SERVICE MANUAL FOR THE S130 SERIES STARTER MOTOR

TROUBLESHOOTING, DIAGNOSTICS AND REPAIR

Prestolite electric

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S130L STARTER MOTORS

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S130L STARTER MOTOR

INTRODUCTION

The starter motor is suitable for use with multi-cylinder high compression diesel engines of up to 14 litres capacity. Various mounting flange configurations are available to suit many different applications.

The starter motor is nominally 130mm (5,125in) in diameter and 433mm (17in) long. It is of co-axial construction, i.e., the two stage operating solenoid switch unit being mounted internally around the armature shaft. The entire range is splash and dust proof and oil sealed at the drive end. Only insulated return machines are available.

The starter is designed to enable the pinion to engage with the teeth of the flywheel under reduced power thus avoiding heavy engagement shock and excessive wear. Full power is applied only when the pinion is fully engaged. A mechanical locking device holds the pinion in full engagement until either the starter button is released or the overspeed is operated.

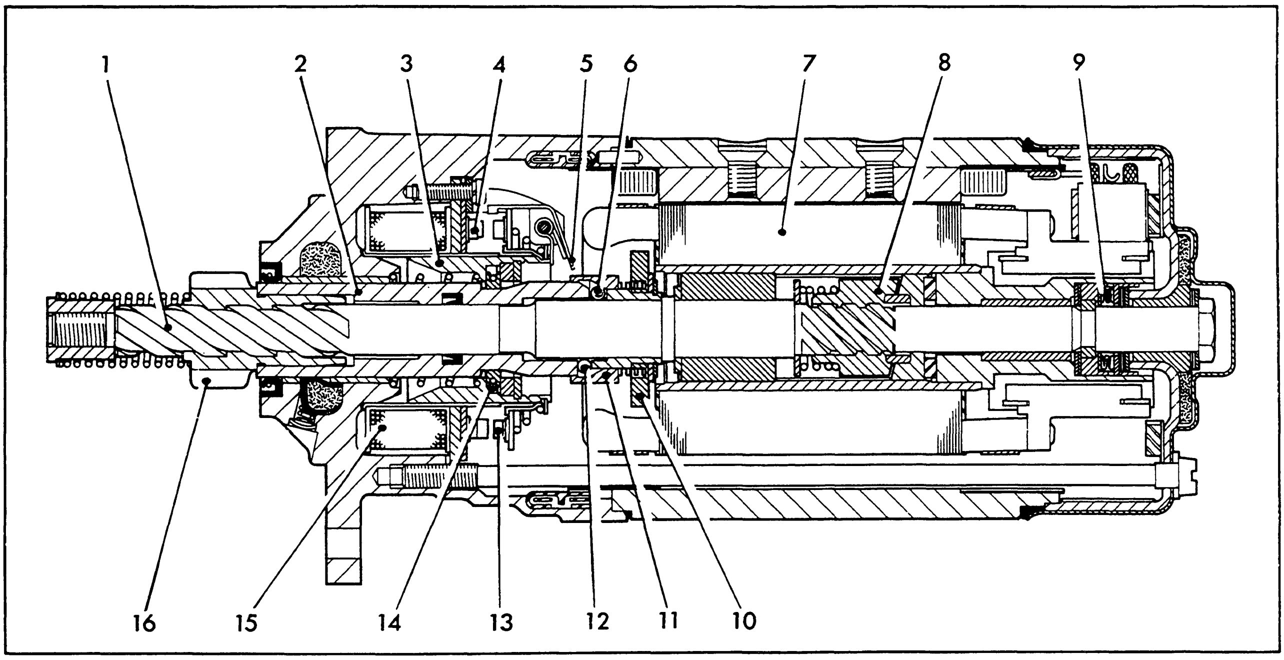
To prevent the armature being rapidly accelerated by the engine when it first starts, a ratchet device is included that allows the armature shaft to be accelerated independently of the armature. Overspeed protection is provided by a centrifugally operated release device which prevents the armature from being driven by the engine at excessively high speeds.

OPERATION

(See Fig 1)

When the starter solenoid(15) is energised, its hollow plunger(3) moves forward carrying four spring loaded steel segments which bear against the shoulder of the pinion sleeve(2) and move the pinion(16) forward.

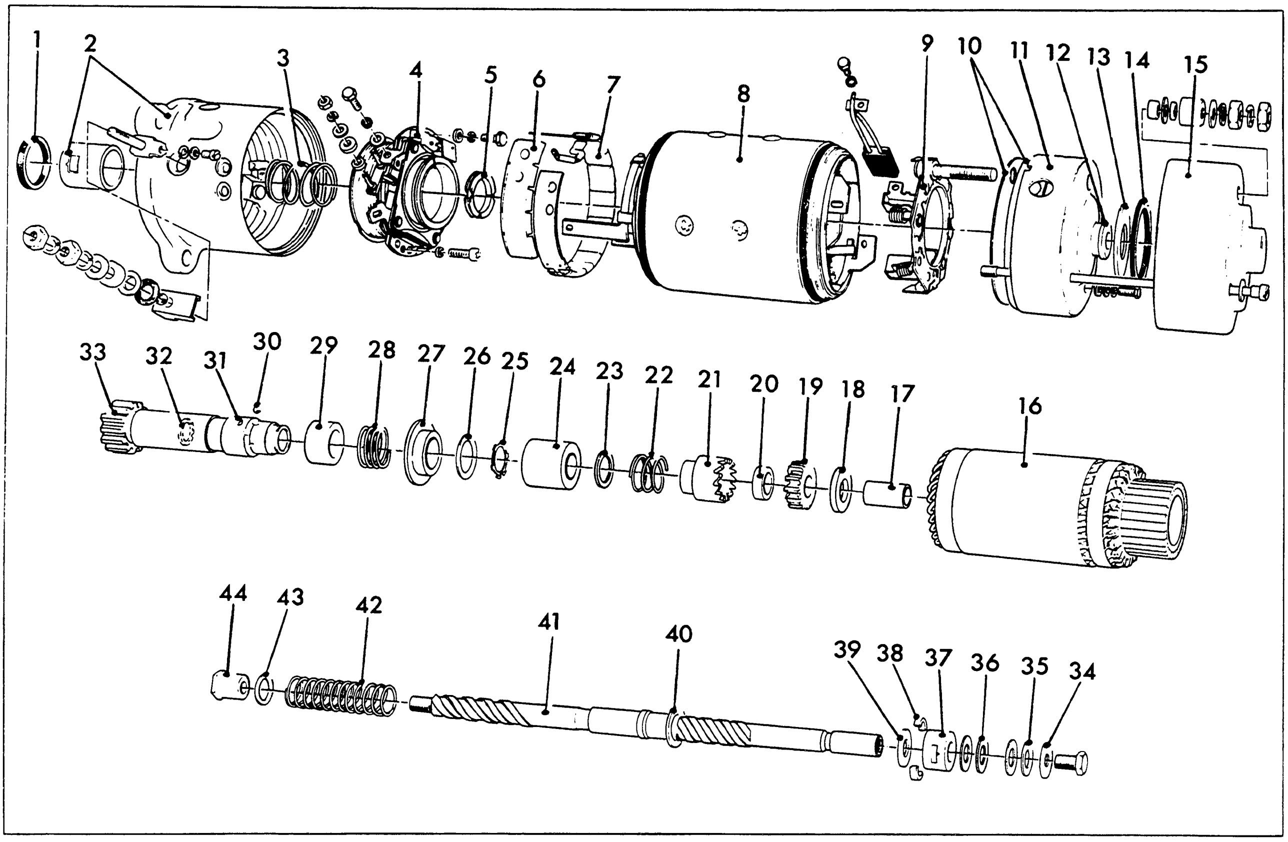
At the same time, the movement of the plunger closes the first stage contacts(13) and current is applied to the field and armature windings via a built in resistor. The resistor reduces the current flow to the windings with a result that the armature(7) rotates under reduced power and the pinion is driven into initial engagement with the engine flywheel by means of the armature shaft helix(1).



