voltmeter between the coil L.T. terminal(s) marked '+' and a good earth point on the vehicle frame (do not disconnect the cable). Switch on the ignition. **4–6V should be registered.** If so, proceed to next test (para. iii).

(1) If the test is unsatisfactory due to a low voltage being registered, check the ignition switch supply voltage to the ballast resistance unit. Connect the voltmeter between the 'SW' terminal of the ballast resistance unit and a good earth point on the vehicle frame (partially withdraw the cable connector, sufficient only to enable an insulated test prod to make contact with the 'SW' terminal blade). With the ignition switched on, **battery voltage should be registered** if the ignition switch and associated wiring are satisfactory.

If so, switch off the ignition and extend the test by checking the resistance of each of the resistors in the ballast resistance unit (use a good quality battery-operated ohmmeter and refer to Fig. 4). If necessary, renew the ballast resistance unit.

(2) If the test is unsatisfactory due to a high voltage being registered, remove the distributor moulded cover and check the position of the timing rotor.

If a ferrite rod in the timing rotor is in close proximity with the core of the pick-up module, triggering (unbalancing) of the pick-up module could occur and this would cause the primary winding circuit to be switched off by the power transistor in the amplifier unit, in which case it would be normal for a high voltage to be registered during the test. If this is the case, crank the engine and position the timing rotor so that two of the ferrite rods are an equal distance either side of the pick-up module core, then repeat the original test.

If it is found that the timing rotor has come to rest in a normal position with none of its ferrite rods in close proximity with the core of the pick-up module, then the previously unsatisfactory test result could be due to a fault associated with one of the following:

Ignition Coil: Check with the ohmmeter, the continuity and resistance of the primary winding (refer 3 iv).

Ballast Resistance Unit: Check with the ohmmeter, the resistance of each of the resistors (refer Fig. 4).

Amplifier Unit: Satisfactory working of the amplifier unit is confirmed if the next two tests (para's iii and iv) are both satisfactory.

(iii) Check Voltage Drop on Earth Side (or Amplifier Unit Side) of Ignition Coil

Connect the voltmeter between the coil L.T. terminal marked '—' and a good earth point on the vehicle frame (do not disconnect the cable). With the ignition switched on, **a voltmeter reading between zero and 2V should be obtained.** If so, leave the ignition switched on and the voltmeter connected and proceed to the next test (para. iv).

If the test is unsatisfactory (more than 2V registered), a faulty amplifier unit is indicated and the complete unit must be renewed.

(iv) Check the Switching Action of the Amplifier Unit

In reference to the previous test (para. iii), remove the distributor moulded cover and then crank the engine until one of the ferrite rods in the timing rotor is bridging the two limbs of the pick-up module core (ferrite rod in line with the timing mark groove on the top of the pick-up module). **The voltmeter reading obtained in the previous test (para. iii), should now be greatly increased to approximately 12V,** indicating that the ignition coil primary winding circuit has been switched 'OFF'. If so, proceed to performance testing (para. v).

If the test is unsatisfactory (voltmeter reading is unchanged from that obtained in the previous test (para. iii), a fault is indicated in either the amplifier unit or the distributor pick-up module and both these units must now be checked (refer 'Note' under the heading 'dwell angle' in the following para. v).

(v) Check the Running Performance of the Ignition System

Note: If 'Crypton' or similar type test equipment is not available (or if the engine will not start) proceed direct to para. vi.

Run the engine at charging speed (approximately 3,000 rev/min) and check the battery terminal voltage. **This should be 13.5–14.5V,** if the charging system is satisfactory, in which case proceed to check the following:

Primary traces	These are similar to conventional ignition systems.
Dwell angle	22°–27°.

If the dwell angle exceeds 27°, a faulty distributor timing rotor is indicated and this should be checked by substitution. If the dwell angle is less than 22°, check the gap between the distributor pick-up module and timing rotor (refer 3 vi). If the gap is correct, suspect the amplifier unit and the distributor pick-up module. NOTE: **Check the amplifier unit and pick-up module by substitution, checking first the amplifier unit and then the pick-up module. (If this sequence of proving the units is not maintained, the substitute pick-up module may be damaged if a fault exists in the original amplifier unit.)**

If substitute amplifier and pick-up module units are not available for testing purposes, check the original unit as follows:

To check the amplifier unit: First, check the position of the distributor timing rotor. If a ferrite rod in the timing rotor is in close proximity with the core of the pick-up module, for the purpose of the following test, it will be necessary to crank the engine and reposition the timing rotor so that two of the ferrite rods are approximately an equal distance either side of the pick-up module core. Disconnect the cable from the 'SW' terminal of the ballast resistance unit (alternatively, disconnect the later fitment three-terminal moulded connector from the 'SW' side of the ballast resistance unit) and connect a moving-coil ammeter (e.g. 0–20A range) in series with the 'SW' cable and the 'SW' terminal of the ballast resistance unit. **Note:** Due to close proximity of the 'SW' terminal blade to the frame of the ballast resistance unit, take care to avoid short-circuiting the ammeter connection to the frame. **Switch on the ignition. 5–6.5A should be registered.** If so, extend the test by separating the two moulded connectors between the distributor and amplifier units, then connect both the outside terminals of the amplifier connector alternately to the centre terminal. **The ammeter reading should remain unchanged from the previous test.** If the ammeter reading increases by more than 0.5A the amplifier unit is faulty and must be renewed.

To check the pick-up module: Connect one lead of the ohmmeter to the centre terminal of the pick-up module moulded connector and connect the other lead of the ohmmeter alternately to each of the outside terminals of the same connector. **Continuity of the primary and secondary windings of the pick-up module will be indicated by a reading on the ohmmeter, which in each case should conform to the resistance values given in (3 vi).** If the pick-up module winding test is satisfactory, inspect the ferrite adjusting screw near the bottom limb of the pick-up module 'E'-shaped core. **If the original factory adjustment of this screw shows signs of having previously been interfered with** (indicated by a broken seal around the screw) **the pickup module should be renewed.**

Secondary traces	These are similar to conventional ignition systems.
Sparking plug kv	8–11 (If unsatisfactory, check coil H.T. kv and if this is satisfactory, suspect H.T. cables).
Ignition coil H.T. kv	18–20.
Distributor H.T. rotor arm kv	6.
Ignition timing	Refer vehicle specification.
Centrifugal auto-advance	Refer 3 (vii).
Vacuum retard	Refer 3 (viii).

Note: The following tests (para's vi and vii) only apply if testing in this paragraph has not been carried out.

(vi) Check Whether a High-Tension (H.T.) Spark is Available at the Centre Terminal of the Distributor

When continuing testing direct from para. iv, the distributor moulded cover will already be removed and a ferrite rod in the timing rotor will be bridging the core of the pick-up module. (Ferrite rod in line with the timing mark groove on top of the pick-up module). This position of the timing rotor is necessary to carry out the following test.

Remove the H.T. cable from the centre terminal of the cover and position the cable-end conductor about $\frac{3}{16}''$ (0.187″ or 4.76 mm) from a clean and unpainted part of the engine **(well clear of the carburetter and petrol pipes).**

Switch on the ignition, then grasp the edge of the timing rotor and rock the rotor a few times in the direction of rotation (which is towards the vacuum unit). **A spark should regularly occur,** according to the number of times the timing rotor is moved. If so, proceed to the next test (para. vii).

If the test is unsatisfactory (no spark), inspect the ignition coil H.T. cable and terminal connection at the coil. If the H.T. cable and terminal connection are found to be satisfactory, the coil should either be individually 'performance tested' or proved by substitution.

(vii) Check for Satisfactory Distribution of the High-Tension (H.T.) Voltage from Ignition Coil to Sparking Plugs

Check the Distributor H.T. Rotor Arm

Providing a satisfactory spark is known to be available at the centre terminal of the distributor (previous testing para. v refers), the ignition coil H.T. voltage can be utilised for testing the insulation of the H.T. rotor arm electrode. Carry out the same test as detailed in the previous para. (vi), but this time position the cable-end conductor near to the rotor arm electrode. **Only a very faint trace of a spark, or no spark, should occur.**

Check the Distributor Moulded Cover

The inside and outside of the distributor moulded cover should be clean, dry, and free from contamination by oil. Closely inspect the inside of the cover. 'Tracking' of the H.T. spark will be indicated by a thin greyish-white line or, sometimes more obviously, by signs of charring of the moulding. In such cases the fault can normally be rectified only by renewing the moulded cover. Check the carbon brush and spring for freedom of movement in the moulding. Check whether the spring is making electrical contact with the bottom of the brush-and-spring housing. Check whether the brush needs renewing. The normal amount of brush protruding from the moulding when the brush-and-spring assembly is in an unloaded condition, should be approximately $\frac{5}{32}$" (0.156" or 4 mm). The original brush-and-spring should not normally require renewing, but if the brush dimension previously referred to becomes worn to $\frac{3}{32}$" (0.093" or 2 mm) the brush-and-spring assembly should be renewed. Should this become necessary, the cause of premature failure of the brush should be ascertained. Check that the top of the rotor arm electrode where it contacts the brush is highly polished. Look for scoring of the electrode, which may previously have been caused by incorrectly using rough glass-paper or emery cloth to clean the electrode. (It is sufficient to wipe clean the rotor arm with a petrol-moistened cloth). If the centre of the moulding around the brush-and-spring housing shows signs of damage, check that the rotor arm is fully-located on the distributor shaft.

Check the High-Tension Cables

The general condition of the H.T. cables can be considered satisfactory if the cables are clean and dry, free from contamination by oil, and the insulation shows no signs of cracks.

If the engine fails to start, or misfires, the H.T. cables may previously have been removed and then accidentally refitted to the sparking plugs in the incorrect firing order. If this is not the cause of the fault, check whether a satisfactory spark occurs at the sparking plug end of each of the H.T. cables.

First prevent the engine from starting by disconnecting the H.T. cables from the sparking plugs. Connect to each of the H.T. cable connectors in turn, a sparking plug known to be good. With sparking plug resting on engine, switch on the ignition and crank the engine. **A spark should regularly occur.**

If the test is satisfactory, the fault must be due to one of the following causes:- sparking plugs, carburation (or fuel supply), or an engine fault.

If the test is unsatisfactory,

(1) If there is no sparking at the test plug, **check the centre terminal connection in the distributor cover.**

(2) If a weak spark occurs, **check the connections in the distributor cover.**

(3) If there is no spark from one or more H.T. cable(s), **check the connection of the faulty cable(s) in the distributor cover.**

(b) Servicing the Amplifier Unit

The printed circuit wiring board assembly comprises all working parts of the amplifier unit. It is not a practical or economical proposition to carry out repairs to the printed circuit wiring board assembly. If the amplifier unit has failed, it must be renewed complete.

During production of the amplifier unit, a special test is carried out at the factory to determine whether the body (collector) of the power transistor is short-circuiting to the frame of the amplifier unit. Depending on the result of this power transistor insulation test, it is sometimes necessary to re-position the printed circuit wiring board assembly in a satisfactory position before finally tightening the fixing screws. For this reason, the printed circuit wiring board assembly 'fixing screws' should not be disturbed. Fig. 3 (b) shows the printed circuit wiring board assembly partially removed from the amplifier unit and the purpose of this illustration is to show the enclosed side of the printed circuit wiring board assembly, so making it unnecessary to disturb its original position.

(c) Servicing and Dismantling the Distributor

Note: If the distributor is in need of a major repair or overhaul, remove the unit from the vehicle. In such cases the following information can be used as a general guide to complete dismantling, in which case disregard para. (ii).

(i) Remove the moulded cover and the H.T. rotor arm.

(ii) Check the pick-up module gap, by placing a feeler gauge 0.020–0.022" (0.50–0.55 mm) between the core of the pick-up module and the timing rotor (see Fig. 1, item 6). If necessary, adjust the gap by altering the position of the pick-up module assembly.

Inspect the timing rotor, paying particular attention to the ferrite rods. (Removing the timing rotor is dealt with in para. iii).

Check the pick-up module pick-up arm for satisfactory automatic vacuum-retard movement. The bearing surfaces of the pick-up arm, and the peg on the pick-up arm which actuates the vacuum operating rod, should be lubricated sparingly with 'Rocol' grease No. 30863 or, alternatively, 'Mobilgrease' No. 2. (If it is necessary to apply more grease to the bearing surfaces of the pick-up arm, push the pick-up arm sideways against the pressure of the bearing spring whilst applying the grease).

Inspect the centrifugal auto-advance mechanism. To do this it will be necessary to remove the timing rotor and separate the micro-housing from the distributor body (see para. iii and vi). The auto-advance mechanism should be lubricated with a liberal quantity of the same grease previously specified for the pick-up arm. If necessary, apply a fresh application of grease.

Finally, apply a few drops of clean engine oil (e.g. S.A.E. 30 grade) to the felt pad in the top of the rotor carrier shaft, until the pad is sufficiently soaked.

(iii) Removing the Timing Rotor

Remove the circlip from the groove in the rotor carrier shaft, then remove the corrugated spring washer and the timing rotor from the shaft.

Lucas 'Opus' 3 (Mk II) Electronic Ignition System
(Fitted to Jaguar "E" Type Series III)

(iv) Removing the Pick-up Module Assembly

After removing the timing rotor (para. iii), removing the pick-up module (and also reassembly of the pick-up module) is facilitated if the pick-up arm is removed complete with the pick-up module, the pick-up module fixing screws are then more accessible for removal and refitting.

To remove the pick-up module-and-pick-up arm assembly: Lift the vacuum operating rod from the peg on the pick-up arm, remove the pick-up arm bearing spring and then slide the pick-up arm sideways to disengage it from its bearing in the micro-housing. It is now a simple matter to separate the pick-up module from the pick-up arm.

The pick-up module cable-assembly grommet should be removed from its location in the micro-housing by gripping the cables and pushing free the top part of the grommet into the micro-housing first, the retaining lip at the bottom of the grommet can then be freed from the bottom of the hole in the micro-housing. (During reassembly, the retaining lip at the bottom of the grommet should be located in the hole first and the top part of the grommet should then be pushed fully-home).

(v) Removing the Vacuum Unit

After removing the timing rotor (para. iii), or when proceeding with dismantling from the previous para. (iv), remove the vacuum unit as follows:– Use a pin-punch 0.073″ (1.85 mm) to tap out the roll pin which secures the vacuum unit in the micro-housing. After the roll pin has been removed, the vacuum unit can be removed after its operating rod has been lifted from the peg on the pick-up arm.

(vi) Centrifugal Auto-Advance Mechanism

After removing the timing rotor (para. iii), or when continuing with dismantling from the previous para. (v), access to the auto-advance mechanism can be obtained by separating the micro-housing from the distributor body and this is achieved by removing the three spring-loaded fixing screws from inside the micro-housing.

The control springs can now be removed from their fixing posts and if necessary the springs renewed.

The centrifugal weights can also be removed, and if necessary renewed, after the rotor carrier has been removed from the distributor shaft and this is achieved by removing the screw located beneath the felt lubricating pad in the top of the rotor carrier.

The auto-advance mechanism should be lubricated with 'Rocol' grease No. 30863 or, alternatively, 'Mobilgrease' No. 2 (same as specified for the bearing surfaces of the pick-up arm). Prior to reassembly of the auto-advance mechanism, grease should be applied to either the pivot holes in the weights or the pivot posts of the rotor carrier before it is fitted to the distributor shaft. When the auto-advance mechanism is in a completely assembled state, the whole of the mechanism should be smeared with the grease previously specified. Finally, the rotor carrier shaft should be initially lubricated, by applying a few drops of clean engine oil (e.g. S.A.E. 30 grade) inside the top of the rotor carrier shaft before replacing the felt lubricating pad in the top of the shaft. After the felt pad has been fitted, soak the pad with a few drops of the oil previously specified.

(vii) The Distributor Body Assembly

In the unlikely event of premature failure of any part comprising the distributor body assembly (shaft-and-action plate assembly, ball-race bearing, bearing bush, thrust washer and driving gear), the distributor must be serviced by renewing the body assembly complete.

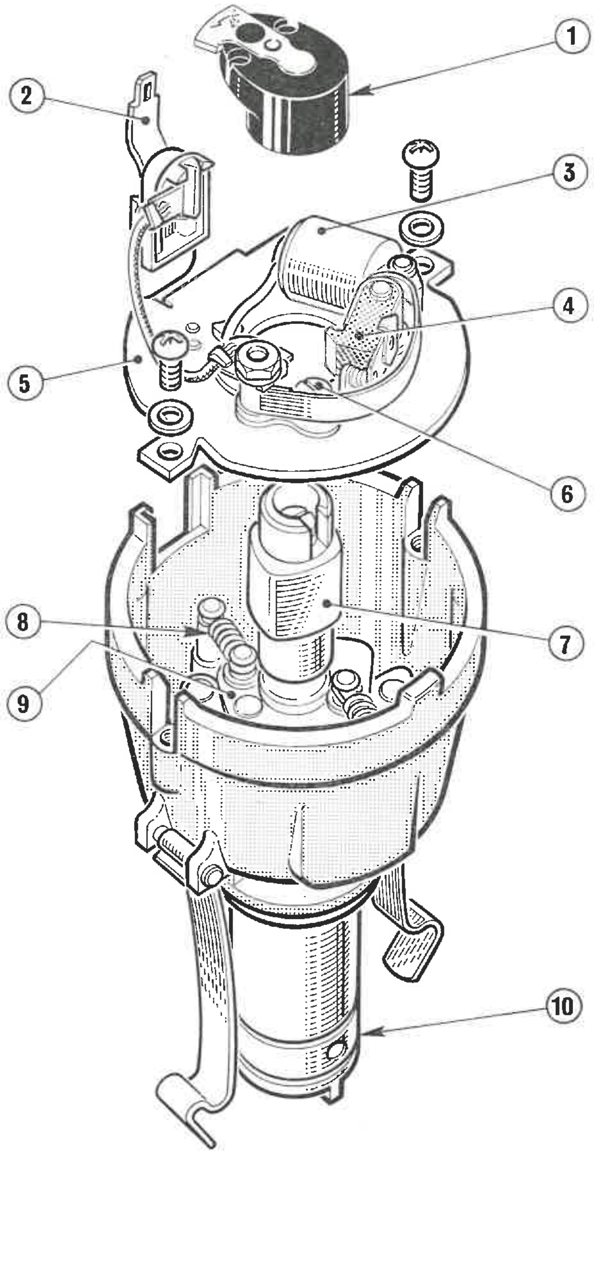
Note: This is due to the fact that special tooling would be required to carry out repairs to the distributor body assembly. One type of tool being necessary to carry out nail-punch riveting of both ends of the driving gear fixing pin and another tool to critically position the driving gear on the shaft of a new shaft-and-plate assembly, while the driving gear fixing pin hole is drilled through the shaft.

(viii) Reassembling the Distributor

Reassembling the distributor is simply a reversal of the dismantling procedure.

Do not forget to locate the 'Allen screws' and flat washers in the elongated holes of the body before fitting the micro-housing to the body, otherwise the micro-housing will again have to be removed (see Fig. 2, item 31).

DISTRIBUTORS, MODELS 22D, 23D AND 25D



1 Rotor arm
2 L.T. terminal
3 Capacitor
4 Contact set
5 Contact breaker base plate
6 Fixed contact securing screw
7 Cam
8 Automatic advance control springs
9 Automatic advance mechanism
10 Drive dog and thrust washer

Fig. 1 Model 23D distributor, complete with conventional contact set

1. DESCRIPTION

The basic models are as follows:–

Model 25D – Incorporates centrifugal advance and vacuum advance/retard mechanisms. Micrometer adjustment is also included in the majority of units.

Model 23D – Has only centrifugal advance mechanism.

Model 22D – Similar to Model 25D but has longer body to permit the use of two bearing bushes. A mechanical tachometer drive take-off point is sometimes built into the body for certain applications.

This range of distributors incorporates many components which are directly interchangeable between the three basic models. Both 4- and 6-cylinder versions of each model are available, the number of cylinders being denoted by a suffix number in the model description, i.e. 25D4 or 22D6.

All models have aluminium bodies with bearing bushes and incorporate a rolling weight automatic advance mechanism.

The bearing bushes are oil-impregnated before assembly in the distributor and in service are lubricated automatically by oil-mist from the engine.

Distributors, Models 22D, 23D and 25D

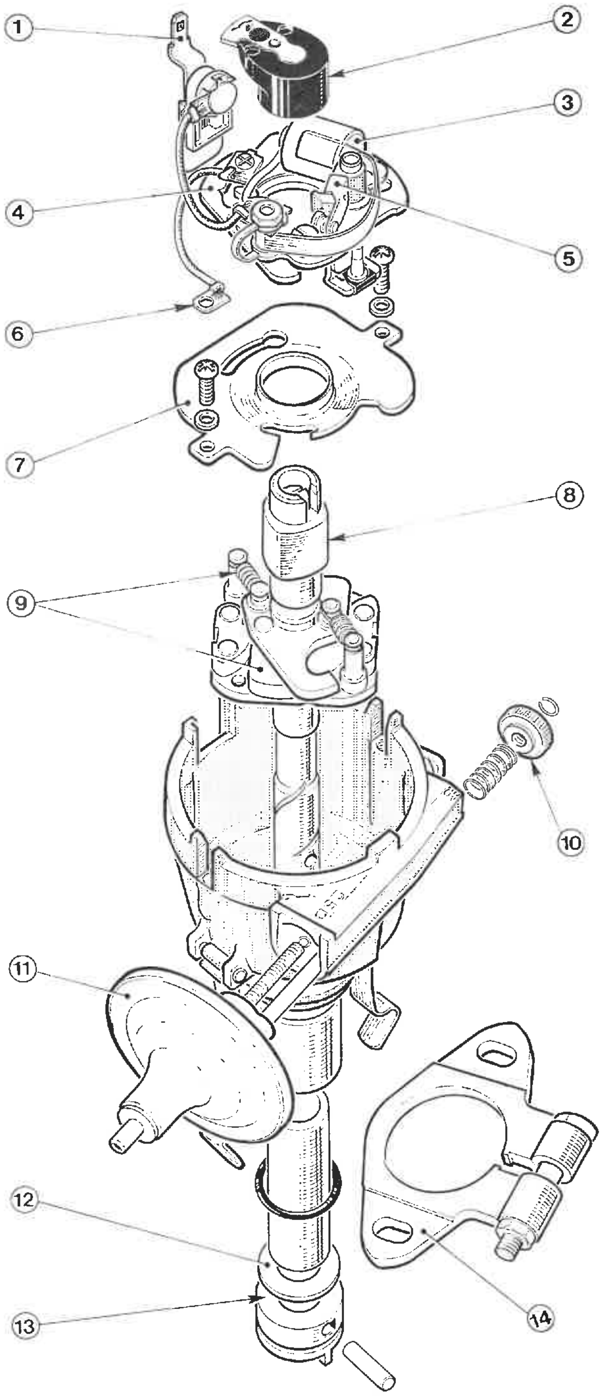
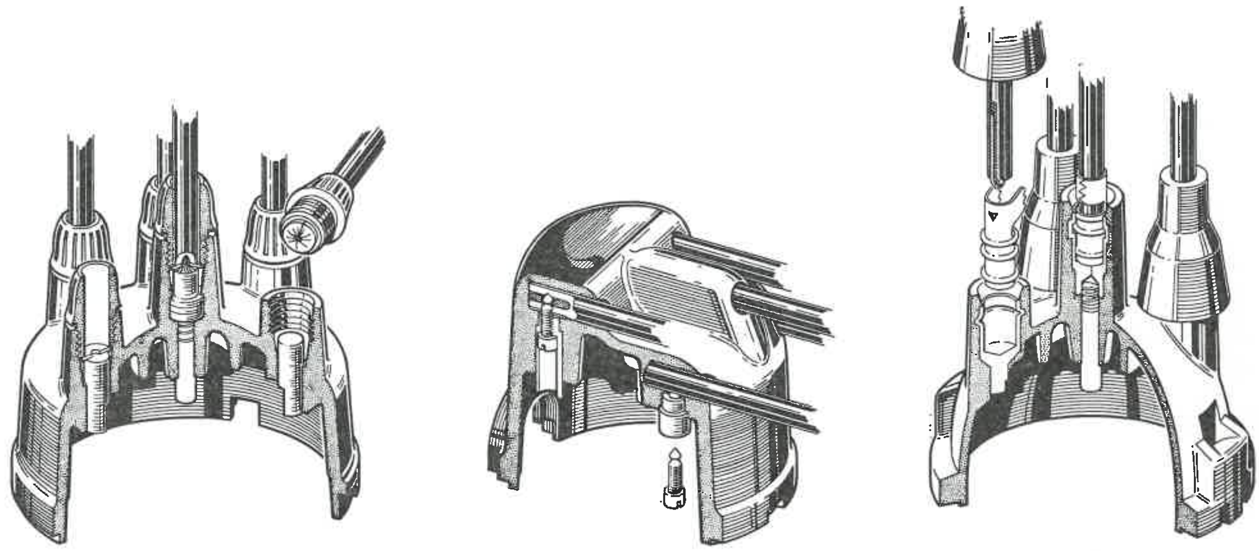


Fig. 2 Model 25D distributor, complete with one-piece contact set

1 L.T. terminal
2 Rotor arm
3 Capacitor
4 Contact breaker moving plate
5 Contact set
6 Contact breaker earth terminal
7 Contact breaker base plate
8 Cam
9 Automatic advance springs and weights
10 Micrometer adjustment nut
11 Vacuum unit
12 Thrust washer
13 Drive dog and pin
14 Securing plate

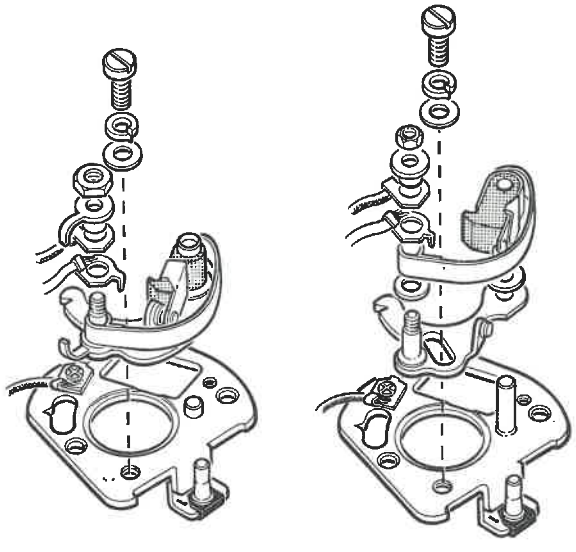


Vertical 'Screw-in' Horizontal Vertical 'Push-in'

Fig. 3 Typical distributor covers

Distributor Covers

Both horizontal and vertical outlet distributor covers are available. (Fig. 3). Earlier distributors with vertical outlet covers had conventional screw type terminals, which use knurled nuts to secure the H.T. cable in the chimney. Horizontal outlet versions had pointed screws, located inside the moulded cover as part of the electrode and these pierced the H.T. cable.



(a) Fig. 4 (b)

(a) One-piece contact set and contact breaker plate
(b) Conventional contact set and contact breaker plate

Later distributors have "push-in" type H.T. terminals and are confined to vertical outlet covers. These rely on a shaped connector which is crimped to the end of the H.T. lead to form a tight "push-in" fit in the chimney insert of the cover.

Contact Breaker Assemblies

The contact point gap setting is standard throughout the range and should be within the limits 0·014″ – 0·016″ (0·35 mm – 0·40 mm).

Originally all these distributors had conventional contact sets, comprising fibre heel, insulating bushes and washers (Fig. 4b).

Later distributors have a modified contact breaker assembly incorporating a one-piece contact set. The contact breaker heel pivots on its own hollow pivot post which is positioned over a short locating stud on the contact breaker base plate.

Fig. 4a illustrates a modified base plate and contact breaker assembly. As the moving contact is smaller than the fixed contact, alignment is established when the moving contact has its diameter completely within that of the fixed contact. The two contacts need not be concentric. Insulation of the steel terminal post is provided by two nylon bushes joined together by a short link.

Vacuum Units

The characteristics of vacuum units are set during manufacture and cannot be adjusted in service. The complete vacuum unit must be replaced if a fault develops.

The performance details of a vacuum unit are marked on the casing using a code number. The figures in such a code, i.e. 3/24/12, stand for:–

(a) (b) (c)

(a) Vacuum in inches of mercury ("Hg) at which the unit commences to function.

(b) Vacuum ("Hg) at which maximum advance (retard) occurs.

(c) Maximum advance (retard) in degrees.

Full details of individual test figures for these codes are given in Publication No. SB222, Test Data Manual, Section 6, against the appropriate code number.

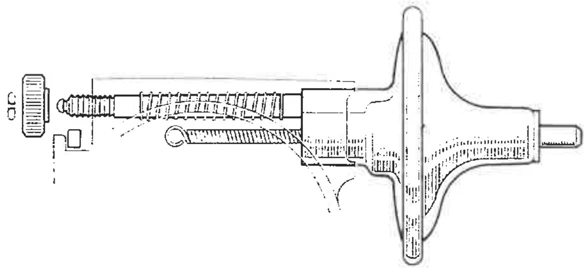


Fig. 5 Typical vacuum unit (advance type)

(i) **Typical Advance Unit**

The normal advance type units afford additional advance when the engine speed is high and lightly loaded.

(ii) **Retard Type Unit**

Certain engines incorporate an emission control system to limit obnoxious fumes from the exhaust. A retard vacuum unit is used to control the engine speed when the emission control system operates, during idling and over-run conditions.

Retard type units have an 'R' incorporated in the code marking, e.g. 4/8/5R.

Two versions of the retard only vacuum unit are used:–

(a) A typical advance unit mounted on the opposite side of the distributor to its normal position so that the C.B. moving plate is pulled in the direction of rotation.

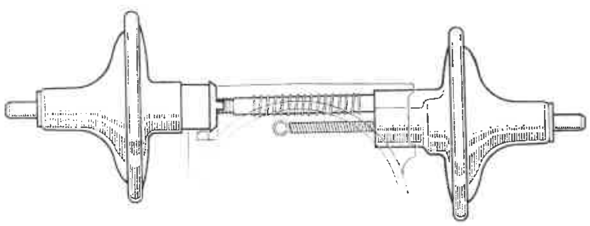


Fig. 6 Twin vacuum units (double-acting)

(b) The retard section of a single capsule double-acting unit (see sec. iv). In such cases the outlet from the advance side is sealed.

(iii) **Twin Vacuum Units (Double-Acting)**

Some emission controlled engines require two vacuum units. A retard unit is mounted on the opposite side of the distributor body to the advance unit, Fig. 6. The two vacuum units are linked by a rod mechanism and then connected to the contact breaker moving base plate.

(iv) **Typical Single Capsule, Double-Acting Vacuum Unit**

The double-acting vacuum unit incorporates both advance and retard characteristics, Fig. 7. Both codes are stamped on the casing.

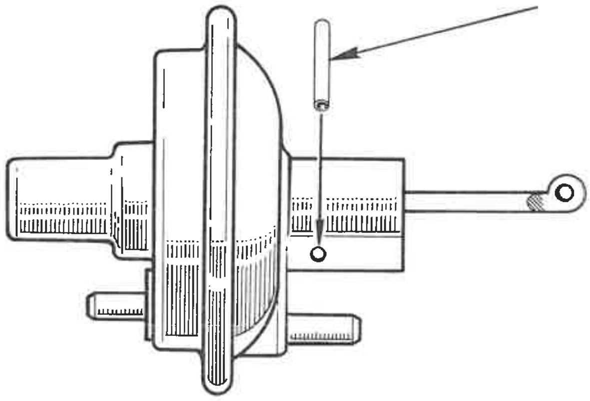


Fig. 7 Single capsule, double-acting vacuum unit

2. ROUTINE MAINTENANCE

Normal maintenance consists of general cleaning, contact breaker inspection, checking and adjusting contact gap setting and lubrication at regular intervals.

(a) Contact breaker adjustment — after first 500 miles (800 km)

When a new vehicle or replacement contact set has completed the first 500 miles (800 km), check that the contact gap is within the limits 0·014" – 0·016" (0·35 mm – 0·40 mm).

(i) With the distributor cover and rotor arm removed, rotate the engine until the contacts are fully open, i.e. when the operating heel is on the highest part of the cam lobe.

(ii) A feeler gauge 0·015" (0·38 mm) thick should be a sliding fit between the contact surfaces. (Any trace of piling must be removed, otherwise a false setting will be obtained, see para (b)). If the gap is incorrect, slacken the screw securing the fixed contact plate and adjust its position until the gauge can be inserted as a sliding fit. A screwdriver blade should be inserted between

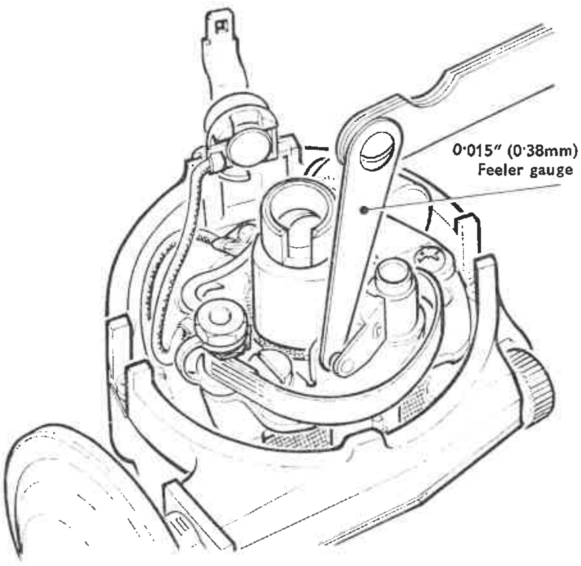


Fig. 8 Setting the contact point gap

the recess at the end of the fixed contact plate and the base plate and used as a lever to adjust the setting. When the gap is correct, tighten the securing screw and recheck the gap on each cam lobe.

(b) Cleaning and lubrication every 6,000 miles (5,650 km)

Thoroughly clean the distributor cover, inside and outside with a clean dry cloth, paying particular attention to the spaces between the metal electrodes. Check that the electrodes are not excessively eroded and that there are no signs of tracking. Ensure that the small carbon brush in the centre of the cover is unbroken and moves freely in its holder.

Examine the contact breaker. The contact points must be free from grease and oil. If the points are burned, blackened or rough (badly pitted and piled) they should either be replaced or cleaned with a fine carborundum stone or emery cloth and then wiped with a petrol-moistened cloth to ensure they are absolutely clean and free from carborundum deposits etc.

Cleaning is made easier by removing the contact breaker assembly. Disconnect the connections from the L.T. terminal post. Slacken and take out the screw securing the fixed contact plate. Remove the contact point assembly.

Before refitting the assembly (for sequence see Fig. 4) lubricate as follows:–

(i) Lightly smear the cam with Retinax 'A' or equivalent grease.

(ii) Inject one or two drops of clean engine oil (SAE.30) through an aperture in the contact breaker base plate to lubricate the auto-advance mechanism.

(iii) Lift off the rotor arm and apply a few drops of clean engine oil (SAE.30) to the top of the exposed screw to lubricate the cam bearing. It is not necessary to remove the screw since there is a clearance for the passage of oil.

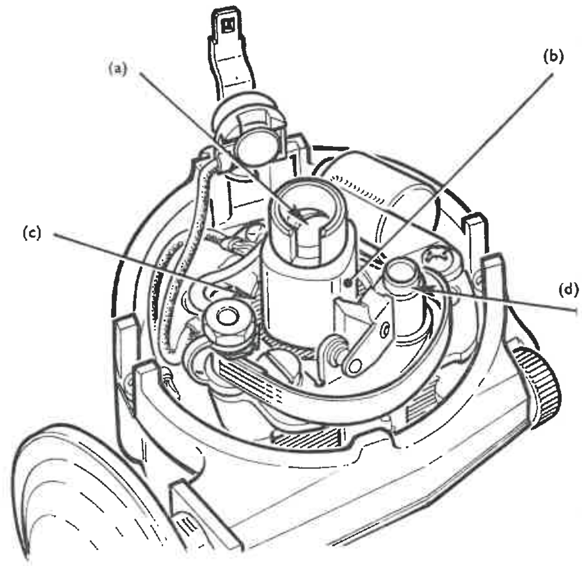


Fig. 9 Lubricating the distributor

(a) Apply 2 or 3 drops of clean engine oil
(b) Lightly smear cam with Retinax 'A' or equivalent grease
(c) Add several drops of clean engine oil
(d) One-piece contact set—lightly smear outside of hollow pivot post with Retinax 'A' or equivalent grease

(iv) **Earlier contact set.** Apply 1 drop of clean engine oil (SAE.30) to the top of the pivot post on the contact breaker base plate.

One-piece contact set. Lightly smear the outside of the hollow pivot post with Retinax 'A' or equivalent grease.

Note: *Take care to prevent oil or grease contaminating the contact points. All surplus must be wiped away immediately.*

After reassembly, set the contact gap within the limits 0·014" – 0·016" (0·35 mm – 0·40 mm), except in the case of a new contact set. The limits are then extended to 0·019" (0·48 mm) to allow for bedding in of the new contact breaker heel. For method of adjustment see para. 2(a).

3. DESIGN DATA

(a) **4-cylinder units:–**

Firing angles: 0°, 90°, 180°, 270° ± 1°
Dwell angle: 60° ± 3°
Open period: 30° ± 3°

6-cylinder units:–

Firing angles: 0°, 60°, 120°, 180°, 240°, 300° ± 1°
Dwell angle: 35° ± 3°
Open period: 25° ± 3°

(b) Contact breaker point gap: 0·014″ – 0·016″ (0·35 mm – 0·40 mm).

(c) Contact breaker spring tension, measured at contacts: 18 – 24 ozf. (5 – 6·6 Newtons)

(d) Capacitor: 0·18 – 0·23 microfarad.

(e) Automatic timing controls: Refer to Section 5 of Publication No. SB222 against the appropriate distributor Service No. for test details of the automatic advance and vacuum timing control mechanisms.

(f) Securing plate:

Maximum tightening torque –
Trapped nut and rotating bolt – 30 lbf/in. (5·25 k N/m).
Trapped bolt and rotating nut – 50 lbf/in. (8·76 k N/m).

4. SERVICING — FAULT DIAGNOSIS

Before testing the ignition system, ensure the battery is in good condition and at least 70% charged. Check the specific gravity of the electrolyte in each cell with a hydrometer. If the individual cell readings vary by more than 40 points (0.040), the battery is suspect and should be removed for testing by a Lucas battery agent.

State of charge	S.G. readings corrected to 15°C (60°F)	
	Climates normally below 25°C (77°F)	Climates normally above 25°C (77°F)
Fully charged	1.270 – 1.290	1.210 – 1.230
70% charged	1.230 – 1.250	1.170 – 1.190
Discharged	1.100 – 1.120	1.050 – 1.070

Electrolyte Temperature Correction

For every 10°C (18°F) *below* 15°C (60°F) *subtract* 0.007.
For every 10°C (18°F) *above* 15°C (60°F) *add* 0.007.

(a) Testing in position to locate cause of uneven firing

Run the engine at a fast idling speed. If possible, short circuit each plug in turn between the plug terminal and cylinder block or alternatively lift off each plug connector in turn. Short circuiting the plug or removing the connector of the defective cylinder will not cause an appreciable change in the running note.

When the suspect cylinder has been located, stop the engine and remove the H.T. cable from the sparking plug terminal. Restart the engine and hold the cable end about 0·25″ (6 mm) from a clean unpainted part of the engine. If the sparking at the end of the lead is strong and regular, the sparking plug should be removed, cleaned and adjusted or a replacement fitted. If, however, there is no spark or the sparking is weak and irregular, examine the H.T. cable and connections to the plug and distributor cover. Renew the cable if the insulation is cracked, perished or the cable end connector is damaged.

Clean and examine the distributor cover. Check that the carbon brush moves freely. If a replacement brush is required, the correct type must be used. If there is any evidence of tracking (indicated by a thin burnt line between two or more electrodes or between one of the electrodes and earth), a replacement cover must be fitted.

If the fault still persists, proceed with further checks to the following:–

Contact points – see Section 2, paras a and b.
Capacitor – see Section 4, para b, (vii).
Shaft side-play – see Section 5, para d.
All wiring connections.

(b) Testing in position to locate cause of ignition failure

Note: *COIL CONNECTIONS – Coils marked '+' and '—' have the '—' terminal connected to the distributor contact breaker on a negative earth system, and to the ignition switch on a positive earth system. (Meter connections shown are for negative earth systems).*

(i) Supply to the ignition coil

Connect voltmeter between a good earth and the feed or 'SW' terminal of the coil, Fig. 10. With the contact points closed, switch on the ignition. Battery voltage should be registered or in the case of a ballasted ignition system approximately 6V for a 12V system.

Zero reading indicates an open circuit between the battery and the coil.

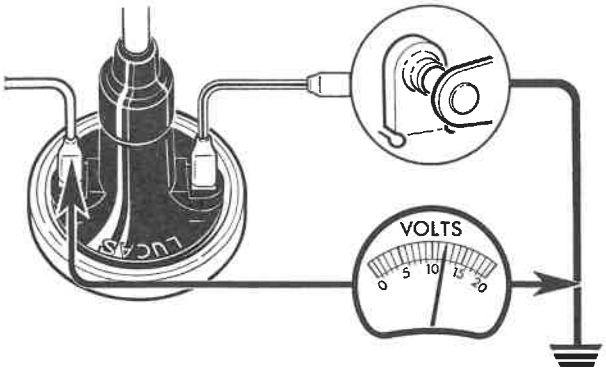


Fig. 10 Checking the supply voltage at the coil (contact points closed)

(ii) Coil primary winding

Connect voltmeter between a good earth and distributor side or 'CB' terminal of the coil, Fig. 11. Battery voltage should be registered when the ignition is switched on and the contact points are open.

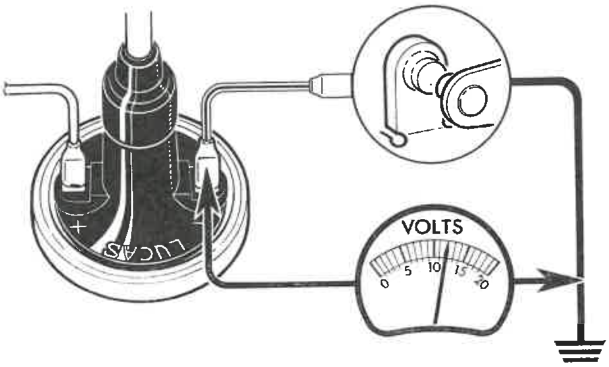


Fig. 11 Checking the primary winding (contact points open)

If satisfactory proceed to para (iv).

If a zero reading is obtained it indicates either:–

(a) Open circuit of coil primary winding.

(b) Short circuit to earth in the coil to distributor L.T. lead or in the distributor.

To locate the cause of failure, disconnect the lead from the coil 'CB' terminal. Leave voltmeter still connected to the coil 'CB' terminal and the ignition on, check voltmeter reading:–

Zero – Faulty coil (open circuit primary winding.

Battery voltage – Coil satisfactory, but there is an earth fault in the coil to distributor lead or in the distributor. To check the lead, reconnect it to the coil and disconnect at the distributor. Connect the voltmeter between the free end of the lead and earth. If the lead is satisfactory, battery voltage will be registered and the fault must therefore lie within the distributor, proceed to para (iii). A zero reading indicates short to earth in the lead which must be rectified. Proceed to para (v), if further testing of the system is required.

(iii) Distributor earth

If testing indicates a short circuit to earth in the distributor, check:–

(1) the contact points are opening correctly. Conventional contact sets require an insulating washer under the moving contact;

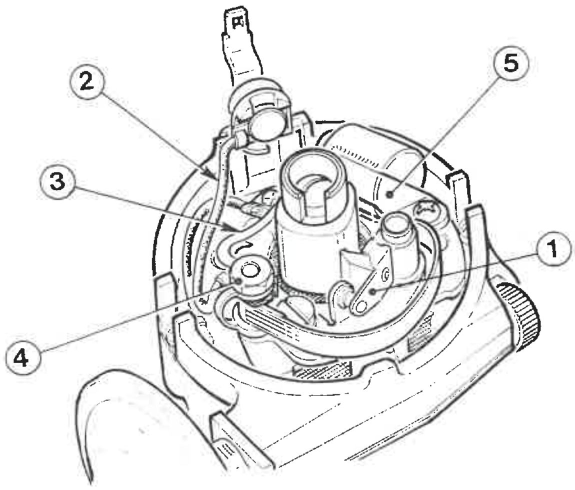


Fig. 12 Checking for distributor earths

(2) the flexible lead connecting the distributor L.T. terminal to the moving contact (terminal post);

(3) the capacitor lead connected to the terminal post;

(4) the terminal post connections are assembled correctly, see Fig. 4;

(5) the capacitor is not short circuited by removing the capacitor from its mounting position.

