SERVICE MANUAL

Volume 2

Ford

Power Products

INDUSTRIAL PRODUCTS SERVICE MANUAL
FOR
2720 RANGE ENGINES

VOL. 2 –ELECTRICAL EQUIPMENT

Ford Power Products

CONTENTS

INTRODUCTION

The purpose of this Service Manual is to enable the various types of electrical equipment to be correctly serviced and maintained at optimum performance levels.

This only applies to original equipment supplied by Ford with the engine.

The appropriate parts of this publication should be read in conjunction with the relevant sections of Volume 1 of the current issue of the 2720 Range Service Manual.

SECTION I - STARTING SYSTEM

CONTENTS

THE STARTING SYSTEM

INTRODUCTION

Two makes of starter motors are used on the 2720 range of engines, these are:

1. Lucas Type M50
2. CAV Type CA45G

A marine version of each make is also available; both of these use marine finished components for greater protection against corrosion and can be readily identified by the special white marine paint finish.

Both marine versions are suitable for insulated return wiring systems, the Lucas M50 Marine starter being fitted with an insulated main negative terminal and an additional solenoid negative terminal. In all other respects the marine versions are similar in mechanical construction to their standard industrial counterparts.

LUCAS M50 and M50 MARINE STARTER MOTORS

DESCRIPTION

Where differences between the two types exist, these will be pointed out in the following text.

The pre-engaged starter (Fig. 1) is a four pole four brush machine of 127 mm (5 in) diameter, having a solenoid operated roller clutch drive. The solenoid incorporates two sets of contacts which provide two-stage switching. 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; full cranking torque then develops.

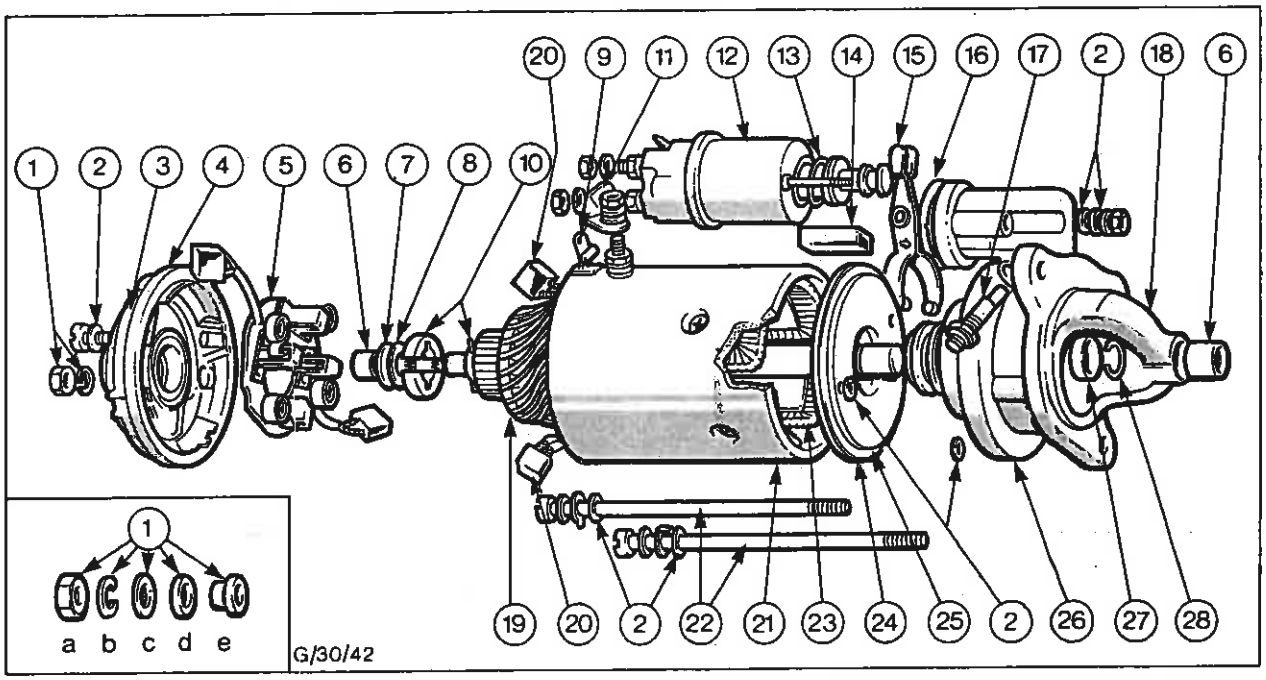


Fig. 1 - Starter, Dismantled. Inset Shows Different Negative Terminal Components for Marine Version

1. Nut and Spring Washer (C/E Cover Earth Stud)
2. Sealing Washers
3. Commutator End Cover
4. Sealing Ring
5. Brush Gear Assembly comprising Earth Brushes and Springs } Insulated Negative Brushes on Marine Version
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 (Deleted on Marine Versions)
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
25. Intermediate Bracket
26. Drive Assembly
27. Thrust Collar
28. Jump Ring

(a) Nut
(b) Spring Washer
(c) Plain Washer
(d) Insulated Washer (Outside Cover)
(e) Insulated Bush (Inside Cover)

On occasions when the 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. (Figs. 2, 3 and 4)

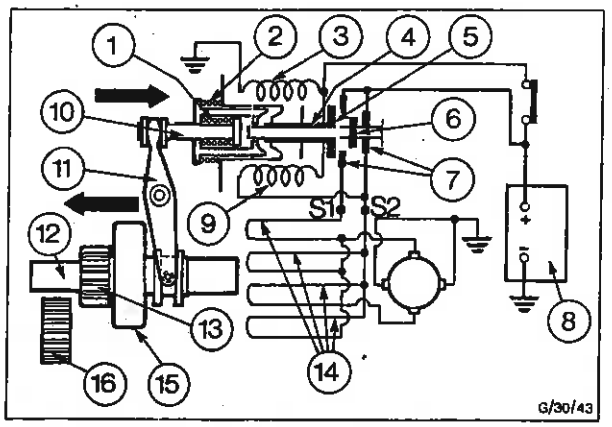


Fig. 2 - Explanation of Two-Stage Switching

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. Ring Gear

NOTE: The wiring shown in Figs. 2, 3 and 4, is for the standard earth return system. Fig. 5 shows the insulated return system wiring used on marine starter applications.

The solenoid is energised in the conventional manner to move the pinion towards the ring gear on the engine flywheel.

The roller clutch prevents the armature from rotating excessively if the drive remains in mesh with the flywheel after the engine has started.

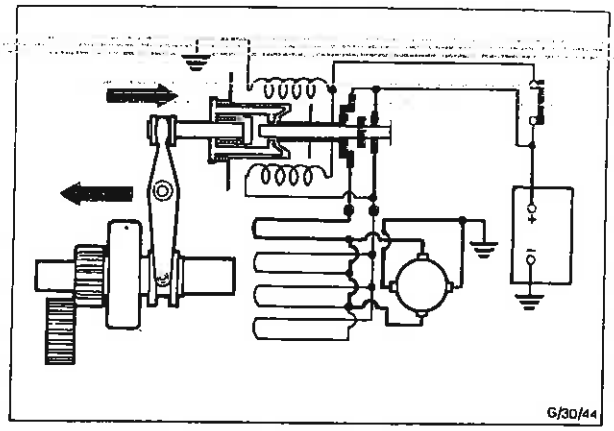


Fig. 3 - Showing Tooth to Tooth Abutment

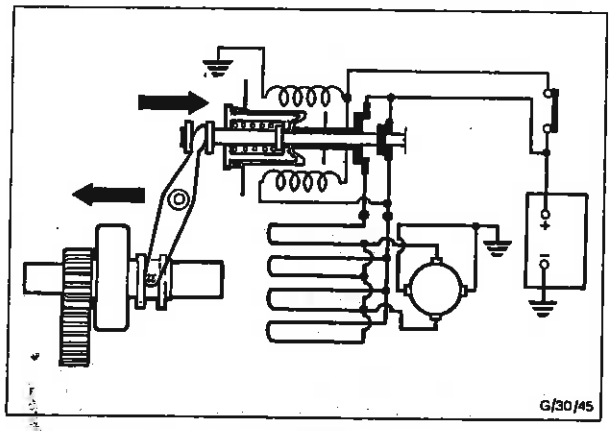


Fig. 4 - Showing Meshing Position

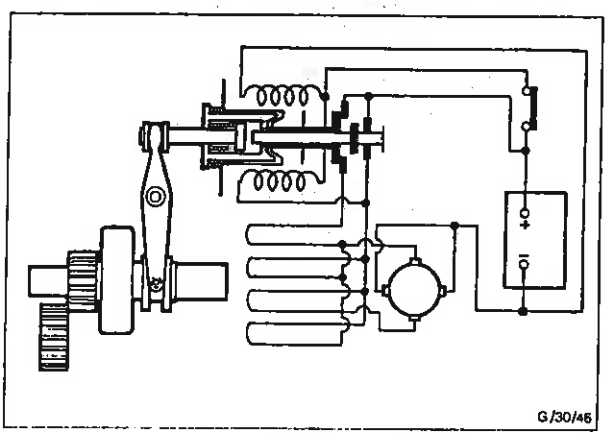


Fig. 5 - Insulated Return Wiring System

The starter motor is oil and watertight (except from the bell housing) and the seals are located as follows:

1. Between the commutator end cover and yoke.

2. Between the intermediate bracket and yoke.

3. Between the solenoid and drive-end bracket.

4. At both ends of the through bolts, at the earthing stud, solenoid fixing studs, and brush gear plate securing screws (in the outer face of the commutator end cover), see Fig. 1.

ROUTINE MAINTENANCE

No routine maintenance is necessary, the tightness of the electrical connections should however be checked periodically.

The starter motor should be dismantled for detailed inspection during major engine overhaul.

The commutator should also be examined and the bearing bushes renewed; refer to section on 'Bench Inspection'.

OVERHAULING THE STARTER MOTOR

To Dismantle

1. Remove the copper link which connects the solenoid terminal S2 to the yoke terminal.

2. Disconnect the flexible link connecting the solenoid terminal S1 to the first stage field coil inside the yoke.

3. Remove the solenoid securing nuts, washers and seals and withdraw the solenoid unit complete with gasket from the drive end fixing bracket. Also the small sealing washer from the solenoid fixing studs.

NOTE: 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 the plunger from the fork in which it pivots at the top of the drive engagement lever.

4. Remove the sealing grommet which is wedged between the fixing bracket and yoke. This is not fitted to marine versions.

5. Remove the through bolts complete with washers and sealing washers.

6. Remove the two screws from the outer face of the commutator end cover. (These screws secure the brush gear to the inner face of the end cover).

On marine starter motors, remove the negative terminal nut, spring washer, plain washer and insulating washer.

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 brush gear in position on the commutator.

On marine starter motors, the negative terminal and insulating bush will also be left in position.

7. To remove the brushgear assembly, grip the commutator end of the armature shaft and pull the armature forward so as to fully expose commutator and brushgear. Using a wire hook or a small screwdriver, lever up the brush springs so that the brushes can be disengaged from their brush boxes. Remove the brushgear assembly.

8. Withdraw the yoke assembly from the armature and drive end bracket. Remove the sealing ring between the yoke and intermediate bracket.

9. Unscrew the eccentric pivot pin from the fixing bracket and remove the drive end fixing bracket drive engagement lever, armature complete with roller clutch drive and intermediate bracket.

NOTE: Separation of the fixing and intermediate bracket may cause two small sealing washers to become dislodged from a recess in the through bolt holes of the fixing bracket. Ensure these are retrieved.

10. Dismantle the armature assembly roller clutch and intermediate bracket using a tubular tool (e.g. box spanner). Remove the thrust collar from the armature shaft, ensuring that if any packing shims have been fitted these are retrieved.

Bench Inspection

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 38 mm (1,5 in) before a replacement armature becomes necessary. If the skimming operation has been carried out the commutator surface must be polished with very fine glass paper or emery cloth. The insulation slots must not be under cut.

If there are signs of thrown solder or the conductors have lifted from the commutator segments, the motor has probably been over speeding. Check the operation of the roller clutch drive.

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, renew. If the armature is satisfactory, renew the bearings in both end brackets.

Check armature insulation with a 110V ac 15W test lamp connected between one of the commutator segments and the armature shaft (Fig. 6).

If the lamp lights, the insulation is unsatisfactory.

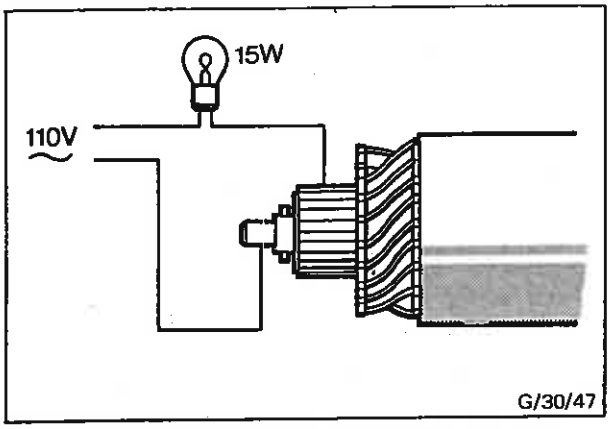


Fig. 6 - Armature Insulation Test

Check the armature for short-circuit windings, using "GROWLER" equipment test gear.

Brushes should move freely in the brush boxes. Sticking brushes should be cleaned with a petrol moistened cloth.

Brushes which are worn to less than specified length must be renewed. Service brushes are preformed and do not require "bedding" to the commutator.

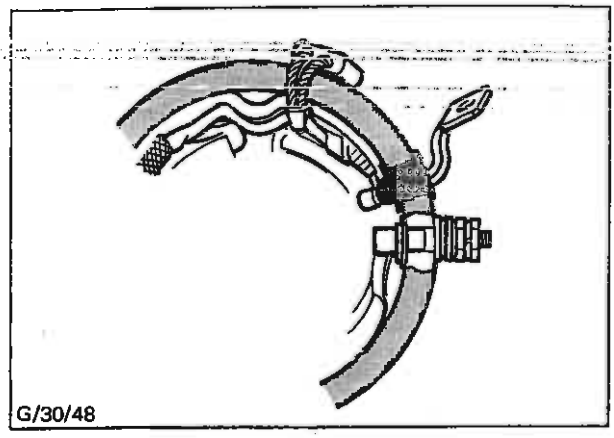


Fig. 7 - Brush and Terminal Arrangement (Field Coils)

Renewing the Field Coil Brushes

Place the yoke assembly on its end, with the brush and terminal arrangement uppermost. Cut the worn brush flexible lead as near as possible to the field coil conductor. Carefully prise the brush flexible jointing 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 flexible leads and position one each side of the conductor. Pinch the ends of the flexible leads and conductor together with long nosed pliers and bend the brush and flexibles over the edge of the yoke to help hold the leads in position during soldering (Fig. 7). Solder the brush flexible leads to the field coil conductor, using an iron of sufficient size to make a good quick joint without overheating the components. Repeat the operation for the second brush.

Renewing Earth Brushes on Standard Starter

Place a hot soldering iron on the rolled over contact holding the brush flexible joint. When the solder is molten, using a small screwdriver, prise up the metal sufficiently to allow removal of the old brush lead. Insert the new brush lead and solder it in place.

Renewing Negative Brushes on Marine Starter

The negative terminal and brush assembly must be replaced as a complete unit.

Checking the Spring Pressure

Brush spring pressure should be checked with the whole of the brush gear loosely assembled to the commutator (i.e. all four brushes assembled in their working position). Hold the brush gear assembly firmly centralised on the commutator and apply a pull-type spring gauge to each spring in turn (Fig. 8). The reading should be within the specified limits when the spring just leaves the brush.

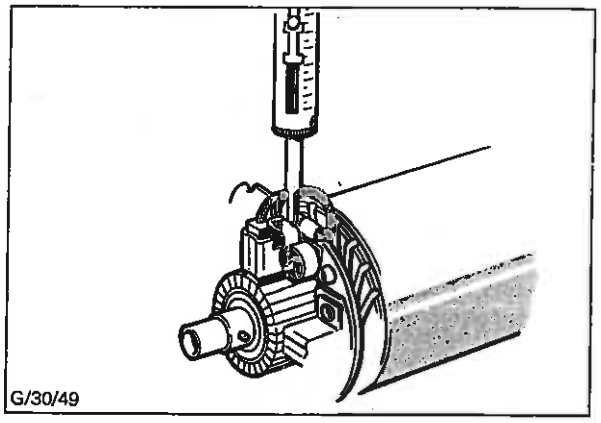


Fig. 8 - Checking Brush Spring Pressure

Checking the Brush Gear Insulation

Connect a 110 V a.c. 15 Watt test lamp between a clean part of the brush gear plate and each insulated brush box in turn.

If the lamp lights, the insulation between the brush boxes and the brushgear is unsatisfactory and the brush gear assembly must be renewed.

Checking Field Coil Insulation

Ensure that both insulated brushes are clear of the yoke and connect a 110 V 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. Also check the insulation of the yoke terminal.

If the field coils are faulty, the assembly should be renewed.

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 faults. Check the various joints of the field coil assembly and look for discolouration (due to burning) of the winding insulation tape, which could indicate short-circuited windings. If in doubt, the field coil should be proved by substitution.

Renewing the Field Coil Assembly

Before disturbing the original fitting of the field coils, 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 10,32 mm (0,406 in) 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 terminals.

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 to the specified torque. Tighten the yoke terminals lower fixing nuts to the specified torque value.

NOTE: 'Studlock 270' compound should be applied to the pole retaining screws.

Bearings

The commutator end cover intermediate bracket and drive end fixing bracket are fitted with self lubricating porous bronze 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 light engine oil at 100°C (212°F) 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 exceed the following dimensions:

Commutator-end cover bush 12,82 mm (0,505 in).

Intermediate bracket bush 28,62 mm (1,127 in).

Drive end fixing bracket bush 17,4 mm (0,675 in).

The bush in the commutator end cover can be removed by inserting a 14,30 mm (0,563 in) 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 12,712 mm (0,5005 in)

Intermediate bracket bush 31,054 mm (1,1226 in)

Drive end fixing bracket bush 17,030 mm (0,6705 in)

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 (cold climate) Retinax 'A' (hot climate).

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. 9) 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.

Before dismantling the solenoid, check for coil winding continuity and satisfactory closing of the first and second stage contacts associated with terminals S1 and S2 as follows:

Standard Starter

Connect a resistance meter between terminal S2 and earth to measure resistance of both coils in series; a reading of approximately 0,8 ohm should be indicated.

Connect one meter lead to the 'BATT' terminal and the other meter lead to terminals S1 and S2 in turn; there should be no continuity. Repeat the test while depressing the solenoid plunger by hand; zero resistance should be indicated in each case.

Marine starter

Connect meter between terminal S2 and the negative 'Lucar' blade terminal to measure the resistance of both coils in series; a reading of approximately 0,8 ohm should be indicated.

Connect one meter lead to the 'BATT' terminal and the other meter lead to terminals S1 and S2 in turn; there should be no continuity. Repeat the test while depressing the solenoid plunger by hand; zero resistance should be indicated in each case.

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 to Fig. 9.

Remove the two screws securing the terminal and base assembly to the solenoid body. Apply a hot soldering iron alternatively to each of the 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 securely and, while continually pulling on the moulded cover, apply a soldering iron alternatively to the two soldered connections until terminal and base assembly is free. When remaking 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 the specified torque.

Check insulation between windings and solenoid body on marine starter.

NOTE: On marine starters, an additional 'Lucar' blade (18) is fitted to provide the negative connection to the solenoid coil.

To Reassemble

1. Fit the intermediate bracket and drive assembly to the armature. (Check that the shims have been included between the armature core and the intermediate bracket).

2. Fit the sealing ring to the groove in the intermediate bracket. Also fit the sealing washers to the fixing bracket, one at each end, through the bolt entry point and one on the dowel peg (Fig. 9).

3. Assemble the armature sub-assembly to the fixing bracket, locating the intermediate bracket with the dowel peg in the fixing bracket.

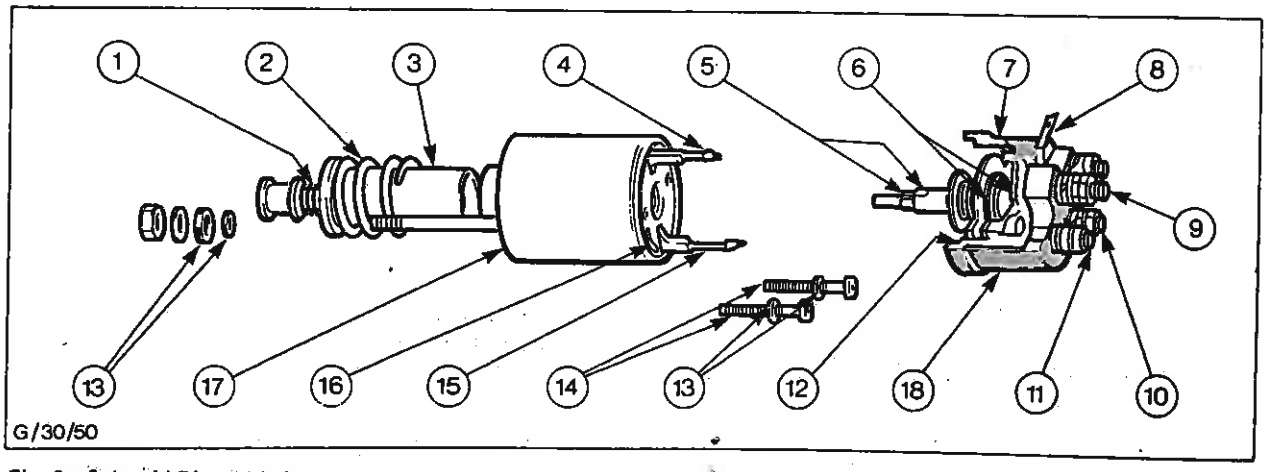


Fig. 9 - Solenoid Dismantled

1. Lost Motion Spring
2. Plunger Return Spring
3. Plunger
4. Start of Shunt and Series Windings ('Lucar' Terminal)
5. Brass Sleeve and 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
18. 'Lucar' Negative Terminal Blade - See 'Note'

4. Slide the yoke assembly over the armature and locate with the dowel peg protruding through the edge of the intermediate bracket. At this stage check for sufficient clearance between the armature and the field coil conductors, particularly at the through bolt entry points.

5. Locate partially in their holders the two earth or negative brushes and then the two field brushes. The spring should be wedged against the sides of the brushes to hold them temporarily in the lifted position for reassembly purposes.

6. Place the brush gear assembly partially over the commutator (as far as the brush flexible leads will allow). Locate the two through bolts in the half-holes of the brush gear plate and screw the bolts a few threads into the fixing bracket to position the brush gear plate in its correct assembly position.

7. Press the brushes on to the commutator and check that the springs are properly located before finally fitting the brush gear assembly to its working position.

8. Position the armature with the brake shoe cross peg in line with the two threaded holes in the brush gear plate.

9. Remove the two through bolts, but do not disturb the position of the brush gear plate.

10. 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).

11. Position the brake shoes in the commutator end cover with the cross peg slot in line with the two smallest of the four holes in the cover.

12. Fit sealing ring to the commutator end cover.

On marine starters, place insulating washer, large diameter end first, onto the negative terminal of the brush gear plate.

13. Locate the dowel peg in the end cover approximately in line with the dowel hole in the end face of the yoke and loosely assemble the end cover on the armature shaft and to the yoke.

14. First, fix the two through bolts and then fix the two brush gear securing screws, (difficulty in locating the threads of the brush gear securing screws is avoided by fixing the through bolts prior to the brush gear securing screws).

On marine starters, assemble the insulating washer, plain washer and spring washer onto the negative terminal and secure with the nut.

15. 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 assembled.

16. Fit the block shaped sealing grommet between the yoke and solenoid mounting portion of the fixing bracket. (Soaping the grommet will facilitate fitting).

NOTE: This sealing grommet is not fitted to marine starter motors.

17. Fit the solenoid plunger to the drive engagement lever. Fit the solenoid unit (positive 'Lucar' terminal blade uppermost) complete with gasket and sealing washers.

18. Connect the solenoid terminals S1 and S2 to the starter flexible link and yoke terminal respectively.

Pinion Setting

The position of the pinion must be set after reassembling the starter motor.

The amount of adjustment of the eccentric pivot 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 a coat of 'Studlock' 270 compound 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 the specified torque.

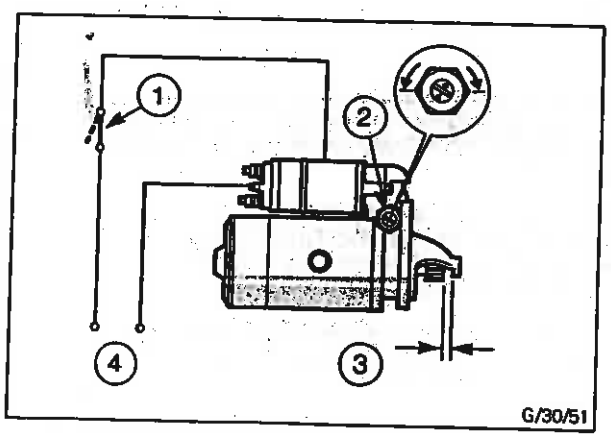


Fig. 10 - Setting the Pinion Movement
1. Switch
2. Eccentric Pivot Pin
3. Dimension when the Solenoid is Energised
4. To 6 volt Test Supply

To check or carrry out the adjustment, connect a 6 volt supply between the solenoid 'Lucar' terminal and the starter frame (this will move the pinion forward to the fully engaged position). With the pinion pressed lightly back, measure the space between the front pinion and the thrust collar on the armature shaft. This should be 0,40 to 0,63 mm (0,015 to 0,025 in).

NOTE: On marine starters, connect the 6V supply between the solenoid positive and negative 'Lucar' blade terminals.

CAV CA45G & CA45G-M STARTER MOTORS

DESCRIPTION

The CA45G starter motor is 114 mm (4,5 in) in diameter. It is of co-axial construction, the two stage operating solenoid switch unit being mounted internally around the armature shaft - (Fig. 11).

All CA45G starters are splash and dust proof. A sealed version is also available that incorporates additional drive end oil seals; these prevent oil from the flywheel housing entering the starter.

The design of the starter is such that pinion engagement occurs under reduced power thus avoiding heavy engagement shock and excessive wear of the pinion and flywheel teeth.

Full power is applied only when the pinion is fully engaged. The pinion is locked in the fully engaged position to prevent premature ejection.

An overspeed device is incorporated that prevents the armature from being driven at excessively high speeds by the engine.

OPERATION

The main terminals are permanently connected to the battery supply, operation of the starter being controlled by the application of battery power to the solenoid terminal(s).

On CA45G starter motors intended for earth return wiring systems, only one solenoid terminal is provided; the other side of the solenoid winding is earthed to the starter motor casing - (Fig. 13).

On CA45G starter motors intended for insulated return wiring systems and on marine versions, two solenoid terminals are provided - (Fig. 14).

When reading the following text describing the sequence of operation, refer to Fig. 12 which shows the starter [illegible]

When the starter solenoid is energised, its plunger moves forward. Four spring loaded steel segments mounted in the plunger bear against a shoulder on the pinion sleeve and move the pinion sleeve and integral pinion forward to its first position. At the same time, the first stage contacts close and current is applied to the starter windings via a built-in resistor. The armature rotates under reduced power and the pinion is driven into engagement by means of the armature shaft helix.

When the pinion is almost fully forward, the second stage contacts close, shorting out the resistor and applying full battery power to the starter windings. When the pinion sleeve is fully forward it is locked in position by four balls located in the sleeve which drop into an annular groove in the armature shaft. A spring loaded sleeve slides over the balls to keep them in position.

As the pinion sleeve moves fully forward, a ramp on the sleeve forces the four spring loaded segments outwards where they are held in position by the magnetic field of the solenoid.

Should the engine start to drive the armature at a speed in excess of the permitted maximum, then the overspeed device will operate. This consists of four additional steel balls housed in the pinion sleeve. At speeds of between 10,000 and 13,000 rpm they move outwards under centrifugal force against a ramp on the locking collar. The locking collar is forced back against its spring thus releasing the four locking balls from the annular groove in the armature shaft. The pinion is now driven back along the helix to its original position; the shoulder passing through the four steel segments which are being held out by magnetic force. The starter will continue to run unloaded until switched off.

If the starter is switched off before the overspeed device has operated, the solenoid plunger, in moving back, pushes the locking collar backwards and releases the locking balls thus enabling the pinion sleeve to return to its original position.

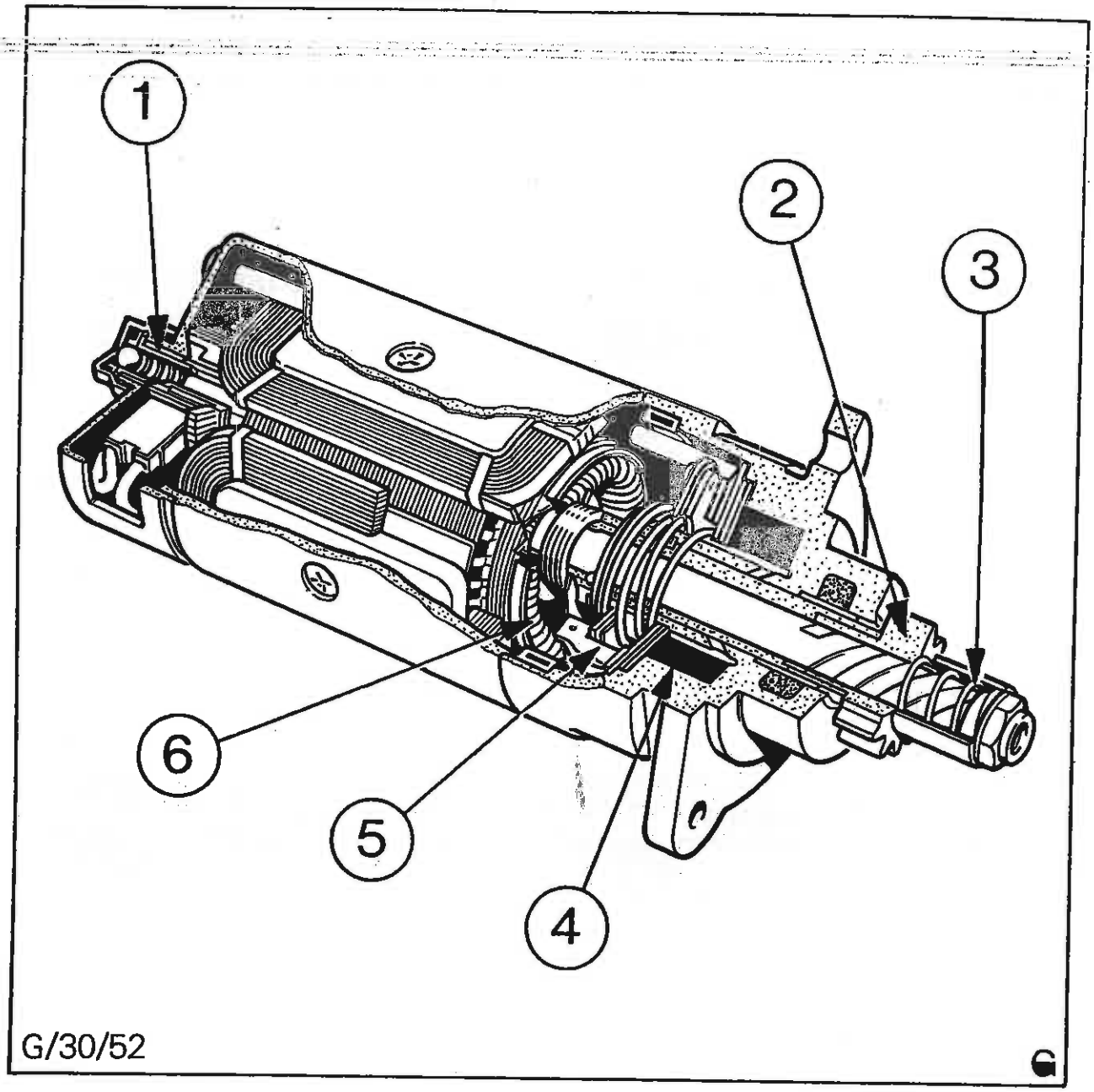


Fig. 11 - The Starter Motor - Part Sectioned
1. Recoil Mechanism
2. Pinion Assembly
3. Pinion Spring
4. Solenoid Assembly
5. Trigger Mechanism
6. Resistor

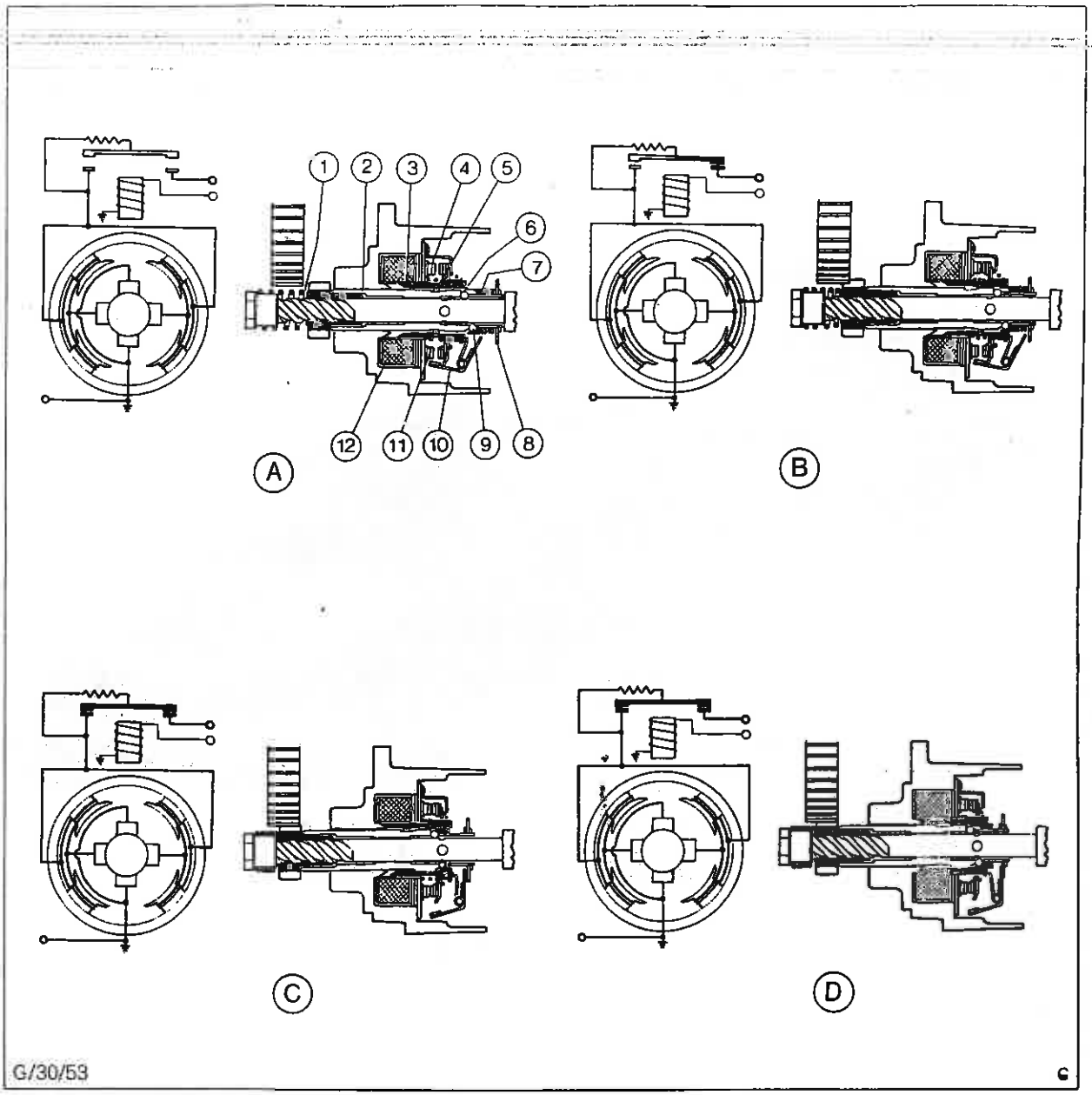


Fig. 12 - Operational Sequence of CA45G Starter

A. At rest position.

B. Engaging position: Solenoid plunger is drawn forward and 1st stage contacts close. Pinion is engaged and armature rotates.