Key to Numbers:-

1. Armature shaft helix
2. Pinion sleeve
3. Solenoid plunger
4. 2nd Stage contacts
5. Switch trigger
6. Locking ball
7. Armature
8. Ratchet assembly
9. Recoil unit
10. Trip plate
11. Locking collar
12. Overspeed ball
13. 1st stage contacts
14. Spring loaded segments
15. Solenoid coil
16. Pinion

Fig 1. Section view of S130L Starter Motor



Key to Numbers:-

1. Oil seal – drive end shield
2. Bearing bush and drive end shield
3. Plunger return spring
4. Solenoid switch
5. Spring loaded segments
6. Insulator
7. Resistor
8. Yoke
9. Brush gear assembly
10. Insulating plate and strip
11. Commutator end shield
12. Bearing bush-commutator end shield
13. Lubrication pad
14. Rubber sealing ring
15. Commutator end cover
16. Armature core
17. Bearing bush-commutator
18. Thrust washer
19. Ratchet sleeve
20. Thrust ring
21. Ratchet
22. Ratchet spring
23. Thrust washer
24. Bearing – drive end
25. Circlip] fitted to late
26. Washer] type starters
27. Trip plate
28. Spring – locking collar
29. Locking collar
30. Locking ball
31. Overspeed ball
32. Oil seal
33. Pinion sleeve
34. Thrust washer
35. Shims – fitted between thrust washer and end shield bearing
36. Shims – fitted between recoil housing and end shield bearing
37. Recoil unit
38. Split collet
39. Spacing washer
40. Thrust washer
41. Armature shaft
42. Pinion return spring
43. Thrust washer
44. Pinion stop nut

Fig 2. Exploded view of S130L starter motor.

The pinion, prevented from rotating by the inertia of the engine flywheel, is then brought further into engagement by the action of the helix on the slowly rotating armature shaft. Just before the pinion becomes fully engaged, the trip plate(10) on the end of the pinion sleeve operates the switch trigger(5). This causes the second stage contacts(4) to close, short out the resistor and hence apply full battery power to the starter windings.

When the pinion is in full engagement with the flywheel, it is locked in position by four locking balls(6) located in holes in the pinion sleeve(2). These balls drop in front of the radiused shoulder on the shaft when the pinion has travelled fully forward and a spring loaded collar(11) slides over the balls to hold them in position. Thus the pinion cannot be ejected prematurely until the starter button is released or until the overspeed device operates.

As the pinion sleeve moves fully forward, a ramp on the sleeve(2) forces the four spring loaded segments(14) outwards where they are held in position by the magnetic field of the solenoid(15).

When the engine starts, the pinion is rapidly accelerated by the engine flywheel and the ratchet device(8) inside the armature now operates and allows the pinion to accelerate at a faster rate than the heavier armature. When the armature reaches the same speed as the pinion the ratchet ceases to operate.

Should the engine start to drive the armature at a speed in excess of the permitted maximum, then the overspeed device will operate. This consists of 4 overspeed balls(12) housed in the pinion sleeve(2) which at speeds between 10,000 to 13,000 r.p.m. exert sufficient centrifugal force on the inside ramp of locking collar(11) to push it backwards against the spring thus releasing the four locking balls from the annular groove in the armature shaft. The pinion is now driven backwards along the helix to its original position; the shoulder of the sleeve passing through the four steel segments still held outwards by the solenoid magnetic field. The starter will continue to run unloaded until the starter button is released.

If the starter is switched off before the overspeed device has operated the solenoid plunger(3), in moving back, pushes the locking collar backwards and releases the locking balls thus enabling the pinion sleeve to return to its original position.

In order to overcome the recurrence of a tooth to tooth abutment between the pinion and fly-wheel, the starter incorporates an armature recoil unit(9) comprising a recoil housing containing 'belleville' washers which are preloaded by a locking plate. This is fitted between the back of the armature and the commutator end bearing housing.

Whenever the pinion is prevented from rotating, the action of the helix on the slowly rotating armature shaft will be to force the armature back against the recoil mechanism thus compressing the 'belleville' washers. As soon as the starter button is released, the 'belleville' washers thrust the armature forwards. This forward movement, in conjunction with the shaft and pinion helices, frees the pinion and ensures that it takes up a new position for the next engagement.

DISMANTLING

COMMUTATOR END SHIELD

Clamp the starter horizontally in a suitable soft jawed vice as shown in Fig 3, gripping the yoke (9) only. The large terminal (1) Fig 4 at the commutator end should be at the 12 o'clock position.

Using the pinion holding tool, Part No. 6244-39, as shown in Fig. 3 to prevent the shaft from rotating, partially unscrew the left handed pinion stop nut (6) two or three turns only.

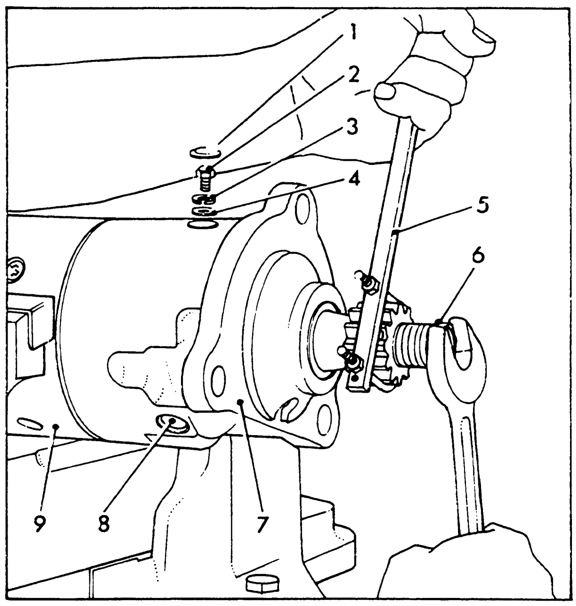
Note: on anti-clockwise rotation starters, the pinion stop nut has a right hand thread.

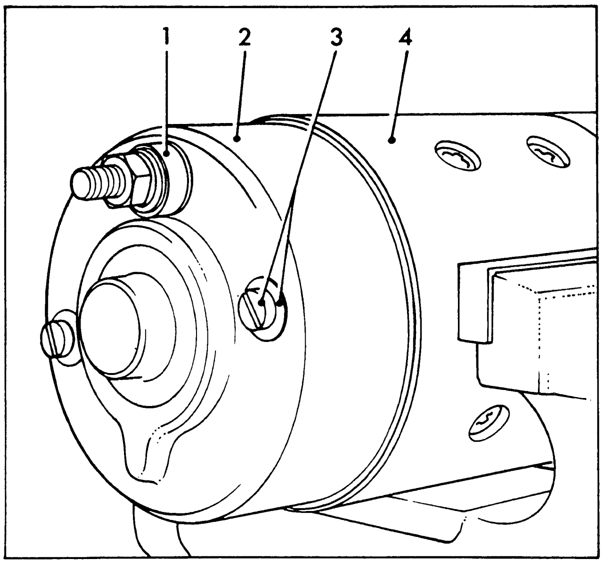
Key to Numbers:-

1. Core plug
2. Field terminal screw
3. Spring washer
4. Plain washer
5. Pinion holding tool, Part No. 6244-39
6. Pinion stop nut
7. Drive end shield
8. Core plug
9. Yoke

Fig 3 Method of removing pinion stop nut

Remove the two core plugs (1) and (8) shown in Fig 3 from the drive end shield with a sharp pointed tool and discard them. Unscrew and remove the two field terminal screws (2) together with the two spring washers (3) and plain washers (4).

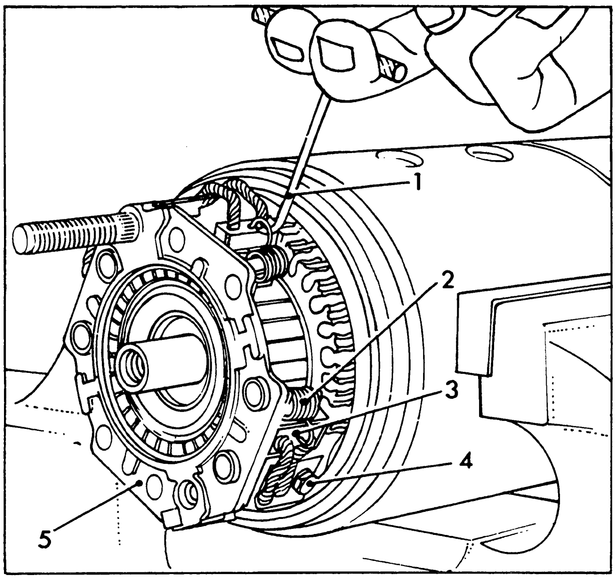




Key to Numbers:-

1. Return terminal assembly
2. Commutator end shield cover
3. Through bolt and sealing washer
4. Yoke

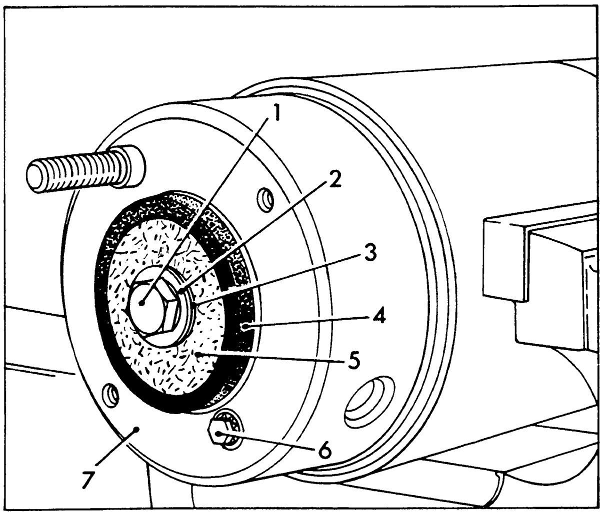
Fig 4 View of commutator end shield cover



Key to Numbers:-

1. Hooked tool
2. Brush spring
3. Brush
4. Screw-brush tag
5. Brushgear assembly

Fig 6 Removing brushgear



Key to Numbers:-

1. Retaining bolt — end shield
2. Thrust washer
3. Shims — fitted behind thrust washer
4. Rubber sealing ring
5. Felt lubrication pad
6. Hexagon headed screw
7. Commutator end shield

Fig 5 View of commutator end shield with cover removed.