(iv) Coil to distributor L.T. lead

Connect voltmeter between a good earth and distributor L.T. terminal. With the ignition on and the contact points still open, check the voltmeter reading.

Battery voltage – L.T. lead is satisfactory.

Zero – Broken or open circuit lead (assuming the correct result was obtained in para (iii).

(v) Check contact points

Connect voltmeter between a good earth and distributor L.T. terminal. With the ignition and contact points closed, voltmeter reading should be zero, see Fig. 13.

If the voltmeter registers a voltage:–

(a) Contact points may not be closing.

(b) Contact points may be dirty or oily.

(c) A bad earth connection may be indicated, i.e. a broken flexible earth lead or a poor connection between the distributor body and the engine block.

(d) Ensure the flexible lead between the distributor L.T. terminal and the terminal post is not broken.

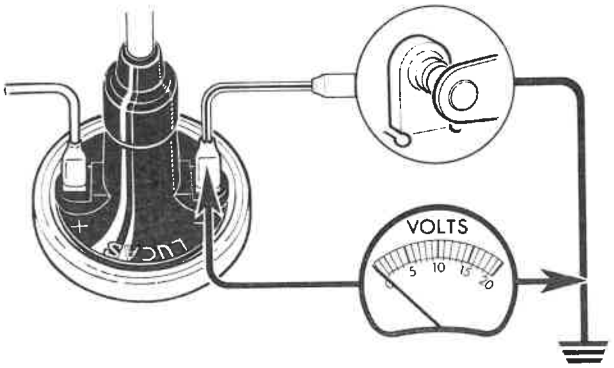


Fig. 13 Checking contact points (contact points closed)

(vi) Check H.T. spark to distributor

Remove H.T. lead from centre terminal of distributor cover and connect free end to 3-point gap, or hold end termination approximately 0·25″ (6 mm) away from a clean unpainted part of the engine. The earth side of the 3-point gap must be connected to a good earth on the engine. Ensure contacts are closed, switch on the ignition and when the contacts are flicked open, a strong H.T. spark should be obtained across the gap.

If a strong spark is obtained each time the contacts are flicked open, the ignition coil and capacitor are serviceable. A spark will still be obtained even if the capacitor is open-circuit, but it will be weaker than normal. To check, proceed to para (vii).

However, if a spark is not obtained, the ignition coil secondary winding is probably defective and the ignition coil should be replaced.

(vii) Checking the capacitor

The capacitor is checked by substitution. The original capacitor must be disconnected and a test capacitor connected between the distributor L.T. terminal and a good earth. A strong H.T. spark should now be obtained when the contacts are flicked open with the ignition switched on.

If the spark obtained is stronger than in the previous test, the capacitor should be replaced.

(viii) Check distributor rotor arm

Connect an H.T. lead in the coil chimney and hold the free end 0·125″ (3 mm) from the rotor arm electrode. With the ignition on, contacts are flicked open. If a strong spark is produced, the rotor arm is shorted to earth via the cam head and should be replaced.

(The H.T. spark referred to should not be confused with the faint sparking due to electrostatic charge and leakage.)

5. SERVICING — DISMANTLING

Spring back the clips and remove the distributor cover.

If a driving gear or dog is fitted to the shaft and has to be removed, note the relative positions between it and the rotor arm electrode. A gear should be marked to ensure correct re-assembly whereas a dog normally has offset tongues which should lie to the left of the centre-line when they are in line with the rotor arm electrode, see Fig. 14.

Lift the rotor arm off the cam.

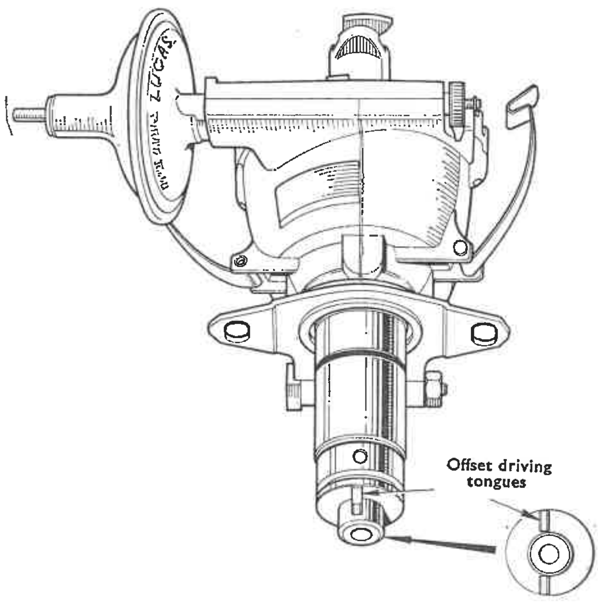


Fig. 14 Typical drive arrangement

When the distributor is fitted with a vacuum unit, the link connecting the vacuum unit to the contact breaker moving plate should be lifted off the tapered post. Remove the two screws at the edge of the contact breaker base plate to allow the contact breaker assembly and the L.T. terminal to be lifted clear.

Knock out the securing pin and remove the thrust washer, dog or gear. If the distributor is fitted with a mechanical tachometer take-off point, remove the two screws securing the tachometer gear cover and gasket and withdraw the gear from its housing. The complete shaft assembly, with the cam and automatic advance mechanism can then be separated from the body.

To remove a micrometer adjustment and vacuum unit, take off the circlip on the end of the micrometer screw thread and turn the adjustment nut until it is off its thread. Take care not to lose the ratchet and coil spring located under the micrometer nut. The vacuum unit can then be removed. In the case of twin vacuum units the small spring clip which retains the additional or retard vacuum unit must first be removed to allow the additional unit to be screwed off the end of the inter-connecting rod while the other unit is held against its spring pressure to the body of the distributor (Fig. 6). If a single capsule double-acting vacuum unit is fitted, the roll pin (Fig. 7) should be knocked out and the vacuum unit then withdrawn from the distributor body.

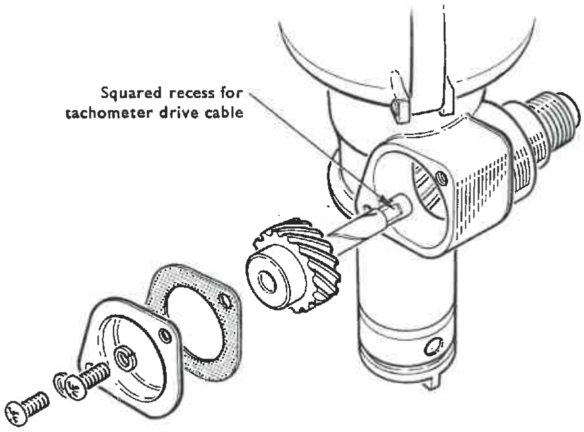


Fig. 15 Typical tachometer 'take-off' attachment

(a) Contact breaker assembly

To dismantle the contact breaker completely remove the nut, insulation piece(s) and connections from the pillar on which the contact breaker spring is anchored. Lift off the spring and insulating washers beneath it.

Remove the screw securing the fixed contact plate together with the plain and spring washers, and take off the plate.

Slacken and remove the self-tapping screw to free the capacitor.

The contact breaker plate assemblies of 22D and 25D distributors can be further dismantled by turning the moving plate clockwise and pulling to release it from the base plate.

(b) Replacement contacts

If the contacts are so badly worn that replacement is necessary, they must be renewed as a pair and not individually.

(c) Shaft and action plate

The dismantling and re-assembling of the automatic advance mechanism must be carried out carefully to avoid damaging the springs, which would alter the characteristics.

Carefully remove the springs. Slacken and withdraw the screw inside the cam and lift off the cam. Before removing the weights, note the position of the cam slots. Note also that a distance collar is fitted on the shaft underneath the action plate.

(d) Bearings

If the bearings are worn to such an extent that excessive side play of the shaft is evident, the complete distributor must be replaced.

6. SERVICING — RE-ASSEMBLY

The following instructions assume that complete dismantling has been undertaken.

(a) Before re-assembling the automatic advance mechanism to the shaft and action plate, the top section of the shaft (cam spindle), the top of the action plate, the cam foot weight pivots and all working surfaces of the weights and action cams should be smeared with Rocol MP (Molypad) lubricant. Assemble the mechanism and fit the cam securing screw.

Ensure the springs are not stretched or damaged during re-assembly.

(b) Ensure the distance collar is in position and then liberally smear the distributor shaft with Rocol MP (Molypad) before insertion into the bearing.

It is important to ascertain that the shaft is free to rotate without binding.

(c) If the distributor has a manual tachometer take-off point, insert a liberal quantity of Rocol 30863 Molybdenum grease into the gear housing. Refit the gear and secure the gasket and gear cover in position.

(d) If the distributor is fitted with a vacuum unit and micrometer adjustment (models 22D and 25D), ensure the ratchet for the milled adjustment nut is in position. Slide the vacuum unit into its housing and refit the spring, milled adjusting nut and securing circlip.

All other vacuum units should be fitted using a reversal of the dismantling procedure.

(e) Re-assemble the contact breaker assembly.

Where applicable, i.e. 22D and 25D distributors, lightly smear all the base plate bearing surfaces with Rocol MP (Molypad) lubricant. Assemble the base and moving plates together using a reversal of the dismantling procedure.

Before fitting the contact set ensure the moving contact pivot post has been lightly smeared with Retinax 'A' or equivalent grease. The fixed contact securing screw should only be loosely fastened at this stage.

Fit the capacitor and assemble the terminal post connections as shown in Fig. 4.

(f) Refit the complete contact breaker assembly into the distributor body and engage the link from the vacuum unit (if fitted) and slide the terminal block into its slot. Insert and tighten the two base plate securing screws. On models 22D and 25D one of these screws also secures the free end of the contact breaker earthing cable.

(g) Lightly smear the cam with Retinax 'A' or equivalent grease.

Note: *Take care to prevent oil or grease contaminating the contact points. All surplus must be wiped away immediately.*

(h) Set the contact point gap within the limits 0·014″ – 0·016″ (0·35 mm – 0·40 mm) or for a new contact set 0·019″ (0·48 mm) maximum, and tighten the fixed contact securing screw. Check the gap for each cam lobe.

(i) Refit the rotor arm, locating the moulded projection in the rotor arm with the keyway in the shaft, and push fully home.

(j) Refit the thrust washer and drive dog or gear to the shaft. The tongues of the dog must lie to the left of the centre-line of the shaft when they are in line with the rotor arm electrode, (Fig. 14).

Note: *A new shaft can be drilled using the hole in the dog or gear as a guide, (Fig. 16). Drill size $\frac{3}{16}$″ (0·1575″) (4·76 mm).*

If the distributor shaft has a fibre thrust washer, a 0·002″ (0·05 mm) feeler gauge should be inserted as a temporary spacer between the dog and the thrust washer. (This is to ensure correct distributor shaft end float.) Maximum permissible end float is 0·005″ (0·13 mm). Whilst drilling, the shaft and action plate must be pushed down from the cam end. The dog must also be held firmly compressing the thrust washer and feeler gauge against the shank. Fit the pin and caulk over the holes to retain the pin.

If a brass thrust washer is used, the 0·002″ (0·05 mm) gauge is not required. The brass washer is fitted with the raised "pips" facing the dog. When the pin is fitted, the driving end of the shaft must be sharply tapped with a mallet to flatten the three pips on the washer and ensure the correct amount of end float.

(k) Refit the moulded cover.

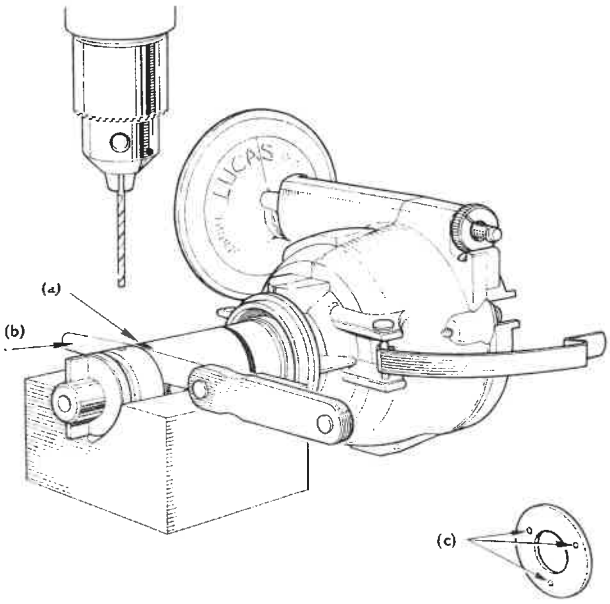
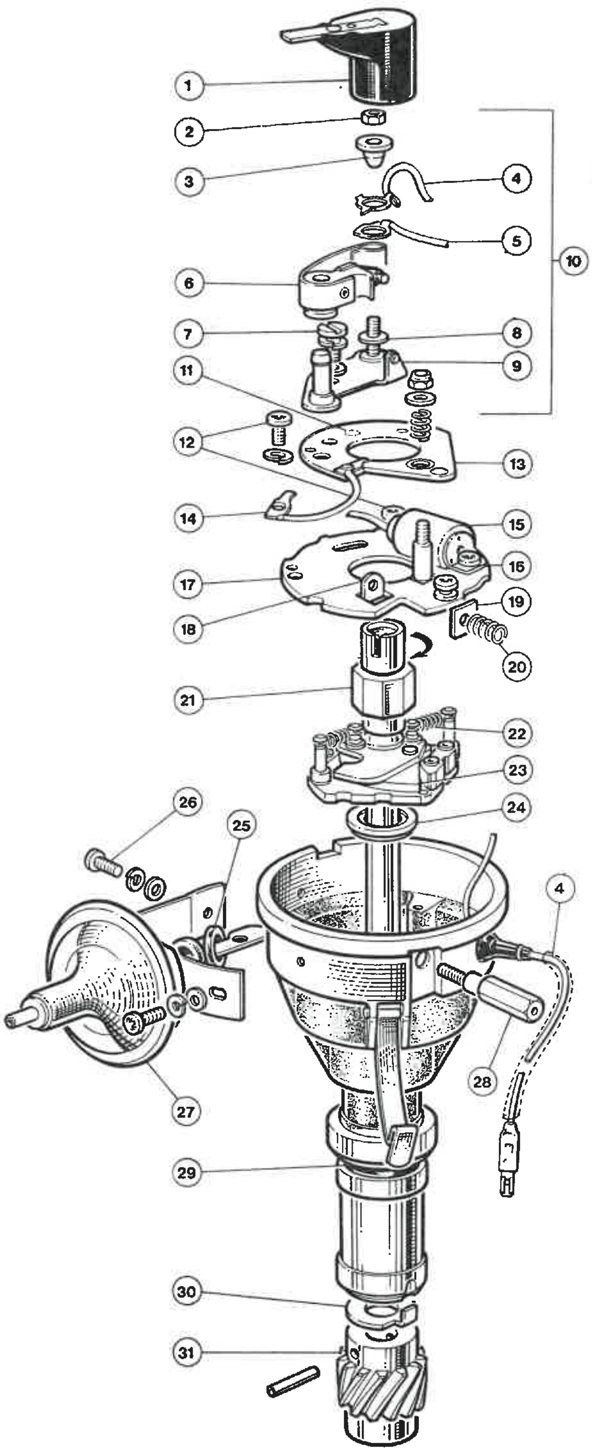
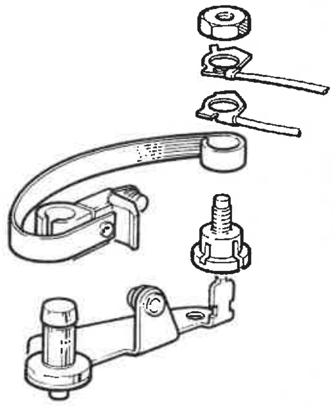


Fig. 16 Drilling the shaft

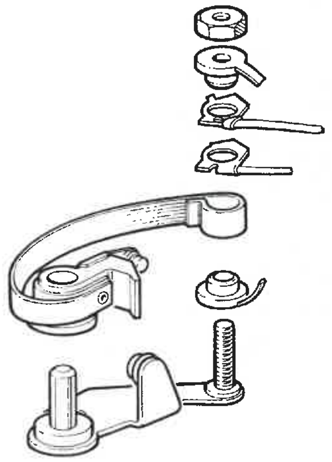
(a) Fibre washer (b) 0·002″ (0·05mm) Gauge (c) Raised pips

MODEL 35D8 DISTRIBUTORS





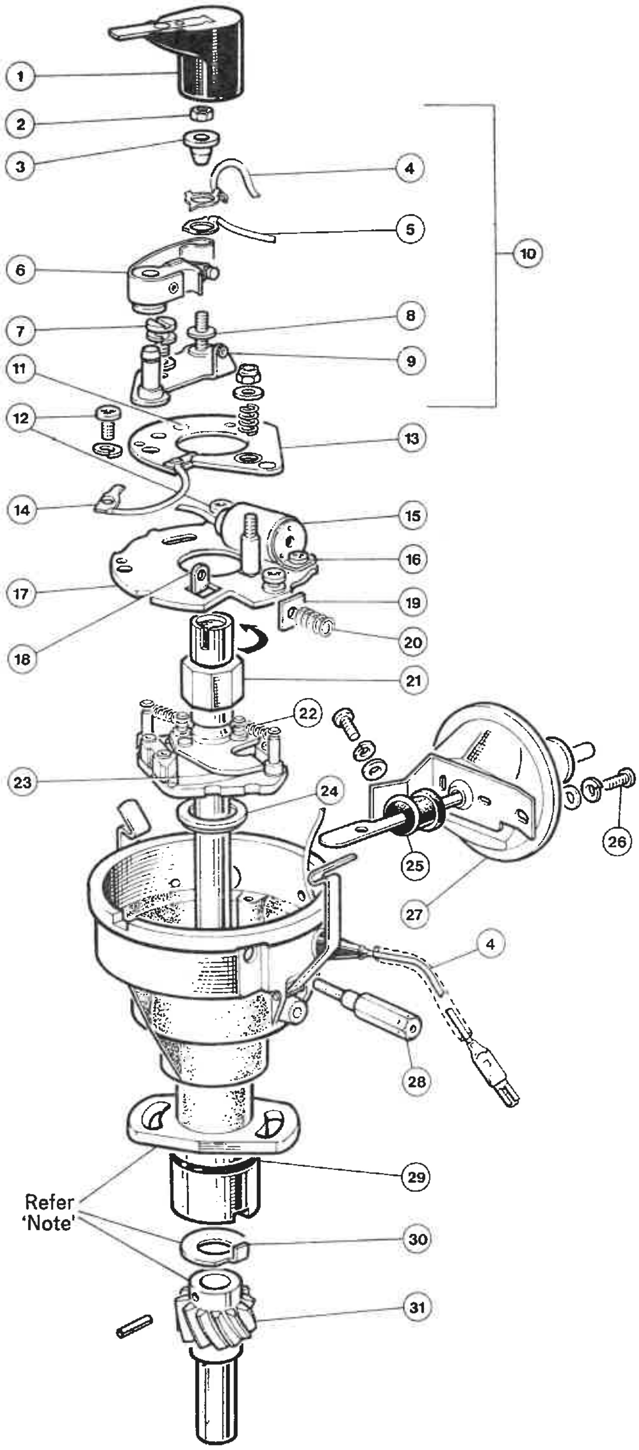
Alternative contact-breakers

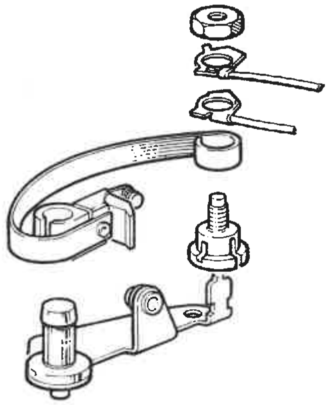


- **1** Rotor
- **2** Fixing nut
- **3** Insul bush
- **4** L.T. cable (fly-lead)
- **5** Capacitor cable
- **6** Moving contact
- **7** Screw and washer
- **8** Insul washer
- **9** Fixed contact plate
- **10** Contact set (items 2–9)
- **11** Vacuum actuating peg, riveted to underside of plate
- **12** C/B screw and washer (3 off)
- **13** Contact-breaker base plate
- **14** Earth lead
- **15** Capacitor
- **16** Screw and washer
- **17** Contact-breaker bearing plate
- **18** Threaded hole } item 28
- **19** Plastic friction strip } item 28
- **20** Tension spring } item 28
- **21** Eight-lobe cam
- **22** Centrifugal timing control springs
- **23** Centrifugal timing control weights
- **24** Distance collar
- **25** Grommet
- **26** Screw and washer (2 off)
- **27** Vacuum unit
- **28** C/B dwell-angle adjuster
- **29** 'O' ring oil seal
- **30** Thrust washer
- **31** Driving gear

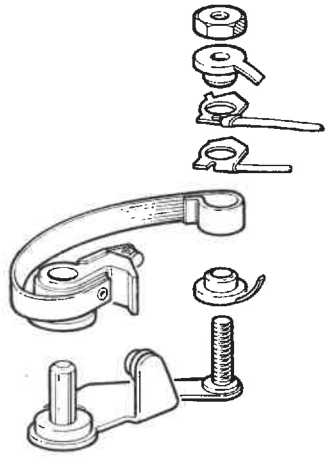
Fig. 1 Typical model 35D8 distributor with offset pivot contact-breaker (anti-clock rotation, viewed from drive-end, and advance vacuum unit)

Model 35D8 Distributors





Alternative contact-breakers

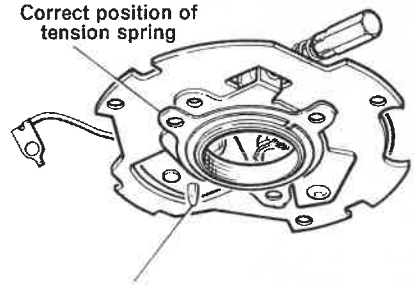


1 Rotor
2 Fixing nut
3 Insul bush
4 L.T. cable (fly-lead)
5 Capacitor cable
6 Moving contact
7 Screw and washer
8 Insul washer
9 Fixed contact plate
10 Contact set (items 2–9)
11 Vacuum actuating peg, riveted to underside of plate
12 C/B screw and washer (3 off)
13 Contact-breaker base plate
14 Earth lead
15 Capacitor
16 Screw and washer
17 Contact-breaker bearing plate
18 Threaded hole } item 28
19 Plastic friction strip } item 28
20 Tension spring } item 28
21 Eight-lobe cam
22 Centrifugal timing control springs
23 Centrifugal timing control weights
24 Distance collar
25 Grommet
26 Screw and washer (2 off)
27 Vacuum unit
28 C/B dwell-angle adjuster
29 'O' ring oil seal
30 Thrust washer
31 Driving gear

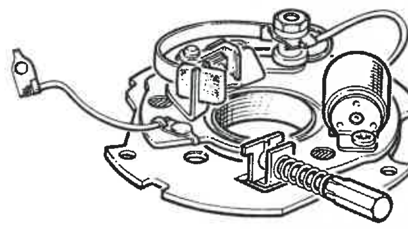
Fig. 2 Typical model 35D8 distributor with offset pivot contact-breaker (clock rotation, viewed from drive-end, and advance vacuum unit)

Note: Method of fixing may vary, and items 30 and 31 may be driving dog arrangement shown in Fig. 5.

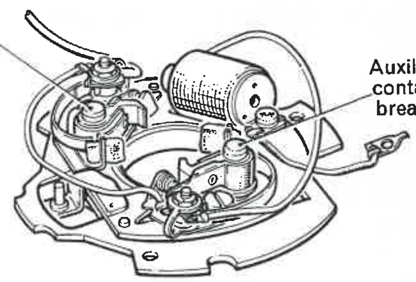
Model 35D8 Distributors



Underside view of concentric single contact-breaker assembly, showing correct positioning of 3-lobe tension spring



Concentric single contact-breaker assembly



Concentric twin contact-breaker assembly (alternative fitment). Correct position of tension spring as shown above

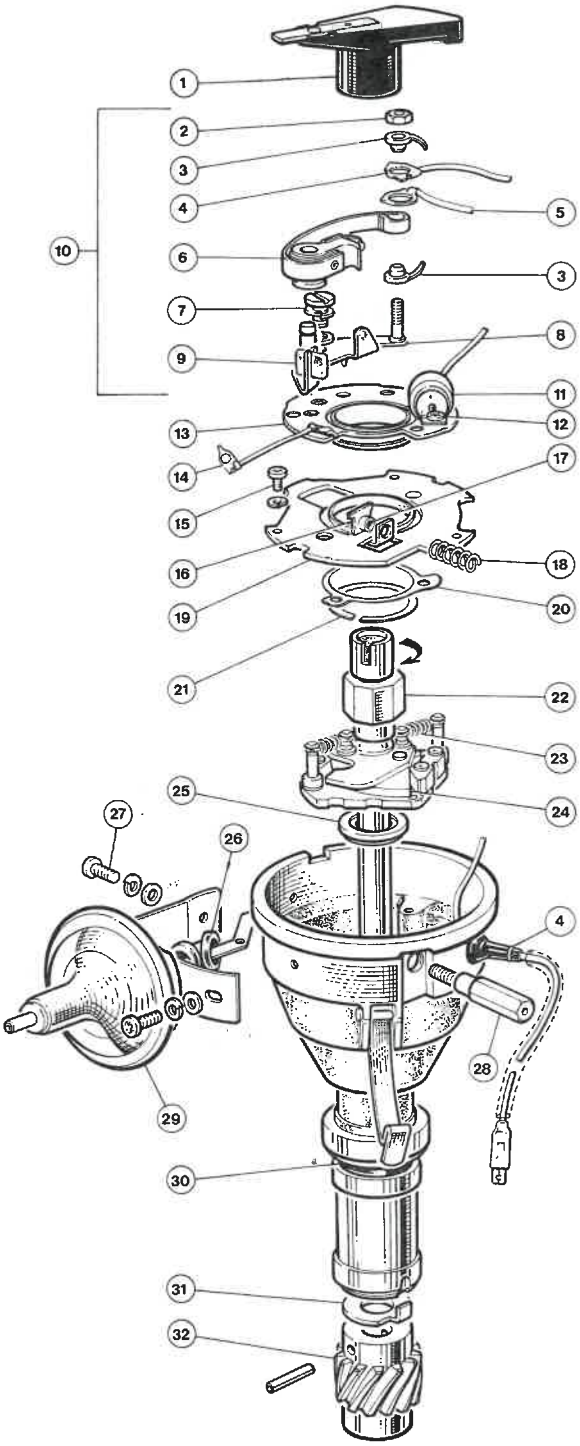
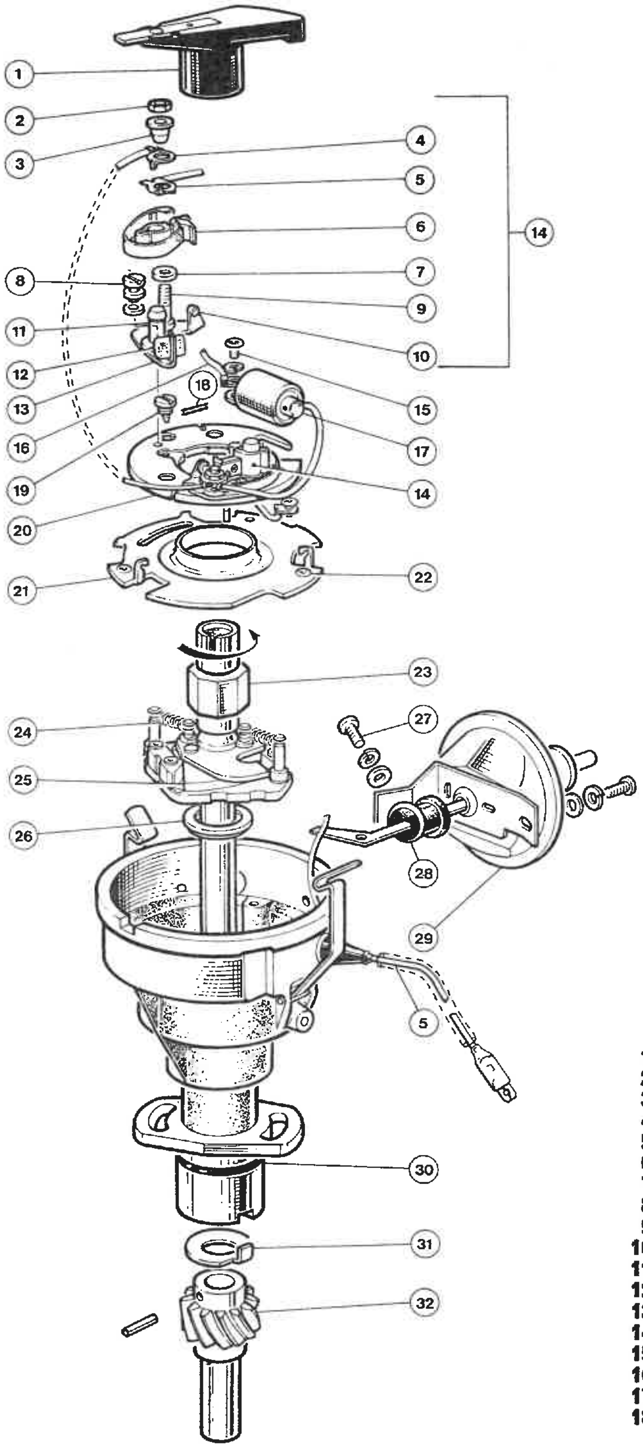
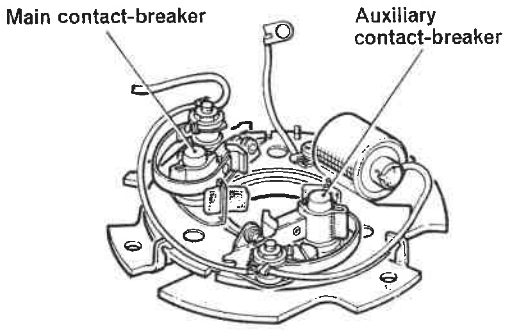


Fig. 3 Typical model 35D8 distributor with single or twin concentric contact-breaker(s) (anti-clock rotation, viewed from drive-end, and advance vacuum unit)

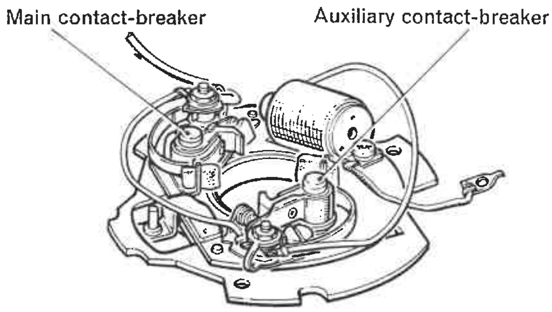
1 Rotor
2 Fixing nut
3 Twin insul bush
4 L.T. cable (fly-lead)
5 Capacitor cable
6 Moving contact
7 Screw and washer
8 Fixed contact plate
9 Felt pad
10 Contact set (items 2–9)
11 Capacitor
12 Screw and washer
13 C/B base plate
14 Earth lead
15 Screw and washer (3 off) for C/B bearing plate
16 Plastic friction strip
17 Threaded hole
18 Tension spring
19 Contact-breaker bearing plate
20 Three-lobe tension spring
21 Circlip
22 Eight-lobe cam
23 Centrifugal timing control springs
24 Centrifugal timing control weights
25 Distance collar
26 Grommet
27 Screw and washer (2 off)
28 C/B dwell-angle adjuster
29 Vacuum unit
30 'O' ring oil seal
31 Thrust washer
32 Driving gear

Model 35D8 Distributors





Concentric twin contact-breaker assembly (early type)



Concentric twin contact-breaker assembly (later type)

1. Roter
2. Fixing nut
3. Insul bush
4. Contact-breaker L.T. cable
5. Main L.T. cable (fly-lead)
6. Moving contact
7. Insul washer
8. Screw and washer
9. L.T. terminal post
10. Contact
11. Pivot post
12. Felt pad
13. Fixed contact plate
14. Contact set (items 2–13)
15. Capacitor fixing screw
16. Earth lead
17. Capacitor
18. Tension spring (base-plate)
19. Vacuum unit connecting peg
20. Contact-breaker base-plate
21. Contact-breaker bearing plate
22. Fixing screws
23. Eight-lobe cam
24. Centrifugal timing-control springs
25. Centrifugal timing-control weights
26. Distance collar
27. Screw and washer (2 off)
28. Grommet
29. Vacuum unit
30. 'O' ring oil seal
31. Thrust washer
32. Driving gear

Fig. 4 Typical model 35D8 distributor with twin concentric contact-breakers (clock rotation, viewed from drive-end, and advance vacuum unit)

Model 35D8 Distributors

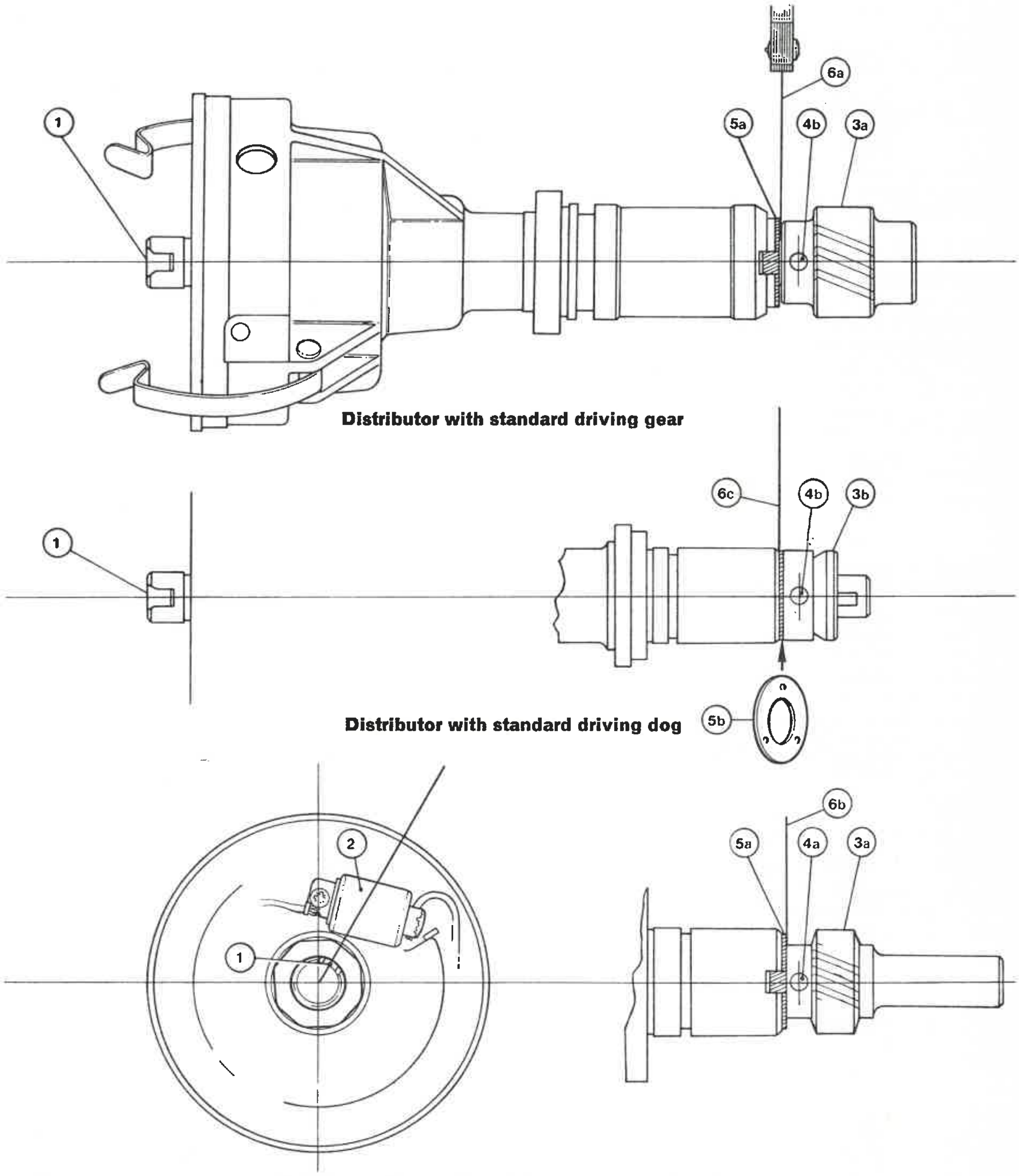


Fig. 5 Positioning driving dog or gear on distributor shaft

1 Rotor arm keyway in shaft
2 Capacitor
3 (a) Driving gear
(b) Driving dog (note offset driving tongue)
4 (a) Fitting pin and hole 3 mm (1/8") diameter
(b) „ „ „ „ 4 mm (3/16") „
5 (a) Steel thrust washer (with locking tab located in distributor shank)
(b) Brass thrust washer (fitted with raised 'pips' facing driving dog)
6 (a) End-float feeler gauge 0·18–0·30 mm (0·007–0·012")
(b) „ „ „ 0·13–0·23 mm (0·005–0·009")
(c) „ „ „ 0·13–0·25 mm (0·005–0·010")

Note: Reference 6(c) 0·13 mm (0·005") max. when fitting new thrust washer

Model 35D8 Distributors

1. GENERAL

These high performance distributors incorporate contact-breakers, either single or twin, operated by an eight-lobe cam. Lightweight construction and consequent low inertia of the contact-breaker(s) prevent contact-breaker bounce at high engine speeds.

The distributors incorporate conventional auto-advance mechanism and a vacuum unit (advance-type, retard-type or double-acting type). An advance-type vacuum unit is fitted to improve fuel economy, when the throttle is partially open, while a retard-type vacuum unit is provided to operate in conjunction with an exhaust emission control system, incorporated in the engine design. The retard-type vacuum unit retards ignition timing during engine idling and over-run conditions. The associated emission control system is designed to reduce air pollution from the vehicle exhaust fumes.

Single contact-breaker distributors incorporate a dwell-angle adjuster screw (Figs. 1, 2 and 3, item 28), which enables the dwell-angle (closed-contact period) to be set accurately, while the engine is running, and so obtain the optimum performance from the distributor.

Twin contact-breaker distributors (Figs. 3 and 4) have no provision for dwell-angle adjustment, because the auxiliary contact-breaker provides increased dwell-angle period, affording sufficient time for the ignition coil primary windings to be energised at high speeds, and thus resulting in an improved ignition spark. The twin contact-breakers are connected in parallel, each moving contact having a common connection to the low tension (L.T.) terminal of the distributor. Static ignition timing is carried out in conjunction with the 'main' contact-breaker, the 'auxiliary' contact-breaker being ignored during this process. (The 'main' and 'auxiliary' contact-breakers are shown in Figs. 3 and 4, inset illustration.)

Operation of Twin Contact-Breaker

Before the main contact-breaker opens, the auxiliary contact-breaker is already open and ineffective. As the distributor cam rotates further, the main contact-breaker **'opens'** breaking the ignition primary circuit, and producing a high tension ignition spark. The auxiliary contact-breaker then **'closes'** having the additional function of switching **'ON'** the ignition primary circuit, before the main contact-breaker closes. In this way the auxiliary contact-breaker increases the dwell-angle period, affording sufficient time for the ignition coil primary windings to be energised at high engine speeds.

The main contact-breaker now **'closes'**, but does not operate at this stage, because the auxiliary contact-breaker is also closed and the ignition primary circuit is switched **'ON'**.

Finally, the auxiliary contact-breaker **'opens'** again, but does not operate, because the main contact-breaker is still closed and holds the ignition primary circuit switched **'ON'**.

Further rotation of the cam causes the main contact-breaker to open again, and the cycle of operations is repeated leading to the production of the next H.T. spark.

2. ROUTINE MAINTENANCE

Occasionally wipe clean the outside of the distributor moulded cover, the H.T. leads and insulated tops of the sparking plugs.

(a) Single Contact-Breaker Distributors

(i) After the first 1600 kilometers (1000 miles)

Check the contact-breaker gap, using a dwell-angle meter, or alternatively, a test-lamp or voltmeter, suitable for the vehicle electrical system.

Checking with dwell-angle meter

With the engine running at approximately normal working speed, check that the dwell-angle (closed-contact period) is within 26°–30°. If not, reset the contact-breaker gap by turning the dwell-angle adjuster screw. (Clockwise to decrease and anti-clockwise to increase the dwell-angle.)

Note: Reset contact-breaker gap with decreasing dwell-angle adjustment, commencing above 32° and decreasing to a nominal 27°.

Checking with test-lamp or voltmeter (alternative to using dwell-angle meter)

1. Remove distributor moulded cover.
2. Turn engine until contact-breaker heel rests on peak of cam. (Removing sparking plugs facilitates this operation.)
3. Operate ignition switch to 'ON'.
4. Connect test-lamp, or voltmeter, between earth and the distributor fly-lead connection on the ignition coil. (Do not disconnect the fly-lead.) **The test-lamp should light or the voltmeter should register the system voltage.**
   Leave test-lamp or voltmeter connected and proceed to 5.
5. Reset the hexagonal adjuster screw, as follows: With adjuster screw pressed towards distributor body, turn adjuster 'anti-clockwise' until the test-lamp goes off or the voltmeter needle returns to 'zero' (contact-breaker now just closed). Turn the adjuster a further half-turn (three flats of the adjuster).
   Finally, turn the adjuster screw carefully 'clockwise' until the test-lamp lights or the voltmeter registers the system voltage (contact-breaker now just open) and then turn the adjuster five more flats. The contact-breaker gap is now set to provide the correct dwell-angle.

(ii) Every 9600 kilometers (6000 miles)

Examine the contact-breaker. If cleaning is necessary, use a petrol-moistened cloth. If the contact surfaces show signs of burning or excessive wear, dismantle the contact-breaker and refinish the contact surfaces with a carborundum stone or fine emery cloth and then wipe clean with the petrol-moistened cloth. During reassembly of the contact-breaker, smear the moving-contact pivot post with Shell Retinax 'A' or equivalent grease (in the case of a new contact-set, the pivot post is pre-lubricated).

After servicing the contact-breaker, reset the contact gap, as previously described in (i).

Finally, lubricate the distributor as subsequently detailed in (c).

(b) Twin Contact-Breaker Distributors

(i) After the first 1600 kilometers (1000 miles)

Check each contact-breaker gap, with a feeler gauge, as follows:

Turn engine until the heel of each contact-breaker in turn rests on a peak of the cam (removing sparking plugs facilitates this operation). Insert feeler gauge between the contacts and check whether the gap is within the limits 0.35–0.40 mm (0.014–0.016″). If necessary, the gap can be adjusted after slackening the fixed-contact securing screw.

(ii) Every 9600 kilometers (6000 miles)

Examine the contact-breakers. (Servicing is detailed in 2 (a) (ii), first para.). After servicing the contact-breaker, adjust the gap as detailed in previous para. (i).

Note: If new contact-sets are fitted, initial adjustment of the gaps should be 0.40–0.45 mm (0.016–0.018″), which allows for 'bedding-in' of the moving-contact heels.

(c) Lubrication

(i) Shell 'Retinax A' or equivalent grease

Lightly smear the grease on the working surface of the cam and on each contact-breaker pivot post. (The contact-breakers will need dismantling to enable the grease to be applied. If new contact-sets are fitted, the pivot post is pre-lubricated.)

Certain distributors have a felt pad fitted to the contact-breaker(s), to augment lubrication of the cam. This pad does not require periodic lubrication, as it was impregnated before fitting.

(ii) Shell 'Turbo 41' or clean engine oil

Apply the oil sparingly to the felt pad in the top of the cam beneath the rotor arm (to lubricate the cam spindle), and through the aperture at the base of the cam (to lubricate the auto-advance mechanism).