C. Cranking position: Pinion fully engaged. Locking balls retained by locking collar and 2nd stage contacts closed.

D. Overspeed position: Centrifugal force exerted on overspeed balls has pushed locking collar back. Segments are held out by solenoid flux. Pinion is now free to be driven out of engagement.

1. Pinion Return Spring
2. Pinion Sleeve
3. Solenoid Plunger
4. 1st Stage Contacts
5. Segments
6. Overspeed Balls
7. Lock Collar
8. Trip Collar
9. Locking Balls
10. Trigger
11. 2nd Stage Contacts
12. Solenoid

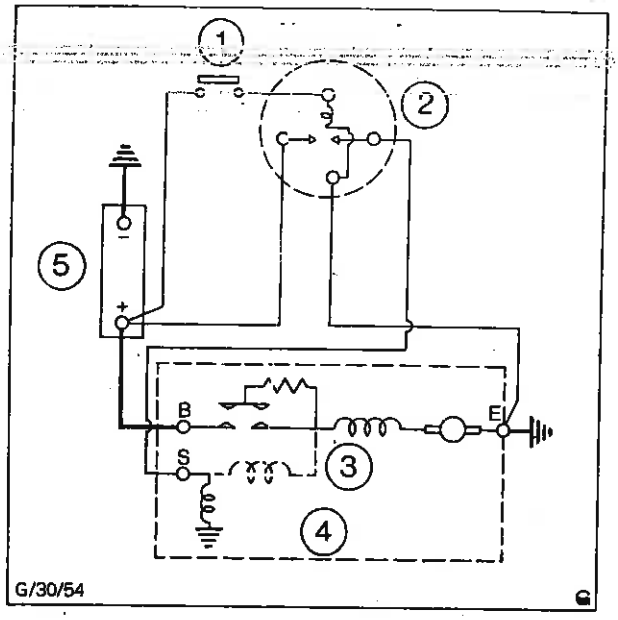


Fig. 13 - Starter Wired for Earth Return Wiring System
1. Starter Push Switch
2. Relay
3. 12V Winding Shown Dotted
4. Starter Motor
5. Battery

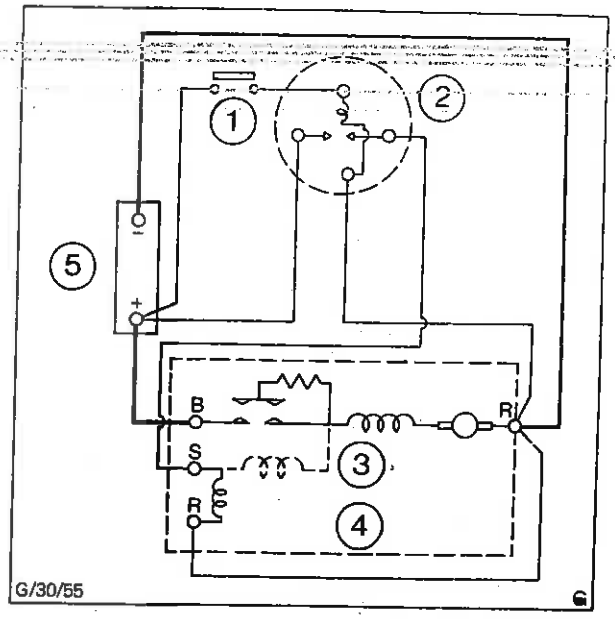


Fig. 14 - Starter Wired for Insulated Return Wiring System
1. Starter Push Switch
2. Relay
3. 12V Winding Shown Dotted
4. Starter Motor
5. Battery

ROUTINE MAINTENANCE

Very little servicing is necessary but in order to ensure maximum life and trouble-free starting, we suggest that the following maintenance procedures be undertaken at regular intervals, the length of which are dependent on operating conditions.

Brushgear

Remove the commutator cover, and ensure that the brushes are free in their holders by lifting the brush springs clear of the brushes and pulling gently on the brush leads. If a brush is inclined to stick, remove it from its holder and clean the brush and the inside of the holder with clean cloth moistened in carbon tetrachloride. Be sure to replace the brush in its original position, so that the curvature of its contact surface accurately conforms with the commutator periphery.

See that the braided sleeving on the brush leads has not become burnt or charred, thus creating the danger of short circuits.

Brushes must be replaced as soon as the specified minimum length is reached.

Replace the commutator cover, ensuring that the yoke windows are fully covered and that the cover fixing screw is at the bottom of the starter when the starter is mounted on the engine. This is most important, as fuel oil and water may enter the machine if the cover is not correctly positioned.

Lubrication

The drive end bearing is lubricated by a wick contained in a large oil reservoir in the drive end shield. The capacity of this reservoir is such that it requires no attention during routine maintenance but should be refilled when the starter is dismantled at major overhaul periods.

This is done by removing the starter and adding a quantity of the specified oil through the oil filler hole in the drive end shield. The filler hole lies beneath a core plug which must be removed to gain access to the filler hole. New plugs only must be fitted and care taken to ensure a positive fit in the filler hole.

An oil impregnated bearing is fitted at the commutator end of the machine and requires no attention during service. Under no circumstances should any attempt be made to grease the bearing as this may adversely affect its self-lubricating properties.

Cables and Mounting Bolts

The starter should be examined to ensure that its mounting bolts are securely fastened, and that all cable connections are clean and tight. The cables should also be inspected for fractures, particularly at the point where the cable enters the terminal lug. The cable insulation should be free from chafing or deterioration due to oil contamination.

To ensure effective operation of the starter it is recommended that the total voltage drop in the cables, starter switch, relay or any other switch in the circuit, does not exceed 0,5 volt at 38 ampere for the starter solenoid circuit and 0,25 volt at 5,3 ampere for the relay switch circuit.

OVERHAULING THE STARTER MOTOR

Dismantling

The figures in brackets relate to Fig. 15 unless otherwise stated.

Disconnect the battery, disconnect all motor wiring connections and remove the starter motor from the engine.

1. Remove the two core plugs (29) in the drive end shield (5) with a sharp pointed instrument.

2. Unscrew the two field terminal screws (30) that are exposed when the core plugs are removed.

3. Remove commutator cover (37).

4. Unscrew the brush lead screws, raise the brush springs and remove the brushes from the holders. It should be noted that removal of the brush lead screws also frees the field coil connections.

5. Unscrew and remove end cap (32). When removing the cap, care must be taken not to lose steel ball (18) which is under pressure from spring (34).

6. Withdraw spring (34).

7. Remove circlip (17) and then withdraw thrust washer (33) and shim washers (16).

8. Unscrew and remove the two through-bolts (35).

9. Carefully remove commutator end shield (15) and collect shims (36) from the end of the armature shaft. Keep these shims separate so that if the armature is to be refitted, end float adjustment is simplified by refitting the original shims.

10. Tap drive end shield (5) away from yoke (14) with a hide or wooden mallet, and then withdraw end shield complete with armature.

11. Secure the armature in an armature clamp, and, using either a 7/16 in BSF box spanner or socket with the chamfered lead ground away, unscrew the pinion stop nut (49) in the direction of the starter rotation. Remove the thrust washer (48), shim washer (47), pinion return spring (2) and helix dust cover (1).

12. Remove core plug (4) and spring (3) from the drive end shield.

13. Release the ball lock mechanism by pushing the end shield towards the armature. With the lock collar held in this position, unscrew the pinion until the helix disengages. Finally, slide the pinion, together with the drive end shield, off the armature shaft, and collect the four steel balls (8) - six balls on 24V starters - and the four overspeed balls which may fall through into the inside of the pinion sleeve. Remove the armature from the armature clamp.

14. Using the circlip pliers, remove circlip (11) from the end of the pinion sleeve. Remove shim.

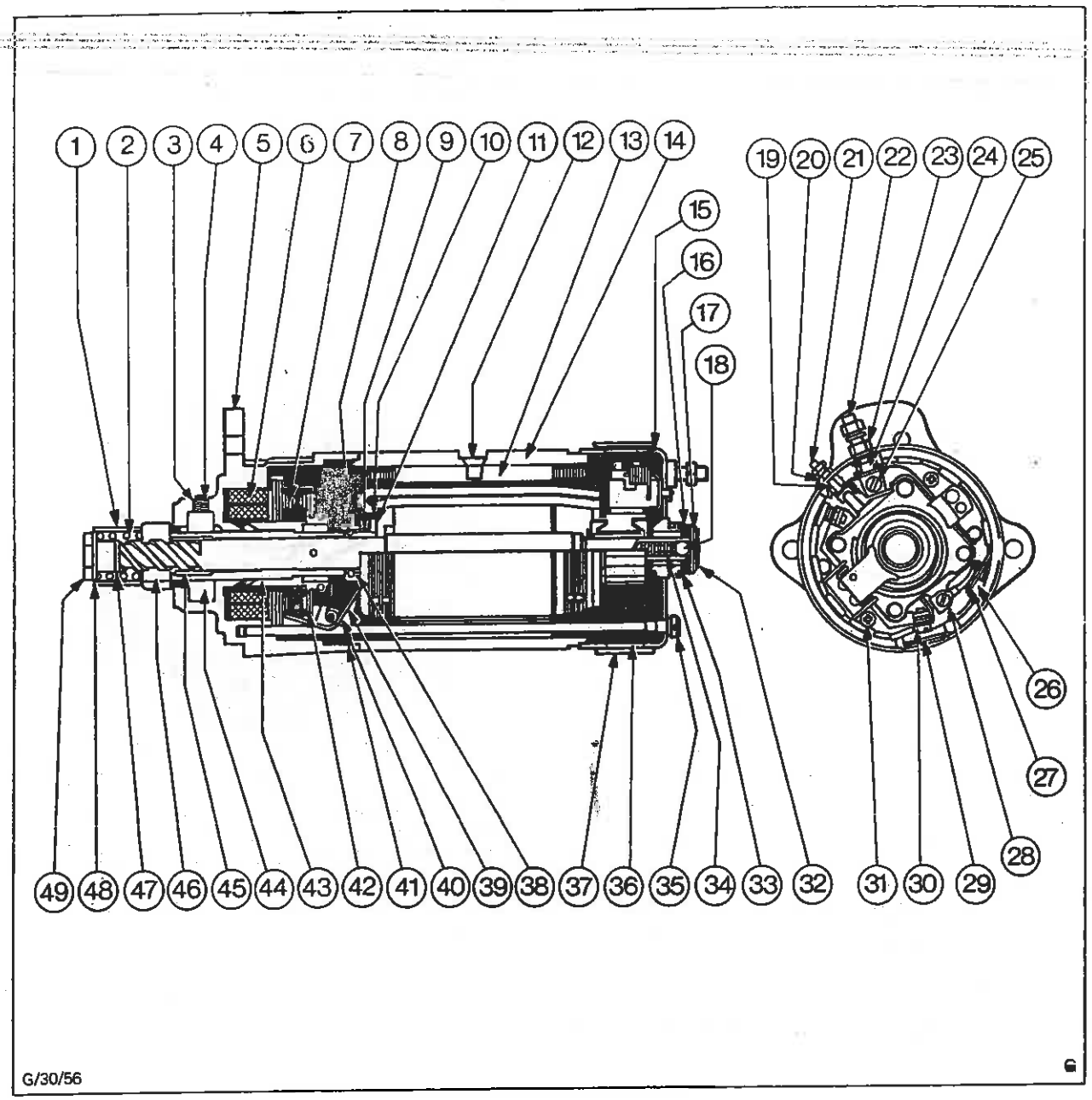


Fig. 15 - Sectional View of Starter

1. Helix Cover
2. Pinion Spring
3. Pinion Return Spring
4. Lubricator Core Plug
5. Drive End Shield
6. Solenoid Assembly
7. First Contact
8. Locking Balls
9. Lock Collar Spring
10. Trip Collar
11. Circlip
12. Pole Screw
13. Pole Shoes
14. Yoke
15. Commutator End Shield
16. Shim Washers
17. Circlip
18. Steel Ball
19. Insulating Bush
20. Terminal Nut
21. Solenoid Terminal
22. Main Terminal
23. Terminal Nut
24. Insulating Bush
25. Screw
26. Spacer
27. Resistor Rivet
28. Resistor Flexible Lead
29. Core Plug
30. Field Terminal Screw
31. Self Tapping Screws
32. End Cap
33. Thrust Washer
34. Recoil Spring
35. Through Bolts
36. Shims
37 Commutator Cover
38. Lock Collar
39. Trigger
40. Resistor
41. Trigger Spring
42. Second Contact
43. Solenoid Plunger
44. Lubricator Wick
45. Dust Scraper Ring
46. Pinion Assembly
47. Shim Washer
48. Thrust Washer
49. Pinion Stop Nut

15. Remove trip collar (10, lock collar spring (9); and lock collar (38).

16. Withdraw pinion assembly (46) from the drive end shield. If any burrs can be seen on the pinion, these should be carefully removed by use of a stone before withdrawing the pinion.

17. Detach the resistor flexible lead (28) from the moving contact plate. On insulated return machines there is a link to a binding post on the moving contact.

18. Free the resistor (40) from the drive end shield by punching out the securing rivet (27) with a suitable punch. Withdraw the resistor and the two nylon bushes (26).

19. Unscrew main terminal nuts (23) and screw (25). Remove insulating bush (24) and then withdraw main terminal (22) from inside the housing. (Rotating the terminal axially through 180° simplifies this operation).

20. Remove nuts (20) and insulating bush (19) from solenoid terminal (21). Push the terminal well into the drive end shield so that it is clear of its hole.

NOTE: On insulated return starters, also remove similar parts from the adjacent 'R' terminal.

21. Unscrew self-tapping screws (31) and withdraw solenoid assembly (6) and main terminal insulator.

22. Remove the four segments and the 'garter' spring from the annular groove in the bore of the solenoid plunger.

INSPECTION AND REPAIR OF COMPONENTS

NOTE: It is essential to remove all brush dust etc. from components by using dry compressed air before making electrical tests.

Armature Windings

If the armature windings are suspect, they can be tested for continuity and short circuits by means of a 'growler' armature tester; if such a machine is not available, the armature may be tested by substitution.

Check the insulation by connecting a 100V 'Megger' type tester between each commutator segment and the armature shaft. The resistance indicated should be at least 1 Megohm.

Solenoid Unit

The coils can be checked for open or open circuits by measuring current consumption at nominal voltage. 12 VOLT STARTER SOLENOIDS ONLY are dual wound and consist of a pull-in and hold-on winding, therefore before testing these, a link should be made between the base of the contact assembly (3) Fig. 16, and the terminal lug (8) on earth return versions, or between the green lead and terminal lug (8) on insulated return versions.

Test the coils in accordance with the instructions given in the table Fig. 17. A good quality moving coil ammeter with a range of 0-100 ampere should be connected in series with one of the voltage supply leads.

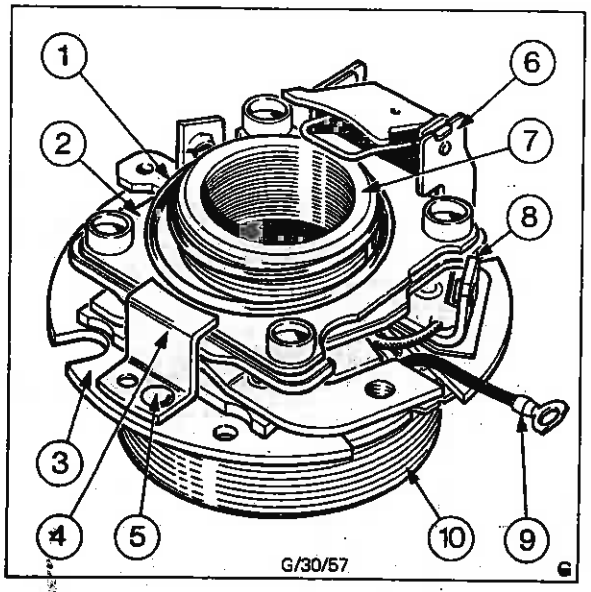


Fig. 16 - Solenoid Switch Assembly
1. Plunger Spring
2. Moving Contact Assembly
3. Fixed Contact Assembly
4. Contact Stop
5. Rivet
6. Trigger Assembly
7. Plunger
8. Fixed Contact Lug
9. Terminal Tag
10. Solenoid Coil

Starter Type	Voltage Supply & Connections	Correct Ammeter Readings
12V Earth Return	12V Between Black Lead & (3), Fig. 6	39A (59A for Sealed Starters)
12V Insulated Return	12V Between Black & Green Leads	As Above
24V Earth Return	24V Between Black Lead & (3), Fig. 6	16A (19A for Sealed Starters)
24V Insulated Return	24V Between Black & Green Leads	As Above

Fig. 17 - Solenoid Coil Testing Data

NOTE: On some starter solenoids, the green lead is replaced by a yellow lead.

Examine the contacts and, if necessary, clean them with white spirit or very fine carborundum paper. The first stage gap should be 2,1 mm (0,083 in) with a bottom limit of 1,93 mm (0,076 in) and a maximum of 2,5 mm (0,098 in). Press down the plunger and check that the second stage contacts make only after the trigger is tripped. Slight adjustments can be made by bending the brass contact stop (4), Fig. 16.

If the contacts are badly burnt, gap excessive or coils appear to have overheated, the solenoid can be replaced as a complete unit or serviced as follows:

1. Remove the burred over ends of the rivet (5) Fig. 16, also the rivets securing the trigger assembly (6) using a 4,75 mm (0,187 in) diameter drill.

2. Carefully punch out the rivets and remove the contact stop (4) and trigger assembly. Examine the trigger assembly for wear on the pivot points, if excessive, fit a new trigger assembly.

3. Withdraw plunger (7) and plunger spring (1) moving contact assembly (2) and inner spring as one assembly.

4. Unsolder the red solenoid lead connected to the fixed contact lug (8) on 12 volt machines, also the bare solenoid lead connected to the fixed contact baseplate on all earth return machines.

5. Remove the fixed contact assembly (3).

6. Locate the fixed contact assembly (3) on the solenoid coil (10). Ensure the contact plate rivet holes line up with those in the solenoid coil plate.

7. Replace the assembly consisting of the plunger, moving contact and springs. The rectangular shaped extension on one side of the moving contact assembly must face the two rivet holes for the trigger.

8. Push the solenoid plunger fully home. With the plunger held in this position, replace the contact stop (4) and trigger assembly (6) and rivet them in position.

9. Solder the red solenoid lead to the fixed contact lug (8) on all 12 volt machines. On all earth return machines, solder the other bare solenoid lead to the fixed contact baseplate, localising the area of solder. Test security of joint with a sharp tug on the lead.

10. Check that the first stage contact gap is within limits as already described.

Commutator End Bearing

Ensure that the commutator end bearing is tight in its housing, and check the side play between armature shaft and bearing. If this is excessive, either a replacement commutator end shield and bearing assembly should be fitted, or the bearing should be renewed as follows:

1. Press the old bearing out of the end shield using special tool No. 5693-240.

2. With the same tool, press the new bearing (after smearing with light oil) into the end shield. After assembly, the bearing should not protrude from either end of the housing; no machining should be attempted. A special plug gauge, 5693-275 is available for checking the bush bore. The end of the gauge marked 'NOT GO" should not enter the bush.

NOTE: The bearing must not be soaked in oil prior to assembly as it is impregnated with a special lubricant by the manufacturer.

Drive End Shield

Check the internal diameter of the drive end bearing with the special plug gauge 5693-267. If the bearing is worn, the drive-end shield MUST be replaced as an assembly. Service exchange drive end shields are available under the appropriate part number.

IMPORTANT: On new and replacement drive end shields, a leatheroid retaining pad is fitted in the oilway. This MUST be removed to prevent the bearing being oil starved. Check that the felt pad is free to move under the influence of the spring.

NOTE: Do not fit the lubricator pad spring (3), Fig. 15 and core plug (4) at this stage, as pressure on the felt pad will prevent the pinion sleeve from being fitted.

Examine the dust scraper ring (45) and if worn or damaged, remove and discard it.

NOTE: In the case of sealed starter motors, an oil seal is fitted in place of a dust scraper ring.

Clean out the groove in the end shield and fit a new dust ring, using special Service Tool 5693-299. In the case of sealed starter motors, fit a new oil seal the correct way round as shown in Fig. 18.

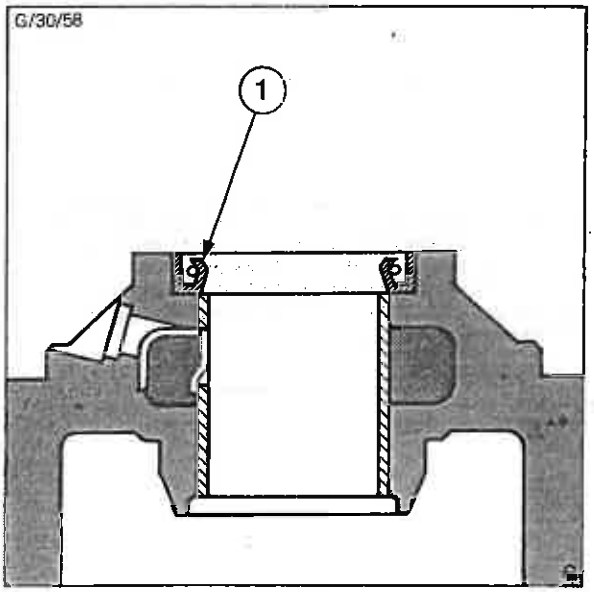


Fig. 18 - Drive End Shield Oil Seal
1. Correct Position for Oil Seal

Pinion

If the pinion teeth are badly worn or damaged, change the pinion. See that the new pinion has the same number of teeth, and is a free sliding fit on the armature shaft. If necessary, lightly lap the pinion and shaft using a fine lapping paste. Remove all traces of lapping paste, using a bottle brush to ensure absolute cleanliness of the pinion helix. When the pinion is fitted with an oil seal inside, all burrs or sharp edges on the armature shaft and helix must be removed with an abrasive stone otherwise these will tear the oil seal. Fit a new seal with the 'U' channel facing towards the pinion teeth end - See Fig. 19.

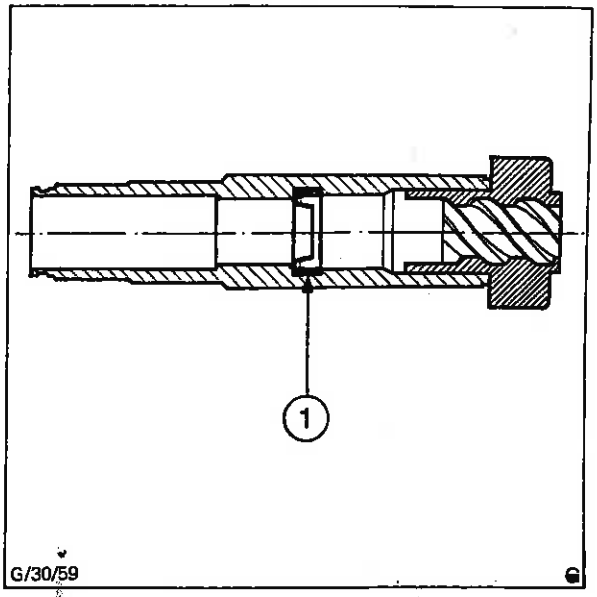


Fig. 19 - Pinion Oil Seal

Springs

See that the springs are undamaged and have not lost tension. The tension of the springs when compressed should be as follows:

Spring	Compressed Length	Tension
Lock Spring	9,53 mm (0,375 in)	0,765 to 0,878 kgf (1,69 to 1,94 lbf)
Recoil Spring	33,35 mm (1,313 in)	12,0 to 13,39 kgf (26,5 to 29,5 lbf)
Pinion Spring	31,75 mm (1,250 in)	3,5 to 3,85 kgf (7,75 to 8,5 lbf)
Pinion Spring (oil sealed starter)	37,3 mm (1,469 in)	4,4 to 4,6 kgf (9,81 to 10,19 lbf)

Commutator

If the commutator surface is dirty or discoloured, it can be cleaned with a very fine grade of glass paper (do not use emery cloth or carborundum paper). In cases where the surface is badly pitted or grooved, the armature should be set up in a lathe and the commutator skimmed. A rough cut should first be made, removing just sufficient copper to clear traces of grooving or pitting, after which a light cut should be taken, using a diamond tipped tool to obtain the desired high quality finish. Finally, remove all traces of swarf using dry compressed air.

The recess in the commutator is required only for initial manufacture, and can therefore be eliminated when skimming is undertaken. Minimum diameter to which the commutator can be reduced is 39,2 mm (1,56 in) and the radius at the junction of the risers and the commutator must not exceed 1,0 mm (0,040 in). Do not skim the risers.

The commutator must not be undercut otherwise brush dust tracking may occur.

Armature Shaft

Examine the recesses in the armature shaft for burrs caused by the steel balls and carefully stone these off.

Inspect the shaft helices for signs of damage or excessive wear. Finally, clean the helices with paraffin and smear them with a small quantity of grease. No attempt should be made to machine the armature core.

Field Windings

Before making electrical tests, remove all traces of brush dust, etc. by blowing with dry compressed air.

The windings can be tested for earths to the yoke using a 100 volt 'Megger'. A minimum resistance of 1 Megohm should be indicated.

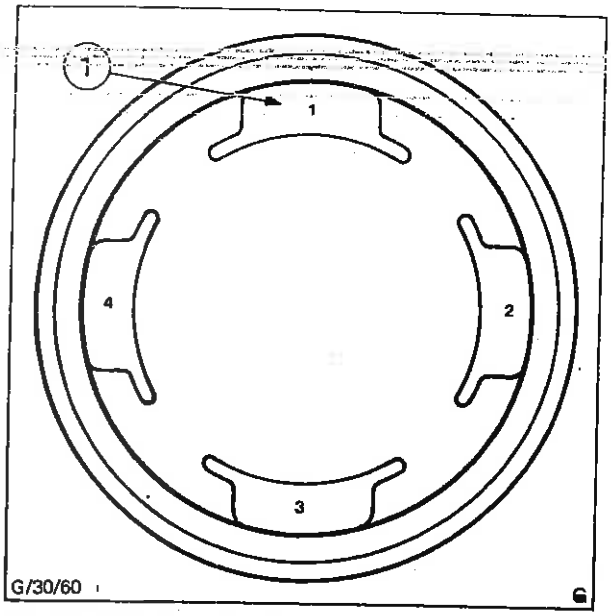


Fig. 20 - Position of Poleshoes in Yoke
1. Corresponding Numbers Adjacent

There is no easy way of checking for initial shorts in the coils as their resistance is very low. New coils should be tried if the existing ones are suspect. Unserviceable coils should be renewed as follows:

1. Unscrew pole screws (12) Fig. 15 and remove the poleshoes (13) and windings, noting the position of the windings and poleshoes in order to facilitate re-assembly.

2. Fit the new windings into the yoke and replace the poleshoes. Concentricity is achieved by machining the poleshoes and the poleshoes must be replaced in their original positions, otherwise they may foul the armature. As an aid to correct assembly, the poleshoes are numbered and must be replaced in the positions shown in Fig. 20.

3. Insert and tighten the pole fixing screws (12), Fig. 15, using a poleshoe screwdriver. Care must be taken that the poleshoes are correctly aligned in the yoke, otherwise they will not bed down fully and may foul the armature.

Brushgear

Check the brushgear insulation using a 100 volt 'Megger' type tester. Insulation resistance must be not less than 1 Megohm. Ensure the brush holders are tight.

(a) Earth return machines:
Check insulation between insulated brush holders and the frame. Make sure that the earthed brush boxes are making good electrical contact with the end shield.

(b) Insulated return machines:
Check insulation between ALL brush holders and the frame.

Brushes

The brushes should always be renewed at overhaul periods in order to ensure maximum life between overhauls. It is essential that replacement brushes are fitted in complete sets.

Replacement brushes must be well 'bedded', i.e. shaped to the commutator periphery. To do this, wrap a strip of fine glass paper around the Commutator and 'bed' the assembled brushes on its surface. Remove all traces of dust and abrasive with dry compressed air. Ensure that no particles of abrasive are embedded in brushes or commutator.

Brush Springs

The brush spring pressure should be within the range 2,7 to 3,4 kgf (6 to 7,5 lbf). To check the pressure remove the brushes from the holder and, with a suitable spring balance hooked under the lip of the spring, raise the lip to the height of the brush. If the spring pressure is outside limits, fit new brush springs.

ASSEMBLY

The figures in brackets refer to Fig. 15 unless otherwise stated.

1. Fit the protection collar (special service tool No. 6244-6) over the end of the pinion sleeve and insert the pinion assembly into the drive-end shield, ensuring that the dust scraper ring (45) or, in the case of sealed starters, the oil seal, is not damaged in the process.

2. Place the assembly of pinion and end shield on the bench, pinion side downwards, and detach the protection collar from the pinion sleeve.

3. Before assembling the four segments (1), Fig. 21, check that they are free from burrs and sharp edges. Place the garter spring (2), on a clean flat surface, and with the fingers position the four segments inside the spring so that they lie end to end in a circle. The garter spring will fit in the outer groove of the segments and hold them together.

