STARTING MOTOR MODEL M50 EARTH-RETURN (OIL AND WATER TIGHT)
(WITH ACTUATING SOLENOID MODEL 18S AND ROLLER CLUTCH DRIVE MODEL 9SD)

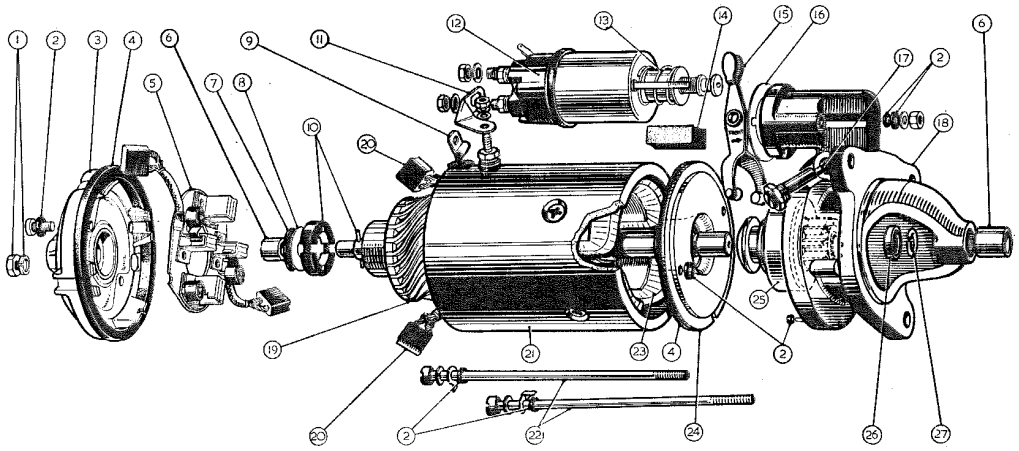


Fig. 1 Starting motor, dismantled

1 Nut & spring washer (C/E cover earth stud)
2 Sealing washer(s)
3 Commutator end cover
4 Sealing ring
5 Brushgear assembly comprising Earth brushes and springs
6 Bearing bush
7 Fibre washer
8 Steel thrust washer
9 Flexible link
10 Brake shoes and cross peg
11 Copper link
12 Solenoid unit
13 Return spring
14 Sealing grommet
15 Engagement lever
16 Gasket
17 Eccentric pivot pin
18 Drive end fixing bracket
19 Armature
20 Insulated brushes
21 Yoke
22 Through bolts
23 Field coils
24 Intermediate bracket
25 Drive assembly
26 Thrust collar
27 Jump ring

1. DESCRIPTION

This pre-engaged starting motor is a four-pole four-brush machine, 5″ (127 mm) diameter and having a solenoid-operated roller clutch drive. The solenoid incorporates two sets of contacts which provide two-stage switching. Normally, when the starting motor is operated the pinion moves into full engagement with the engine flywheel ring-gear and the first and second-stage contacts of the solenoid close simultaneously connecting all four field coils of the starter to the battery, and full cranking torque then develops. On occasions when tooth-to-tooth abutment occurs, the solenoid plunger continues to move by compressing a drive engagement spring inside the plunger. This plunger movement causes the first-stage contacts to close, connecting one of the field coils to the battery. The starter armature now turns at low speed and the pressure of the drive engagement spring, combined with push screw assistance from the drive helix, causes the pinion to move into mesh. When the pinion is fully engaged, the solenoid second-stage contacts close and the remaining three field coils are connected to the battery (Refer Fig. 2a, b & c).

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

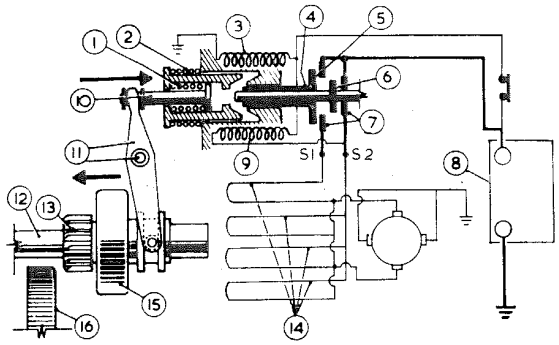
The starting motor is oil and watertight (except from the bell housing), and has neoprene seals:

(i) Between commutator end cover and yoke.

