# PRE-ENGAGED STARTER MODEL 3M100PE

## (With Actuating Solenoid Model 19S and Roller Clutch Drive Model 7SD)

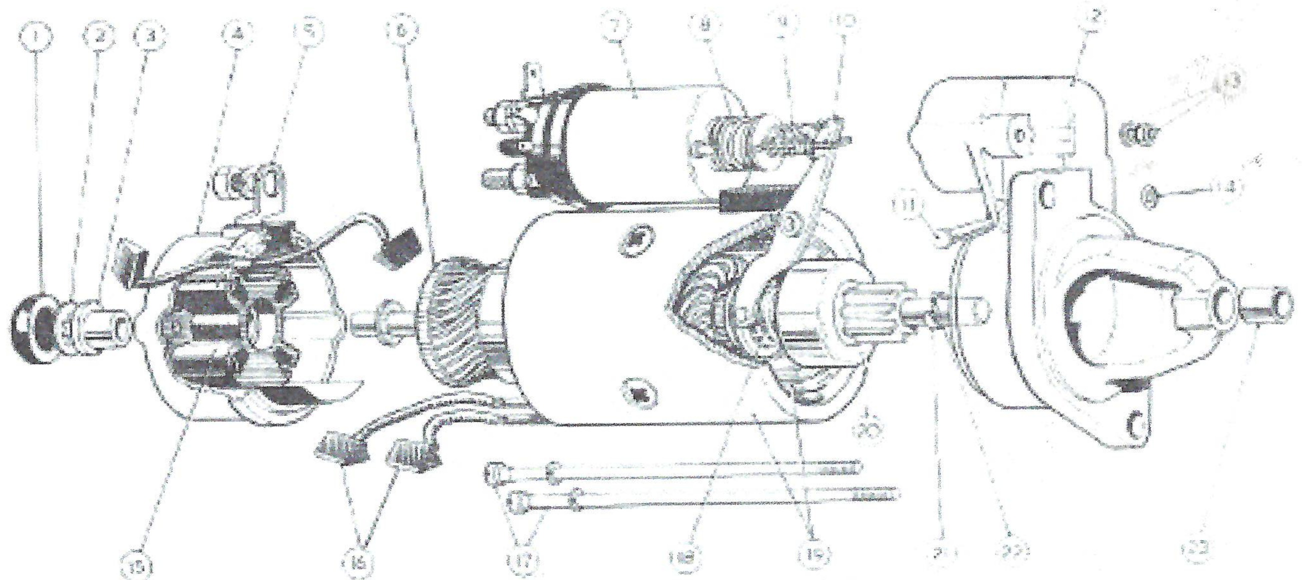

Fig. 1 Starter motor, dismantled

1 End cap
2 Retaining ring
3 Bearing bush
4 Commutator end cover
5 Connector link (solenoid to starter)
6 Armature
7 Solenoid unit 19S
8 Return spring
9 Lost motion spring
10 Drive engagement lever
11 Pivot pin
12 Drive end bracket
13 Solenoid fixing nut and washer (2 off)
14 Pivot pin retaining ring
15 Brush box moulding
16 Brushes
17 Through bolts
18 Spacing spring
19 Yoke and field coil assembly
20 Drive assembly
21 Thrust collar
22 Jump ring
23 Bearing bush

## 1. DESCRIPTION

The model 3M100PE pre-engaged starter is a four-pole four-brush machine, 4 in. (100 mm) diameter, with a series parallel field, an armature with a face-type commutator and a solenoid-operated roller clutch drive.

The face-type commutator on the end face of the armature works in conjunction with a fully-insulated brushgear assembly, comprising two pairs of wedge-shaped brushes and coil type springs assembled into a brushbox moulding, which is riveted to the inside of the commutator end cover. The brushes are provided with a keyway to ensure correct fitting and the springs are held captive in the brush-box moulding.

The supply voltage to the starter is applied (via the solenoid) direct to a pair of brushes. The four field coils are manufactured in series, with the start and finish of the windings terminating at a brush, and the centre point between two pairs of the coils is earthed direct to the frame of the starter by a riveted connection to the yoke. This method of connecting the field coils provides a series-parallel field circuit (see Fig. 2).

End-float and axial movement of the armature is determined by the position in which a special type of 'Spire' retaining ring is fixed to the armature shaft, where it extends through the commutator end bracket (refer Fig. 1, item No. 2).

