SECTION M

ELECTRICAL EQUIPMENT

ILLUSTRATIONS

Illustrations - Continued

313

M.1. - GENERAL DESCRIPTION

All wiring diagrams and diagnosis charts will be found at the end of this Section.

The electrical system is a 12-volt earth return type employing either POSITIVE or NEGATIVE earth polarity. The system incorporates the charging, lighting, starter, ignition and auxiliary circuits, operating through a fuse mounted on the vehicle's bulkhead. The charging circuit employs a D.C. Generator. An A.C. Alternator is available from Lotus Cars (Service) Limited.

Negative earth polarity was introduced at Chassis No. 7895 (at commencement of Series 4 cars).

Polarity

Extreme care must be exercised when fitting service replacements to ensure that they suit the vehicle's earth polarity.

Certain units are interchangeable or adaptable for use with either earth polarity, but others fitted with electronic devices would become irreparably damaged if connected to an opposite polarity. The effects of polarity on the units are summarised as follows:-

Batteries, Ignition Coils, Ammeters:

These are suitable for both positive and negative earth systems provided they are connected to suit the vehicle's earth polarity.

Control Boxes:

These are suitable for both positive and negative earth systems, and if connected into a system with an opposite polarity, will automatically repolarize themselves, provided that the cables to the 'D' and 'F' positions are correctly connected.

D.C. Generators (Dynamos):

These are suitable for both positive and negative earth systems, provided they are repolarized after fitting.

Radios:

These are designed for one or other polarity and reversed connections will destroy the transistors. However, it is possible for a competent radio engineer to alter the internal connections to suit an opposite polarity.

Electric Clocks, Tachometers and Alternators:

These are designed for one or other polarity and cannot be adapted to suit an opposite polarity. Incorrect connections will render the instrument useless.

Servicing Equipment

It is important to note that the servicing of the system cannot be carried out satisfactorily unless the equipment recommended is available. Further, it will be seen that special equipment is needed for dismantling and re-assembling some units of the system, and should this equipment not be available, dismantling must not be attempted.

We recommend the Avometer 'Model 12' testing equipment (obtainable from Avo Ltd., 92-96 Vauxhall Bridge Road, London S.W.1, England), or the Wilkson 'WIL/25 Mk.1' two meter set (obtainable from J. Wilkes & Son (Electrical) Ltd., Bredon, Tewkesbury, Gloucester, England), both of which have been specially designed for automotive use and enables a wide range of checking operations to be carried out.

An instrument for testing the car instruments 'in situ' is available under Part No. 36 M 6183.

M.2. - BATTERY.

Description

The battery features a 'clean-top' design with a one-piece manifold venting system. The terminal posts are the flat type drilled to accomodate the bolts passing through the cable connectors.

The battery is mounted in the boot (trunk) and held in position by a clamp.

Batteries are supplied either filled and charged or 'dry-charged', that is with the cells in a charged condition and without electrolyte. Details of preparing 'dry-charged' batteries are given in later paragraphs.

Maintenance

Battery maintenance consists mainly of regular inspection and servicing.

1. Keep the battery and its surroundings clean and dry. Give particular attention to the top of the battery to prevent electrical leakage between the terminals.
2. Remove the manifold vent cover, and see that the vent holes are clear.
3. Check the electrolyte level and top up, when necessary. The correct level is just up to the perforated splashguard. Do not over-fill or acid will escape through the vent holes with detrimental effect to the connections and adjacent parts of the car. The use of a Lucas Battery Filler (or similar) will be found helpful in this topping-up process, as it ensures that the correct electrolyte level is automatically obtained and also prevents distilled water from being spilled over the top of the battery. Distilled water should always be used for topping-up. In an emergency, however,

drinking water or clean rain water may be used. The following waters must not be used:-

Salt water, chlorinated water, chemically softened water or stagnant water. Never use a naked light when examining a battery, as the mixture of oxygen and hydrogen given off by the battery when on charge, and to a lesser extent when standing idle, can be dangerously explosive.

If a battery is found to need an excessive amount of topping-up, the cause should be sought. If an excessive charge is suspected, check the regulator setting. If one cell in particular is at fault, examine the container for cracks. NEVER transfer electrolyte from one cell to another.