3. TECHNICAL DATA

Direction of rotation ...	According to arrow-marking on distributor body.
Firing angles	0.45°, 90° etc., ±1°
Dwell-angle (closed-contact period):	
(i) Single contact-breaker distributors	26–28°
(ii) Twin contact-breaker distributors	Determined by contact-breaker gap.
Contact-breaker gap:	
(i) Single contact-breaker distributors	Determined by dwell-angle setting.
(ii) Twin contact-breaker distributors	0.35–0.40 mm (0.014–0.016″) 0.40–0.45 mm (0.016–0.018″) Initial setting for new contact set.
Contact-breaker spring loading	5–7N or 512–680 gf (18–24 ozf).
Capacitor	0.18–0.25 microfarad.

4. SERVICING, DISMANTLING AND REASSEMBLY

(a) Bench Servicing and Dismantling

Except in the case of removal and refitting of the driving gear or driving dog, servicing is facilitated by lightly clamping the distributor upright in the jaws of a vice.

(i) Servicing the contact-breaker(s) and general lubrication

(Refer 2. ROUTINE MAINTENANCE).

(ii) Renewing the vacuum unit and initial dismantling

Distributors with offset pivot contact-breaker (Figs. 1 and 2)

Remove the moulded cover and the rotor arm.

Remove the nut and the washer and spring, securing the contact-breaker base plate to the pivot post. Lift the contact-breaker base plate assembly (complete with contact-breaker) from the pivot post, to disengage the base plate actuating peg from the vacuum unit operating lever. Remove the two screws which secure the vacuum unit to the side of the distributor body. Remove the vacuum unit and renew, if necessary.

If further dismantling is required, refer subsequent para's (iii) and (iv).

Distributors with single 'concentric' contact-breaker (Fig. 3)

Remove the moulded cover and the rotor arm.

Disengage the vacuum unit actuating peg from the vacuum operating lever, by first removing the cheese-headed fixing screw and then lifting the one-piece contact-breaker assembly from the base plate (see underside view of the contact-breaker assembly, Fig. 3, showing vacuum unit actuating peg on the underside of the fixed contact plate). Remove the two screws securing the vacuum unit to the side of the distributor body, remove the vacuum unit and, if necessary, renew.

If further dismantling is required, refer subsequent para's (iii) and (iv).

Distributors with twin 'concentric' contact-breakers, earlier type (Fig. 4)

Remove the moulded cover and rotor arm. Remove the two securing screws from the side of the distributor body.

Grasp the vacuum unit and pull on the vacuum unit until the contact-breaker base plate assembly has been rotated into a stop position. Slots in the base plate will now be in a position enabling the contact-breaker base plate assembly (complete with contact-breaker and capacitor) to be lifted and disengaged from the bearing plate. Still holding the vacuum unit, lift the contact-breaker base plate assembly and disengage the actuating peg from the vacuum operating lever, the vacuum unit can then be removed and if necessary renewed.

If further dismantling is required, refer subsequent para's (iii) and (iv).

Distributors with twin 'concentric' contact-breakers, later type (Figs. 3 and 4)

Remove the moulded cover and the rotor arm.

Remove the two screws securing the vacuum unit to the side of the distributor body.

Grasp the vacuum unit and pull on the vacuum unit until the contact-breaker base plate assembly has been rotated into a stop position. Still holding the vacuum unit, disengage the vacuum operating lever from the actuating peg and then remove the vacuum unit and, if necessary, renew.

If further dismantling is required, refer subsequent para's (iii) and (iv).

(iii) Renewing: Auto-advance springs, cam and centrifugal weights

Dismantle the distributor to the stage previously detailed in (ii), according to the type of contact-breaker (single offset-pivot, single concentric, and twin concentric earlier and later types).

Remove the three securing screws and lift the contact-breaker bearing plate (C.B. sub-assembly in the case of a twin concentric contact-breaker later type) from the distributor body. Access can now be obtained to the auto-advance springs, cam, and centrifugal weights, which if necessary can be renewed.

(iv) Renewing: Driving dog or gear, and the shaft-and-action plate assembly

Note: (1) The driving dog, or gear, is fitted in a particular position on the distributor shaft. To facilitate reassembly, before removing either the driving dog or the gear, note relative positions between the driving dog or gear and the rotor arm keyway in the shaft (see Fig. 5).

Note: (2) For service purposes: A new driving gear is supplied with the fitting pin hole pre-drilled, whereas a new driving dog is supplied with the fitting pin hole partially-drilled through one side of the dog only. A new shaft-and-action plate assembly is supplied with the shaft undrilled. Completion of the drilling of the fitting pin hole through the driving dog, or drilling of the fitting pin hole through the shaft, must be carried out after the driving dog or gear has been correctly positioned on the shaft (see Fig. 5).

Removing the driving dog or gear

Lightly clamp or carefully support the shank of the distributor, then drive or press the fitting pin from the driving dog or gear. Use a pin punch 3 mm or 4 mm ($\frac{1}{8}''$ or $\frac{3}{16}''$) diameter, according to the fitting pin size.

After removing the driving dog or gear and the thrust washer, the shaft-and-action plate assembly can be withdrawn from the distributor body.

When the shaft-and-action plate assembly is refitted, ensure the distance collar is fitted to the shaft beneath the action plate (see Figs. 1 to 4) and smear the shaft with clean engine oil.

Fitting the driving dog or gear

To ensure the thrust washer and the driving dog or gear are correctly assembled, on the distributor shaft, refer Fig. 5. Note the following main points:

(1) **Distributors with driving gear:** The steel thrust washer has a locking tab which engages in a keyway in the distributor shank.
Distributors with driving dog: The brass thrust washer has three raised 'pips' which must face the driving dog.

(2) The driving dog or gear must be positioned relative to the rotor arm keyway in the shaft.

(3) The end-float controlling feeler gauge is positioned differently for the purpose of fitting a driving dog and a driving gear.

With the thrust washer and the driving dog or gear and the end-float controlling feeler gauge in position as shown in Fig. 5, use the hole provided in the driving dog or gear as a guide for the drill and pass the appropriate size drill through the shaft and through the other side of the driving dog or gear. (Apply pressure to the rotor arm end of the shaft, whilst carrying out the drilling operation, so ensuring the correct amount of end-float when the feeler gauge is removed.) After removing the feeler gauge, secure the driving dog or gear with the fitting pin and lightly rivet both ends of the pin.

(b) Reassembly

The general reassembly of the distributor is simply a reversal of the dismantling procedure. During reassembly, lubricate the following parts:

(i) Cam spindle and moving parts of the centrifugal auto-advance mechanism:— Smear with Shell 'Turbo 41' oil, or clean engine oil.

(ii) Nylon bearing pads and the vacuum actuating-arm connecting peg on the underside of the contact-breaker base plate:— Smear with Rocol No. 30863 grease or equivalent lubricant.

(iii) The cam and contact-breaker pivot post:— Smear with Shell 'Retinax A' grease, or equivalent lubricant.

(iv) The felt pad located in the top of the shaft (beneath the rotor arm):— Apply a few drops of Shell 'Turbo 41' oil, or clean engine oil.

DISTRIBUTOR MODELS 43D, 44D AND 45D

1 H.T. moulded cover
2 H.T. brush and spring
3 Sub-assembly
4 Rotor arm
5 Contact-breaker assembly
6 Capacitor, L.T. terminal and fly-lead assembly
7 C.B. bearing plate assembly
8 Sub-assembly
9 Felt lubricating pad (cam spindle)
10 Centrifugal auto-advance springs
11 Cam
12 Centrifugal auto-advance weights
13 Sub-assembly (cam, weights, shaft and plate)
14 Nylon distance collar. (Note correct method of assembly, with chamfer underneath)
15 Steel thrust washer
16 Sealing cover screws (2)
17 Sealing cover
18 Clamping plate, bolt and nut assembly ('a' shoulder for retaining nut or bolt captive)
19 Thrust washer
20 Driving dog
21 Mills pin
22 'O' ring oil-seal

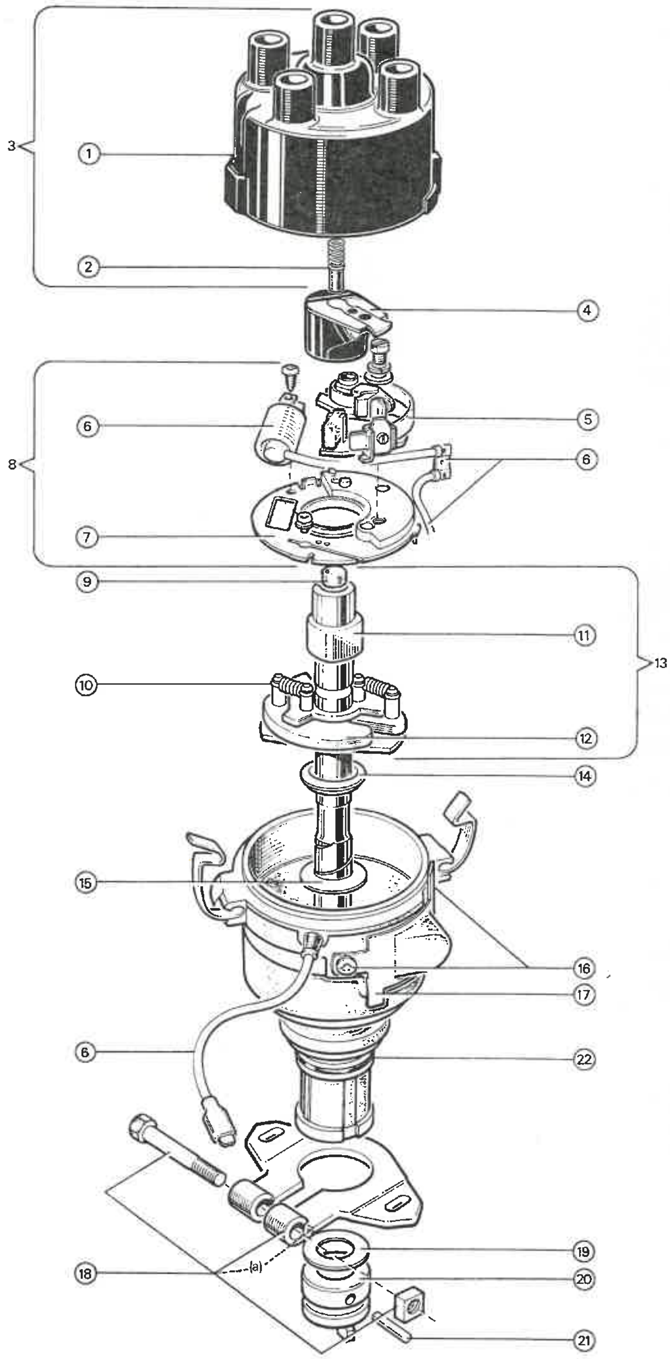


Fig. 1 Typical model 43D distributor

(i) 4-cylinder could be 6-cylinder (Type references 43D4 and 43D6 respectively)
(ii) Driving dog could be driving gear

Distributor Models 43D, 44D and 45D

1 H.T. moulded cover
2 H.T. brush and spring
3 Sub-assembly
4 Rotor arm
5 Contact-breaker assembly
6 Capacitor, L.T. terminal and fly-lead assembly
7 C.B. bearing plate and base plate assembly
8 Sub-assembly
9 Felt lubricating pad (cam spindle)
10 Centrifugal auto-advance springs
11 Cam
12 Centrifugal auto-advance weights
13 Sub-assembly (cam, weights, shaft and plate)
14 Nylon distance collar. (Note correct method of assembly, with chamfer underneath)
15 Steel thrust washer
16 Vacuum unit securing screw(s) and washer(s)
17 Vacuum unit and bracket assembly (advance-acting)
18 Clamping plate, bolt and nut assembly ('a' shoulder for retaining nut or bolt captive)
19 Thrust washer
20 Driving dog
21 Mills pin
22 'O' ring oil-seal

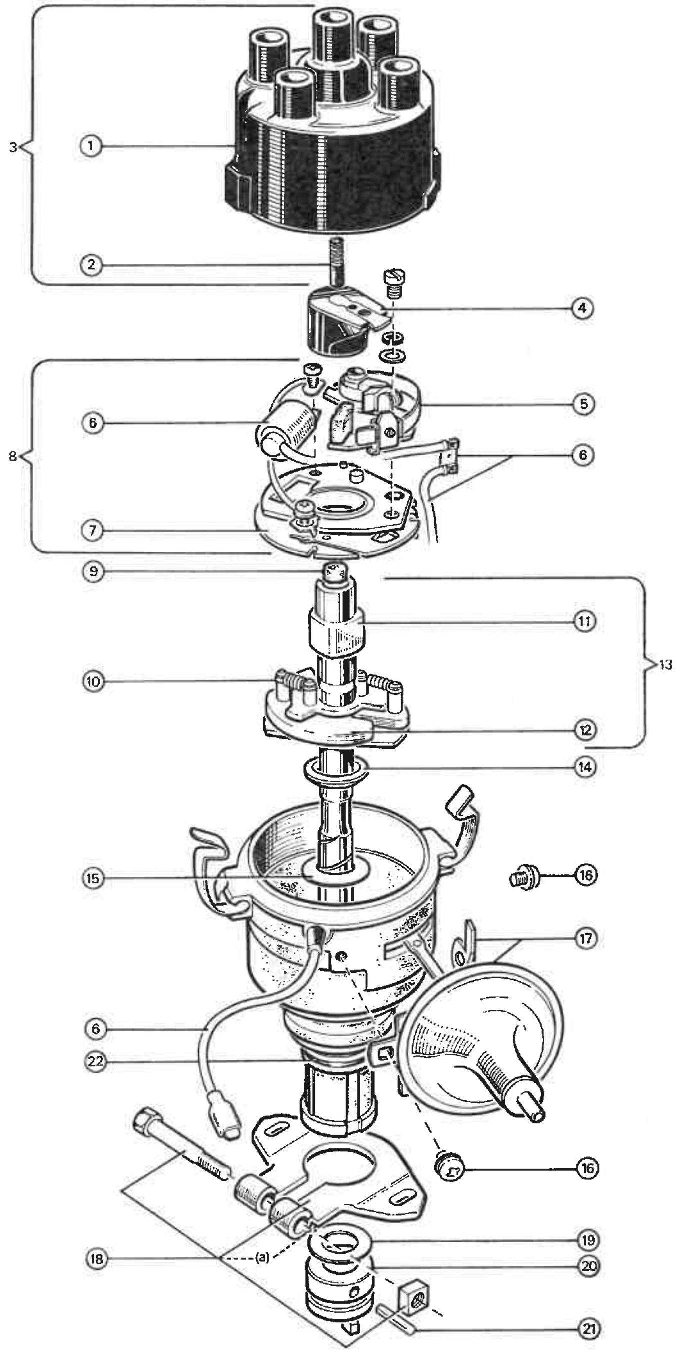
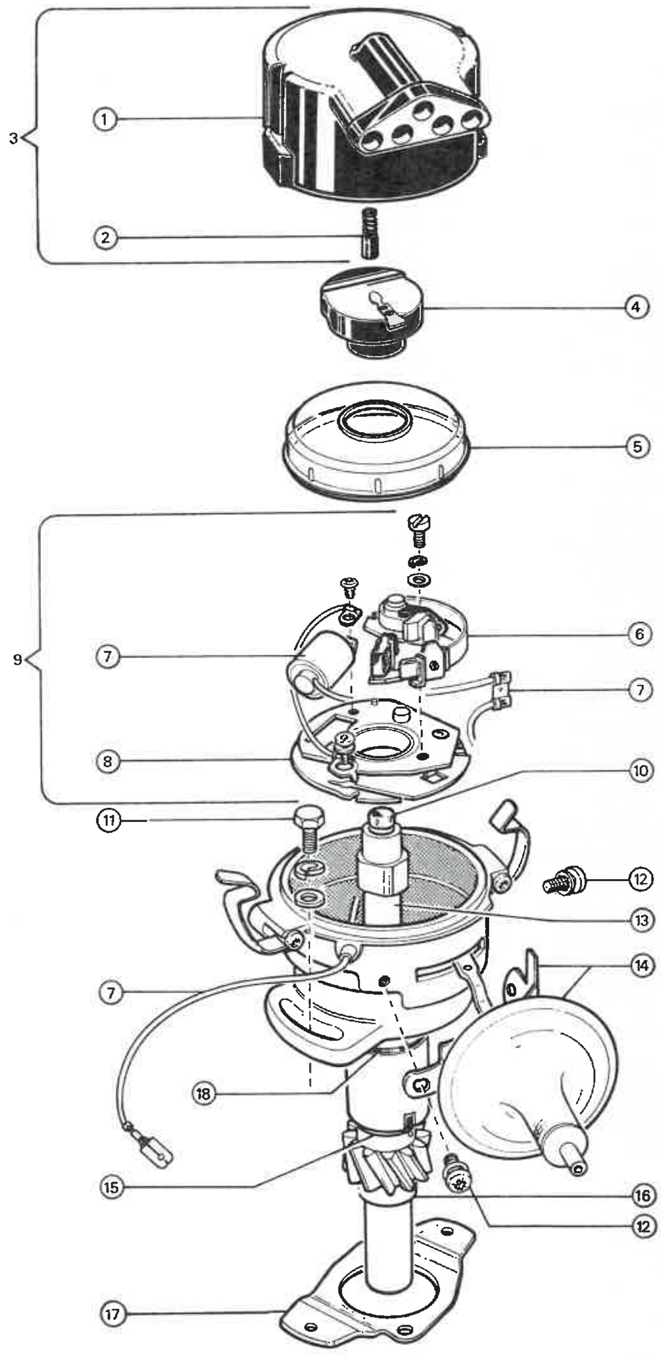


Fig. 2 Typical model 45D distributor

(i) 4-cylinder could be 6-cylinder (Type references 45D4 and 45D6 respectively)
(ii) Driving dog could be driving gear
(iii) Vacuum unit type and fitting position could vary



1 H.T. moulded cover
2 H.T. brush and spring
3 Sub-assembly
4 Rotor arm
5 H.T. anti-flash plastic shield
6 Contact-breaker assembly
7 Capacitor, L.T. terminal and fly-lead assembly
8 C.B. bearing plate and base plate assembly
9 Sub-assembly
10 Felt lubricating pad (cam spindle)
11 Distributor fixing bolt and washers (2)
12 Vacuum unit securing screw and washers (2)
13 Sub-assembly (cam, weights, shaft and plate)
14 Vacuum unit and bracket assembly (advance-acting)
15 Steel thrust washer
16 Driving gear
17 Adaptor plate (distributor fixing)
18 'O' ring oil-seal

Fig. 3 Early-design model 44D distributor (Part No. 41402)

Note: Superseded by later-design distributor (Part No. 41589). See Fig. 4

1 H.T. moulded cover
2 H.T. brush and spring
3 Sub-assembly
4 Rotor arm
5 H.T. anti-flash plastic shield
6 Contact-breaker assembly
7 Capacitor, L.T. terminal and fly-lead assembly
8 C.B. bearing plate and base plate assembly. (Note 'POZIDRIV' securing screws have a special self-tapping thread)
9 Sub-assembly
10 Felt lubricating pad (cam spindle)
11 Distributor fixing bolt and washers (2)
12 Vacuum unit securing screw and washers (2)
13 Sub-assembly (cam, weights, shaft and plate)
14 Vacuum unit and bracket assembly (advance-acting)
15 Steel thrust washer
16 Driving gear
17 Adaptor plate (distributor fixing)
18 'O' ring oil-seal

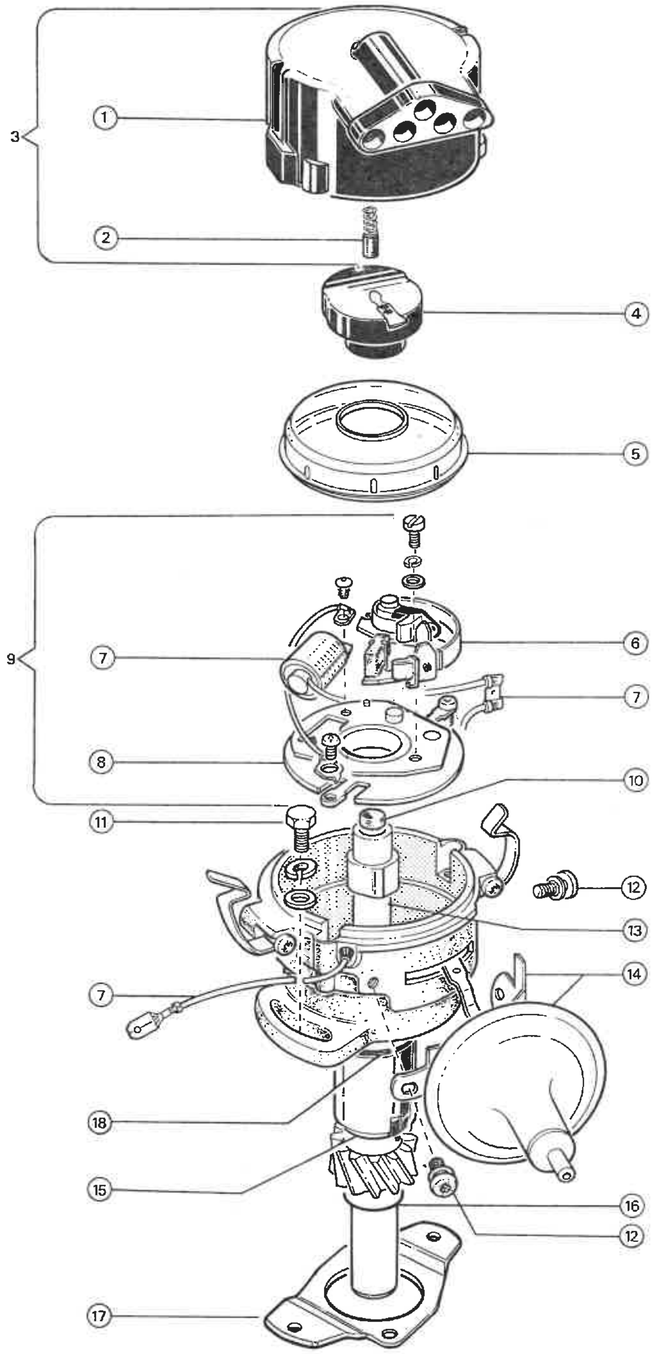


Fig. 4 Later-design model 44D distributor (Part No. 41589)
Note: Same as Fig. 3 except for item 8 and body and cover design

1. GENERAL

(a) Special Features

Compared with the 23/25D range, these distributors have improved performance, lighter weight, easier servicing, quieter operation and splash-proof cover.

(i) Improved performance

Achieved by a lightweight contact-breaker modified cam profile and re-designed auto-advance mechanism. The contact-breaker has a low operating inertia and this in conjunction with the modified cam profile prevents contact-breaker bounce at high engine speeds. This maintains the dwell-angle (closed-contact) period within certain limits, providing sufficient time for the ignition coil primary windings to be energised at high engine speeds and resulting in an improved ignition spark.

(ii) Lighter weight

Achieved by the combined lightweight construction of major components.

(iii) Easier servicing

Achieved by new design contact-breaker sub-assembly, incorporating one-piece lightweight contact-breaker (or contact set) with clip-in method of L.T. terminal connection. This facilitates quick renewal of the contact set, because small sundry parts associated with the conventional terminal post are eliminated.

(iv) Quieter operation

Achieved jointly by:

1. The lightweight contact-breaker and modified cam profile which (besides improving distributor performance) reduces make-and-break noise of the contact-breaker.
2. A new design auto-advance mechanism, which is both simpler and lighter in construction.

(b) Application and Design Variations

(i) Models 43D and 45D (Figs. 1 and 2)

These distributors supersede and interchange with the 23D and 25D range of distributors, fitted to cars and light commercial vehicles. Model 43D supersedes 23D and model 45D supersedes 25D. Produced in 4- and 6-cylinder versions, type references are 43D4, 43D6, 45D4 and 45D6.

Model 43D is less vacuum unit, whereas model 45D incorporates either an advance-type or retard-type vacuum unit (later-production 45D distributors may incorporate a double-acting advance/retard vacuum unit).

Later-production model 45D distributors may also incorporate micrometer timing adjustment, except when fitted with a double-acting vacuum unit.

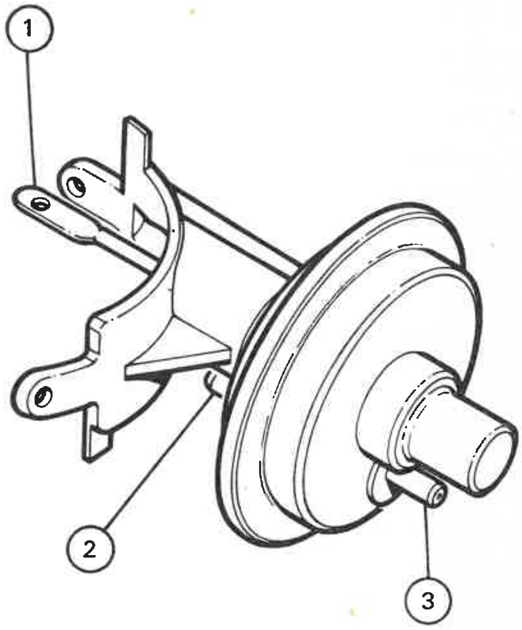


Fig. 5 Double-acting advance/retard vacuum unit (Retard function used in conjunction with exhaust emission control, incorporated in the engine design)

1 Actuating lever (connection to tapered peg, riveted to underside of contact-breaker base plate)
2 Vacuum-retard pipe connection
3 Vacuum-advance pipe connection

Note: An advance-type vacuum unit is fitted to improve fuel economy, when the throttle is partially open, while a retard-type vacuum unit is provided to operate in conjunction with an exhaust emission control system, incorporated in the engine design. The retard-type vacuum unit retards ignition timing during engine idling and over-run conditions. The associated emission control system is designed to reduce air pollution from the vehicle exhaust fumes.

(ii) Model 44D (Figs. 3 and 4)

This is a specially designed 4-cylinder distributor, type reference 44D4. Application is limited to vehicles where the positioning of the distributor on the engine, prevents the engine compartment from accommodating the basic 45D4 distributor.

In addition to being shorter than a 45D4 distributor, other special features of the 44D4 distributor are:

1. Extra-shallow side-entry type H.T. moulded cover (instead of H.T. moulded cover with vertical-entry cable connections).

2. Rotor arm with H.T. anti-flash groove around underside of moulding (necessary because reduced length of distributor results in close proximity of the rotor-arm electrode to distributor frame).
3. H.T. anti-flash plastic shield, located on the rim of the distributor body and completely covering the contact-breaker sub-assembly (necessary for the reason given in 2 above, and also because of close proximity of H.T. moulding electrodes to distributor frame).
4. Distributor fixing: Larger diameter shank than 45D and flange-and-adaptor plate fixing (instead of clamp-plate fixing).

Note: RADIO/TELEVISION INTERFERENCE SUPPRESSION. The carbon brush in the H.T. moulded cover is a non-resistive type, not capable of suppressing radio and television interference signals. Legal requirements in this respect are achieved by using suppression (resistive-type) H.T. cables.

2. ROUTINE MAINTENANCE

Occasionally wipe clean the outside of the distributor moulded cover, the H.T. leads and insulated tops of the sparking plugs.

(a) After the first 1600 kilometers (1,000 miles)

Check the contact-breaker gap

Either by using a special gauge, which eliminates turning the engine, or by carrying out the following basic procedure.

Turn engine until the heel of the contact-breaker rests on a peak of the cam (removing the sparking plugs facilitates this operation). Insert feeler gauge between the contacts and check whether the gap is within the limits 0.35–0.40 mm (0.014–0.016″). If necessary, slacken the cheese-headed screw securing the fixed-contact and adjust the gap (see Fig. 6).

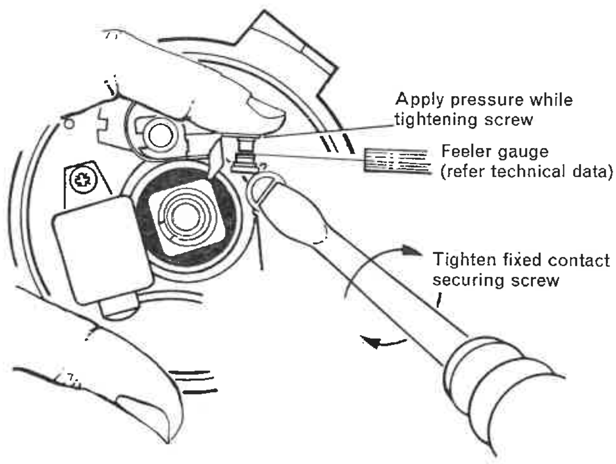


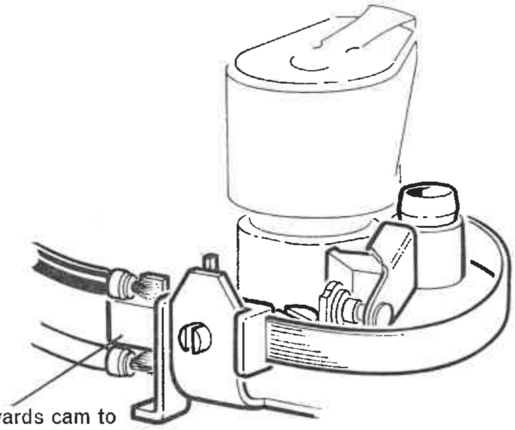
Fig. 6 Contact-breaker adjustment

(b) Every 9600 kilometers (6,000 miles)

(i) Examine the contact-breaker

If cleaning is necessary, use a petrol-moistened cloth. If the contact surfaces show signs of burning or excessive wear, dismantle the contact-breaker and refinish the contact surfaces with a carborundum stone or fine emery cloth, then wipe clean with the petrol-moistened cloth. Alternatively, renew the contact-breaker (one-piece contact set).

To remove the contact-breaker: Press the terminal end of the moving-contact spring towards the cam. This will disengage the spring from the insulating-piece attached to the terminal post, the capacitor lead and fly-lead can then be detached from the



Note: Correct method of assembly of L.T. terminal (Cable clips must face outward)

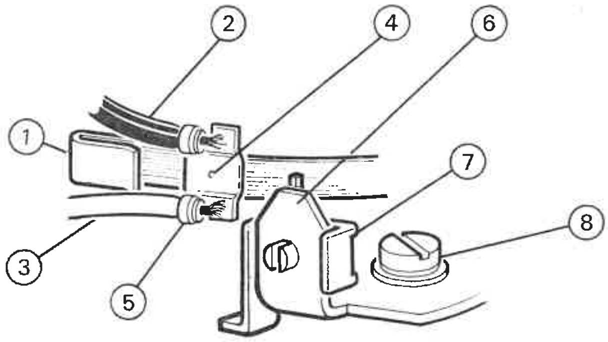


Fig. 7 Contact-breaker and L.T. terminal arrangement (Dismantling and correct reassembly of L.T. terminal)

1 Folded end of moving-contact spring
2 L.T. fly-lead (Black)
3 Capacitor lead (Orange)
4 L.T. terminal
5 Cable clips
6 Terminal post
7 Nylon insulating piece
8 Fixed-contact securing screw

folded end of the spring (see Fig. 7). Remove the cheese-headed screw securing the fixed-contact and lift the contact-breaker from the base plate.

Note 1: The cheese-headed screw securing the contact-breaker should be fitted with two washers, a plain flat washer (lower) and a spring washer (upper). If the spring washer is inadvertently omitted, the end of the screw will foul the bearing plate. This would interfere with the action of the base plate and vacuum unit (44D and 45D distributors) and insufficient securing of the contact-breaker (43D distributors).

Note 2: When refitting the capacitor and fly-lead connecting terminal in the folded end of the moving-contact spring, ensure the cable clips face outward (see Fig. 7), otherwise the lower clip may foul the fixing contact plate and short-circuit the contact-breaker.

After servicing and refitting the contact-breaker, set the contact gap to 0.35–0.40 mm (0.014–0.016″). Procedure is detailed in 2 (a). If a new contact set is fitted, set the contact gap to 0.40–0.45 mm (0.016–0.018″) to allow for initial bedding-in of the plastic heel.

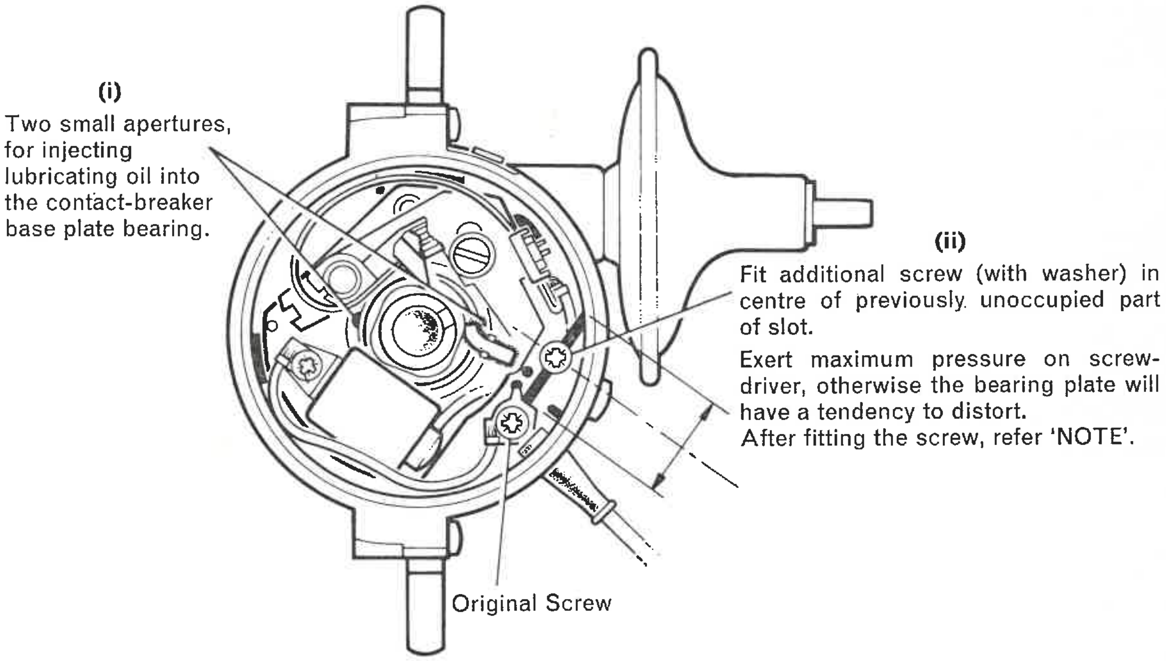
(ii) Lubrication

Shell Retinax 'A' or equivalent grease

Lightly smear the contact-breaker pivot post, and also the working surface of the cam. The felt pad fitted to the contact-breaker augments lubrication of the cam. This does not require periodic lubrication, as it is impregnated before fitting.

Shell Turbo '41' oil, or clean engine oil

Apply the oil sparingly: To the felt pad in the top of the cam, beneath the rotor arm (to lubricate the cam spindle) and, except distributors without a vacuum unit, through two small apertures in the contact-breaker base plate, see Fig. 8, (to lubricate the base plate bearing).



Note: After fitting the additional screw, check whether the original screw is still tight. If necessary, further tighten each screw alternately, until both are fully tight.
If fitting the additional screw results in distortion of the bearing plate and/or impaired movement of the base plate (actuated by the vacuum unit), then the modification is unsatisfactory and either the contact-breaker sub-assembly or its bearing plate-and-base plate assembly must be renewed.

Fig. 8

(i) Where to lubricate the contact-breaker base plate bearing
(ii) Fitting an additional securing screw in the contact- breaker bearing plate of early-design model 44D distributors (fig. 3 and Text 4(a), part (iii) refers). The additional screw and associated washer must be the same as the original fitment: Screw 54123366 and Washer 129066, obtainable by special order through LUCAS depots and agents.

The auto-advance mechanism does not require periodic lubrication. The mechanism is initially smeared with a special long-lasting oil lubricant (specified in 5. Reassembly), which is sufficient until the distributor is either renewed or overhauled.

3. TECHNICAL DATA

Direction of rotation:	According to arrow-marking on distributor body.
Firing angles:	0–90° – 180°–270° ±1° (4-cylinder) 0–60° – 120°–180° etc. ±1° (6-cylinder)
Dwell-angle: (closed-contact period)	51° ±5° (4-cylinder) 34° ±5° (6-cylinder)
Contact-breaker gap:	0.35–0.40 mm (0.014–0.016″) 0.40–0.45 mm (0.016–0.018″) Initial setting for new contact set.
Contact-breaker spring loading: (measured at contacts)	5.7N or 522–680 gf (18–24 ozf)
Capacitor:	0.18–0.25 microfarad
Clamping plate tightening torques: (except 44D distributors)	34.59 kg cm or 3.40 Nm (30 lbf in) trapped bolt and rotating nut. 57.66 kg cm or 5.65 Nm (50 lbf in) trapped nut and rotating bolt.

4. SERVICING, DISMANTLING AND REASSEMBLY

(a) Bench servicing and dismantling

Except in the case of removing and refitting the driving dog, or driving gear, servicing is facilitated by lightly clamping the distributor upright in the jaws of a vice.

(i) Check the H.T. moulded cover

Look for obvious damage to the cover, necessitating its renewal. Damage to the brush-and-spring housing (caused by the rotor not being fully-located on the shaft) will not only necessitate the cover being renewed, but also the rotor.

Closely inspect the cover, looking for a crack or signs of a breakdown in insulation ('tracking' or short-circuiting of the H.T. spark), usually indicated by a thin greyish-white line or sometimes more obviously by charring of the moulding. In either case, the cover will need renewing.

Note 1: During inspection of the inside of the cover, slight burning of the distributing-segments will be noticed. This is a normal condition and no attempt should be made to remove this burning from the segments, otherwise the air gap between the segments and rotor electrode will be adversely increased. This in turn will cause excessive burning of the segments and rotor electrode, and also overload the ignition coil.

Check the carbon brush for freedom-of-movement in its housing and at the same time check whether the brush is excessively worn. The length of brush freely protruding from the moulding should be approximately 4 mm (0.156″ or $\frac{5}{32}$″) and the tip of the brush should be bevelled. If these conditions are not as stated, the brush and its associated spring must be renewed, as a service-assembly.

Note 2: Wear of the H.T. carbon brush is normally negligible. If the tip of the brush is flat (it should be bevelled), the brush is excessively worn and this could have been caused by excess spring pressure (deliberate over-stretching of the spring) or inferior finish of the rotor electrode at its point-of-contact with the brush. This particular point on the rotor electrode should have a smooth finish, but not necessarily bright.

Do not use either emery cloth or glass-paper to refinish the rotor electrode, as scoring of the electrode will cause excessive brush-wear.

(ii) Check the rotor

Look for obvious damage to the rotor, necessitating its renewal.

The rotor may be damaged due to it fouling the brush-and-spring housing inside the H.T. moulded cover.

Alternatively, the rotor moulding may show signs of a breakdown in insulation. This would be indicated by a thin greyish-white line, or more obviously by charring of the moulding, caused by 'tracking' (short-circuiting) of the H.T. spark.

If neither of these fault conditions apply, and providing there is no evidence of excessive wear of the H.T. carbon brush due to scoring of the rotor electrode at its point-of-contact with the brush, it is reasonable to assume the rotor is satisfactory.

Note 1: Slight burning of the edge of the rotor electrode, is a normal condition. It is not necessary to remove this burning from the rotor electrode ('Note 1' under previous heading (i) refers).

Note 2: If a misfiring fault persists (during testing the distributor, or when it is refitted to the vehicle), the rotor can be proved by substitution or, alternatively, proved in situ by utilising the ignition coil H.T. voltage for testing the insulation of the rotor electrode. Position the ignition coil H.T. cable-end conductor near the rotor electrode, and carry out the procedure necessary to produce a H.T. spark. **No spark, or only a very faint trace of a spark should occur.**

(iii) Servicing the contact-breaker

Procedure for servicing the contact-breaker is detailed in 2. ROUTINE MAINTENANCE, sub-heading (b) part (i).

If the contact-breaker sub-assembly is a type which is an expansion-fit in the distributor body (Fig. 8), do not unnecessarily disturb the 'POZIDRIV' self-tapping securing screw. (Two screws are incorporated in early-design later-production model 44D distributors).

Removing this type of contact-breaker sub-assembly from the distributor body should be confined to occasions when it is necessary to renew either the auto-advance springs or the assembly comprising cam, weights, shaft-and-plate. (Subsequent heading (vi) refers.)

When servicing the contact-breaker, it is sufficient to check whether the contact-breaker sub-assembly is secure in the distributor body. If not, and the condition cannot be rectified by further tightening of the 'POZIDRIV' screw(s), then it will be necessary to renew either the contact-breaker sub-assembly or its associated bearing plate-and-base plate assembly. (Subsequent heading (vi) refers.)

An exception would be early-design first-production model 44D distributors (produced before November 1973) with only one 'POZIDRIV' screw securing the contact-breaker sub-assembly in the body. Providing this screw is already tight, or can be further tightened until fully-tight, loose-fitting of the contact-breaker sub-assembly can usually be rectified by fitting an additional securing screw, and washer. (Positioning the additional screw is important, so are other special conditions relating to the modification. See Fig. 8.) If the modification proves to be unsatisfactory, in which case either the contact-breaker sub-assembly or its associated bearing plate-and-base plate assembly must be renewed, it is still advisable to fit the additional securing screw.

(iv) Capacitor

Complete failure of the capacitor is confirmed, if d.c. electrical continuity exists between terminal and case. Check this with a battery-operated ohmmeter, or test lamp.

Providing the preliminary test is satisfactory, it is reasonable to assume the capacitor is in good condition but if the history of the distributor is known and there is reason to suspect otherwise (e.g. difficult

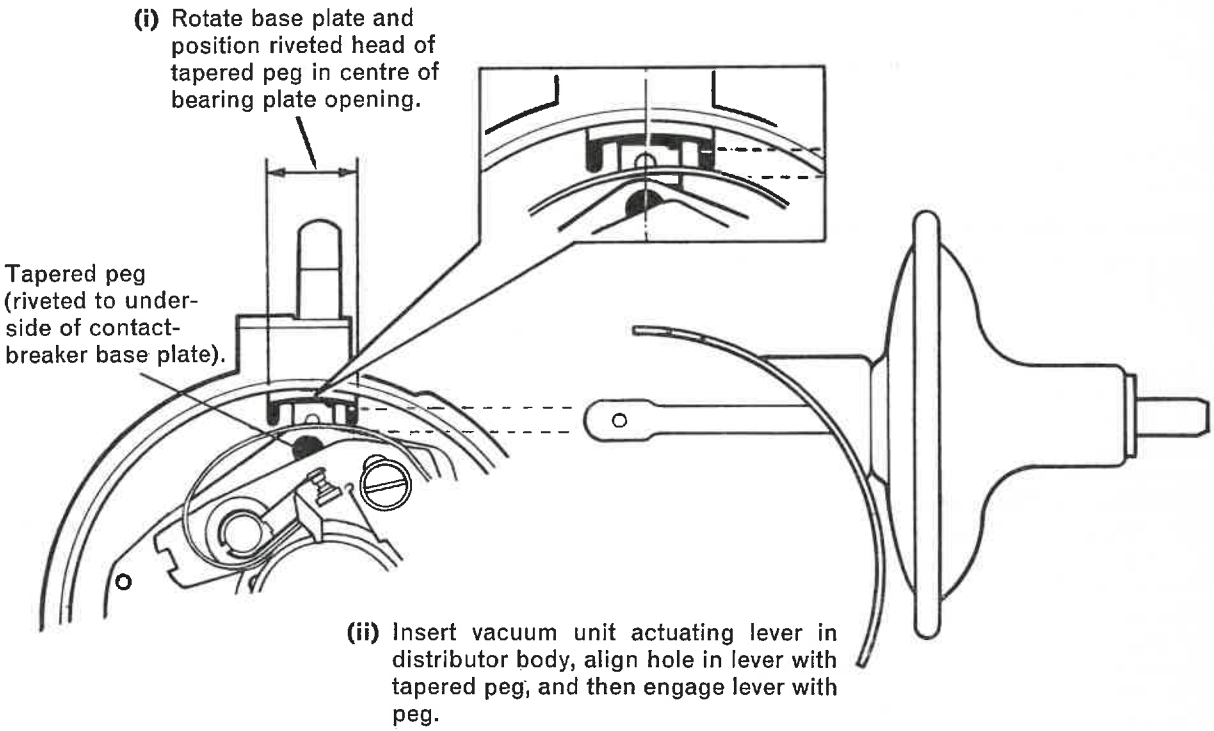


Fig. 9 Positioning contact-breaker base plate, to facilitate fitting the vacuum unit

starting, misfiring, or the contact-breaker excessively burnt, sometimes to the extent that the plastic heel of the moving contact is partially melted and consequently distorted), then the capacitor should be proved by substitution.