4. Place the solenoid switch on the bench, coil end upwards and, with the fingers, gently push the garter spring and segment assembly into the bore of the solenoid plunger so that it fits into the recess provided. It will be found easier if one segment is located in the recess first and then the other three can be edged into position.

5. Place the solenoid terminal, solenoid terminal insulator, and main terminal insulator on solenoid assembly as shown in Fig. 22.

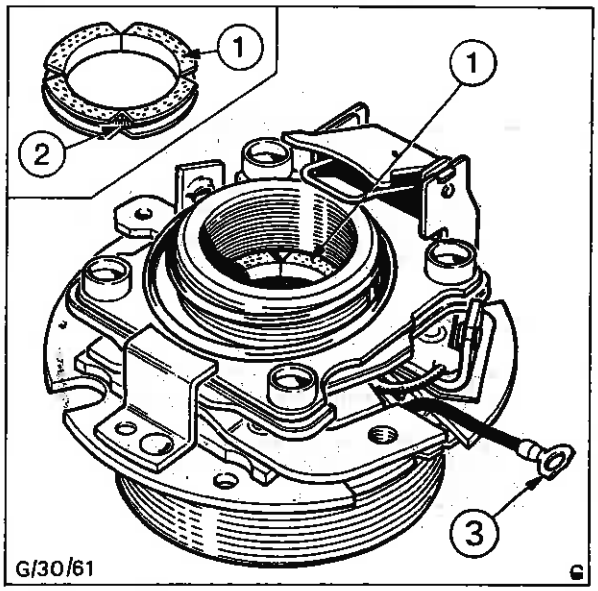


Fig. 21 - Segments and Garter Spring Assembly
1. Segment
2. 'Garter' Spring
3. Terminal Tag

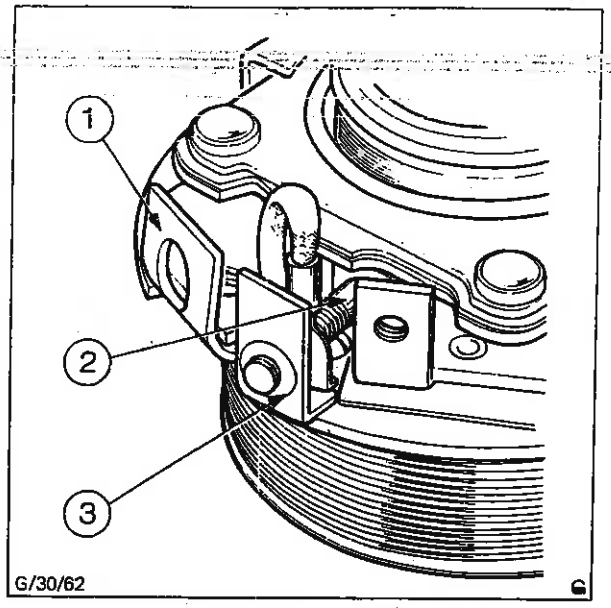


Fig. 22 - Solenoid Terminal and Insulators
1. Main Terminal Insulator
2. Solenoid Terminal
3. Solenoid Terminal Insulator

6. Insert the solenoid assembly into the drive end shield and fasten it in position with spring washers and self-tapping screws (31). Drop the anodised metal strip on the inside face of the main terminal insulator.

7. Push the solenoid terminal (21) into its hole, and replace bush (19), spring washer and nut (20).

NOTE: On insulated return models there is an additional solenoid lead, coloured green or yellow, which must be attached to its terminal screw exactly as above. This is the 'R' terminal.

8. Insert main terminal (22) into position from inside the housing, and replace bush (24), rubber ring, insulating washers, plain washers, spring washers and nut (23). Pressing down the plunger gives room to insert the main terminal. Do not tighten until operation 9 has been carried out. Add the solenoid terminal tag (3), Fig. 21.

9. Replace spring washer and screw (25) and tighten securely. Now tighten nut (23) to the specified torque value.

10. Fit the lock collar (38) to the pinion sleeve, making sure that the 45° chamfer inside the collar is facing towards the solenoid assembly.

11. Replace the spring (9), trip collar (10), and secure in position with circlip (11), dished side downwards. Make sure that the circlip locates in the locking collar groove. Check with gauge 6244-3 for seating squarely.

12. Insert resistor (40) into its recess in the drive end shield, and secure it in position by means of bush and spacer (26) and rivet (27).

13. Connect the resistor lead to the lug on the solenoid assembly by means of washer and screw (28).

NOTE: On insulated return models, there is a link bar between the lug and a corner of the moving contact. The link is secured to the lug by a washer and screw and the other end is attached to a post together with the resistor flexible lead by means of a washer and nut.

14. Insert lock balls (8) and the four overspeed balls into the pinion sleeve holes from inside the bore, using grease to hold them in position.

NOTE: 12 volt starters have four lock balls and 24 volt starters have six lock balls.

15. Assemble the pinion and end shield assembly to the armature as follows:

(a) Pull the pinion out of the drive end shield until lock collar (39) is pressed back against its spring by the end of solenoid plunger (43). Keep it in this position until otherwise stated.

(b) Press lock balls (8) fully into their holes to allow free entry of the armature shaft.

(c) Slide the pinion and end shield assembly on the armature shaft, taking care not to displace the lock balls.

(d) Engage the pinion with the shaft helix, and then release the pull on the pinion. Screw the pinion onto the shaft and check that the pinion locking mechanism engages.

(e) Finally, support the weight of the drive end shield, and rotate the pinion first in one direction and then on the other to ensure that the pinion is free on the shaft and that the locking mechanism functions correctly. The locking mechanism can be released by pulling lock collar (38) back against its spring.

16. Mount the armature in an armature clamp. Assemble the helix dust cover (1), the pinion return spring (2), the shim washer (47), and the thrust washer (48), onto the pinion shaft. Screw a NEW Pinion stop nut (49) onto the shaft in the opposite direction of starter rotation. Using a 7/16 in BSF socket with the chamfered lead ground away, tighten the pinion stop nut to the specified torque value. On oil sealed starters ONLY, use Loctite grade 'D' on the nut thread.

17. Assemble the armature and drive end shield assembly to yoke (14), ensuring that the dowel in the yoke locates in the slot in the end shield.

NOTE: The joint between the yoke and each end shield should be sealed with Wellseal compound.

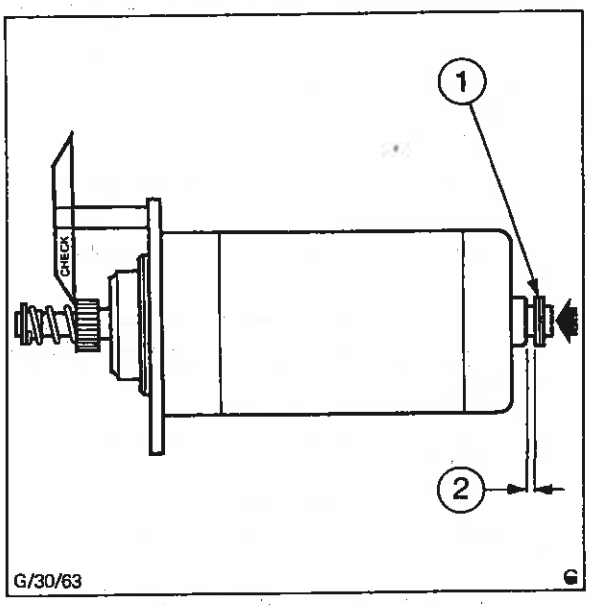


Fig. 23 - Adjustment of Armature End Float
1. Thrust Washers
2. Gap 'X'

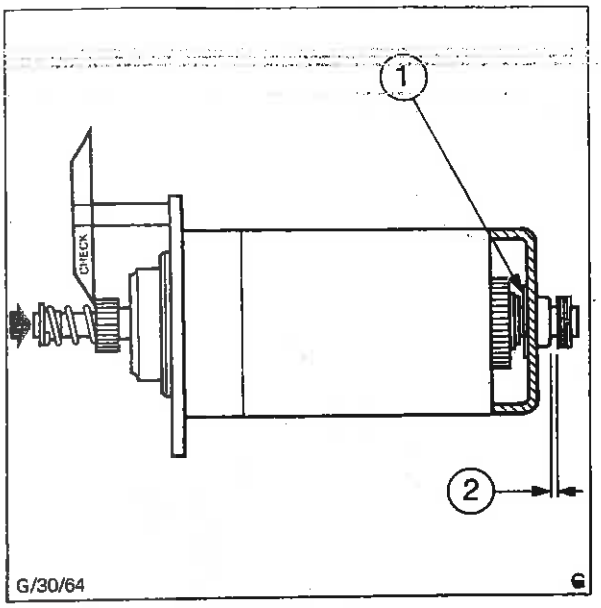


Fig. 24 - Adjustment of Armature End Float
1. Shim Washers
2. Gap 'X'

18. Check that shims (36) have all been removed from the armature shaft, and then replace comutator end shield (15). Fit through bolts (35) and tighten securely to the specified torque.

19. Replace the thrust washer (33) and circlips (17), but do not fit shims (16).

20. The armature end float, and the distance between the pinion and mounting flange, must now be adjusted as follows, using gauge 5693-222, 5693-222A or 5693-222B as appropriate:

(a) Bolt the gauge onto the mounting flange with the arm marked "CHECK" towards the pinion as shown in Fig. 23, then push the armature towards the drive end of the machine until the pinion face just touches the gauge. With the armature held in this position, measure gap 'X' between thrust washers (33) and the commutator end shield, using feeler gauges. Shim washers, having a total thickness equivalent to the measurement taken by the feeler gauges should then be fitted between the thrust washer and circlip. The shim washers must be well greased before use, and are available in two thicknesses 0,10 and 0,20 mm (0,004 and 0,008 in). A combination of these sizes giving the closest approximation to the required dimension should be used.

(b) When this has been done, push the armature towards the commutator end of the machine as shown in Fig. 24 and again measure gap 'X' which should now be within the limits 2,03 + 0,50 - 0,00 mm (0,079 + 0,02 - 0,00 in) using Tool No. 6244-4 go/no-go gauge.

NOTE: If the gap is outside this limit, remove the commutator end shield, and fit shim washers (36) on the armature shaft to the value of the excess. For example, if this is 3,04 mm (0,120 in), shim washers having a total thickness 0,51 to 1,01 mm (0,020 to 0,040 in) should be fitted, i.e. four shims each 0,20 mm (0,008 in) thick. These shims must be smeared with grease before use.

Replace commutator end shield, thrust washers, shim washers as described in paragraph (a) and the circlip.

(c) Smear steel ball (18) and spring (34) with grease and insert them in the bore in the armature shaft. Replace end cap (32), twisting it in the direction of starter rotation to lock it in place.

NOTE: If a screwed end cap is originally fitted in place of the bayonet type, the starter motor must be held vertically, commutator end uppermost and the thrust pad attached to the cap with grease. The cap must be tightened to the specified torque value and the two thin corners of the hexagon caulked to slots in the bearing collar with a punch.

(d) Check that any variation in the relationship of pinion position to check gauge is within the limits of + 0,076 to -0,050 mm (+0,003 to -0,002 in).

Rectify if necessary by varying the shims as in operation 20(b).

21. Fill the reservoir in the drive end shield with oil, and insert spring (3). Replace core plug (4) using special tool 5693-300.

22. Connect the field windings and the free end of the resistor to the solenoid switch lugs by means of screws and washers (30).

23. Fit the brushes and place the brush springs in position. Connect the brush leads and the field winding leads to the brush gear. Check that the brush leads allow free movement of the brushes in their holders.

TESTING

Engagement mechanism

WARNING: Under no circumstances should BOTH Main terminals be connected to the supply during these tests, otherwise the pinion will rotate at high speed when pulled forward, causing injury to the operator.

1. With the machine disconnected, pull the pinion forward, by hand, approximately 1,6 mm (0,0625 in) and release. The pinion should return to its original position.

2. Energise the solenoid when cold by applying a battery voltage of 12 volt for 12 volt starters or 24 volt for 24 volt starters. For all tests the battery should be well charged, in good condition, and of recommended minimum capacity - refer to Fig. 25. The battery should be connected between the solenoid terminal 'S' and earth terminal for machines designed for earth return systems, and between the solenoid terminal 'S' and the solenoid terminal 'R' for insulated return machines. When the solenoid has been energised, the pinion should move forward for a distance of 6,3 mm (0,25 in) minimum.

3. With the solenoid still energised, pull the pinion forward by hand. The locking mechanism should now come into operation locking the pinion in the forward position.

4. Disconnect the supply to the solenoid. The pinion must return to its disengaged position in one sharp movement.

5. Check the recoil spring action by applying compression spring balance to the driving end of the armature shaft. The force required before backward movement of the shaft occurs should be 13,6 to 17,2 kgf (30 to 38 lbf).

Performance Tests

For the purpose of these tests, the brushes must be bedded over at least 80% of their contact area.

CAUTION: If the starter is allowed to run without engaging a suitable flywheel, the pinion will not be restrained from rotating in the initial stages, and thus will not complete the forward movement necessary to trip the second stage contacts. Under these conditions, the resistor will remain in circuit and may be damaged by overheating. Moreover, prolonged running on first stage contacts may cause grooving of the solenoid trip mechanism. For these reasons, the starter should always be run in conjunction with a flywheel, but if this is not possible, the running period must not exceed five seconds.

1. Mount the starter on the starter test bench, with a 3,18 mm (0,125 in) clearance between the face of the pinion and the face of the test bench flywheel.

2. Connect the terminals as shown in Fig. 13 or 14 to a fully charged battery of suitable voltage and capacity not less than that shown in the Test Data table, Fig. 25.

3. Complete ten engagements into a partly locked flywheel to ensure that the engaging mechanism is operating satisfactorily. Non-engagement may be caused by a tight drive end bearing, or by the pinion binding on the armature shaft.

4. Check the lock torque (LT), the running torque (RT) and the light running torque (LR) of the starter according to the Test Data table, Fig. 25.

NOTE: It is important that the battery is adequately charged, in good condition and of the minimum capacity specified. A partly charged battery or one in poor condition will not provide current sufficient to reach the specified torque figures.

After tests have been successfully completed, replace the core caps (29). Using tool No. 5693-298, replace the commutator end cover, ensuring that the windows are fully covered and that the cover fixing screw is at the bottom of the starter when the machine is mounted on the engine.

Nominal Voltage of Starter	Type of Test	Minimum Battery Capacity	Torque Figures			Current in Amperes	Terminal Voltage	Speed
			Nm	kgf m	lbf ft			
12	LT	135Ah	48	4,9	35,5	1240 max.	4,5	-
	RT	135Ah	20	2,1	15	690 max.	8,0	1220 min.
	LR	135Ah	-	-	-	100 to 150	12,0	7000
24	LT	78Ah	52	5,3	38	910 max.	9,2	-
	RT	78Ah	23	2,4	17	555 max.	15,2	1550 min.
	LR	78Ah	-	-	-	60 to 100	24,0	7000

Fig. 25 - Test Data

LT = Lock Torque RT = Running Torque LR = Light Running Torque

SPECIFICATIONS

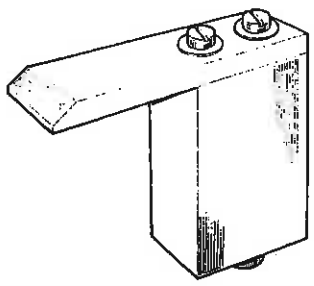
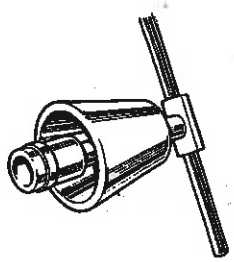
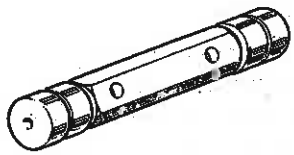
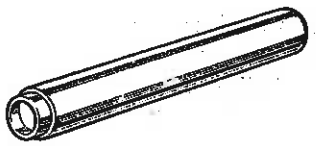
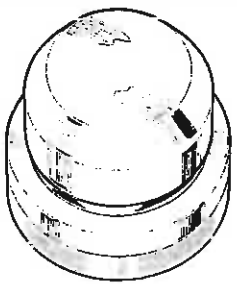
TYPE	M50 & M50 Marine	CA45G	CA45G-M (Marine)
Operating Voltage	12V	12V or 24V	12V or 24V
Wiring System	Earth Return	Earth or Insulated Return	Insulated Return
No. of Brushes	4	4	4
Minimum Brush Length	8 mm (0,313 in)	12,7 mm (0,5 in)	12,7 mm (0,5 in)
Brush Spring Tension	11,7 N (1,2 kgf or 42 ozf)	26 to 33N (2,7 to 3,4 kgf or 6 to 7 lbf)	26 to 33 N (2,7 to 3,4 kgf or 6 to 7 lbf)
Minimum Commutator Diameter	38 mm (1,5 in)	39,2 mm (1,56 in)	39,2 mm (1,56 in)
Drive End Bearing Lubrication (Ford Specification SM-2C-1017A)	-	SAE 20W	SAE 20W
Armature Shaft Recoil Spring Compression	-	135 to 170 N (13,6 to 17,2 kgf or 30 to 38 lbf)	135 to 170 N (13,6 to 17,2 kgf) or 30 to 38 lbf)

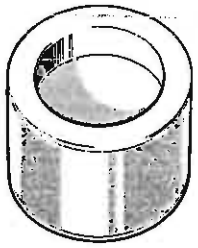
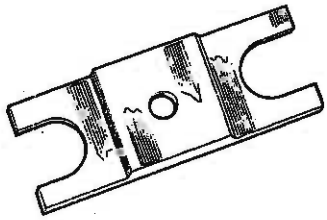
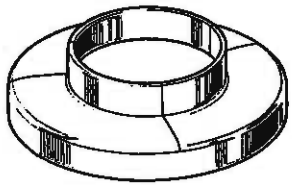
TIGHTENING TORQUES

	Nm	kgf m	lbf ft
M50 & M50 Marine Starter Motors			
Pivot Pin Lock Nut	21,7	2,2	16
Through Bolts	10,8	1,1	8
Brushgear Securing Screws	3,4	0,35	2,5
Solenoid Unit Securing Nuts	6,1	0,6	4,5
Solenoid Upper Terminal Nuts (S1 and S2)	3,4	0,35	2,5
Solenoid Main Terminal Nut	4,1	0,4	3
Starter Earthing Stud Nut	8,1	0,8	6
Starter Negative Terminal Nut (Marine Unit)	5	0,5	3,5
Pole Shoe Retaining Screws	27	2,8	20
Terminal and Base Assembly Retaining Screws	2,4	0,25	1,8
CA45G & CA45G-M Starter Motors			
Through Bolts	9,5 to 10,2	0,97 to 1,04	7 to 7,5
Main Terminal Nuts	6,8	0,7	5
Pinion Stop Nut	54 to 68	5,5 to 6,9	40 to 50
End Cap (Threaded Type), Where Fitted	9,5 to 13,6	0,97 to 1,38	7 to 10

SPECIAL TOOLS - CA45G and CA45G-M STARTER MOTORS

All the special tools listed are available from:
CAV Ltd., Warple Way, Acton, London, W3, England.

Tool No.	Description	Identification
5693-222 5693-222A 5693-222B	Gauge, Setting Pinion (1,876 in gap) Gauge, Setting Pinion (0,813 in gap) Gauge, Setting Pinion (1,001 in gap)	
5693-240	Extractor, Commutator End Bearing	
5693-267 5693-275	Plug Gauge, Checking Drive End Bearing Plug Gauge, Checking Comm. End Bearing	
5693-298 5693-300	Plug Punch, Fitting Core Plugs (Large) Plug Punch, Fitting Core Plugs (Small)	
5693-299	Tool, Fitting Dust Scraper Ring in Drive End Shield	

Tool No.	Description	Identification
6244-3	Gauge, Trip Plate Circlip	
6244-4	Feeler Gauge, Checking Armature Recoil End Float (Comm. End)	
6244-6	Assembly Ring, Fitting Pinion Scraper Ring	

SECTION 2 - CHARGING SYSTEM

CONTENTS

INTRODUCTION

The following alternators are available for use with the 2720 range of engines:

Lucas 17ACR'M':	12V, 36A	marine alternator
Lucas A115:	12V, 45A	industrial alternator
Lucas A133:	12V, 65A	industrial alternator
CAV AC5R:	12V, 60A	industrial alternator
CAV AC5M:	12V, 75A	marine alternator
CAV AC5R:	24V, 35A	industrial alternator
CAV AC5M:	24V, 36A	marine alternator

Marine alternators can be readily identified by their special white marine paint finish.

Because of their mechanical and electrical similarity, the 17ACR'M', A115 and A133 alternators are grouped together in one sub-section for servicing purposes.

A separate sub-section deals with the AC5 range of alternators and is followed by a chapter on the AC5R alternators which differ mainly from the AC5 machines in having an integral regulator.

MAINTENANCE

General

Normally the charging system will require very little attention but it should be kept free from a build up of dirt and a check made if it fails to keep the battery charged. This may be due to a slipping drive belt.

1. Occasionally inspect the drive belt for wear and correct tension and see that the alternator is properly aligned with respect to the drive. A slack belt will wear rapidly and because of slip may not drive the alternator at the required speed. Too tight a drive belt will impose a severe side thrust on the alternator bearings and shorten their life. Check with the engine hand book for correct belt tension.

2. Keep the alternator reasonably clean with a cloth moistened with a suitable cleansing fluid such as 'Genklene', 'Inhibsol' or trichlorethylene. Where applicable, ensure that ventilation slots and air spaces are clear and unobstructed.

3. Where a separate regulator is fitted, remove any accumulated dirt from the exterior and ensure that cooling air can pass freely over the casing.

Checking System Operation

The charging system is so designed that a flow of current indicated either by the extinguishing of the warning light or as shown on an ammeter is sufficient evidence that the system is in proper working order.

Accordingly, no electrical tests should be made to the installation unless:

a) The warning light fails to illuminate when the alternator is stationary and the switch is closed, or fails to extinguish when the alternator is running.

b) No charging current shows on ammeter.

c) The battery is flat.

d) The battery is 'boiling, indicating loss of voltage control.

If any of the foregoing conditions apply, the procedure detailed under 'Fault Finding' for the type of alternator concerned, should be followed in order to identify the source of the trouble.

GENERAL PRECAUTIONS

1. NEVER disconnect battery cables from the battery or connecting leads from the charging or control circuits while the engine is running.

2. NEVER 'flash' any charging or control cables to earth.

3. NEVER use a high voltage resistance tester ('Megger') for testing alternator circuits.

4. ALWAYS connect a 'slave' battery in parallel, i.e. +ve to +ve and -ve to -ve. Connect -ve lead first.

5. ALWAYS disconnect the battery leads before connecting a battery charger.

6. ALWAYS disconnect the battery and alternator leads before arc welding on any part of the vehicle or equiment.

7. NEVER run an alternator with the main terminals open circuit with the rotor field coil engergised.

8. NEVER use high voltages to test diodes (use 24 volt maximum).

9. NEVER use a lever on the alternator stator or rear housing when adjusting the fan belt.

10. NOTE the polarity of connections to battery, alternator and voltage regulator. Incorrect connections may result in irreparable damage to semi-conductor devices.

LUCAS TYPE 17ACR'M', A115 & A133 ALTERNATORS

CONTENTS

LUCAS TYPE 17ACR'M', A115 & A133 ALTERNATORS

INTRODUCTION

All three alternators are similar in construction and generate current in exactly the same way. The A115 and A133 machines are intended for automotive and industrial applications where an earth return wiring system is employed.

The 17ACR'M' machine is intended for marine applications using an insulated return wiring sytem; it has marine finished components offering greater resistance to corrosion and can be readily identified by its special white marine paint finish.

DESCRIPTION

Mechanical Construction

All machines are of the revolving field and stationary armature type and have built-in rectifiers and voltage regulators. The field coil is contained within the 'claw' type rotor which is supported by a sealed bearing at each end.

Fig. 1 shows an exploded view of the 17ACR'M' alternator and Fig. 2 shows an exploded view of the A115 and A133 alternators.

Terminal Arrangement

Fig. 3 shows the terminal arrangement of the 17ACR'M' machine and Fig. 4 shows the terminal configuration for the A115 and A133 models.

Alternator Output Control

Integral electronic voltage regulator unit of micro-circuit construction.

Rectifier

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

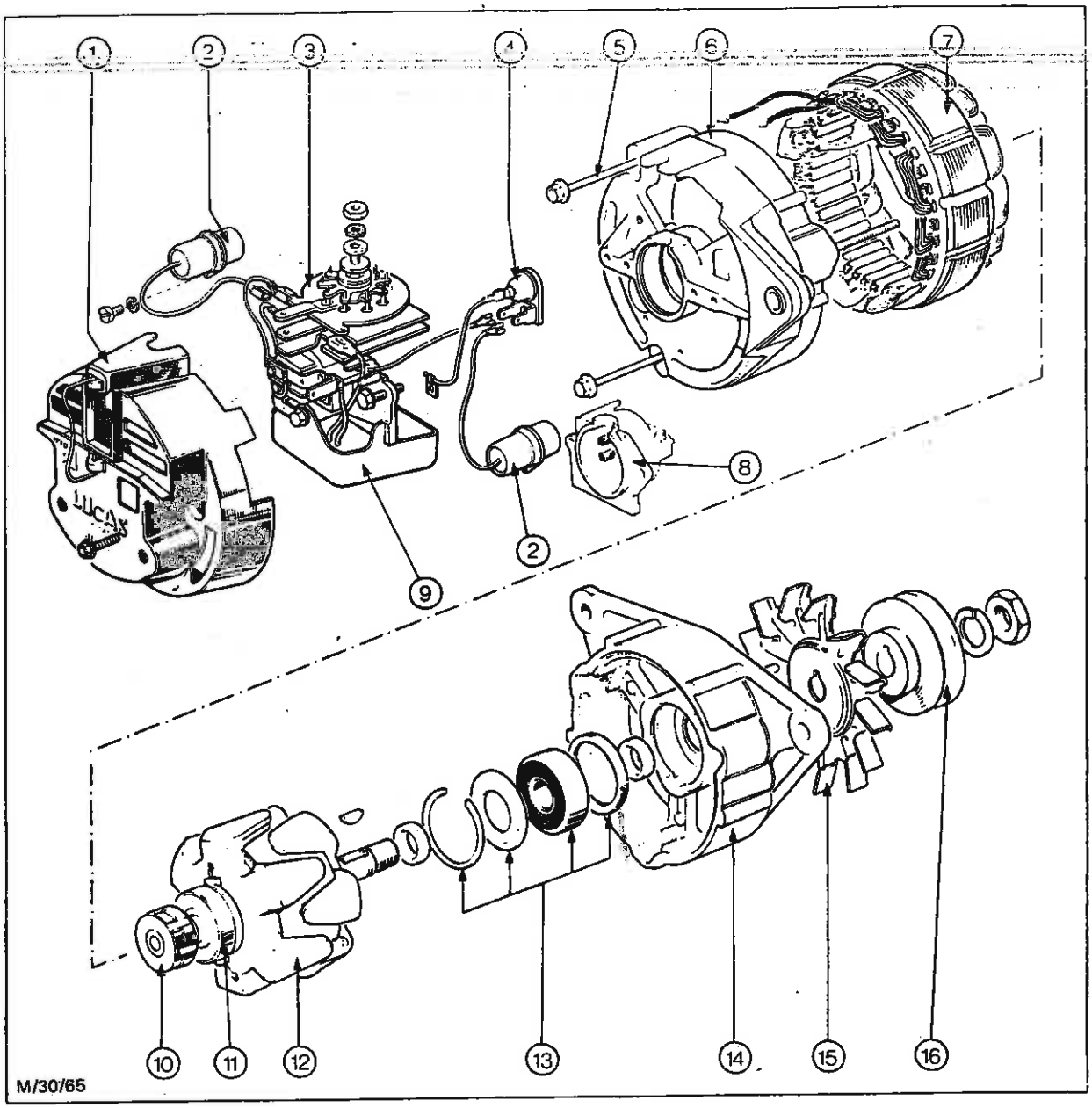


Fig. 1 - Exploded View of 17ACR'M' Marine Alternator

1. Cover
2. Suppression Capacitor
3. Rectifier
4. Anti-Surge Diode
5. Through Bolts
6. Slip Ring End Bracket
7. Stator Assembly
8. Brush Box Assembly
9. Regulator
10. Slip Ring Assembly
11. Slip Ring End Bearing
12. Rotor Assembly
13. Drive End Bearing Assembly
14. Drive End Bracket
15. Fan
16. Drive Pulley

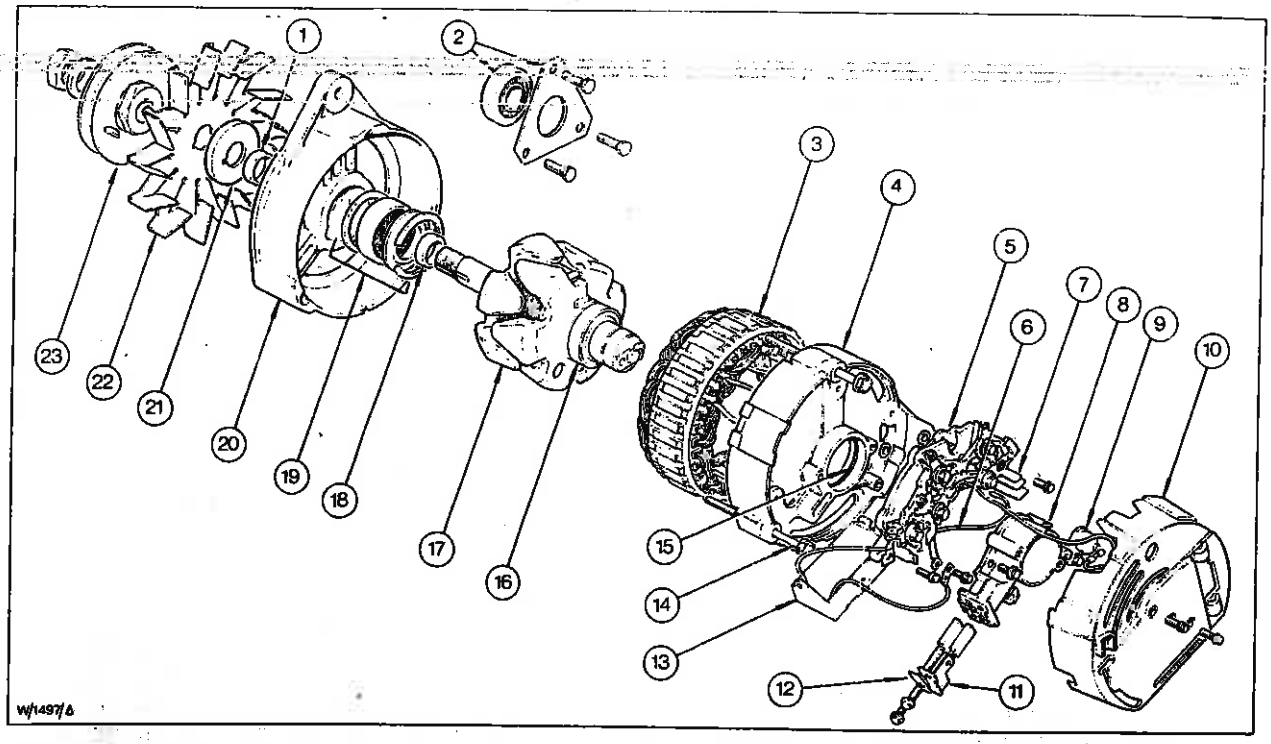


Fig. 2 - Exploded View of A115 and A133 Alternators
1. Bearing Spacer
2. Drive End Bearing (A133 Model)
3. Stator Winding
4. Slip Ring End Housing
5. Rectifier
6. Sensing Lead (A133 Model Only)
7. Output Terminals
8. Brush Box
9. Surge Protection Diode
10. End Cover
11. Outer Brush Mounting Plate
12. Inner Brush Mounting Plate
13. Voltage Regulator
14. Through Bolt
15. 'O' Ring
16. Slip Ring End Bearing
17. Rotor
18. Bearing Spacer
19. Drive End Bearing (A115 Models)
20. Drive End Housing
21. Clamping Plate
22. Cooling Fan
23. Pulley

Surge Protection Device

A special avalanche-diode is fitted to the outer face of the slip ring end bracket. It is connected between the 'IND' terminal and the alternator frame or negative terminal. Its function is to protect the regulator from high transient voltages which may occur in the charging system. Since it can only provide limited protection for the regulator under normal working conditions, the general precautions applying to alternators must be observed - refer to page 29.