There is no need to set the drive pinion and therefore the operating position of the drive engagement lever is non-adjustable. The plain-type pivot pin on which the lever swivels is retained in the fixing bracket by a small special type of 'Spire' retaining ring (refer Fig 1, item 14).

A feature of a pre-engaged starter is that the pinion is fully-engaged with the engine flywheel before cranking torque is developed. Normally, when the starter is operated, the pinion moves into full engagement with the engine flywheel and the solenoid contacts close to connect the starter to the battery. Full cranking torque is then developed. On occasions when tooth-to-tooth abutment occurs, the solenoid plunger continues to move by compressing a drive engagement spring inside the plunger. This plunger movement causes the solenoid contacts to close, connecting the starter to the battery. The starter armature now commences to rotate and the pressure of the drive engagement spring, combined with push-screw assistance from the drive helix, causes the pinion to move into mesh. Full cranking torque is then developed.

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

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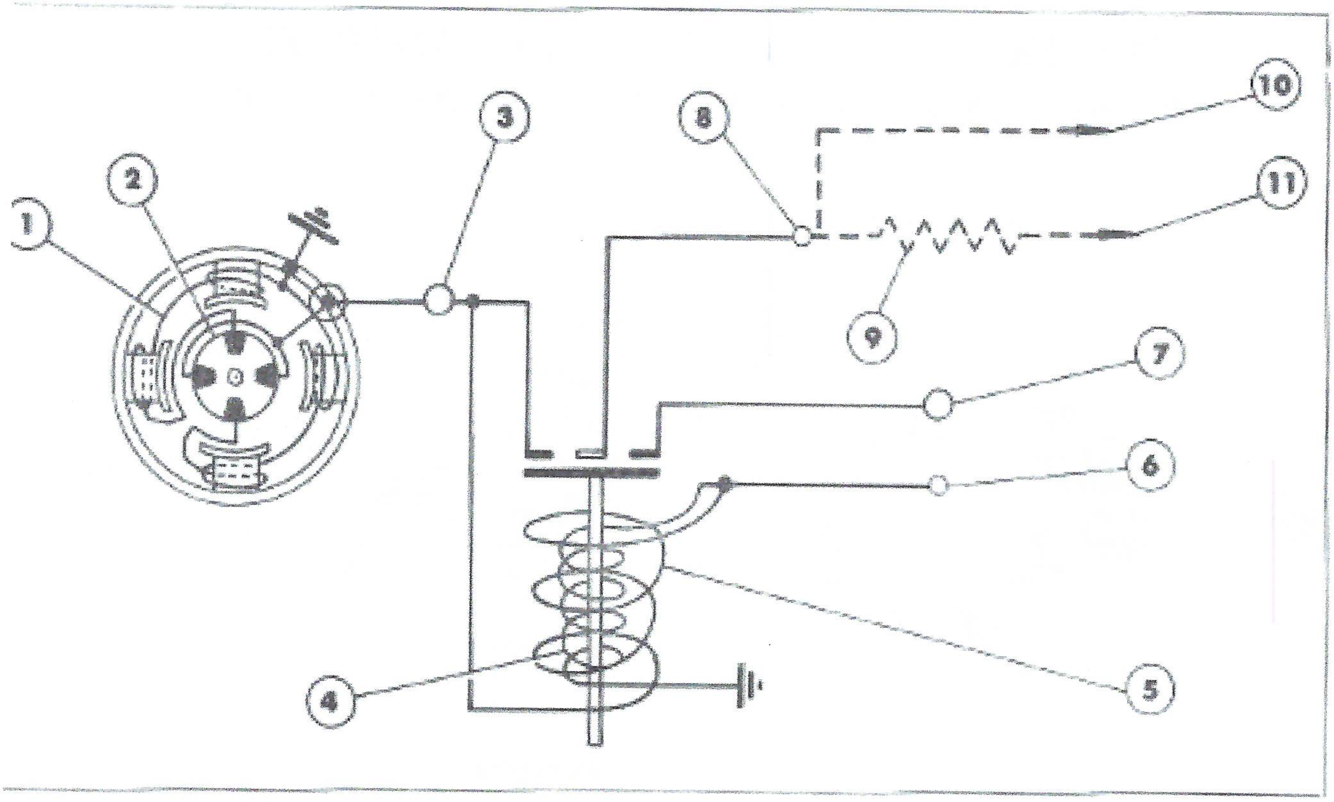


**Fig. 2 Internal connections of starter and solenoid. (Broken lines applicable only when ballast ignition coil is used)**

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

Note: Oil and water-tight versions of this starter will include special sealing features. Particularly in the case of the solenoid plunger and drive operating mechanism, which will be effectively sealed from the bell housing.