(v) Renewing the vacuum unit

(Not applicable to 43D distributor)

Remove the two screws securing the vacuum unit to the distributor body. Grip the vacuum unit in the hand, and with a downward movement disengage the vacuum unit actuating-lever from the tapered peg of the contact-breaker base plate (moving plate), then withdraw the vacuum unit from the body.

Refitting the vacuum unit is facilitated by swivelling the contact-breaker base plate so that the riveted head of the tapered peg is positioned as shown in Fig. 9. This enables the hole in the vacuum unit actuating-lever to be visually aligned with the tapered peg of the contact-breaker base plate, so facilitating engagement of the lever with the peg. It is then only necessary to refit the vacuum unit securing screws.

(vi) Renewing:

Contact-breaker sub-assembly

Auto-advance springs

Assembly comprising cam, weights, shaft-and-plate

Unless preliminary dismantling has already been carried out, now remove:

H.T. moulded cover

Rotor arm

H.T. anti-flash shield (model 44D distributor)

Vacuum unit (44D and 45D distributors)

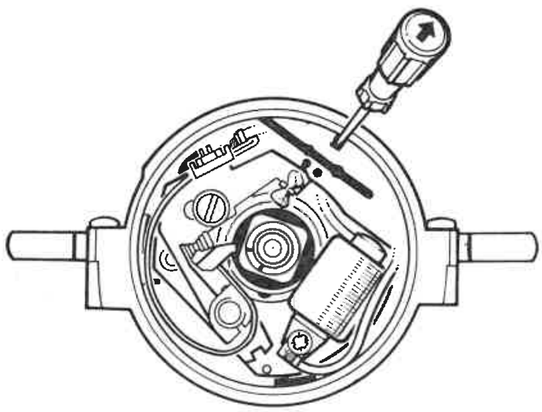
Following removal of the previously-mentioned parts, the contact-breaker sub-assembly can be removed. Recommended procedure for removing an expansion-fit type contact-breaker sub-assembly from the distributor body is detailed in Fig. 10.

Later-design model 44D distributors, Part No. 41589 (Fig. 4), incorporate a contact-breaker sub-assembly of conventional type, secured in the distributor body by two small 'POZIDRIV' screws diametrically opposed. Following removal of these screws, the contact-breaker sub-assembly can be withdrawn from the body.

Note 1: An expansion-fit type contact-breaker sub-assembly is unsuitable for refitting once it has been removed from the distributor body. It is recommended that either the contact-breaker sub-assembly or its associated bearing plate-and-base plate assembly is renewed, otherwise difficulty may be experienced in securing the contact-breaker sub-assembly in the body.

Note 2: In the case of model 44D distributor (Part No. 41402), the expansion-fit type contact-breaker sub-assembly should be fitted with an additional securing screw (see Fig. 8).

Following removal of the contact-breaker sub-assembly, the auto-advance springs can be renewed



Note:

Before carrying out this dismantling, refer Text 4(a) part (iii).

(i) Remove 'POZIDRIV' screw(s) from slot in contact-breaker bearing plate.

(ii) Insert small electrician's-type screwdriver in slot provided in edge of contact-breaker bearing plate. Lever screwdriver in direction of arrow and prise the edge of the limb from the groove in the body.

(iii) Disengage grommet and L.T. fly-lead from entry hole in body.

(iv) Insert shaft of medium-sized screwdriver through the elongated aperture in side of body. Lever screwdriver in direction of arrow, so that the end of the screwdriver forces the contact-breaker bearing plate upwards from the groove in the body. Following this operation, the contact-breaker sub-assembly should be free to be withdrawn from the body.

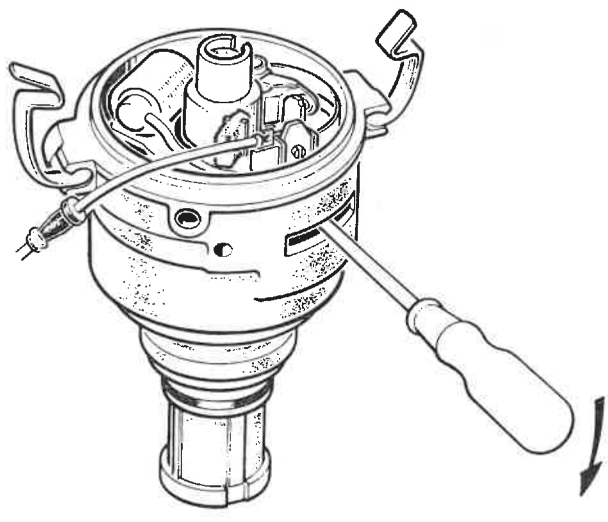


Fig. 10 Dismantling procedure: expansion-fit type contact-breaker sub-assembly

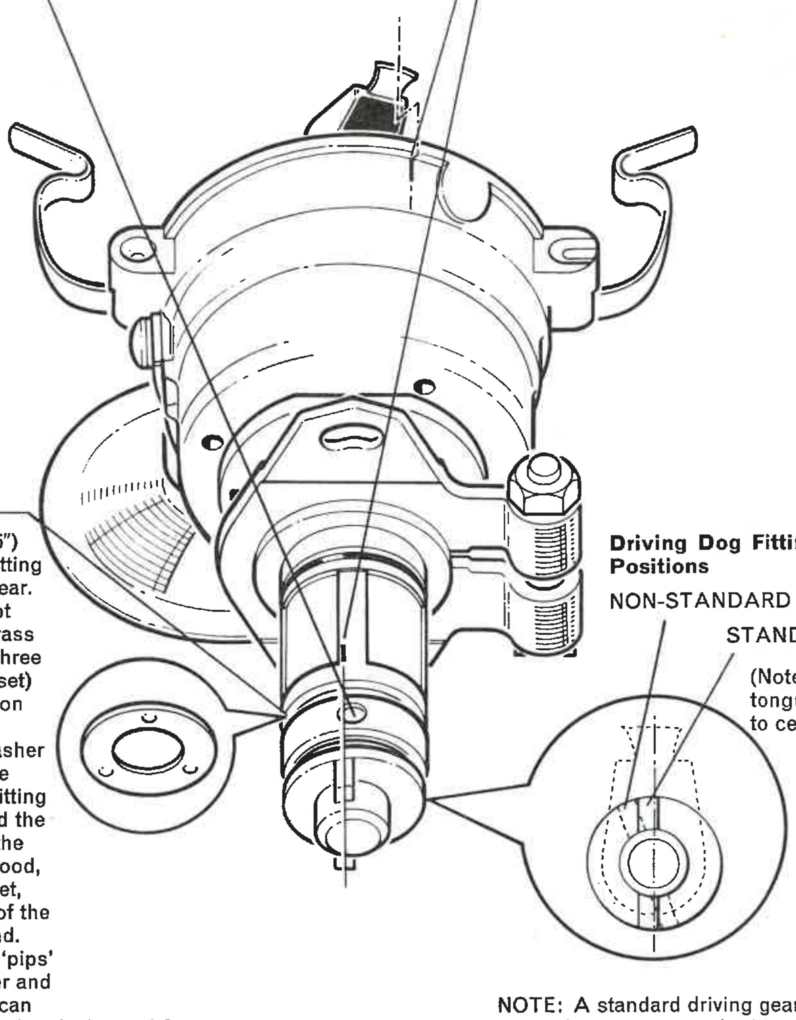


Fig. 11 Removing and refitting a driving dog, or gear (refer 'Note')

but dismantling will need extending to include removal of the driving dog, or gear, if the assembly comprising cam, weights, shaft-and-plate is to be renewed. This would neither be economical nor result in a satisfactory repair, if the shaft bearing in the body is excessively worn (more than just perceptible side-movement of the shaft). In this case the distributor should be exchanged for a factory reconditioned unit, in preference to carrying out a repair.

Should it be decided to renew the assembly comprising cam, weights, shaft-and-plate, in the case of a distributor fitted with a driving dog, the fitting position of the driving dog must be identified before it is removed from the shaft (see Fig. 11).

A driving dog is fitted to the shaft with a mills pin. A driving gear is fixed to the shaft with a roll pin. A mills pin is solid steel, a roll pin is formed from sheet steel.

Carefully support the shank of the distributor and press the fitting pin from the driving dog or gear, using a suitably-sized pin punch according to the fitting pin-size. Alternatively, lightly clamp the shank of the distributor in a vice and drive the fitting pin from the driving dog or gear. In some cases it may be necessary to file away ring punching from both sides of the driving dog or gear, to enable the pin to be removed.

After removing the driving dog or gear, the assembly comprising cam, weights, shaft-and-plate can be withdrawn from the distributor body.

Before commencing reassembly, refer subsequent heading 5.

5. REASSEMBLY

(a) Fitting the assembly comprising cam, weights, shaft and plate

Ensure the nylon distance collar and the steel thrust washer are assembled on the shaft, beneath the action plate. Sequence of assembly of these parts, and correct fitting of the distance collar with the

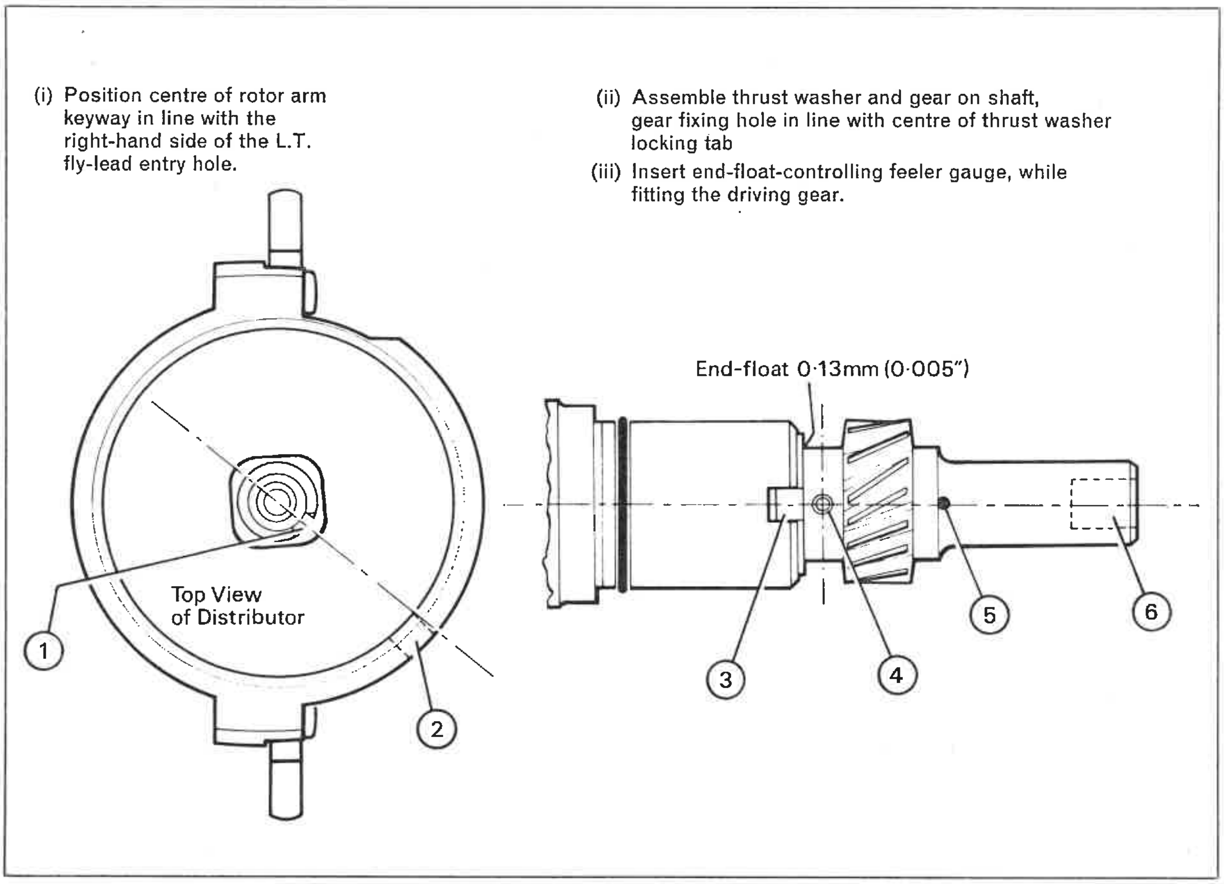


Fig. 12 Fitting a non-standard driving gear (with extended shaft)

1 Rotor arm keyway in shaft
2 L.T. fly-lead entry hole
3 Thrust washer locking tab
4 Roll pin, drill size 3.2 mm (⅛" or 0.125") diameter
5 Oil hole
6 'Auxiliary' hexagon take-off drive incorporated in shaft

chamfer underneath, is important (see Figs. 1 and 2, items 14 and 15). This also applies to distributors illustrated in Figs. 3 and 4, where the distance collar and thrust washer are not shown.

Prior to assembling the shaft in the bearing, lubricate the bearing and the bearing portion of the shaft and the centrifugal auto-advance mechanism with Rocol MP (molypad) oil. Alternatively, use clean engine oil to lubricate the bearing and the bearing portion of the shaft, but alternative lubricant for the auto-advance mechanism should be heavy-duty and equivalent to that specified.

(b) Fitting the driving dog, or gear

Refer Figs. 11 and 12.

(c) Fitting an expansion-fit type contact-breaker sub-assembly

The 'POZIDRIV' self-tapping securing screw, and associated washer, should be as specified and an additional screw and washer should be fitted in the case of a model 44D distributor (see Fig. 8).

(d) Fitting the vacuum unit

(Distributor models 44D and 45D)

Refer Fig. 9.

(e) Contact-breaker adjustment

Refer Fig. 6.

(f) Final lubrication

Smear Shell Retinax 'A' (or equivalent) grease, on the working surface of the cam.

Apply Shell Turbo '41' oil (or clean engine oil), sparingly to the felt pad in the top of the cam. Except distributors without a vacuum unit, apply the same oil sparingly through two small apertures in the contact-breaker base plate (see Fig. 8). **Do not oil the felt pad fitted to the contact-breaker** (Part 2 b, para. ii, refers).

Finally, fit rotor arm and H.T. moulded cover.

LIGHTING AND SIGNALLING

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Issue 1 November 1966

HEADLAMP MODELS 2FR AND 2FRP

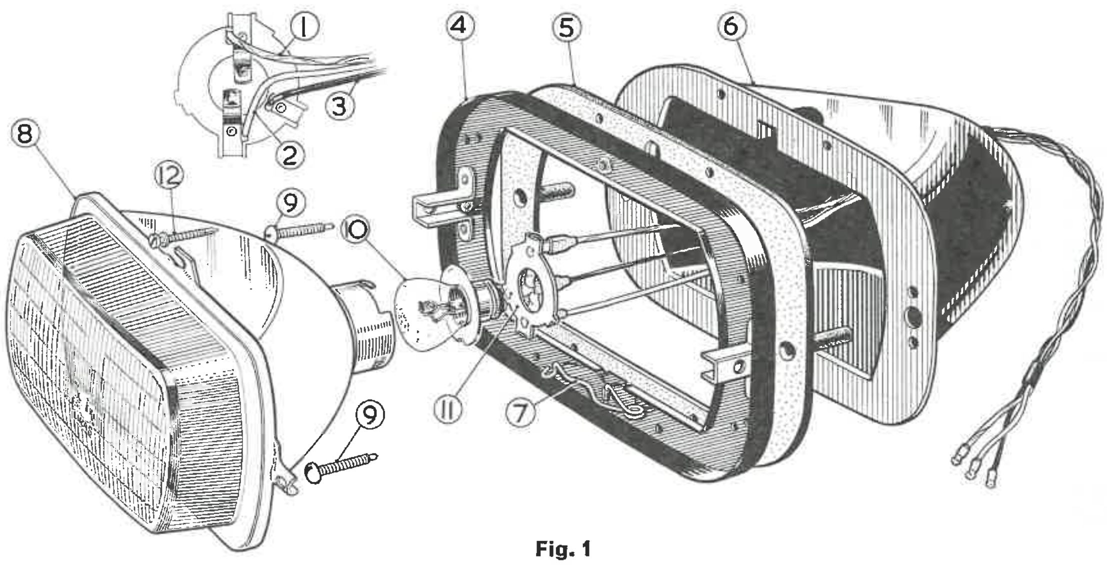


Fig. 1

1 Blue-with-Red: to dip beam filament
2 Blue-with-White: to main beam filament
3 Black: to earth
4 Mounting plate
5 Body gasket
6 Body
7 Spring, retaining
8 Light unit
9 Screws, trimmer (horizontal)
10 Bulb
11 Contact plate assembly
12 Screw, trimmer (vertical)

1. DESCRIPTION

This rectangular-shaped headlamp incorporates a glass-and-metal light unit and a replaceable pre-focused bulb. Model 2FRP is fitted also with a replaceable pilot bulb. The light unit is carried on a mounting plate providing the reference surface from which the light unit can be adjusted horizontally and vertically.

The 2FR lamp is shown dismantled in Fig. 1. It illustrates the type of main bulb* used in early production units fitted to right-hand drive vehicles. Fig. 2 illustrates the type of bulb† fitted to all 2FR and 2FRP lamps for left-hand drive vehicles, and also to lamps for right-hand drive vehicles since early 1967. Beamsetting procedure varies according to which of these bulbs is fitted (see "Beam Adjustment").

WARNING: Do not attempt to clean the aluminised internal surface of the reflector.

* Lucas No. 451 (80/60 watt) or 452 (60/60 watt).

† Lucas No. 410 (45/40 watt, clear) or 411 (45/40 watt, cadmium yellow).

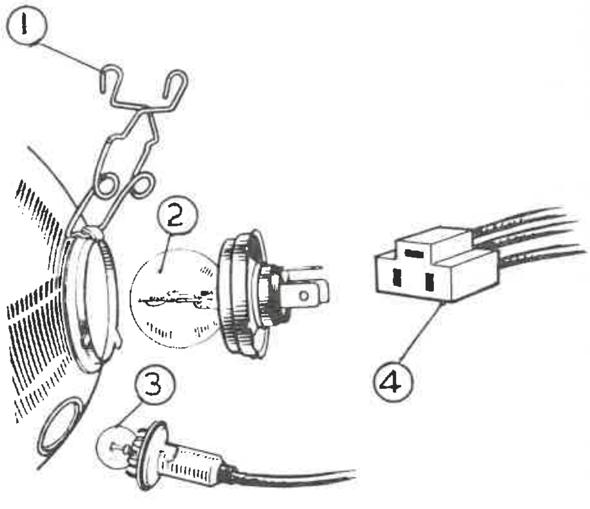


Fig. 2

1 Bulb retaining clip
2 Main bulb
3 Pilot bulb
4 Adaptor

2. LIGHT UNIT OR BULB REPLACEMENT

(a) Light Unit

Remove the radiator grille, lamp rim and dust-excluding rubber as applicable. Disengage the retaining spring (Fig. 1) from the lower edge of the light unit. Draw the unit forward until it clears the horizontal trimmer-screw guards and then turn the light unit sufficiently clockwise to clear the vertical trimmer screw.

(i) Light units fitted with bulb No. 451 or 452

Leaving the cable connections to the contact plate assembly undisturbed, carefully press in and turn anti-clockwise the contact plate which can then be withdrawn from the light unit followed by the bulb.

(ii) Light units fitted with bulb No. 410 or 411

Detach the adaptor from the bulb terminals, release the bulb-retaining spring clips and withdraw the bulb.

(b) Bulb

In some applications the bulb is accessible with the lamp in situ. In others, when a lamp body is fitted, bulb replacement necessitates removal of the light unit and bulb as described in 2 (a).

The pilot bulbholder of 2FRP lamps is a push fit into an aperture in the rear of the reflector.

When fitting the new bulb ensure that the projection on the replacement bulb flange locates correctly with the light unit.

3. BEAM ADJUSTMENT

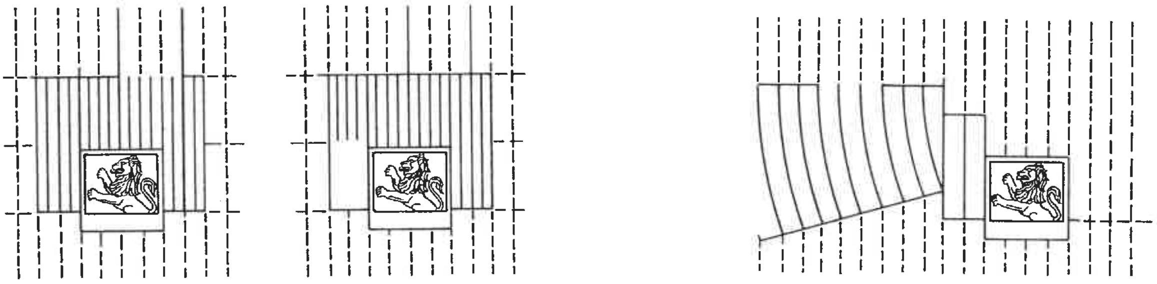
Three trimmer screws are provided for beam adjustment. Access to these screws — from lamp front or rear — varies according to vehicle design and the car manufacturer's instruction should be sought where the approach is not obvious.

(a) Left-hand drive vehicles

Lamps fitted to left-hand drive vehicles will be set on the dipped (meeting) beam in the normal manner.

(b) Right-hand drive vehicles

Lamps fitted to right-hand drive vehicles will be set according to the type of bulb. This can be quickly ascertained by reference to Fig. 3 where (a) shows the lens pattern at the centre of light units fitted with bulbs numbered 451 or 452, and (b) and (c) show the equivalent portion of the two types of lens pattern associated with number 410 or 411 bulbs.



(a) (b) (c)

Fig. 3

(a) Centre of lens pattern of 2FR right-hand drive light unit employing No. 451 or 452 bulb

(b) Centre of lens pattern of early production 2FR right-hand drive light unit employing No. 410 or 411 bulb

(c) Centre of lens pattern of later type of 2FR right-hand drive light unit employing No. 410 or 411 bulb

(i) Lamps incorporating bulb No. 451 or 452 should be set on main beam using a beamsetter with its cam set ½° down.

(ii) Lamps fitted with bulb No. 410 or 411 must be set on the dipped beam. The procedure requires the addition of an opaque perspex screen, dimensioned and marked as shown in Fig. 4(a) and (b) and positioned in front of the light-sensitive cell in the beamsetter by means of the centrally-fixed stud. The dipped beam pattern of the lamp with the 410 or 411 bulb will correspond closely with the marking on the perspex screen and the lamp will be correctly set when, with the beamsetter cam set ½° down, the beam pattern and screen marking coincide.

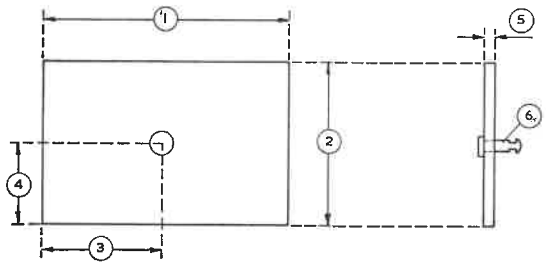


Fig. 4 (a)

1 9″ (228.6 mm)
2 5″ (127.0 mm)
3 4½″ (114.3 mm)
4 2½″ (63.5 mm)
5 ⅛″ (3.2 mm)
6 ¼″ (6.3 mm) dia. x ½″ (12.6 mm) long stud grooved $\frac{1}{16}$″ (1.5 mm) wide and deep, $\frac{1}{16}$″ from end. Stud drive fit in screen

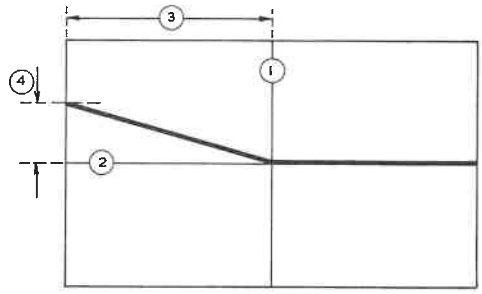


Fig. 4 (b)

1 Headlamp centre-line (vertical)
2 Headlamp centre-line (horizontal)
3 4½″ (114.3 mm)
4 1¼″ (31.7 mm)

WINDSHIELD WIPERS & WASHERS

INDEX

Issue 3 October 1968
Supersedes Issue 2 November 1967

WINDSHIELD WIPER MODEL 5W

1. DESCRIPTION

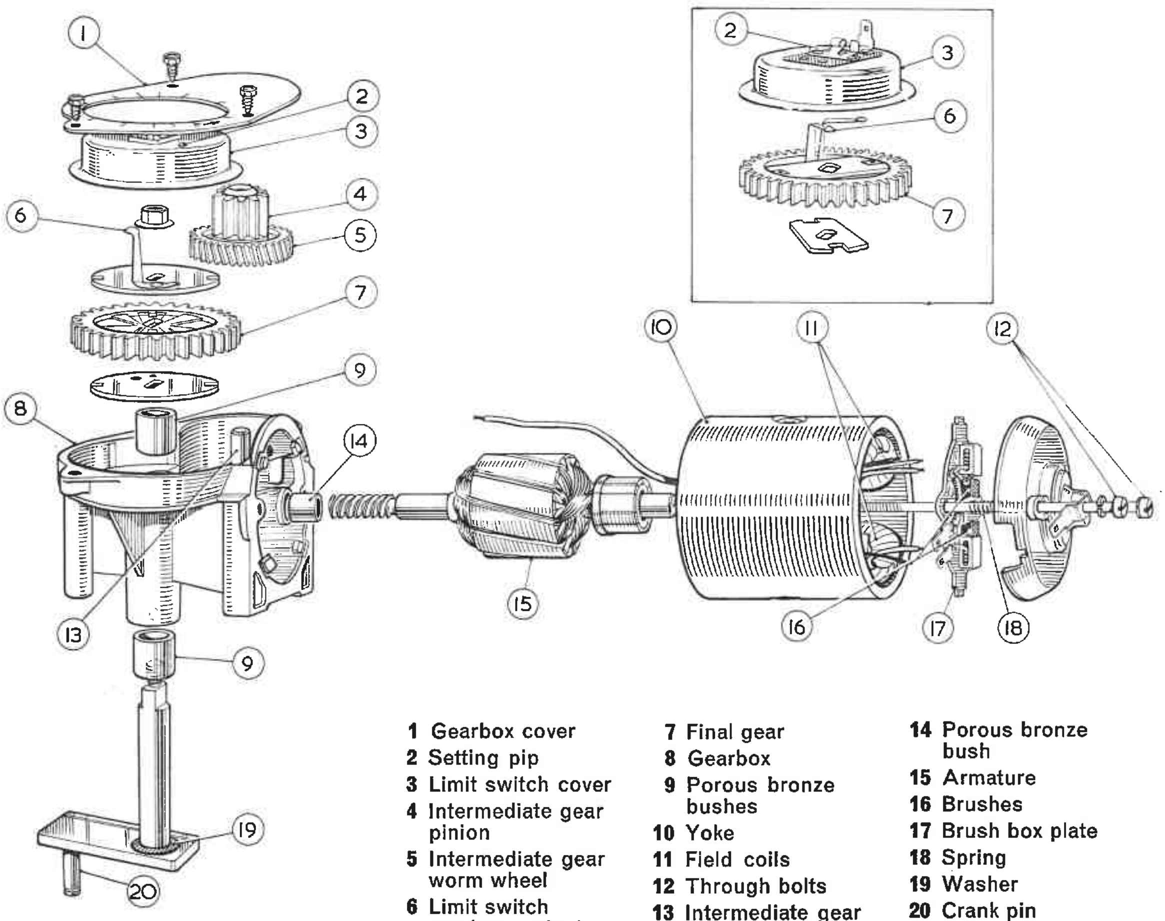
The high-output 5W motor unit is designed to work with the longer arms and blades used on the larger windshields fitted to modern commercial vehicles. The output from the motor is transmitted via a rotating crank and links to reciprocating drop arms on the spindles upon which the wiper arms and blades are mounted. These components may be arranged either as a single assembly on a rigid mounting bracket, or fitted separately to the vehicle, when adjustable-length links are provided to suit individual installations.

The motor is a shunt-connected two-pole unit with a cylindrical yoke. The armature is carried on porous pre-lubricated bearings, that at the commutator end being of the spherical self-aligning type. The armature shaft is extended in the form of three-start worm gearing which drives a worm wheel — the first stage of a two-stage reduction gear system. The second stage consists of a spur-toothed pinion which drives the final gear. An adjustable rotary limit switch is incorporated in the gear-box cover to effect self switching of the wiper motor and thus ensure that the arms and blades "park" at the end of the wiping cycle during which the motor is switched off.

The 5W motor unit is shown dismantled in Fig. 1.

2. ROUTINE MAINTENANCE

The motor gearbox, armature bearings and spindle bearings, are lubricated during manufacture and do not require periodic lubrication.



1 Gearbox cover
2 Setting pip
3 Limit switch cover
4 Intermediate gear pinion
5 Intermediate gear worm wheel
6 Limit switch moving contact
7 Final gear
8 Gearbox
9 Porous bronze bushes
10 Yoke
11 Field coils
12 Through bolts
13 Intermediate gear shaft
14 Porous bronze bush
15 Armature
16 Brushes
17 Brush box plate
18 Spring
19 Washer
20 Crank pin

Fig. 1 Windscreen Wiper Motor Model 5W, showing (inset) alternative components for insulated return motors

Windshield Wiper Model 5W

Oil, tar spots or similar contaminating substances should be removed from the windshield with methylated spirits (denatured alcohol). Silicone or wax polishes must never be used for this purpose.

Efficient wiping is dependent upon keeping the wiper blades in good condition. Worn or perished blades are readily removed for replacement.

3. TECHNICAL DATA

	12-volt	24-volt
(i) Light running current after 60 seconds from cold (with blades and arms removed or arms locked back off windshield):	3.3 amp max.	2.0 amp max.
(ii) Light running speed of final gear after 60 seconds from cold:	37–41 rev/min	37–41 rev/min
(iii) Resistance of armature winding at 60°F (15.5°C) measured between adjacent commutator segments:	0.13–0.18 ohm	0.60–0.80 ohm
(iv) Resistance of field winding at 60°F (15.5°C):	7.8–8.8 ohms	31.0–35.0 ohms

4. SERVICING

(a) Systematic Check of Faulty Wiping Equipment

If unsatisfactory operation of the wiping equipment is experienced (despite the supply voltage to the motor being adequate) this may be caused by a fault that is electrical or mechanical in origin. Before dismantling is resorted to, consideration should be given to the nature of the fault.

The symptoms and remedial procedure associated with the more common causes of wiper failure (or poor performance) are described in (i) and (ii) below.

(i) Frictional Wiper Blades

Excessive friction between apparently satisfactory wiper blades and the windshield may result in a marked slowing of the wiping rate when the blades are operating on a windshield that is only partially wet.

A further symptom is that the blades become noisy at each end of the wiping arc. When possible the blades should be temporarily replaced with a set known to be in good condition. If, by this action, the fault is confirmed, the original blades should be renewed.

It is important when doing this to use only the Lucas recommended replacement blades.

(ii) Low Wiping Speed or Irregular Movement of the Blades

To determine whether a low wiping speed is due to excessive mechanical loading of the linkage system or wheelbox spindles, or to poor motor performance, the linkage must first be disconnected at the rotary crank (see Fig. 1).

Measuring the Light Running Current and Speed

Connect a first-grade moving-coil ammeter in the motor supply cable and measure the light running current. Also observe the operating speed by timing the speed of rotation of the rotating crank. With the motor and linkage system disconnected the light running current should not exceed 3.1 amperes (12-volt) or 1.9 amperes (24-volt). The final gear speed should be 37–41 rev/min.

If the motor does not run, or the light running current and speed are not as stated, an internal fault in the motor is indicated; a replacement motor should be fitted, or the motor removed for detailed examination.

Checking the Linkage System and Wheelboxes

If the light running current and speed are correct, check the linkage system and wiping spindles. The linkage rods should be checked for correct length and the wiping spindles for free rotation.

(b) Dismantling the Motor

CAUTION: **Before dismantling the motor note the position of the limit switch cover setting pip in relation to the gearbox cover. On reassembling the motor it is essential to maintain this relationship to ensure correct parking of the wiper blades.**

Withdraw the three gearbox cover retaining screws and lift off the cover and limit switch carrier. Unscrew the nut securing the final gear to the output shaft and rotary link. Before dismantling further, note the angular relationship between the rotary crank pin and the limit switch moving contact so that these components can be re-assembled in like manner. Tap the shaft clear and remove the final gear, taking care not to lose the dished washer that is fitted beneath it.

Withdraw the intermediate gear.

Unscrew the two through bolts from the commutator end cover. Withdraw in turn the cover, brushgear plate, yoke and armature.

Note that anti-rattle springs are sleeved over the through bolts, between the cover and brushplate.

(c) Bench Inspection

After dismantling, examine individual items.

(i) Replacement of Brushes

The flexible brush connectors are soldered to terminal tags. Brushes worn to, or approaching ⅛″ (3 mm) in length must be renewed. The brushes are square in section. When inserting a brush into a brush-box take care to keep the side of the brush from which the flexible emerges turned towards the soldered connection.

(ii) Checking of Brush Springs

The brush springs can be withdrawn from the brush boxes once the brushes are held clear.

A good spring will exert a force of 5–7 oz.f (140–200 gr.f) when compressed to 0.158″ (4 mm) in length. Springs which fail to do this should be renewed.

(iii) Testing and Servicing the Armature

Use armature-testing equipment to check the armature windings for open circuits and short circuits.

Test the soundness of the armature insulation using a mains test lamp (Fig. 2). Lighting of the lamp indicates faulty insulation.

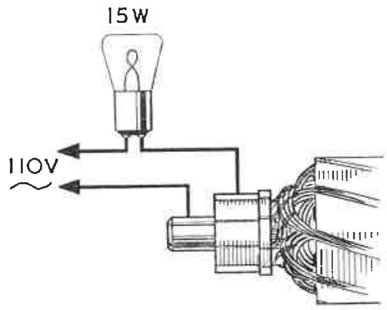
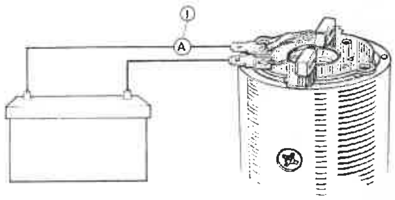


Fig. 2 Armature Winding Insulation Test

If the commutator is worn, it can be lightly skimmed while the armature is mounted in a lathe. Afterwards, clear the inter-segment spaces of copper swarf.

(iv) Testing and Servicing the Field Coils

Check the resistance of the field windings using an ohmmeter connected between the two 'Lucar' terminals on the brushgear plate (keep the brushes well clear of each other during this test). If an ohmmeter is not available, connect an ammeter in series with a 12 or 24-volt supply, as appropriate, across the same terminals (see Fig. 3).



1 Ammeter

Fig. 3 Field Coil Resistance Test

No reading indicates open-circuit field coil(s).

Normal readings are either as given in 3 (iv) if an ohmmeter is used, or 1.5 amperes for 12-volt coils and 0.7 ampere for 24-volt coils, if the alternative test is made.

Ohmic readings much below, or current readings much above, these values indicate short-circuited field coils.

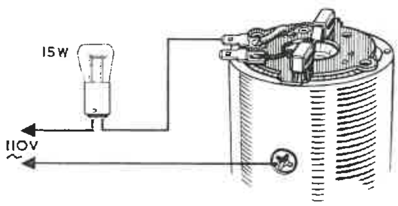


Fig. 4 Field Coil Insulation Test

Connect a 110-volt A.C. supply in series with a 15-watt test bulb between one of the 'Lucar' blades and one of the pole shoe screws (see Fig. 4). The test lamp will light if the insulation of the coils is faulty.

Field coils can be withdrawn after the pole shoe screws are removed. Refit pole shoes in their former position and ensure that the tape around the coils does not get trapped between the mating surfaces of the pole shoes and the yoke. Ensure that each pole shoe is sitting squarely in the yoke before tightening its securing screw.

(v) Inspection of Gear System

Examine the gear system, especially the gearwheel teeth, replacing any part which shows signs of wear or damage.

(d) Re-assembly

This is a reversal of the dismantling procedure described in 4(b). Ensure that the limit switch cover setting pip is in the original position. (See below for adjustment procedure should this be necessary.) Take care not to damage the brushes when fitting the brushgear plate over the commutator.

When re-assembling lubricate the following parts:

Lubricate sparingly the output shaft and armature shaft bearings using Shell Turbo 41 oil. Also the wheelbox spindles if these have been removed from the wheelboxes.

If any gearbox lubricant has been lost in the dismantling of the motor, further Ragosine Listate or Shell Retinax 'A' grease lubricant should be added.

Each of the following parts should be tightened to the torque indicated:

Through bolts:	20 lbf in	(0.23 kgf m)
Pole shoe screws:	40 lbf in	(0.46 kgf m)
Rotary link:	80 lbf in	(0.92 kgf m)

Check the armature end-float following the re-assembly of the motor. Slacken the end-float adjuster nut and carefully screw in the adjuster until resistance is felt. (Make this adjustment while holding the yoke vertical, with the commutator end cover lowermost.)

Screw the adjuster back for quarter turn and lock it in this position. This corresponds to an end-float of 0.004″–0.008″ (0.1–0.21 mm).

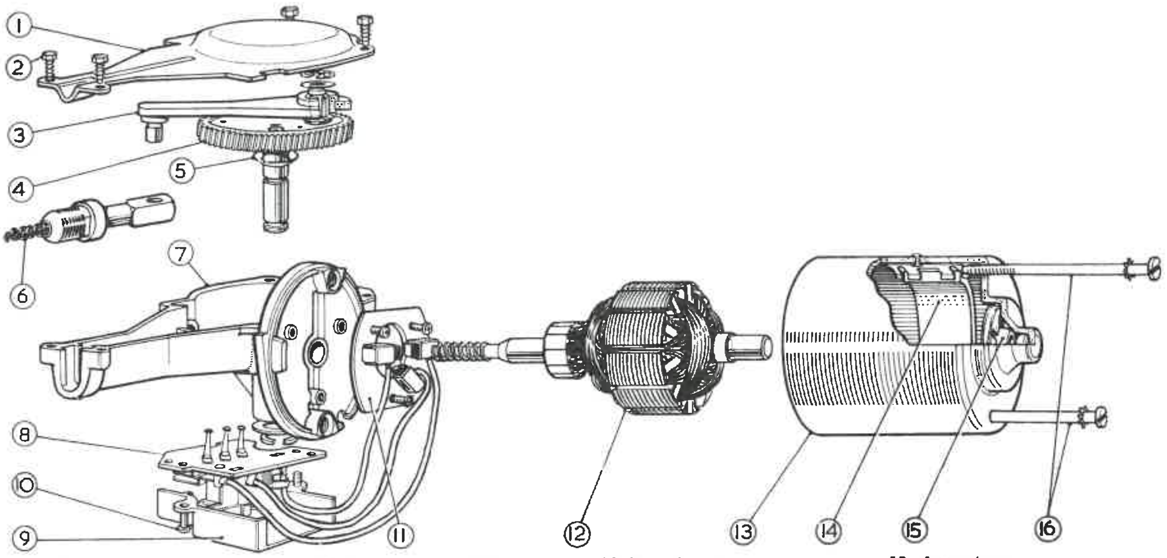
(e) Adjustment of Limit Switch

To adjust the parking position of the wiper blades, slacken the three gearbox cover screws and rotate the limit switch cover slightly in the appropriate direction. Retighten the gearbox cover screws when the desired parking position is reached.

IMPORTANT: If the wiper motor is fitted to the vehicle, this adjustment should be made while the motor is operating under normal service conditions, i.e. with a well-charged battery (or with the generator running above cut-in speed) and with the windshield wet.

Limit switch adjustment made with a partially discharged battery or dry windshield may prove unsatisfactory when normal service conditions are encountered.

WINDSHIELD WIPER MODEL 12W



1 Cover, gearbox
2 Screw, gearbox cover fixing
3 Rod, connecting
4 Shaft and gear
5 'Dished' washer
6 Cable rack, with crosshead
7 Gearbox
8 Plate, switch
9 Cover, switch plate
10 Screws, switch cover fixing
11 Brushgear, comprising: Insul plate and brush-boxes, Brushes, Springs, Screws, fixing
12 Armature
13 Yoke
14 Field magnets
15 Bush, self-aligning
16 Bolts, fixing

Fig. 1 Windshield Wiper Motor Model 12W (two speed)

1. DESCRIPTION

Windshield wiper model 12W comprises a self-switching power unit which drives two wiper arm wheel-boxes by means of a flexible cable rack running through a rigid tube. The two-pole motor has a permanent magnet field consisting of two ceramic magnets housed in a cylindrical yoke. A two-start work gear formed on the extended armature shaft drives a moulded gearwheel within the die-cast gearbox. Motion is imparted to the cable rack by a connecting rod and crosshead actuated by a crankpin carried on the gearwheel.

Associated with the terminal assembly (positioned below the gearbox) are three fixed contacts running on an insulated brass slip-ring secured to the underside of the gearwheel. One of these fulfils the function of providing contact for a self-switching limit switch, while the others — in conjunction with a special control switch — provide regenerative braking of the armature to give immediate armature deceleration, and thus consistent parking of the blades, when the motor is switched off.

The motor is produced in single and two-speed form. To provide the latter requirement, the brush box plate is fitted with a third brush to which the armature positive feed is switched when the second (higher) speed is required.

2. ROUTINE MAINTENANCE

All bearings are adequately lubricated during manufacture and require no maintenance.

Oil, tar spots or similar deposits should be removed from the windshield with methylated spirits (denatured alcohol). Silicone or wax polishes must not be used for this purpose.

Efficient wiping is dependent upon keeping wiper blades in good condition. Worn or perished blades are readily removed for replacement.

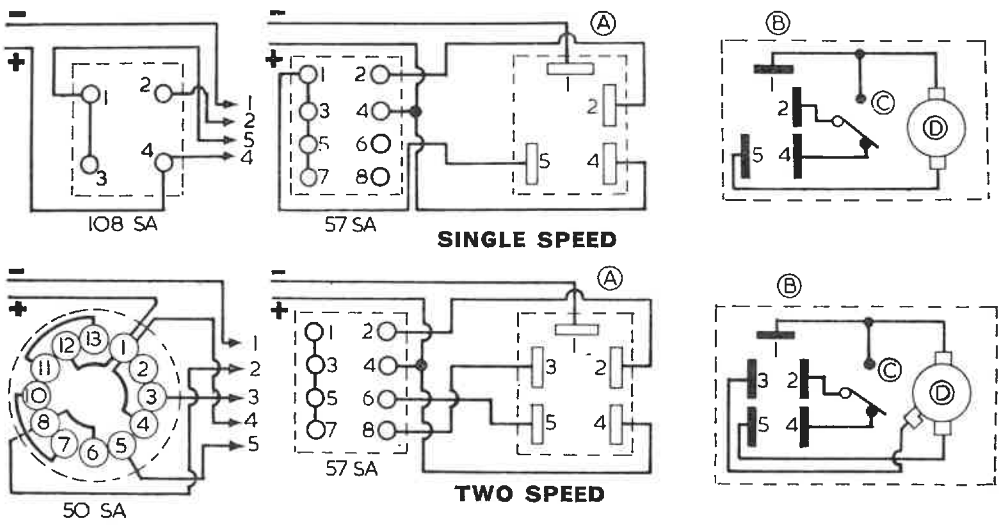
3. TECHNICAL DATA

	12-volt	24-volt
(i) Typical light running current (i.e. with cable rack disconnected) after 60 seconds from cold:	1.5 amp. (normal speed) 2.0 amp. (high speed)	0.8 amp. (normal speed) 1.0 amp. (high speed)
(ii) Light running speed after 60 seconds from cold:	46–52 rev/min (normal speed) 60–70 rev/min (high speed)	
(iii) Resistance of armature winding at 60°F (15.5°C) measured between adjacent commutator segments:	0.23–0.35 ohms	1.0–1.4 ohms

4. SERVICING

Note: Since the motor is of permanent magnet design, the direction of rotation of the armature depends on the polarity of the supply to its terminals. If it is necessary to run the motor while it is removed from the vehicle, the negative supply cable must be connected to motor terminal number 1 and the positive supply cable to terminal number 5 for normal speed or terminal number 3 for high speed. (See Fig. 2).