(ii) Between intermediate bracket and yoke.

(iii) Between solenoid and drive-end bracket.

(iv) At both ends of the through bolts, at the earthing stud, at the solenoid fixing studs and brushgear plate securing screws in the outer face of the commutator end cover.

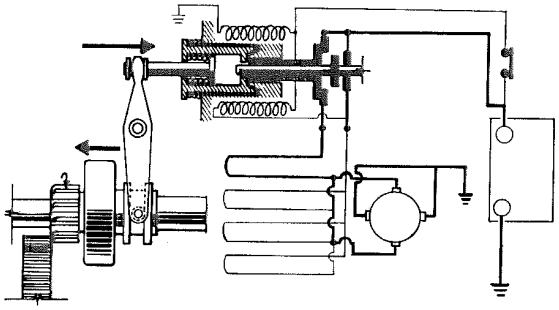


Explanation of two-stage switching (Fig. 2a)

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

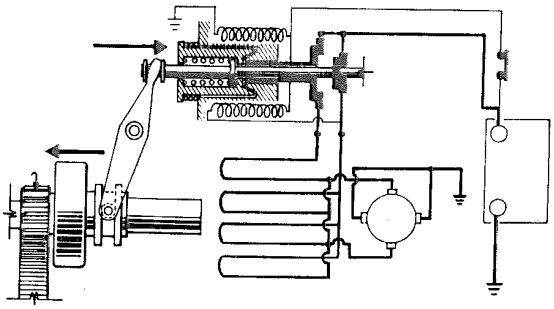
1 Engagement spring
2 Return spring
3 Solenoid hold-on winding
4 Switch operating spindles (concentric)
5 First switch contacts
6 Second switch contacts
7 Fixed contacts
8 Battery
9 Solenoid operating winding
10 Plunger
11 Operating lever and pivot
12 Armature shaft
13 Pinion
14 Field system: Four field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

Starting Motor Model M50 Earth-Return (Oil and Water Tight)



(Fig. 2b)

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



(Fig. 2c)

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

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

2. ROUTINE MAINTENANCE

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

The starting motor should be dismantled for detailed inspection during major engine overhaul. The commutator should also be examined and the brushes and bearing bushes renewed (see 4 (d) i, ii & v).

3. TECHNICAL DATA

The starting motor performance is dependent on the capacity and state of charge of the associated battery The following are typical performance figures obtained with a 12 V 128 Ah (20h rate) battery in a 70% charged condition, at 20°C (68°F).

Lock torque: 34.0 lbf ft (46.10 Nm) with 980 A.

Torque at 1,000 rev/min: 16.0 lbf ft (21.70 Nm) with 590 A.

Light running current approx.: 100 A at 5,500–7,500 rev/min.

4. SERVICING

(a) Testing in Position

Starter cranks engine, but at reduced speed.

(i) Check the Battery.

Ensure that the battery is in a good state of charge. S.G. readings should be

State of Charge	Specific Gravity Readings Corrected to 15°C (60°F)	
	Climates normally below 25°C (77°F)	Climates normally above 25°C (77°F)
Fully Charged	1.270 – 1.290	1.210 – 1.230
70% Charged	1.230 – 1.250	1.170 – 1.190
Discharged	1.100 – 1.120	1.050 – 1.070

Electrolyte Temperature Correction

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

If there is a variation of more than 40 points (0.040) between any cell readings, the battery is suspect and should be removed for testing by a battery agent.

(ii) Check that the battery and starter connections are tight.

Particular attention should be paid to the battery terminal connections and earth connections to the vehicle frame. Do not overlook the engine earth cable (or flexible strap), usually fitted between the engine and the vehicle frame.

If the wiring connections appear to be satisfactory, but the fault persists, check with a moving-coil voltmeter (0–20V range) to ascertain whether sufficient voltage is being applied to the starting motor under load conditions.

Note: During the voltmeter checks, the starting motor must be made to crank the engine without actually starting it. In the case of petrol engines, if necessary disconnect the low-tension circuit of the ignition coil between the coil and the distributor, and in the case of diesel engines, switch off the fuel supply.