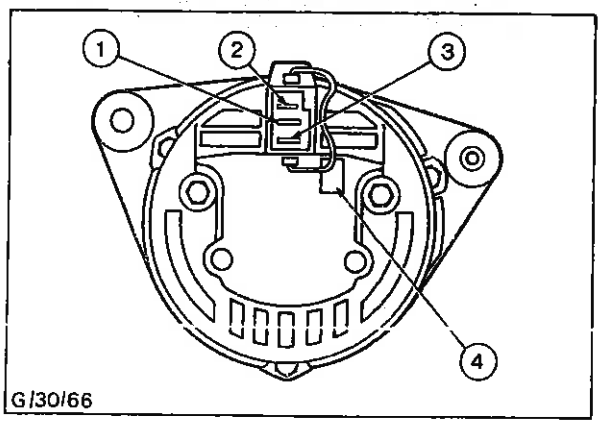


Fig. 3 - 17ACR'M' Alternator (Battery-Sensed European Terminations)
1. Main +ve Terminal
2. 'IND' Connection to Warning Light
3. Main -ve Terminal
4. 'S' Terminal for Battery Sensing

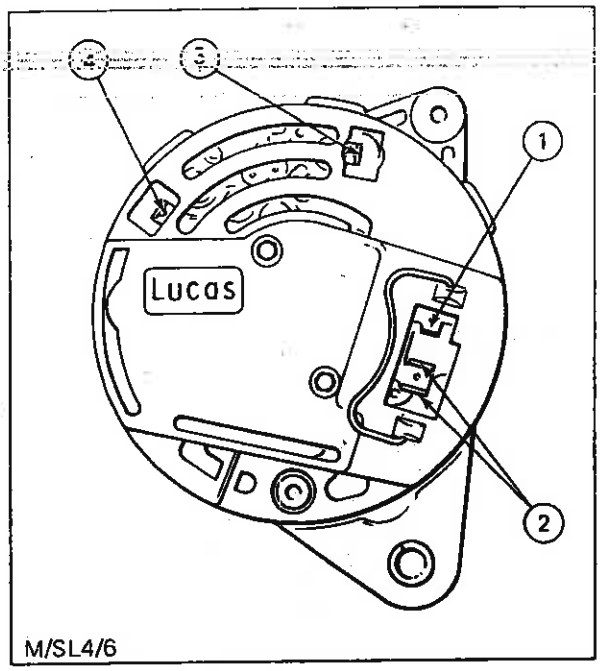


Fig. 4 - A115 & A133 Alternators (Machine-Sensed European Terminations)
1. 'IND' Connection to Warning Light
2. Main +ve Terminals
3. Connection for Electronic Tachometer (Truck Applications Only)
4. Additional +ve Terminal for External Suppression capacitor (Truck Applications Only)

Note: Negative connection is through the alternator frame.

Suppression Capacitors

Two suppression capacitors are fitted into the slip ring end bracket of 17ACR'M' alternators as standard equipment. One suppression capacitor can be mounted on the outside of the slip ring end cover on the A115 and A133 alternators for truck applications only.

OPERATION - Refer to Fig. 5, 6 or 7

When the isolation switch 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 'IND' and the carbon brushes contacting the rotor slip rings, the alternator regulator and earth or negative return line. 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 its 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 to, or 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. The type of sensing system used on the A115 and A133 alternators is machine sensing.

The regulator senses the alternator generated output voltage via the regulator connections inside the alternator.

On the 17ACR'M' alternator, a separate terminal allows direct connection to be made to the battery for sensing battery voltage.

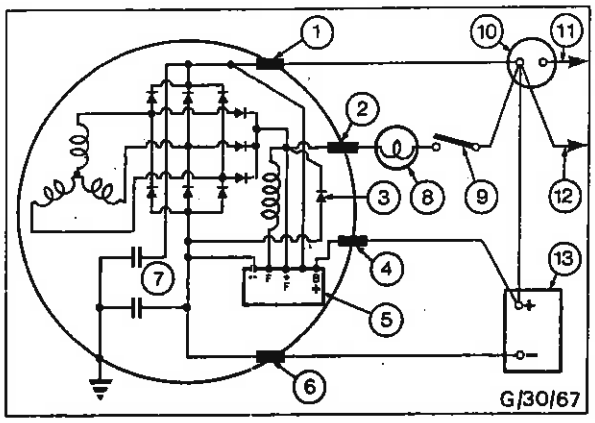


Fig. 5 - Battery-Sensing System, 17ACR'M' Marine Alternator
1. Main +ve Terminal
2. 'IND' Terminal
3. Surge Protection Device (Avalanche Diode)
4. 'S' Terminal (Sensing)
5. Regulator
6. Main -ve Terminal
7. Suppression Capacitors
8. Warning Light
9. Ignition switch
10. Solenoid
11. Starter
12. Load
13. Battery

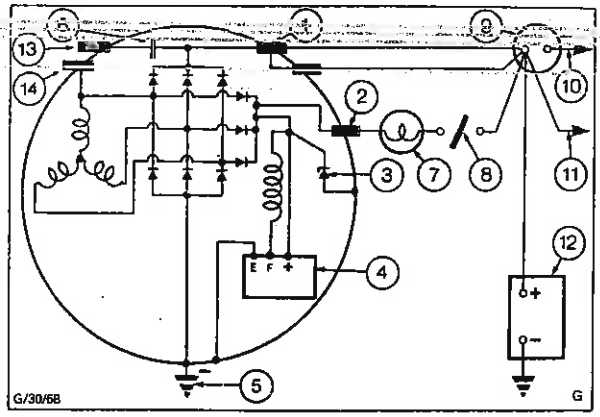


Fig. 6 - Machine-Sensing System, A115 Alternator
1. Main +ve Terminals
2. 'IND' Terminal
3. Surge Protection Device (Avalanche Diode)
4. Regulator
5. Earth Return
6. Externally Mounted Suppression Capacitor (where fitted)
7. Warning Light
8. Isolation Switch
9. Solenoid
10. To Starter
11. To Load
12. Battery
13. Additional +ve Terminal
14. Additional Single Phase a.c. Output Terminal for Electronic Tachometer (Truck Applications only)

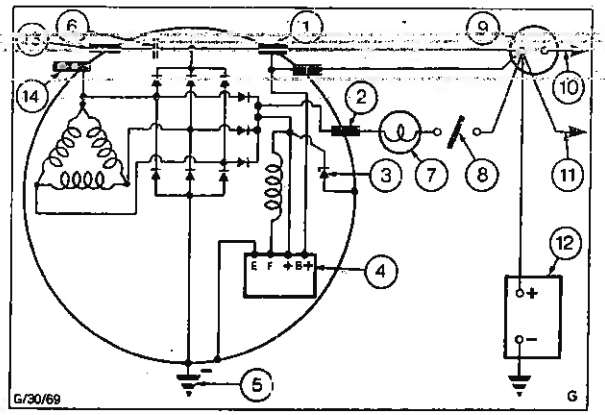


Fig. 7 - Machine-Sensing System, A133 Alternator
1. Main +ve Terminals
2. 'IND' Terminal
3. Surge Protection Device (Avalanche Diode)
4. Regulator
5. Earth Return
6. Externally Mounted Suppression Capacitor (where fitted)
7. Warning Light
8. Isolation Switch
9. Solenoid
10. To Starter
11. To Load
12. Battery
13. Additional +ve Terminal
14. Additional Single Phase a.c. Output Terminal for Electronic Tachometer (Truck Applications only)

FAULT FINDING

General Precautions

Before carrying out any tests check that all terminal connections are correct - see Fig. 5, 6 or 7 as appropriate.

DO NOT REMOVE OR REPLACE ANY ELECTRICAL CONNECTIONS WHILE THE ENGINE IS RUNNING. If, during the following tests, it is necessary to disconnect leads from the regulator, ensure that they are connected to the correct terminals when replacing them. Incorrect connections, however brief, can cause irreparable damage to the regulator components.

Test Equipment Required

1. A British Standard first grade 0 to 20V moving coil voltmeter

2. A British Standard first grade 0 to 100A moving coil ammeter (this will not be required if an ammeter is already fitted).

3. A hydrometer.

Test Procedure

1. Check with the 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	Specified 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
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		

2. 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.

3. Switch on the isolation switch, (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 operation 5.

If the warning light is illuminated, start the engine and run it above idling speed. The warning light should be extinguished. If the warning light is not extinguished, refer to operation 4.

4. Stop the engine, then 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 13 mm (0,5 in).

If the driving belt is not the cause of the fault, remove the alternator 'IND'/MAIN terminals connector plug. If warning light remains illuminated, check for short circuit to frame or negative line between the 'IND' cable-end and warning light. If warning light is now extinguished, refit the alternator connector plug and proceed direct to operation 5.

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

Remove connector plug from alternator and connect voltmeter positive lead to the 'IND' and +ve socket in turn while the voltmeter negative lead is connected to earth or negative lead. Battery voltage should be indicated in each case.

If the test is unsatisfactory, the continuity fault in the external cable circuit(s) must be traced and remedied - refer to Fig. 32.

If the test is satisfactory, refit connector plug to the alternator and proceed to operation 6.

NOTE: In addition to the voltmeter used in the previous test (op. 5), unless the installation is fitted with an ammeter, it will be necessary to connect the test ammeter in series with the cable(s) connected to the main output +ve terminal(s) of the alternator.

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

7. Start engine, increase speed (ignore voltmeter at this stage) and observe the ammeter reading. If ammeter registers zero current, the alternator is faulty and must be removed from the vehicle for individual testing (proceed to '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 to 14,4V should be registered (alternator-controlled voltage), in wich 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 operation 8.

8. Check for a high resistance fault in the charging system, by carrying out two separate volt drop tests on the positive and negative side of the charging circuit. Tests must be carried out with all the alternator cables connected. (The connector plug is open-ended to facilitate testing).

9. Switch on the head-lamps or other electrical equipment to load the charging system and run the engine at a fairly high speed (simulating normal working speed), and connect the voltmeter as follows:

10. Positive-side volt drop test

Connect voltmeter between the alternator main output +ve terminal and the +ve terminal of the battery. (Voltmeter red lead to alternator and black lead to battery).

The test is satisfactory if the voltmeter registers 0 to 0,5V.

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

11. Earth or negative-side volt drop test

Connect a voltmeter between the alternator frame (or negative terminal on 17ACR'M' unit) and the negative terminal of the battery. (Voltmeter black lead to alternator and read lead to battery).

The test is satisfactory if the voltmeter registers 0 to 0,25V.

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

12. If the volt drop tests are satisfactory, remove the alternator from the vehicle and proceed to 'Bench Testing'.

PRELIMINARY INSPECTION

It is not necessary to fully dismantle the alternator in order to check the brushes, slip rings, field coil winding and rectifier pack for serviceability.

Brushes, Slip Rings and Field Coil

Detach the moulded cover and remove the regulator and brush box assembly as detailed in 'Partial Dismantling' on page 38 or 39 as appropriate.

It is not necessary to remove the suppression capacitors or the surge diode, provided that the relevant leads are disconnected.

Check the brushes and brush box as detailed under the heading 'Brushgear' in the 'Component Inspection and Renewal' Section and renew parts as necessary.

Visually inspect the slip rings for signs of wear or damage. Using a good quality test meter such as an 'Avometer', check that the resistance measured across the slip rings (Fig. 25 or 26) is in accordance with the figure given in 'Specifications'. An appreciably lower field coil resistance than that stated could mean a short circuit between the coils; a higher reading suggests that the contact surfaces of the slip rings need cleaning. An infinity reading would indicate an open circuit in the field. Unless the foregoing tests indicate that further dismantling is necessary, replace the brush box assembly and regulator, connect all leads correctly and replace the cover as detailed in 'Final Assembly' on page 50 or 51 as appropriate.

Rectifier Pack

Remove the brush box assembly and regulator, unsolder the stator leads and remove the rectifier pack as detailed in 'Partial Dismantling' on page 38 or 39 as appropriate.

Test the rectifier pack as detailed in the 'Component Inspection and Renewal' section (Fig. 31 or 32) and renew the complete unit if faulty.

Replace the rectifier pack, brush box assembly and regulator as detailed in 'Final Assembly' on page 50 or 51 as appropriate.

PARTIAL 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 to 'Further Dismantling'.

17ACR'M' Alternator

1. Remove the two hexagon headed screws and detach the moulded slip ring end cover.

2. Disconnect the leads (1) at the surge diode and rectifier. Remove the two screws (2) and detach both suppression capacitors (3) - see Fig. 8.

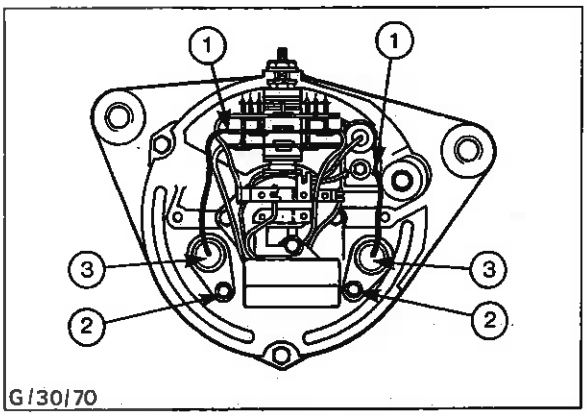


Fig. 8 - Removing Suppression Capacitors

3. Disconnect the lead (1), then remove screw (2) securing the surge diode lead. Remove screw (3) and detach surge diode (4) - see Fig. 9.

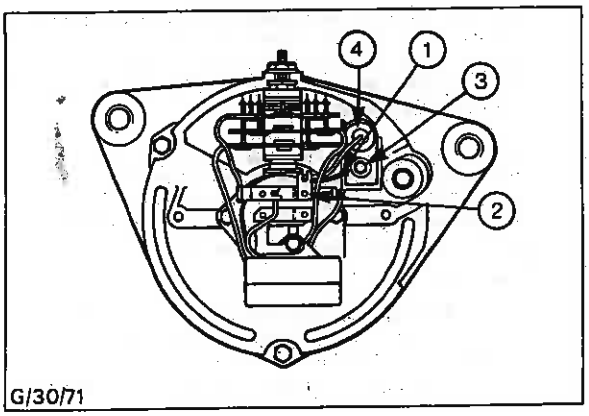


Fig. 9 - Removing Surge Diode

4. Make a note of the regulator leads terminations, then disconnect leads (1) from the rectifier. Remove screw (2) securing remaining two regulator leads. Remove screw (3) and detach regulator (4) - see Fig. 10.

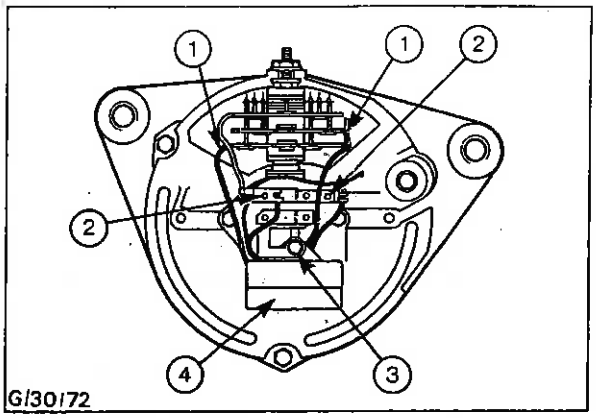


Fig. 10 - Removing Regulator

5. Disconnect lead (1) from the rectifier. Remove the two screws (2) and detach the brush box assembly (3) - see Fig. 11.

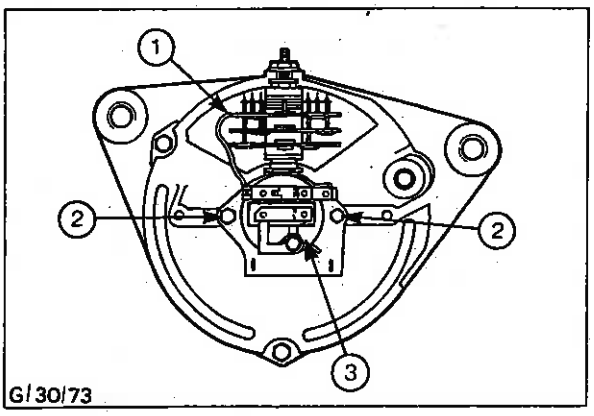


Fig. 11 - Removing the Brush Box

6. Clamp the alternator securely. Using a heat shunt as shown in Fig. 46, unsolder the stator leads from the rectifier. Slacken the securing nut (1) and remove the rectifier pack (2) - see Fig. 12.

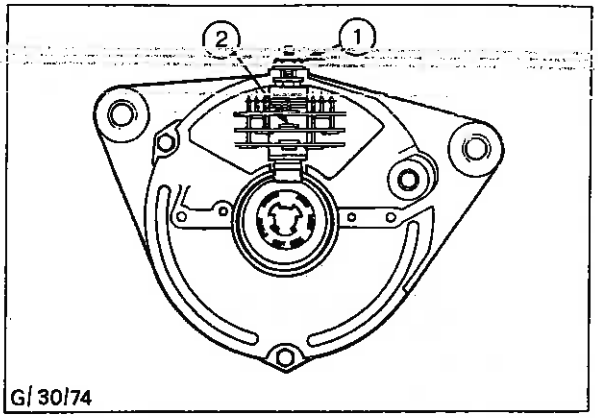


Fig. 12 - Removing the Rectifier Pack

A115 and A133 Alternators

1. Remove the two hexagon headed screws and detach the moulded slip ring end cover.

2. Disconnect lead (1), remove screw (2) and detach the surge diode (3) - see Fig. 13.

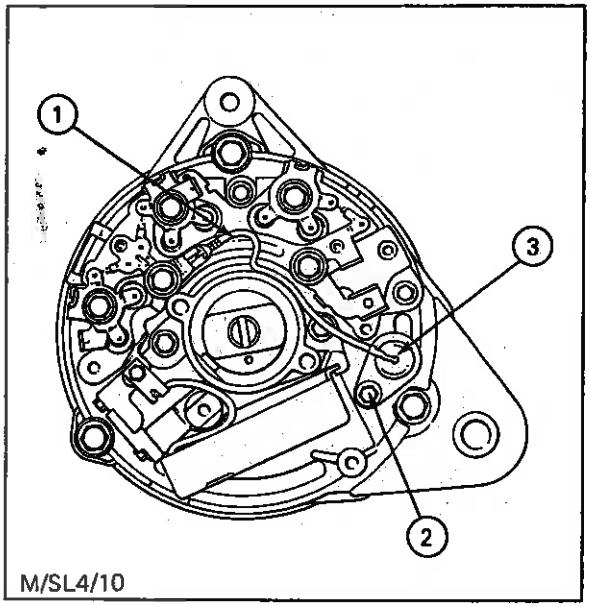


Fig. 13 - Removing the Surge Diode

3. Make a note of the connections to the regulator (1), then remove screws (2) securing the regulator leads. Remove the lower brush spring plate screw (3) and detach the regulator - see Fig. 14.

NOTE: The regulator fitted to the A133 alternator has three leads.

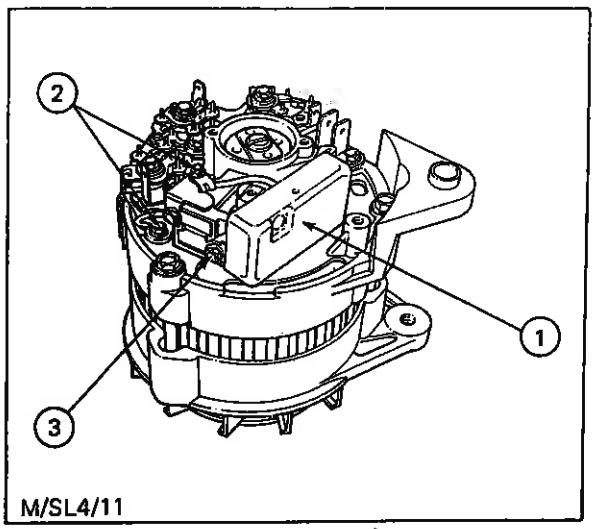


Fig. 14 - Removing the Regulator

4. Remove the top brush spring plate screw (1) and withdraw the brushes (2). Remove two screws (3) and detach the brush box (4) - see Fig. 15.

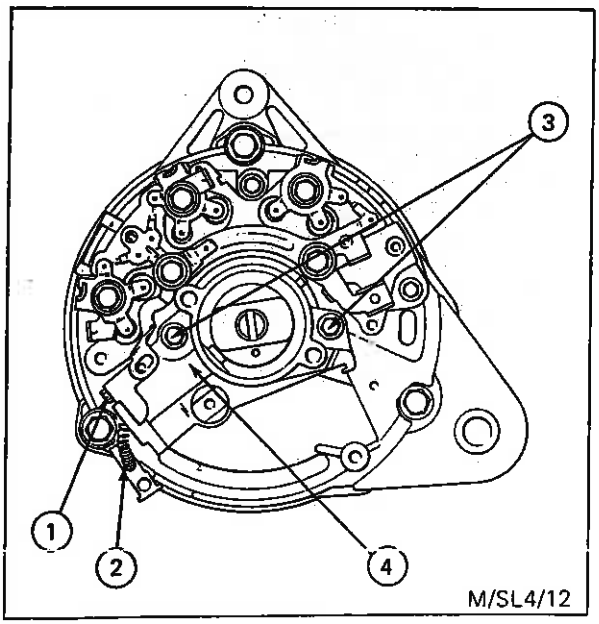


Fig. 15 - Removing the Brush Box

5. Unsolder and remove the three stator leads (1). Remove the two remaining screws (2) and lift off the rectifier assembly (3) - see Fig. 16.

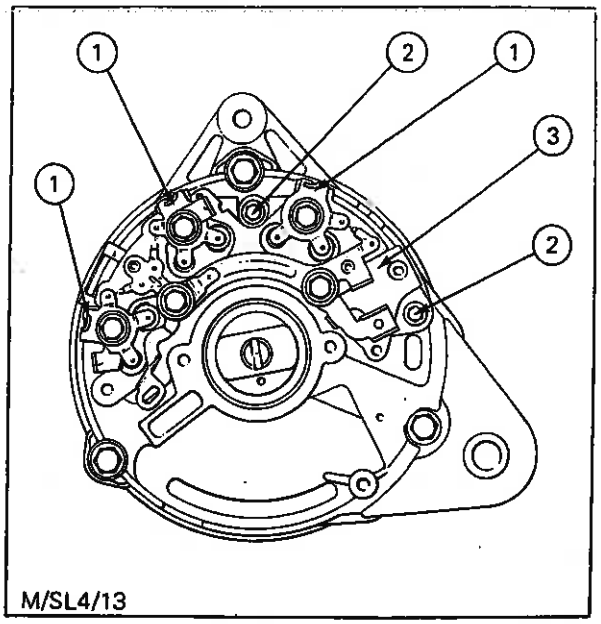


Fig. 16 - Removing Rectifier Assembly

FURTHER DISMANTLING

17ACR'M' Alternator

1. Remove 'through bolts' (1) and detach slip ring end bracket (2). If end bracket proves difficult to remove, use a soft face mallet to tap upwards beneath each bolt housing (3) in turn - see Fig. 17.

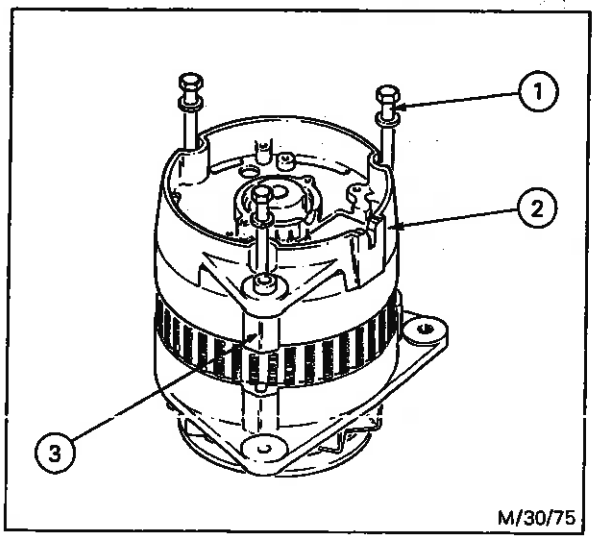


Fig. 17 - Removing Slip Ring End Bracket

2. Remove stator assembly (1) - see Fig. 18.

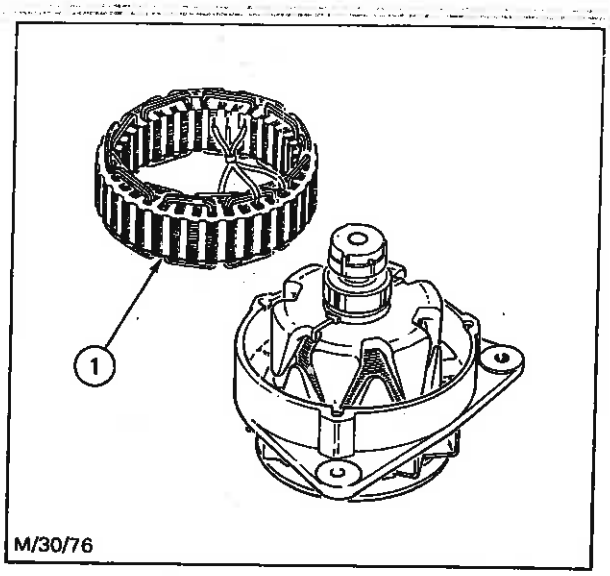


Fig. 18 - Removing Stator Assembly

3. Remove nut (1) and washer (2) and detach pulley (3) and fan (4) - see Fig. 19.

Apply flat-ended engineer's punch, or chisel, to the end of the Woodruff key (5) and drive key from shaft. Remove fan spacer (6).

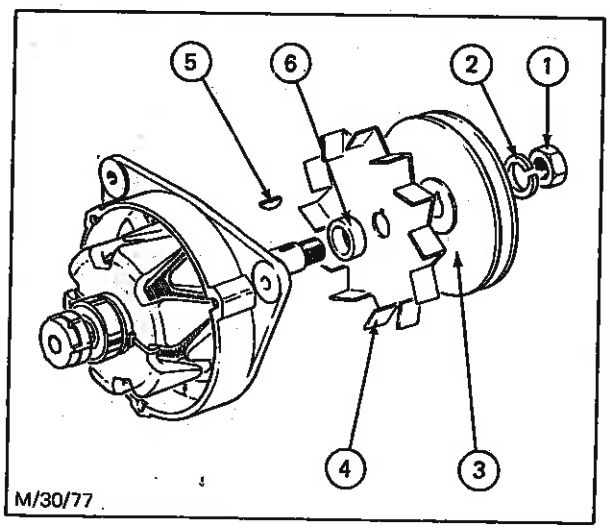


Fig. 19 - Removing Pulley and Fan

4. Press rotor shaft (1) from drive end bearing (2) using a bench press. Detach and retain spacing collar (3) - see Fig. 20.

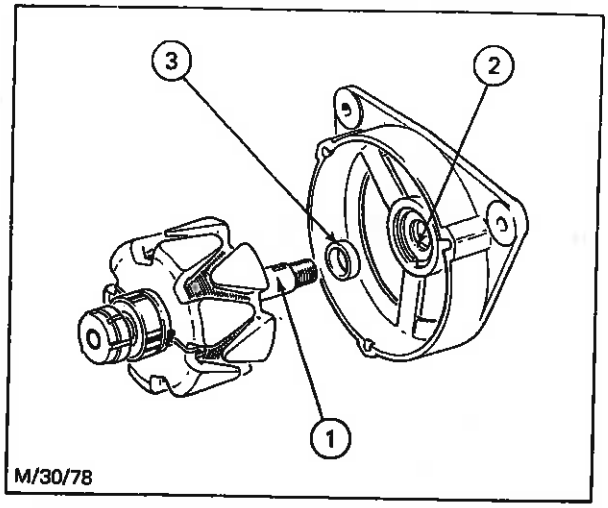


Fig. 20 - Removing Rotor

A115 & A133 Alternators

1. Scribe a line across both end brackets and the stator to ensure correct alignment when assembling.

2. Remove the three 'through' bolts (1) and lift off the slip ring end bracket (2) - see Fig. 21. If the end bracket proves difficult to move, use a soft face mallet to tap upwards beneath each bolt housing in turn.

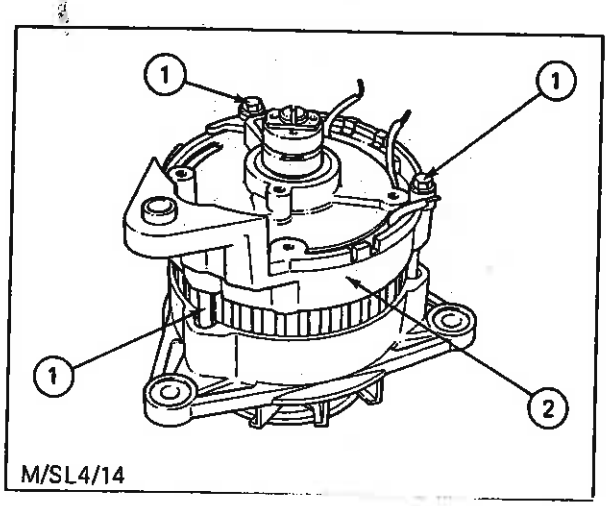


Fig. 21 - Removing Slip Ring End Bracket

3. Lift off the stator assembly (1) - see Fig. 22.

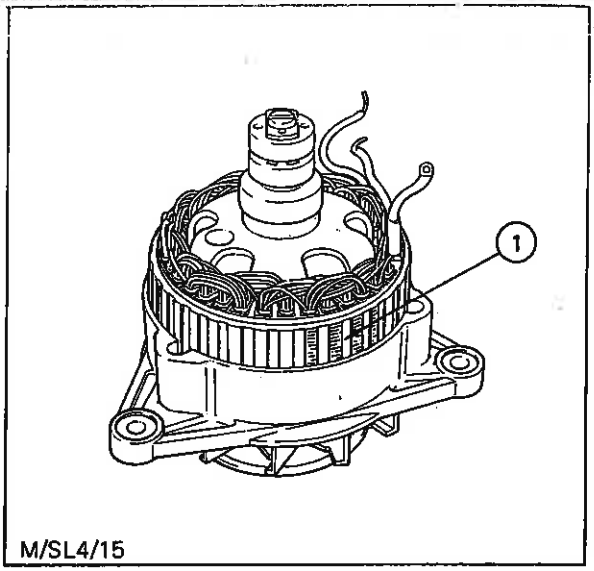


Fig. 22 - Removing Stator

4. Remove nut (1) and washer (2) and detach the pulley (3), fan (4) and clamping plate (5). Apply a flat ended engineer's punch or chisel to the end of the Woodruff key (6) and drive key from the shaft - see Fig. 23. Remove and retain the bearing spacer (7).

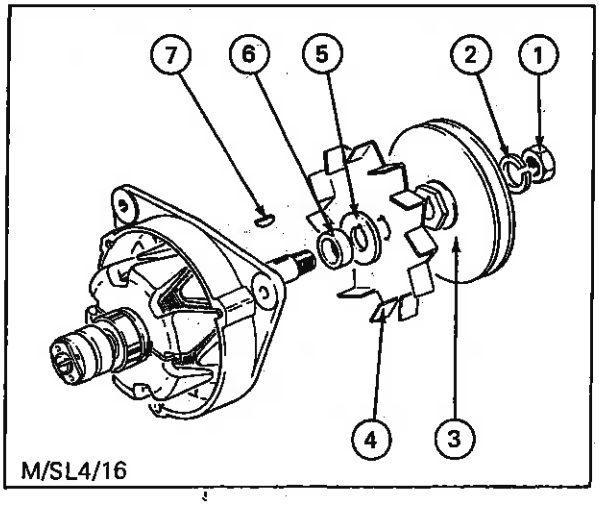


Fig. 23 - Removing Pulley and Fan

5. Press rotor shaft (1) from drive end bearing (2), using a bench press. Detach and retain the bearing spacer (3) - see Fig. 24.

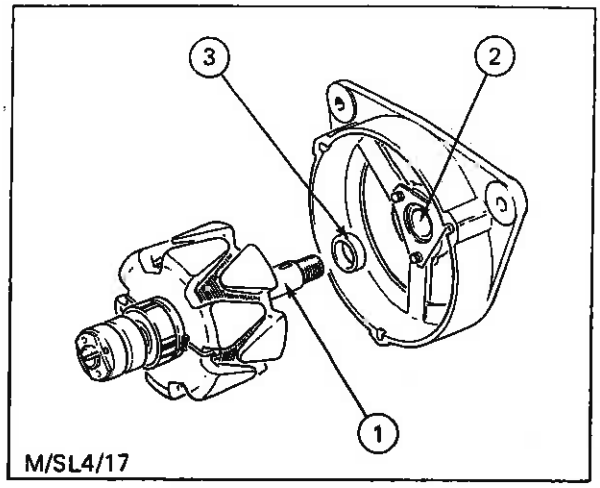


Fig. 24 - Removing Rotor

COMPONENT INSPECTION AND RENEWAL

Brushgear

Renew brushes if they are shorter than the minimum length specified in 'Specifications'.