Windshield Wiper Model 12W



A Moulded terminal connector on cable harness **B** Terminal connector on wiper motor **C** Limit switch **D** Armature

SWITCH INTERNAL CONNECTIONS	OFF	NORMAL SPEED	HIGH SPEED
57 SA (Single speed)	(1-2) (5-6)	(3-4) (5-6)	— —
108 SA " "	(1-2)	(3-4)	— —
57 SA (Two speed)	(1-2) (5-6)	(3-4) (5-6)	(3-4) (7-8)
50 SA " "	(1-2) (5-6) (10-11)	(13-1) (4-5) 8-10)	(12-13) (3-4) (7-8)

Fig. 2 Wiring diagrams for single and two-speed 12W wipers using typical switches

(a) Systematic Check of Faulty Wiping Equipment

If unsatisfactory operation is experienced (despite the supply voltage to the motor being adequate) this may be caused by a fault that is mechanical or electrical in origin. Before resorting to dismantling, consideration should be given to the nature of the fault.

The symptoms and remedial procedures associated with the more common causes of wiper failure (or poor performance) are described in (i) and (ii) below.

(i) Frictional Wiper Blades

Excessive friction between apparently satisfactory wiper blades and the windshield may result in a marked reduction in wiping speed when the blades are opening on a windshield that is only partially wet.

A further symptom is that the blades become noisy at each end of the wiping arc. When possible the blades should be temporarily replaced with a pair known to be in good condition. If this rectifies the fault, fit new blades.

(ii) Low Wiping Speed or Irregular Movement of the Blades

To determine whether a low wiping speed is due to excessive mechanical loading or to poor performance, the cable rack must first be disconnected as described at the commencement of Dismantling the Motor in 4(b).

Measuring Light Running Current and Speed

Connect a first-grade, moving-coil ammeter in series with the motor supply cable and measure the current consumption. Also check the operating speed by timing the speed of rotation of the moulded gear. The current consumption and speed should be as given in 3. With a two-speed motor check also the higher speed and current.

If the motor does not run, or current consumption and speed are not as stated, an internal fault in the motor is indicated and a replacement unit should be fitted or the motor removed for detailed examination (see 4b).

If current consumption and speed are correct, check the cable rack and wheelbox spindles.

Checking Cable Rack and Tubing

Remove the wiper arms and blades and push the cable rack fully home in its tubing.

Hook a spring balance in the hole on the cross-head (into which the pin on the connecting rod normally locates) and withdraw the rack with the balance. The maximum permissible force required is 6 lbf (2.72 kgf).

Badly kinked or flattened tubing must be replaced and any bends of less than 9 in (228 mm) radius must be reformed. Examine the cable rack for signs of damage to the helix.

Checking Wheelboxes

Check the wheelbox spindles for freedom of rotation. Seized units, or those suspected of having damaged gear teeth, must be replaced.

(b) Dismantling the Motor

Withdraw the four gearbox fixing screws and lift off the cover.

Remove the circlip and flat washer securing the connecting rod to the crankpin.

Withdraw the connecting rod, taking care not to lose the second flat washer positioned beneath it on the crankpin.

Remove the circlip and washer securing the shaft and gear.

Before proceeding further, use a smooth file to remove any fraze from the gear shaft. Failure to do this may result in the bearing being scored when the gear is withdrawn.

Remove the gear taking care not to lose the dished washer fitted beneath it.

It is normally unnecessary to detach the crank-pin mounting plate — which is an integral part of the gear shaft — from the moulded gearwheel, since these are serviced only as an assembly. However, should the shaft and gearwheel become separated for any reason it is essential, on re-assembly, to observe the correct angular relationship between the crankpin and the slip ring so that correct parking of the blades will be maintained. Fig. 5 shows the two positions (180° apart) in which the crankpin plate can be assembled to the gearwheel to give parking with cable rack fully extended or fully retracted.

Note: Before removing the yoke assembly mark the yoke and gearbox so that it may be re-assembled in its original position. If the yoke is fitted in the alternative position (i.e. 180° displaced), the motor will run in reverse, causing the internal switching arrangement to function incorrectly and possibly damaging the switch contacts.

Unscrew the two fixing bolts from the motor yoke and carefully remove in turn the yoke assembly and armature. While removed, the yoke must be kept well clear of swarf, etc., which may otherwise be attracted to the pole pieces.

Withdraw the three screws securing the insulating plate to which the brushes are attached. The brush assembly is now retained only by the brush cables.

Remove the screws securing the switch plate and cover. The terminal and brush assemblies may now be detached from the unit.

(c) Bench Inspection

After dismantling, examine individual items.

(i) Brush Replacement

Single-speed (2-brush) motors.

Brushes worn to $\frac{3}{16}$ in (4.8 mm) in length must be renewed. Carefully open the rolled tag crimping the cable insulation, release the cable and tear the brazed cable end from the terminal on the switch plate. Remove and discard the worn brush taking care not to lose the brush spring which is loose in the brushbox.

Clean the terminal plate and connect the new brush flexible by soldering.

Two-speed (3-brush) motors.

Observe single-speed instructions for the two main (diametrically-opposed) brushes. The third brush is stepped in section and requires replacing when the narrow section is worn away so that the full width of the brush is in contact with the commutator.

Fig. 3 shows the correct method of fitting the brushes to the brushboxes for both 2 and 3 brush units. It is particularly important to position the third brush correctly.

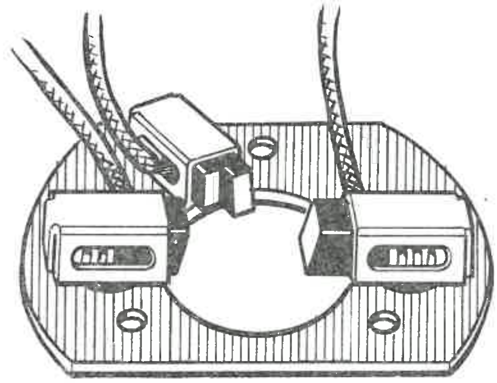


Fig. 3 2-speed motor brush assembly

(ii) Checking Brush Springs

The brush springs can be removed from the boxes once the brushes are held clear.

A good spring will exert a force of 5–7 ozf (140–200 gf) when compressed to 0.158 in (4 mm) in length. Springs which fail to do this should be renewed.

(iii) Testing and Servicing the Armature

Use armature testing equipment to check the armature for open and short circuits.

Test the soundness of the armature insulation by using a mains test lamp (Fig. 4). Lighting of the lamp indicates faulty insulation.

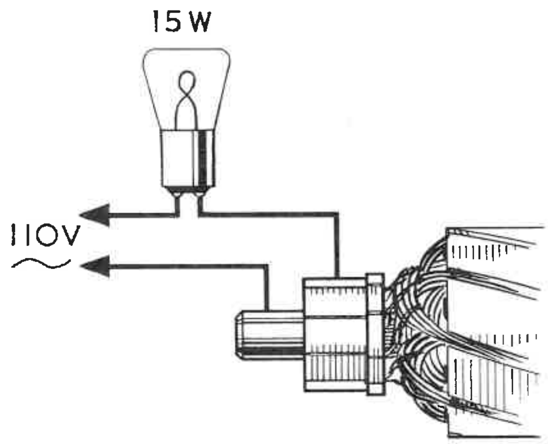


Fig. 4 Armature insulation test

If the commutator is worn, it can be lightly skimmed while the armature is mounted in a lathe.

Afterwards, clear the inter-segment spaces of copper swarf.

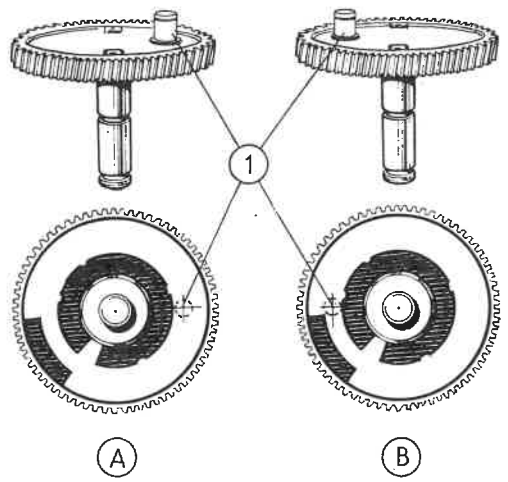


Fig. 5 Alternative positions of crankpin (1) to give
A Parking with cable rack retracted
B Parking with cable rack extended

(iv) Inspection of Moulded Gear

Examine the gearwheel, especially the teeth, for signs of wear or damage. If necessary, a replacement must be fitted.

(d) Re-assembly

This is a reversal of the dismantling procedure described in 4(b).

Take care not to damage the brushes when fitting the armature. Note that the yoke seating rim is slotted to facilitate the passage of the brush flexibles from switch plate to brushboxes.

Lubricate the gear teeth, crosshead and cross-head slide with Ragosine Listate grease. This should also be smeared on the slip-ring on the gearwheel and be liberally applied to the cable rack.

The crankpin should be sparingly lubricated with Shell Turbo 41 oil, as should the wheelbox spindles if they have been removed.

The yoke fixing bolts should be tightened to a torque of 20 lbf in (0.23 kgf m).

Check the armature end-float following the re-assembly of the motor. Slacken the end-float adjuster nut (Fig. 6) and carefully screw in the adjuster until resistance is felt. Make this adjustment while holding the yoke vertical with the end-float adjuster uppermost.

Screw the adjuster back for ¼ turn and lock it in this position. This corresponds to an end-float of 0.004–0.008 in (0.1–0.21 mm).

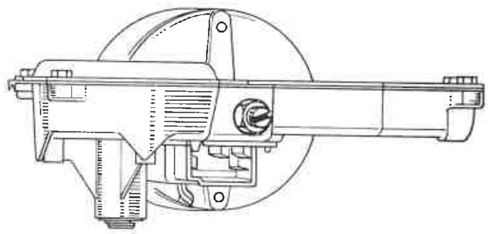


Fig. 6 Armature end-float adjusting screw

SCREENJET MODEL 5SJ

1. DESCRIPTION

Model 5SJ ScreenJet is an electrically operated unit comprising a small permanent-magnet motor driving a centrifugal pump through a 3-piece Oldham type coupling. The motor is remote controlled from a pushbutton and is energised for as long as the push-button is depressed. The general construction can be seen in Fig. 1 where the unit is shown dismantled.

2. ROUTINE MAINTENANCE

When the water level falls to the top of the pump unit, refill the container with clean water up to the base of the filler neck. One measure (10 cc) of Lucas "Crystal Clear" ScreenJet fluid may be added to help dissolve greasy smears and to remove insect deposits from the windscreen.

Keep the container free from sediment and occasionally clean the gauze filter fitted to the underside of the impeller housing. For this purpose turn and lift the cover and pump assembly to detach it from the container. Keep also the jet nozzles clear.

3. TECHNICAL DATA

(a)	Nominal voltage of unit	12	24
(b)	Maximum current consumption	2.0 amp	1.25 amp
(c)	Resistance between commutator segments	2.8–3.1 ohms	10.6–11.7 ohms
(d)	Minimum water delivery pressure	4.5 lbf/in^2 (0.32 kgf/cm^2)	4.5 lbf/in^2 (0.32 kgf/cm^2)
(e)	Minimum water delivery per sec	3.5 cc	3.5 cc
(f)	Container capacity	1.1 litres	1.1 litres
(g)	Diameter of nozzle orifice	.025″–.028″	.025″–.028″

4. SERVICING

(a) Testing the ScreenJet in position

If the ScreenJet operates unsatisfactorily (despite the supply voltage to the terminals being adequate) check first that there is sufficient water in the container and then, that water is ejected from the tube connector with the external tubing disconnected and the push-button operated. If the unit performs satisfactorily when so tested, check the external tubing and nozzles for damage or blockage. Otherwise, the ScreenJet must be dismantled for detailed examination.

(b) Dismantling

Disconnect the external tubing and electrical connections and remove the cover and pump assembly from the container.

Remove the self-tapping screw which secures the motor to the cover, and pull away the motor unit, taking care not to lose the intermediate coupling which connects the armature coupling to the pump spindle coupling.

Remove the armature coupling from the armature shaft by holding the armature shaft firmly with a pair of snipe-nosed pliers and using a second pair of pliers to draw off the armature coupling.

Remove the two self-tapping screws from the bearing plate. The bearing plate and rubber gasket can now be removed.

Remove the two terminal screws.

The terminal nuts and brushes can be removed and the armature withdrawn.

Take care not to lose the bearing washer which fits loosely onto the armature shaft.

The pole assembly should not normally be disturbed. If, however, its removal is necessary, make careful note of its position relative to the motor housing. The narrower pole piece is adjacent to the terminal locations.

Also, the position of the pole clamping member should be observed. When fitted correctly, it locates on both pole pieces. If fitted incorrectly, pressure is applied to one pole piece only.

(c) Bench Testing

If the motor has been overheated, or if any part of the motor housing is damaged a replacement motor unit must be fitted.

If the armature is damaged, or if the windings are loose or badly discoloured, a replacement armature must be fitted.

The commutator must be cleaned with a fluffless, petrol-moistened cloth or, if necessary, by polishing it with a strip of very fine glasspaper.

The resistance of the armature winding should be checked with an ohmmeter. The resistance between commutator segments should be in accordance with the appropriate value given in 3(c).

Brushes worn to less than $\frac{1}{16}$″ (1.6 mm) in length must be renewed.

Check that the brushes bear firmly against the commutator.

(d) Reassembly

Reassembly of the unit is the reversal of the dismantling procedure.

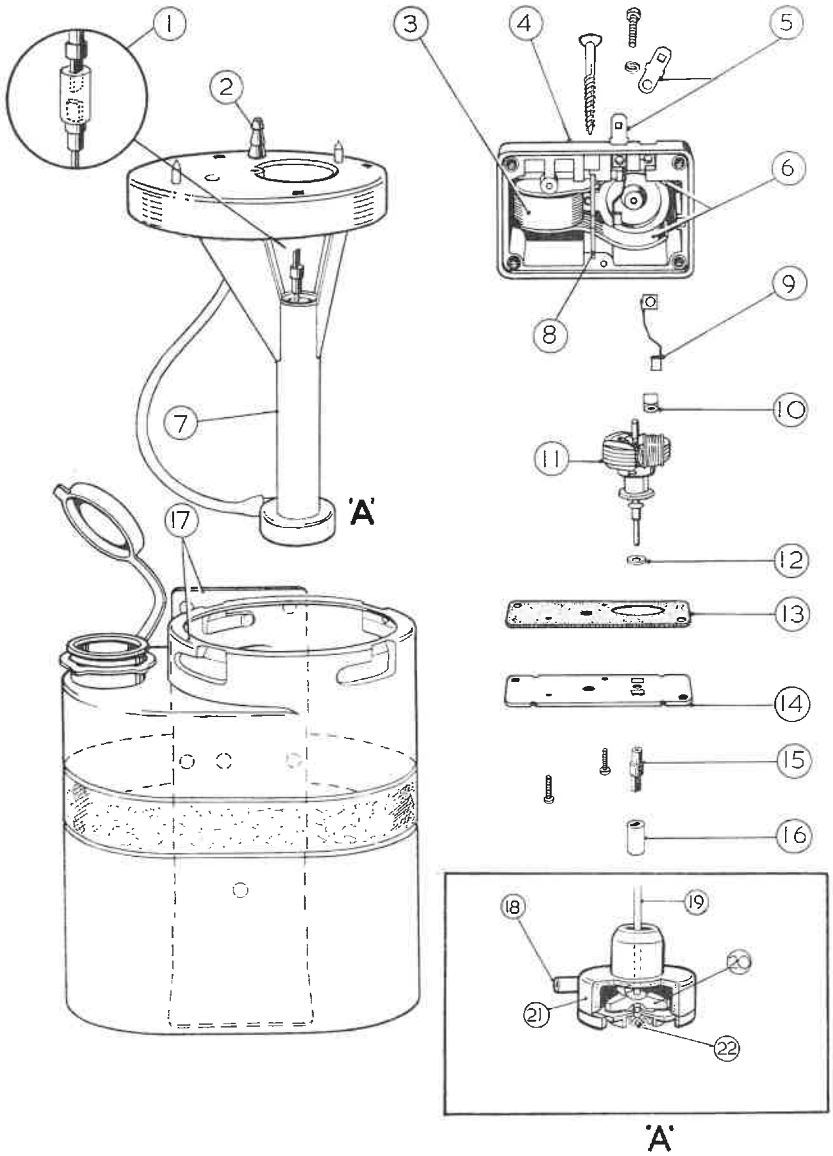
The following points should be observed :

(i) Make sure that the bearing recess in the motor housing is filled with Rocol Molypad molybdenised grease. Remove excessive grease from the face of the bearing boss.

(ii) Check that the pole piece assembly does not rock and that the pole pieces are firmly located on the circular spigot. Ensure that both the pole piece assembly and the clamping member are the right way round, see 4(b).

(iii) Before replacing the motor unit on the cover, ensure that the armature coupling is pushed fully home. Also check that the intermediate coupling is in place.

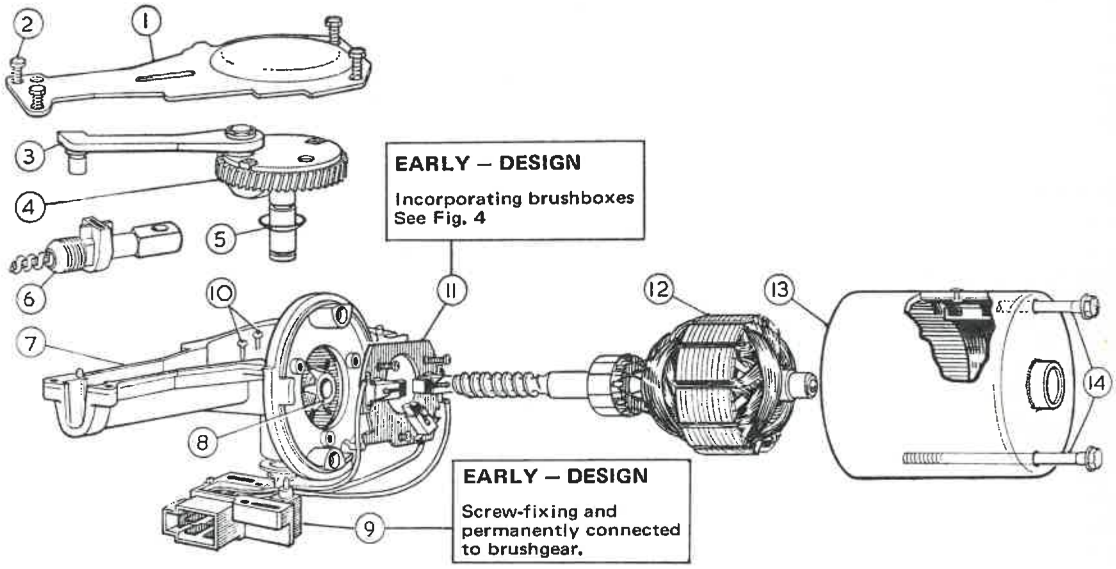
Screenjet Model 5SJ

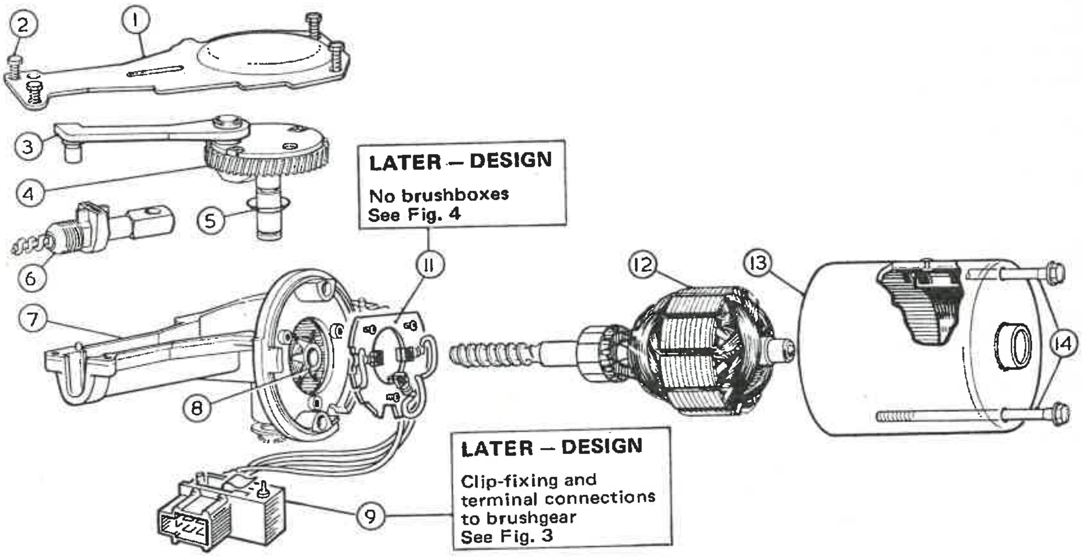


1 Detail of pump coupling
2 Tube connector
3 Permanent magnet
4 Motor casing
5 Terminals
6 Pole pieces
7 Cover & pump
8 Pole piece clamping member
9 Brush
10 Terminal & brush retaining nut
11 Armature
12 Bearing washer
13 Rubber gasket
14 Bearing plate
15 Armature coupling
16 Intermediate (loose) coupling
17 Jar bracket & strap assembly
18 Delivery outlet
19 Spindle
20 Impeller
21 Housing
22 Gauze

Fig. 1 ScreenJet Model 5 SJ dismantled

WINDSHIELD WIPER MODEL 14W





1 Gearbox cover
2 Screw (gearbox cover fixing)
3 Connecting rod
4 Shaft & Gear
5 Dished washer
6 Cable rack with crosshead & outer casing ferrule
7 Gearbox
8 Self-aligning bearing bush
9 Limit switch assembly
10 Screws (limit switch fixing)
11 Brushgear
12 Armature
13 Yoke assembly, comprising: two permanent-magnet poles & retaining clips and armature bearing bush
14 Bolts (yoke fixing)

Fig. 1 Windshield Wiper Model 14W (two-speed)

NOTE: Third brush omitted for single-speed

Windshield Wiper Model 14W

1. DESCRIPTION

Windshield wiper model 14W comprises a self-switching power unit which drives two wiper arm wheel-boxes by means of a flexible cable rack running through a rigid tube. The two-pole motor has a permanent magnet field consisting of two ceramic magnets housed in a cylindrical yoke. A worm gear formed on the extended armature shaft drives a moulded gearwheel within the die-cast gearbox. Motion is imparted to the cable rack by a connecting rod and crosshead actuated by a crankpin carried on the gearwheel.

Associated with the terminal assembly is a self-switching limit switch unit. Two-stage contacts inside the switch are operated by a plunger, which in turn is actuated by a cam on the underside of the moulded gear-wheel inside the gearbox. When the manually-operated control switch is moved to OFF (or park) the motor continues to operate under the automatic control of the limit switch. When the wiper blades reach the parked position, the first-stage contacts open and the motor is switched off. A momentary period follows during which no contact is made by the switch, then the second-stage contacts close causing regenerative braking of the armature which maintains consistent parking of the blades.

The motor is produced in single and two-speed form. To provide the latter requirement, the brush-box plate is fitted with a third brush to which the armature positive feed is switched when the second (higher) speed is required.

2. ROUTINE MAINTENANCE

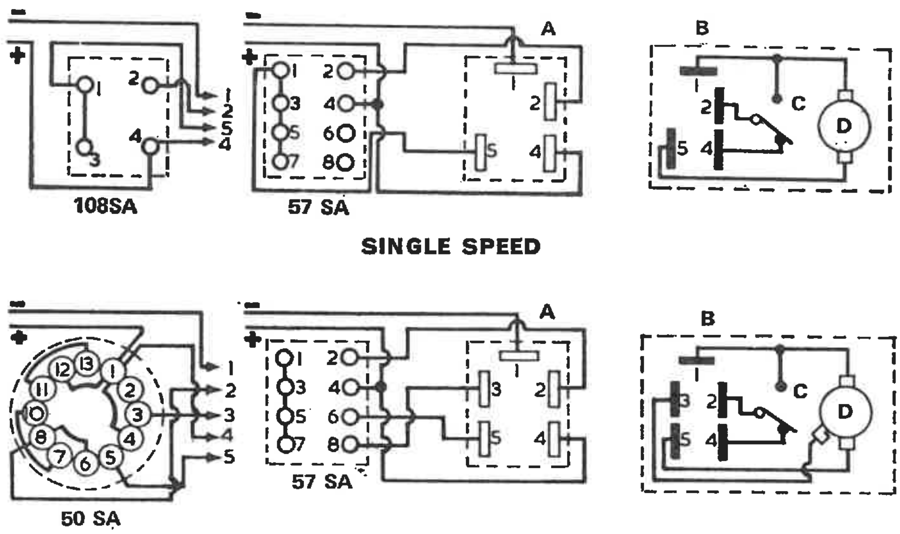
All bearings are adequately lubricated during manufacture and require no maintenance.

Oil, tar spots or similar deposits should be removed from the windshield with methylated spirits (denatured alcohol). Silicone or wax polishes must not be used for this purpose.

Efficient wiping is dependent upon keeping wiper blades in good condition. Worn or perished blades are readily removed for replacement.

3. TECHNICAL DATA

	12-volt	*24-volt*
(i) Typical light running current (i.e. with cable rack disconnected) after 60 seconds from cold:	1.5 amp. (normal speed) 2.0 amp. (high speed)	0.8 amp. (normal speed) 1.0 amp. (high speed)
(ii) Light running speed after 60 seconds from cold:	46–52 rev/min (normal speed) 60–70 rev/min (high speed)	



A Moulded terminal connector on cable harness
B Terminal connector on wiper motor
C Limit switch
D Armature

SWITCH INTERNAL CONNECTIONS	OFF	NORMAL SPEED	HIGH SPEED
57 SA (Single speed)	(1-2) (5-6)	(3-4) (5-6)	— —
108 SA " "	(1-2)	(3-4)	— —
57 SA (Two speed)	(1-2) (5-6)	(3-4) (5-6)	(3-4) (7-8)
50 SA " "	(1-2) (5-6) (10-11)	(13-1) (4-5) (8-10)	(12-13) (3-4) (7-8)

Fig. 2 Wiring diagrams for single and two-speed 14W wipers using typical switches

4. SERVICING

Note : Since the motor is of permanent magnet design, the direction of rotation of the armature depends on the polarity of the supply to its terminals. If it is necessary to run the motor while it is removed from the vehicle, the negative supply cable must be connected to motor terminal number 1 and the positive supply cable to terminal number 5 for normal speed or terminal number 3 for high speed. (See Fig. 2).

(a) Low Wiping Speed, Irregular movement of the Blades, Noisy Operation

(i) Check wiper blades

Excessive friction between apparently satisfactory wiper blades and the windshield may result in a marked reduction in wiping speed when the blades are operating on a windshield that is only partially wet.

A further symptom is that the blades become noisy at each end of the wiping arc.

Prove the blades by substitution.

(ii) Check motor performance

To determine whether a low wiping speed is due to excessive mechanical loading or to poor motor performance, the cable rack must first be disconnected.

Measuring light running current and speed

Connect a moving-coil ammeter in series with the motor supply cable and measure the current consumption. Also check the operating speed by timing the speed of rotation of the moulded gear. The appropriate current and speed are given in 3. TECHNICAL DATA.

If current consumption and speed are not as stated, an internal fault in the motor is indicated and a replacement unit should be fitted or the motor removed for detailed examination.

If current consumption and speed are correct, check the cable rack and wheelbox spindles. (Refer subsequent headings).

Checking cable rack and tubing

Remove the wiper arms and blades and push the cable rack fully home in its tubing.

Hook a spring balance in the hole on the cross-head (into which the pin on the connecting rod normally locates) and withdraw the rack with the balance. The maximum permissible force required is 27N (6 lbf) (2.72 kgf).

Badly kinked or flattened tubing must be replaced and any bends of less than 228 mm (9 in) radius must be re-formed. Examine the cable rack for signs of damage to the helix.

Checking wheelboxes

Check the wheelbox spindles for freedom of rotation. Seized units, or those suspected of having damaged gear teeth, must be replaced.

(b) Wiper Motor Fails to Operate (Testing in situ)

Note : If a two-speed motor is capable of operating at one of its alternative speeds, ignore the following heading (i) and refer subsequent heading (ii).

(i) Check fuse

Check continuity of the fuse. If the fuse is found to be intact, check for good electrical contact between fuse and clips. If these checks are satisfactory, refer subsequent heading (ii).

If the fuse is found to be open-circuit, the cause of its failure must be ascertained.

Renew the fuse, and refer vehicle wiring diagram to determine whether the same fuse controls more than one circuit. If so, then each circuit must be operated alternately to determine which one is causing the fault. If open-circuiting of the fuse only occurs when the wiper control switch is operated (also select high-speed where applicable), then proceed as follows:-

Renew the fuse.

Disconnect the wiring plug from wiper motor.

Operate the wiper control switch, followed by high-speed position where applicable (Ensure IGN/AUX switch is also operative).

If the fuse now remains intact, the wiper motor is proved faulty.

If the fuse again fails, the wiper motor wiring plug cables must be checked for a short-circuit fault. **Only terminal 1 of the wiring plug** (see Fig. 2 **A** for terminal arrangement) **should register 'earth'.** Check this with a voltmeter or test lamp of appropriate voltage (12V or 24V), one side connected to a convenient voltage supply source on the vehicle and the other side (earth side) connected alternately to each of the wiring plug terminals.

(ii) Check supply voltage and earth connection to wiper motor

Note : Testing requires the use of a voltmeter or test lamp of appropriate voltage (12V or 24V).

Disconnect the wiring plug from wiper motor.

Operate the wiper control switch (If the motor is two-speed, select the appropriate speed which fails to function).

Check for supply voltage between wiring plug terminals 1 and 5 (In the case of single-speed, and two-speed motors switched to 'normal speed'), or terminals 1 and 3 (In the case of two-speed motors switched to high-speed). See Fig. 2 **A** for terminal arrangement. **The voltmeter should indicate supply voltage or the test lamp should light.**

If the test is satisfactory, the wiper control switch and associated wiring are eliminated and the wiper motor is proved faulty.

If the test is unsatisfactory, extend the test by transferring the voltmeter connection from wiring plug terminal 1 to a good earth point on the vehicle frame. **The voltmeter should indicate supply voltage or the test lamp should light.**

If this test is satisfactory, the wiper motor earth connection is faulty. Check continuity between wiring terminal 1 and frame.

If testing is still unsatisfactory, the wiper motor supply voltage is not available at the wiring plug terminal to which the voltmeter is connected (either terminal 3 or 5). Identify the colour of the appropriate one of these two cables at the wiper control switch, and check for supply voltage at the switch terminal of the cable.

If voltage is indicated, the cable is proved open-circuit.

If voltage is not indicated, check whether supply voltage is being applied to the input terminal of the switch. If so, the switch is confirmed faulty but otherwise the voltage supply source must be checked.

(c) Erratic Parking of Arms and Blades

Note : Testing requires the use of a voltmeter or test lamp of appropriate voltage (12V or 24V).

Disconnect the wiring plug from wiper motor.

Ensure wiper control switch is OFF.

Check for permanent supply voltage between wiring plug terminals 1 and 4 (see Fig. 2 **A** for terminal arrangement). **The voltmeter should indicate supply voltage or the test lamp should light.**

If the test is unsatisfactory, check continuity between wiring plug terminal 4 and supply voltage source.

If the test is satisfactory, extend testing by transferring the voltmeter or test lamp connection from wiring plug terminal 4 to terminal 5, and connect a test-link between terminals 2 and 4 (Other side of voltmeter or test lamp should still be connected to terminal 1). **The voltmeter should indicate supply voltage or the test lamp should light.**

If this test is satisfactory, the wiper motor limit switch is proved faulty. (Individual testing of the limit switch unit is referred to in (e) Bench Inspection, sub-heading (i).

If testing is unsatisfactory, check continuity between wiring plug terminal 2 and wiper control switch. If continuity is satisfactory, the wiper control switch is proved faulty.

(d) Dismantling

Withdraw the four gearbox cover fixing screws and lift off the cover.

Remove the circlip and flat washer securing the connecting rod to the crankpin.

Withdraw the connecting rod, taking care not to lose the second (larger diameter) flat washer positioned beneath it on the crankpin.

Remove the circlip and washer securing the shaft and gear.

Before proceeding further, use a fine file to remove any fraze from the gear shaft. Failure to do this may result in the bearing being scored when the gear is withdrawn.

Remove the gear taking care not to lose the dished washer fitted beneath it.

It is normally unnecessary to detach the crankpin mounting plate — which is an integral part of the gear shaft — from the moulded gearwheel, since these are serviced only as an assembly. However, should the shaft and gearwheel become separated for any reason it is essential, on reassembly, to ensure the correct angular relationship between the crankpin and the gearwheel-cam so that correct parking of the blades will be maintained. Fig. 5 shows the two positions (180° apart) in which the crankpin plate can be assembled to the gearwheel to give parking with cable rack fully extended or fully retracted.

Unscrew and remove the two fixing bolts from the motor yoke and carefully remove the yoke assembly and armature. While removed, the yoke must be kept well clear of swarf, etc., which may otherwise be attracted to the pole pieces.

Remove the screws which secure the brushgear and the terminal and switch unit and detach from the gearbox both assemblies, linked together by the connecting cables. If the motor is later-design (see Fig. 1) the brushgear and limit switch can be dismantled as individual items. (Refer 'NOTE' Fig. 3).

(e) Bench Inspection

(i) Limit switch unit

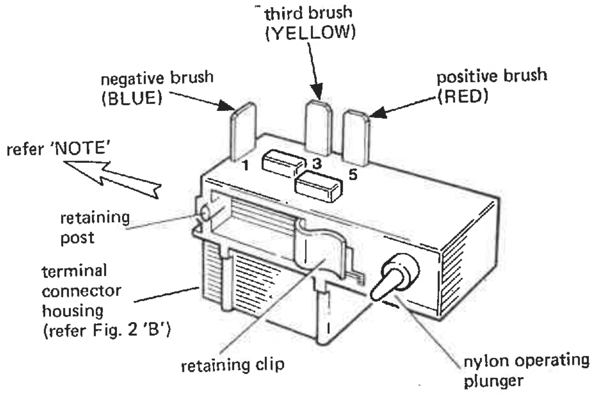


Fig. 3 Later design limit switch.

Note : Lift, or prise, retaining post end of switch from gearbox, then remove switch from motor unit by sliding in direction of arrow.

Depress the limit switch operating plunger and allow it to freely return to its original position, which should be approximately 7 mm ($\frac{9}{32}$ in) protruding from the switch body.

Follow with an electrical test, proving the first-stage and second-stage contacts (Self-switching and dynamic-braking contacts), as follows:-

With switch operating plunger in free position use a battery-operated ohmmeter or test lamp and check for continuity between the connector housing terminals 2 and 4 (see Fig. 2 **B** for terminal arrangement).

The ohmmeter should indicate a zero reading or the test lamp should light.

If the test is unsatisfactory, the limit switch is proved faulty and must be renewed.

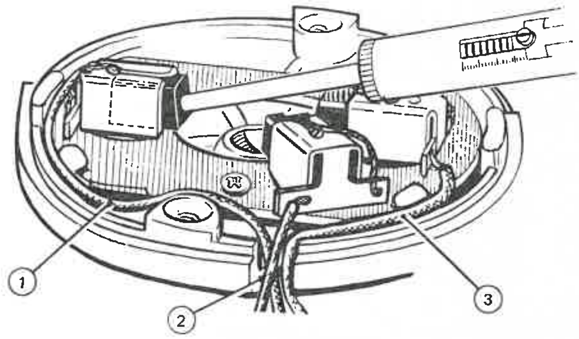
If the test is satisfactory, extend testing by checking for continuity between the connector housing terminals 1 and 2 when the switch operating plunger is depressed approximately 1.5 mm ($\frac{1}{16}$ in). **The ohmmeter should indicate a zero reading or the test lamp should light.**

If this test is unsatisfactory, the limit switch is proved faulty and must be renewed.

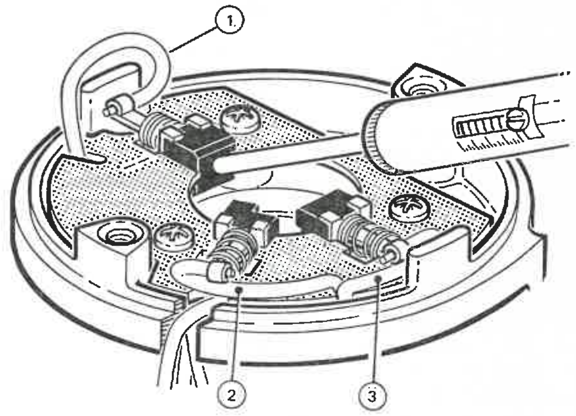
Note : In the event of the limit switch being renewed, it is important to re-connect the cables in accordance with Fig. 3. or Fig. 4.

(ii) Brush replacement

The original specified length of the brushes is sufficient to last the life of the motor. If, due to accidental damage to the brushes or to faulty commutator action, it becomes necessary to renew the brushes, the complete brushgear service assembly



EARLY DESIGN



LATER DESIGN

Fig. 4 Checking brush spring pressure Identification of cable connections.

Press brush to position indicated by broken line. Spring pressure should then be 1·7 N (6ozf or 170gf.).

NOTE: Alternatively, the gauge could be dial-type.

1. Negative brush cable (Blue).
2. Third brush cable two-speed (Yellow).
3. Positive brush cable (Red).

must be fitted. The brushgear assembly must be renewed if the main (diametrically-opposed) brushes are worn to 4.8 mm ($\frac{3}{16}$ in), or if the narrow section of the third brush (2-speed units only) is worn to the full width of the brush.

Check that the brushes move freely.

Note : A standardised service-replacement brushgear assembly incorporates a third (stepped) 2-speed brush, which should be ignored for single-speed applications.

(iii) Checking brush springs

The design of the brushgear does not allow for easy removal of the brush springs. This is due to the fact that, similar to the brushes, the springs are expected to last the life of the motor and should not normally require renewing. In the unlikely event of the spring pressure failing to meet the specified requirements, the complete brushgear service assembly must be replaced, in a similar manner to that detailed for servicing the brushes.

Check the spring pressure in accordance with Fig. 4.

Note : In the event of the brushgear being renewed, it is important to re-connect the cables in accordance with Fig. 3, or Fig. 4.

(iv) Testing and servicing the armature

Use armature testing equipment to check the armature windings for open and short-circuits.

Test the soundness of the armature insulation by using a mains test lamp (Fig. 5). Lighting of the lamp indicates faulty insulation.

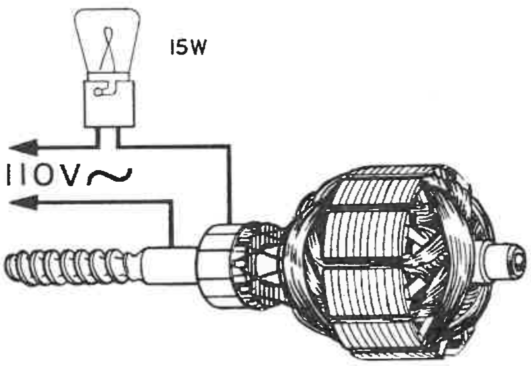


Fig. 5 Armature insulation test

If the commutator is worn, it can be lightly skimmed while the armature is mounted in a lathe.

Afterwards, clear the inter-segment spaces of copper swarf.

(v) Inspection of moulded gear

Examine the gearwheel, especially the teeth, for signs of wear or damage. If the gearwheel needs renewing, a shaft-and-gear service replacement assembly must be fitted.

(f) Re-assembly

This is generally a reversal of the dismantling procedure detailed in 4(d) but special consideration should be given to the following:-

Lubrication

Smear Ragosine Listate grease on the gearwheel teeth, armature shaft worm gear, top of the connecting rod and its connecting pin, and the crosshead slide.

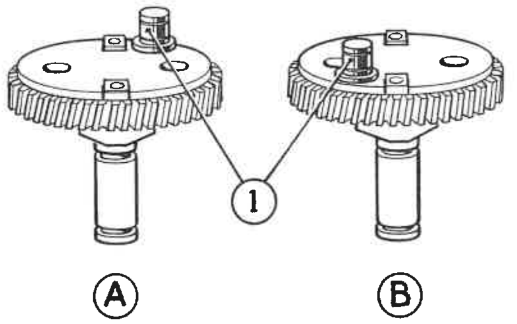


Fig. 6 Alternative positions of crankpin (1) to give
A Parking with cable rack retracted
B Parking with cable rack extended

Apply Shell Turbo 41 oil to the bearing bushes, armature shaft bearing surfaces (sparingly), gearwheel shaft and its crankpin and the felt-oiler washer in the yoke bearing (thoroughly soak).

Refitting the yoke

Before refitting the armature to the yoke (or vice versa) inspect the inside of the yoke and ensure that the thrust disc and the felt-oiler washer are in place in the yoke bearing. The correct method of assembly is with the thrust disc flat against the end face of the bearing, followed by the felt-oiler which must have a hole in the centre to allow the captive ball bearing in the end of the armature shaft to contact the thrust disc.

IMPORTANT: to ensure correct rotation of the motor, the marking on the yoke must be adjacent to the arrow-head marking on the gearbox rim.

The yoke fixing bolts should be tightened to a torque of 1.35–1.80 Nm (12–16 lbf in) (0.138–0.184 kgf m.).

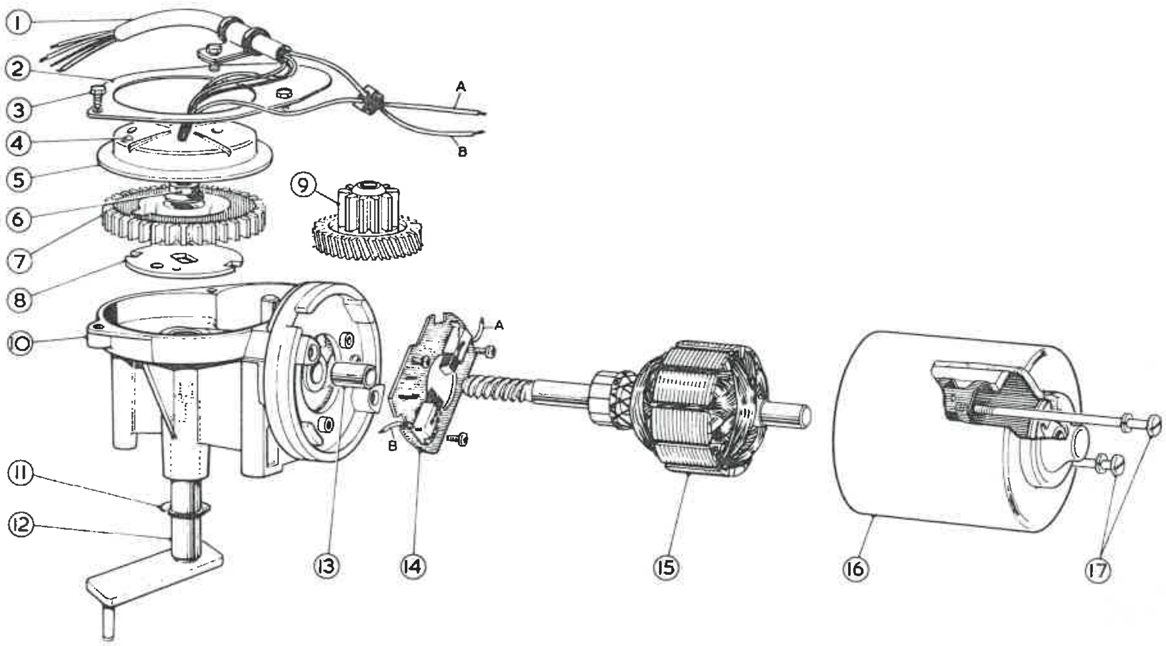
Armature end-float adjustment

Armature end-float is 0.05–0.25 mm (0.002–0.010 in).

A service replacement armature is provided with a thrust screw and locknut as a packaged sundry. This adjustable type thrust screw is for use in replacing the original non-adjustable type (when fitted), as adjustment to the armature end-float will probably be necessary after renewing the armature.