4. When fitting the connectors to the battery, first smear the terminal posts with petroleum jelly or silicone grease.

5. Examine the earth connection to ensure that it is clean and free from rust or corrosion.

6. Specific Gravity Test.

Measure the specific gravity of the electrolyte in each cell in turn, with a hydrometer. The reading given by each cell should be approximately the same; if one cell differs from the other by more than .040, an internal fault in the cell is indicated. If the level of the electrolyte is so low that a hydrometer reading cannot be taken, the battery should be topped-up with distilled water and recharged. No attempt should be made to take a reading after adding the distilled water until the battery has been on charge for at least thirty minutes. NEVER transfer the electrolyte from one cell to another. The appearance of the electrolyte drawn into the hydrometer when taking a reading gives a useful indication of the state of plates; if it is very dirty or contains small particles in suspension, it is possible

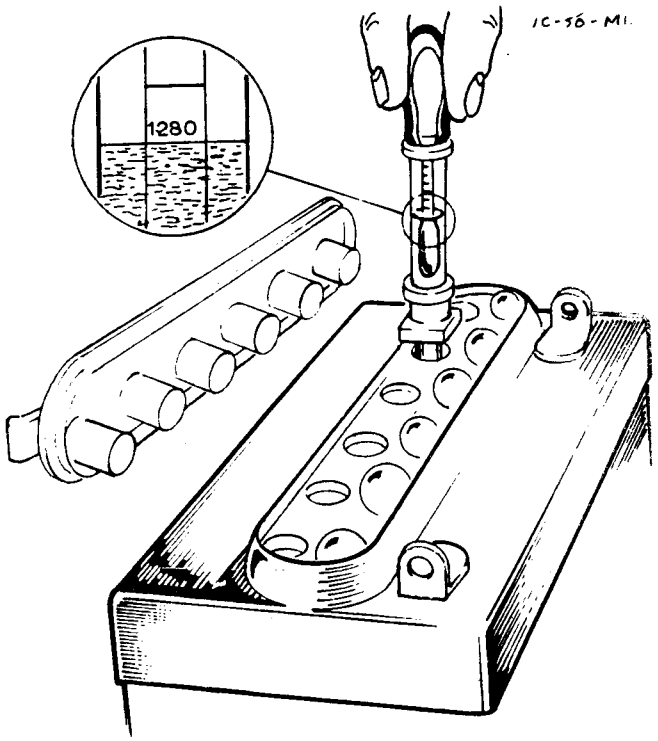


Fig. 1. SPECIFIC GRAVITY TEST

that the plates are in a bad condition.

Check the specific gravity of the electrolyte (see Fig.1) as an indication of the state of charge of the battery, using a hydrometer.

The specific gravities and their indications are as follows:

Climatic temperature of 15°C.

Fully charged	1.280
25% discharged	1.240
50% discharged	1.200
75% discharged	1.160
Fully discharged	1.120 and below

The specific gravity reading varies with the temperature of the acid electrolyte and it is customary to correct it to the corresponding value at a standard temperature of 15°C as follows:-

For each 10°C. above 15°C. add .007 to the reading.

For each 10°C. below 15°C. subtract .007 from the reading.

If the car is out of use for any length of time the battery should not be allowed to run down or to remain in a discharged condition. It should be recharged about every 2 weeks from an independent electrical supply.

7. Heavy Discharge Test

No attempt should be made to carry out a heavy discharge test on this type of battery. The specific gravity test described in the foregoing paragraphs will provide a clear indication of the condition of the battery, provided the test has been carried out correctly. If any doubt remains, the battery should be checked by the nearest Exide agent.

Remember that if the battery is subjected to heavy loads (i.e. long periods of night parking with lights on) without suitable opportunities for recharging, a low state of charge is only to be expected. A fault in the charging system or neglect during a period out of commission may also be responsible for any trouble.

Acid spillage or creepage can be neutralised by wiping the affected area with a fluffless cloth moistened with a dilute alkaline solution such as ammonia.

Recharging from an External Supply

If tests indicate that the battery is discharged, but is otherwise in good condition, it should be recharged either on the vehicle by a period of daytime running or on the bench from an external supply.

If the latter, the battery should be charged until the specific gravity and voltage show no increase over three successive hourly readings. During the charge the electrolyte must be kept level with the top of the separator guard by the addition of distilled water.

A battery in which all cells show a general falling off in efficiency will often respond to the process known as 'cycling'. This process consists of fully charging the battery as described earlier, and then discharging it by connecting to a lamp board, or other load, at the same rate.

Preparing New Batteries

Batteries are normally supplied 'dry-charged' and before fitting to the car must be filled with acid as described under 'Filling the Cells'. No initial charging is necessary, although, if time permits, a short freshening charge is advantageous.

Preparation of Electrolyte

Electrolyte of the specific gravity stated in the following table is prepared by mixing distilled water and concentrated sulphuric acid, usually of 1.840 specific gravity.