(iii) Check the battery terminal voltage under load conditions.

Connect the voltmeter across the battery terminals, and operate the starter switch. The test is satisfactory if the voltage now registered is approximately 10.5-volts (petrol engines) or 10-volts (diesel engines), in which case proceed direct to para (v).

If the voltmeter reading is appreciably lower than previously stated, the starting motor should be removed from the engine for testing and examination.

If a higher voltage reading is obtained, there is a high resistance in the starter circuit or the starter solenoid, or the starting motor is faulty. Do not remove the starting motor from the engine at this stage, proceed to further testing (para. iv).

Note: If the solenoid operates intermittently during the tests and the engine is cranked at a low or irregular speed, there is insufficient voltage at the solenoid operating-winding terminal or the solenoid unit is faulty and must be renewed. For satisfactory operation of the solenoid second-stage contacts, the voltage at the solenoid operating-winding terminal must not be less than 7-volts when the starter switch is operated. A lower voltage indicates that the starter switch or its associated wiring is faulty. First, check the wiring, then prove the starter switch by making a temporary but direct connection between a convenient battery supply point and the solenoid operating-winding terminal. If the solenoid and the starting motor now operate normally, there is a high resistance at the switch contacts and the switch must be renewed.

(iv) **Check battery earth and starter earth.**

Carry out two separate tests. First connect the voltmeter between the battery earth terminal and a good earth point on the vehicle frame, and then between the earth terminal stud on the starter end bracket and a good earth point on the vehicle frame. In each case the starter control switch must be operated. If the voltmeter registers not more than 0.5-volt, the battery earth and starter earth connections are satisfactory.

Note: If the starter earth test is unsatisfactory and no earth cable is fitted between the starting motor and the vehicle frame, check the engine earth cable, or strap, usually fitted between engine and frame.

(v) **Check the voltage at the solenoid main input terminal, under load conditions.**

Note: The solenoid main input terminal is linked to a smaller terminal by a copper strap marked 'BAT'.

Connect the voltmeter between the solenoid main input terminal and a good earth point on the starter or vehicle frame, then operate the starter switch. The voltmeter should register not more than 0.5-volt lower than that obtained at the battery terminals during the test in para. (iii). Approximately 10-volts (petrol engines) and 9.5-volts (diesel engines) should therefore be registered in this test.

If a lower reading is obtained, the heavy-duty cable connecting the battery to the starting motor is unsatisfactory.

If a higher-than-normal reading, previously obtained during the test carried out in para. (iii), is also obtained in this test, the solenoid contacts may be faulty or the starting motor has an internal fault.

In either case, the starting motor should be removed from the vehicle to rectify the fault. Refer to Bench Testing 4 (b).

Starter does not crank the engine.

(i) **Repeat the checks detailed in para (i) and para (ii) of the previous heading.**

Using a moving-coil voltmeter (0–20V range), carry out the following tests:

(ii) **Check that there is battery voltage at the solenoid main input terminal.**

Note: The solenoid main input terminal is linked to a smaller terminal by a copper strap marked 'BAT'.

Connect the voltmeter between the solenoid main input terminal and a good earth point on the starter or vehicle frame. Battery voltage should be registered, indicating that the heavy-duty cable between the battery and the starter, the battery terminal connections, and the battery earth connections, are all satisfactory.

If this test is satisfactory, do not disconnect the voltmeter but proceed to further testing (para. iii).

(iii) **Check the voltage at the solenoid main input terminal, with the starter switch operated (voltmeter connected as in the previous test).**

If the starting motor fails to crank the engine and the voltage falls appreciably, or falls to zero, the starting motor has an internal fault and must be removed from the vehicle for detailed examination.

If the starting motor fails to crank the engine and the voltage remains unaltered, the failure is probably due to one of the following causes:— faulty control switch circuit, or solenoid unit, or there is an internal fault in the starting motor. Proceed to further testing (para. iv).

(iv) **Check the starter control switch circuit.**

Connect the voltmeter between the solenoid operating-winding terminal (small 'Lucar' blade) and a good earth point on the starting motor or vehicle frame, and operate the starter control switch. Battery voltage should be registered and the solenoid should be heard to operate, proving that the control switch circuit is satisfactory.

