STARTING MOTOR MODEL M50
WITH ACTUATING SOLENOID MODEL 14S AND ROLLER CLUTCH DRIVE MODEL 9SD

1. DESCRIPTION

(a) Two-stage Switching

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

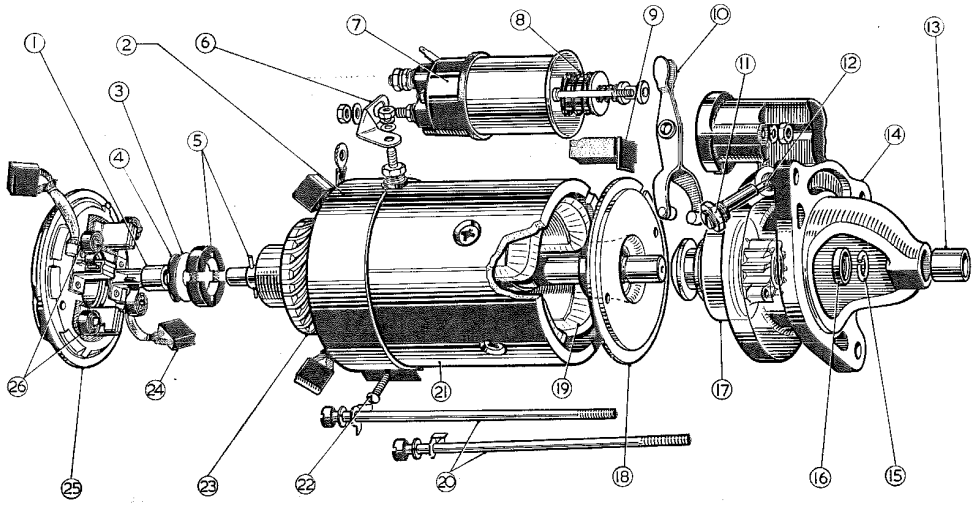


Fig. 1 Pre-engaged starting motor Model M 50 with 14S solenoid

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

*Listed spare parts.

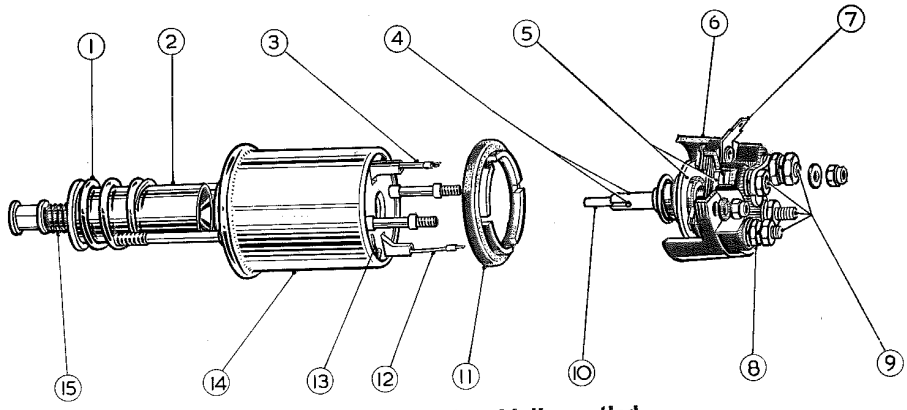


Fig. 2 14S solenoid dismantled

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

*Listed spare parts. Items 2 and 15; 4, 5, 9 and 10; 6 and 7, obtainable only as complete assemblies.