The mixing must be carried out either in a lead-lined tank or in suitable glass or earthenware vessels. Slowly add the acid to the water, stirring with a glass rod. Never add the water to the acid as the resulting chemical reaction causes violent and dangerous spurting of the concentrated acid. The approximate proportions of acid and water are indicated in the following table:-

Climates normally below 27°C. (80° F.):

Add one part (by volume) of acid of 1.840 specific gravity to 3.2 parts (by volume) of pure distilled water to obtain a final specific gravity of 1.260 at 15.5°C. acid temperature.

Climates normally above 27°C. (80°F.):

Add one part (by volume) of acid of 1.840 specific gravity to 4.3 parts (by volume) of pure distilled water to obtain a final specific gravity of 1.210 at 15.5°C. acid temperature.

Heat is produced by the mixture of acid and water, and the electrolyte should be allowed to cool before taking hydrometer readings - unless a thermometer is used to measure the actual temperature, and a correction applied to the reading as previously described - and before pouring the electrolyte into the battery.

Filling the Cells.

Whilst these batteries leave the factory in the fully 'dry-charged' condition, they may slowly lose some charge in storage. In view of this, the following filling instructions must

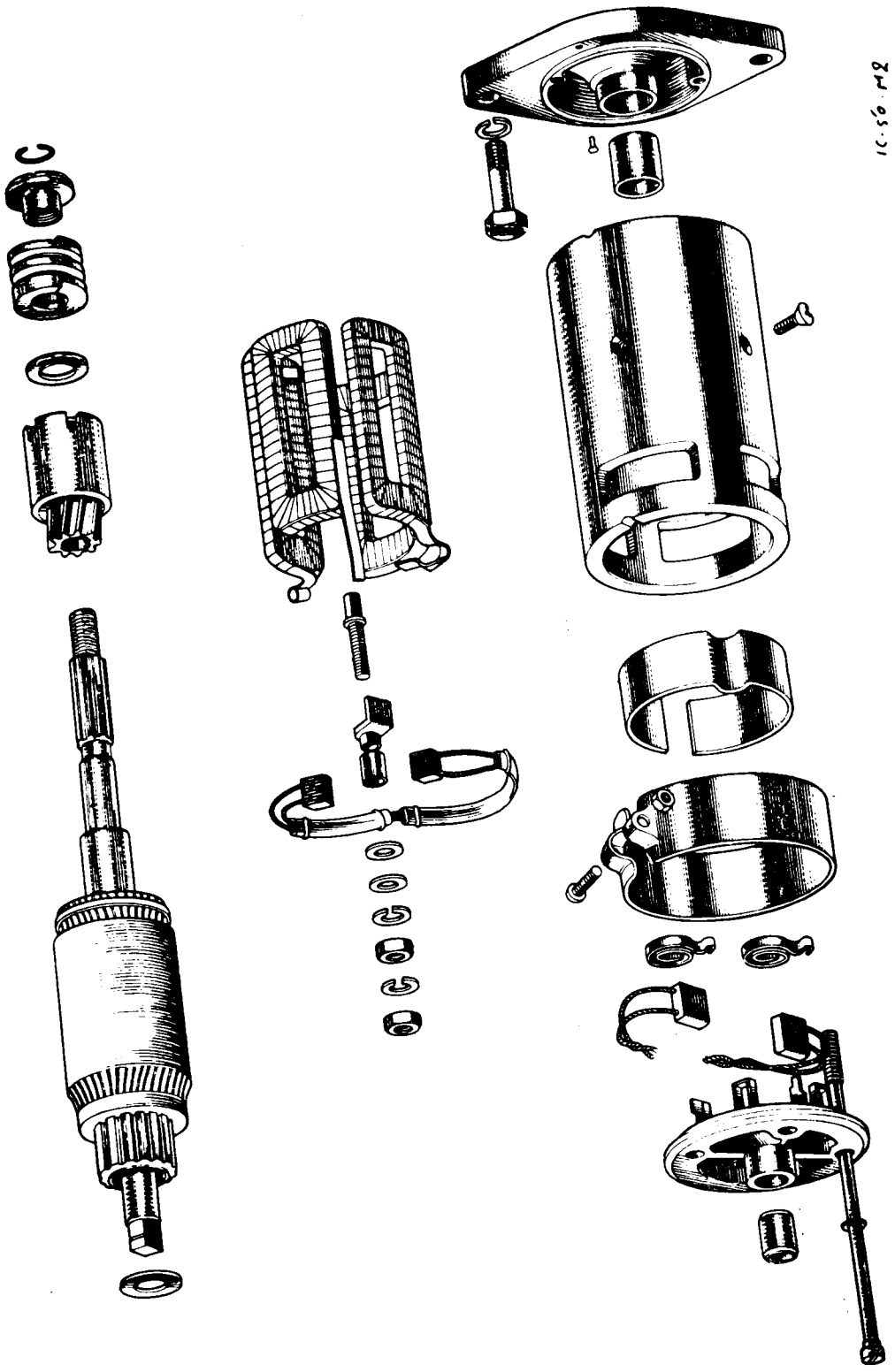


Fig. 2. STARTER MOTOR COMPONENTS - TYPE M35G

be carefully observed:-

With the acid, battery and room temperature between 15.5 - 37.7°C. remove the vent cover or plugs and fill (in one operation) each cell to the separator guard.

Measure the temperature and specific gravity of the electrolyte in each of the cells. Allow to stand for 20 minutes and then re-check the specific gravity and temperature of the electrolyte in each cell.

The battery is then ready for service, unless the above checks show the electrolyte temperature to have risen by more than 5.5°C. or the specific gravity to have fallen by more than 10 'points' (.010 S.G.).

In this event, it will be necessary to re-charge the battery at the appropriate re-charge rate until the specific gravity values remain constant for three successive hourly readings and all cells are gassing freely.

During charging, keep the electrolyte in each cell level with the separator guard by adding distilled water - not acid.

M.3. - STARTER MOTOR (Type 'M.35G').

Description

The starter motor is a four-pole, four-brush machine having an extended shaft which carries the starter drive.

To Remove

1. Disconnect the battery.
2. Remove the cable to starter solenoid.
3. Remove the setscrews securing the starter motor to the engine.

To Replace

1. Reverse the removal procedure.

Maintenance

The following checking procedure should be carried out periodically whilst the starter motor is in service.

1. Remove the metal band cover and blow out any dust or sediment with clean compressed air.
2. Remove any dirt which may remain on the brushgear, by applying a petrol-moistened cloth.
3. Polish the commutator with a dry fluffless cloth and refit the metal band cover.