To obtain a satisfactory end-float adjustment with the motor and gearbox completely assembled, position the unit with the thrust screw uppermost, tighten the thrust screw until abutment takes place and then slacken it off one quarter turn and secure it in this position by tightening the locknut to a torque of 2.25–2.82 Nm (20–25 lbf in) (0.23–0.30 kgf m).

WINDSHIELD WIPER MOTOR MODEL 17W



1 Cable assembly (wiring to connector plug)
2 Gearbox cover
3 Gearbox cover fixing screw
4 Arrow-head marking (limit-switch setting)
5 Limit-switch cover
6 Locknut (final gear-wheel)
7 Final-gearwheel moulding assembly
8 Driving plate (final gearwheel)
9 Intermediate gear
10 Gearbox
11 Dished washer
12 Shaft & link assembly
13 Porous bronze bush
14 Brushgear assembly comprising: Insul plate & brush boxes, brushes, springs & fixing screws
15 Armature
16 Yoke assembly comprising: Two permanent magnet poles & retaining clips, & self-aligning bearing bush
17 Yoke fixing screws

Fig. 1 Windshield Wiper Motor Model 17W

1. DESCRIPTION

Windshield wiper motor model 17W is a single-speed unit designed to operate a link-type wiper installation. Power from the self-switching two-pole permanent-magnet field motor is transferred by a worm gear on the armature shaft to a two-stage reduction gear system. The final gearwheel drive is transmitted via a shaft and rotary link assembly to the links operating the wiper arm spindles. Self-switching of the motor takes place only after the manually-operated control switch has been moved to OFF (or park).

The gearbox incorporates an automatic limit-switch. This switches the motor off and then provides an electrical circuit which causes regenerative braking of the armature to ensure consistent parking of the wiper blades.

The wiper motor is shown dismantled in Fig. 1.

2. ROUTINE MAINTENANCE

All bearings are adequately lubricated during manufacture and require no maintenance.

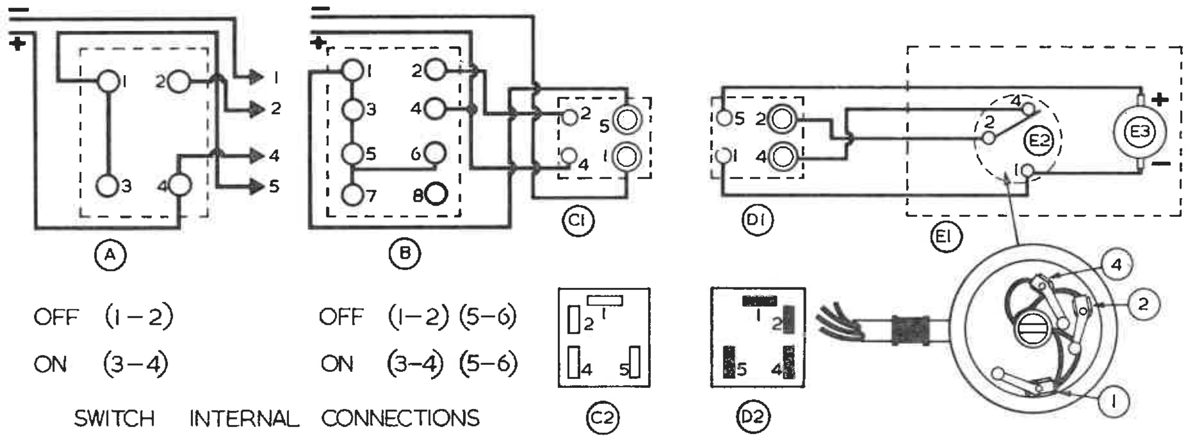
Oil, tar spots or similar deposits should be removed from the windshield with methylated spirits (denatured alcohol). Silicone or wax polishes must not be used for this purpose.

Efficient wiping is dependent upon keeping wiper blades in good condition. Worn or perished blades are readily removed for replacement.

3. TECHNICAL DATA

	12-volt	*24-volt*
(i) Typical light running current (i.e. with the rotary link disconnected from the transmission) after 60 seconds from cold:	1.2 amp.	0.8 amp.
(ii) Light running speed of the rotary link (or final gear-wheel) after 60 seconds from cold:	39–43 rev/min.	

Windshield Wiper Motor Model 17W



A	Alternative type switch (Model 108 SA)	**D1**	Moulded terminal connector attached to wiper motor
B	Switch (Model 57 SA)	**D2**	Alternative type connector
C1	Moulded Terminal Connector attached to cable harness	**E1**	Wiper motor **E2** Limit switch
C2	Alternative type connector	**E3**	Armature

Fig. 2 Wiring diagram using typical switches

4. SERVICING

Note : The correct rotation of a permanent-magnet field motor depends on the polarity of the connections. When the motor is connected to the vehicle wiring, the correct polarity is automatically assured by the design of the moulded terminal connectors. If the vehicle wiring connections are disconnected from the wiper motor (e.g. for test purposes) any alternative voltage source must be applied with due regard for the correct polarity requirements of the motor, otherwise damage to the limit-switch contacts may occur. In practice the switches are numbered as shown in Fig. 2 but the moulded terminal connectors are unmarked, being shown numbered for reference purposes only. The negative polarity must be applied to the moulded connector terminal shown as number 1 and the positive to connector terminal 5.

(a) Systematic Check of Faulty Wiping Equipment

Unsatisfactory operation (if the supply voltage to the motor is adequate) may be caused by a fault that is mechanical or electrical in origin. Before resorting to dismantling, consideration should be given to the nature of the fault.

The symptoms and remedial procedures associated with the more common causes of wiper failure (or poor performance) are described under the following headings (i) and (ii).

(i) Frictional Wiper Blades

Excessive friction between apparently satisfactory wiper blades and the windshield may result in a marked reduction in wiping speed when the blades are operating on a windshield that is only partially wet.

A further symptom is that the blades become noisy at each end of the wiping arc. When possible the blades should be temporarily replaced with a pair known to be in good condition. If this rectifies the fault, fit new blades.

(ii) Low Wiping Speed or Irregular Movement of the Blades

To determine whether a low wiping speed is due to excessive mechanical loading or to poor motor performance, the rotary link must first be disconnected from the transmission linkage.

Measuring Light Running Current and Speed

Connect a first-grade moving-coil ammeter in series with the motor supply cable and measure the current consumption. Also check the operating speed by timing the speed of rotation of the rotary link. The current consumption and speed should be as given in para. 3.

If the motor does not run, or current consumption and speed are not as stated, an internal fault in the motor is indicated and a replacement unit should be fitted or the motor removed for detailed examination, see 4 (b).

If current consumption and speed are correct, check for proper functioning of the transmission linkage and wiper-arm spindles.

(b) Dismantling the Motor and Gearbox

Before commencing to dismantle the unit, make a mark on the gearbox cover adjacent to the arrow-head marking on the limit-switch cover. This precaution will enable the original setting of the limit-switch to be easily determined during the re-assembly stage.

Proceed to dismantle as follows:

Remove the yoke fixing bolts complete with spring washers.

Part the yoke assembly from the gearbox. While removed, the yoke must be kept well clear of swarf, etc., which would otherwise be attracted to the permanent magnets. In some instances, the armature may unavoidably be withdrawn with the yoke. If not, carefully remove it.

Remove the fixing screws from the brushgear insulated plate and the gearbox cover, then detach from the gearbox the sub-assembly comprising: brushgear, limit switch, gearbox cover and the connecting cables. If the brushgear and cable assembly are threaded through the hole in the gearbox cover, the cover will be released from the sub-assembly.

All moving parts of the gearbox assembly are retained by a special hexagon-headed lock nut, which secures the final gearwheel to the shaft-and-link assembly.

Note: **The gearwheel train must be prevented from moving while this nut is slackened (or, on reassembly, tightened). This is most easily achieved by securing the rotary link in a vice while the nut is being turned.**

Dismantle the gearbox by first slackening the lock nut. A light tap on the top of the nut will overcome the initial reluctance of the gearwheel to part from the shaft. When the gearwheel is loose enough to enable it to be easily removed from the shaft, completely remove the lock nut and dismantle the parts from the gearbox. Remove, in order, the final gearwheel, its driving plate, the intermediate gearwheel and finally the shaft-and-link assembly. Take care not to lose the dished washer fitted on the shaft.

(c) Bench Inspection

After dismantling, examine individual items.

(i) Brush Replacement

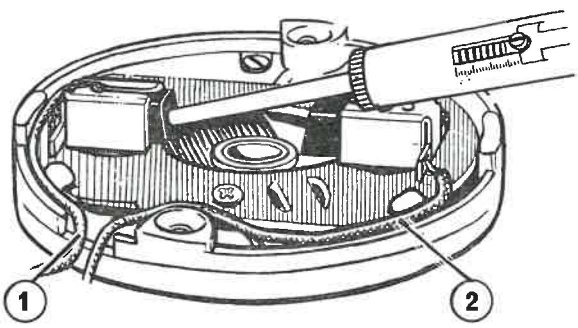
The original specified length of the brushes is sufficient to last the life of the motor. If, due to accidental damage to the brushes or to faulty commutator action, it becomes necessary to renew the brushes, the complete brushgear service-assembly must be fitted. The brushgear assembly will require renewing if the brushes are worn to $\frac{3}{16}$ in (4.8 mm). Check that the brushes move freely in the boxes.

(ii) Checking Brush Springs

The design of the brushgear does not allow for easy removal of the brush springs. Similar to the brushes, the springs are expected to last the life of the motor and should not normally require renewing. In the unlikely event of the spring pressure failing to meet the specified requirements, the complete brushgear service-assembly must be replaced, in a similar manner to that detailed for servicing the brushes.

To check the spring pressure, press on the end face of the brush with a push-type spring gauge (see Fig. 3) until the bottom of the brush is level with the bottom of the slot in the brush box, when the spring pressure reading should be 5–7 ozf (140–200 gf).

Note : In the event of the brushgear being renewed, it is important to reconnect the cables in accordance with Fig. 3.



1 Negative brush cable **2** Positive brush cable

Fig. 3 Checking brush spring pressure

(iii) Testing and Servicing the Armature

Use armature testing equipment to check the armature windings for open and short circuits.

Test the soundness of the armature insulation by using a mains test-lamp (Fig. 4). Lighting of the lamp indicates faulty insulation.

If the commutator is worn, it can be lightly skimmed while the armature is mounted in a lathe. Afterwards, clear the inter-segment spaces of copper swarf.

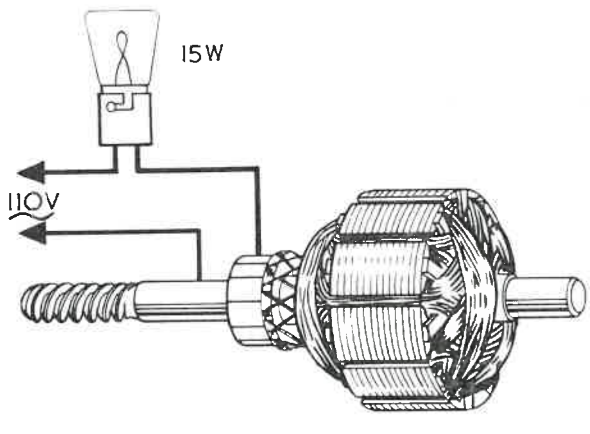


Fig. 4 Armature insulation test

(iv) Inspection of Moulded Gearwheels

Examine each of the gearwheels for signs of damage, particularly in regard to the teeth and the slip-ring on the final gearwheel.

Windshield Wiper Motor Model 17W

(v) Limit Switch

Inspect the inside of the switch cover and ensure that the cable connections are intact and that the contact arms are firmly riveted. To ensure that the contact arms exert the correct pressure upon the slip-ring, the measurement between the contact arm contact-faces and the base upon which they are riveted should be approximately $\frac{9}{32}$ in (7.1 mm).

(vi) Yoke Inspection

Check that the permanent-magnet retaining clips firmly secure the magnets to the inside face of the yoke.

(d) Reassembly

During reassembly, special consideration should be given to the following points:

Lubrication

Apply Ragosine Listate grease to the teeth of the gearwheels, the worm gear on the armature shaft and the slip-ring on top of the final gearwheel.

Apply Shell Turbo 41 oil to the final-gearwheel shaft, the bearing bushes and sparingly to the armature-shaft bearing surfaces.

Apply molybdenum di-sulphide oil to the intermediate gearwheel pivot-pin.

General

Before dismantling it was recommended that the position of the limit-switch cover should be marked to indicate the original setting of the switch, so that the correct parking position of the wiper blades would be maintained after reassembly. In conjunction with this, it is also essential to re-fit the final gearwheel with the slip-ring outer-facing segment pointing in the same direction as the rotary link (see Fig. 5).

The final gearwheel fixing nut should be tightened to a torque of 80–90 lbf in (0.91–1.03 kgf m). The rotary link must again be secured — see note in 4(b).

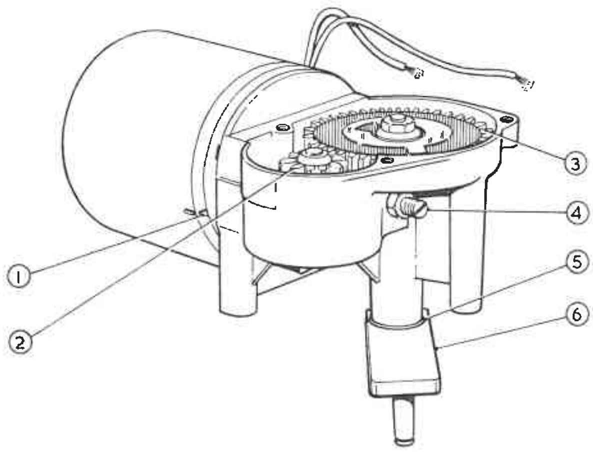
Before re-fitting the brushgear assembly, check the gearbox spacing-ring fixing screws for tightness. If necessary tighten them to a torque of 20 lbf in (0.23 kgf m).

Before fitting a service replacement armature, first slacken the thrust screw in the gearbox to ensure proper fitting of the yoke.

The marking on the yoke must be adjacent to the arrow-head marking on the gearbox rim (see Fig. 5) and the fixing bolts should be tightened to a torque of 12–16 lbf in (0.138–0.184 kgf m).

Armature end-float is 0.002–0.008 in (0.05–0.2 mm) measured with the final gearwheel removed from the gearbox. To obtain satisfactory end-float adjustment, with the motor and gearbox completely assembled, position the unit so that the adjuster screw is uppermost, tighten the adjuster screw until abutment takes place and then slacken it off one quarter turn and secure it in this position by tightening the locknut.

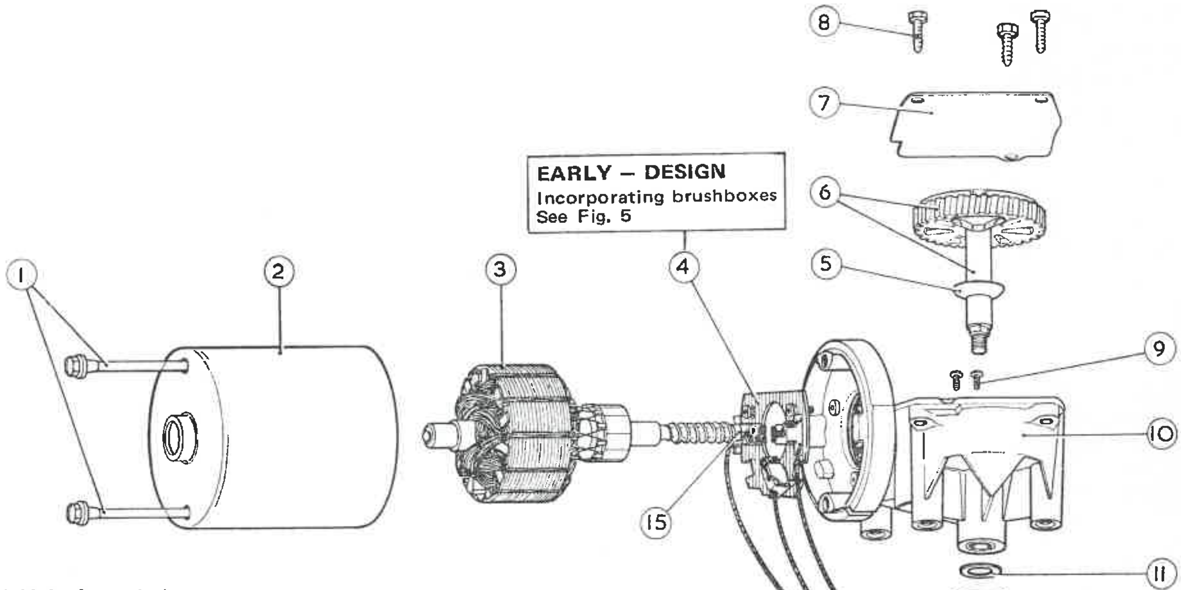
Following reassembly the motor may be noisy due to slight misalignment of the yoke bearing. This can be rectified by giving the rim of the gearbox a series of light taps with a plastic, fibre, or wooden mallet. Take care not to strike the yoke with the mallet, as this may cause damage to either the yoke or the permanent magnets, or both.

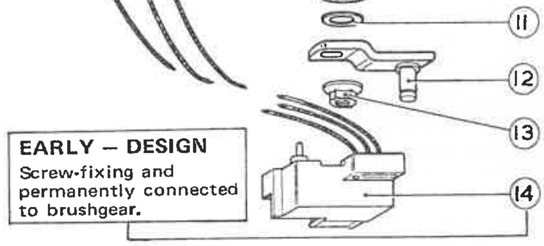


1 Yoke & gearbox assembly markings
2 Intermediate gear
3 Final gearwheel (showing assembly position of gearwheel in relation to shaft & link)
4 Armature end-float adjusting screw
5 Dished washer
6 Shaft & link assembly

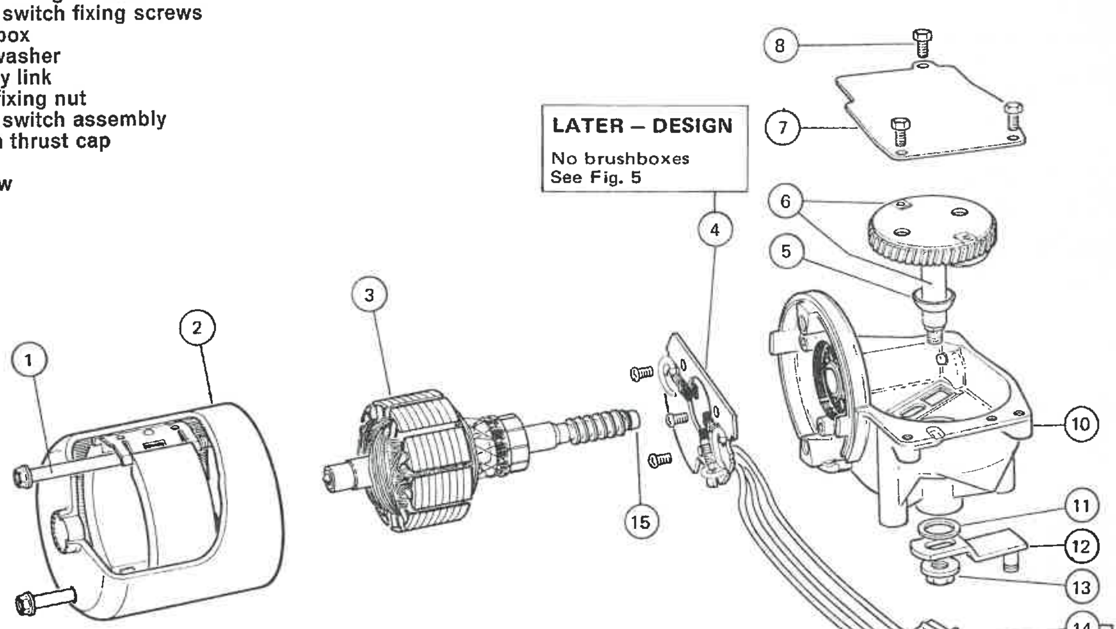
Fig. 5 Gearbox assembly

WINDSHIELD WIPER MODEL 15W





1 Yoke fixing bolts
2 Yoke assembly comprising: two permanent-magnet poles & retaining clips and armature bearing bush
3 Armature
4 Brushgear
5 'Dished' washer
6 Shaft and gear
7 Gearbox cover
8 Cover fixing screws
9 Limit switch fixing screws
10 Gearbox
11 Flat washer
12 Rotary link
13 Link fixing nut
14 Limit switch assembly
15 Nylon thrust cap
16 Blue
17 Yellow
18 Red



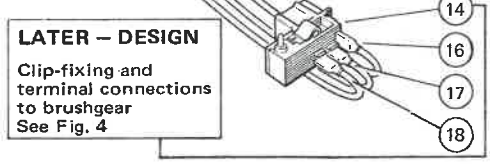
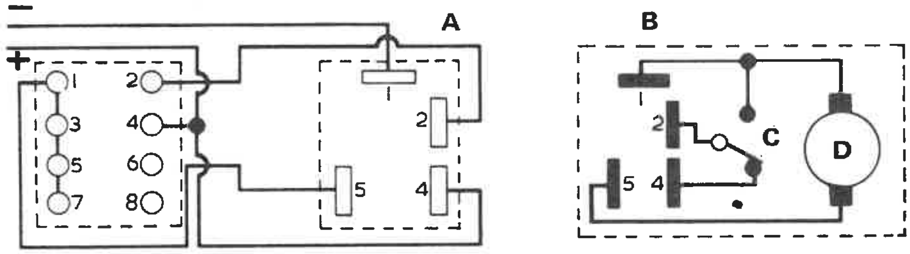


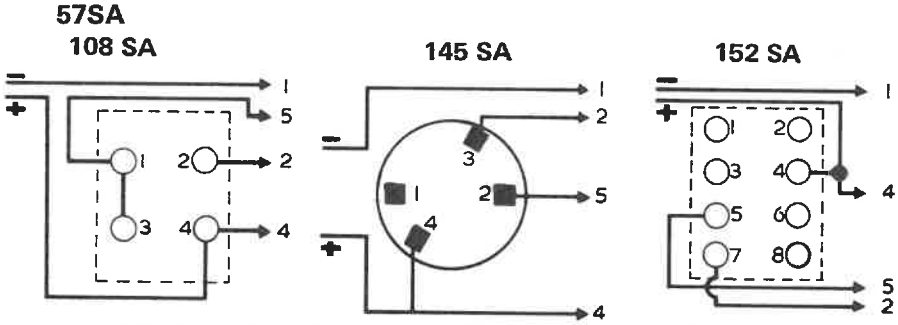
Fig. 1 Windshield Wiper Model 15W (two-speed)

NOTE: Third brush omitted for single-speed

Windshield Wiper Model 15W

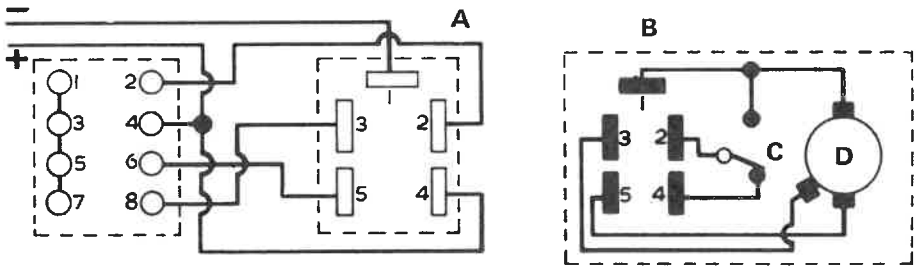
SINGLE SPEED

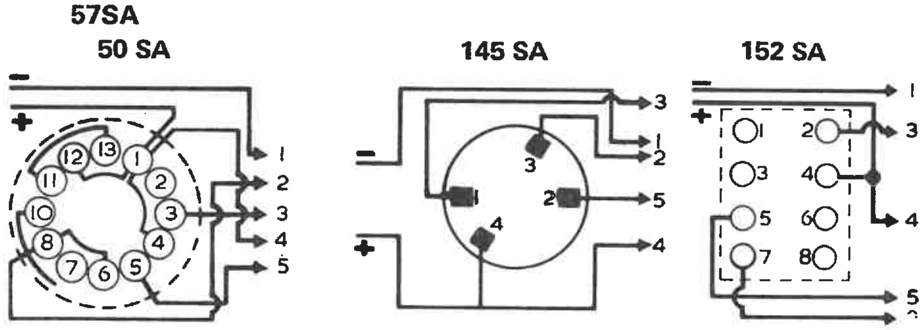




ALTERNATIVE SWITCHES INDICATING MOULDED TERMINAL CONNECTIONS

TWO SPEED





ALTERNATIVE SWITCHES INDICATING MOULDED TERMINAL CONNECTIONS

A Moulded terminal connector on cable harness
B Terminal connector on wiper motor
C Limit switch
D Armature

SWITCH INTERNAL CONNECTIONS	OFF	NORMAL SPEED	HIGH SPEED
57 SA (Single speed)	(1-2) (5-6)	(3-4) (5-6)	—
108 SA "	(1-2)	(3-4)	—
145 SA "	(2-3)	(2-4)	—
152 SA "	(5-7)	(4-5)	—
57 SA (Two speed)	(1-2) (5-6)	(3-4) (5-6)	(3-4) (7-8)
50 SA "	(1-2) (5-6) (10-11)	(13-1) (4-5) (8-10)	(12-13) (3-4) (7-8)
145 SA "	(2-3)	(2-4)	(1-4)
152 SA "	(5-7)	(4-5)	(2-4)

Fig. 2 Wiring diagrams for single and two-speed 15W wipers using typical switches

1. DESCRIPTION

Windshield wiper model 15W is designed to operate a link-type wiper installation. The motor is self-switching to the OFF (or park) position A two-pole permanent magnet field is provided by two ceramic magnets which form part of the yoke assembly. Inside the motor gearbox a worm gear on the armature shaft drives a shaft-and-gear assembly comprising a moulded gearwheel assembled to a location-plate-and-shaft. Power from the motor is transmitted through the gearwheel, location-plate-and-shaft to, finally, a rotary link which serves as a coupling between the motor and the links which operate the wiper arm spindles.

Associated with the terminal assembly is a two-stage plunger operated limit switch. The plunger is actuated by a cam on the underside of the moulded gearwheel inside the gearbox. When the manually-operated control switch is moved to OFF (or park) the motor continues to operate under the automatic control of the limit switch. As the wiper blades near the parked position the first-stage contacts open and the motor is switched off but continues to rotate under its own momentum. The second-stage contacts, to which are connected the positive and negative brushes, then close and regenerative braking of the armature takes place to maintain consistent parking of the blades.

The motor is produced in single and two-speed form. Two-speed operation is provided by a third (stepped) brush incorporated in the brushgear assembly. When the main control switch is moved to the high speed position, the positive feed to the normal brush is transferred to the third brush, and a higher-than-normal wiping speed is obtained. (The higher speed should not be used in heavy snow or on a partially wet windshield).

2. ROUTINE MAINTENANCE

All bearings are adequately lubricated during manufacture and require no maintenance.

Oil, tar spots or similar deposits should be removed from the windshield with methylated spirits (denatured alcohol). Silicone or wax polishes must not be used for this purpose.

Efficient wiping is dependent upon keeping wiper blades in good condition. Worn or perished blades are readily removed for replacement.

3. TECHNICAL DATA

	12-volt	*24-volt*
(i) Typical light running current (i.e. with the rotary link disconnected from the transmission) after 60 seconds from cold:	1.5 amp. (normal speed) 2.0 amp. (high speed)	0.8 amp. (normal speed) 1.0 amp. (high speed)

(ii) Light running speed of the rotary link after 60 seconds from cold:	46–52 rev/min (normal speed) 60–70 rev/min (high speed)

4. SERVICING

Note: Since the motor is of permanent magnet design, the direction of rotation of the armature depends on the polarity of the supply to its terminals. If it is necessary to run the motor while it is removed from the vehicle, the negative supply cable must be connected to motor terminal number 1 and the positive supply cable to terminal number 5 for normal speed or terminal number 3 for high speed. (See Fig. 2).

(a) Low Wiping Speed, Irregular Movement of the Blades, Noisy Operation

(i) Check wiper blades

Excessive friction between apparently satisfactory wiper blades and the windshield may result in a marked reduction in wiping speed when the blades are operating on a windshield that is only partially wet. A further symptom is that the blades become noisy at each end of the wiping arc.

Prove the blades by substitution.

(ii) Check motor performance

To determine whether a low wiping speed is due to excessive mechanical loading or to poor motor performance, the rotary link must first be disconnected from the transmission linkage and the light running current and speed of the motor can then be checked under no load conditions.

Measuring light running current and speed

Connect a moving-coil ammeter in series with the motor supply cable and measure the current consumption. Also check the operating speed by timing the speed of rotation of the rotary link. The appropriate current consumption and speed are given in 3. Technical Data.

If current consumption and speed are not as stated, an internal fault in the motor is indicated and a replacement unit should be fitted or the motor removed for detailed examination.

If current consumption and speed are correct, check for proper functioning of the transmission linkage and wiper-arm spindles.

(b) Wiper Motor Fails to Operate (Testing in situ)

Note: If a two-speed motor is capable of operating at one of its alternative speeds, ignore the following heading (i) and refer subsequent heading (ii).

(i) Check fuse

Check continuity of the fuse. If the fuse is found to be intact, check for good electrical contact between fuse and clips. If these checks are satisfactory, refer subsequent heading (ii).

If the fuse is found to be open-circuit, the cause of its failure must be ascertained.

Renew the fuse, and refer vehicle wiring diagram to determine whether the same fuse controls more than one circuit. If so, then each circuit must be operated alternately to determine which one is causing the fault. If open-circuiting of the fuse only occurs when the wiper control switch is operated (also select high-speed where applicable), then proceed as follows:-

Renew the fuse.

Disconnect the wiring plug from wiper motor.

Operate the wiper control switch, followed by high-speed position where applicable. (Ensure IGN/AUX switch is also operative.)

If the fuse remains intact, the wiper motor is proved faulty.

If the fuse again fails, the wiper motor wiring plug cables must be checked for a short-circuit fault. **Only terminal 1 of the wiring plug** (see Fig. 2 **A** for terminal arrangement) **should register 'earth'.** Check this with a voltmeter or test lamp of appropriate voltage (12V or 24V), one side connected to a convenient voltage supply source on the vehicle and the other side (earth side) connected alternately to each of the wiring plug terminals.

(ii) Check supply voltage and earth connection to wiper motor

Note : Testing requires the use of a voltmeter or test lamp of appropriate voltage (12V or 24V).

Disconnect the wiring plug from wiper motor.

Operate the wiper control switch. (If the motor is two-speed, select the appropriate speed which fails to function).

Check for supply voltage between wiring plug terminals 1 and 5 (in the case of single-speed, and two-speed motors switched to 'normal speed'), or terminals 1 and 3 (in the case of two-speed motors switched to high-speed). See Fig. 2 **A** for terminal arrangement. **The voltmeter should indicate supply voltage or the test lamp should light.**

If the test is satisfactory, the wiper control switch and associated wiring are eliminated and the wiper motor is proved faulty.

If the test is unsatisfactory, extend the test by transferring the voltmeter connection from wiring plug terminal 1 to a good earth point on the vehicle frame. **The voltmeter should indicate supply voltage or the test lamp should light.**

If this test is satisfactory, the wiper motor earth connection is faulty. Check continuity between wiring plug terminal 1 and frame.

If testing is still unsatisfactory, the wiper motor supply voltage is not available at the wiring plug terminal to which the voltmeter is connected (either terminal 3 or 5). Identify the colour of the appropriate one of these two cables at the wiper control switch, and check for supply voltage at the switch terminal of the cable.

If voltage is indicated, the cable is proved open-circuit.

If voltage is not indicated, check whether supply voltage is being applied to the input terminal of the switch. If so, the switch is confirmed faulty but otherwise the voltage supply source must be checked.

(c) Erratic Parking of Arms and Blades

Note : Testing requires the use of a voltmeter or test lamp of appropriate voltage (12V or 24V).

Disconnect the wiring plug from wiper motor.

Ensure wiper control switch is OFF.

Check for permanent supply voltage between wiring plug terminals 1 and 4 (see Fig. 2 **A** for terminal arrangement). **The voltmeter should indicate supply voltage or the test lamp should light.**

If the test is unsatisfactory, check continuity between wiring plug terminal 4 and supply voltage source.

If the test is satisfactory, extend testing by transferring the voltmeter or test lamp connection from wiring plug terminal 4 to terminal 5, and connect a test-link between terminals 2 and 4. (Other side of voltmeter or test lamp should still be connected to terminal 1).
The voltmeter should indicate supply voltage or the test lamp should light.

If this test is satisfactory, the wiper motor limit switch is proved faulty. (Individual testing of the limit switch unit is referred to in (e) Bench Inspection, sub-heading (i).

If testing is unsatisfactory, check continuity between wiring plug terminal 2 and wiper control switch. If continuity is satisfactory, the wiper control switch is proved faulty.

(d) Dismantling

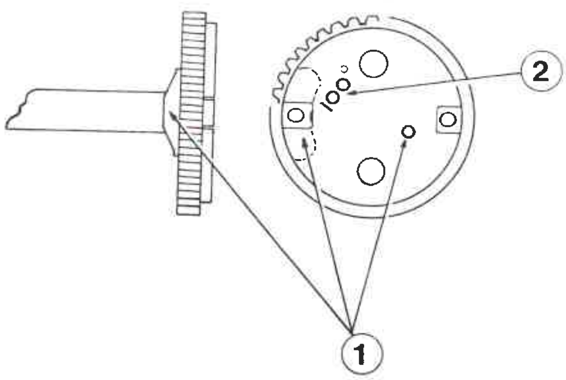
Remove the gearbox cover.

The rotary link may be fitted to the gearwheel shaft in one of two positions (180° apart) depending on the parking requirement of the windshield wiper installation. To ensure that the original parking position is maintained, the position of the rotary link in relation to the zero mark on the gearwheel location plate must be noted before removing the link.

IMPORTANT : The moulded gearwheel inside the gearbox must be prevented from moving while the rotary link fixing nut is slackened (or, on re-assembly, tightened). This is most easily achieved by securing the rotary link in a vice while the nut is turned.

Remove the fixing nut, rotary link and flat washer.

Remove the shaft-and-gear from the gearbox, taking care not to lose the dished washer fitted beneath the gearwheel. It is not normally necessary to dismantle the shaft-and-gear assembly since this is serviced only in an assembled condition. However, should it become necessary to assemble the moulded gearwheel to the location-plate-and-shaft, it is essential to fit the gearwheel in the correct one of the two alternative positions to maintain the original parking position of the wiper blades. The gearwheel is correctly fitted to the location-plate-and-shaft when the 'zero' mark on the location plate (see Fig. 3) is positioned furthest away from the gearwheel cam.



1 Position of gearwheel cam relative to position of zero mark on location plate **2** Gearwheel reference

Fig. 3 Shaft-and-gear assembly

Unscrew and remove the two fixing bolts from the motor yoke and carefully remove the yoke assembly and armature. While removed, the yoke must be kept well clear of swarf, etc., which may otherwise be attracted to the pole pieces.

Undo the two sets of fixing screws and remove from the gearbox the brushgear and the terminal and switch unit assemblies, linked together by the connecting cables. If the motor is late-design (see Fig. 1) the brushgear and limit switch can be dismantled as individual items. (Refer 'NOTE' Fig. 4).

(e) Bench Inspection

(i) Limit switch unit

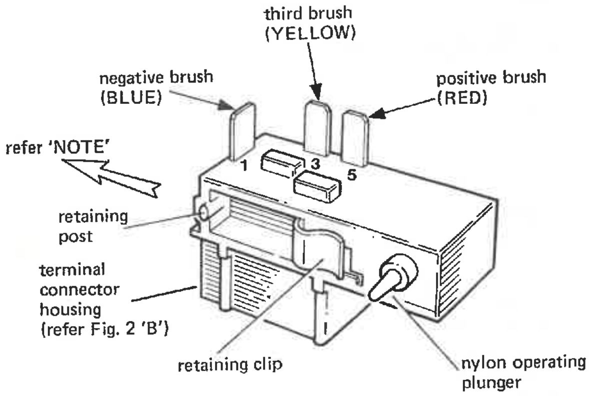


FIG 4 Later design limit switch.

Note : Lift, or prise, retaining post end of switch from gearbox, then remove switch from motor unit by sliding in direction of arrow.

Depress the limit switch operating plunger and allow it to freely return to its original position, which should be approximately 7 mm ($\frac{9}{32}$ in.) protruding from the switch body.

Follow with an electrical test, proving the first-stage and second-stage contacts (Self-switching and dynamic-braking contacts), as follows:-

With switch operating plunger in free position, use a battery-operated ohmmeter or test lamp and check for continuity between the connector housing terminals 2 and 4. (See Fig. 2 **B** for terminal arrangement).

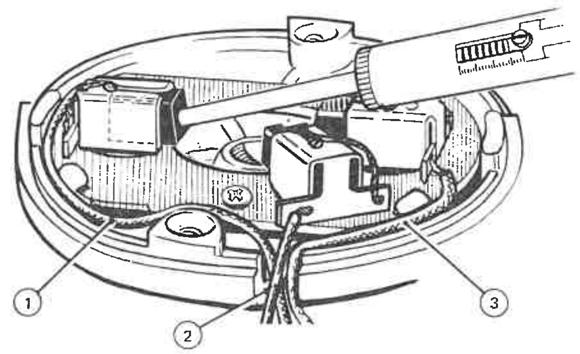
The ohmmeter should indicate a zero reading or the test lamp should light.

If the test is unsatisfactory, the limit switch is proved faulty and must be renewed.

If the test is satisfactory, extend testing by checking for continuity between the connector housing terminals 1 and 2 when the switch operating plunger is depressed approximately 1.5 mm ($\frac{1}{16}$ in). **The ohmmeter should indicate a zero reading or the test lamp should light.**

If this test is unsatisfactory, the limit switch is proved faulty and must be renewed.

Note : In the event of the limit switch being renewed, it is important to re-connect the cables in accordance with Fig. 4 or Fig. 5.



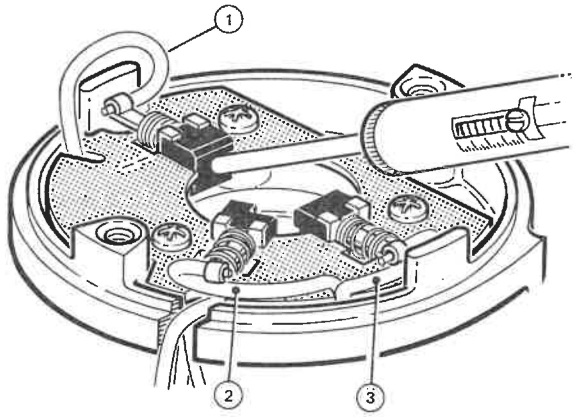


Fig. 5 Later design limit switch. Checking brush spring pressure. Identification of cable connections.

Press brush to position indicated by broken line. Spring pressure should then be 1·7 N (6ozf or 170gf.).

NOTE: Alternatively, the gauge could be dial-type.

1. Negative brush cable (Blue).
2. Third brush cable two-speed (Yellow).
3. Positive brush cable (Red).

(ii) Brush replacement

The original specified length of the brushes is sufficient to last the life of the motor. If due to accidental damage to the brushes, or faulty commutator action, it becomes necessary to renew the brushes, the complete brushgear service-assembly must be fitted. The brushgear assembly must be renewed if the main (diametrically-opposed) brushes are worn to 4.8 mm ($\frac{3}{16}$ in.), or if the narrow section of the third brush (2-speed units only) is worn to the full width of the brush.

Check that the brushes move freely.

Note : A standardised service-replacement brushgear assembly incorporates a third (stepped) 2-speed brush, which should be ignored for single-speed applications.

(iii) Checking brush springs

The design of the brushgear does not allow for easy removal of the brush springs. This is due to the fact that, similar to the brushes, the springs are expected to last the life of the motor and should not normally require renewing. In the unlikely event of the spring pressure failing to meet the specified requirements, the complete brushgear service-assembly must be renewed, in a similar manner to that necessary for servicing the brushes.

Check the spring pressure in accordance with Fig. 5.

Note : In the event of the brushgear being renewed, it is important to re-connect and position the cables in accordance with Fig. 4, or Fig. 5.

(iv) Testing and servicing the armature

Use armature testing equipment to check the armature windings for open and short-circuits.

Test the soundness of the armature insulation by using a mains test lamp (Fig. 6). Lighting of the lamp indicates faulty insulation.

If the commutator is worn, it can be lightly skimmed while the armature is mounted in a lathe.

Afterwards, clear the inter-segment spaces of copper swarf.

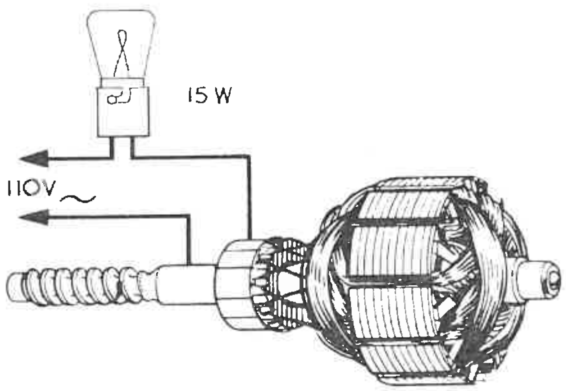


Fig. 6 Armature insulation test

(v) Inspection of moulded gear

Examine the gearwheel, especially the teeth, for signs of wear or damage. If the gearwheel needs renewing, a shaft-and-gear service replacement assembly will have to be fitted.

(f) Re-assembly

This is generally a reversal of the dismantling procedure detailed in 4(d) but special consideration should be given to the following:-

Lubrication

Smear Ragosine Listate grease on the gearwheel teeth and the worm gear on the armature shaft.

Apply Shell Turbo 41 oil to the bearing bushes, armature shaft bearing surfaces (sparingly), gear-wheel shaft, and the felt-oiler washer in the yoke bearing (thoroughly soak).

Assembly of gearwheel and rotary link

Ensure the dished washer is fitted to the shaft beneath the gearwheel, concave side of washer to gearwheel (see Fig. 1, item 5). Also ensure the thrust-washer is fitted between the gearbox and rotary link (see Fig. 1, item 11) and that the rotary link is refitted correctly in one of two possible positions 180° apart on the shaft. (This should have been ascertained prior to dismantling the rotary link from the shaft. Previous sub-heading (d), first para. refers).

Tighten the rotary link fixing nut to a torque of 20.33-22.65 Nm (2.1-2.3 kgf m) (180-200 lbf in).

Refitting the yoke

Before refitting the armature to the yoke (or vice versa) inspect the inside of the yoke and ensure that the thrust disc and the felt-oiler washer are in place in the yoke bearing. The correct method of assembly is with the thrust disc flat against the end face of the bearing, followed by the felt-oiler which must have a hole in the centre to allow the captive ball bearing in the end of the armature shaft to contact the thrust disc.

IMPORTANT: to ensure correct rotation of the motor, the marking on the yoke must be adjacent to the arrow-head marking on the gearbox rim.

The yoke fixing bolts should be tightened to a torque of 1.35–1.80 Nm (12–16 lbf in.) (0.138–0·184 kgf m).