## 2. ROUTINE MAINTENANCE

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

The starter should be dismantled for detailed inspection during major engine overhaul. The commutator should then be serviced if necessary and the brushes and armature bearings renewed (refer 4 (c) i, ii, and iv).

## 3. TECHNICAL DATA

The performance of the starter depends on the capacity and state of charge of the associated battery. The following are typical performance figures obtained with a 12-volt 60 Ah (20 hr. rate) battery in a 70% charged condition at 20°C (68°F).

| | |
|---|---|
| Lock torque: | 16.5 lbf ft (22.37 Nm) with 545 A (max). |
| Torque at 1000 rev/min: | 9.0 lbf ft (12.20 Nm) with 365 A (max). |
| Light running current: | 65A at 6000 rev/min (approx). |

**Solenoid**

| | |
|---|---|
| Closing (or series) winding resistance (measured between the small unmarked 'Lucar' terminal and the main terminal marked 'STA': | 0.25–0.27 ohm |
| Hold-on (or shunt) winding resistance (measured between the small unmarked 'Lucar' terminal and a good earth point on the solenoid body: | 0.76–0.80 ohm |

## 4. SERVICING

For satisfactory starter performance, the battery must be in a good condition and at least 70% charged. Check with a hydrometer the specific gravity of the electrolyte in each of the battery cells. If there is a variation of more than 40 points (0.040) in any cell readings, the battery is suspect and should be removed for testing by a battery agent.

Specific gravity readings should be:

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

**Electrolyte Temperature Correction**

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

If the battery is in good condition and sufficiently charged, and the wiring associated with the battery, starter and operating switch, and the switch itself is satisfactory, a low cranking speed or failure of the starter to crank the engine means that the starter must be removed from the engine for detailed testing and examination. (Proceed to bench testing 4 a).

## (a) Bench Testing

**Determine if the Solenoid is the Cause of the Fault**

(i) Using heavy-duty battery cable and a 0–70A range moving-coil ammeter in series with a 12-volt battery, connect one side of the supply voltage direct to the solenoid-to-starter connecting link and connect the other side of the supply voltage to the starter frame.

The starter should now run under light running conditions, independent of the solenoid unit.

**If the starter does not run, or it runs but the light running current and speed are unsatisfactory (refer 3, Technical Data),** proceed to 4 (b) and dismantle the starter sufficiently to enable the commutator and brushgear to be inspected.

**If the starter runs and the light running current and speed are satisfactory,** the fault could be due to the solenoid unit or the starter. Proceed to further testing (para. ii).

(ii) Transfer the previous test-circuit connection (from the solenoid-to-starter connecting link) to the solenoid main input terminal. Now connect a temporary link between this terminal and the small (unmarked) 'Lucar' terminal blade, to energise the solenoid operating winding.

The solenoid should operate and the starter should run under light running conditions.

**If the starter runs and the light running current and speed are still satisfactory** (as well as in the previous test, para. i), check that there is not a high resistance at the solenoid contacts, which would cause a low cranking speed. Proceed direct to para. iii.

**If the starter does not run** when supply voltage is applied between solenoid main input terminal and frame, and between solenoid operating winding terminal and frame, the solenoid unit is faulty. Proceed direct to para. iv.

(iii) Check that the solenoid contacts close satisfactorily, under load conditions. Connect a low-range moving-coil voltmeter between the solenoid main terminals, and perform lock torque test.

If voltmeter registers practically zero, the solenoid is satisfactory. In that case, a low cranking speed and an unsatisfactory lock torque performance indicate that the starter is faulty. Proceed to 4 (b) and dismantle the starter sufficiently to enable the commutator and brushgear to be inspected.

**Note:** If lock torque equipment is not available, check the solenoid by substitution, and, if necessary dismantle the starter for inspection.

(iv) In reference to previous testing (para. ii), a solenoid fault could be due to open-circuit contacts (in which case a satisfactory repair can be carried out by renewing the terminal-and-base assembly complete with new contacts), or the operating windings may be faulty (in which case the solenoid unit must be renewed).