4. Keep all electrical connections clean and tight. Any which may have become dirty must be cleaned and the contacting surfaces smeared with petroleum jelly or silicone grease.

Testing the Starter Motor

Preliminary Checks on Car.

1. If the starter motor is heard to operate but does not crank the engine, the starter pinion assembly is seized or damaged.
2. Switch on the headlamps and operate the starter control. If the lights become dim, and the starter motor is not heard to operate, the armature is taking current but is not rotating because of a seizure or the pinion being meshed with the flywheel.
3. If the headlamps retain their full brilliance when the starter control is operated, a fault exists in the starter circuit or switch.
4. If the starter motor operates but is sluggish, a fault exists in the battery or cable connections, or the engine may be partially seized.

Starter Cranking Circuit Test.

The most convenient method of testing the circuit is by taking voltage drop readings, using a low range voltmeter. This procedure will locate any excessive resistance due to poor connections or bad cables, which would prevent the delivery of the normal amount of current to the starter motor.

For the purpose of the test, it will be necessary to disconnect the contact breaker lead from the ignition coil to prevent the engine starting. Before carrying out the test, ensure that the battery is in good condition and fully charged.

Voltage Drop Readings:

1. Using a low range voltmeter, connect the negative lead of the voltmeter to the starter terminal and the positive lead to the positive terminal of the battery. Operate the starter switch and note the voltmeter reading.
2. Connect the positive lead of the voltmeter to the starter commutator end bracket and the negative lead to the negative terminal of the battery. Operate the starter switch and again note the voltmeter reading.

The sum of these two readings must not exceed .5 volt.

An unduly high reading means that there is excessive resistance in the starter circuit, in which event each part of the circuit should be checked in turn with particular attention to the solenoid switch connections and all earth connections including the engine bonding strip.

On completion of the test, restore the original ignition connections.

Starter Cranking Voltage Test.

This test should be made after any defects previously located have been corrected. It is a valuable test because it gives an indication of the power absorbed in the starter, and also determines whether sufficient voltage is available to operate the ignition system when the starter motor is in operation.

1. Disconnect the contact breaker lead from the ignition coil to prevent the engine starting.
2. Using a zero to 20 range voltmeter, connect the positive lead of the voltmeter to the starter main terminal and the negative lead to an earth point on the starter mounting bracket.
3. Close the starter switch to crank the engine for a few seconds, and note the voltmeter reading.

The starter motor should crank the engine at a good rate of speed, and the voltage reading should not be less than 9.5 volts. On completion of the test, restore the original ignition connections.

Measuring Light Running Current (on bench).