To remove the commutator end shield cover (2) from the opposite end of the starter motor as shown in Fig 4, unscrew the lock nut from the return terminal assembly (1) and detach the spring washer, plain washer, seal locator, rubber seal, insulating bush and sealing joint.

Unscrew and remove the two through bolts (3) Fig 4 together with their sealing washers and lift off the commutator end shield cover (2) from the yoke (4).

Holding the pinion with tool, Part No. 6244-29 as illustrated in Fig 3, unscrew and remove the end shield retaining bolt (1) together with the thrust washer (2) and shims (3) as shown in Fig 5. Check the number of shims externally fitted behind the thrust washer and retain for use during assembly.

Remove the rubber sealing ring (4) and the felt lubrication pad (5) from the end shield, see Fig 5. Unscrew and remove the small hexagon headed screw (6) from the end shield together with the shake proof washer, plain washer and insulating bush.

Remove the commutator end shield from the yoke together with the insulating plate and strip (10) Fig 2, both of which should come away with the end shield.

During this operation one or more shims (36) Fig 2, internally fitted, may come away with the end shield. Any remaining shims can be left in the recoil housing until this is removed from the armature. Retain any shims removed for use during assembly.

BRUSH GEAR *(See Fig 6)*

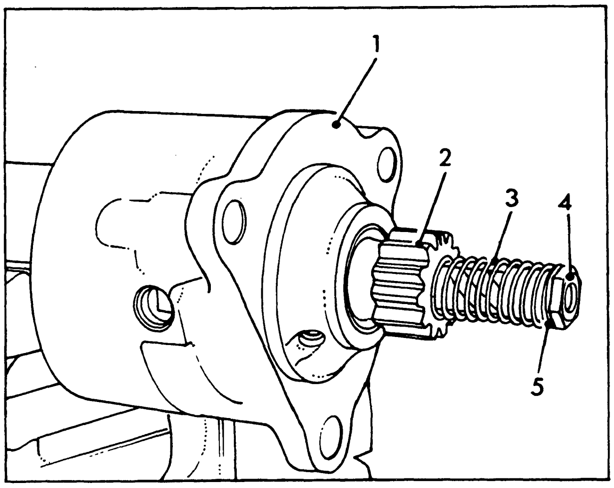
Using a hooked tool, similar to the one illustrated in Fig 6, lift each brush spring (2) in turn and remove the brush from its holder.

When fitted, detach the mica insulating strip from the top of each brush and retain for use during assembly.

Unscrew and remove the two brush tag screws (4) and spring washers which connect the positive brush leads and field coil connectors to the brush holders. The complete brushgear assembly (5) can now be removed.

ARMATURE DRIVE END SHIELD AND PINION ASSEMBLY *(See Figs 7 and 8)*

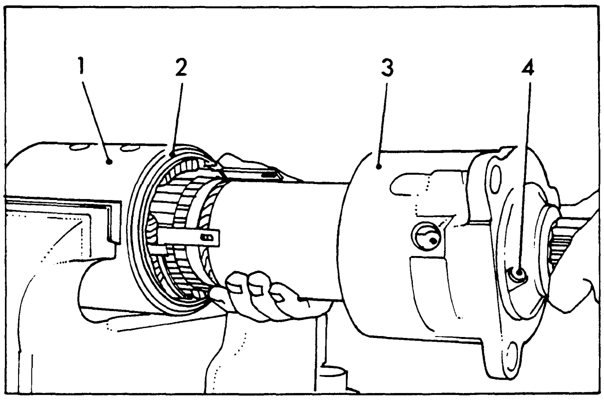
Tap the flange of the end shield (3) with a hide hammer or wooden mallet to separate the drive end shield from the yoke (1). Support the armature as shown in Fig 7, to avoid damaging the winding and commutator and withdraw the complete armature from the yoke. Remove and discard the rubber sealing ring (2).



Key to Numbers:-

1. Drive end shield
2. Pinion
3. Pinion return spring
4. Pinion stop nut
5. Thrust washer

Fig 8 View of drive end shield and pinion assembly



Key to Numbers:-

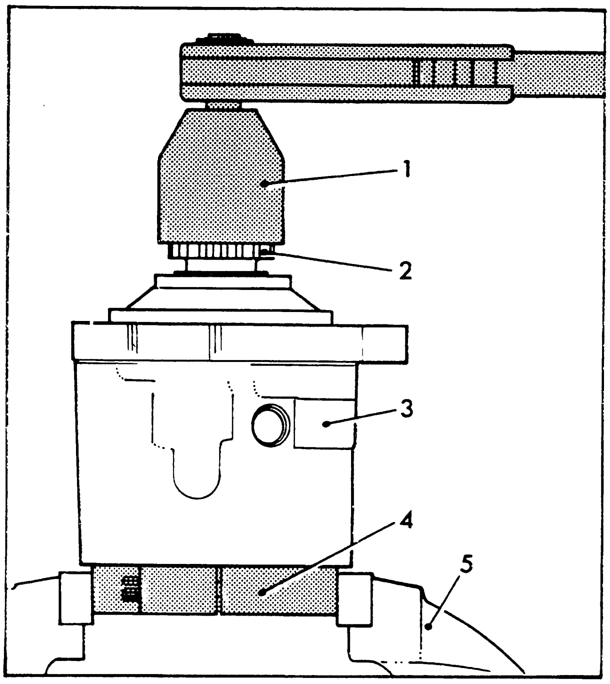
1. Yoke
2. Rubber sealing ring
3. Drive end shield
4. Oiler core plug and spring

Fig 7 Removing the drive end shield from the yoke.

Clamp the armature horizontally in a soft jawed vice and, using a pointed tool, remove the oiler core plug and spring (4) Fig 4. Discard the core plug. Remove the pinion stop nut (4) (previously slackened), thrust washer (5) and pinion return spring (3), see Fig 8.

To release the locking ball mechanism, see Fig 1, push the drive end shield towards the armature and unscrew the pinion sleeve along the helix of the shaft until it disengages. The pinion sleeve together with the drive end shield can now be withdrawn from the armature shaft. Finally, collect any of the eight steel balls which may fall through to the inside of the pinion sleeve or stick to the end of the armature shaft.

To remove the pinion sleeve from the drive end shield on late type starter motors, remove the circlip (2) Fig 2 plain washer (26) and trip plate (27) together with spring (28) and locking collar (29) from the rear end of the pinion sleeve (33). Withdraw the pinion from the drive end shield; and remaining steel balls should now be removed from the pinion sleeve.

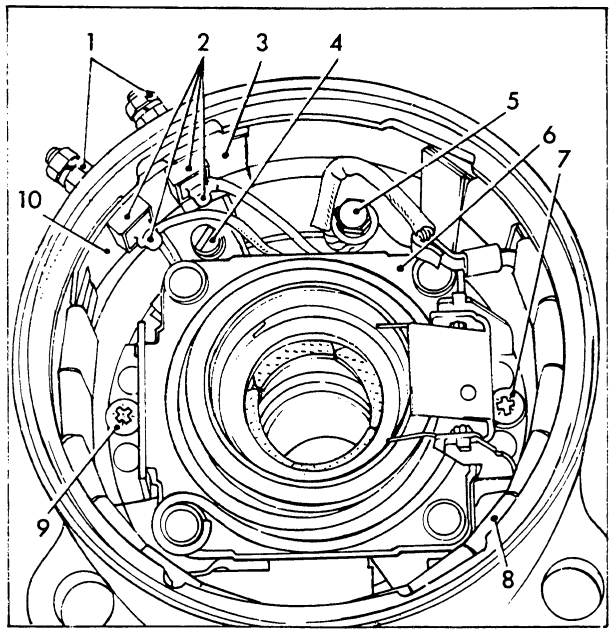


Key to Numbers:-

1. Socket tool, see 'SPECIAL TOOLS' list for appropriate size.
2. Pinion
3. Drive end shield
4. Clamp, tool Part No. 6244-50
5. Bench vice

Fig 9 Method of unscrewing trip plate on early type starters.