It is recommended that new brushes are fitted during a complete overhaul.

Clean dirty brushes with a gasoline moistened cloth. Check brush box for wear and damage and renew as necessary.

Slip Rings - See Fig. 25 or 26 as appropriate

The slip rings (1) should be clean and smooth. If necessary, clean them with a gasoline 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 gasoline 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.

If the slip rings are excessively worn, they should be renewed - see under 'Bearings' for the type of alternator concerned.

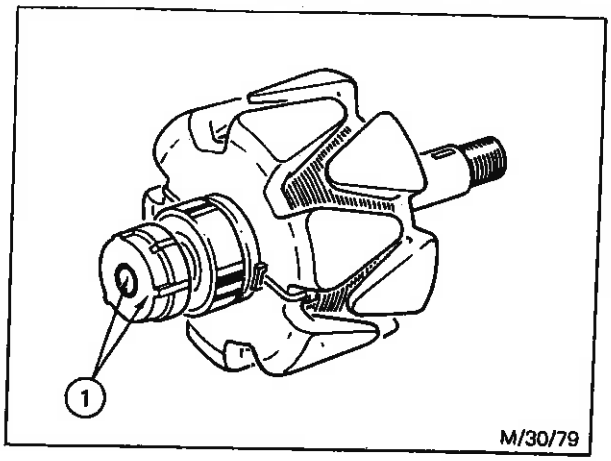


Fig. 25 - Slip Rings, 17ACR'M' Alternator

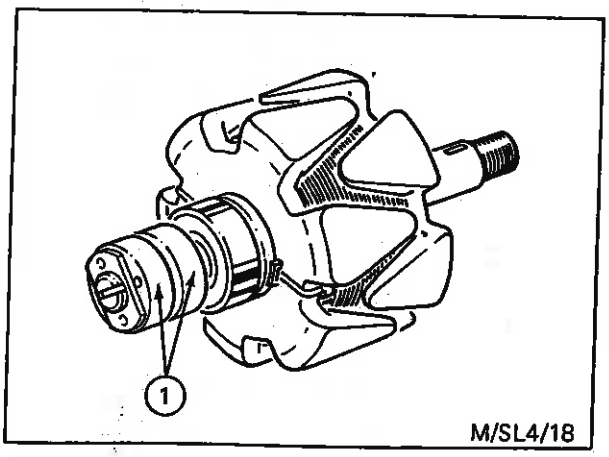


Fig. 26 - Slip Rings, A115 and A133 Alternators

Field Coil

Check field winding continuity and resistance simultaneously, by connecting a resistance meter between the two slip rings - see Fig. 25 or 26 as appropriate. With the meter set to the lowest resistance range, the indicated resistance should be in accordance with the value given in 'Specifications'; if not, the rotor must be renewed.

Test insulatation with a 110V 15W lamp wired as shown in Fig. 27 or 28. The lamp should not illuminate if the insulation is correct. If the lamp lights, renew the rotor.

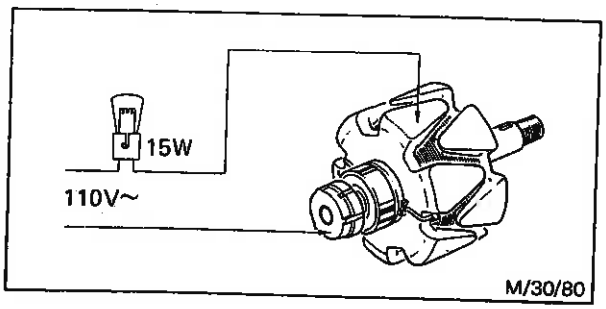


Fig. 27 - Testing Field Coil Insulation - 17ACR'M' Alternator

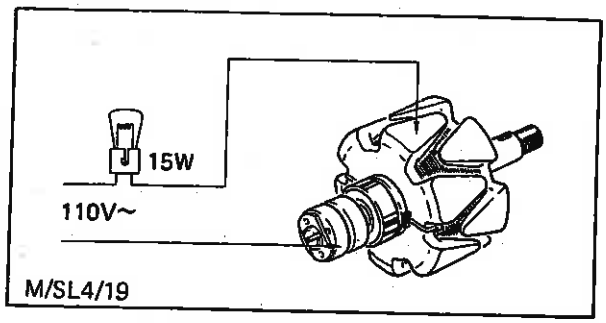


Fig. 28 - Testing Field Coil Insulation - A115 and A133 Alternators

Stator

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 watt rating - see Fig. 29. 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.

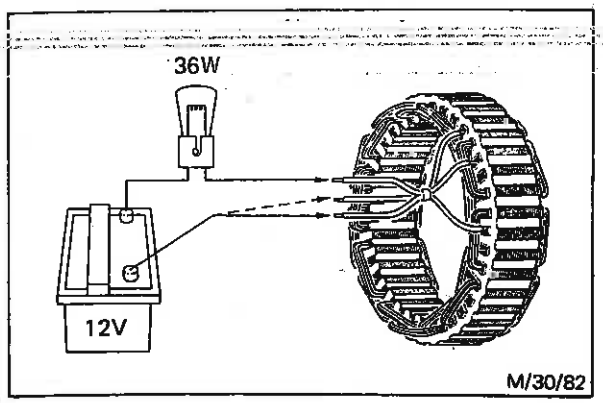


Fig. 29 - Stator Winding Continuity Test

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. 30. The lamp should not light; if it does, renew the stator assembly.

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 short circuiting is apparent, renew the stator assembly.

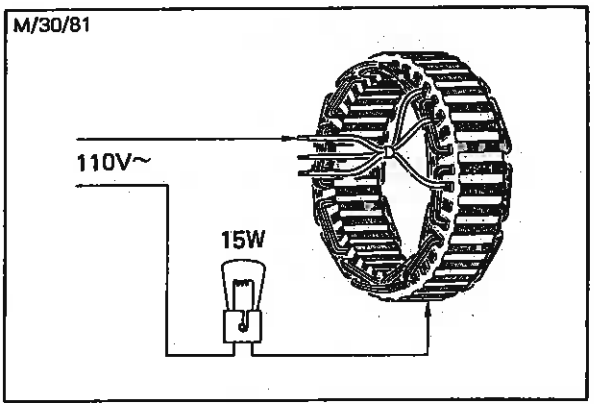


Fig. 30 - Stator Winding Insulation Test

Rectifier Diodes - 17ACR'M' Alternator

Test each of the nine diodes separately, as follows:-

Connect a 12V battery and a 12V test lamp with a maximum rating of 1,5W 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 is soldered. Note whether the 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.

NOTE: A battery operated ohmmeter may be used instead of a test lamp; a high resistance should be indicated in one direction and a low resistance in the reverse direction.

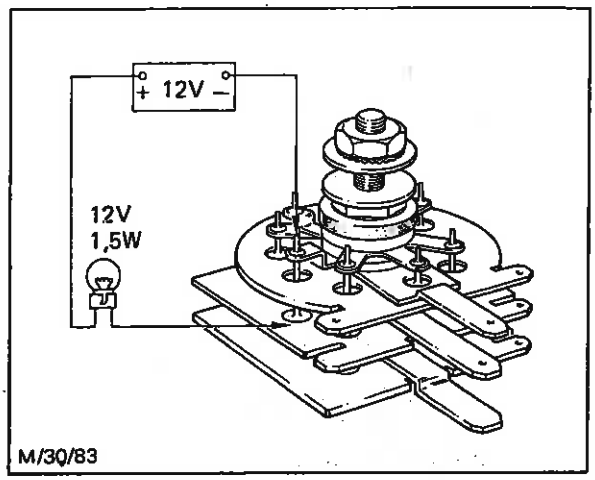


Fig. 31 - Testing Rectifier Diodes - 17ACR'M' Alternator

Rectifier Diodes - A115 and A133 Alternators

Connect a test probe and a 12V 1,5W lamp to the positive terminal of a 12V battery and a second test probe to the battery negative terminal - see Fig. 32.

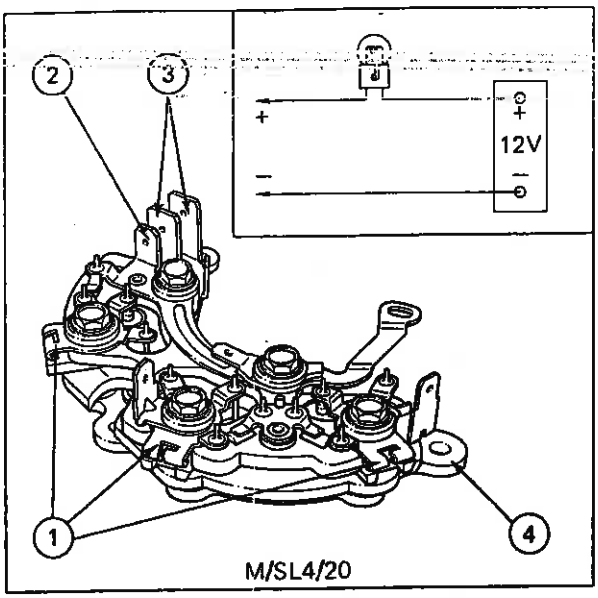


Fig. 32 - Testing Rectifier Diodes - A115 and A133 Alternators
1. Stator Connections
2. IND Terminal
3. Main +ve Terminal
4. Earth Plate

Position the test probes on the rectifier assembly as detailed in the following table. If a lamp condition is obtained that does not agree with the table, a faulty diode is indicated and the complete rectifier assembly must be renewed.

Test Probe Position		Correct Lamp Indication
+ve Probe	-ve Probe	
Earth Plate	Each Stator connection in turn	ON
Each Stator connection in turn	Earth Plate	OFF
Main Output Terminal	Each Stator connection in turn	OFF
Each Stator connection in turn	Main Ouptut Terminal	ON
'IND' Terminal	Each Stator connection in turn	OFF
Each Stator connection in turn	'IND' Terminal	ON

Surge Diode

Connect a 12V 1.5W lamp, 12V battery and test probes as shown in Fig. 32.

Connect the positive probe to the diode case and the negative probe to the diode lead terminal - the lamp should light. If the lamp does not light, renew the diode.

Connect a 24V 6W lamp, 24V battery and test probes as shown in Fig. 33.

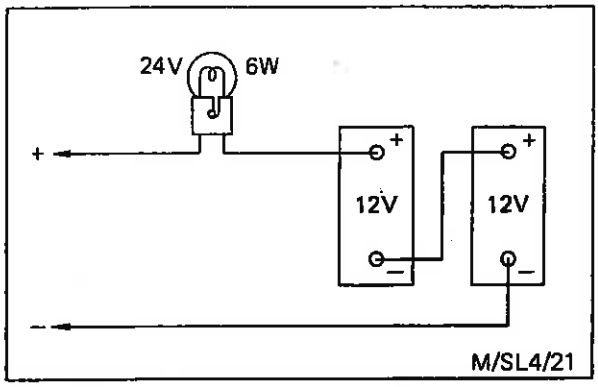


Fig. 33 - Testing Surge Diode

Connect the positive probe to the diode lead terminal and the negative probe to the diode case - the lamp should NOT light. If the lamp lights, the diode should be renewed.

Suppression Capacitors

These can be tested by disconnecting each one in turn during bench testing - refer to operation 5 under 'Test Procedure.

Regulator

This can only be tested by substituting a new unit for the suspect regulator.

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 they 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 - see under 'Slip Ring End Bearing Renewal' or 'Drive End Bearing Renewal' for the type of alternator concerned.

Slip Ring End Bearing Renewal - 17ACR'M' Alternator

Unsolder the field winding connections (1) from the slip rings (2) using a light weight soldering iron, e.g. 25W - see Fig. 34.

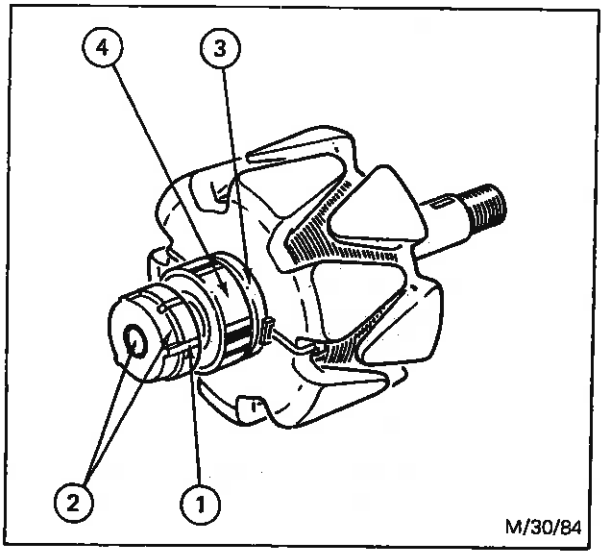


Fig. 34 - Slip Rings and Bearing Renewal - 17ACR'M' Alternator

Withdraw the slip rings from the rotor shaft using a suitable puller.

Position the two halves of a bench press support plate beneath the shoulder of the nylon distance piece (3) and press the rotor shaft from the bearing (4).

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.

Ensure that the new nylon distance piece (3) is in position and that the field coil leads are correctly located.

Press the new bearing (4) into position.

Press the slip ring moulding into position ensuring that the spring retainer is fitted inside it.

Re-solder the field coil leads to the slip rings using a light weight soldering iron, e.g. 25W and resin cored solder only.

Slip Ring End Bearing Renewal - A115 and A133 Alternators

Unsolder the field winding connection (1) from the outer slip ring (2) - see Fig. 35.

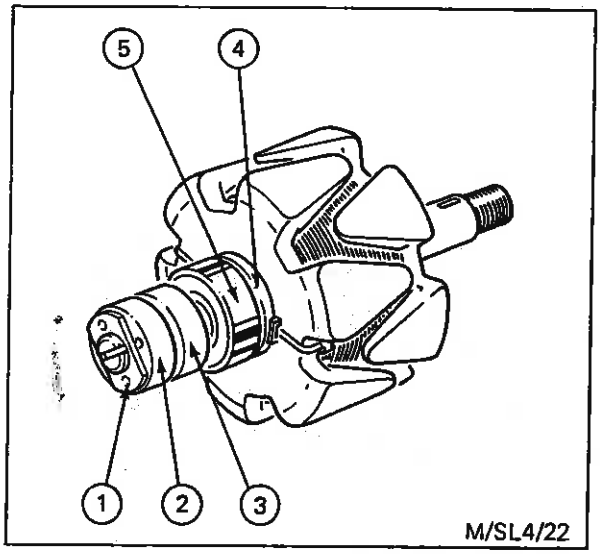


Fig. 35 - Slip Rings and Bearing Renewal - A115 and A133 Alternators

Withdraw the outer slip ring from the rotor shaft using a suitable puller. Unsolder the field winding connection from the inner slip ring (3) and withdraw it from the rotor shaft.

Position the two halves of bench press support plate beneath the shoulder of the nylon distance piece (4) and press the rotor shaft from the bearing (5).

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.

Ensure that the new nylon distance piece (4) is in position and that the field coil leads are correctly located.

Press the new bearing (5) into position.

Press the inner slip ring (3) into position, ensuring that the holes locate over the two field coil leads.

Re-solder the shorter field coil lead to the inner slip ring using a lightweight soldering iron, e.g. 25W and resin cored solder only.

Press the outer slip ring into position, ensuring that one of the holes locates over the remaining field coil lead.

Resolder the field coil lead to the outer slip ring.

Drive End Bearing Renewal - 17ACR'M' and A115 Alternators

After removing the bearing retaining circlip (1) and plate (2), the drive end bearing (3) 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 - see Fig. 36

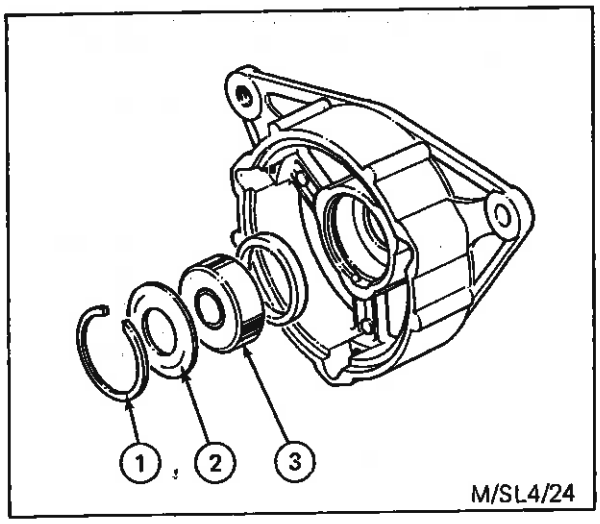


Fig. 36 - Drive End Bearing Renewal - 17 ACR'M' and A115 Alternators

When refitting the bearing, ensure correct sequence of assembly of sundry parts associated with the bearing - see Fig. 1 or 2 as appropriate.

Drive End Bearing Renewal - A133 Alternator - Refer to Fig. 37

After removing the retaining plate screws (1) and plate (2), the drive end bearing (3) 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.

When refitting the bearing, ensure correct sequence of assembly of sundry parts associated with the bearing - see Fig. 2.

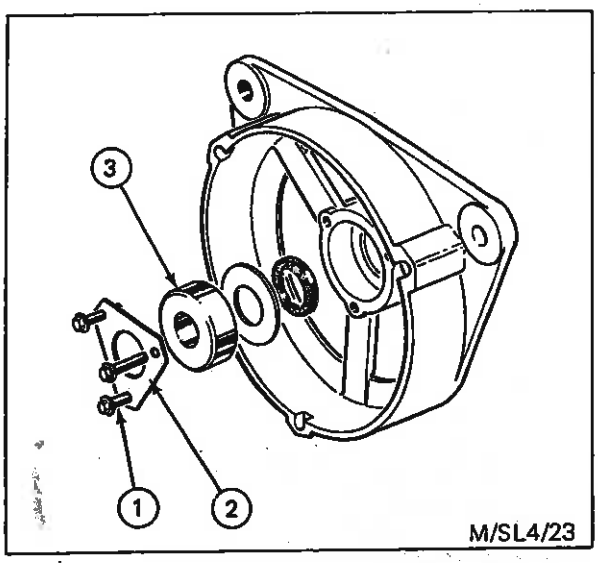


Fig. 37 - Drive End Bearing Renewal - A133 Alternator

INITIAL ASSEMBLY

17ACR'M' Alternator

1. Position the rotor spacing collar (1) on the shaft (2) - see Fig. 38. Press the rotor shaft through the drive end bearing and (where applicable) slide the fan spacer (3) onto the shaft, recess side towards bearing.

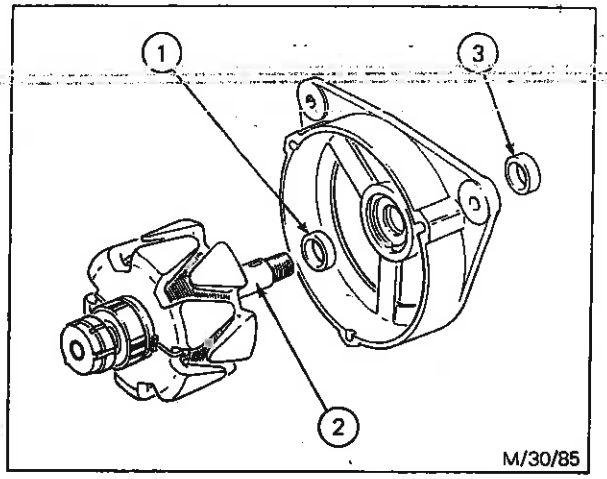


Fig. 38 - Assembling Rotor and Drive End Bracket

2. Fit the Woodruff key (1) to the shaft and place the fan (2) and drive pulley (3) in position. Secure pulley with the spring washer (4) and nut (5) - see Fig. 39.

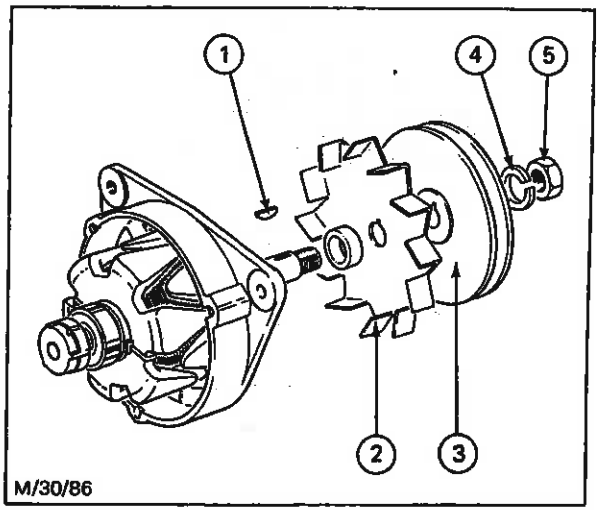


Fig. 39 - Replacing Fan and Pulley

3. As shown in the inset of Fig. 40, fit the stator assembly in the drive end bracket so that the stator connecting leads (1) are centrally positioned between the alternator fixing lugs, then assemble the slip ring end bracket (2) to the stator laminations and finally secure into a sub-assembly by fitting the through bolts (3). Tighten bolts to the torque value given in 'Specifications'.

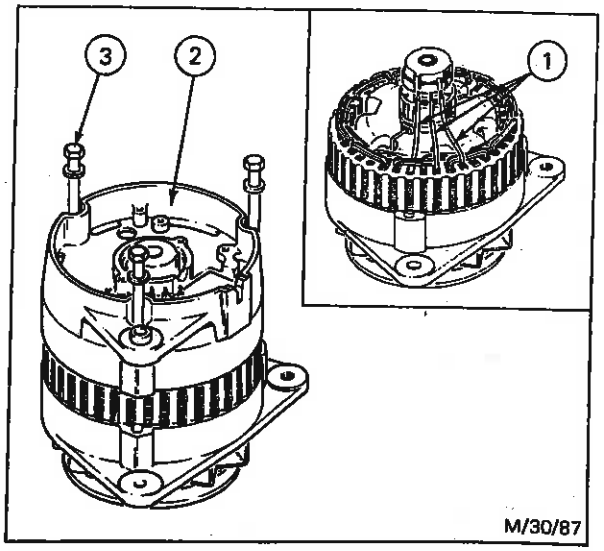


Fig. 40 - Assembling Stator and Slip Ring End Bracket

A115 and A133 Alternators

1. Position the bearing spacer (1) on the rotor shaft (2) - see Fig. 41 - and press the rotor shaft through the drive end bearing (3).

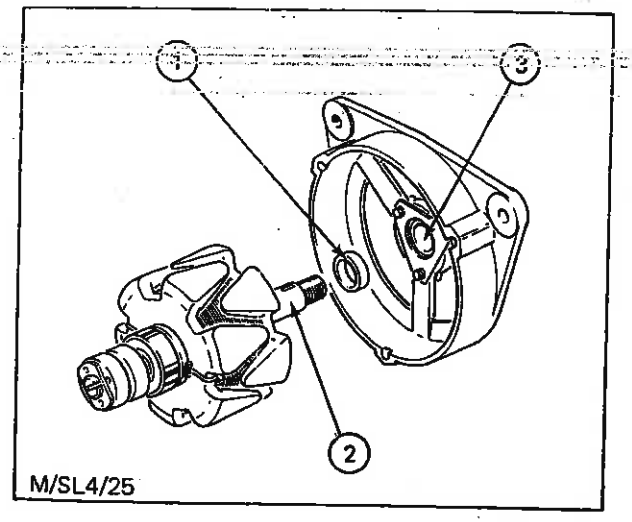


Fig. 41 - Assembling Rotor and Drive End Bracket

2. Slide the bearing spacer (1) onto the rotor shaft and fit the Woodruff key (2) - see Fig. 42. Slide the clamping plate (3), fan (4) and pulley (5) onto the shaft and secure with spring washer (6) and nut (7). Tighten nut to the recommended torque value - see 'Specifications'.

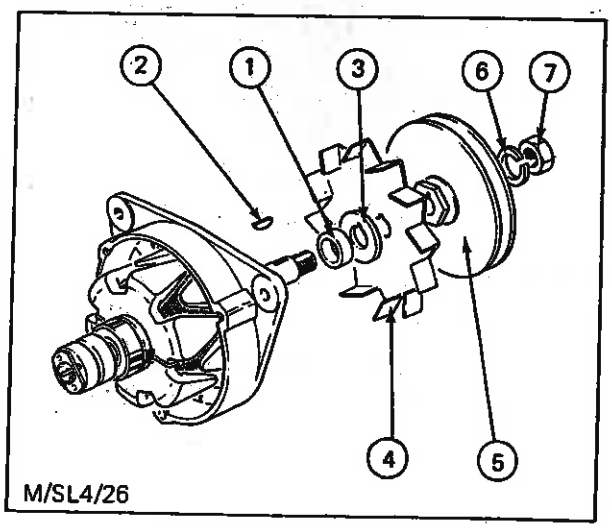


Fig. 42 - Replacing Fan and Pulley

3. Position the stator (1) on the drive end bracket (2) so that the lines scribed when dismantling align - see Fig. 43.

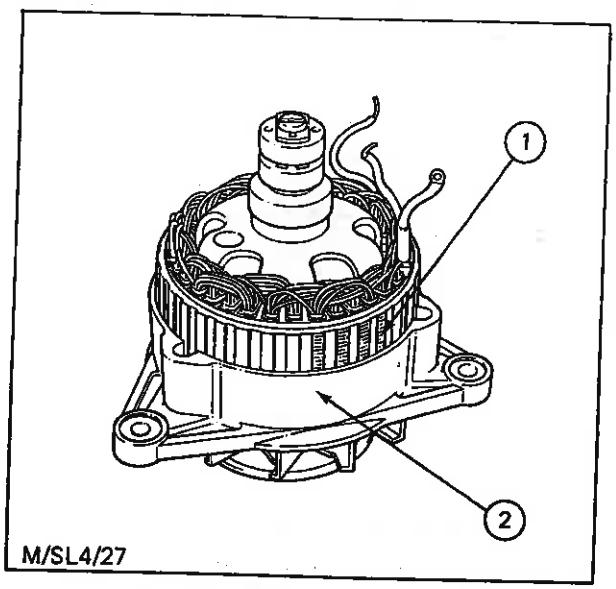


Fig. 43 - Replacing the Stator

4. Offer up the slip ring end bracket (1) to the stator (2) so that the lines scribed when dismantling align and the three stator leads (3) pass through the end bracket slots as shown - see Fig. 44.

Secure assembly with the three 'through' bolts (4) tightened to the correct torque value - refer to 'Specifications'.

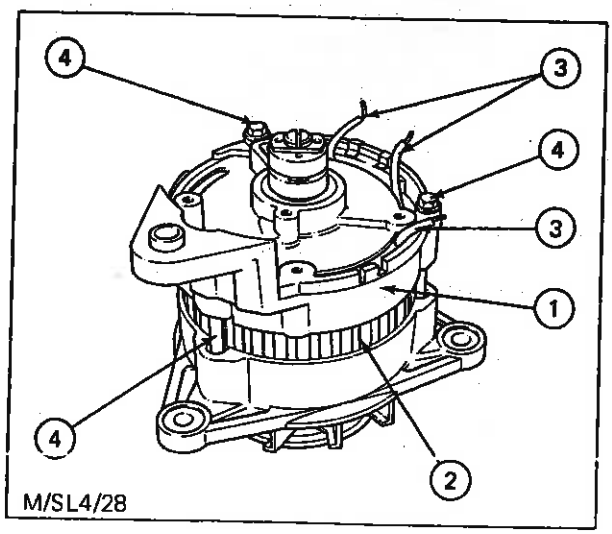


Fig. 44 - Replacing Slip Ring End Bracket

FINAL ASSEMBLY

17ACR'M' Alternator

1. Clamp the alternator securely, place the rectifier pack (1) in position and secure with the nut (2) - see Fig. 45.

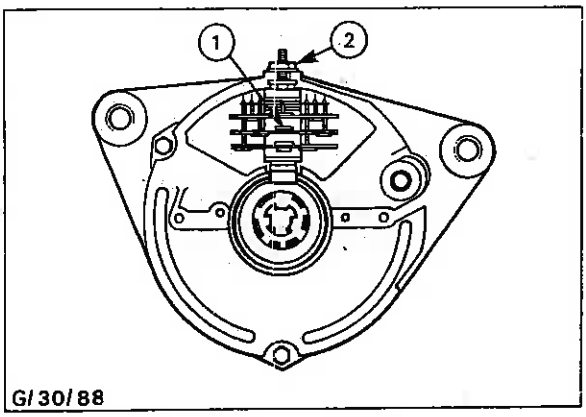


Fig. 45 - Replacing the Rectifier Pack

2. Solder the stator leads to the diode connecting pins using 'M' grade 45-55 resin cored solder. 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. 46.

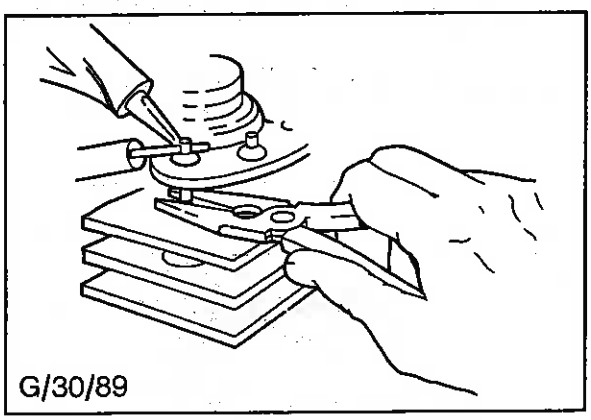


Fig. 46 - Soldering Diode Connections

3. Place the brush box assembly (1) in position and secure with the two screws (2). Connect lead (3) to the rectifier - see Fig. 47.

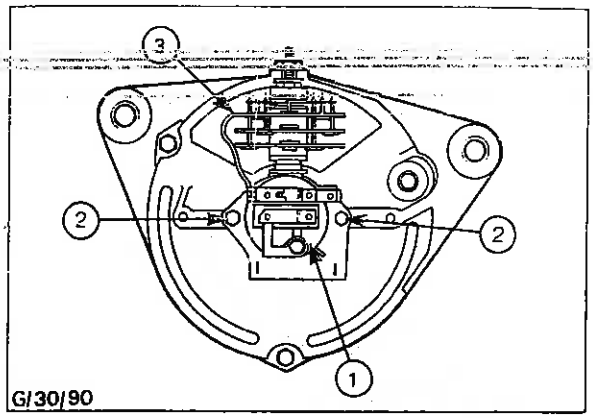


Fig. 47 - Replacing the Brush Box

4. Place regulator (1) in position and secure with screw (2). Refer to notes made when dismantling then connect two leads (3) to the rectifier. Place remaining two regulator leads in their correct positions on the brush box and secure with screws (4) - see Fig. 48.

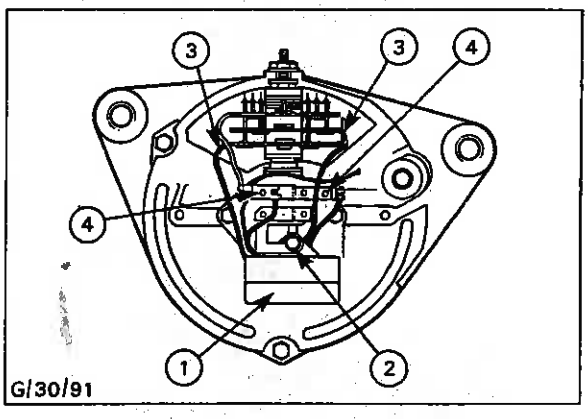


Fig. 48 - Replacing Regulator

5. Replace surge diode (1) and secure with screw (2). Secure the surge diode lead with screw (3), then connect regulator lead (4) - see Fig. 49.

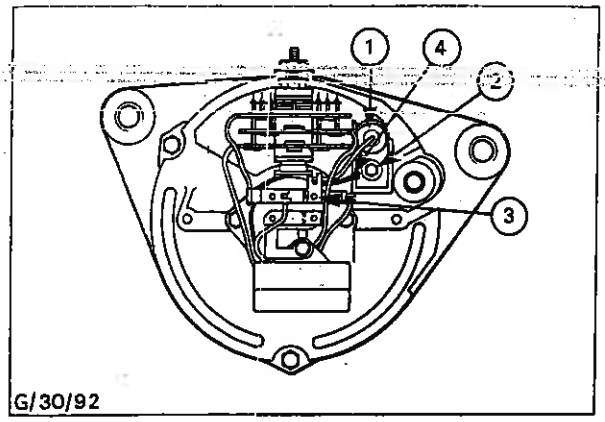


Fig. 49 - Replacing Surge Diode

6. Replace the two suppression capacitors (1) and secure with screws (2). Connect their leads (3) - see Fig. 50.

Replace the moulded slip ring end cover and secure with the two hexagon headed screws.