Secure the starter motor in a vice, then connect the motor in series with a starter switch, a zero to 800 range ammeter, and a 12-volt battery in good condition and fully charged.

Use heavy duty starter cable in the circuit and utilise a fixing lug on the starter motor as an earthing point. Operate the switch and note the reading on the ammeter. The motor should run at a high speed and the light running current should be 45 amperes.

Servicing the Starter Motor

Dismantling

1. Remove the metal band cover, hold back the brush springs and lift the brushes from their holders.
2. Remove the nuts from the terminal post which protrudes from the commutator end bracket.
3. Unscrew the two through bolts from the commutator end bracket and remove the commutator end bracket from the yoke.
4. Remove the driving end bracket with armature and drive from the yoke.
5. If it is necessary to remove the drive end bracket from the armature, it can be slid off after the drive has been dismantled.

Brushgear

Check that the brushes move freely in their holders by holding back the brush springs and pulling gently on the flexible connectors. If movement is sluggish remove the brush from its holder and clean its sides with a fluffless petrol-moistened cloth. Replace the brush in its original position. Brushes which are worn to .3125 in. (8 mm.) in length must be renewed. The brushes are pre-formed so that bedding to the commutator is unnecessary. Check the tension of the brush springs by means of a spring scale. The correct tension is given in 'Technical Data'. New springs must be fitted if the tension is low. Check the tension of any new spring and ensure that it makes contact with the centre of the brush top.

Commutator

A commutator in good condition will be smooth and free from pits and burned spots. Clean the commutator with a petrol-moistened cloth. If this is ineffective, carefully polish with a strip of fine emery paper, while rotating the armature.

To remedy a badly worn commutator, dismantle the starter drive as described in later paragraphs and remove the armature from the end bracket. Mount the armature in a lathe, rotate at high speed and take a light cut with a very sharp tool. Do not remove any more metal than is necessary. Finally polish with very fine emery paper.

The insulators between the commutator segments must not be undercut.

Armature

An armature can be tested for open circuits, short circuits, and earthed circuits, by following the procedure described in earlier paragraphs for the generator.

Before carrying out the tests, check for lifted commutator segments and loose turns in the armature winding.

These may be due to the starter motor having remained engaged while the engine was running, thus causing the armature to be rotated at excessive speed.

A damaged armature must always be renewed. No attempt should be made to machine the armature core or to true a distorted armature shaft. An indication of a bent shaft or a loose pole shoe may be given by scored armature laminations.

Field Coils

Continuity Test:

If the lamp fails to light in the following test, an open circuit in the field coils is indicated and the defective coils must be renewed.