To remove the pinion sleeve from the drive end shield on early type starter motors, fit the clamp tool (4) Part No. 6244-50, as shown in Fig 9 over the trip plate boss and tighten the clamp screw to secure the tool in position.



Insert the drive end shield and clamp tool in the jaws of a vice as shown in Fig 9.

Using the appropriate sized socket tool (1), see 'SPECIAL TOOLS' list on page 27, unscrew the pinion two or three turns. Remove the assembly from the vice and remove the clamp tool, Part No. 6244-50 from the trip plate.

Unscrew and remove the trip plate together with the spring and locking collar. Remove the pinion sleeve from the drive end shield and remove any steel balls remaining in the pinion sleeve.

SOLENOID SWITCH UNIT *(See Fig 10)*

Remove the screw (5) connecting the flexible lead from the resistor to the moving contact switch.

Unscrew the terminal nuts (1) from the two solenoid terminals (2) and remove the nuts, spring washer, plain washer, nylon bush and rubber sealing ring from each terminal.

> **Note: There are three solenoid terminals on machines for single and dual start operation that employ a starter protection unit for automatic start applications.**

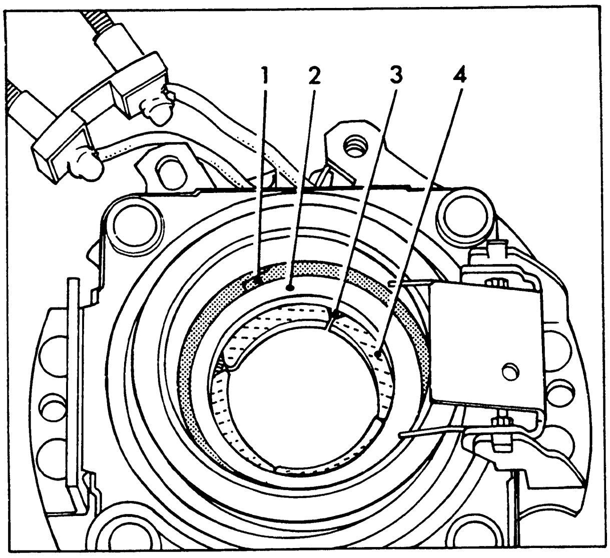
Pull the solenoid terminals (2) inwards so that they are clear of the resistor plate and remove the resistor together with the leatheroid insulator from the drive end shield.

Unscrew and remove the main terminal screw (4), spring washer and plain washer. Remove the two 'Posidrive' screws (7)-(9) with their spring washers. Withdraw the complete solenoid switch assembly from the drive end shield and lift out the plunger return spring.

Key to Numbers:-

1. Terminal nuts, spring washer, plain washer, nylon washer and rubber sealing ring.
2. Solenoid insulators and terminals.
3. Leatheroid insulator
4. Main terminal screw, spring washer
5. Screw – connecting flexible lead from resistor to moving contact switch.
6. Switch assembly
7. 'Posidrive' screw and spring washer
8. Resistor
9. 'Posidrive' screw and spring washer
10. Resistor plate

Fig 10 View of terminal connections and screws locating solenoid switch unit.



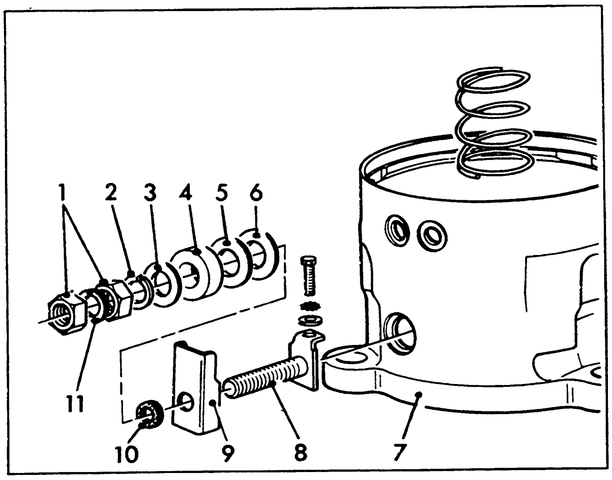
Key to numbers:-

1. 'Spirolox' circlip
2. Segment retaining washer
3. Retaining spring
4. Segments

Fig 11 View of solenoid plunger segments

Using a thin bladed screw driver, remove the 'Spirolox' circlip (1) as shown in Fig 11, by levering the end inwards and then winding it out of its groove.

Lift out the segment retaining washer (2) and the four segments (4) together with their retaining spring (3).



Key to Numbers:-

1. Locknuts
2. Spring washer
3. Plain washer
4. Seal locator
5. Insulating washer
6. Sealing washer
7. Drive end shield
8. Main terminal
9. Moulded insulator
10. Rubber seal
11. Spring washer

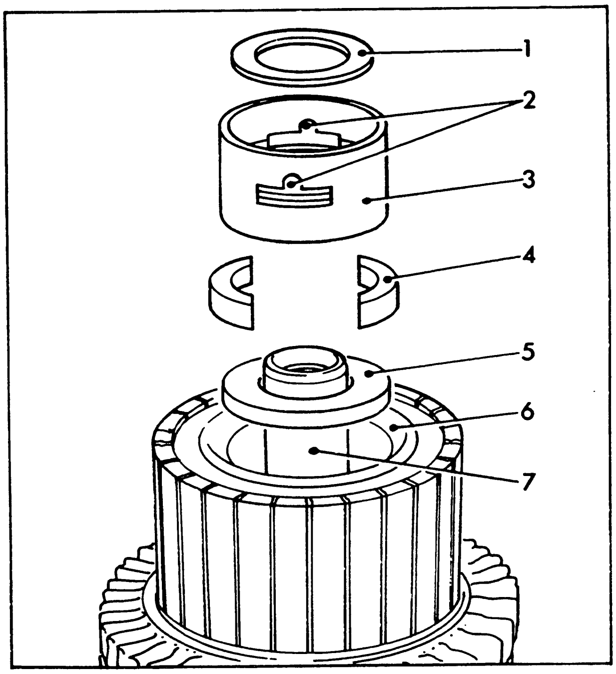
Fig 12 Exploded view of drive end shield main terminal assembly.

To remove the main terminal from the drive end shield as shown in Fig 12, unscrew and remove the two locknuts (1), spring washers (2) and (11), plain washer (3), seal locator (4), insulating washer (5), and sealing washer (6).

Withdraw the main terminal from inside the end shield complete with rubber seal (10) and moulded insulator (9).

ARMATURE *(See Figs 13 and 14)*

To remove the shaft from the armature assembly, lightly clamp the shaft vertically in a soft jawed vice so that the commutator is uppermost as shown in Fig 13.

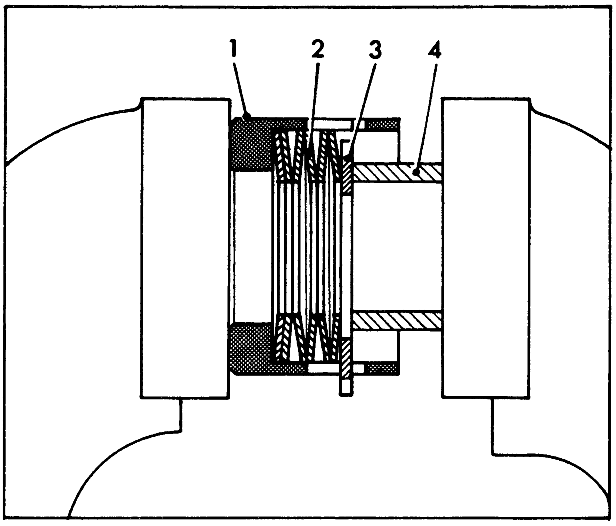


Key to Numbers:-

1. Shims
2. Withdrawal holes
3. Recoil unit
4. Collet
5. Thrust washer
6. Commutator sleeve
7. Armature sleeve

Fig 13 Exploded view of recoil unit and collets retaining the armature shaft.