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

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

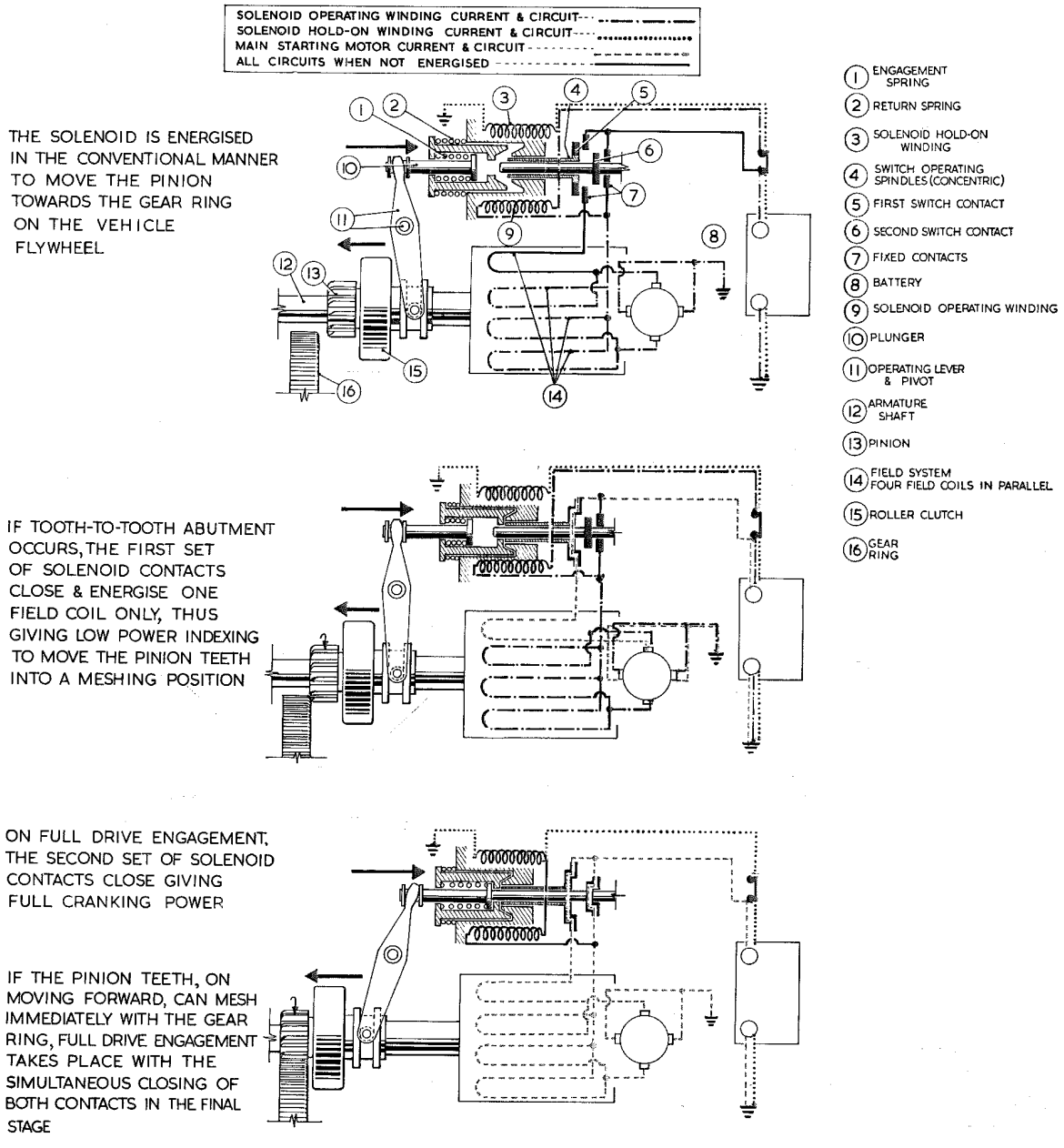


Fig. 3 Explanation of Two-Stage Switching

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

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

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

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

(b) Standard and Oil Sealed Versions

For applications where the starting motor is liable to be splashed with fuel oil, a sealed version is used. This differs from the standard version in the following ways:—

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

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

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

(iv) The through bolt threads are sealed.

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

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

2. ROUTINE MAINTENANCE

Routine maintenance is not necessary, although an occasional check should be made on the tightness of the electrical connexions.

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

3. TECHNICAL DATA

(i)	Lock torque:	37.5 lbf ft (5.2 kgf m) with 1070 amperes at 5.0 terminal volts.
(ii)	Torque at 1000 rev/min:	18.6 lbf ft (2.6 kgf m) with 650 amperes and 7.5 terminal volts.
(iii)	Light running current:	100 amperes at 5,500 - 7,500 rev/min.