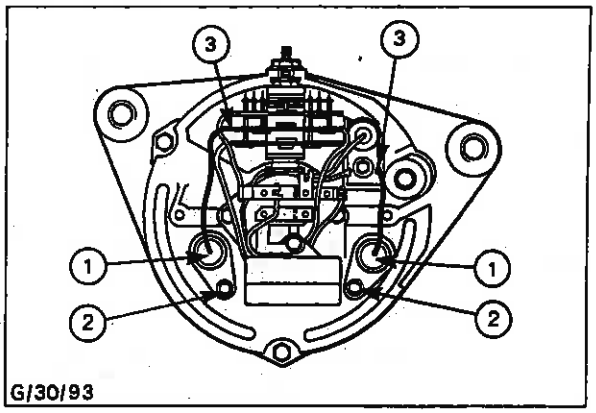


Fig. 50 - Replacing Suppression Capacitors

A115 and A133 Alternators

1. Place the rectifier assembly (1) in position and secure with two screws (2) - see Fig. 51. Solder each of the stator leads to its terminal (3) using a lightweight (25W) soldering iron and resin cored solder.

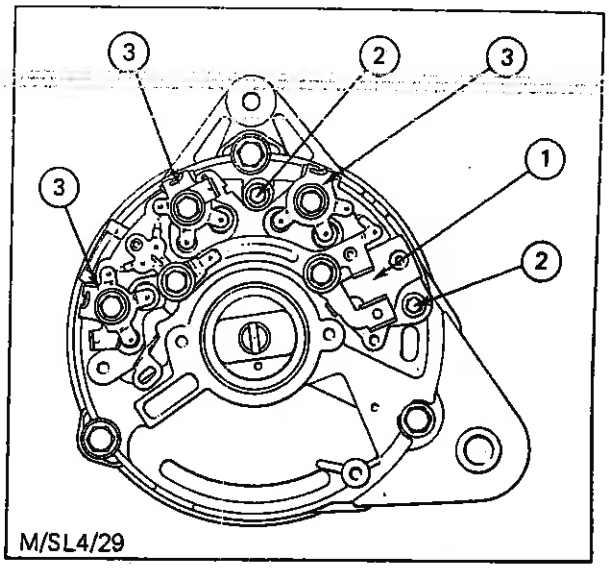


Fig. 51 - Replacing Rectifier Assembly

2. Place the brush box (1) in position and secure with the two screws (2) - see Fig. 52.

Insert the brushes (3) into the brush box, ensuring that they slide easily into position and bear against the slip rings.

Place the top brush spring plate (4) in position ensuring that the rubber gasket is correctly clamped beneath it and secure with screw (5).

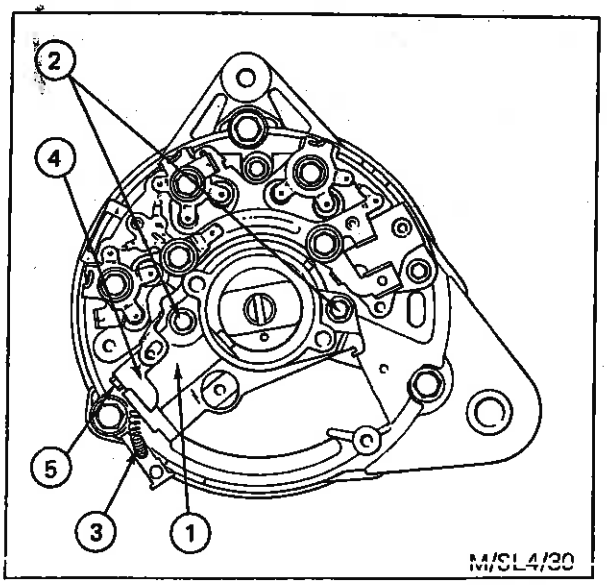


Fig. 52 - Replacing the Brush Box

3. Place regulator (1) in position with its lips located in the slot in the brush box - see Fig. 53.

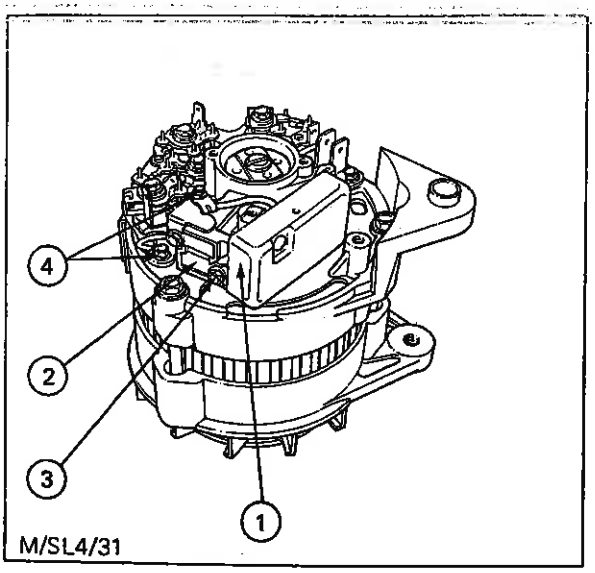


Fig. 53 - Replacing the Regulator

Place the bottom brush spring plate (2) in position with the rubber gasket correctly positioned beneath it and secure spring plate and regulator with screw (3).

Connect the regulator leads in accordance with the notes made when dismantling and secure with screws (4).

NOTE: The regulator fitted to the A133 alternator has three leads.

4. Place surge diode (1) in position and secure with screw (2) - see Fig. 54.

Connect surge diode lead (3) to 'Lucar' blade on rectifier assembly.

Place moulded cover in position and secure with the two hexagon headed screws.

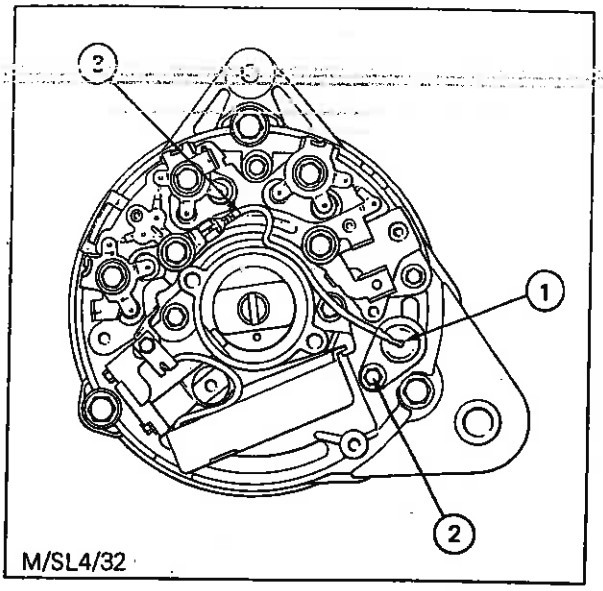


Fig. 54 - Replacing the Surge Diode

BENCH TESTING

Equipment Required

1. Test machine with variable speed control capable of driving the alternator at speeds up to 6000 rpm.

NOTE: Wiring used in the test circuit must be of equivalent grade to that used in vehicle alternator installations, i.e. 14/010 (14/0,25 mm) grade for the 'IND' and 'S' terminal cables and 84/012 (84/0,30 mm) grade for the main positive and negative terminal cables.

2. Fully charged 12V battery.

3. Carbon pile or similar variable electrical load capable of carrying a current of 70 ampere at 12V.

4. 12V 2,2W warning lamp.

5. 0 to 100A moving coil ammeter.

6. 0 to 20V moving coil voltmeter.

Test Procedure

Clamp the alternator in the test rig, with the alternator moulded slip-ring end cover removed to expose the regulator connections. Connect the test circuit as shown in Fig. 55 or 56.

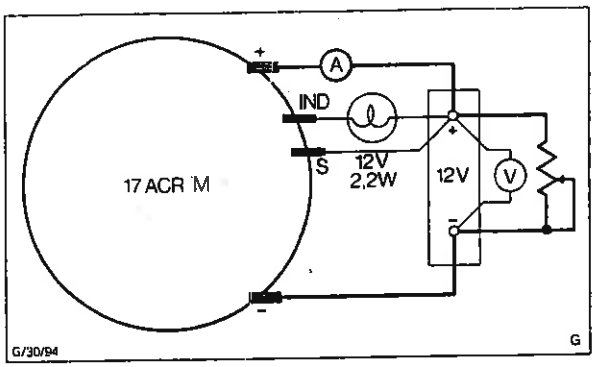


Fig. 55 - 17 ACR'M' Bench Test Circuit

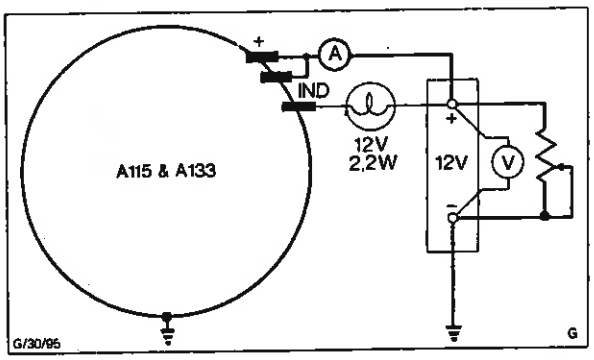


Fig. 56 - A115 and A133 Bench Test Circuit

The warning lamp should be illuminated; if it is, proceed direct to operation No. 4.

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. Carry out operation No. 1.

1. Connect a link between the regulator 'F' and -ve terminals (metal link to black lead on 17ACR'M' alternator or regulator case to earth on A115 and A133 alternators). If this results in the warning light now being illuminated, the regulator is faulty and it must be renewed. If the regulator is not faulty, proceed with operation No. 2.

2. Remove the brush box moulding (refer to 'Preliminary Inspection') and check brushes, slip rings and field coil as instructed. Renew parts as necessary.

3. Render the regulator inoperative by linking its 'F' terminal to earth or negative terminal - refer to operation No. 1.

4. Run the alternator in the test rig at a slowly-increasing speed. At the cutting-in speed (see 'Specifications') and with 13,5V indicated, the warning light should be extinguished; proceed with operation No. 5.

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

NOTE: Do NOT disconnect any wiring while the alternator is running.

If the result is still unsatisfactory, the alternator is faulty and must be dismantled for detailed inspection to determine and rectify the fault.

5. Providing the first half of the test is satisfactory (warning light extinguished), increase alternator speed to 6000 rpm and adjust the variable load resistor until the voltmeter registers 13,6V. The ammeter should register the maximum rated output of the alternator - refer to 'Specifications'.

If this second half of the test is unsatisfactory, the suppression capacitor(s) and/or surge protection device 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.

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.

6. This test assumes the alternator output test (operation 5) 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 or negative terminal.

Run the alternator at 6000 rpm, until the ammeter registers less than 10A. If the voltmeter registers 13,6 to 14,4V, the regulator is working normally. If the voltmeter reading is outside the limits specified, the regulator must be renewed.

SPECIFICATIONS

Model	37A68M	415	423
Nominal Voltage	12V	12V	12V
Nominal D.C. Output at 6000 rpm	36A	45A	65A
Wiring Polarity	Insulated Return	Negative Earth Return	Negative Earth Return
Maximum Permissible Speed	15000 rpm	15000 rpm	15000 rpm
Regulated Voltage	13,6 to 14,4V	13,6 to 14,4V	13,6 to 14,4V
Stator Connection	Star	Star	Delta
Cutting-In Speed (Approx.)	1550 rpm	2100 rpm	1500 rpm
Number of Rotor Poles	12	12	12
Rotor Field Coil Resistance	3 to 3,5 ohms	3,2 ohms	3,2 ohms
Minimum Brush Length	8 mm(0,312 in)	10 mm (0,4 in)	10 mm (0,4 in)

Tightening Torques			
'Through' Bolts	4,5 to 6,2 Nm (46 to 63,3 kgf cm or 40 to 55 lbf in)		6,3 to 7,3 Nm (64,2 to 74,4 kgf cm or 56 to 65 lbf in)
Pulley Retaining Nut	27,2 to 47,5 Nm (2,8 to 4,8 kgf m or 20 to 35 lbf ft)		
Rectifier Assembly Bolts	-	3,4 to 4,0 Nm (34 to 40 kgf cm or 30 to 35 lbf in)	
Rectifier Pack Nut	4 to 4,5 Nm (40 to 46 kgf cm or 35 to 40 lbf in)	-	-
Drive End Bearing Retaining Plate Screws	-	-	5 to 5,5 Nm (50 to 56 kgf cm or 45 to 48 lbf in)

CAV TYPE AC5 ALTERNATOR

CONTENTS

CAV TYPE AC5 ALTERNATOR

DESCRIPTION

The alternator (Fig. 57) is a three phase machine of the revolving field and stationary armature type and is self limiting in current output. Rectification of the output into direct current is provided by means of six silicon diodes contained in the slip ring end shield and connected in a three phase bridge circuit between the stator and output terminals. A second rectifier bridge is formed by using three auxiliary diodes and these supply the energy for the alternator field coil which is fed through slip rings and brushes. This arrangement of auxiliary diodes prevents the battery from discharging through the field coil when the alternator is stationary.

The rotor is supported by sealed ball bearings housed in the two end shields which are secured to the stator by 'through' bolts. A moulded brush box containing the two brushes is positioned in the end shield. Cooling is carried out by air flow through the alternator, induced by a radial fan at the drive end. The heat sinks in which the diodes are fitted are also finned to assist heat dissipation.

A baffle and seal fitted at the slip ring end provides for limited protection against the entry of foreign matter. Marine versions are available with a cowl in place of the baffle to prevent the emission of radio frequency interference; the connecting cables are then taken through screening braid which is terminated at the cowl. Marine alternators use special 'corrosion resistant components and are finished in a white marine paint.

The separate voltage regulator is a fully transistorised unit and contains no moving parts. Being sealed at the time of production, adjustments or repairs are not possible. Should a fault be attributed to the regulator, then it must be renewed.

NOTE: The alternator shown in Fig. 57 is a type AC5A machine which has an 8 pole rotor and a 24 slot stator. Later type AC5B alternators have 12 pole rotors and 36 slot stators but are otherwise similar in construction. The slip ring brushes on AC5B machines are not replaceable separately as are the brushes shown on the AC5A alternator.

OPERATION

Each alternator and its associated regulator operates as a system to charge and maintain the battery in a charged condition. Operation is such that a flat battery will be charged in a minimum of time and a good battery will be held in that condition by a trickle charge. The alternator cannot be overloaded since the machine is designed to be self limiting in current output.

Alternator

The initial field excitation is supplied from the battery through the warning light when the start switch is closed, connected as shown in Fig. 58.

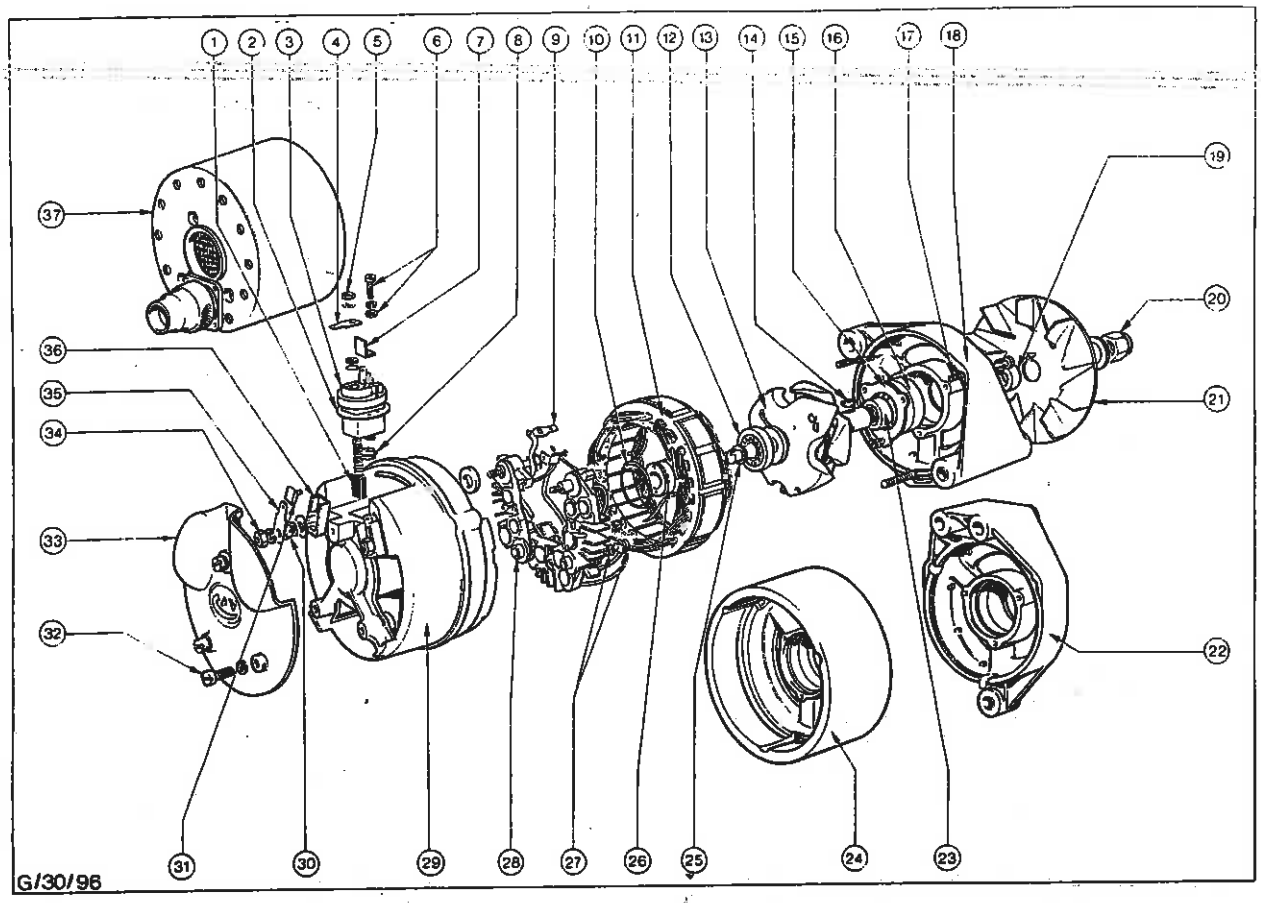


Fig. 57 - AC5 Alternator Exploded View

1. Brush
2. Gasket
3. Brush Holder
4. Lucar Blade
5. Field Terminal Nut and Washers
6. Retaining Screw and Washers
7. Insulator
8. Grommet
9. 'A' Lead
10. 'O' Ring
11. Stator
12. Bearing
13. Rotor
14. Woodruff Key
15. Clamp Plate
16. Bearing
17. Through Bolt
18. Drive End Shield
19. Fan Spacer
20. Pulley Nut
21. Fan
22. Drive End Shield - Swing Mounted Double Hole
23. Bearing Spacer
24. Drive End Shield - Cradle Mounted
25. Circlip
26. Slip Rings
27. Heat Sink Securing Screw
28. Diodes and Heat Sink Assembly
29. Slip Ring End Shield
30. Round Slotted Nut
31. Insert
32. Baffle Screw
33. Baffle
34. Main Terminal Nut
35. Lucar Blade
36. Shroud
37. Cowl (Marine Applications)

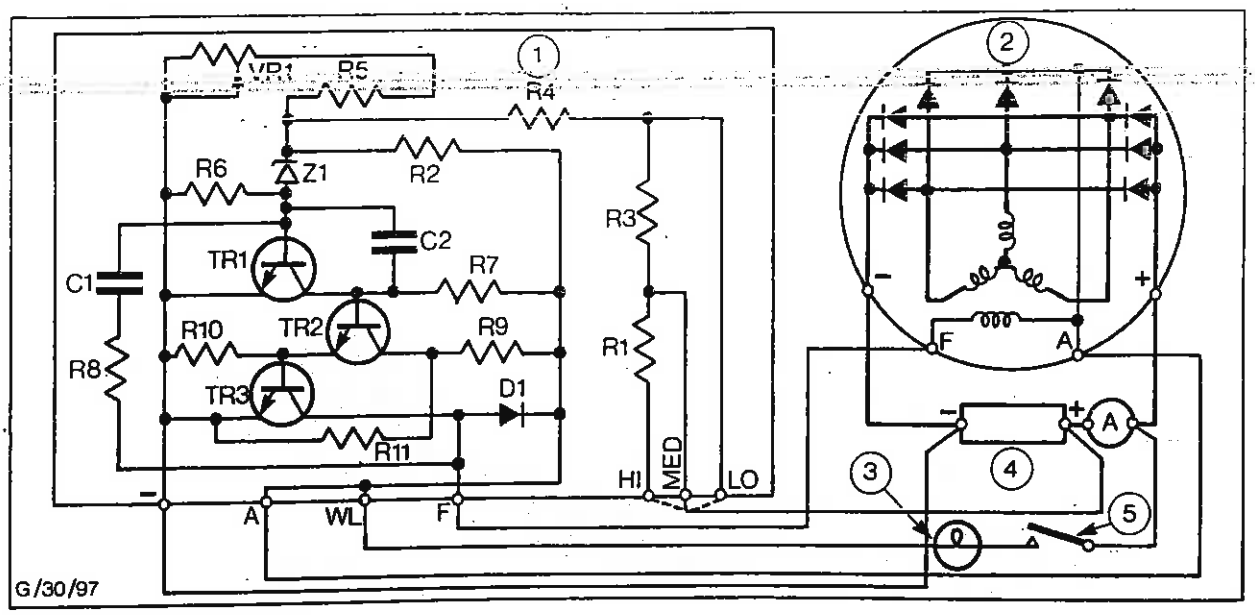


Fig. 58 - Schematic Wiring Diagram of AC5 Charging System

The voltage generated from the initial field excitation is rectified by the three auxiliary diodes and supplements the field current from the battery to rapidly build-up the voltage to the full battery value. At that moment, the potential at alternator terminals 'A' and '+ve' is equal, consequently the warning light is extinguished and all the field current is now supplied from the alternator terminal 'A'. When the voltage at terminal 'A' rises in excess of battery voltage, the value at the alternator positive terminal will also rise and charging current will be supplied to the battery. Terminal 'A' will not supply any charging current to the battery, but will supply any load connected between point 'p' and negative - see Fig. 59.

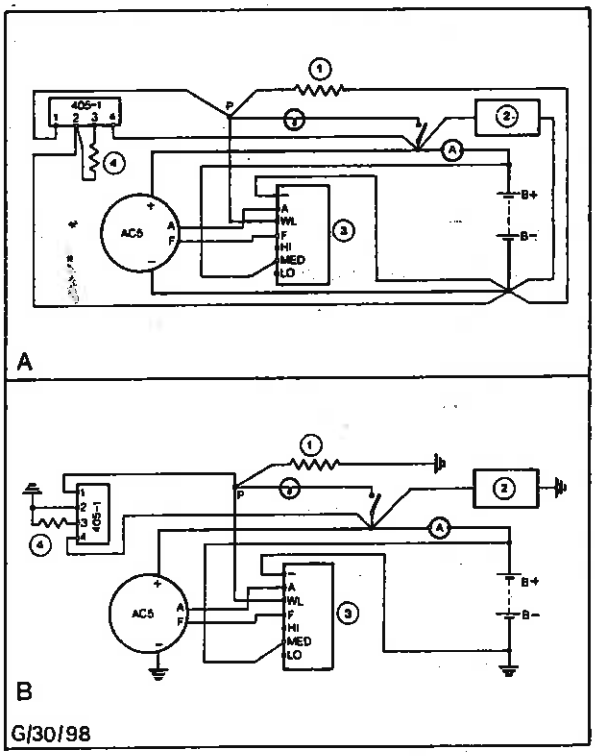


Fig. 59 - Theoretical Circuits for 24 Volt Systems

A. Insulated Return
B. Negative Earth Return

Regulator

The function of the regulator is to control the alternator output voltage. This is done by rapidly switching on and off the alternator field voltage by means of transistors, while a Zener diode provides the voltage reference - refer to Fig. 58 while reading the following explanation.

When the alternator is running, the regulator is supplied by three auxiliary diodes mounted in the alternator slip ring end shield (see Fig. 60).

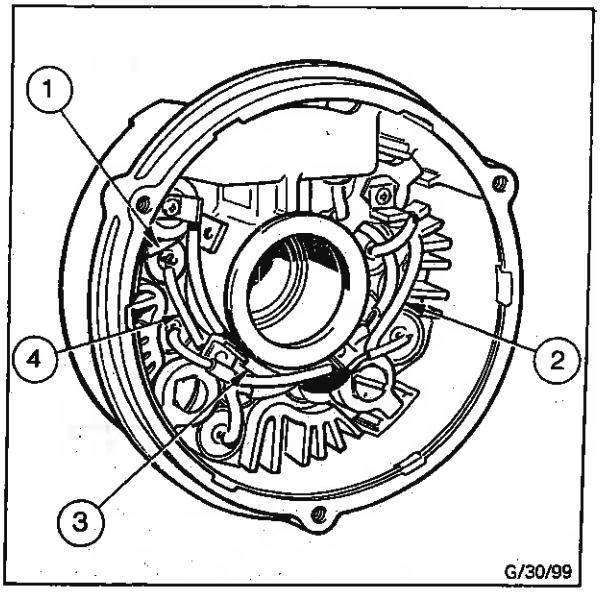


Fig. 60 Diode End Shield
1. Rectified Collector Leads
2. dc Output Lead ('+ve')
3. dc Output Lead ('-ve')
4. Auxiliary Diode Leads

By virtue of the connection through R7, the base circuit of transistor TR2 is conducting so that by normal transistor action, current also flows in the collector-emitter of TR2 which thus acts as closed switch and allows the base circuit of TR3 to conduct. Again, by normal transistor action, TR3 acts as a closed switch and allows full voltage to appear across the alternator field. The rising voltage appears across the potential divider consisting of R3, R4, R5 and VR1. According to the setting of the potentiometer VR1, a proportion of this potential is supplied to the Zener diode Z1, a device which only conducts when a certain voltage across it is reached. Therefore the Zener diode conducts when the alternator output voltage rises to a predetermined value and current flows in the base circuit of TR1. TR1 now acts as a closed switch and diverts the current supplied to the base circuit of TR2 which therefore switches off, causing TR3 to switch off the field supply.

Since the field supply is removed the alternator output voltage falls and this fall is sensed by Z1, which no longer conducts and causes TR1 to switch off. Now the base current is supplied to TR2 which switches on, thus switching on the power transistor TR3. Again full voltage is supplied to the alternator field and the line voltage is restored, initiating the action previously described.

The principle of operation of the 440 regulator requires certain necessary additions. Fast switching of the power transistor TR3 is desirable to reduce internal heat generation and this is achieved by positive feedback via capacitor C1 and resistance R8, which allows TR1 base to sense any change of state of TR3 and thus speed up the change.

Diode D1 is a discharge path field current when TR3 switches off, preventing generation of high reverse voltage across the transistor. Capacitor C2 between the base and collector of TR1 prevents ripple on the rectified output from adversely affecting regulation.

CIRCUITRY AND CONNECTIONS

The standard alternator is produced for insulated return systems but it can be installed in a negative earth return system by connecting the negative terminal to the equipment frame or vehicle chassis as appropriate. Typical circuit diagrams for 24V systems are shown in Fig. 59.

Alternator Main Terminals

The terminals are designed to prevent accidental reversal of connections and consequent damage to the alternator. The positive terminal is distinguished by two flats along its threaded length, together with a plastic insert pressed into the insulating shroud. The plastic insert allows a standard Lucar connector with a standard sleeve to be connected to the positive terminal. The same standard Lucar connector is used on the negative terminal but the negative lead has an enlarged sleeve which cannot be connected to the positive terminal because of the insert.

The 12 volt models and marine versions are similarly provided with a positive termiinal having 2 flats but have no Lucar blades. Special Ross Courtney lugs are fitted to the leads. On the positive lead, the hole in the lug is specially shaped and it will only fit the positive terminal.

Regulator Terminals and Alternator Field Terminals

To prevent accidental reverse polarity connections, a clip-on multi-plug connector for the regulator and an inhibitor type connector for the alternator field terminals are used on some installations.

Sensing Leads

The 'Sensing' leads from the 440 regulator terminals, negative (-) and positive (HI, MED or LO whichever is applicable) should be connected as close to the battery as possible. Their combined voltage drop must not exceed 0,25V at 2,5A (24 volt system) or 0,3V at 3,6A (12 volt system). Connections to the vehicle frame or chassis must not be used for these 'Sensing' circuits. This means that it is necessary to use two wires, both of which return to the battery.

Alternator Only Loads

Certain electrical equipment is normally only required to operate when the engine is running (and consequently when the alternator is producing current). This equipment such as heaters, fans, demisters, etc. is often referred to as 'alternator only' loads and can be connected directly to the 'A' terminal of the alternator as shown in Fig. 59. Should these loads become excessive, the alternator output could be prevented from building up normally.

Maximum permitted 'alternator only' loads are 5A on 24V systems and 10A on 12V systems. A type 405 relay is available for 24V systems which enables resistive loads of up to 22A or inductive loads of up to 15A to be supported, the alternator having to operate the relay coil only. Fig. 59 shows the connections for 'alternator only' loads, with and without the type 405 relay.

FAULT FINDING

General Precautions

Before carrying out any tests, check that all terminal connections are correct - see Fig. 58.

DO NOT REMOVE OR REPLACE ANY ELECTRICAL CONNECTIONS WHILE THE ENGINE IS RUNNING.

If, during the following tests, it is necessary to disconnect leads from the regulator, ensure that they are connected to the correct terminals when replacing them. Incorrect connections, however brief, can cause irreparable damage to the regulator components.

Test Equipment Required

1. A British Standard first grade moving coil voltmeter, 0 to 50V range.

2. A British Standard first grade moving coil ammeter, 0 to 100A range (this will not be required if an ammeter is already fitted).

Test Procedure

1. Connect the voltmeter across the battery terminals.

2. If an ammeter is not already fitted, connect the test ammeter in the alternator positive line as shown in the wiring diagram in Fig. 58.

3. Close the 'Start' switch and observe that the warning light illuminates; if it does, proceed to Operation 5. If no light is observed, check the bulb and renew it if it is defective. If the bulb is serviceable and still no light appears, disconnect the lead from 'WL' terminal of the regulator and connect the lead to the equipment frame or vehicle chassis, as appropriate; the warning lamp should illuminate if the 'Start' switch and associated wiring is correct. Re-connect the lead to the regulator 'WL' terminal.

4. If the warning lamp does not illuminate and the bulb, switch and wiring have been checked and found to be correct, check the regulator by first switching off the 'start' switch and disconnecting the lead from the 'F' terminal on the regulator.

Clip this lead to the negative terminal on the regulator and switch on the 'start' switch. If the light now appears, the regulator is faulty and must be replaced by a new regulator. (The regulator is a sealed non-repairable unit). If no light appears, then the alternator is faulty and requires workshop attention.

5. Start the engine and allow it to run at a fast idling speed. Observe that:

a) The warning light is extinguised and that

b) The ammeter records a small charging current, dependent on idling speed.

Failure to meet these requirements indicates that the alternator is faulty and requires attention. Do not proceed with operations 6 and 7 if the alternator is faulty.

6. Momentarily increase the engine speed to maximum permitted rpm and observe that charging current is as stated in 'Specifications' at the end of this section of the Service Manual.

NOTE: If the battery is in a fully charged condition, it will be necessary to connect an electrical load across it having the following minimum wattage ratings:

24V - 720W
12V - 636W

Failure to reach the stated current output indicates a faulty alternator. Do not proceed with Operation 7 if the alternator is faulty.

7. With the alternator running at approximtely half speed, switch off all the electrical loads. Depending on the connection selected for the positive sensing wire (LO, MED or HI) the voltage should rise to between 26 and 28 volt on 24 volt systems and between 13 and 14 volt on 12 volt systems. At the same time the current reading should drop appreciably. Failure to meet these conditions indicates a faulty regulator.

PRELIMINARY INSPECTION

It is not necessary to fully dismantle the alternator in order to check the brushes, slip rings and field coil winding for serviceability.

Remove the baffle/cowl and the brush box assembly as detailed at the beginning of the 'Dismantling' Section; where applicable, remove the brushes as directed. Check the brushes and brush box as detailed under the heading 'Brushgear' in the 'Component Inspection and Renewal' Section and renew parts as necessary.

Visually inspect the slip rings for signs of wear or damage. Using a good quality test meter such as an 'Avometer', check that the resistance measured across the slip rings is in accordance with the figure given in the 'Specifications'. To ensure that the correct measurement is obtained, take several readings, turning the rotor slightly between measurements.