1. Connect a 12-volt battery and bulb in series with two pointed test prods.

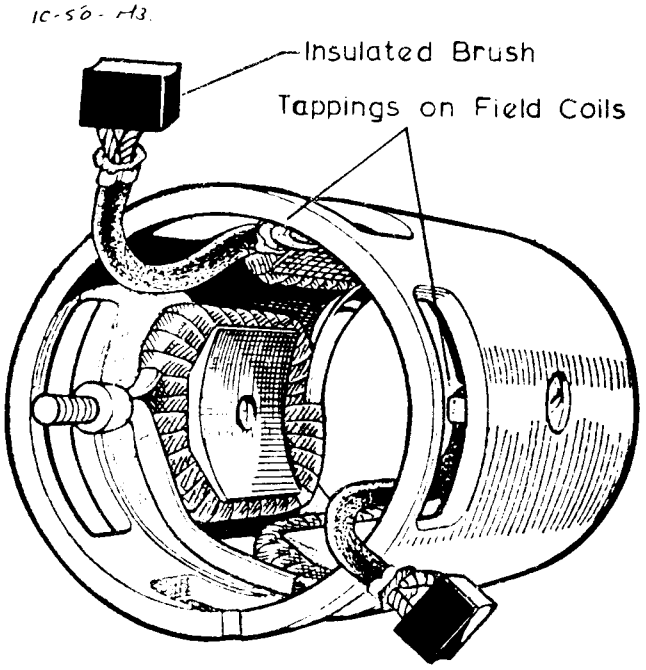


Fig. 3. INSULATED BRUSH CONNECTIONS TO FIELD COIL TAPPINGS - M35G

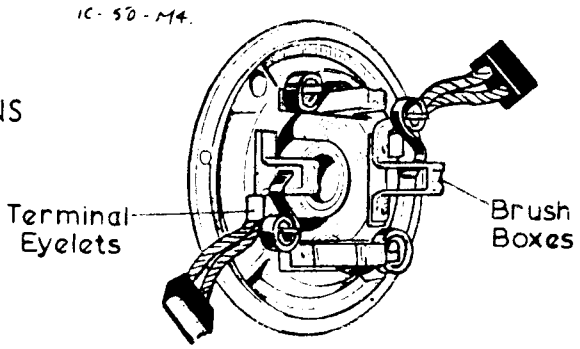


Fig. 4. COMMUTATOR END BRACKET - M35G

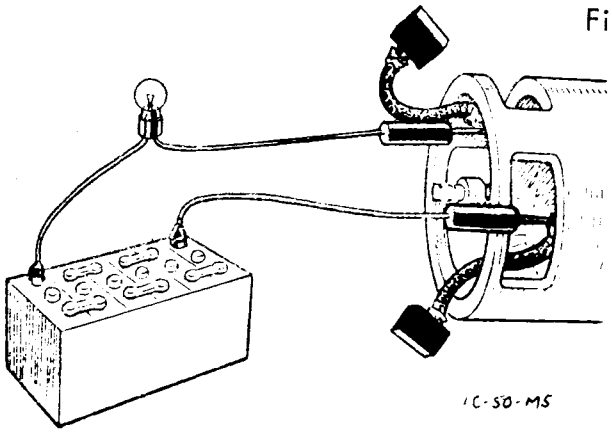


Fig. 5. FIELD COIL CONTINUITY TEST -M35G

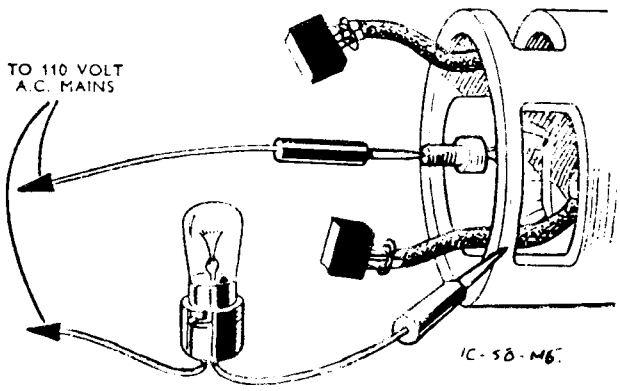


Fig. 6. FIELD COIL INSULATION TEST - M35G

2. When the prods are placed on the brush tappings, the bulb should illuminate. Lighting of the lamp does not necessarily indicate that the field coils are in order. It is possible that a field coil may be earthed to a pole-shoe or to the yoke.

Insulation Test:

Connect a 110 volt A.C. test lamp between the terminal post and a clean part of the yoke. Lighting of the lamp indicates that the field coils are earthed to the yoke and must be renewed.

Renewing the Field Coils:

This operation should be carried out with the aid of a pole-shoe screwdriver as illustrated in Fig.24.

1. Using a pole-shoe screwdriver, unscrew the four pole-shoe retaining screws.
2. Remove the insulation piece which is fitted to prevent the intercoil connectors from contacting the yoke.
3. Mark the yoke and pole-shoes in order that they may be refitted in their original positions.
4. Draw the pole-shoes and coils out of the yoke and lift off the coils.
5. Fit the new field coils over the pole-shoes and place them in position inside the yoke. Ensure that the taping of the field coils is not trapped between the pole-shoes and the yoke.
6. Locate the pole-shoes and field coils by lightly tightening the fixing screws.
7. Refit the insulation piece between the field coil connections and the yoke.
8. Finally, tighten the screws, by means of the pole-shoe screwdriver.

Bearings

Bearings which are worn to such an extent that they will allow excessive side play of the armature shaft must be renewed. To renew the bearing bushes proceed as follows:

1. Press the bearing bush out of the end bracket.
2. Press the new bearing bush into the end bracket, using a shouldered highly-polished mandrel of the same diameter as the shaft which is to fit into the bearing. Porous bronze bushes must not be enlarged after fitting, or the porosity of the bush may be impaired.

Before fitting a new porous bronze bearing bush, it should be completely immersed for 24 hours in clean engine oil. On occasions of urgency, this period may be shortened by heating the oil to 100°C. (212°F.) when the time of immersion may be reduced to

2 hours. The oil must be allowed to cool before removing the bearing from the oil.

M.4. - STARTER MOTOR (Type 'M.35J')

Description

This type of starter motor is a four-pole, four-brush machine with inertia drive. It incorporates the following design changes over the previous type.

A 29-slot armature with face type moulded commutator. A continuously wound, field winding made of aluminium, earthed at the drive end, either by a flexible copper connection soldered into a recess in the yoke assembly, or by a rivetted eyelet, and at the commutator end terminating with a pair of brushes.