If this test proves to be satisfactory, the failure must be due to a faulty solenoid unit or a fault inside the starting motor. In either case the starting motor should be removed from the vehicle for more detailed testing and examination (refer 4 b).

If the test is unsatisfactory, first check the wiring associated with the switch and then prove the switch by making a temporary but direct connection between a convenient battery supply point and the solenoid operating-winding terminal. The solenoid and starter should now operate, indicating that the starter control switch is faulty and must be renewed.

(b) Bench Testing

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

(i) If the solenoid contacts are satisfactory, the cause of starter failure can only be determined by dismantling the unit for detailed inspection. Proceed to 4 (c) and dismantle the unit to the stage noted for checking the commutator and brushgear.

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

(c) Dismantling

Remove copper link, which connects solenoid terminal S2 to yoke terminal.

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

Remove solenoid securing nuts. Take from the fixing studs a metal washer and a sealing washer of similar size.

Withdraw solenoid unit complete with gasket from drive-end fixing bracket, retrieving at the same time a small sealing washer which seals the threads of the solenoid fixing studs. Note that the solenoid plunger will be left attached to the starter when the main part of the solenoid is withdrawn.

To remove the solenoid plunger, grip plunger by hand, and lift up the front end of the plunger. Withdraw plunger from the fork in which it pivots at the top of the drive engagement lever.

Remove sealing grommet which is wedged between fixing bracket and yoke, where the solenoid attaches to the bracket.

Remove through bolts complete with spring washer, locking washer and sealing washer.

Remove two Phillips-recess screws from outer face of commutator end cover. (These screws, complete with sealing washers, secure the brushgear assembly to the inner face of the end cover).

The commutator end cover assembly comprising sealing ring, brake shoe assembly, steel thrust washer, fibre packing washer and bearing bush can now be removed, leaving the brushgear still in its working position on the commutator.

Note: At this stage of dismantling, inspect brushes and commutator to see if these are the cause of starter failure. Information regarding inspecting and servicing commutator and brushgear is given in 4 (d) i & ii.

To remove brushgear assembly, grip the commutator end of the armature shaft and pull the armature forward so as to fully expose commutator and brushgear. Use a wire hook, or alternatively a small screwdriver on the edge of the brushgear plate, to lever up the brush springs so that the brushes can be disengaged from their brushboxes. The whole of the brushgear assembly can now be removed from the commutator and detached from the insulated brushes of the yoke assembly.

Withdraw yoke assembly from armature and drive-end bracket.

The sealing ring between yoke and intermediate bracket should now be removed from its retaining groove in the bracket.

Unscrew eccentric pivot pin from the side of fixing bracket.

The assembly comprising drive-end fixing bracket, drive engagement lever, and armature complete with roller clutch drive and intermediate bracket can now be dismantled.

During dismantling of these parts, two small sealing washers which are fitted in a recess of the through bolt holes in the face of the fixing bracket where it joins the intermediate bracket, may become dislodged when the fixing bracket and intermediate bracket are separated. Make a special point of retrieving these seals.

The armature assembly comprising roller clutch drive and intermediate bracket can now be dismantled. The drive assembly and intermediate bracket are retained on the armature shaft by a jump ring, locating in a groove in the armature shaft and retained by a thrust collar. By using a tubular tool (e.g. a box-spanner) the thrust collar can be driven squarely off the jump ring, which can then be removed from its groove. Make a special point of retrieving any packing shim(s), which may be assembled on the armature shaft between the intermediate bracket and the armature core. These control the armature end float to 0.025″ (0.63 mm) max.

(d) Bench Inspection

After dismantling the motor, examine the individual items as follows:—

(i) Commutator

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 prior to using the petrol-moistened cloth. EMERY CLOTH MUST NOT BE USED.

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

If there are signs of thrown solder or the conductors have lifted from the commutator segments, the motor has probably been overspeeding. Check the operation of the roller clutch drive (4 (d) vi).

If the armature fouls the pole-shoes, it indicates worn bearings, loose pole-shoes, or the armature shaft is distorted. Check the armature in a lathe. If it is out of true, it should be renewed. If the armature is satisfactory, renew the bearings in both end brackets (4 (d) v).