NOTE: It is essential to establish whether the alternator being checked is an 8 pole or 12 pole machine - refer to 'Specifications'. Should the type label be missing or damaged, it is possible to count the number of rotor poles through the slots in the drive end shield after removing the drive pulley. Fig. 57 shows the construction of an 8 pole machine.

An appreciably lower field coil resistance than that stated could mean a short circuit between the coils; a higher reading suggests that the contact surfaces of the slip rings need cleaning. An infinity reading would indicate an open circuit in the field.

Unless the foregoing tests indicate that further dismantling is necessary, replace the brushgear assembly and the baffle or cowl.

DISMANTLING

1. Remove all surface dirt and grease with a rag or brush dipped in paraffin or other suitable cleaning fluid. Avoid excess liquid entering the alternator through gaps in the casing.

2. Lightly clamp the alternator in a bench mounted vice with soft faced jaws.

3. Unscrew and remove the three screws (1) and spring washers and detach the baffle or cowl from the slip ring end shield - see Fig. 61.

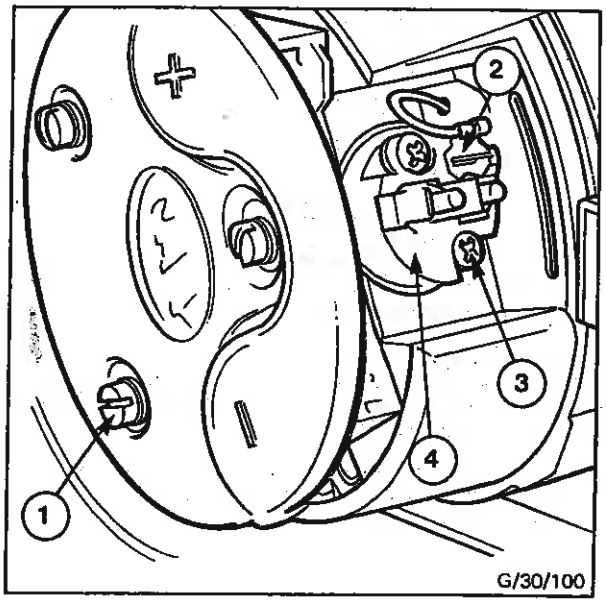


Fig. 61 - Removing Baffle and Brush Box

4. Disconnect the lead (2) from terminal 'A' of brush box, remove the two retaining screws (3), complete with spring and plain washers and withdraw brush box (4) complete with brushes. Discard gasket.

5. Remove field terminal retaining nuts (1), crinkle washers (2), 'Lucar' blades (3) and insulator (4) from terminal posts. Withdraw brushes (5) and field terminal posts (6) from brushbox. Discard sealing rings (7) - see Fig. 62 (Brushboxes on AC5B alternators cannot be dismantled).

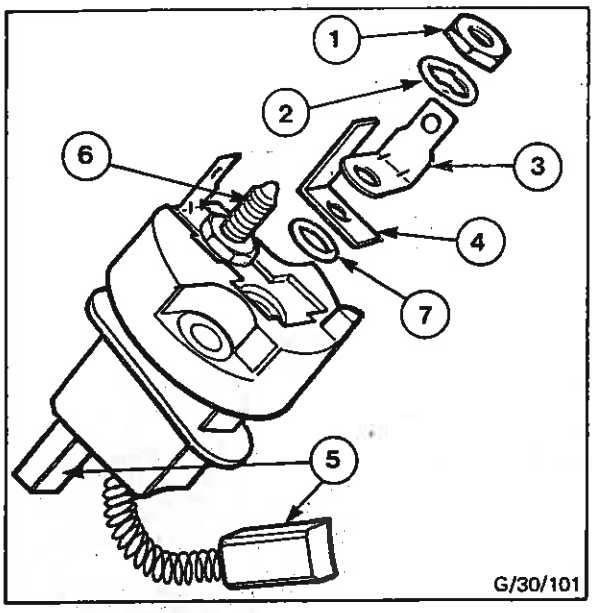


Fig. 62 - Dismantling Brush Box

6. Remove pulley securing nut and washer and withdraw the pulley. Remove fan and, on machines with metal fans, the fan spacer. Extract the 'Woodruff' key from the rotor shaft.

Before proceeding further, a line should be lightly scribed across both end shields and stator to facilitate alignment on reassembly.

7. Remove the three 'through' bolts and spring washers, then remove the alternator from the vice. When 'Loctite' grade 'A' has been used to secure the through bolts, local heat should be applied with a heated soldering iron, or a small flame to loosen them. No part should be overheated. Using a hide faced mallet, tap the drive end shield away from the stator. As shown in Fig. 63, carefully withdraw the drive end shield complete with rotor from the stator and slip ring end shield, taking care not to damage the slip rings. Do not damage the slip rings when laying drive end shield and rotor assembly on the bench.

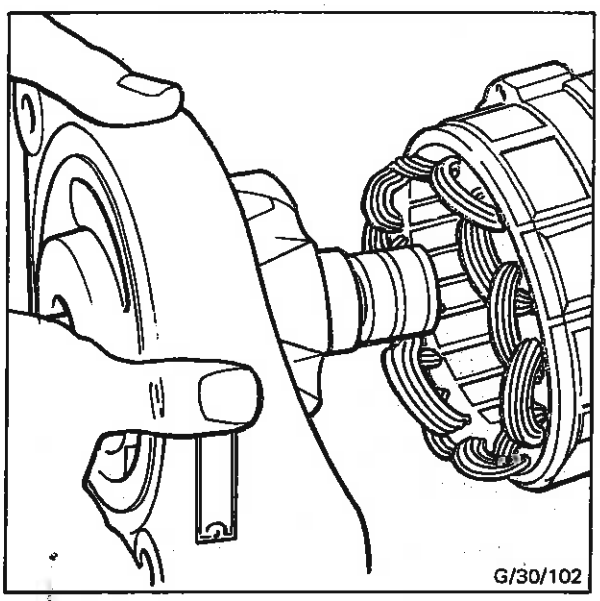


Fig. 63 - Removing Rotor from Stator

8. Place the stator and slip ring end shield assembly on the bench with the end shield uppermost. Do not lift the assembly by the end shield as this will cause the whole weight of the stator to be taken on the three stator leads.

9. Unsolder the three stator phase leads (1) from the heat sink terminal tags, (DO NOT REMOVE TAGS FROM HEAT SINKS) and separate the slip ring end shield from the stator, using a hide faced mallet if necessary - see Fig. 64.

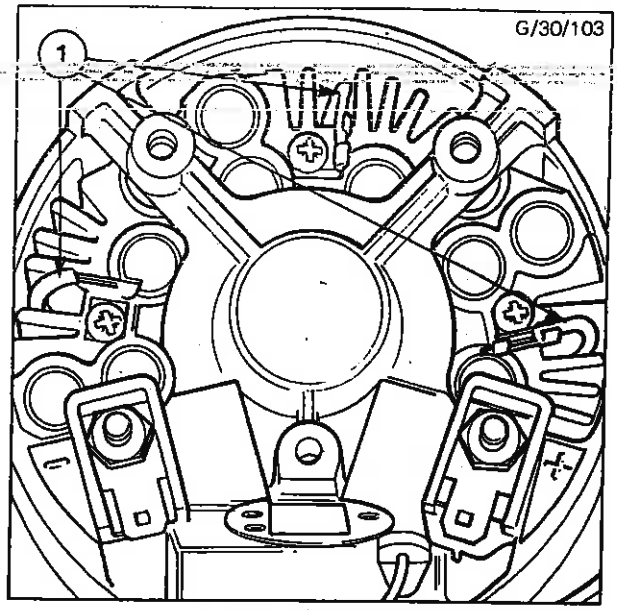


Fig. 64 - Removing Stator Terminations

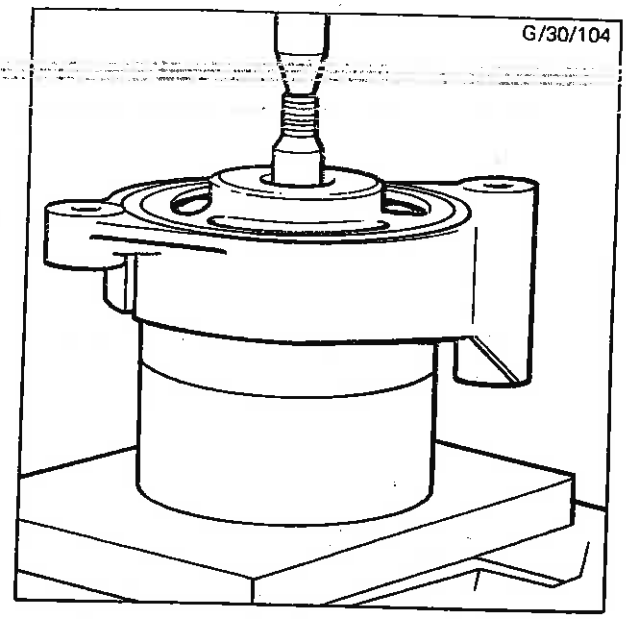


Fig. 65 - Removing Rotor from Bearing

10. Remove and discard the 'O' ring (where fitted) from the slip ring end shield bearing housing, using a sharp pointed probe. Do not damage 'O' ring groove.

11. As shown in Fig. 65, place the drive end shield (drive shaft upwards) over a suitable large diameter cylinder so that the rotor is encased within the cylinder and the cylinder seats squarely against the three end shield webs. A discarded 100 to 115 mm (4 to 4,5 in) dia. starter motor or dynamo yoke is admirable for this operation, but care must be excercised to ensure the end face of the yoke does not cut into the web radii). Support the rotor from underneath while pressing it out of the drive end shield with a standard fly-press.

NOTE: It is unnecessary to strip the diode assembly from the slip ring end shield unless it is established that there is a fault in one or more of the diodes - see under 'Diodes' in the 'Component Inspection and Renewal' Section.

COMPONENT INSPECTION AND RENEWAL

General

After dismantling, all components should be thoroughly cleaned with an approved cleansing agent before examination. The stator frame and rotor shaft should be wiped clean with a non-fluffy rag moistened with white spirit; take care to avoid the spirit coming into contact with the winding insulation and stator leads.

Examine all parts generally for cracking, corrosion, serviceability of threads, score marks and excessive wear. The 'Nyloc' pulley nut can be used again provided the nylon insert is in reasonable condition.

Ensure that all traces of carbon dust are removed with a compressed air line before carrying out any insulation tests. do NOT 'spin' the bearings with the air line; this can damage the balls, rollers and tracks.

In addition to the usual workshop facilities, the following electrical equipment will be required.

Equipment Required

1. 'Avometer' or similar high grade multi-test meter.
2. Moving coil dc ammeter with 0 to 100 ampere range.
3. 100V 'Megohm' tester or similar non destructive insulation tester.
4. 24V test battery.
5. Variable electrical load capable of carrying a current of 60A at 24V.
6. Single pole ON/OFF switch rated at 60A, 24V minimum.
7. 24V 44/48W lamp and holder.

Brushgear

Ensure that the brush box is free from cracks or damage. Check that the brushes are undamaged and can slide freely in their holders; if at all sluggish, lightly polish the brush sides with a smooth file. Remove all traces of dust before refitting the brushes to the holders.

Brushes should be renewed if they are shorter than the minimum length stated in 'Specifications'. It is recommended that new brushes are fitted during a complete overhaul.

NOTE: On the later AC5B alternators, the brushes are not removable; they can however be withdrawn gently against spring tension far enough for the total length to be measured. Great care must be taken not to withdraw them too far or the springs may be stretched or broken off.

Bearings

Check bearings for excessive play and smoothness of operation. If they are defective in any way they must be renewed. Since the bearings are sealed and cannot be lubricated, any evidence of dryness will necessitate renewal.

The drive end bearing should be renewed as follows:

1. Remove the three screws and washers securing the clamp plate. If the screws prove difficult to remove due to any thread locking compound used, heat the complete end shield assembly to approximately 100°C. Remove the clamp plate.

2. Remove the bearing from the housing; if necessary, press it out using a suitable drift.

3. Press a new bearing into the housing while ensuring that the bearing remains perfectly square to the housing.

4. Place clamp plate in position and secure with three screws and washers. Renewal of the slip ring end bearing will necessitate removal of the slip rings - see under the heading 'Slip Ring and Bearing Renewal'.

Stator

1. Examine stator windings for security and condition. Check stator leads for deterioration of insulation and mechanical damage. Should a lead be broken or damaged, cut it back to a sound part and join on a length of flexible cable. Solder the joint then slide a length of glass fibre sleeving over the joint. The sleeving should be slid on far enough to be neatly tied to the stator windings at the original lashing point.

2. Subject the stator to a 100V insulation test between each of the three leads in turn and the frame. The minimum resistance should be 10 megohm in each case.

3. Wire a test circuit consisting of 24V battery, ON/OFF switch, variable resistor, ammeter and voltmeter across two of the stator leads as shown in Fig. 66.

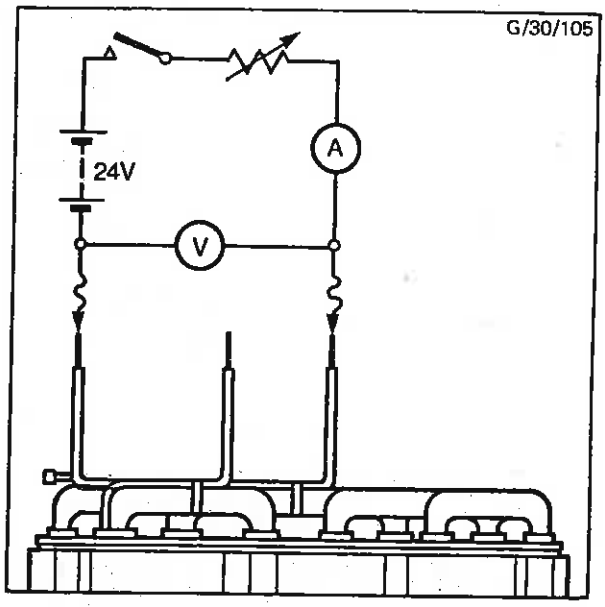


Fig. 66 - Testing Stator Coils

4. Close the switch and quickly adjust the variable resistor until a current of 20 ampere is indicated; note the reading on the voltmeter, then open the switch immediately.

5. Repeat operations 3 and 4 across the two remaining pairs of stator leads; the volt drop reading obtained in each case should be noted down. Each of the three voltage readings should be the same and should conform to the appropriate figure given in 'Specifications'. Should the test prove unsatisfactory, the stator must be renewed.

Rotor

1. Check the rotor visually for any sign of damage or rubbing. Examine the field windings for damage or deterioration of the insulation and check that they are held securely in position.

2. Check the insulation between each slip ring and the rotor shaft with the 100V insulation tester; a minimum resistance of 10 Megohms should be indicated.

3. With the 'Avometer' set to the lowest resistance range, measure the resistance between slip rings; this should be in accordance with the appropriate figure given in 'Specifications'.

Failure to meet the requirements of tests 2 and 3 will necessitate renewal of the rotor assembly.

5. Examine the slip rings for signs of wear and scoring. The slip rings may be skimmed to the minimum diameter figure given in 'Specifications' - refer to the instructions given under the heading 'Slip Rings and Bearing Renewal' for the recommended machining procedure.

Slip Rings and Bearing Renewal

1. Unsolder the ends of the field leads from the slip ring terminal posts (1) - see Fig. 67.

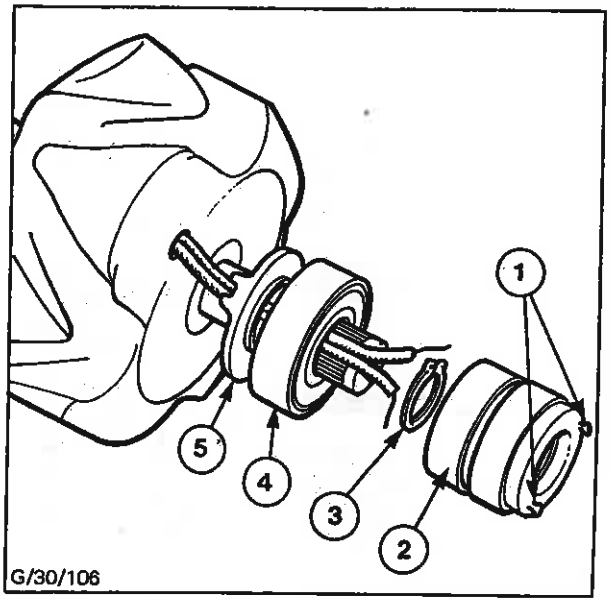


Fig. 67 - Removing Slip Rings and Bearing

2. Using the extractor shown in Fig. 68, withdraw the slip ring assembly (2) - see Fig. 67. Removal of the slip ring assembly will render it unserviceable and a new one must be fitted.

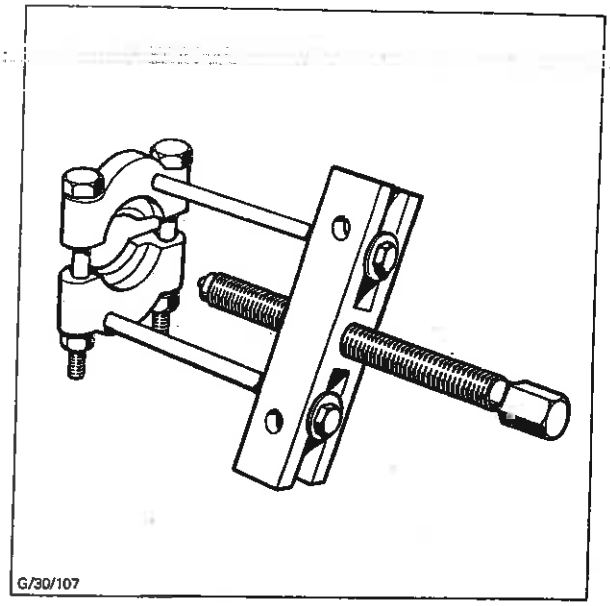


Fig. 68 - 'Sykes' Type Extractor

3. Remove bearing circlip (3). Adjust the jaws of bearing extractor so that the jaws locate between the outer race (4) and the bearing spacer (5) and withdraw bearing.

4. Examine bearing spacer for cracks and distortion. Clean out groove. Renew spacer if damaged.

5. Detaching the rotor leads from the slip ring assembly imposes mechanical stresses that may weaken the leads and produce the possibility of failure under operating conditions at a later date. It is strongly recommended that the leads are renewed in the following manner.

Cut the leads so that the subsequent joints are staggered as shown in Fig. 69(A). Trim back the glass-fibre sleeving and lightly twist a new length of 21 SWG Lumex copper wire to the existing wire and solder together. Snip off excess wire. Apply a liberal coating of insulating varnish and slide a short length of 2 mm glass-fibre sleeving over the join so that it slides inside the existing sleeve, Fig. 69(B). Apply a further coating of varnish and slide on a new length of 3 mm glass-fibre sleeving to abutt the original sleeve. Apply a final coat of varnish to the outside.

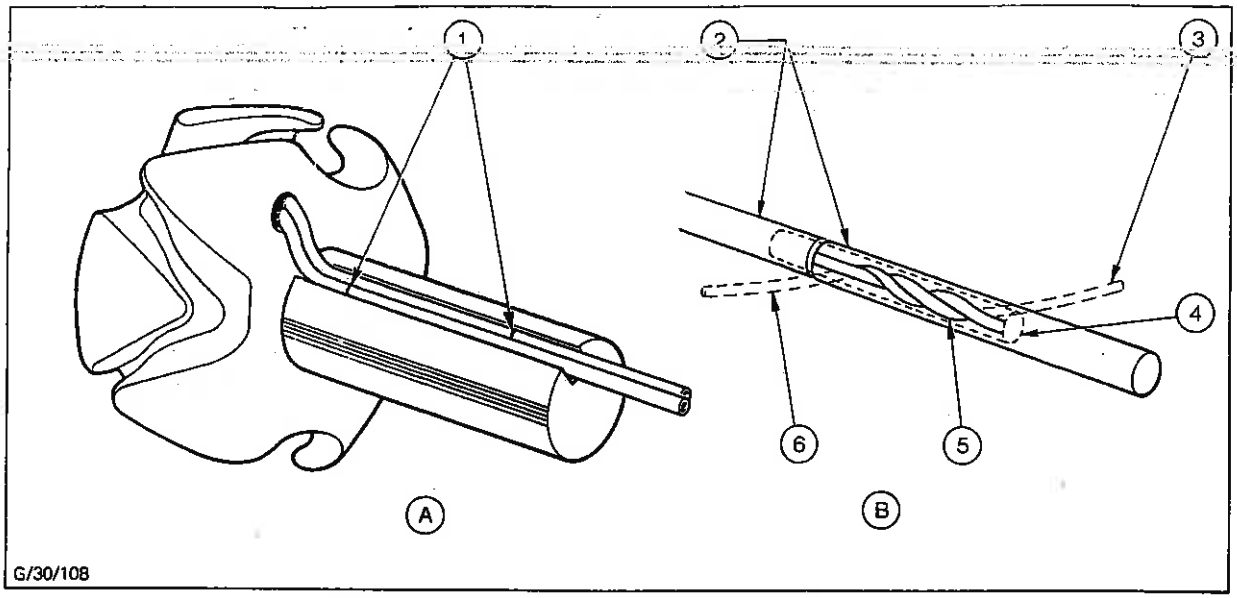


Fig. 69 - Renewing Field Coil Leads

6. Place the rotor (drive end downwards) in a suitable fixture of a bench press so that the weight is supported on the rotor claws. Refit the bearing spacer (1) over the rotor shaft so that the moulded groove is in the correct position to contain the field leads (2) from the rotor. Press into position - see Fig. 70.

7. Press new bearing (3) onto the rotor shaft and fit a new circlip (4), ensuring it is fully seated and a tight fit in its groove.

8. Pass the two field leads through the bore of a new slip-ring assembly (5) and locate the slip ring on the shaft with the terminal posts positioned at 90° relative to the shaft lead slot as shown.

9. Place press tool (see Fig. 71) so that the spigot registers in the slip ring-bore with the cut-away portion in line with the field leads as shown in the insert of Fig. 70. Gently press the slip-ring down until the press tool spigot abutts the rotor shaft. Feed the field coil leads past the cut-away portion of the press tool as they appear.

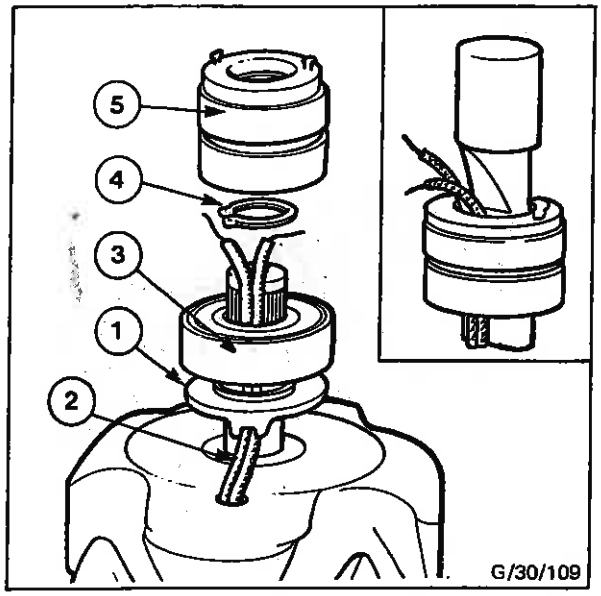


Fig. 70 - Fitting Bearing and Slip Rings

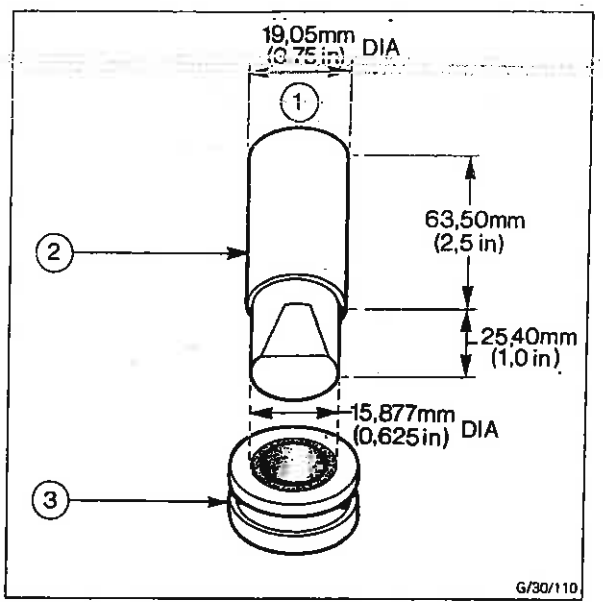


Fig. 71 - Slip Ring Press Tool
1. Mild Steel Rod
2. Slip Ring Press Tool
3. Slip Rings

10. Trim off the ends of the glass-fibre sleeve to leave approximately 6,5 mm (0,25 in) projecting beyond the rotor shaft. This will prevent the field leads from shorting onto the shaft during service. Wrap the leads around the terminal posts of the slip ring, cut to length, and solder in position.

11. Plug with 'Silcoset 151' any gap that appears where the leads enter the spacer between the spacer and the rotor claws. Wipe off any surplus Silcoset 151.

12. Mount the rotor drive end shaft in a suitable lathe, locating the steady on the outer race of the SRE bearing. Lightly skim the slip-rings to ensure that they are concentric with the SRE bearing to within 0,05 mm (0,002 in). Remove the minimum amount of metal to achieve this degree of concentricity and do not reduce the slip ring diameter to below the minimum diameter given in 'Specifications'. To obtain the required surface finish, it is essential that a highly finished diamond or tungsten carbide tipped cutting tool be used for this operation.

Slip Ring End Shield

Examine the internal bore of the bearing housing for signs of wear caused by the bearing outer race having been revolving in the housing; if this has occurred, the end shield must be renewed.

'Offer up' the slip ring end bearing to the housing to ensure that it will be a tight fit when fully installed. Failure to meet this requirement will necessitate a new end shield.

NOTE: Certain factory reconditioned end shields contain a steel sleeve in the bearing housing.

Diodes

Using the following method, all the diodes can be tested while the three heat sinks are still assembled in the slip ring end shield:

1. Connect a test probe in series with a 48 watt 24 volt lamp on the positive terminal of 24 volt dc supply. Connect another test probe to the negative terminal of the dc supply.

2. Carry out all the tests detailed in the following table:

Test No.	Position of Test Probes		Diode Under	Correct Test Lamp
	Positive Probe	Negative Probe	Test	Indication
1	Each heat sink in turn	Terminal D+	Positive	Lamp illuminates
2	Terminal D+	Each heat sink in turn	Positive	No illumination
3	Terminal D-	Each heat sink in turn	Negative	Lamp illuminates
4	Each heat sink in turn	Terminal D-	Negative	No illumination
5	Each heat sink in turn	Terminal A	Auxiliary	Lamp illuminates
6	Terminal A	Each heat sink in turn	Auxiliary	No illumination

Should a test lamp indication occur that does not agree with the table, then the heat sink being tested contains a faulty diode and must be renewed - see under 'Heat Sink Renewal'.

NOTE: A broken lead or a high resistance solder joint between a diode and its termination could show symptoms similar to a faulty diode; check for these faults before removing a heat sink.

Heat Sink Renewal

1. a) 12 volt machine and marine version.

Remove external positive and negative main terminal nuts, spring washers, terminal post retaining nuts, spring and plain washers and nylon washers.

b) 24 volt machine

Remove external positive and negative main terminal nuts, spring washers, and Lucar blades. Remove round slotted nuts (using key - see Fig. 72) spring and plain washers and nylon terminal shrouds.

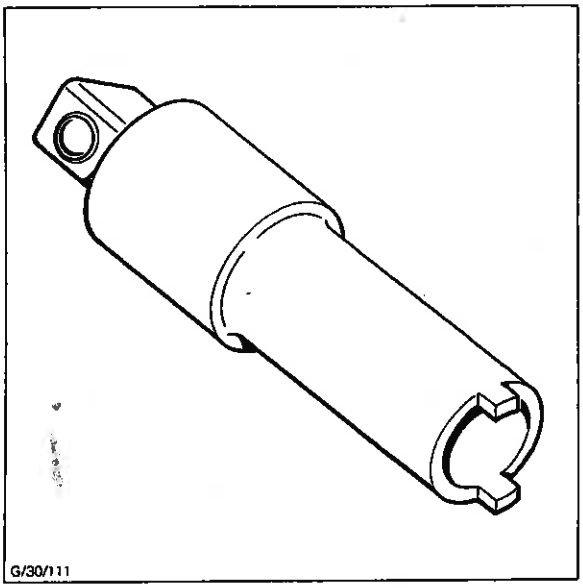


Fig. 72 - Key for Slotted Terminal Nut

2. Working from the other side of the end shield, slide the 'A' lead grommet (1) out of its slot in the end shield and pull the lead (2) through the end shield - see Fig. 73.

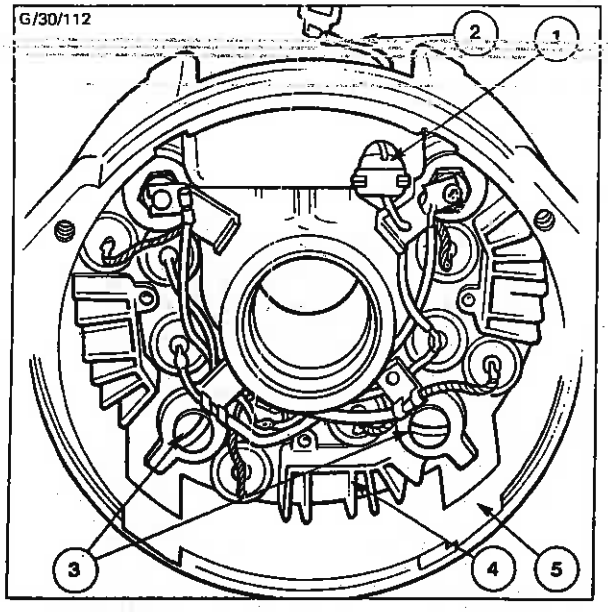


Fig. 73 - Removing Heat Sink Assembly

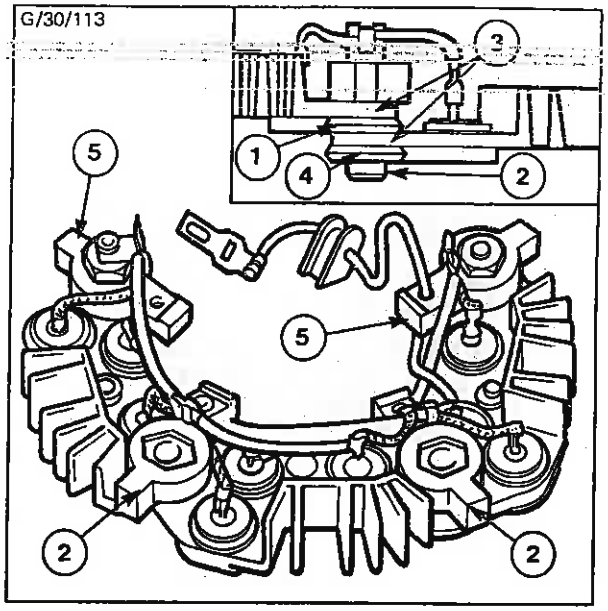


Fig. 74 - Assembling New Seat Sink

3. Remove the two heat sink securing screws (3) and spring and plain washers. Withdraw complete heat sink assembly (4) and take out the insulating strip (5).

4. Snip the two copper braids of the faulty heat sink diodes close to their respective right angled terminal tags and unsolder the sleeved lead from the third diode. Remove appropriate nylon retaining washers and withdraw heat sink.

5. Assemble the new heat sink in position (see parts list for identification) so that the complete assembly takes the form shown in Fig. 74. Place a nylon insulating washer (1) on each locator (2) so that they are interposed between adjacent heat sinks (3) as illustrated. Replace outside nylon retaining washers (4) on both locators (2) and on main terminal locators (5).

NOTE: On marine versions, when a new heat sink is fitted or if the existing heat sink paint is damaged, paint the heat sink with 'Yacht Blue Polyurethane Enamel 107' obtainable from Sanderson and Co., Hull, Yorkshire, England.

6. Solder the two diode braids to the appropriate angle tags. Note the length of the braids are such that it is impossible to connect them incorrectly.

7. Solder sleeved wire to remaining diode.

WARNING: Excessive heat can cause immediate and permanent damage to diodes. It is recommended that a pair of long nosed pliers be used to grip the diode shank to act as a thermal shunt and that the soldering operation be carried out as quickly as possible.