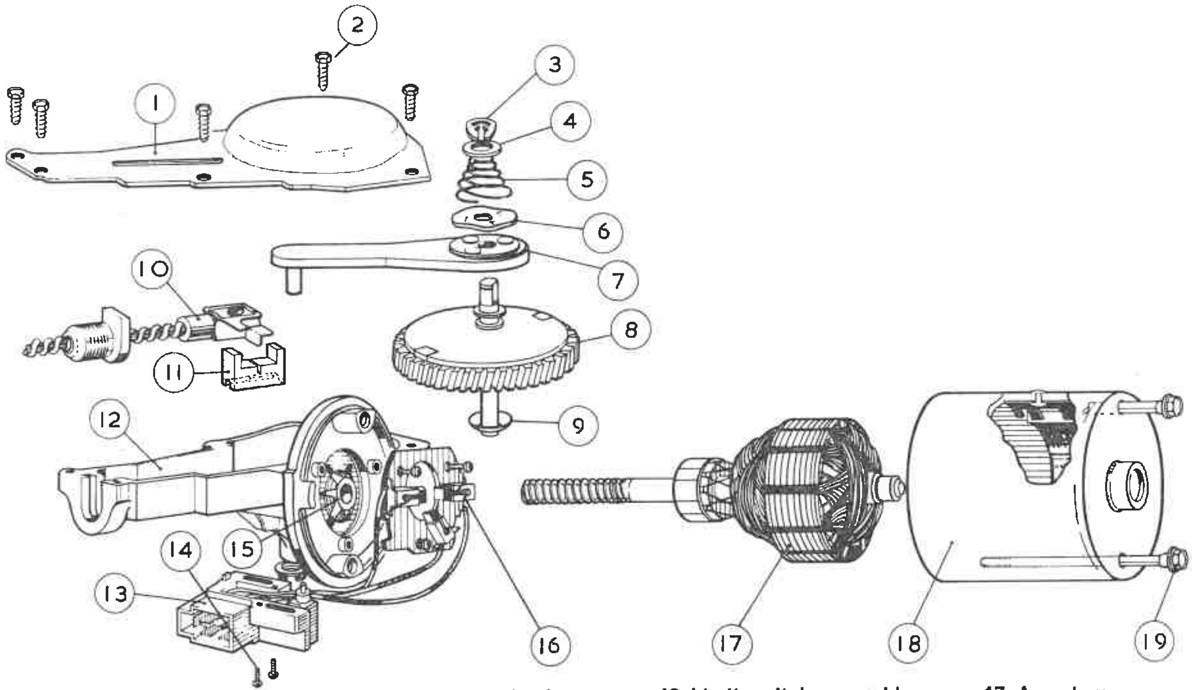
Armature end-float adjustment

Armature end-float is 0.05–0.25 mm (0.002–0.010 in.).

A service replacement armature should be provided with a thrust screw and locknut as a packaged sundry. This adjustable type thrust screw is for use in replacing the original non-adjustable type (when fitted), as adjustment to the armature end-float will probably be necessary after renewing the armature.

To obtain a satisfactory end-float adjustment with the motor and gearbox completely assembled, position the unit with the thrust screw uppermost, tighten the thrust screw until abutment takes place and then slacken it off one quarter turn and secure it in this position by tightening the locknut to a torque of 2.25–2.82 Nm (20–25 lbf in.) (0.23–0.30 kgf m).

WINDSHIELD WIPER MODEL 16W



1 Gearbox cover
2 Screw (gearbox cover fixing)
3 Circlip
4 Washer
5 Conical spring
6 Friction plate
7 Connecting rod assembly including eccentric cam
8 Moulded gearwheel
9 'Dished' washer
10 Cable rack with cross-head and outer casing ferrule
11 Moulded slider block (cable rack attachment) limit-switch operating
12 Gearbox
13 Limit-switch assembly
14 Screws (Limit-switch fixing)
15 Self-aligning bearing bush
16 Brushgear, comprising: Insul plate and brush-boxes, brushes, springs, fixing screws
17 Armature
18 Yoke assembly, comprising: Two permanent-magnet poles and retaining clips and armature bearing bush
19 Bolts (yoke fixing)

Fig. 1 Windshield Wiper Motor Model 16W (two speed)

1. DESCRIPTION

Windshield wiper model 16W comprises a two-speed self-parking power unit which drives two wiper arm wheelboxes by means of a flexible cable rack running through a rigid tube. The two-pole motor has a permanent magnet field consisting of two ceramic magnets housed in a cylindrical yoke. A worm gear formed on the extended armature shaft drives a moulded gearwheel within the die-cast gearbox. Motion is imparted to the cable rack by a connecting rod and crosshead actuated by a crankpin carried on the gearwheel.

The gearbox incorporates the self-parking mechanism which automatically parks the wiper blades at the end of the wiping cycle in which the manually-operated control is switched off. The self-parking action is achieved by contacts inside the control switch which automatically reverse the polarity of the supply connections to the motor. This causes the motor to operate in the opposite direction to normal rotation during the parking cycle. The reversing action of the motor causes an eccentric cam in the crankpin bearing part of the connecting rod to rotate independently, enabling the connecting rod movement to be extended beyond its normal travel. This extended movement of the connecting rod is used to move a moulded slider-block into a position where a cam on its underside strikes the operating plunger of a limit switch (part of the terminal assembly unit) and first-stage contacts inside the switch are opened to switch off the motor. Following a momentary period during which no contact is made by the limit switch, continued momentum of the motor and further movement of the switch operating plunger closes second-stage contacts inside the switch and this causes regenerative braking of the armature which maintains consistent parking of the wiper blades. Two-speed operation is obtained by switching the positive feed to the third brush (with a stepped contact face) when the second (higher) speed is selected by the control switch.

Note : Alternative Parking Position

To change the parking position of the wiper blades from one side of the windshield to the other (to suit either right-hand or left-hand drive vehicles) the moulded slider-block and limit-switch unit must be re-positioned by turning through 180°. To reposition the slider block, first dismantle the connecting rod as detailed in 'Dismantling the Motor', para. 4(b). To reposition the limit-switch unit, the switch operating plunger must be located in the alternative slot provided in the gearbox, after the unit has been turned through 180°. The switch fixing screw holes are elongated to allow adjustment of the switch operating position.

WARNING. Whenever the slider-block or limit-switch and terminal assembly unit are dismantled, it is essential on reassembly to maintain the correct operating relationship between the cam of the slider block and the switch operating plunger, otherwise damage will occur when the motor is started. The slider-block has a slot machined in each of its two end faces, these slots being of unequal depth. To ensure correct operation of the parking sequence the slider-block must be re-assembled with the deeper of these slots facing the switch operating plunger.

2. ROUTINE MAINTENANCE

All bearings are adequately lubricated during manufacture and require no maintenance.

Oil, tar spots or similar deposits should be removed from the windshield with methylated spirits (denatured alcohol). Silicone or wax polishes must not be used for this purpose.

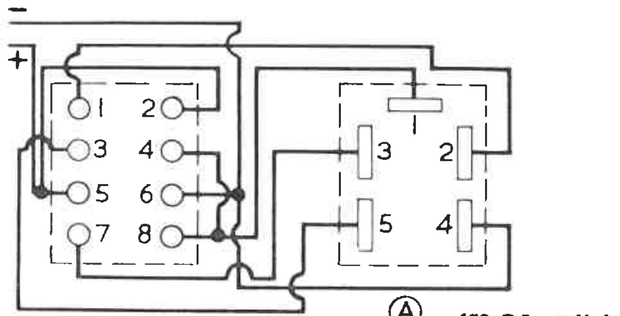
Efficient wiping is dependent upon keeping wiper blades in good condition. Worn or perished blades are readily removed for replacement.

3. TECHNICAL DATA

	12-volt	*24-volt*
(i) Typical light running current (i.e. with cable rack disconnected) after 60 seconds from cold:	1.5 amp. (normal speed) 2.0 amp. (high speed)	0.8 amp. (normal speed) 1.0 amp. (high speed)
(ii) Light running speed after 60 seconds from cold:	46–52 rev/min 60–70 rev/min	(normal speed) (high speed)

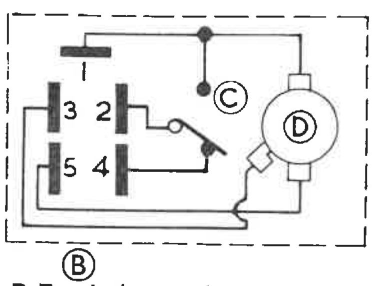
4. SERVICING

Note: Since the motor is of permanent magnet design, the direction of rotation of the armature depends on the polarity of the supply to its terminals. If it is necessary to run the motor while it is removed from the vehicle, the negative supply cable should be connected to motor terminal number 1 and the positive supply cable to terminal number 5 for normal speed or terminal number 3 for high speed. (See Fig. 2).

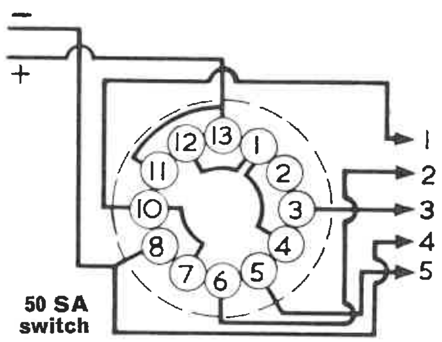


A Moulded terminal connector on cable harness

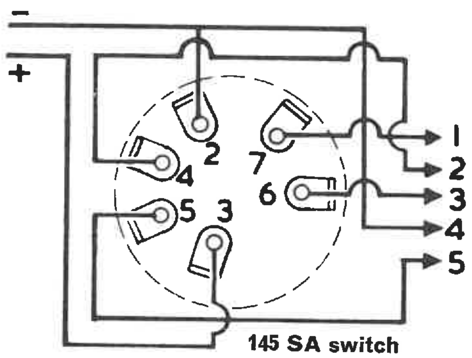
152 SA switch



B Terminal connector on wiper motor
C Limit switch **D** Armature



50 SA switch



145 SA switch

ALTERNATIVE SWITCHES INDICATING MOULDED TERMINAL CONNECTIONS

SWITCH INTERNAL CONNECTIONS	OFF	NORMAL SPEED	HIGH SPEED
152 SA	(1–3) (2–4)	(3–5) (4–6)	(5–7) (6–8)
50 SA	(1–2) (5–6) (10–11)	(13–1) (4–5) (8–10)	(12–13) (3–4) (7–8)
145 SA	(4–5) (3–7)	(3–5) (2–7)	(3–6) (2–7)

Fig. 2 Wiring diagram using typical switches

(a) Systematic Check of Faulty Wiping Equipment

Unsatisfactory operation (if the supply voltage to the motor is adequate) may be caused by a fault that is mechanical or electrical in origin. Before resorting to dismantling, consideration should be given to the nature of the fault.

The symptoms and remedial procedure associated with the more common causes of wiper failure (or poor performance) are described in (i) and (ii) below.

(i) Frictional Wiper Blades

Excessive friction between apparently satisfactory wiper blades and the windshield may result in a marked reduction in wiping speed when the blades are operating on a windshield that is only partially wet.

A further symptom is that the blades become noisy at each end of the wiping arc. When possible the blades should be temporarily replaced with a pair known to be in good condition. If this rectifies the fault, fit new blades.

(ii) Low Wiping Speed or Irregular Movement of the Blades

To determine whether a low wiping speed is due to excessive mechanical loading or to poor motor performance, the cable rack must first be disconnected as described at the commencement of 'Dismantling the Motor' in 4(b).

Measuring Light Running Current and Speed

Connect a first-grade moving-coil ammeter in series with the motor supply cable and measure the current consumption. Also check the operating speed by timing the speed of rotation of the moulded gear. The current consumption and speed(s) should be as given in para. 3.

If the motor does not run, or current consumption and speed are not as stated, an internal fault in the motor is indicated and a replacement unit should be fitted or the motor removed for detailed examination (see 4b & c).

If current consumption and speed are correct, check the cable rack and wheelbox spindles.

Checking Cable Rack and Tubing

Remove the wiper arms and blades and push the cable rack fully home in its tubing.

Hook a spring balance in the hole on the cross-head (into which the pin on the connecting rod normally locates) and withdraw the rack with the balance. The maximum permissible force required is 6 lbf (2.72 kgf).

Badly kinked or flattened tubing must be replaced and any bends of less than 9 in. (228 mm) radius must be reformed. Examine the cable rack for signs of damage to the helix.

Checking Wheelboxes

Check the wheelbox spindles for freedom of rotation. Seized units, or those suspected of having damaged gear teeth, must be replaced.

(b) Dismantling the Motor

Withdraw the gearbox cover fixing screws and lift off the cover.

Prise the circlip from the groove in the gearwheel crankpin and remove, in the following sequence, the flat washer, conical spring, wavy friction-plate, connecting rod assembly and another (smaller) flat washer which fits next to the gearwheel.

Remove the circlip and washer securing the shaft and gear.

Before proceeding further, use a smooth file to remove any fraze from the gear shaft. Failure to do this may result in the bearing being scored when the gear is withdrawn.

Remove the gear taking care not to lose the dished washer fitted beneath it.

Note: Before removing the yoke assembly observe how the yoke and gearbox are marked so that it may be re-assembled in its original position.

Unscrew and remove the two fixing bolts from the motor yoke and carefully remove the yoke assembly and armature. While removed, the yoke must be kept well clear of swarf, etc., which may otherwise be attracted to the pole pieces.

Remove the screws which secure the brushgear and the terminal and switch unit and detach from the gearbox both assemblies, linked together by the connecting cables.

(c) Bench Inspection

After dismantling, examine individual items.

(i) Brush Replacement

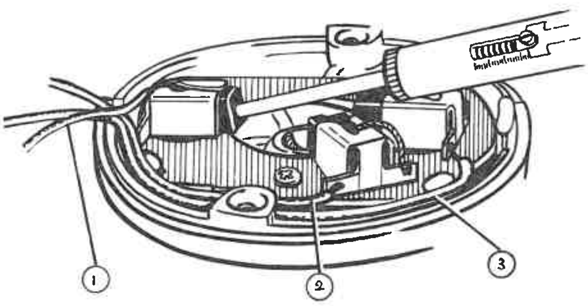
The original specified length of the brushes is sufficient to last the life of the motor. If due to accidental damage to the brushes, or faulty commutator action, it becomes necessary to renew the brushes, the complete brushgear service assembly must be fitted. The brushgear assembly must be renewed if the main (diametrically-opposed) brushes are worn to $\frac{3}{16}$ in (4.8 mm), or if the narrow section of the third brush is worn to the full width of the brush.

Check that the brushes move freely in the boxes.

(ii) Checking Brush Springs

The design of the brushgear does not allow for easy removal of the brush springs. This is due to the fact that, similar to the brushes, the springs are expected to last the life of the motor and should not normally require renewing. In the unlikely event of the spring pressure failing to meet the specified requirements, the complete brushgear service assembly must be replaced in a similar manner to that necessary for servicing the brushes.

To check the spring pressure press on the end face of the brush with a push-type spring gauge (see Fig. 3) until the bottom of the brush is level with the bottom of the slot in the brush box, when the spring pressure reading should be 5–7 ozf (140–200 gf).



1 Cable colour blue & green 2 Cable colour yellow & green
3 Cable colour red & green

Fig. 3 Checking brush spring pressure

Note: In the event of the brushgear being renewed, it is important to re-connect and position the cables in accordance with Fig. 3.

(iii) Testing and Servicing the Armature

Use armature testing equipment to check the armature windings for open and short circuits.

Test the soundness of the armature insulation by using a mains test lamp (Fig. 4). Lighting of the lamp indicates faulty insulation.

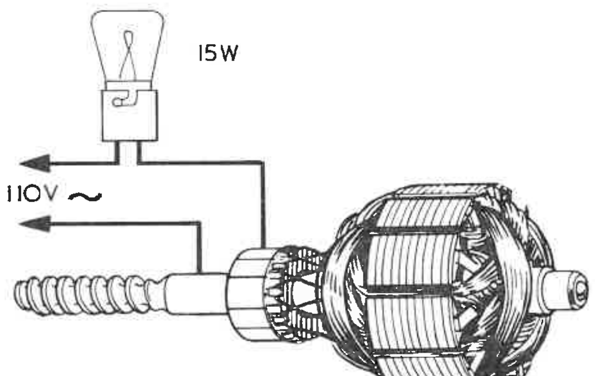


Fig. 4 Armature insulation test

If the commutator is worn, it can be lightly skimmed while the armature is mounted in a lathe.

Afterwards, clear the inter-segment spaces of copper swarf.

(iv) Inspection of Moulded Gear

Examine the gearwheel, especially the teeth, for signs of wear or damage. If necessary, a replacement must be fitted.

(d) Re-assembly

This is generally a reversal of the dismantling procedure detailed in 4(b) but special consideration should be given to the following:

Lubrication

A liberal quantity of Ragosine Listate grease is necessary for lubricating all moving parts inside the gearbox.

Apply Shell Turbo 41 oil to the bearing bushes, armature shaft bearing surfaces (sparingly), gearwheel shaft, and the felt-oiler washer in the yoke bearing (thoroughly soak).

Re-assembly of Yoke

Before refitting the armature to the yoke inspect the inside of the yoke and ensure that the thrust disc and the felt-oiler washer are in place in the yoke bearing. The correct method of assembly is with the thrust disc flat against the end face of the bearing, followed by the felt-oiler washer which must have a hole in the centre to allow the captive ball bearing in the end of the armature shaft to contact the thrust disc.

If the felt-oiler is renewed, check that the replacement is provided with the necessary hole and, if not, make a $\frac{1}{8}$" (3 mm) diameter hole in the centre of the felt. (A felt-oiler without a hole could result in the armature end-float becoming excessive in service due to the ball bearing wearing away the felt after the end-float adjustment has been made). Soak the felt-oiler in Shell Turbo 41 oil.

The yoke fixing bolts should be tightened to a torque of 12–16 lbf in. (0.138–0.184 kgf m). If a service replacement armature is being fitted, it is advisable to first slacken the armature end-float thrust screw before tightening the yoke fixing bolts. Afterwards, reset the thrust screw.

Armature End-Float Adjustment

Armature end-float is 0.002"–0.008" (0.05–0.2 mm). To obtain a satisfactory end-float adjustment with the motor and gearbox completely assembled, position the unit with the thrust screw uppermost, tighten the thrust screw until abutment takes place and then slacken it off one quarter turn and secure it in this position by tightening the locknut.

Assembly of Gearwheel and Connecting Rod

Ensure that the self-parking mechanism and connecting rod are re-assembled to the crankpin in the sequence of assembly illustrated in Fig. 1. Fit the smaller of the two flat washers beneath the connecting rod.

SWITCHGEAR AND RELAYS

INDEX

Issue 3 November 1967
Supersedes Issue 2 October 1966

ALTERNATOR WARNING LIGHT CONTROL MODEL 3AW

1. DESCRIPTION

(a) Application

Alternator Warning Light Control Model 3AW, is a thermally operated relay for controlling the switching on and off of a facia panel warning light. It is connected through alternator terminal 'AL' to the centre point of one pair of the six alternator diodes, and to earth (or return wiring). The indication given by the warning light is similar to that provided by the ignition (or 'No Charge') warning light used with dynamo charging systems. The warning light is illuminated when the alternator is stationary or is being driven very slowly. The light is switched off as soon as the alternator voltage begins to rise. If the voltage does not rise for any reason — a broken alternator driving belt for example — the warning light remains illuminated.

The unit is suitable for use with earth return installations of either polarity and with insulated return wiring. It can be used with either 12-volt or 24-volt alternators. When used in 24-volt installations, an external ballast resistor is connected between terminal 'AL' on the unit and 'AL' on the alternator.

The full circuit is shown in Fig. 2.

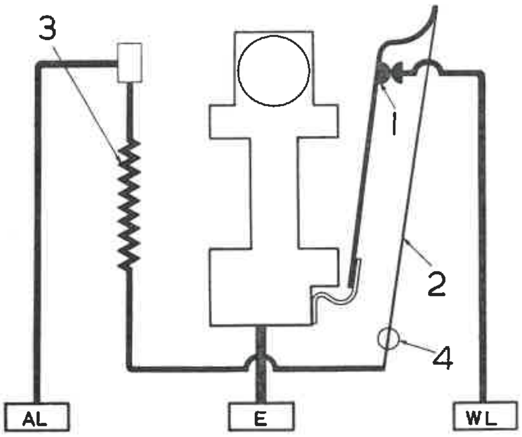


Fig. 1

Internal circuit, showing

1 Contacts
2 Actuating wire
3 Ballast resistor
4 Glass bead

Another application is to control the diesel engine starting aid inhibitor relay used on 12-volt circuits, in addition to the charge indicator warning lamp bulb.

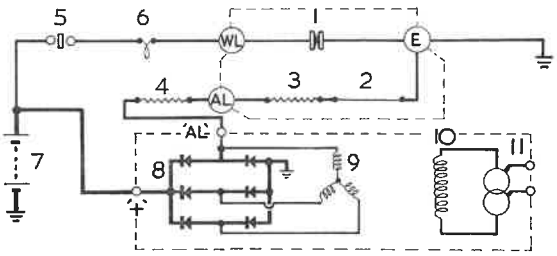


Fig. 2
Circuit of warning light control, battery and alternator, showing

1 Contacts
2 Actuating wire
3 Internal ballast resistor
4 External ballast resistor (24-volt units only)
5 Ignition switch
6 Warning light
7 Battery
8 Alternator diodes
9 Stator windings
10 Rotor winding
11 Slip rings

Caution: Because of the external similarity of the Alternator Warning Light Control Model 3AW to Flasher Unit Model FL5, a distinctive green label is applied to the aluminium case of model 3AW. Care must be taken to avoid connecting either of these units into a circuit designed for the other.

Alternator Warning Light Control Model 3AW

(b) Operation

The unit consists essentially of a pair of contacts held closed against spring tension by a length of nickel-chrome resistance wire. When cold, the wire is in tension: when current flows through the wire, it heats up and lengthens, allowing the contacts to open.

When the ignition switch (or equivalent device on diesel engine vehicles) is closed, current flows from the battery, through the ignition switch (or equivalent) and panel warning light to terminal 'WL' on the unit; thence, across the closed contacts, down the moving contact arm and hinge spring to terminal 'E', and back to the battery. The warning light is then illuminated.

When the engine is started (and providing the charging system is operating and in working order), a small low-voltage current from the alternator enters the unit by terminal 'AL', passes through the internal ballast resistor and actuating wire, down the moving contact arm and out through terminal 'E'. This current heats the actuating wire and causes it to lengthen. The actuating wire is resistance-brazed to the upper end of the moving contact arm which, being spring loaded at its lower end by the hinge spring, moves away from the fixed contact. The warning light circuit is thus interrupted and the light goes out.

2. ROUTINE MAINTENANCE

The unit is sealed and no routine maintenance is necessary.

3. TECHNICAL DATA

(a) Resistance values

Resistance of actuator wire and internal ballast resistor (measured with an ohmmeter connected between terminals 'AL' and 'E'):	14–16 ohms
Resistance of external ballast resistor (used in 24-volt circuits only):	14–16 ohms

(b) Ratings of Associated Warning Light Bulbs

12-volt installations:	2.2 watts (Lucas Bulb No. 987, M.E.S. cap, 11 mm dia. envelope).
24-volt installations:	2.8 watts (Lucas Bulb No. 650, M.E.S. cap, 11 mm dia. envelope; or Lucas Bulb No. 993, M.E.S. cap, 15 mm dia. envelope).

(c) Terminals

The unit has three blade-type terminals conforming to British Standard AU17. The unit can also be plugged into the standard S.A.E. socket adaptor.

4. SERVICING

(a) Replacement procedure

Caution: A faulty diode in the alternator or an intermittent or open circuit in the alternator-to-battery circuit can cause excessive voltages to be applied to the warning light control. Therefore, to prevent possible damage to the replacement unit, it is important first to measure the voltage between the alternator terminal 'AL' and earth (or return wiring), using a first-grade 0–20-volt moving coil voltmeter.

To check the voltage at alternator terminal 'AL', run the machine at 3,000 rev/min. The voltage should be of the order 7 to 7.5 volts (12-volt alternator) or 14–15 (24-volt). If a higher voltage is indicated, first check all charging circuit connections and then, if necessary, the alternator diodes (as described in PART A) before fitting a replacement unit. In the case of a low voltage, check the alternator (as described in PART A).

If the voltage at terminal 'AL' is satisfactory, proceed as described below.

(b) Testing in Position

Symptom	*Action*
Warning light fails to illuminate when the ignition switch (or equivalent) is turned on	Check the warning light bulb. Check the warning light control, if possible by substitution. If a substitute unit is not readily available, check the original unit in situ, as follows. Move the ignition switch (or equivalent) 'ON' and use a test link or the blade of a small screwdriver to connect together terminals 'WL' and 'E' of the warning light control. If the test results in the warning light being illuminated, this proves that the warning light control is faulty and the unit should be renewed.

	If the test does not result in the warning light being illuminated, a fault is indicated in the external circuit of the warning light control. Check all wiring and connections between the warning light control terminal 'WL' and battery feed to the switch, and check wiring and connections between the warning light control terminal 'E' and frame (or between 'E' terminal and return wiring side of the battery in the case of insulated-return vehicles). If the circuit wiring and connections are satisfactory, check the continuity of the warning light bulbholder and switch. **Note:** The warning light bulb should previously have been checked.
Warning light fails to go out when the alternator is being driven.	Check warning light control by substitution.
	Check the continuity of the circuit between terminals 'AL' on the alternator and warning light control.
Warning light shows intermittent flickering light.	Check for loose wiring connections.
	Check warning light control by substitution.

(c) Bench Testing

The performance of the warning light control can be checked with a 12-volt battery (having exposed intercell connectors) and a 12-volt test lamp.

(i) Connect the battery and test lamp in series with the 'WL' and 'E' terminals of the warning light control (see Fig. 3). **The bulb should light.**

Leave the battery and test lamp connected and proceed to further testing (para ii).

(ii) Connect terminal 'AL' of the warning light control to a 6-volt tapping on the battery (Connection 1, Fig. 3). **The bulb should go out within five seconds.**

Transfer the 'AL' connection to a 12-volt tapping on the battery (Connection 2, Fig. 3) and maintain this connection for ten seconds, then immediately transfer the connection to a 2-volt tapping on the battery (Connection 3, Fig. 3). **The bulb should light within five seconds.**

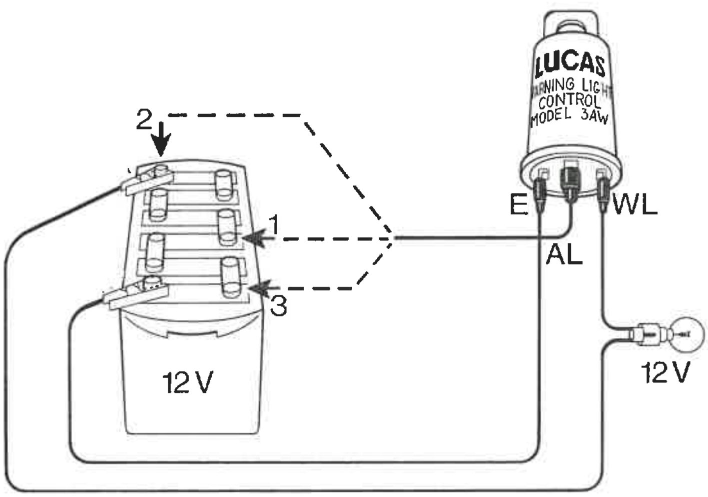
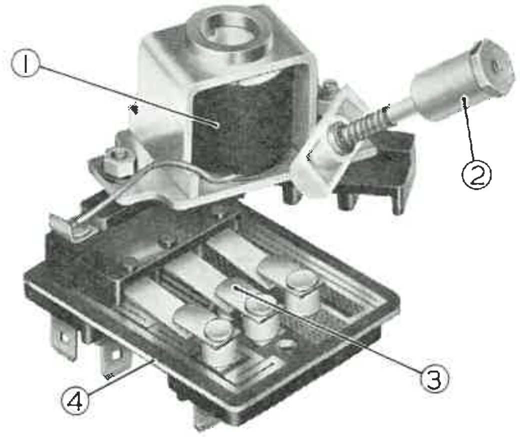


Fig. 3 Bench testing the Warning Light Control
(Broken lines indicate sequence of alternate connections)

TWO-LEVEL SIGNALLING RELAY MODEL 11RA

1. DESCRIPTION

The purpose of this relay is to connect resistors in series with the rear direction indicators and brake lights to reduce their illumination intensity at night. Relays having blue covers cause a reduction in light intensity of 2:1, while those with yellow covers give a 4:1 reduction. The relay employed depends on the optical design of the signalling lamps on the vehicle. If relay renewal becomes necessary in service, the appropriate replacement unit must be used to achieve the correct degree of dimming.



1 Solenoid
2 Plunger
3 Contact assemblies
4 Base plate (with printed circuit resistors)

Fig. 1 Relay dismantled to show construction

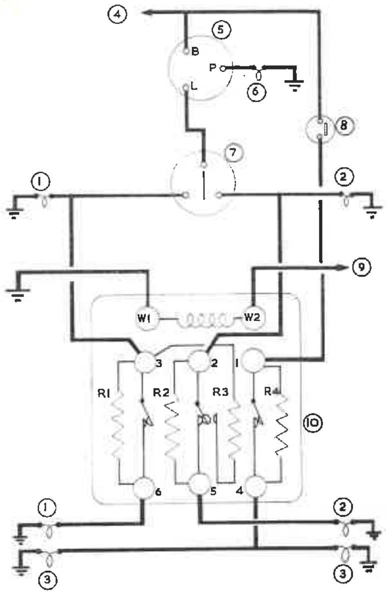
Fig. 1 illustrates the construction of the relay, while Fig. 2 shows its internal connexions, together with the complete circuit diagram of the two-level signalling system.

The relay is of triple pole design, having two sets of normally closed contacts and one set of changeover contacts. The resistors are in the form of a printed circuit (except in 24 volt units when R3 is a separate wire-wound component).

The operating coil is fed from the lighting switch, being energised at all times when side or head lamps are in use. Operation of the relay causes the normally closed contacts to open, connecting resistors R1, R2 and R4 into the circuits of the rear signalling lamps as shown. At the same time, resistor R3 is connected between relay terminals 2 and 3: when either pair of direction indicators are flashing, an additional current flowing through R3 and the filament of the non-operative lamps to earth compensates for the reduced current taken by the dimmed rear lamp, so maintaining the designed flashing rate.

2. ROUTINE MAINTENANCE

None required, apart from ensuring that terminal connexions are secure.



1 Direction-indicator lamps (L.H.)
2 Direction-indicator lamps (R.H.)
3 Brake lamps
4 To ignition switch
5 Flasher unit
6 Pilot warning lamp
7 Direction-indicator switch
8 Brake lamp switch
9 To side and tail lamp switch
10 Relay

Fig. 2 Internal connexions of 11RA relay and circuit diagram of two-level signalling system (External connexions shown in heavy line)

3. TECHNICAL DATA

	Part No.	*33245*	*33248*	*33267*
(i)	Nominal voltage	12	12	24
(ii)	Colour of cover	Yellow	Blue	Blue
(iii)	Nominal resistance of operating coil (ohms)	36	36	143
(iv)	Nominal resistor values (ohms):			
	R1, R2	2.75	1.35	4.9
	R3	70	70	270
	R4	1.6	0.42	1.45
(v)	Cut-in voltage	5–10	5–10	10–20
(vi)	Drop-off voltage	1 (min.)	1 (min.)	2 (min.)

4. SERVICING

Moulded covers are available as spares. Otherwise servicing is by replacement of the complete unit.

(a) Checking Cut-in and Drop-off Voltages

If the relay is removed from the vehicle, place it in its normal mounting position, i.e. with "TOP" on moulded cover uppermost.

Remove the moulded cover.

TWO-LEVEL SIGNALLING RELAY MODEL 11RA

1 Direct current supply
2 Rheostat
3 Relay
4 Voltmeter

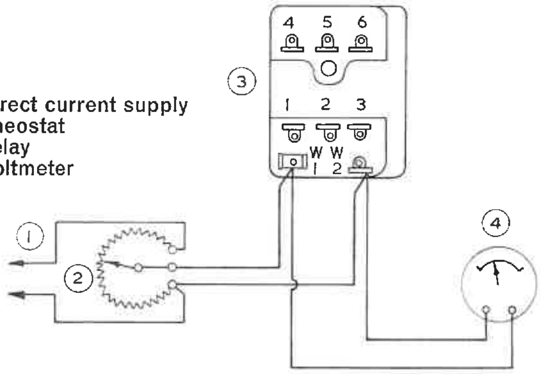


Fig. 3 Test circuit for checking cut-in and drop-off voltages

Connect a d.c. supply of appropriate nominal voltage, with rheostat control, to terminals W1 and W2, together with a first-grade moving coil voltmeter (Fig. 3).

Slowly increase voltage from zero, when relay should be seen to operate between the cut-in limits given in para 3(v).

Raise voltage to nominal working value.

Slowly decrease voltage until relay drops off. This should occur at a value exceeding the minimum given in para 3(vi).

If cut-in and drop-off voltages are not in accordance with those specified, a new relay must be fitted.

(b) Mechanical Setting

Adjustment of mechanical setting will not be necessary in normal service. The following instructions are given only to enable the original setting to be restored should it have been disturbed.

Remove the moulded cover.

Turn hexagonal end of relay plunger fully clockwise.

Energise operating coil with supply of appropriate nominal voltage.

Turn plunger anticlockwise until the lower normally-open contacts (i.e. those associated with R3) just close. This should be indicated electrically, using a continuity tester connected between relay terminal 2 and the rivet securing the lower fixed contact, accessible on the underside of the base.

Turn the plunger a further 90° in an anticlockwise direction, plus any further small rotation necessary to align the hexagon with the recess in the moulded cover, when fitted.

Remove the supply from the operating coil.

Finally, refit the moulded cover.

RELAY UNIT MODEL 2TU

1. DESCRIPTION

This unit enables the direction-indicator flasher unit on a vehicle to control also the direction-indicator lamp(s) on an associated trailer in such a way that the lamps on towing vehicle and trailer flash in unison, but without placing extra electrical load on the flasher unit. It also provides indication of bulb failure in the trailer direction-indicator lamp(s). Further, when the towing vehicle is equipped with an hydraulically operated brake lamp switch (12-volt systems only), provision is made for feeding the trailer brake lamps simultaneously without overloading the switch.

The unit is brought into operation automatically when the plug and socket connexion between towing vehicle and trailer is made.

1 P.v.c. cover
2 Fuse
3 Terminal compartment
4 Moulded body

Fig. 1 Relay unit, with p.v.c. cover removed

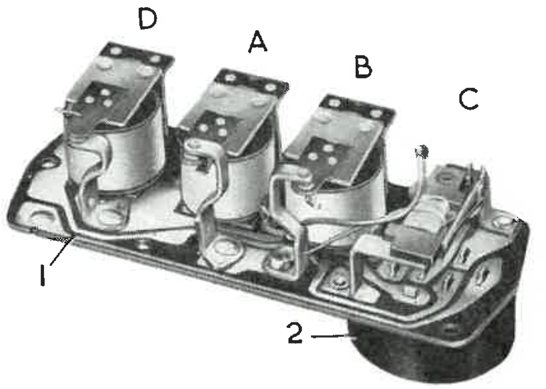
(a) Construction

Model 2TU unit is illustrated in Figs. 1 and 2, while Fig. 3 shows a diagram of the internal connexions and terminal arrangement. Fig. 4 shows the complete circuit connexions. The relays are marked A, B, C and D in the illustrations for ease of reference. The terminals are grouped and numbered as shown in Fig. 3, connexions being made by 'Lucar' connectors.

Relays A and B are identical, and have normally-closed contacts connected in series with the trailer left and right-hand direction indicator lamp(s) respectively.

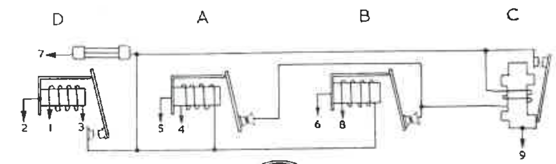
Relay C is a current-operated relay, having normally-open contacts connected in series with the pilot warning lamp for the trailer direction-indicator lamp(s).

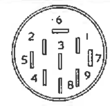
Relay D, when fitted, has normally-open contacts in series with the trailer brake lamps.



1 Printed circuit
2 Terminal compartment
A Relay for trailer direction-indicator lamps (left hand)
B Relay for trailer direction-indicator lamps (right hand)
C Relay for trailer pilot warning lamp
D Relay for trailer brake lamps (when fitted)

Fig. 2 Internal construction





1 Earth
2 Trailer brake lamps
3 Vehicle brake lamps
4 Vehicle D.I. lamp(s) L.H.
5 Trailer D.I. lamp(s) L.H.
6 Trailer D.I. lamp(s) R.H.
7 Ignition switch
8 Vehicle D.I. lamp(s) R.H.
9 Trailer pilot lamp

Terminal layout

Fig. 3 Diagram showing internal connexions and terminal arrangement

(b) Operation (Refer to Fig. 4)

(i) Direction-Indicators

When the ignition switch is closed, current flows from the battery, through the fuse and operating coils of relays A and B to earth via the filaments of the vehicle direction-indicator lamps: the value of this current is too small to cause these lamps to be illuminated. The relays are energised and their contacts open to prevent illumination of the trailer direction-indicator lamp(s).

Relay Unit Model 2TU

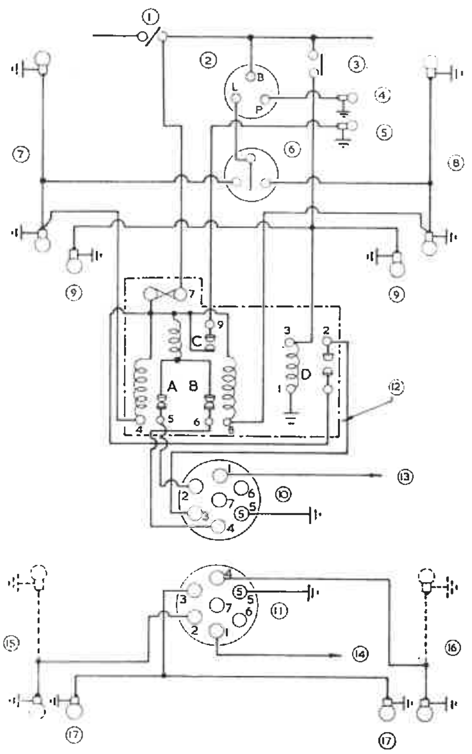


Fig. 4(a)

1 Ignition switch
2 Flasher unit
3 Brake lamp switch
4 Pilot warning lamp for vehicle direction-indicator lamps
5 Pilot warning lamp for trailer direction-indicator lamps
6 Direction-indicator switch
7 Direction-indicator lamps on towing vehicle (left hand)
8 Direction-indicator lamps on towing vehicle (right hand)
9 Brake lamps on towing vehicle
10 Socket (on towing vehicle)
11 Plug (on trailer)
12 2TU relay unit
13 To side-and-tail lamps' circuit on towing vehicle
14 To side-and-tail lamps' circuit on trailer
15 Direction-indicator lamps on trailer (left hand)
16 Direction-indicator lamps on trailer (right hand)
17 Brake lamps on trailer

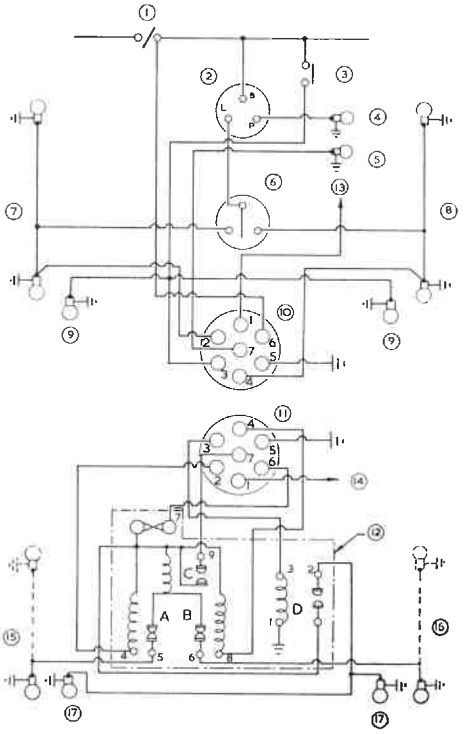


Fig. 4(b)

Wiring diagrams for relay unit mounted (a) on towing vehicle and (b) on trailer

Turning the direction-indicator switch to left or right causes the vehicle flasher unit and direction-indicator lamps to function in the normal manner. Each time the vehicle lamps are 'on', a voltage is applied at the earthed end of relay coil A or B equal to that at the feed end, so that the winding is de-energised. Its associated contacts close to connect the trailer direction-indicator lamp(s) direct to the supply through the operating coil of relay C. Conversely, when under normal flasher action the vehicle direction-indicator lamps are 'off', the relay is again energised and the contacts open to disconnect the trailer direction-indicator lamp(s). In this way, simultaneous flashing of vehicle and trailer direction-indicator lamps is achieved.

Provided the correct load current is taken by the trailer direction-indicator lamp(s), relay C becomes energised and its contacts close, illuminating a second pilot warning lamp in the towing vehicle. In the event of bulb failure leading to zero or reduced current, the relay will not operate, giving warning to the driver in the normal manner.

(ii) Brake Lamps

Operation of the brake lamp switch illuminates the brake lamps on the towing vehicle and also energises relay D (when fitted). Its associated contacts close to feed the trailer brake lamps direct from the supply via the fuse and ignition switch.

This fourth relay is usually only necessary when an hydraulically-operated brake lamp switch is used on a 12-volt system. On 24-volt systems employing this type of switch, it is normal practice to employ a relay in the vehicle brake lamp circuit, while mechanically-operated switches on either 12 or 24 volt systems are usually able to carry the additional current loading of the extra lamps with safety.

When relay D is omitted, a direct feed to the trailer brake lamps is made via the plug and socket connector.

2. ROUTINE MAINTENANCE

None required apart from ensuring that the terminal connexions are secure.

3. TECHNICAL DATA

Part Number		33275	33276	33288	33278	33289
(i)	Nominal voltage	12	12	12	24	24
(ii)	Used when trailer has direction-indicator lamp(s) at	Rear only	Rear only	Front and rear	Rear only	Front and rear
(iii)	Fuse rating (amps)	10	10	10	5	5
(iv)	Nominal resistance of coil (ohms):					
	Relays A and B	76	76	76	258	258
	Relay D (when applicable)	76	—	76	—	—
(v)	Cut-in voltage:					
	Relays A and B	6–8	6–8	6–8	12–16	12–16
	Relay D (when applicable)	6–8	—	6–8	—	—
(vi)	Drop-off voltage:					
	Relays A and B	4	4	4	4	4
	Relay D (when applicable)	4	—	4	—	—
(vii)	Relay C:					
	Contacts must close with coil current (amps) of	1.5	1.5	3.0	0.85	1.75
	Contacts must not close with coil current (amps) of	1.0	1.0	2.1	0.5	1.2

4. SERVICING

The moulded body, retaining screws, p.v.c. cover and fuse are available as spares. Otherwise, servicing is by replacement of the complete unit, ensuring that the Part Number of the replacement is the same as that of the original fitment.

(i) A blown fuse on Model 2TU unit will be indicated by complete failure of all trailer direction-indicator and brake lamps.

(ii) In the event of any one trailer lamp not lighting, first check the particular bulb for filament failure. Also see that all connexions in the particular circuit are properly made.

(iii) Non-operation of a relay due to its winding having become open-circuited for any reason will result in the following symptoms:

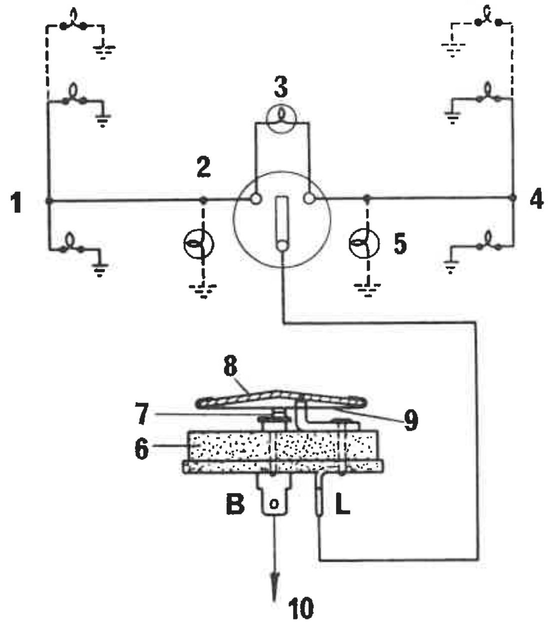
Relay A. On switching on the ignition, the trailer left-hand direction-indicator lamp(s) will be permanently lit, as also will the trailer pilot warning lamp in the towing vehicle, due to the relay contacts remaining closed.

Relay B. As above, except right-hand instead of left-hand.

Relay C. The trailer direction-indicator lamp(s) will not be illuminated, since their feed is through the operating coil of this relay. The trailer pilot warning lamp will not light as the relay contacts will remain open.

Relay D. The trailer brake lamps will not be illuminated, since the relay contacts will remain open.