Check armature insulation with a 110V a.c. 15W test lamp connected between one of the commutator segments and the armature shaft (Fig. 3). If the lamp lights the insulation is unsatisfactory.

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

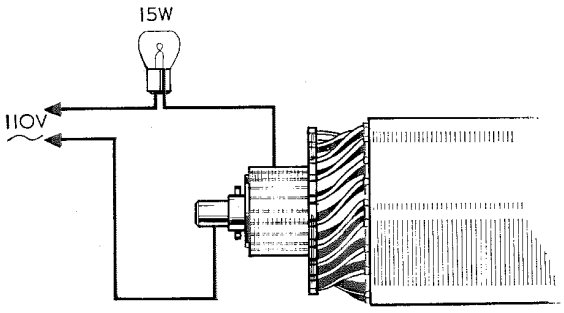


Fig. 3 Armature winding insulation test

(ii) Brushgear

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

Brushes which are worn to approximately 0.313″ (8 mm) in length must be renewed. Service replacement brushes are preformed and do not require 'bedding' to the commutator.

Renewing the Brushes

Insulated brushes (field coil): Place the yoke assembly on its end, with brush and terminal arrangement uppermost (Fig. 4). Cut the worn brush flexibles as near as possible to the field coil conductor. Carefully prise the brush flexible joining-part of the conductors away from the yoke, to provide sufficient space for soldering new brushes in position. Separate the ends of the two brush flexibles and position one each side of the conductor. Pinch the ends of the flexibles and conductor together with long-nosed pliers and bend the brush and flexibles firmly down over the edge and outside of the yoke (as illustrated in Fig. 4). This will help to retain the brush and its flexibles in position during the soldering operation and also prevent solder from running too far down the flexibles.

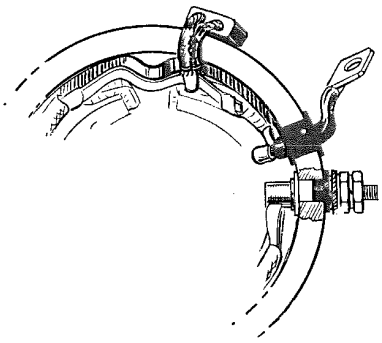


Fig. 4 Brush and terminal arrangement

Earth brushes (brushgear plate): Place the hot soldering iron on the rolled-over portion of the brush flexible joint. When the solder inside the joint is sufficiently heated, use a screwdriver and lever up the rolled-over portion enough to enable the worn brush flexible to be pulled clear of the joint.

Checking the Spring Pressure

Brush spring pressure should be checked with the whole of the brushgear loosely assembled to the commutator (i.e. all four brushes assembled in their working position). Hold the brushgear assembly firmly centralised on the commutator and apply a pull-type spring gauge to each spring in turn (Fig. 5). The spring pressure reading should be 42 ozf (11.70 N).

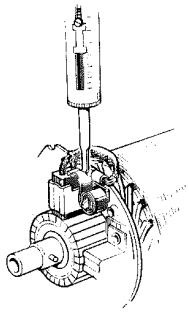


Fig. 5 Checking brush spring pressure

Checking the Brushgear Insulation

Connect a 110V a.c. 15 watt test lamp between a clean part of the brushgear plate and each of the two insulated brushboxes in turn.

If the lamp lights, the insulation between the brushboxes and the brushgear plate is unsatisfactory and the brushgear assembly must be renewed.

(iii) Checking Field Coil Insulation

Ensure that both insulated brushes are clear of the yoke and connect a 110V a.c. 15 watt test lamp between the eyelet of the flexible link and a clean part of the yoke. If the lamp lights, there is a short circuit between the field coils and the yoke. The field coil assembly must therefore be removed.

(iv) Field Coil Continuity and Inter-winding Insulation.

Due to the very low resistance of the field coils and the method of interconnecting the conductors, the continuity of the field coils and the presence of a short-circuit between windings can only be determined by using special equipment. The field coils should be visually inspected *in situ* for signs of obvious fault(s). Check the various joints of the field coil assembly and look for discoloration (due to burning) of the winding insulation tape, which could indicate short-circuited windings. If, in doubt, the field coil assembly should be proved by substitution.