Remove the recoil unit (3), together with the shims (1), from inside the commutator sleeve (6). If the recoil housing is too tight in the sleeve, two holes are provided in the wall of the housing to allow it to be removed with a pair of hooked implements.



Key to Numbers:-

1. Recoil housing
2. "Belleville" washers
3. Lockplate
4. Suitable length of tube on bar

Fig 14 Method of compressing "Belleville" washers

Slide the two collets (4) Fig 13 outwards from the groove in the shaft, the armature can now be removed with a twisting motion.

Remove the two collets (4) Fig 13 and the thrust washer (5) from inside the commutator sleeve (6).

Note: On early type machines, shims may be fitted under the thrust washer.

Retain all shims and thrust washers for future use when assembling. Remove the shaft from the vice.

To dismantle the recoil unit, compress the "Belleville" washers (2) slightly in a vice using a suitable pice of bar or tube (4) as shown in Fig 14.

The lock plate (3) can then be tapped sideways until the tongue on one side is clear of the groove in the wall of the housing. Release the tension and lift out the lock plate and "Belleville" washers.

COMPONENT INSPECTION AND RENEWAL

ARMATURE

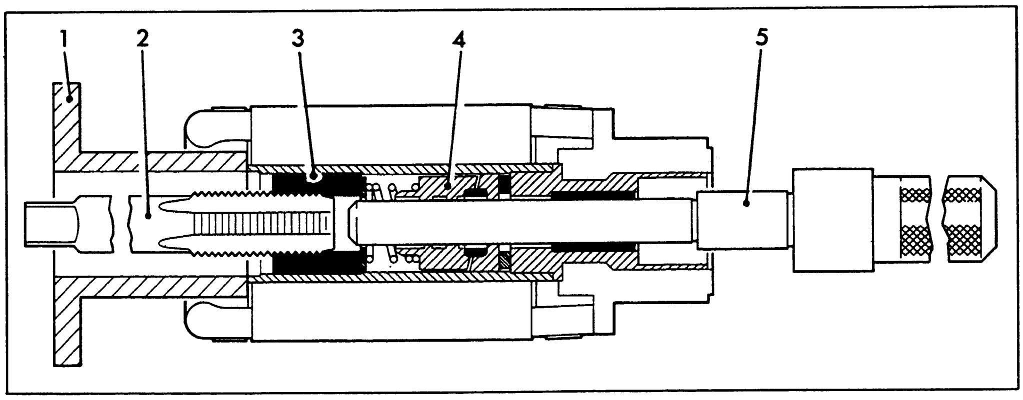
Examine the armature windings visually for damage to the insulation. Ensure that the binding at each end of the windings is secure and in good condition.

Before testing the insulation, remove all traces of brush dust etc, with dry compressed air.

Test the windings for continuity, shorted turns and insulation with a "Growler" armature testing machine.

Check the drive and commutator end bearing bushes for wear by measuring their internal diameters. The maximum permissible bore size is 20,075 mm (0,790 in) for the drive end bearing bush and 16,118 mm (0,635 in) for the commutator end bearing bush. If the internal diameter of either bush is greater than these limits, both must be renewed.

Note: Before removing or pressing in bushes the armature should be supported on suitable diameter mounting blocks or thick bore tubes. These should have an internal diameter to enable the bushes to pass freely through the mounting blocks and also have an outside diameter to enable each tool to be inserted into their respective drive and commutator ends of the armature, as illustrated in Figs. 15 and 16. Compliance with these instructions will preclude the possibility of distortion to the armature windings and also the commutator segments from the force exerted by the press.



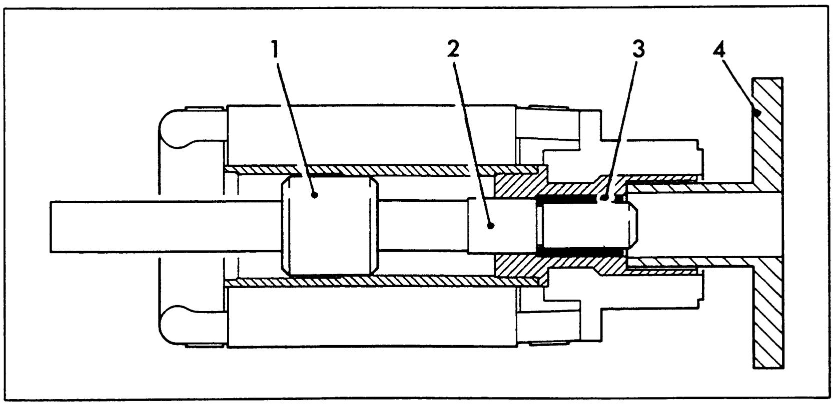
Key to Numbers:-

1. Mounting block – armature support.
2. Tap, tool Part No. 6244-32.
3. Drive end bearing bush.
4. Ratchet assembly
5. Pin tool, Part No. 6244-31.

Fig 15 Method of removing armature drive end bearing bush.

To remove the drive end bearing bush (3), tap a thread into the bush using tool, Part No. 6255-32 as shown in Fig 15. Leave the tap (2) in position and press out the bush from the commutator end using tool, Part No 6244-31.

Remove the complete ratchet assembly (4), see Fig 15 from inside the armature. Examine the ratchet components for signs of excessive wear and renew any parts as necessary.



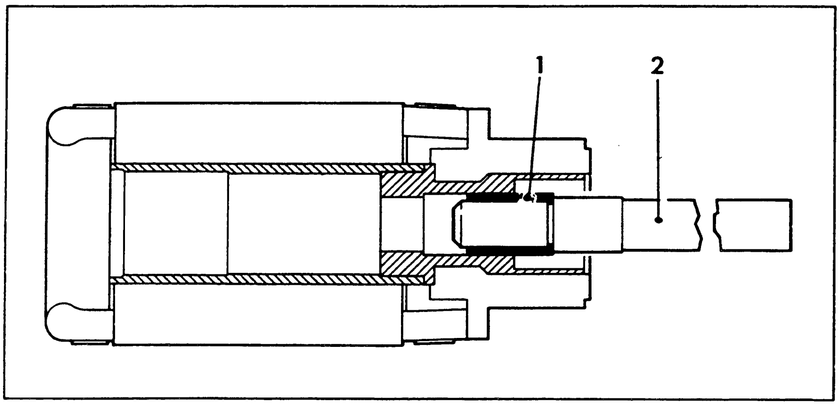
Key to Numbers:-

1. Guide tool, Part No. 6244-36
2. Pin tool, Part No. 6244-37
3. Commutator end bearing bush.
4. Mounting block – armature support.

Fig 16 Method of removing commutator end bearing bush.

To remove the commutator end bearing bush (3), insert the spigot end of tool, Part No. 6244-37 into the bush as shown in Fig 16, slide the guide tool, Part No. 6244-36 over the shaft to locate in the armature housing and press out the bush (3) from the drive end.

Note: On early machines, the commutator end bush as illustrated in Fig 18 can be removed inwards towards the drive end either by using a suitable extractor or alternatively it can be removed by driving it out with a sharp pointed implement.

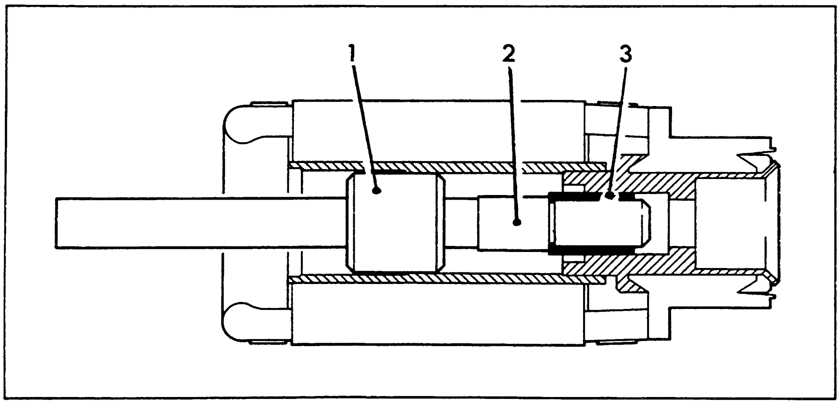


Key to Numbers:-

1. Commutator end bearing bush
2. Spindle tool, Part No. 6244-37.

Fig 17 Method of pressing in commutator end bearing bush.

To fit a new commutator end bearing bush (1), place the bush on the spigot end of the spindle tool (2), Part No. 6244-37 as shown in Fig 17 and press the bush into the commutator bearing housing.