Providing the solenoid-to-starter connecting link is first disconnected from the solenoid terminal 'STA', both solenoid windings can be simultaneously checked (in series) as follows:

Connect a good quality ohmmeter between solenoid terminal 'STA' and a good earth point on the solenoid body or starter frame. **A reading of 1.01–1.07 ohms should be obtained.**

**Note:** Alternative to using an ohmmeter, connect a 0–20A range moving-coil ammeter in series with a 12-volt battery, solenoid terminal 'STA' and a good earth point on the solenoid body or starter frame. **A reading of 11.2–11.8A should be obtained.**

If the solenoid operating windings are satisfactory, it confirms that the solenoid failure is due to faulty contacts. The solenoid unit should **therefore be repaired or renewed.**

## (b) Dismantling

If access to the commutator and brushgear only is required, proceed direct to para. (ii) which deals with removing the commutator end cover.

### (i) Removing the Solenoid

Remove the nut and washer which secures the solenoid-to-starter connecting link to solenoid terminal 'STA'.

Remove the nuts and washers which secure the solenoid unit to the fixing bracket. Pull back the connecting link from the solenoid terminal, and at the same time lift the terminal end of the solenoid clear of the connecting link, then withdraw the major part of the solenoid from the fixing bracket. Remove the plunger from the drive engagement lever, by gripping the plunger in the hand and applying an upward lift at the front end of the plunger.

**(ii) Removing the Commutator End Cover**

Before removing the commutator end cover, ensure that a service replacement 'Spire' retaining ring is available as a new fitment for use during re-assembly of the starter. This is necessary because this type of retaining ring is a press fit (or drive fit) on the armature shaft and if the original fitting of the retaining ring is disturbed, it becomes unsatisfactory for further use.

Remove the end cap seal to gain access to the 'Spire' retaining ring.

Remove the retaining ring before unscrewing the through bolts. Using an engineers chisel, cut through a number of the retaining ring claws until the grip on the armature shaft is sufficiently relieved to allow the retaining ring to be removed.

Remove the nut and washer which secures the solenoid-to-starter connecting link to solenoid terminal 'STA'. (This will already have been done, if the solenoid has previously been removed as a preliminary to complete dismantling).

Remove the two through bolts.

After removing the through bolts, the commutator end cover can be removed from the rest of the starter by partially withdrawing the cover from the yoke and then disengaging the two field coil brushes from the brush box moulding.

**Note:** At this stage of dismantling, check the commutator and brushgear (refer 4 c, para. i and ii).

**(iii)**

After removing the commutator end cover, continue dismantling by withdrawing the yoke and field-coil assembly from the armature and fixing bracket sub-assembly. Do not disturb the field-coil assembly in the yoke (refer to 4 c, para. iii).

**(iv)**

If the 'Spire' retaining ring is removed from the drive engagement lever pivot-pin and the pivot-pin is then withdrawn from the fixing bracket, the armature assembly comprising roller clutch drive and lever assembly can then be separated from the fixing bracket.

**Note:** The pivot-pin retaining ring, similar to the one at the commutator end (except for size), must be renewed if the original fitting is disturbed.

**(v)**

The roller clutch drive and lever assembly is removable from the armature shaft as a complete unit. Using a tubular tool (e.g. a box spanner) drive the thrust collar squarely off the jump ring and then after removing the jump ring from the groove in the armature shaft, slide the thrust collar and the roller clutch drive and lever assembly off the shaft. It is unnecessary to dismantle the drive engagement lever from the roller clutch drive, since both these parts are serviced as a complete assembly. (The operation of the roller clutch drive should be checked as detailed in 4 c, para. v).

### (c) Bench Inspection

After dismantling the starter, examine the individual items as follows:

**(i) Armature**

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

In some cases it may be necessary to skim the commutator. The minimum thickness to which the commutator copper may be skimmed, before a replacement armature becomes necessary, is 0.140 in. (3.5 mm). The skimming operation should be terminated by polishing the commutator surface with a flat pad of very fine glass paper or emery cloth, then wipe clean with a petrol-moistened cloth. DO NOT UNDERCUT THE INSULATION SLOTS.

If the armature shows signs of 'thrown' solder, or lifted conductors, over-speeding of the armature is indicated. (Check the operation of the roller clutch drive, 4 c, para. v).