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

4. SERVICING

(a) Testing in Position

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

(b) Bench Testing

(i) Disconnect the battery earth cable. Disconnect and remove the starting motor from the engine.

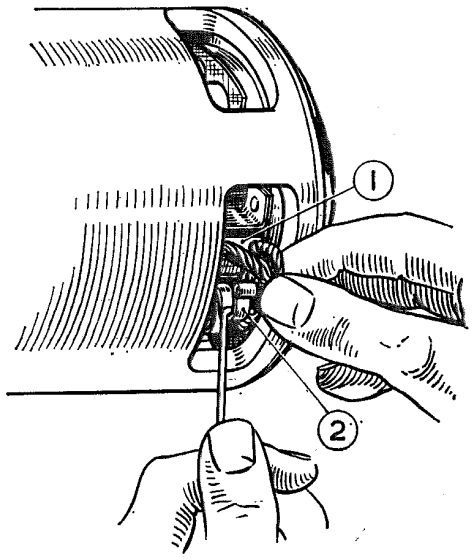
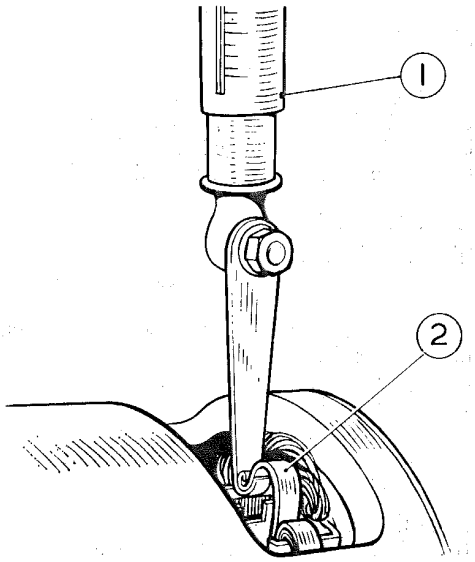


Fig. 4 Checking brushgear
1 Brush **2 Brush Spring**

(ii) Checking the brushgear

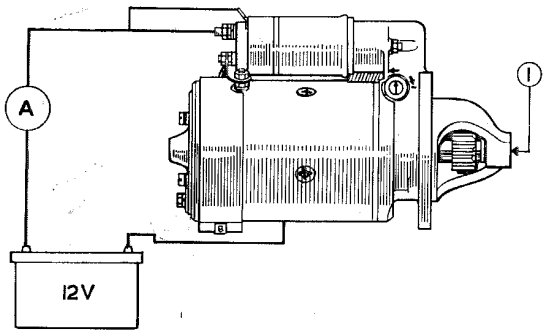
Slacken the cover band pinch bolt and slide the band off the yoke. Check that the brushes are free to move in their holders as shown in Fig. 4. If necessary, remove the brushes and clean with a fluffless petrol-moistened cloth. Refit cleaned brushes in original positions. Renew brushes when worn to (or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



1 Spring Balance 2 Brush Spring

Fig. 5 Checking brush spring pressure

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



1 Apply tachometer here

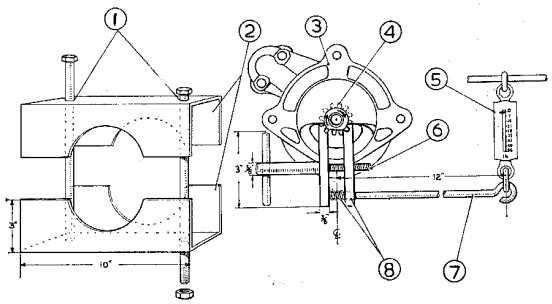
Fig. 6 Measuring the light running current and speed

(iii) Measuring the light running current

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

(iv) Measuring lock torque and current

Keeping the same electrical connexions, carry out a lock torque test as shown in Fig. 7 and compare with the values given in para 3. If a constant voltage supply is used, it is important to adjust this to be 5 volts at the starting motor terminal when testing.