Renewing the Field Coil Assembly

Before disturbing the original fitting of the field coils in the yoke, pay particular attention to the following:—

The close-forming of the field coil conductors to the yoke to ensure adequate clearance for the armature.

A minimum clearance of 0.406″ (10.32 mm) between the edge of the field coil assembly and the end face of the yoke.

The forming of the conductors around the two through bolt entry points.

The build-up of the insulators and washers associated with the yoke terminal (Fig. 4).

Use a wheel-operated or power-assisted screwdriver to unscrew and refit the pole-shoe retaining screws. The fitting operation will be facilitated by using pole-shoe expanding equipment and the screws should be progressively tightened. Tighten pole-shoe screws to a torque of 20 lbf ft (27.11 Nm), and yoke terminal lower fixing nut to 2.0 lbf ft (2.71 Nm).

(v) Bearings

The commutator-end cover, intermediate bracket and drive-end fixing bracket are fitted with self-lubricating porous bronze bearing bushes. New bushes should be allowed to stand for 24 hours at room temperature completely immersed in clean light engine oil. Alternatively the bush may be immersed in the above lubricant at 100°C for two hours and allowed to cool before removal. Bushes must not be reamed after fitting otherwise the self-lubricating qualities will be impaired.

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

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

The bush in the commutator end cover can be removed by inserting a 0.563″ (14.30 mm) thread tap and then withdrawing the tap complete with the bush.

The bushes in the intermediate bracket and drive-end fixing bracket can be removed by using a press, or by supporting the bracket and carefully tapping the bush out with a mandrel.

New bushes should be pressed or carefully driven squarely into position using a shouldered polished mandrel with a bush fitting dimension as follows:—

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

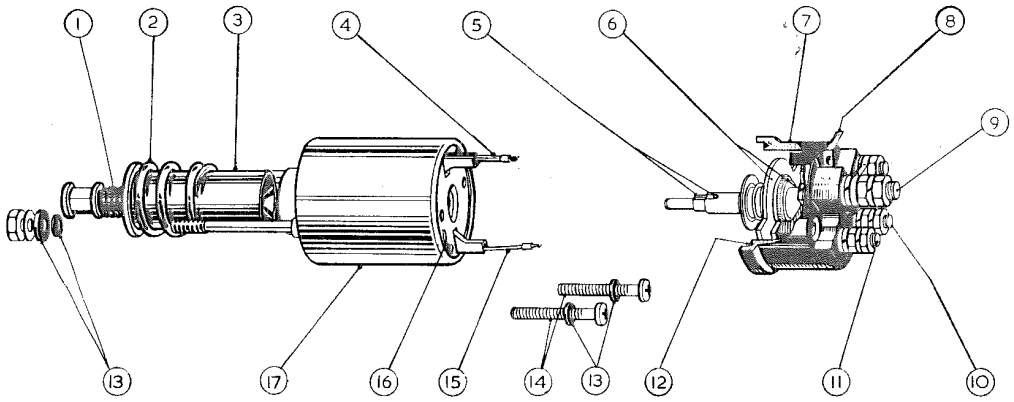
(vi) Roller Clutch and Drive Operating Mechanism.

The roller clutch is an over-running device which prevents the armature from rotating at excessive speed if the drive is held in engagement, after the engine has started.

A roller clutch drive assembly in good condition provides instantaneous take-up of the drive in one direction while it is free to rotate in the other. The assembly should move freely along the armature shaft splines without roughness or tendency to bind. All moving parts should be smeared liberally with Shell SB2628 (home market and cold climate): Retinax 'A' (hot climate).

(vii) Solenoid

In addition to the engagement spring inside the plunger, and the return spring outside the plunger, the solenoid plunger is also fitted with a lost-motion spring (Fig. 6) which provides a measure of lost motion as the drive commences to disengage, ensuring that the solenoid contacts are open before the pinion retracts. This also takes effect if the pinion remains engaged with the flywheel ring gear when the solenoid switch is released.



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

Fig. 6 Solenoid Model 18S, dismantled

Checking the operation of the solenoid is dealt with in 4 (b).

Renewing Contacts

After being in service for long periods, the contacts may require renewing. If this is necessary the major part of the solenoid can be retained and the solenoid repaired by fitting a service replacement contact set comprising terminal-and-base assembly (Refer Fig. 6).