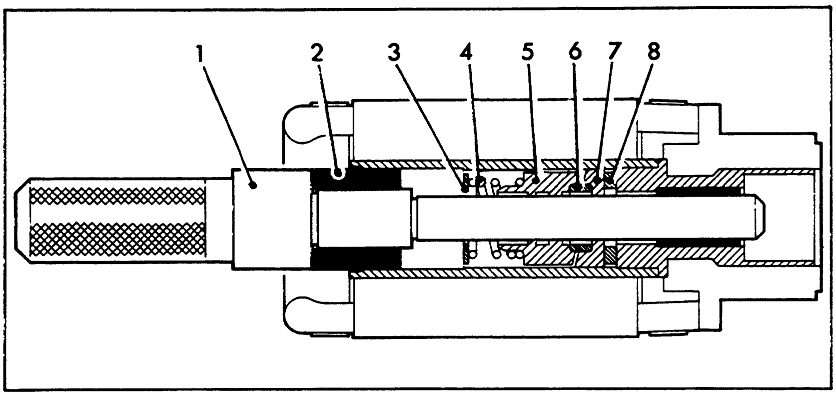
Key to Numbers:-

1. Guide tool, Part No. 6244-36
2. Spindle tool, Part No. 6244-37
3. Commutator end bearing bush

Fig 18 Method of pressing in commutator end bearing bush on early machines.

Note: On early machines, the commutator end bush (3) as illustrated in Fig 18 is positioned on the spigot end of the spindle tool, (2), Part No. 6244-37 and the guide tool (1), Part No. 6244-36 slid over the shaft.

Place the assembly tool into the armature so that the commutator bush is just entered into the bearing housing and the guide is in position in the drive end housing. Apply pressure to the end of the pin to press the commutator bush fully home.



Key to Numbers:-

1. Spindle tool, Part No. 6244-31
2. Drive end bearing bush
3. Thrust washer
4. Ratchet spring
5. Ratchet
6. Thrust ring
7. Ratchet sleeve
8. Thick thrust washer

Fig 19 View of rachet assembly and method of pressing in drive end bearing bush.

Lightly smear the ratchet components, see Fig 19 with Aero Shell 16 grease, then assemble them into the armature in the following order:- Thick thrust washer (8), ratchet sleeve (7), thrust ring (6), ratchet (5), spring (4) and thin thrust washer (3). The teeth on the sleeve and ratchet must be in mesh.

To fit a new drive end bearing bush (2), see Fig 19, position the bush on the spigot end of the spindle tool (1), Part No 6244-31 and insert the spindle through the ratchet assembly into the armature end bush. Apply pressure to the end of the spindle until the drive end bush is pressed fully home. The force required will be between 3000 and 6000 Kgf (3 to 6 tonf).

Before fitting the armature shaft examine for signs of damage or excessive wear; pay particular attention to the ratchet and pinion helices for sharp edges and the shoulder of the annular groove for the steel locking balls.

A dirty or discoloured commutator can be cleaned with a fine grade of glass paper: **emery or carborundum paper must not be used.**

Where the commutator is pitted or grooved, the armature should be set up in a lathe and the commutator skimmed. A rough cut should be taken to remove all traces of pitting and grooving and then a light cut taken with a diamond tipped tool to achieve the ring finish required.

Note: The commutator must be concentric with the armature bearing bushes to within ± 0,05 mm (0,002 in). The minimum diameter to which the commutator can be skimmed is 58,90 mm (2,319 in).

The full width of the commutator segment insulators should be undercut to a minimum depth of 1 mm (0,040 in).

BRUSHGEAR

Inspect the complete brushgear assembly visually for any signs of damage. Ensure that all brush boxes are securely riveted in position and that the insulators under two of the boxes are not cracked or chipped. Remove all traces of brush dust etc., with dry compressed air, then test the insulation between positive and negative brush boxes with a 100V 'Megger' or similar test instrument. A reading of 1 Megohm should be obtained.

Check that all threads are undamaged and that brush springs are in good condition and correctly located.

Examine brushes and renew them if they are damaged or less than 10 mm (0,390 in) in length. It is recommended that all brushes are renewed when the starter is being completely overhauled. New brushes should be 'bedded in' as follows:-

Insert the new brushes into their holders and temporarily position the complete brushgear assembly into the end shield. Secure it in place with the return terminal nut and the smaller hexagonal headed set screw.

Wrap the commutator with a strip of fine galsspaper (abrasive side out) and secure it with adhesive. Place the commutator end shield onto the armature shaft, while lifting the brushes to clear the commutator. With the armature held in a suitable clamp and the springs pressing the brushes against the commutator, rotate the commutator end shield slowly, thus sanding the end faces of the brushes to match the curvature of the commutator. When 80% of the contact area conforms to the commutator curvature, remove the glasspaper and clean the commutator, brush faces and commutator bearing of all carbon and abrasive dust.

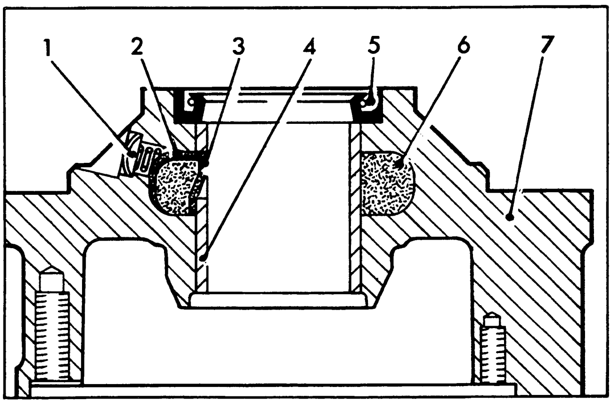
Note: Before assembling the commutator end shield onto the armature shaft, the shaft must be assembled into the armature – see under heading 'ARMATURE SHAFT' on page 19.

DRIVE END SHIELD

Remove the oil seal (5) from the drive end shield (7) by levering out and discard the seal, see Fig 20.

Inspect the drive end shield casting visually for any cracks, damage to the sealing ring recess at the yoke end or damage to the mounting flange.

Inspect the bore of the bearing bush (4) for wear and measure the internal diameter. If the bore size exceeds 32,10 mm (1,264 in) the bearing must be removed as follows:



Key to Numbers:-

1. Oiler core plug and spring
2. Leatheroid pad for spring
3. Leatheroid pad (temporary fitting only)
4. End shield bearing bush
5. Oil seal
6. Felt wick
7. End shield

Fig 20 Section of drive end shield assembly

Remove the oiler sealing plug and spring (1). Press out the bush from the end shield using tool, Part No. 6244-41 and discard the rectangular shaped felt wick (6).

Fit a new wick in position so that it is in line with the oiler hole.

To prevent swarf from getting onto the felt wick during the pressing in of the bush, it is recommended that a thin piece of leatheroid is fitted into the rectangular cut-out in the bush as follows:-

Slide the bush over a suitable mandrel held horizontally in a vice. Place a piece of leatheroid over the cut-out in the side of the bush and tap all round the edge of the aperture with a light hammer. The leatheroid pad (3) will be cut exactly to size and will fit snugly in position.

Insert the split retaining collar tool, Part No. 6244-42 into the bore of the drive end shield, to keep the felt wick (6) in position and press in the new bush (4) with tool, Part No 6244-41.

With the drive end shield under the press, flange uppermost, place the new bush in position so that the rectangler cut-out is at the top and in line with the oiler hole. Press the bush fully home with tool, Part no. 6244-41 until the top of the bush is flush with the bottom of the oil seal counterbore as shown in Fig 20.

The felt wick retaining collar tool, Part No. 6244-42 will be pushed out of the drive end shield during this operation.

Mount the end shield in a lathe and centre it until the bore of the oil seal recess is concentric to within 0,15 mm (0,006 in). Fine bore the bush to give an internal diameter of 32,08 to 32,05 mm (1,263 to 1,262 in).

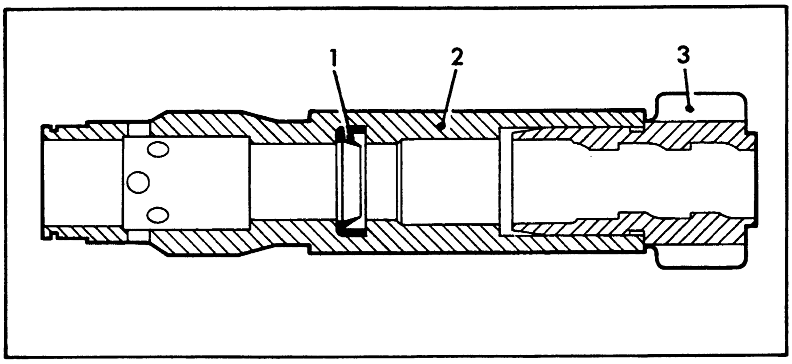
Remove the leatheroid pad (3) from the rectangular cut-out in the bush and press in a new oil seal (5) with the lip of the seal facing outwards as shown in Fig 20.