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

Fig. 7 Measuring lock torque

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

(v) Fault diagnosis

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

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

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

(c) Dismantling

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

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

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

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

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

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

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

(d) Bench Inspection

After dismantling the motor, examine individual items.

(i) Replacement of brushes

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

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

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

Check that the new brushes move freely in their boxes.

(ii) Commutator

A commutator in good condition will be burnished and free from pits or burned spots. Clean the commutator with a petrol-moistened cloth. If the commutator is badly worn, mount the armature between centres in a lathe, rotate at high speed and take a light cut with a very sharp tool. Do not remove more metal than is necessary. The minimum diameter to which the commutator can be machined, before a replacement armature assembly becomes necessary, is 1.5". Finally, polish with very fine glass paper. The insulators between the commutator segments MUST NOT BE UNDERCUT.

(iii) Armature

Lifted conductors

If the armature conductors are found to be lifted from the commutator riser, overspeeding is indicated. In this event, check that the clutch assembly is operating correctly.

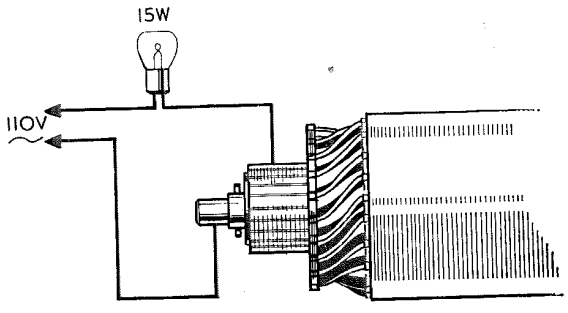


Fig. 8 Armature winding insulation test

Fouling of armature core against the pole faces

This indicates worn bearings or a distorted shaft. A damaged armature must in all cases be replaced and no attempt should be made to machine the armature core or to straighten a distorted armature shaft.

Winding insulation and short circuit tests

To check the insulation of the armature windings use a 110-volt a.c. 15 watt test lamp as shown in Fig. 8. Before testing, remove all traces of brush dust with a dry air blast.

The test lamp must not light when connected between the commutator segment and the armature shaft.

If a short circuit in the windings is suspected, check the armature on a "growler".

If the armature failure cannot be remedied, a replacement must be fitted.

(iv) Insulation test of field coils

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

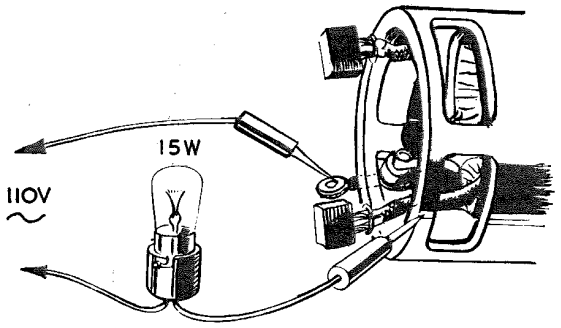


Fig. 9 Field coil insulating test using low voltage mains

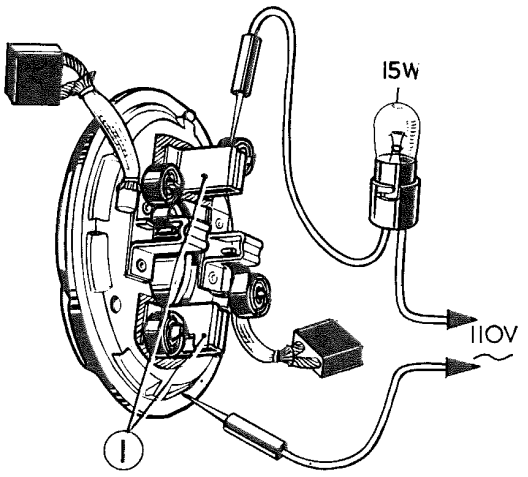
Using the same equipment, check also the insulated pair of brush boxes on the commutator-end bracket. Clean off all traces of brush deposit before testing. Connect the test lamp between each insulated brush box and the bracket (Fig. 10).