FLASHER UNIT MODEL 8FL



1 Direction Indicator Lamps (L.H.)
2 D.I. Switch
3 Single Pilot Warning Lamp
4 Direction Indicator Lamps (R.H.)
5 Alternative Connections for two Pilot Warning Lamps
6 Base Moulding
7 Contacts
8 Vane
9 Metal Ribbon
10 To Battery Supply via Ignition Switch

Fig. 1 Circuit diagram with 8FL flasher unit

1. DESCRIPTION

Flasher unit model 8FL is a current-sensitive snap-action switch which automatically and continuously breaks and makes the circuit to the direction-indicator (signal) lamps while a turn signal is being given.

It is extremely important that the flasher unit be used only with the bulb loading for which it is designed, otherwise it may not conform to the performance limits required by law. The unit is produced in a number of different current ratings to suit the individual requirements of variously-composed flasher lamp circuits. If flasher unit replacement becomes necessary it is essential that only another of the same part number is used. It is likewise important to maintain low-resistance circuit connections and also to use only identical replacements when changing failed bulbs.

To minimise the possibility of fitting an incorrect replacement flasher unit, the part number and current rating are stamped in colour on the cover of the unit, a different colour being associated with each current rating.

(a) Operation

The circuit is shown in Fig. 1. When the direction-indicator switch is turned to left or right the appropriate signal lamp bulbs are immediately illuminated, the current flowing via flasher unit terminal B, the normally-closed contacts, the metal ribbon, the metal vane, and terminal L. Current flowing through the metal ribbon causes the latter to heat and expand, allowing the vane to relax and so to open the contacts. The signal lamp bulbs are now extinguished, the ribbon cools and re-tensions the vane, closing the contacts for the cycle to be repeated.

The snap action of the vane provides audible indication of flasher unit operation, while the pilot lamp(s) gives visual indication of operation. Normally, if one signal lamp bulb fails, audible warning ceases while the pilot lamp and remaining signal lamp(s) remain on but do not flash. An occasional unit may however continue to operate but at a significantly slower rate, immediately obvious to the driver.

2. ROUTINE MAINTENANCE

The flasher unit requires no maintenance in service.

3. SERVICING

If correct operation of the signal bulbs is not obtained when the direction-indicator switch is turned in either direction, check the flasher unit, either by substitution with an identically-rated unit, or by withdrawing the cables from its two terminals and linking together the ends of these cables. The flasher bulbs should then light on each side of the vehicle in turn as the switch is turned in each direction. The flasher unit cannot be serviced and must be replaced if proved faulty.

FLASHER UNIT, MODEL FL5

(12-VOLT AND 24-VOLT)

1. GENERAL

The FL5 flasher unit is a current-sensitive relay, providing a dual function in the operation of direction-indicator flashing lamp systems. The main function is to operate the direction-indicator lamps at a pre-determined flashing rate (60–120 flashes/minute) and its secondary function is to operate a warning light capable of indicating a fault in the system.

Normal operation of the system is indicated by the warning light flashing in unison with the direction-indicator lamps, flashing of the warning light in some cases being supplemented by audible operation of the flasher unit (metallic 'clicks' in unison with the warning light flashes).

The FL5 flasher unit is designed for road vehicles with 2-lamp or 4-lamp direction-indicator flashing lamp systems (see Fig. 2). These applications use individual FL5 flasher units, varying in operating voltage and wattage (lamp loading). Because of these variations, and because of the similarity between FL5 flasher units and model 3AW warning light control unit used in alternator installations, it is essential when renewing the flasher unit to refer to the manufacturing details marked on the side of the cover (part number, voltage and wattage) to ensure the correct unit is fitted.

How the flasher unit operates

Alternate heating and cooling of an actuating wire, due to the influence of an electrical current intermittently flowing through it, causes the wire to expand and contract and this in turn causes thermal-operation of the main armature and alternate closing and opening of its associated contacts. Operation of these main contacts causes the direction-indicator lamps to flash ON and OFF at a controlled rate and correspondingly causes a series-winding to magnetise and demagnetise the flasher unit steel core. Under the electro-magnetic influence of the steel core, a secondary armature is made to operate in unison with the main armature and closing and opening of the secondary armature contacts causes the warning light to flash in unison with the direction-indicator lamps.

With reference to Fig. 1, when the direction-indicator switch is operated, a small current flows between flasher unit terminals 'B' and 'L' via the steel core, main armature, actuating wire, ballast resistor and series winding. (The direction-indicator lamps are prevented from lighting at this stage, because current flowing in the circuit is limited by the ballast resistor). Limited current flowing through the actuating wire causes it to be heated and this in turn causes the wire to expand and results in thermal-operation of the main armature and closing of its contacts. Closing of the main contacts diverts current from the actuating wire and ballast resistor, and the actuating wire commences to cool and contract. Simultaneously, and while the contacts remain closed for a limited period until the actuating wire has sufficiently cooled and contracted, current flows through the series winding to terminal 'L' and the direction-indicator lamps are illuminated at this stage due to the appropriate current now flowing in the circuit. Current flowing through the series winding magnetises the steel core and electro-magnetic attraction

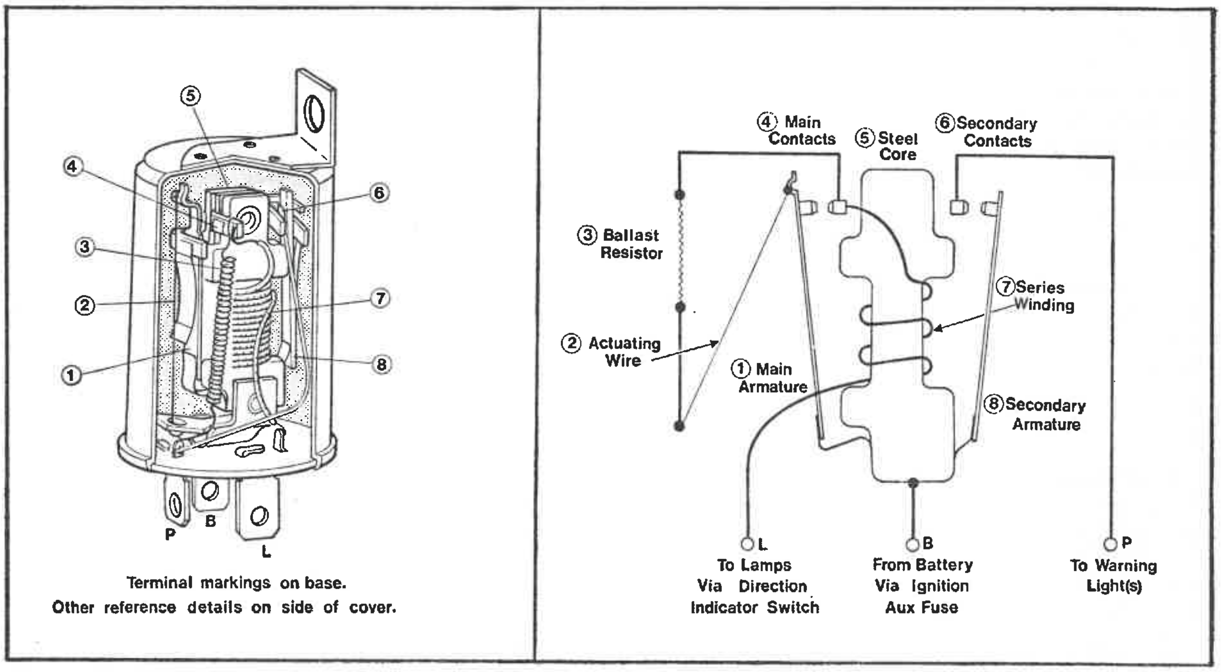


Fig. 1 Constructional details and internal electrical connections of FL5 flasher unit

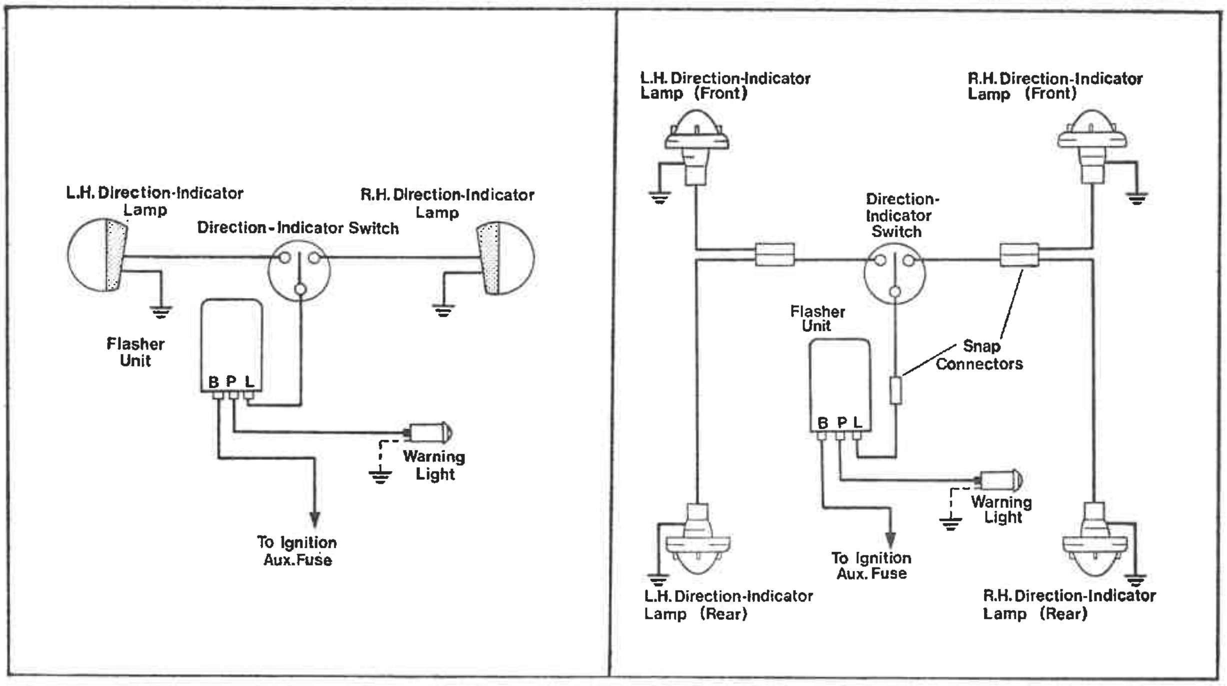


Fig. 2 Typical 2-lamp and 4-lamp direction-indicator lamp systems.

of the secondary armature and closing of its contacts enables current to flow between terminals 'B' and 'P', and the warning light is illuminated in unison with the direction-indicator lamps. At this intermediate stage, electromagnetic attraction of the main and secondary armatures to the steel core ensures that their respective contacts remain firmly closed. When the actuating wire has sufficiently cooled and contracted to overcome the magnetic influence of the steel core over the spring-tensioning of the main armature, the main contacts open, the steel core is de-magnetised, the secondary contacts open and the direction-indicator lamps and warning light are simultaneously extinguished. Limited current again flows through the actuating wire and ballast resistor, and the operating-cycle is repeated.

2. TECHNICAL DATA

	12-volt units	*24-volt units*
Rating of direction-indicator lamp bulbs:	21-watt	24-watt
Rating of warning light bulbs:	2.2 or 1.5-watt	2.8-watt
Flasher unit operating frequency:	60–120 flashes/minute	

3. SERVICING

The flasher unit is a factory-sealed unit with no serviceable parts.

A fault in the direction-indicator lamp system is indicated if:

The warning light is not illuminated.

The warning light flashes but not at the normal rate.

The warning light is illuminated but does not flash.

(a) Testing to Locate the Fault

Note: If the battery is in a very low state-of-charge, the flasher unit may not be capable of operating while the engine and vehicle are stationary.

With the IGN/AUX switch ON: Move the direction-indicator switch to both operating positions in turn and determine by visual inspection whether normal flashing of the direction-indicator lamp(s) is occurring each side of the vehicle.

Determine which of the following sub-headings (i) to (iv) is appropriate to the fault symptom, and refer to details.

(i) Direction-indicator lamp(s) flashing normally each side of vehicle, but warning light not illuminated

Check the warning light bulb. If the bulb is found to be satisfactory, the flasher unit is probably faulty.

Prove the flasher unit by substitution or, alternatively, prove it *in-situ*, by connecting its terminals 'B' and 'P' together (with the IGN/AUX switch ON). This should result in the warning light being illuminated, in which case the flasher unit is proved faulty and must be renewed. If the test does not result in illuminating the warning light, check for open-circuit fault between flasher unit terminal 'P' and the warning light bulb-and-bulbholder.

Dual warning lights: Non-illumination of one warning light, will probably be due to bulb failure. Non-illumination of both warning lights, will probably be due to flasher unit failure.

(ii) Direction-indicator lamp(s) flashing normally each side of vehicle, and warning light illuminated but not operating normally

Flasher unit is faulty and must be renewed.

(iii) Direction-indicator lamp(s) not flashing normally on one side of vehicle, and warning light is not illuminated or is illuminated but not operating normally

If a direction-indicator lamp does not light, first check for bulb failure. If the bulb is not the cause of the fault, check for a faulty earth connection, particularly between bulb-and-bulbholder.

If direction-indicator lamp(s) 'flicker', suspect a high-resistance fault. Check direction-indicator lamp(s) for faulty earth connection, particularly between bulb-and-bulbholder. Check for loose cable connection(s). Finally, check the direction-indicator switch.

(iv) Complete failure of direction-indicator lamp system

The fault could be due to:

No supply voltage applied to flasher unit terminal 'B' (open-circuit 'blown' fuse, due to ageing of the fuse or due to a short-circuit not necessarily associated with the direction-indicator lamp system).

Faulty flasher unit.

Faulty direction-indicator switch.

First, using a voltmeter or test-lamp of appropriate voltage to that of the system voltage, check whether there is battery voltage between flasher unit terminal 'B' and earth (cable connection GREEN). According to the test result, refer to details under one of the following appropriate headings.

Battery voltage between flasher unit terminal 'B' and earth

Testing so far is satisfactory, in which case the fault could be due to the flasher unit or the direction-indicator switch.

Prove the flasher unit by substitution or, alternatively, prove it *in-situ*, as follows: With the IGN/AUX switch 'ON' and the direction-indicator switch in either of its operative positions, use a small electricians'-type screwdriver and short-circuit together the wiring connections to flasher unit terminals 'B' and 'L', cable colours GREEN and LIGHT-GREEN/BROWN. (The wiring need not be disconnected and a plug-in type flasher unit need only be partially withdrawn from its socket to enable the appropriate terminals to be short-circuited).

If test results in illumination of direction-indicator lamp(s), the flasher unit is proved faulty and must be renewed.

If test does not result in illumination of direction-indicator lamp(s), the direction-indicator switch is suspect.

No voltage between flasher unit terminal 'B' and earth

Check the IGN/AUX fuse. (If there is more than one fuse in the same fuse holder, the IGN/AUX fuse can be identified by wiring connections WHITE and GREEN to the input and output sides of the fuse respectively). Remove the fuse from its holder and visibly check continuity of the fuse wire. If it is not obvious that the fuse is faulty, check its continuity with a battery-operated ohmmeter or test-lamp circuit.

If the fuse is found to be open-circuit: Ascertain whether this is due to simply ageing of the fuse, or a short-circuit fault. Renew the fuse, and then operate separately all circuits associated with the IGN/AUX fuse (e.g. direction-indicator lamp system, stop lamps, windshield wipers and washers, etc.). If the new fuse 'blows', as a result of operating a particular circuit, a short-circuit in the circuit undergoing test must be traced and remedied.

If the fuse is not the cause of the fault: Check for a faulty electrical connection between the metal ends of the fuse and the fuse holder clips. Clean the metal ends of the fuse and the fuse holder clips with fine emery cloth and ensure when refitting the fuse that it is tight in the fuse holder clips. If the fault persists, it will be necessary to use a voltmeter or test-lamp and ascertain whether there is battery voltage between the input and output sides of the fuse holder clips and earth. (Ensure IGN/AUX switch is 'ON' during the test). If there is battery voltage between only one fuse holder clip and earth, it confirms that the electrical connection between fuse-end and clip on the no-voltage side of the fuse is faulty. Alternatively, no battery voltage between either of the fuse holder clips and earth, confirms an open-circuit between the input-side of the fuse holder (wiring connection(s) WHITE) and the supply voltage source, in which case the open-circuit fault must be traced and remedied.

ANCILLARY ENGINE EQUIPMENT

INDEX

AIR PUMP MODEL AP1F

1. DESCRIPTION

This belt-driven pump introduces air into the exhaust manifold while the engine is running to assist in reducing the toxic content of the exhaust gas of petrol-engined vehicles. It is designed for engines of 1000 cc to 4000 cc capacity.

(a) Construction

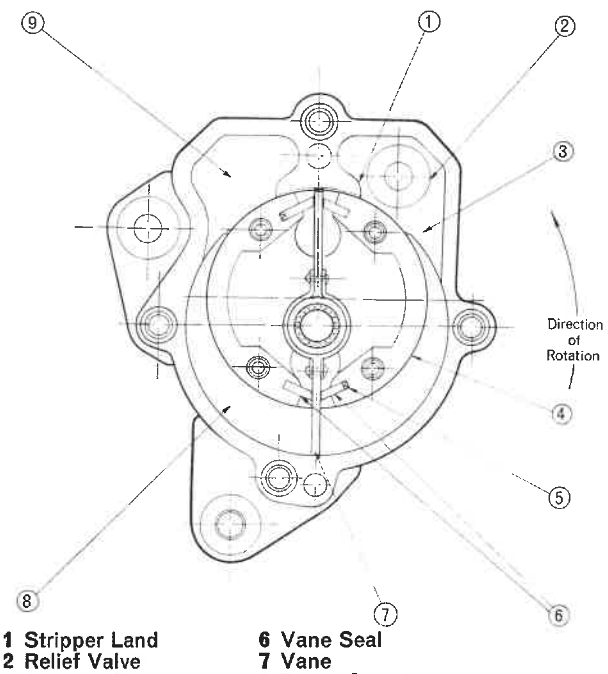
The main parts of the air pump comprise the pump body, the port-end cover, the rotor and vane assembly and the relief valve. Its construction is shown in Figs. 2 & 3.

The rotor is supported by a ball bearing at the driving end and a needle roller bearing at the port end.

The rotor drive-end bearing is circlip-retained in the pump body while the port end bearing is carried on a journal which forms part of the port end cover. The eccentrically-positioned fixed vane shaft forms an extension to the inner face of the journal.

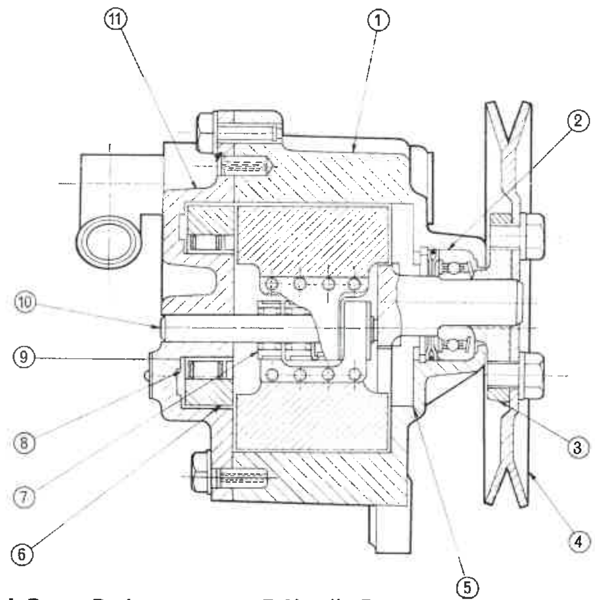
Two slots in which vanes slide are positioned at opposite sides of the hollow rotor. Spring-loaded carbon vane seals bear on the vanes to prevent air leaking to the inside of the rotor. A spring is positioned behind one of each pair of vane seals. The vanes

Fig. 1



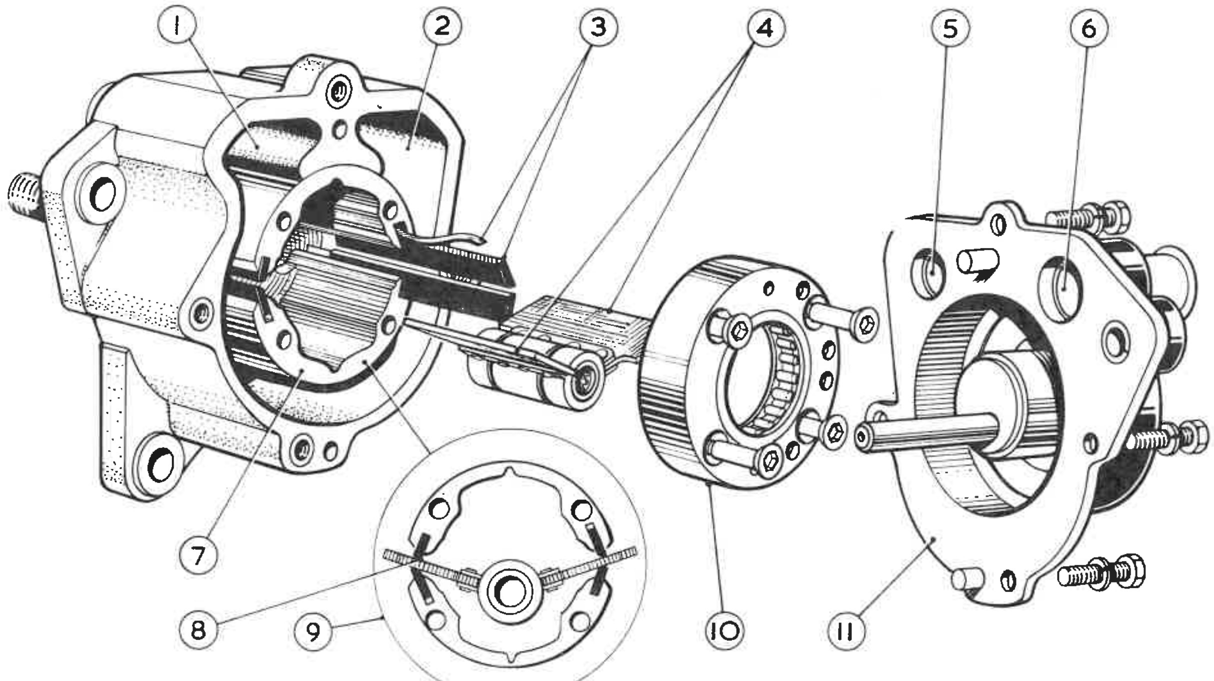
1 Stripper Land
2 Relief Valve
3 Exhaust Chamber
4 Rotor
5 Vane Spring
6 Vane Seal
7 Vane
8 Pump Chamber
9 Intake Chamber

Fig. 2 Sectioned end view of air pump



1 Pump Body
2 Ball Bearing
3 Drive Hub
4 Pulley
5 End Plate
6 Rotor End Plate
7 Needle Bearing (Pump Vanes)
8 Needle Bearing (Rotor Shaft)
9 Inner Race
10 Vane Shaft
11 Port-End Cover

Fig. 3 Sectioned side view of air pump



1 Intake Chamber
2 Exhaust Chamber
3 Vane Seal & Spring Assembly
4 Vane Assemblies
5 Exhaust Port
6 Intake Port
7 Rotor
8 Chamfered Edge to Inside
9 Arrangement of Vanes & Vane Seals
10 Rotor End Plate
11 Port-End Cover

Fig. 4 Air Pump Model AP1F dismantled

are independently mounted and rotate freely on the needle roller bearings carried by the vane shaft.

Initially, the tips of the vanes may slightly foul the pump body, but the vanes quickly 'bed' and thereafter run with minimum clearance.

(b) Operation

Air, drawn through the air cleaner and inlet pipe to the intake chamber, is trapped between the two vanes and the inner surface of the pump body. The vanes (rotating clockwise when viewed from the drive end) transfer the air into the exhaust chamber and so, via an external non-return valve, to the exhaust manifold.

Minimal clearance between the rotor and stripper land effectively prevents air leaking from the exhaust to the intake chamber.

The relief valve is fitted to the exhaust chamber to safeguard the pump from over-pressurisation at any time.

The air pump runs with little noise. If abnormal pump noise cannot be traced to belt slip or any other obvious cause the pump must be removed from the engine and dismantled for detailed inspection.

2. ROUTINE MAINTENANCE

Periodically check the tension of the pump driving belt. If belt adjustment is required, slacken the pump fixing bolts and move the pump body by hand only until there is a total deflection of $\frac{1}{2}$ in (13 mm) at the mid-point of the longest span of the belt.

DO NOT APPLY PRESSURE TO THE PUMP BODY WITH A LEVER.

The pump will normally require servicing only at 50,000 mile (80,000 km) intervals and no maintenance is required between these periods.

3. TECHNICAL DATA

Model:	AP1F
Construction:	positive displacement system semi-articulated type
Number of vanes:	2
O/D of inlet pipe:	19 mm
O/D of inlet pipe:	16 mm
Theoretical delivery volume:	140 cc/rev.
Max. speed:	8000 rev/min.

4. SERVICING

(a) Dismantling

Dismantle the pump in the following manner.

Withdraw the four pulley-fixing bolts. Mount the pump on a housing bracket made from angle iron and mount the whole in a vice as shown in Figure 5.

WARNING: Do not grip the aluminium pump body or the drive hub in the vice jaws or damage may occur.

Withdraw the four port-end cover fixing screws.

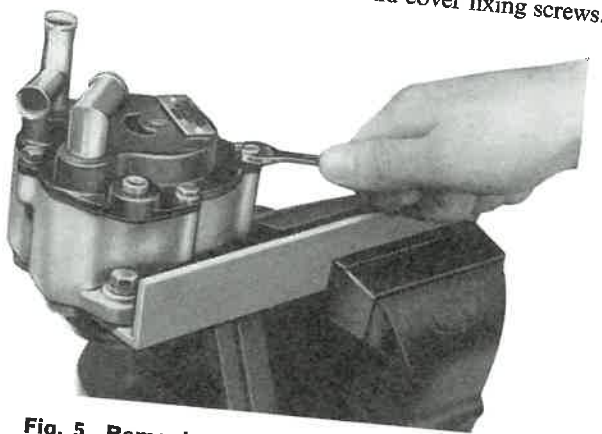


Fig. 5 Removing the port-end fixing screws

Withdraw the port-end cover from the pump body. If there is difficulty in separating the two, carefully tap the cover vertically using a plastic-faced or wooden mallet.

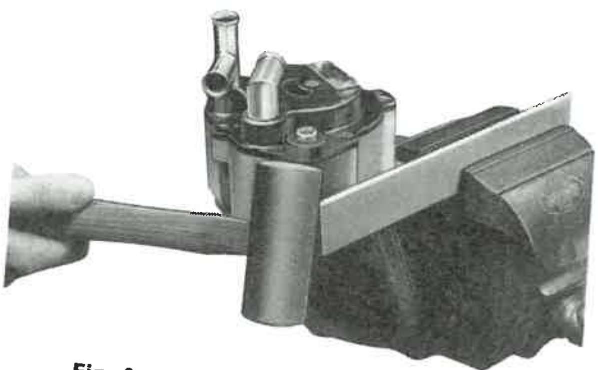


Fig. 6 Withdrawing the port-end cover

Remove the four socket-headed screws which secure the rotor end plate to the rotor. The threaded holes are unequally spaced to ensure that the rotor end plate is re-assembled into its original position.

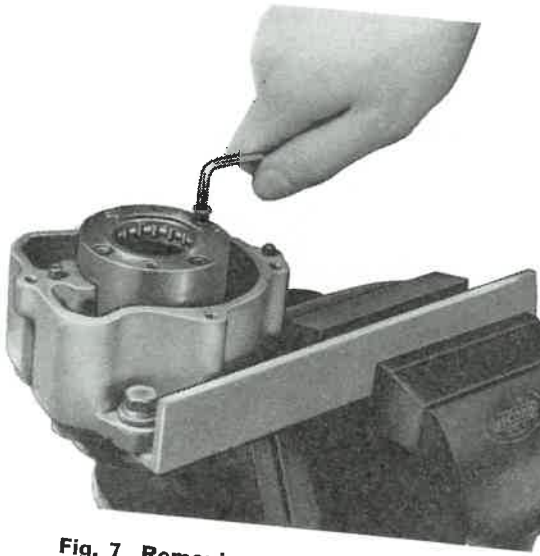


Fig. 7 Removing the rotor end plate

Lift the vane assemblies clear of the rotor. Wash the needle roller bearings in clean paraffin (kerosene) and dry them with a dry air blast.

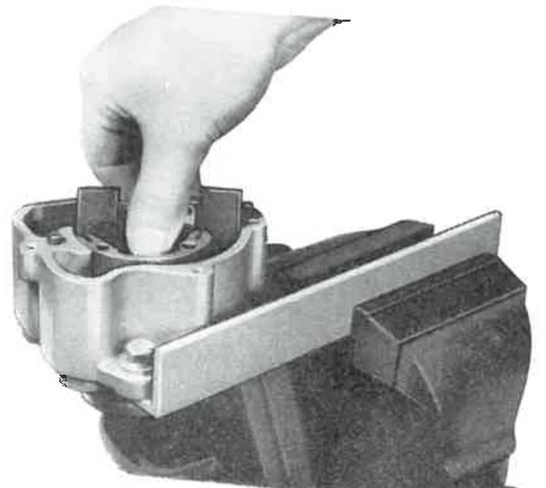


Fig. 8 Removal of the vane assemblies from the rotor

Check the vane needle bearings for wear by inserting a 0.375 in (9.525 mm) dia. shaft into the vane bearings. If satisfactory, repack the bearings with ESSO 'Andok' 260 lubricant. Renew the vane assemblies if the bearings are worn or if there is evidence of excessive grooving of the vanes by the vane seals.

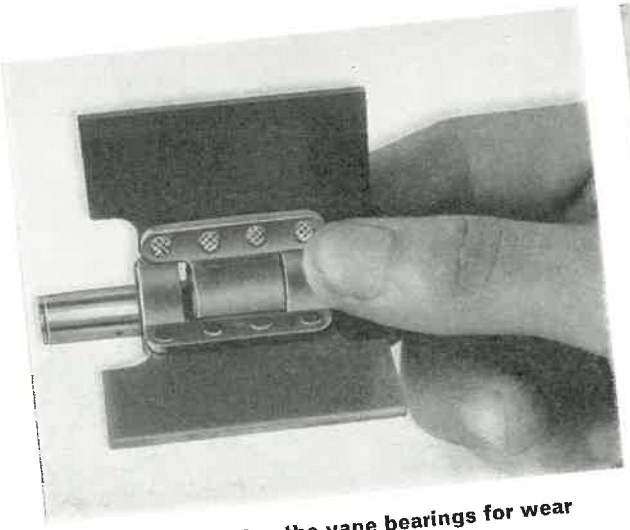


Fig. 9 Checking the vane bearings for wear

Remove the vane seals and springs from the rotor.

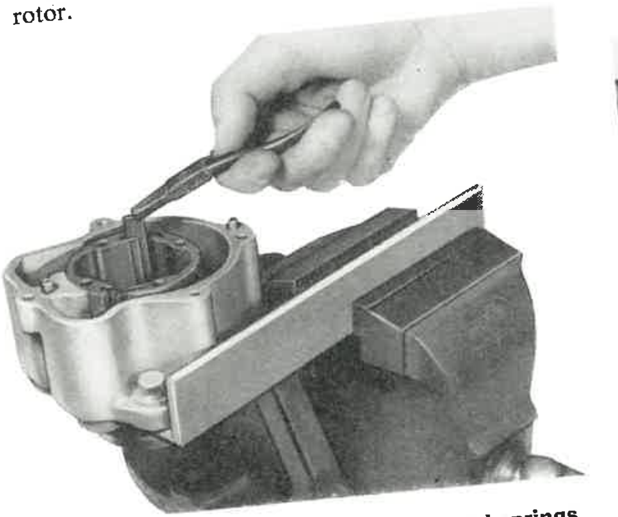


Fig. 10 Removal of the vane seals and springs

Wash the rotor end plate in clean paraffin (kerosene). If the bearing does not rotate smoothly It must be replaced with a new one in the following manner:—

Push the bearing out from the port-end cover side of the rotor end plate. Care must be taken not to deform the rotor end plate by supporting it with a suitable ring.

Using a press, insert the new bearing into the housing from the port-end cover side. Keep the lettered side of the bearing outer ring facing the port-end cover. Insert the bearing until it is $\frac{1}{32}$ in (0.8 mm) below the face of the rotor end plate. Do not attempt to drive the bearing into position using a hand tool.

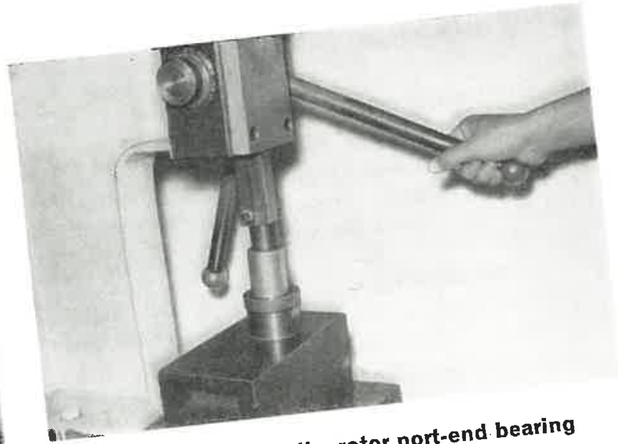


Fig. 11 Renewing the rotor port-end bearing

The relief valve is a press fit into the pump body and can be pressed out with a $\frac{1}{2}$ in (12.6 mm) dia. soft metal drift. The illustration shows this being carried out with the pump assembled, the drift being inserted through the outlet pipe to contact the relief valve.

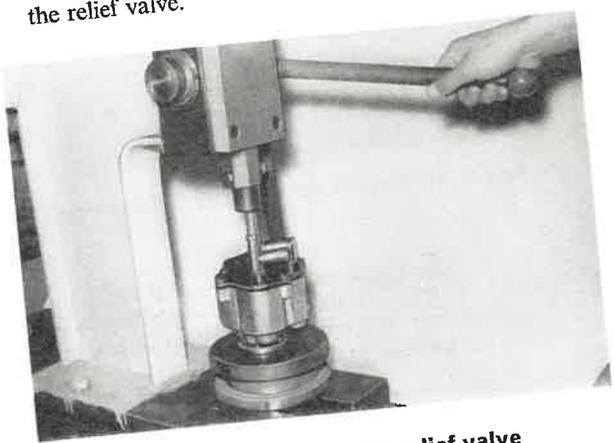


Fig. 12 Removal of the relief valve

Use a concave-faced tool for inserting the new valve so that it bears only on the periphery of the valve.

The illustration shows a suitably-dimensioned tool.

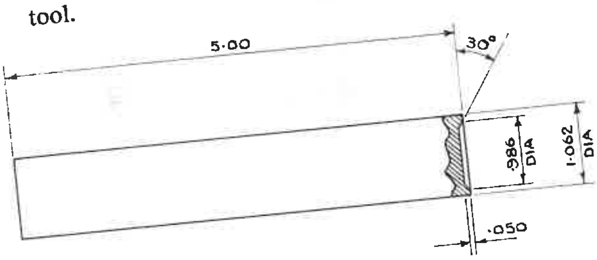


Fig. 13 Details of the relief valve fitting tool

(b) Reassembly

Assemble the vanes into the rotor so that one vane is positioned beneath the stripper land.

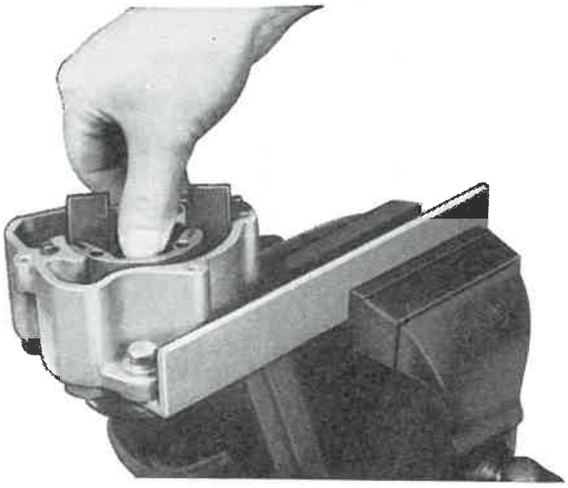


Fig. 14 Reassembling the vanes into the rotor

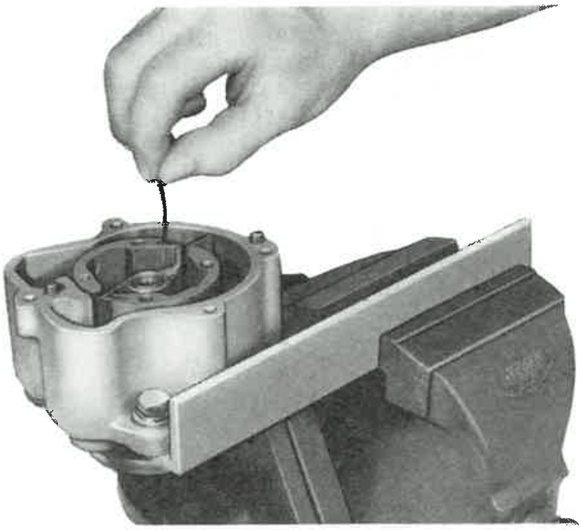


Fig. 16 Insertion of a vane seal spring

Insert the vane seals with the slanting side towards the vane and with the sharpest corner outwards. Refer to the inset to Fig. 4 which shows the rotor assembly in plan.

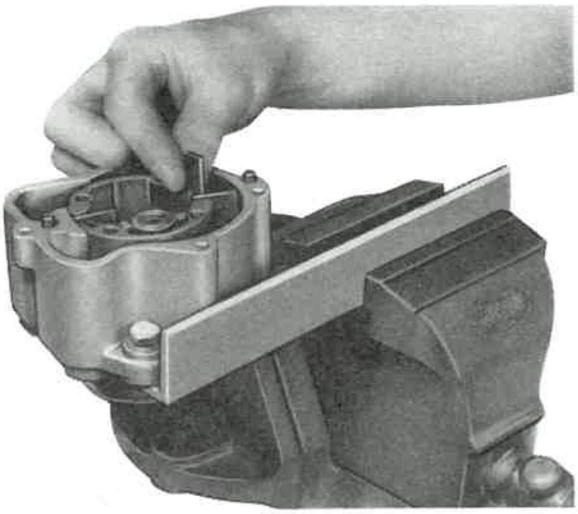


Fig. 15 Insertion of the vane seals

Insert a spring behind each of the vane seals in the deeper slots with the convex side of the spring towards the vane seal.

Clean and apply Andok '260' lubricant to the rotor end plate bearing.

Place the rotor end plate in position and secure it with the four screws. Tighten the screws to the torque of 6 lbf ft (0.83 kgf m).

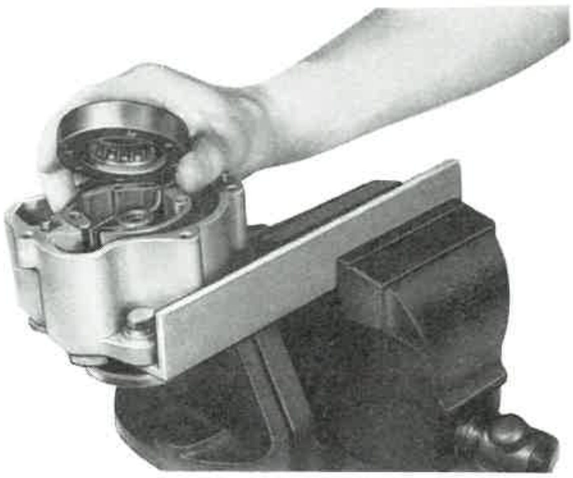


Fig. 17 Reassembling the rotor end plate

Insert the vane shaft into the vane bearings and refit the port-end cover to the pump body. If necessary, use a mallet to drive the dowel pins in the cover fully home. Tighten the cover fixing screws to the torque of 5.0 lbf ft (0.7 kgf m).

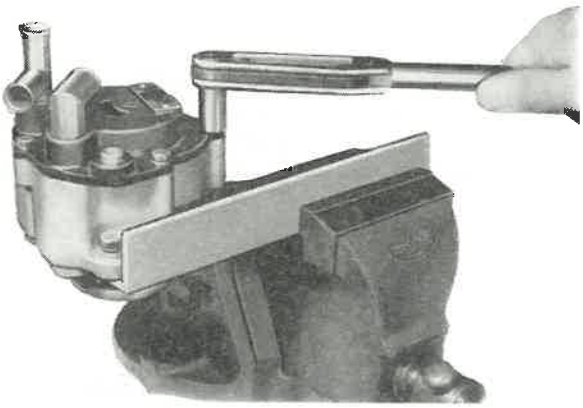


Fig. 18 Tightening the port-end cover screws

(c) Test Procedure

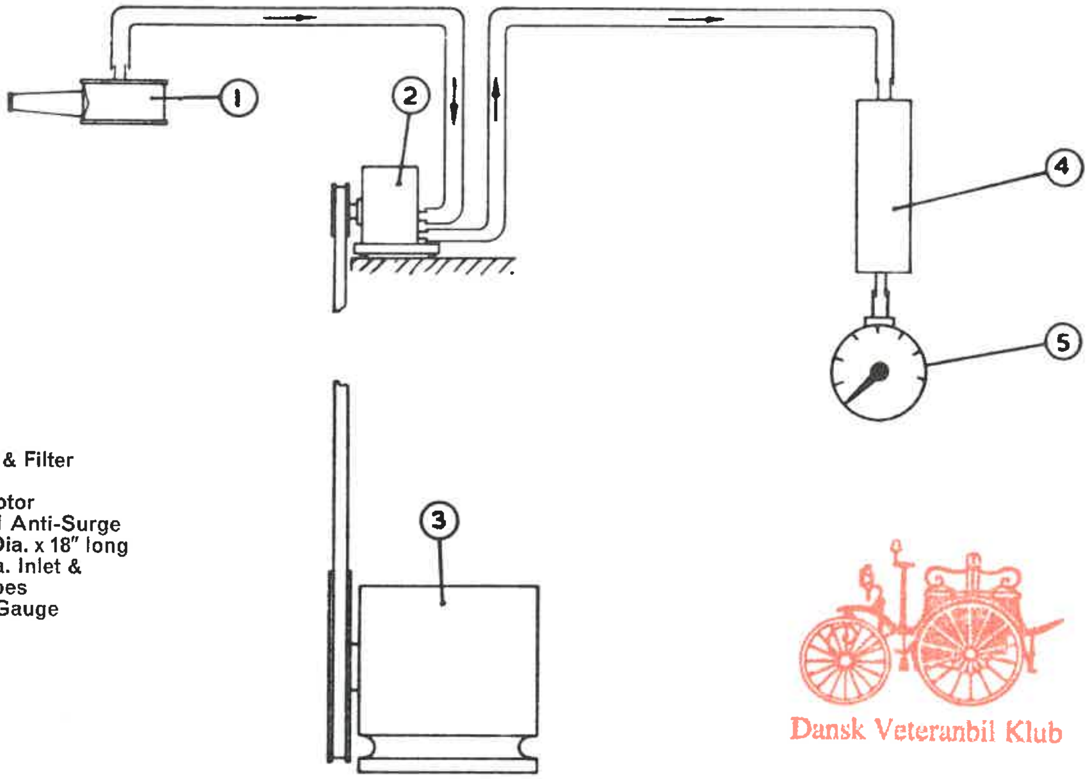
Following reassembly the pump should be tested with the equipment shown in Fig. 19. The pump should be fitted to a bench-mounted L-shaped bracket and belt driven by a variable speed motor. The drive ratio employed must ensure that the pump rotor speed does not exceed 8000 rev/min.

Select a pressure gauge of a range in which the low values obtaining can be clearly read. The anti-surge tank ensures that the pressure gauge reading obtained is free of pulsations.

Run the pump at 1000 rev/min. The pressure gauge should register approx. 3 lb/in^2.

Gradually increase speed until the relief valve is heard to operate. This should occur with a pressure reading of no less than 4½ lb/in^2. and not more than 7½ lb/in^2. Replace the valve if it operates outside these limits.

Following reassembly of the air pump to the vehicle engine run the pump and check the installation for air leaks.



1 Air Intake & Filter
2 Pump
3 Driving Motor
4 Cylindrical Anti-Surge Tank 3½" Dia. x 18" long with ⅝" Dia. Inlet & Outlet Tubes
5 Pressure Gauge

Fig. 19 Arrangement of test circuit