PINION SLEEVE

Examine the bearing surfaces of the pinion sleeve (2) for signs of excessive wear or damage. The oil seal (1) in the bore of the sleeve should be renewed when a complete overhaul is being undertaken.

Using a hooked tool to extract the oil seal from the pinion sleeve, withdraw the seal from the end opposite to the pinion. Fit a new seal into the bore from the same end with the lip of the seal, facing towards the pinion (3) as shown in Fig 21. Ease the seal into its groove using a round ended tool that will not damage the seal.

If the pinion teeth shows signs of damage or excessive wear, the complete pinion must be renewed. The new pinion complete with oil seal is available as an assembly.



Key to Numbers:-

1. Oil seal
2. Pinion sleeve
3. Pinion head

Fig 21 Position of pinion sleeve oil seal

SOLENOID SWITCH UNIT

Inspect the complete unit visually for any signs of damage or excessive wear, paying particular attention to the insulation of the coil and coil leads. Ensure that all insulating bushes are undamaged and that rivets are tight.

Coil continuity can be checked with a test instrument such as an 'Avometer', using one of the resistance ranges. Alternatively a low voltage battery and lamp wired in series can be employed.

Test the coil insulation with a 100 volt 'Megger' or similar insulation tester. A reading of over 1 megohm should be obtained between coil leads and plunger sleeve.

Should the coil (7) prove to be faulty, then the complete solenoid and switch assembly must be renewed.

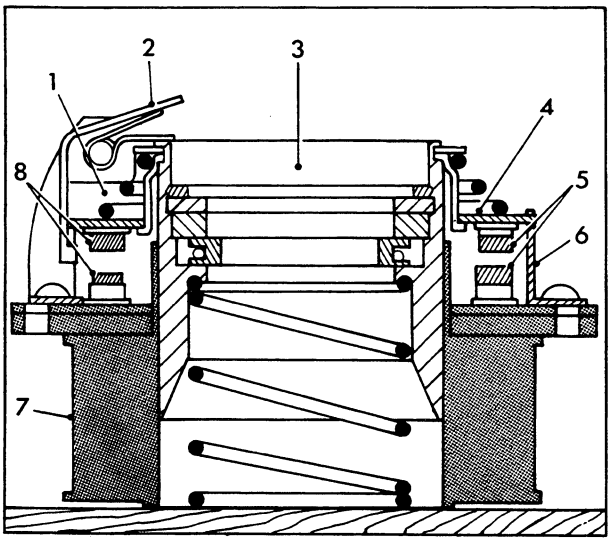
To check that the switch is operating correctly, stand the plunger return spring on the bench and place the solenoid switch unit over it, coil downwards, as shown in Fig 22.

Apply downward pressure to the top of the plunger (3) and check that the first stage contacts (5) close. While still maintaining the pressure, depress the trigger (2); the second stage contacts (8) should now snap together. Hold the coil down onto the bench and then release the downward pressure on the plunger; the moving contact plate (4) should be moved upwards by the plunger return spring so that it latches behind the step on the trigger (2).

Check the condition of both first and second stage contacts. If necessary, clean them with very fine carborundum paper then wipe them over with white spirit. Should the contacts be excessively burnt or pitted they must be renewed.

The solenoid switch can be exchanged as a replacement unit, alternatively the moving contact plate can be renewed as follows:-

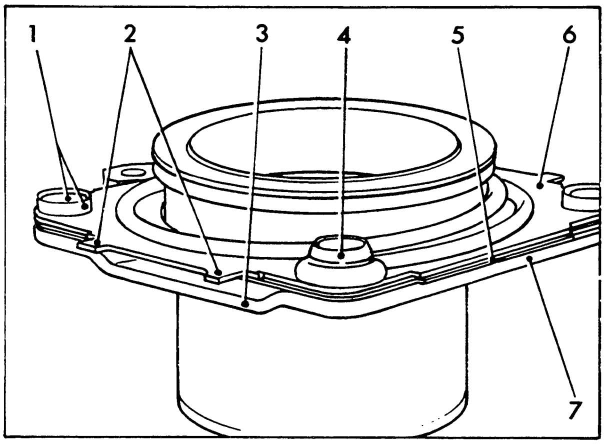
Spring the two arms of the trigger guide (1) apart and remove the trigger (2) complete with spring and spindle.



Key to Numbers:-

1. Trigger guide
2. Trigger
3. Plunger
4. Moving contact plate
5. First stage contacts
6. Contact stop
7. Coil
8. Second stage contacts

Fig 22 Method of checking operation of solenoid switch unit.



Key to Numbers:-

1. Rivet and insulating bush
2. Lips on latch plate
3. Second stage contacts
4. Long insulating bush
5. Insulator
6. Latch plate
7. Moving contact

Fig 23 Switch moving contact assembly

Using a 6 mm (0,197 in) drill, remove the underside of each of the four rivets (1) Fig 23 retaining the contact stop (6) and trigger guide (1) shown in Fig 22. Knock out the rivets using a pin punch and remove contact stop and trigger guide. The moving contact and plunger assembly can now be removed followed by the fixed contact plate.

Using a 5 mm (0,197 in) drill, remove the underside of each of the four rivets holding the moving contact assembly (7) together, see Fig 23. Knock out the rivets using a pin punch. The moving contact and insulator (5) can now be removed from the latch plate (6).

When fitting the new moving contact, first assemble the insulator and moving contact to the latch plate ensuring that the second stage contact is adjacent to one of the two lips on the latch plate as shown in Fig 23. Insert each of the four new rivets through one of the insulating bushes (1) and then through the latch plate, insulator and moving contact.

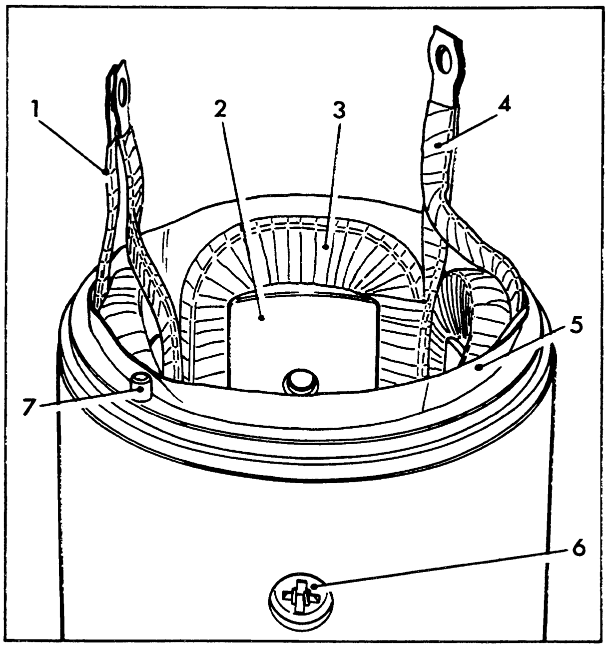
Note: Ensure that the long insulating bush (4) is passed through the spring eye and that it is in the position shown.

Support the rivet heads and spin, or punch, the other end of the rivets over.

When assembling the complete switch unit place the fixed contact plate onto the coil ensuring that the angled slot locates over the raised moulded part of the coil bobbin cheek.

Lightly smear the outside diameter of the plunger and the bore of the coil tube with Aero Shell 16 grease, then place the plunger into the coil tube and position the moving contacts so that they align correctly with their fixed counterparts.

Position the trigger guide adjacent to the second stage contacts and insert two rivets through trigger guide, moving contact plate and fixed contact plate. Invert the assembly and support the rivet heads on a suitable support while the other end of the rivets are spun or punched over.



Key to Numbers:-

1. Field coil connector
2. Pole shoe
3. Field coil
4. Field coil connector
5. Leatheroid strip
6. Pole screw
7. Dowel Pin

Fig 24 View of field coils and connectors

Place the contact stop in position and secure this with two rivets as already described.

Offer up the trigger assembly so that the spring ends rest on top of the plunger, then spring it into position between the guide arms, ensuring that the ends of the spindle enter correctly into the two holes.

Check the operation of the complete unit as already described.

Examine the four segments (4) Fig 11 for signs of wear or cracking and, if necessary, renew all segments together with their spring as a complete assembly.

Check each pole shoe is in its correct position with the stamped number on the end facing towards the drive end of the yoke.