The armature insulation can be checked by connecting a 110-volt a.c. 15-watt test lamp between a commutator segment and the shaft (refer Fig. 3). **The lamp should not light.**

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

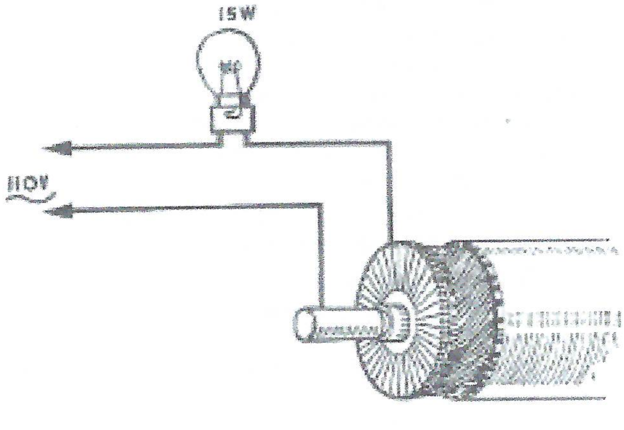


**Fig. 3 Armature insulation test**

If the armature laminations have been in contact with the pole-shoes, the armature bearings are probably excessively worn. First, check that the pole-shoes are tight and that the armature runs true in a lathe. Then, if necessary, renew the armature bearings (refer 4 c, para. iv).

**(ii) Brushgear**

Check that the brushes move freely in the brush box moulding. Sticking brushes should be cleaned with a petrol-moistened cloth. Brushes which are worn to approximately 0.375 in. (9.5 mm) in length, must be renewed.

**Renewing the brushes:** Note which of the two field coil conductors is fitted with the long and short brush-flexibles, then cut the worn brush-flexibles from the field coils and solder the new brushes in position. Replace the other two brushes complete with terminal link and moulded rubber grommet. Ensure the new brush set is correctly fitted in accordance with Fig. 4.

**Note:** Use only resin-cored type solder.

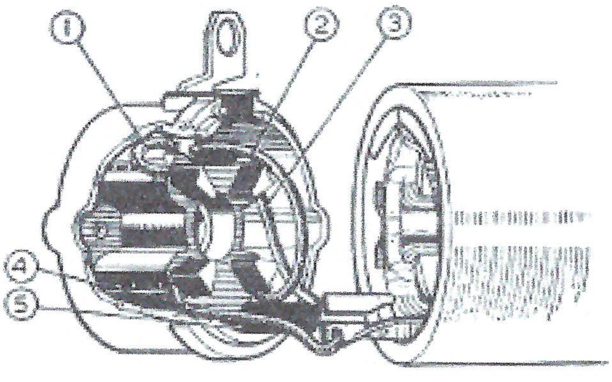


**Fig. 4 Brushgear and terminal arrangement**

1 Short brush-flexible, C/E cover
2 Long brush-flexible, ,,
3 Long brush-flexible, field winding
4 Short brush-flexible, ,,
5 Insulation piece

**Brush spring pressure:** To measure the brush spring pressure, position a new brush in each of the brush boxes in turn and then press on top of the brush with a push-type spring gauge (refer Fig. 5) until the top of the brush protrudes about 0.062 in. (1.5 mm) from the brush box moulding, when the spring pressure reading should be 36 ozf (10.0 N).

Check the insulation of the brush springs by connecting a 110-volt a.c. 15-watt test lamp between a clean part of the commutator end cover and each of the springs in turn. The lamp should not light.

Check that the connecting link grommet is in good condition.

**(iii) Yoke and Field Coil Assembly**

The field coils should be visually inspected in-situ for signs of obvious fault(s). Check the inter-