8. Apply lamp test as detailed under the heading 'Diodes' to ascertain that the diodes are functioning correctly.

9. Replace the complete heat sink assembly (1) in the end shield and secure with the two screws (2) and spring and plain washers - see Fig. 75.

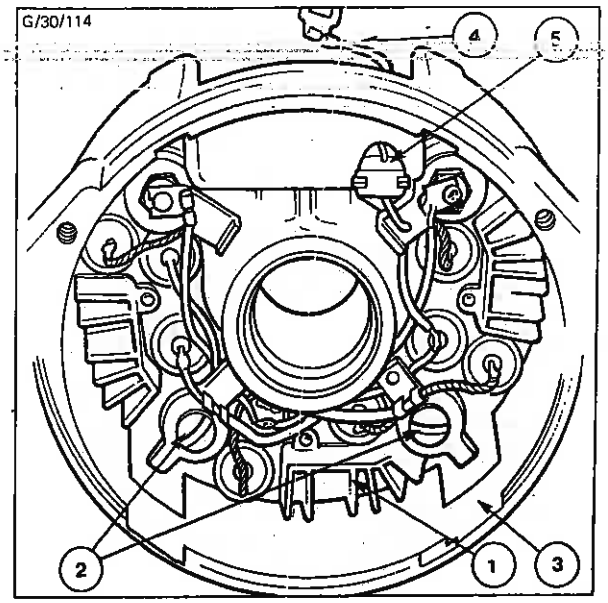


Fig. 75 - Replacing Heat Sink Assembly

10. Place the insulating strip (3) in position.

11. Pass the 'A' lead (4) through the slot in the end shield and slide the grommet (5) into position in the slot.

12. (a) 12 volt machine and marine version

Replace nylon washers, plain and spring washers, main terminal post retaining nuts, spring washers and main terminal nuts.

(b) 24 volt machine

Replace nylon terminal shrouds, plain and spring washers and round slotted nut (use key - see Fig. 72). Replace Lucar blades, spring washers and terminal nuts.

NOTE: The terminal shroud fitted to the positive terminal has a plastic insert.

ASSEMBLY

Normal workshop practices should be followed taking special care to keep working surfaces and tools clean.

1. Lay the stator on the bench with the three leads facing upwards.

2. Hold the end shield over the stator, so that the three wide spaces on the heat sink finning coincide with the three stator leads. Carefully lower the slip ring end shield onto the stator and align scribe marks. (Refer to operation No. 6 of 'Dismantling' procedure). Insert stator phase leads (1) into heat sink tags and solder in position - see Fig. 76.

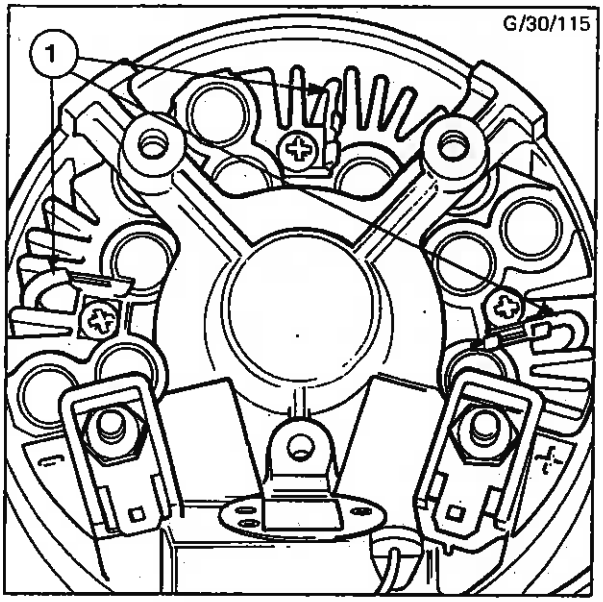


Fig. 76 - Terminating the Stator Leads

3. Fit bearing spacer over the rotor drive shaft and insert drive shaft through the bore of the drive end shield ball race.

4. Place the drive end shield on a bench press so that the bearing housing is firmly supported and the rotor shaft can pass through the support plate - see Fig. 77.

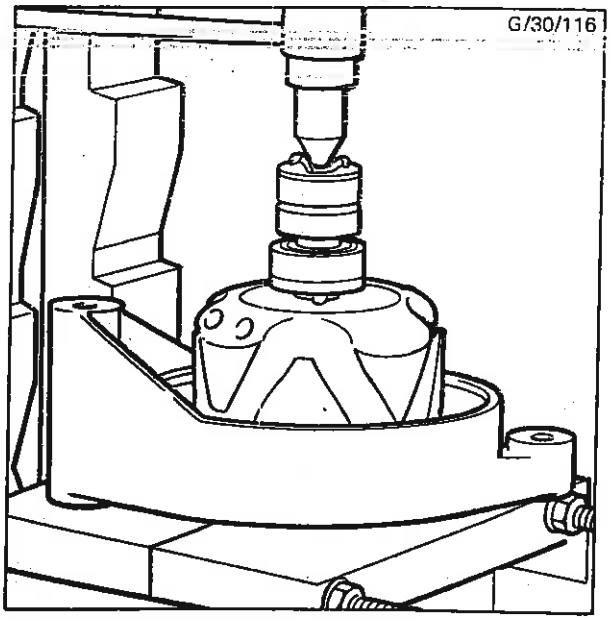


Fig. 77 - Assembling Drive End Shield

5. Press the rotor shaft fully into the bearing taking care not to damage the slip rings, slip ring terminals or field coil leads; a truncated cone shaped mandrel fitted to the press spindle will rest on the end of the shaft and clear the slip ring terminals.

6. Fit new 'O' ring (supplied in seal and gasket set) to groove in internal bore of slip-ring bearing housing. Smear the inside of the 'O' ring with light grease to assist bearing entry.

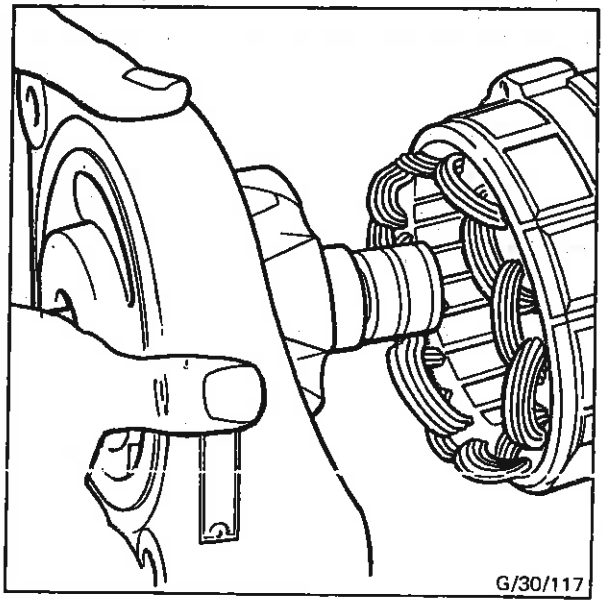


Fig. 78 - Assembling Rotor and Stator

7. Support the rotor and drive end shield assembly as shown in Fig. 78 and pass the rotor through the stator so that the slip ring end bearing enters the bearing housing in the slip ring end shield. Great care must be taken not to damage the slip rings during this operation.

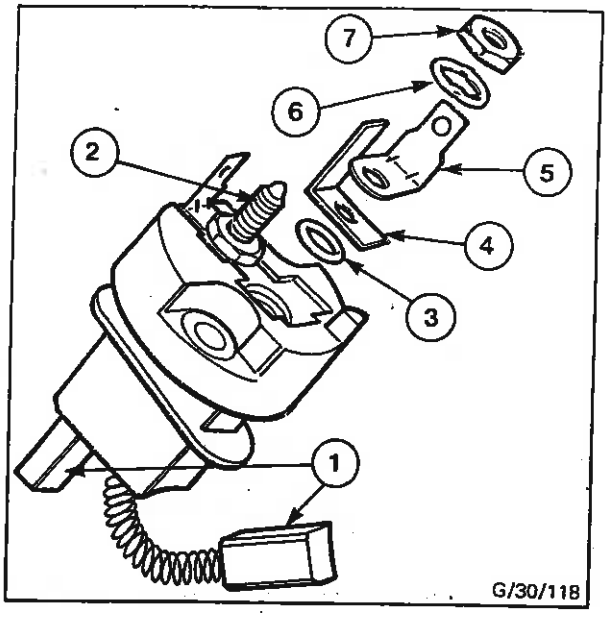


Fig. 79 - Assembling Brushes

8. Press the stator and slip ring end shield assembly up to the drive end shield as far as possible by hand, ensuring again that the scribed lines are in alignment. Place a locking washer onto each of the three through bolts and coat the threads with 'Loctite' grade A. Insert the bolts and tighten them evenly and progressively whilst gently tapping the slip ring end shield with a hide face mallet to draw end shields squarely into position. Finally tighten the through bolts to the specified torque figure.

9. Refit brushes (1) to brush box, making sure that the terminal posts (2) are fully seated. Thread new 'O' sealing rings (3) over both the terminal posts and assemble insulator (4) to one of the terminals. Fit Lucar blades (5) and crinkle washers (6) to both terminals and secure with terminal nuts (7) - see Fig. 79.

Marine versions have one Lucar blade and one threaded stud.

10. Fit a new gasket (supplied in seal and gasket set) to the brush box moulding and assemble brush gear (1) to the slip ring end shield. Correct positioning is ensured by the locating dowel. Secure with retaining screws (2) and plain and spring washers. Reconnect 'A' lead (3) to terminal post marked 'A', secure with crinkle washer, plain washer and terminal nut - see Fig. 80.

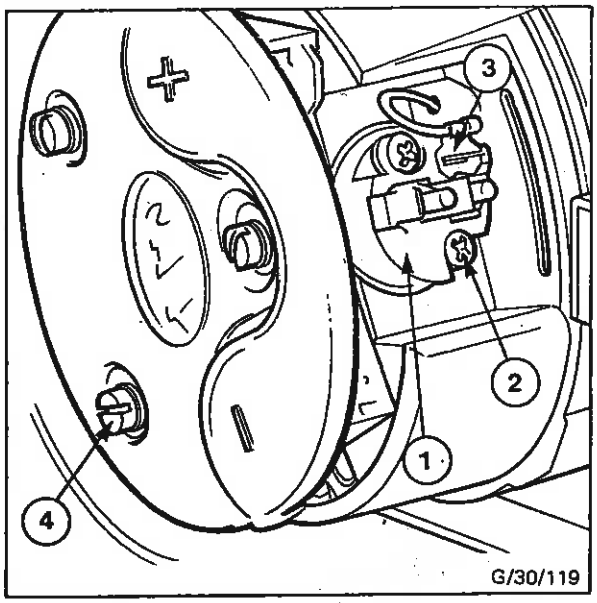


Fig. 80 - Replacing Brush Box and Baffle

11. Fit baffle or cowl to slip-ring end shield and secure with screws (4) and spring washers.

12. Fit Woodruff key, fan pulley and pulley nut. Tighten pulley nut to the specified torque value.

BENCH TESTING

Equipment Required

1. Test machine with variable speed control capable of driving the alternator at speeds up to 6000 rpm.

2. Fully charged 12V or 24V battery to suit system voltage.

3. Carbon pile or similar variable electrical load capable of carrying a current of 60 ampere at system voltage.

4. Type 440A 12V or 24V regulator to suit system voltage.

5. Non-destructive 110 volt flash tester or 110 volt 'Megohm' meter.

6. 'Avometer' or similar multi-test meter.

7. Warning lamp of correct voltage and not less than 2 watt rating.

8. British Standard first grade moving coil dc voltmeter with a range of 0 - 50 volt.

9. British Standard first grade moving coil dc ammeter with a range of 0 - 100 ampere.

10. 3 ampere fuse and holder.

11. Single pole ON/OFF switch.

Static Testing

1. Connect one lead of the insulation tester to the alternator housing and the other lead to each terminal in turn. If 'Megohm' meter is used, the minimum insulation resistance should be 10 megohm in each case.

2. Select the lowest resistance range on the multi-test meter then connect its leads to terminals 'A' and 'F'. A low resistance should be indicated that varies slightly when the rotor is turned slowly by hand. Large variations in resistance usually indicate sticking brushes or dirty slip rings.

3. Rectify any faults before proceeding with further tests.

Performance Testing

1. Mount the alternator on the test machine and connect the 'F' terminal to the main negative terminal via the 3 ampere fuse. Connect the voltmeter across the two main terminals.

Type of Alternator	Cutting-in Speed	Current Output at 2000 rpm	Current Output at 3000 rpm	Current Output at 4000 rpm
12V 55A (8 pole rotor)	1250 rpm at 14V	30,5A	46A	50A
12V 75A (12 pole rotor)	1200 rpm at 14V	46A	64A	71A
24V 30A (8 pole rotor)	1250 rpm at 28V	16,5A	25,5A	29A
24V 35A (12 pole rotor)	1050 rpm at 28V	23A	30A	34A

Fig. 81 - Performance Testing Figures

2. Start up the test machine and slowly increase speed until the appropriate cutting in speed given in the table, Fig. 81, is reached. The voltage indicated on the voltmeter should be as specified in the same table.

If no voltage is obtained, it will be necessary to polarise the rotor by connecting a battery of the correct voltage across the field coil; connect battery positive to terminal 'A' and battery negative to terminal 'F'. Observe that the voltage indicated is that specified in the table, then disconnect the battery; the voltage reading should remain at the correct figure.

3. Stop the test machine, disconnect the voltmeter and remove the fused link from between the main negative terminal and terminal 'F'.

4. Wire the alternator to the test circuit as shown in Fig. 82; the switch should be in the OFF position initially.

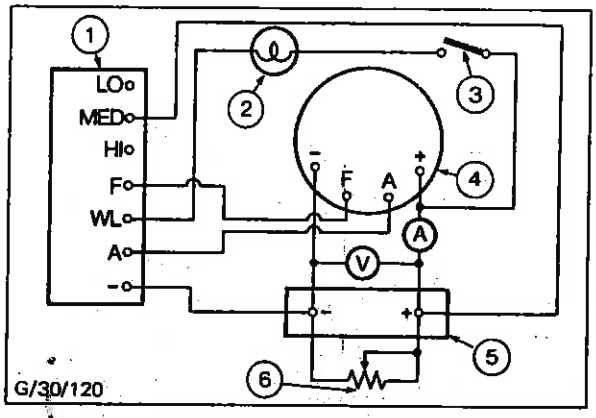


Fig. 82 - Alternator Test Circuit
1. Type 440 Regulator
2. Warning Lamp
3. ON/OFF Switch
4. AC5 Alternator
5. Battery
6. Variable Electrical Load

The adjustable load must be set so that the battery is sufficiently discharged to allow the alternator to develop its full output. If the battery is in a fully charged condition, the voltage regulator will automatically taper off the alternator output and prevent the following tests from being correctly carried out.

5. Close the warning lamp switch; the lamp should illuminate.

6. Start up the test machine and increase speed until the first current output speed shown in the table Fig. 81 is reached; compare the current output of the alternator with that given in the table. Check the alternator output at each of the other stated speeds against the figures shown in the table.

Some variation from the stated outputs is permissible but failure to reach within 10% of the required figures indicates a faulty alternator. Do not continue testing until the fault has been found and rectified.

DO NOT REMOVE ANY CONNECTIONS WHILE THE ALTERNATOR IS RUNNING.

Testing the Regulator

If required, the regulator associated with the alternator can be tested by substituting it for the test circuit regulator and proceeding as follows:

Set alternator speed to 3000 rpm and switch off loads connected across the battery. Depending on the connection selected for the positive sensing wire (LO, MED, HI) the voltage should rise to between 26V and 28V on 24 Volt system or 14V and 15V on 12V system and then remain constant. At the same time the current reading should drop appreciably.

This test indicates that the regulator is working correctly. With sensing wire connected to +Med and load adjusted to 15 ampere the voltage reading should be 27,25 to 27,75V on 24V system or 13,5 to 14V on 12V system. With sensing wire connected to +HI, the reading should be 1 volt up, and if connected to +LO, 1 volt down (0,5 volt on 12 volt models).

Alternatively the regulator can be tested independently of the alternator as follows:

Testing the Regulator Without an Alternator

Equipment Required

1. First grade moving coil 0 to 50V dc voltmeter or multi-test meter with 0 to 50V dc range.

2. Potentiometer, 2000 ohm 3W.

3. 12V 2,2W or 24V 2,8W test lamp as appropriate.

4. Diode, 50V 1A rating.

5. Single pole push switch.

6. 36V dry cell battery (4 type PP9 batteries are suitable).

7. 12V or 24V lead acid battery as appropriate.

Wire the regulator into the test circuit as shown in Fig. 83.

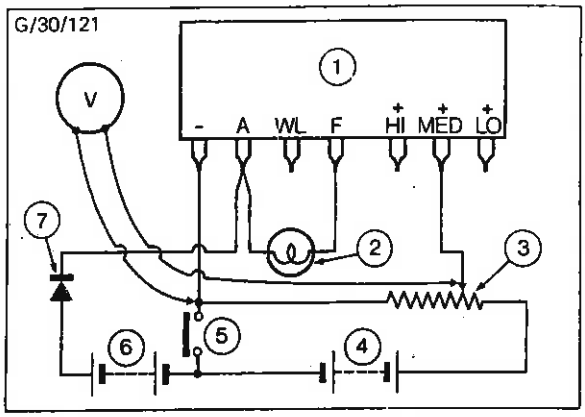


Fig. 83 - Regulator Test Circuit
1. Regulator Under Test
2. Warning Lamp
3. Potentiometer
4. 36V Dry Battery
5. Push Switch
6. Lead Acid Battery
7. Diode

The diode is included to prevent accidental reverse polarity connections which could damage the regulator. The diode must be connected as shown.

1. Operate the test switch and, if necessary, adjust the potentiometer until the bulb lights.

2. Adjust the potentiometer slowly until the bulb extinguishes and note the voltmeter reading; it should be within the voltage limits specified in the following table, (Fig. 84) if the regulator is operating correctly. This figure is the nominal voltage at which the regulator controls the alternator; this can be 0,5V higher when actually operating in a normal charging circuit.

Type of Regulator	Voltage at which Bulb Extinguishes
24V	27,3 to 27,7V
12V	13,55 to 13,95V

Fig. 84 - Regulator Control Voltages

3. If required, the regulator can be tested further by connecting the potentiometer lead to the '+HI' and then the '+LO' terminals. The voltages at which the lamp extinguishes should be as shown in the following table, Fig. 85.

DO NOT REMOVE ANY CONNECTIONS WHILE THE ALTERNATOR IS RUNNING.

Type of Regulator	'+HI' Connection	'+LO' Connection
24V	28,6 to 30V	26,3 to 26,7V
12V	14,05 to 14,45V	13,05 to 13,45V

Fig. 85 - +HI and +LO Regulator Control Voltages

SPECIFICATIONS

Nominal Voltage	12V	12V	24V	24V
Maximum Output (Hot)	55A	75A	30A	35A
No. of Rotor Poles	8	12	8	12
No. of Stator Slots	24	36	24	36
Rotor field coil resistance	3,1 to 3,3 ohm	3,1 to 3,3 ohm	9,4 to 9,8 ohm	10,1 to 10,7 ohm
Volt drop measured between any two stator leads	2V at 20A	1,5V at 20A	8V at 20A	7,8V at 20A
Maximum Speed	10,000 rpm			
Brush Spring Loading	227 gf (8 ozf)			
Min. Usuable Brush Length	8 mm (0,312 in)			
Slip Ring Minimum Diameter	28,85 mm (1,136 in)			
Maximum Ambient Operating Temperature	70°C (158°F)			
Cooling System	Built-in Fan			
Regulator	Remote mounted Type 440 (fully transistorised)			
Cutting-in Speed	Refer to Table, Fig. 54 and paragraphs 1 and 2 under the heading 'Performance Testing'.			

CAV TYPE AC5R ALTERNATOR

CONTENTS

CAV TYPE AC5R ALTERNATOR

DESCRIPTION

The AC5R alternator is very similar to the AC5 alternator in mechanical construction and in the way in which current is generated. The major difference is in the voltage regulator which is an integral part of the AC5R machine; it is mounted on the slip ring end shield as illustrated in Fig. 86. The regulator is of solid state circuitry throughout and is fully encapsulated for maximum protection; no adjustments are required and the unit must be renewed if found to be faulty.

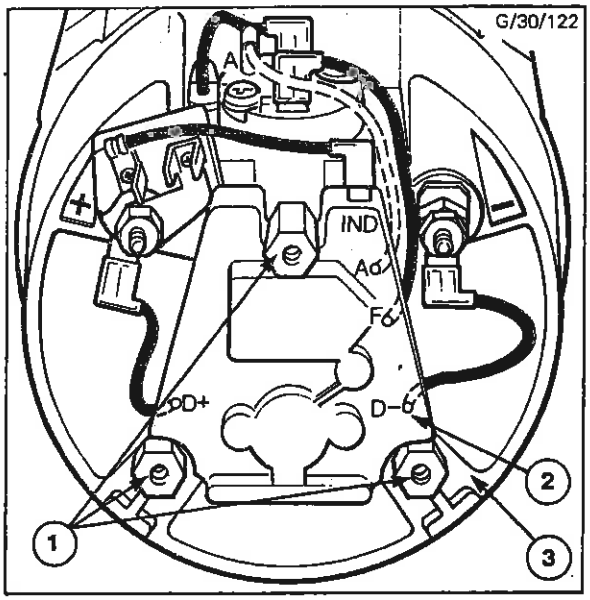


Fig. 86 - Slip Ring End Shield and Regulator
1. Regulator Securing Pillars
2. Regulator
3. End Shield

Both 12V and 24V versions of the AC5R alternator are available.

PRELIMINARY TESTING

Since the alternator and regulator are an integrated unit, it is essential to establish whether the alternator or regulator is faulty before servicing the alternator.

1. Remove all surface dirt and grease with a rag or brush moistened with paraffin or other suitable cleaning fluid. Avoid excess liquid entering the alternator through gaps in the casing.

2. Remove the three screws and washers and detach the cover.

3. Disconnect the 'F' lead from the alternator brush box terminal.

4. Connect a test link between the brush box 'F' terminal and the alternator main '-ve' terminal - see Fig. 87.

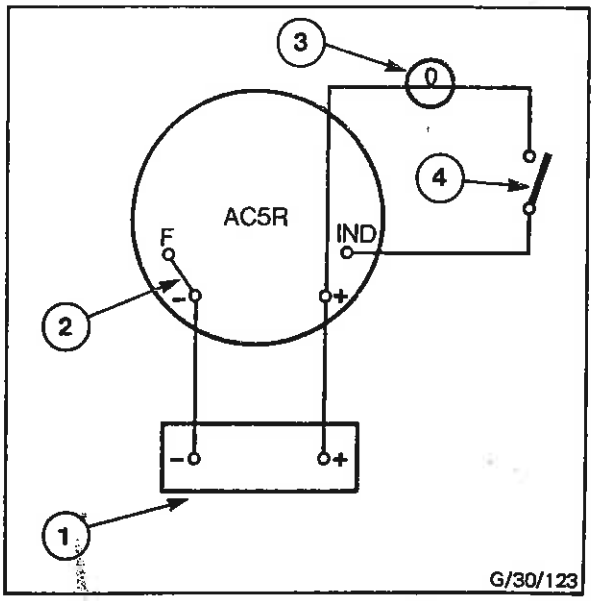


Fig. 87 - Preliminary Testing
1. 12V or 24V Battery
2. Test Link
3. 2W Minimum Warning Lamp (12V or 24V)
4. Switch

5. As shown in Fig. 87, wire the alternator to a 12V or 24V battery as appropriate and connect a 12V or 24V 2W minimum warning lamp and switch between the alternator main '+ve' terminal and the alternator 'IND' terminal.

NOTE: Check that the lamp and switch function correctly before wiring them into the circuit.

6. Close the switch and watch the lamp. If the lamp lights, the regulator is faulty; if the lamp does not light, the alternator is faulty.

DISMANTLING

1. Remove all surface dirt and grease with a rag or brush dipped in paraffin or other suitable cleaning fluid. Avoid excess liquid entering the alternator through gaps in the casing.

2. Remove the three screws and washers and detach the cover.

3. Make a written note of all regulator electrical connections in order to facilitate assembly at a later stage.

4. Unscrew and remove the three pillars (1) with their spring and plain washers and detach the regulator (2) from the slip ring end shield - see Fig. 86.

5. If the alternator is faulty, refer to the AC5 alternator instructions for the correct inspection and dismantling procedures.

TESTING THE REGULATOR

Equipment Required

1. Voltmeter or multi-test meter with a range of 0-30V.

2. 200 ohm 10W resistor.

3. 400 ohm 10W variable resistor.

4. 2W minimum test lamp (12V or 24V as appropriate).

5. Single pole ON/OFF switch.

6. 12V or 24V battery to suit alternator output voltage.

7. 6V battery for 12V alternator or 12V battery for 24V alternator.

NOTE: One or both batteries can be of the dry cell type as the current drawn during testing is very small.

Test Procedure

1. Thoroughly clean the regulator and 'Lucar' connections, then examine regulator visually for signs of cracking or other forms of damage. If the regulator is damaged, it must be discarded.

2. Wire the regulator test circuit as shown in Fig. 88.

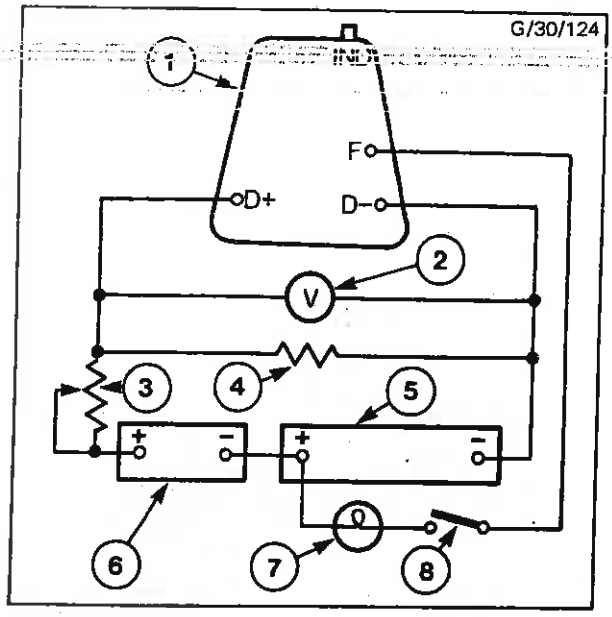


Fig. 88 - Regulator Test Circuit
1. Regulator
2. Voltmeter 0 to 30V
3. 400 ohm 10W Variable Resistor
4. 200 ohm 10W Resistor
5. 12V or 24V Battery to Suit Alternator Output Voltage
6. Additional Battery (6V for 12V Alternator or 12V for 24V Alternator)
7. 2W Minimum Warning Lamp (12V or 24V)
8. Single Pole ON/OFF Switch

3. Close the switch; if the lamp does not light, the regulator is faulty and must be discarded.

4. With switch closed and lamp illuminated, adjust the variable resistor to increase the voltage reading on the voltmeter; the lamp should go out when 13,75V is indicated in the case of a 12V alternator or 28,5V for 24V alternators.

If the lamp remains illuminated, discard the regulator and replace it with a new unit.

ASSEMBLY

Before fitting the regulator, the alternator should be tested for insulation and field coil continuity, as under heading 'Static Testing' in the AC5 alternator servicing instructions.

1. Position the regulator (1) on the slip ring end shield (2) the correct way round as shown in Fig. 89 and secure with the three pillars (3) and spring and plain washers. Tighten pillars to 1,7 to 2,3 Nm (0,17 to 0,23 kgf m or 15 to 20 lbf in).

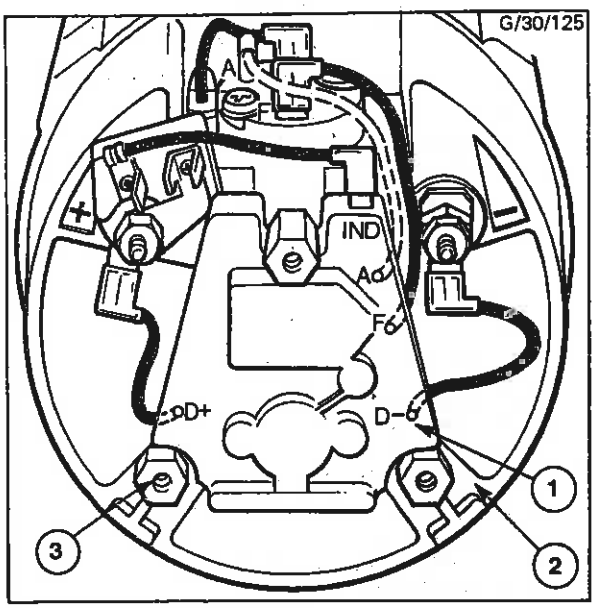


Fig. 89 - Replacing the Regulator
1. Regulator
2. End Shield
3. Regulator Securing Pillars

2. Refer to the notes made when dismantling and connect the leads to the correct terminals. The following table gives the connections but the 'A' lead is not present on all regulators.

Regulator Lead 'D+' to Alternator Main '+ve' Terminal

Regulator Lead 'D-' to Alternator Main '-ve' Terminal

Regulator Lead 'F' to Brush Box Terminal 'F'

Regulator Lead 'A' to Brush Box Terminal 'A'

Alternator 'IND' Lead to Regulator 'IND' Terminal

3. Fit cover and secure with the three screws and washers. Tighten screws to 1,4 to 1,7 Nm (0,14 to 0,17 kgf m or 12 to 15 lbf in).

TESTING THE ALTERNATOR

Equipment Required

1. Test machine with variable speed control capable or driving the alternator at speeds up to 6000 rpm.

2. Fully charged 12V or 24V battery as appropriate.

3. Carbon pile or similar variable electrical load capable of carrying a current of 60 ampere at 12V or 36 ampere at 24V.

4. 2W minimum warning lamp (12V or 24V as appropriate).

5. British Standard first grade moving coil dc voltmeter with a range of 0-50 volt.

6. British Standard first grade moving coil dc ammeter with a range of 0-100 ampere.

7. Single pole ON/OFF switch.

Test Procedure

1. Mount the alternator (with integral regulator correctly installed and connected) on the test machine and connect the test equipment as shown in Fig. 90; the switch should be open initially.

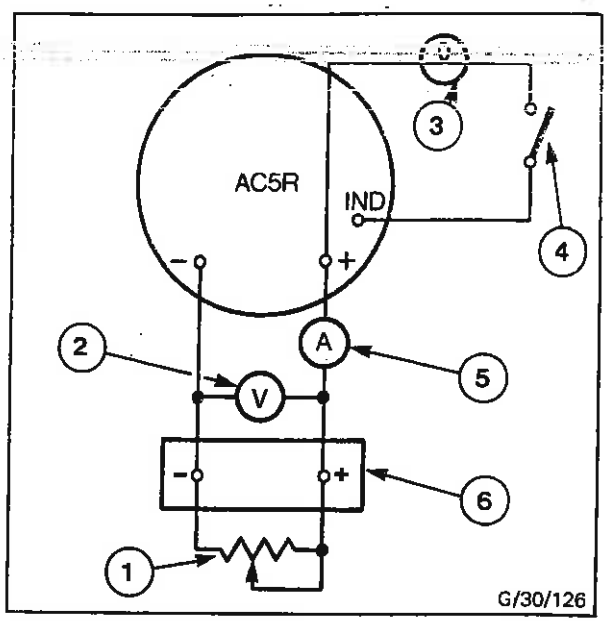


Fig. 90 - Alternator Test Circuit
1. Variable Electrical Load
2. Voltmeter
3. 2W Minimum Warning Lamp (12V or 24V)
4. Single Pole ON/OFF Switch
5. Ammeter
6. 12V or 24V Battery

The adjustable load must be set so that the battery is sufficiently discharged to allow the alternator to develop its full output. If the battery is in a fully charged condition, the voltage regulator will automatically taper off the alternator output and prevent the following tests from being correctly carried out.

2. Close the warning lamp switch; the lamp should illuminate.

3. Start up the test machine and increase speed until the first current output speed shown in the following table is reached; compare the current output of the alternator with that given in the table. Check the alternator output as each of the other stated speeds against the figures shown in the following table.

Type of Alternator	Cutting-in Speed	Current Output at 2000 rpm	Current Output at 3000 rpm	Current Output at 4000 rpm
12V	1000 rpm at 14V	41A	53A	58A
24V	1050 rpm at 28V	23A	30A	34A

Some variation from the stated outputs is permissible but failure to reach within 10% of the required figures indicates a faulty alternator. Do not continue testing until the fault has been found and rectified.

DO NOT REMOVE ANY CONNECTIONS WHILE THE ALTERNATOR IS RUNNING.