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

Replacing the field coils

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

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



1 Insulated Brush Boxes

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

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

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

(v) Bearing replacement

The commutator-end, drive end and intermediate brackets are each fitted with a porous bronze bush. Replace any bush in which the internal diameter is worn in excess of the maximum permissible measurement, which is given as follows:—

Commutator-end bracket bearing:			0.505″	
Intermediate	,,	,,	1.127″	★
Drive-end	,,	,,	0.675″	★

The bushes in the intermediate and drive-end brackets can be pressed out, while that in the commutator-end bracket is best removed by inserting a $\frac{9}{16}$″ tap squarely into the bearing and withdrawing the bush with the tap. Before fitting a new porous bronze bearing bush, immerse it for 24 hours in clean engine oil.

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

★ *Amendment to previous issue*

★ for Commutator-end bracket bush: 0.5005″
„ Intermediate „ „ : 1.123″
„ Drive-end „ „ : 0.6705″
Porous bronze bushes must not be reamed out after fitting or the porosity of the bush will be impaired.

(e) Checking the Roller Clutch Drive Assembly

A roller clutch drive assembly in good condition will:-

(i) Provide instantaneous take-up of the drive in the one direction.

(ii) Rotate easily and smoothly in the other.

(iii) Be free to move round or along the shaft splines without roughness or tendency to bind.

Should the assembly not meet any of these requirements, a replacement unit must be fitted.

All moving parts should be smeared liberally with Rocol "Molydest" grease, starting motor grade, or an equivalent alternative.

(f) Reassembly

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

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

Nuts on solenoid terminals:
24 lbf in (0.28 kgf m)
Solenoid fixing nuts:
4.5 lbf ft (0.62 kgf m)
Starting motor through bolts (¼″ diameter):
8.0 lbf ft (1.1 kgf m)
Starting motor through bolts (⅝″ diameter):
10.0 lbf ft (1.38 kgf m)

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

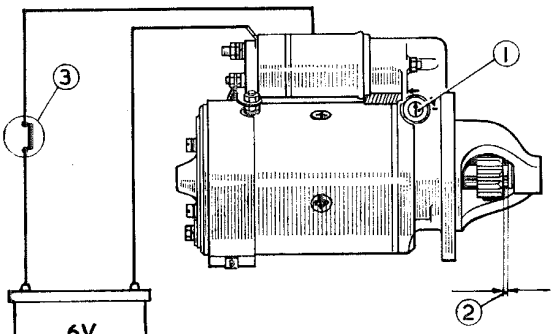
(g) Setting Pinion Movement

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

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

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

For correct setting this distance should be 0.015″— 0.025″. ★



1 Eccentric Pivot Pin
2 0.015″–0.025″ when solenoid is energised ★
3 Switch

Fig. 11 Setting pinion movement limit

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

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

5. SOLENOID MODEL 14S

(a) Current Checking of Solenoid Windings

The series and shunt windings of the operating coil can be checked individually by removing the solenoid external connexions and carrying out low voltage direct current consumption tests. To do this, 44/012 cable is required, together with two moving coil ammeters (one calibrated 0—40 and the other 0—10) and a 4-volt constant voltage supply. The tests should be carried out with the windings cold. The solenoid internal connexions are shown in Fig. 3.

(i) Closing or series winding

Using the 0—40 range ammeter, connect the 4 volt supply between the main terminal "S2" and the "Lucar" terminal. This should cause a current of 26-31 amperes to be indicated on the ammeter. If no current flows, the winding is open-circuited and a replacement unit must be fitted.

★ *Amendment to previous issue*

(ii) Hold-on or shunt winding

Using the 0—10 range ammeter, connect the 4 volt supply between the "Lucar" terminal and the solenoid body. This should cause a current of 5.5—6.5 amperes to be indicated on the ammeter.

If no current flows, the winding is open-circuited and a replacement unit must be fitted.

Note: The resistance values of the two windings are 0.13—0.15 ohm (closing winding) and 0.63—0.73 ohm (hold-on winding).

(b) Replacement of terminal base and contacts assembly

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

Remove the two nuts securing the moulded cover, together with the rubberised spring washers.

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