Remove the two screws securing the terminal-and-base assembly to the solenoid body. Apply a hot soldering iron alternately to each of the two soldered terminal connections and wait for the solder to run free. Shake most of the melted solder out of the joint(s) by tapping the solenoid terminal ends sharply down on the bench. Now clamp the solenoid body in a vice and while continually pulling on the moulded cover, apply the soldering iron alternately to the two soldered connections until terminal-and-base assembly is freed. When re-making soldered connections, avoid dry-soldered joints by ensuring that the parts are clean and adequately heated before applying solder. Tighten the terminal-and-base assembly fixing screws to a torque of 1.8 lbf ft (2.44 Nm).

(e) Reassembly

Sequence of assembling components is illustrated in Fig. 1.

The following tightening torques apply to general assembly of the starting motor. (Other tightening torques are quoted elsewhere if associated with a particular fitting operation.)

Through bolts	8.0 lbf ft (10.84 Nm)
Brushgear securing screws in commutator end cover...	2.5 lbf ft (3.40 Nm)
Solenoid-unit fixing stud nuts	4.5 lbf ft (6.10 Nm)
Solenoid upper-terminal nuts S1 and S2	2.5 lbf ft (3.40 Nm)
Solenoid main battery connection terminal nut (when connecting the cable) ...	3.0 lbf ft (4.06 Nm)
Starter earthing stud nut in commutator end cover (when connecting the cable) ...	6.0 lbf ft (8.13 Nm)

The following method of reassembly is recommended:—

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

Fit sealing ring to groove in intermediate bracket. Also, fit sealing washers to fixing bracket, one at each through bolt entry point and one on dowel peg (Fig. 1).

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

Slide yoke assembly over armature and locate yoke with dowel peg protruding through edge of intermediate bracket.

At this stage, check for sufficient clearance between armature and field coil conductors, particularly at through bolt entry points.

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

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

Now press the brushes on the commutator and check that the springs are properly located before manipulating the brushgear assembly further on the commutator and into its approximate working position.

Position the armature with brake-shoe cross peg in line with the two threaded holes in the brushgear plate.

Remove the two through bolts, but do not disturb the positioning of brushgear plate.

Assemble the fibre washer, steel washer and brake-shoe parts into the commutator end cover (refer to Fig. 1 to ensure correct sequence of assembly).

Position brake shoes in commutator end cover with cross peg slot in line with the two smallest of the four holes in the cover. (This will correspond with previous lining up of the armature shaft cross peg with the threaded holes in the brushgear plate, so ensuring approximate engagement of the cross peg with the brake shoes when fitting the end cover.)

Fit sealing ring to the commutator end cover.

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

Fix first the two through bolts and then the two brushgear securing screws. (Difficulty in locating the threads of the brushgear securing screws is avoided by fixing the through bolts prior to the brushgear securing screws.)

Loosely fit the eccentric pivot pin through the drive engagement lever and into the fixing bracket. (The pivot pin lock nut should not be tightened at this stage, as the pinion position must be set by adjusting the pivot pin when the starter is fully reassembled.)

Fit the block-shaped sealing grommet between the yoke and solenoid mounting portion of the fixing bracket. (Fitting the grommet is facilitated by soaping the grommet before assembly.)

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

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

(f) Pinion Setting

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

The amount of adjustment of the eccentric pivot pin for setting the pinion is 180°, and the centre of this limit is denoted by an arrow-head marking on the fixing bracket. When adjusting the pinion position, first apply gold size to the threads of the pivot pin, then turn the pivot pin until correct adjustment of the pinion is obtained with the arrow-head marking on the end face of the pivot pin within the 180° limit of the fixing bracket marking. After adjustment, secure the pinion setting by tightening the pivot pin lock nut to a torque of 16.0 lbf ft (21.70 Nm).

To check or carry out the adjustment, connect a 6V supply between the solenoid 'Lucar' terminal and the starter frame. (This will move the drive forward to the fully-engaged position.) With the pinion pressed lightly back, measure the space between the front of the pinion and the thrust collar on the armature shaft. This should be 0.015″–0.025″ (0.40–0.63 mm).