A fully insulated brushgear assembly comprising wedge shaped brushes carried parallel to the armature shaft. These brushes are spring-loaded by means of captive coil springs, and are assembled into an asbestos filled bakelite moulding rivetted to the commutator end bracket. The brushes are of assymetric shape to prevent reverse assembly.

Through bolts are eliminated with this arrangement, as both end brackets are fixed independently. On earlier models the drive end bracket is secured by threaded studs welded into the front face of two opposite pole shoes. These studs pass through the bracket, which is secured by means of nuts and spring washers. Later models have drilled and tapped holes in the front face of two opposite pole shoes. The drive end bracket is secured by means of two bolts passing through the bracket and into the tapped holes.

The drive is of the 'SB' design, comprising, pinion carried on a barrel type assembly which is mounted on a screwed sleeve. The sleeve is carried on splines on the armature shaft and is arranged to move along the shaft against a compression spring so as to reduce the shock loading at the moment of engagement.

To Remove and Replace

This is as given in Section 'M.3'.

Maintenance

Routine maintenance is not necessary, but the tightness of the terminal connection should be checked occasionally. The motor should be dismantled for detailed examination during major engine overhauls and the brushes and the bearing bushes should be renewed.

Testing the Starter Motor

Testing in Position

Check that the battery is in a good state of charge, and that the wiring between the battery, starting motor and operating switch is free from excessive volt drops.

If the motor fails to crank the engine after carrying out these checks, it must be

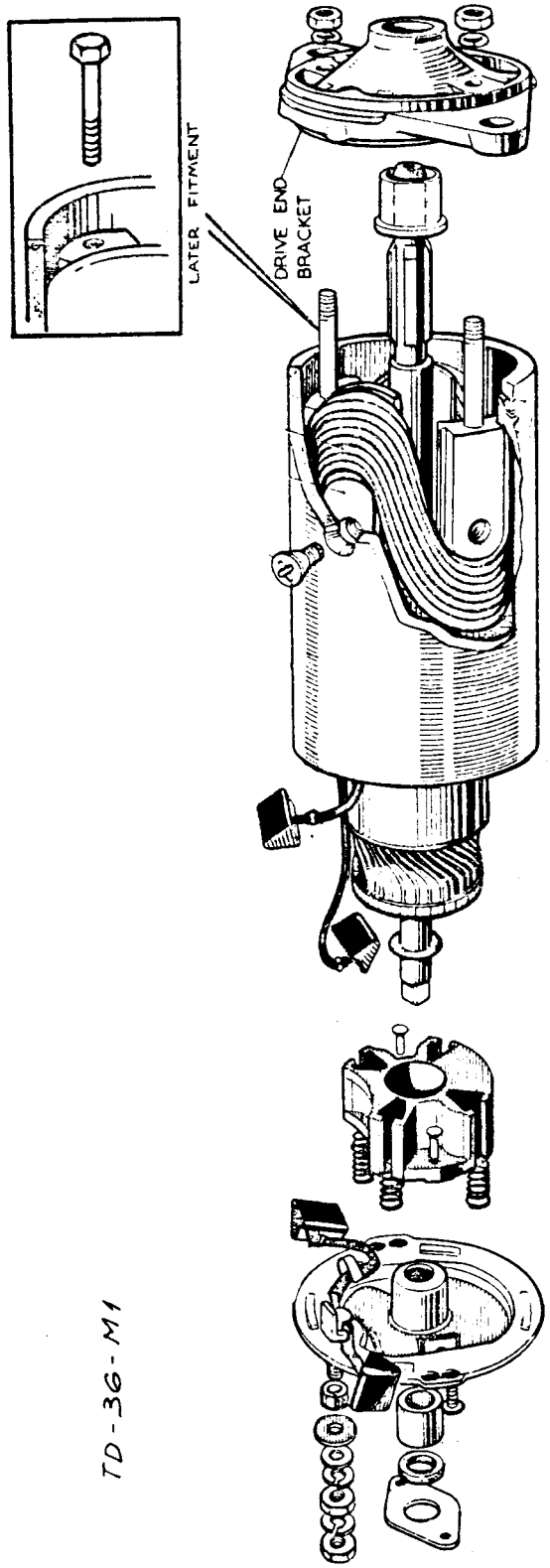


Fig. 7. STARTER MOTOR COMPONENTS - TYPE M35J

removed from the vehicle for detailed examination.

Bench Testing

Disconnect the battery earth cable, and starter cable and remove the starting motor from the engine.