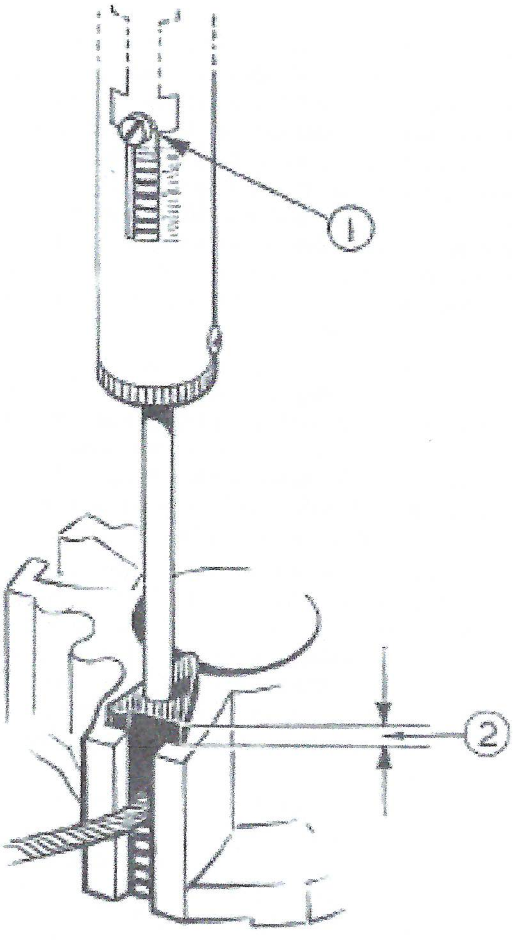


**Fig. 5 Checking brush spring pressure**

1 Push type spring gauge, with sliding marker indicating reading where 'arrowed'
2 0.062 in. (1.50 mm) approx.

connecting joints between coils, the earthed connection of the field winding where it is riveted to the yoke, and look for discolouration (due to burning) of the winding insulation tape, which could indicate short-circuited windings or a short-circuit between the windings and the yoke. A visible fault will eliminate the need for testing and in such cases if necessary the field coil assembly should be removed from the yoke to enable it to be repaired or renewed.

If there are no obvious signs of a fault, the field coil continuity and the insulation between the field coils and yoke can be checked without removing the field coil assembly from the yoke.

**Field coil continuity:** Check by connecting a 12-volt battery-operated test lamp between each of the brushes in turn and a clean part of the yoke. **The lamp should light.**

**Field coil insulation:** Before being able to check the insulation between the field coils and yoke, it will first be necessary to disconnect the earthed end of the winding from the yoke. Before disconnecting the

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winding (refer to the heading 'Renewing the field coils'), determine whether it is justified. Consider the results of the light running and lock torque tests, or alternatively consider the fault symptoms. If the speed and torque were low, and the current consumption high, or the fault symptom was low cranking speed, faulty field winding insulation could be the cause and this interpretation of the starting motor performance would justify disconnecting the earthed end of the field winding to enable a positive check to be carried out.

The field winding insulation can be checked (after disconnecting the winding at the yoke) by connecting a 110-volt a.c. 15-watt test lamp between the disconnected end of the winding and a clean part of the yoke. **The lamp should not light.** Ensure that neither of the brushes, or bare parts of their flexibles, contact the yoke during the test.

**Note:** Due to the very low resistance of the field coil conductors, the presence of a short-circuit between the field coil windings can only be determined by specialised equipment. If the results of all previous testing has been satisfactory, short-circuited field coil windings could be the cause of the fault and the field coil assembly should now be further proved by substitution.

**Renewing the field coils:** Disconnect the end of the field winding where it is riveted to the yoke. To do this, file away the riveted-over end of the connecting-eyelet securing rivet, sufficient to enable the rivet to be tapped out of the yoke. Remove the four pole-shoe screws with a wheel-operated or power-operated screwdriver and withdraw the field coil assembly from the yoke. Wipe clean the inside of the yoke, and the insulating pieces through which the through bolts locate.

Loosely fit the new field coil assembly (with pole-shoes) into the yoke, with the threads of the pole-shoe fixing screws only partially engaged. The through bolt insulating pieces should now be assembled into the yoke, by sliding the shoulders of the insulating pieces between the field coils and the yoke, in a position 180° apart and 90° each side of the field coil brush connection point (refer Fig. 4). Now tighten the pole-shoe screws progressively to a torque of 30 lbf ft (40.70 Nm). Finally, make a good earth connection between the end of the field winding and the yoke.

### (iv) Bearings

The armature bearings, fitted in the commutator end cover and the drive end fixing bracket, are self-lubricating porous-bronze bushes.

New bushes must be completely immersed in Shell 'Turbo 41' oil, or in clean engine oil, for 24 hours at room temperature, before they are fitted. Alternatively, if the lubricant is heated to a temperature of 100°C, 2-hours immersion of the bushes is sufficient, providing the lubricant is allowed to cool before the bushes are removed.

The bushes must **not** be reamed after fitting otherwise the self-lubricating qualities will be impaired.