Measuring Light Running Current

Clamp the motor in a vice, and, using a 12 volt battery and a moving coil ammeter of suitable range, check the light running current and the armature speed. Always use heavy gauge cable for connecting the apparatus.

Under these light load conditions, the starting motor should run freely and the output should be as shown in the Technical Data.

Measuring Lock Torque and Current

Carry out a lock torque test (if possible) and compare the readings with the values given in the Technical Data.

If the motor does not operate, or readings are substantially lower during these tests, the motor probably has an internal fault.

Checking Brushgear and Commutator

Before dismantling the starting motor completely, the commutator end bracket should be removed for inspection of the brushgear and commutator.

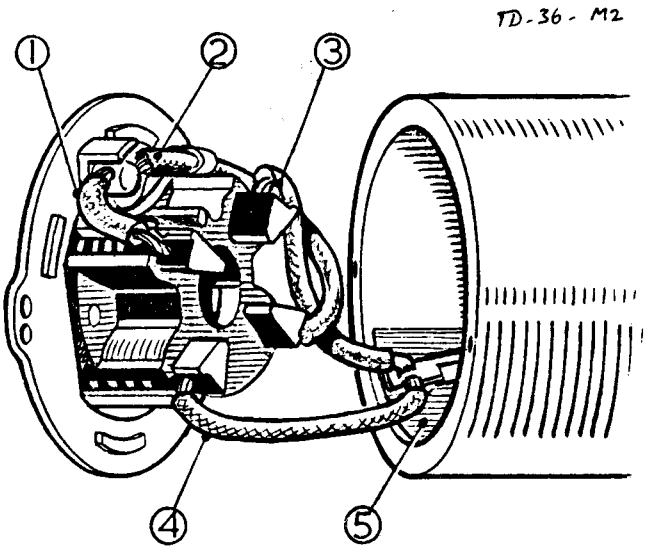
Brushgear

Check that the brushes move freely in their respective guides in the brush box moulding. A sticking brush can be cleaned with a petrol-moistened cloth. Brushes that are worn to approximately .375 in. (9.53 mm.) must be renewed as a set. See Fig. 8.

To replace worn brushes fitted to the main terminal post, remove the terminal from the end bracket and secure in a vice. Cut a 'V' groove into the end of the terminal post and remove the old brush flexibles. The new brush flexibles can now be fitted into the 'V' groove and soldered in to ensure a good electrical connection.

The other two brushes are hot pressed on the free end of the field winding. To replace these, cut off the flexible connectors .25 in. (6.35 mm.) from the hot pressed joint and solder the flexibles of the new brushes in their place. Ensure that after soldering the flexibles are insulated as near to the joint as possible.

The brush springs should be checked for correct tension by means of a push type spring balance. The minimum permissible pressure when the top of a new brush is pressed down its guide to within .063 in. (1.60 mm.) of the brush box shoulder (see Fig. 9) is 28 Ozf (.80 Kgf). If the spring pressures are appreciably lower, the end bracket should be



1. SHORT BRUSH FLEXIBLE C/E BRACKET
2. LONG BRUSH FLEXIBLE " "
3. LONG BRUSH FLEXIBLE FIELD WINDING
4. SHORT BRUSH FLEXIBLE " "
5. YOKE INSULATION PIECE

Fig. 8. POSITION OF BRUSHES

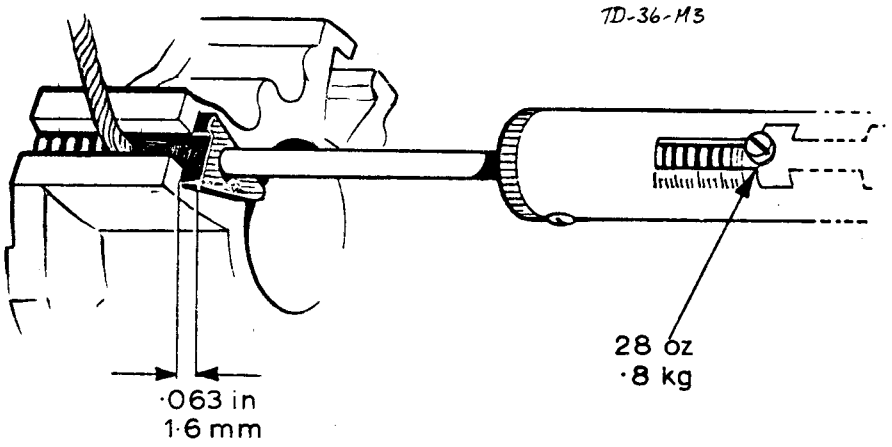


Fig. 9. BRUSH SPRING PRESSURE