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

Worn bushes should be removed by using a wheel-operated press. Alternatively, support the bearing housing and then with a mandrel carefully tap the bush out of the cover or bracket.

New bushes should be pressed into position by means of a shouldered polished mandrel with dimensions as follows:- commutator end cover bush 0.4377 in. (11.117 mm), drive end fixing bracket bush 0.4729 in. (12.011 mm).

### (v) The Roller Clutch Drive Assembly

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

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

### (vi) The Solenoid Unit

Associated with the solenoid plunger are three springs: the plunger and drive return spring, the drive engagement spring which is incorporated inside the plunger to overcome the difficulty of engaging the pinion on occasions of tooth-to-tooth abutment, and the 'lost motion' spring which is assembled to the connecting part of the solenoid plunger to provide a measure of lost motion in the drive operating mechanism as the drive commences to disengage. It is sufficient to check only that the springs are not broken. In the case of the drive engagement spring (inside the plunger), to check the spring it will be necessary to ensure that a spring-loaded pull action exists between the plunger body and the connecting part of the plunger.

Checking the solenoid contacts and winding is dealt with in 4 (a), para. iii and iv.

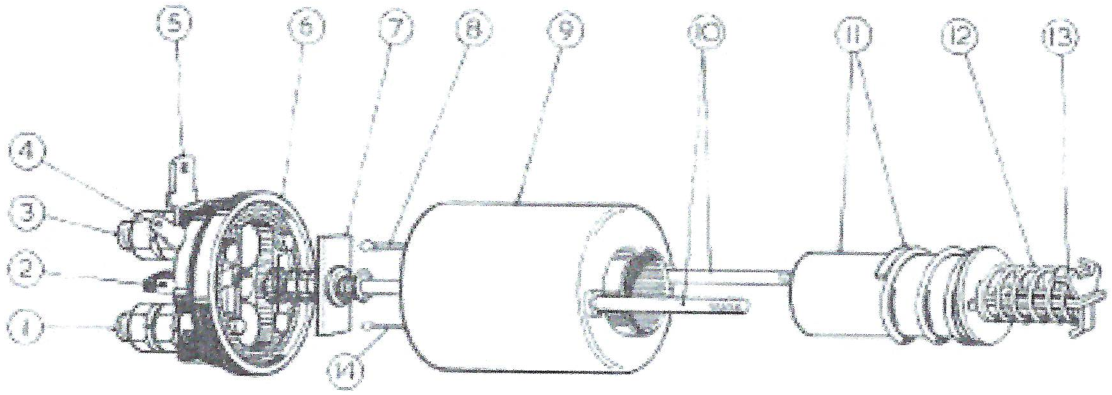


**Fig. 6 Solenoid model 19S, dismantled**

1 Main terminal 'STA'
2 Small 'Lucar' terminal
3 'IGN' Main input terminal
4 'Lucar' terminal (solenoid operating)
5 'Lucar' terminal (main external circuits)
6 Base assembly, comprising, fixed main contacts and ballast ignition 'IGN' contact
7 Moving spindle and contact assembly
8 Start of shunt and series windings ('Lucar' terminal solenoid operating)
9 Solenoid body
10 Solenoid fixing studs
11 Plunger and drive return spring
12 Lost motion spring
13 Spring retaining plate
14 End of series winding (main terminal 'STA')

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

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

## (d) Reassembly

Assembling the starter is simply a reversal of the dismantling procedure. Sequence of assembling components is illustrated in Fig. 1. Fitting the solenoid unit should take place after the commutator end cover has been fitted, otherwise it will be difficult to fit the block-shaped grommet which, when assembled, is compressed between the yoke, solenoid and fixing bracket.

Do not overlook refitting the internal thrust washer to the commutator end of the armature shaft (refer Fig. 1).

**Tightening torques**

| | |
|---|---|
| Through bolts | 8.0 lbf ft (10.84 Nm) |
| Solenoid-unit fixing stud nuts | 4.5 lbf ft (6.10 Nm) |
| Solenoid upper-terminal nuts | 3.0 lbf ft (4.1 Nm) |

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

**Armature end-float**

After completing the ssembly of the starter, drive the 'Spire' retaining ring on the armature shaft into a position which provides a maximum of 0.010 in. (0.25 mm) clearance between the retaining ring and the bearing bush shoulder.

Finally, fit the end cap seal to the commutator end cover.