Viewed from the drive end, the first pole shoe past the dowel pin when proceeding in a clockwise direction should be No. 3. This should be followed by Nos. 4, 1 and 2.

Secure each pole shoe with two screws, finger tight only at this stage. Position the two leatheroid strips under the field coils. One strip at each end of the yoke, ensuring that they are not trapped under the pole shoes, then tighten all eight pole shoe screws fully with a pole shoe screwdriver.

FIELD COILS

Inspect the field coil insulation and the insulating strip at both ends of the yoke visually for any signs of damage. Test the insulation with a 100 volt 'Megger' or similar test instrument. A reading of over 1 Megohm should be obtained between each field coil connection and the yoke.

Note: Before testing the insulation, remove all traces of brush dust etc., with dry compressed air.

If it is required to remove the field coil assembly (3), proceed as follows:-

Make a careful note of the position of both long field coil connectors (1) and (4), relative to the dowel pin (7) at the drive end of the yoke, see Fig 24.

Using a pole shoe screwdriver, unscrew and remove the eight pole screws (6) securing the pole shoes to the yoke. The field coils and poles shoes (2) can then be removed together with both leatheroid strips (5).

When replacing the field coils into the yoke, refer to the notes made when dismantling and ensure that the long connectors at the drive end are in the correct position relative to the dowel pin.

COMMUTATOR END SHIELD

Ensure that the bearing (2) Fig 25 is tight in its housing. Inspect the bore of the bearing for wear and measure the internal diameter. If the bore size exceeds 16,087 mm (0.633 in) the bearing must be renewed as follows:-

Mount the end shield (1) on a bench press and using Tool, Part No. 6244-1, press out the bearing.

To press in a new bearing, invert the end shield so that the centre boss is supported on a suitable mounting block as shown in Fig 25, and press the new bearing into the end shield.

Inspect the insulating plate (3) and insulating strip (4) visually for damage and renew if necessary. Secure the new insulating plate or strip into position with "Bostik" clear adhesive No. 1437.

Ensure that the holes in the insulating plate and strip align correctly with the holes in the end shield and that the insulating strip does not protrude into the spigot recess (5).

Key to Numbers:-

1. Commutator end shield
2. Bearing-commutator end shield
3. Insulating plate
4. Insulating strip
5. Spigot recess
6. Mounting block

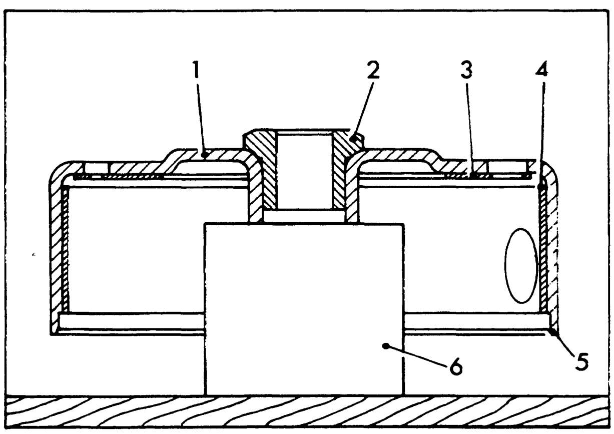
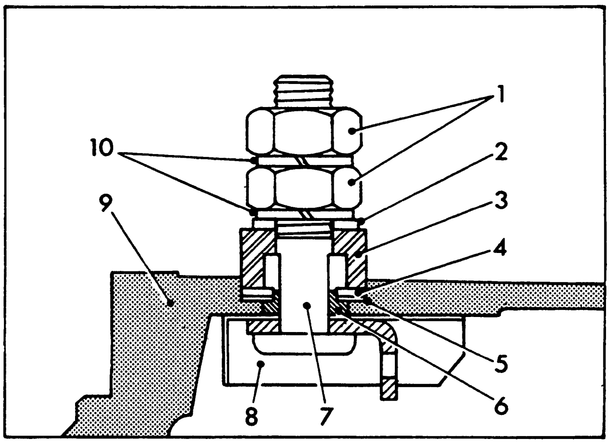


Fig 25 Method of pressing in commutator end shield bearing.



Key to Numbers:-

1. Locknuts
2. Plain washer
3. Seal locator
4. Insulating washer
5. Sealing washer
6. Rubber sealing ring
7. Terminal
8. Moulded insulator
9. Drive end shield
10. Spring washers

Fig 26 Section view of drive end shield main terminal assembly.

Note: In accordance with normal workshop practice, it is recommended that all sealing devices and locking washers are renewed during assembly.

MAIN TERMINAL

To assemble the main terminal (7) to the drive end shield (9), place the moulded insulator (8) over the terminal the correct way round as shown in Fig 26 and slide the rubber sealing ring (6) on to the terminal.

Insert the terminal from inside the drive end shield through the hole with the large counterbore on the outside of the casing.

Assemble onto the terminal in the following order, the thin sealing washer (5), insulating washer (4), seal locator (3), plain washer (2), spring washer (10) and locknut (1). Tighten the nut to the correct torque value of 12,2 to 13,6 Nm (1,244 to 1,383 Kgf m or 9 to 10lbf ft. Fit the second spring washer onto the terminal and screw on the nut finger tight.

SOLENOID SWITCH UNIT

Before assembly ensure that segments (2), spring retaining washer (3) and inside of plunger are clean and free from oil or grease.

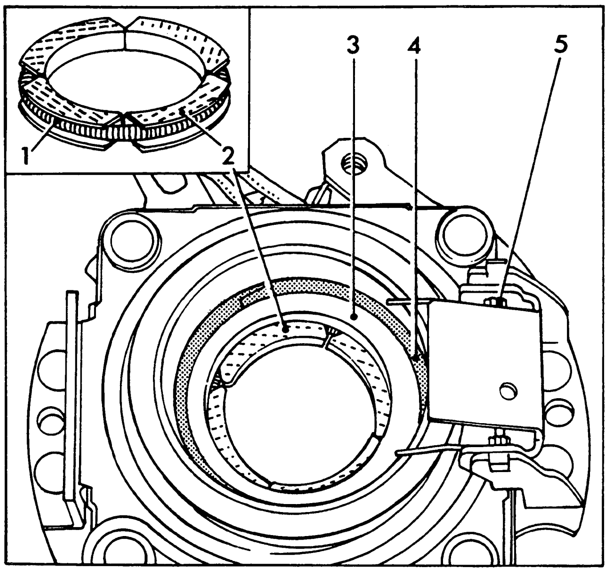
Assemble the segment spring round the four segments to form a circle as shown in Fig 27.

Place the segments centrally into the solenoid plunger and place the retaining washer (3) on top so that the triangular projections on the underside of the washer engage with the gaps between the segments. The slot in the washer must locate over the projection in the wall of the plunger recess to prevent the retaining washer and segments rotating with the pinion.

With the segments and washer correctly positioned, insert the "spirolox" circlip (4) into the groove in the plunger bore and lock the assembly into the plunger housing.

Smear with a light coating of Aero Shell 16 grease the trigger spring and trigger spindle (5), see Fig 27, and the solenoid plunger return spring, see Fig 2.

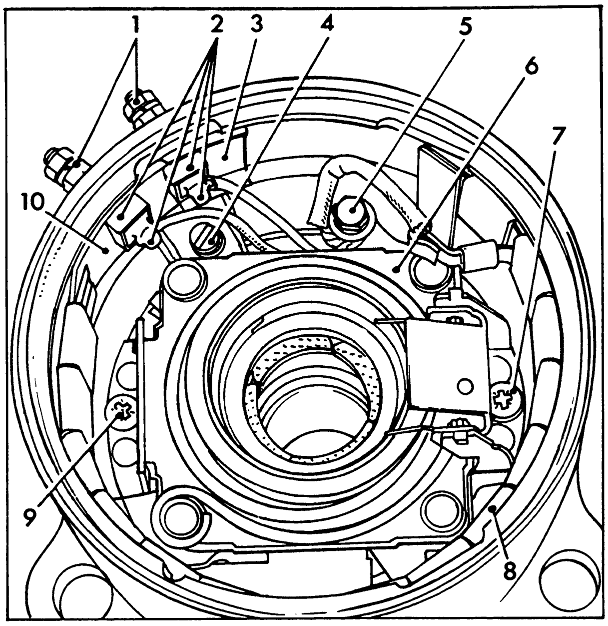
Insert the plunger return spring into the drive end shield followed by the solenoid switch unit.



Key to Numbers:-

1. Spring
2. Segment
3. Retaining Washer
4. "Spirolox" circlip
5. Trigger spindle and spring

Fig 27 Assembling segments to solenoid plunger.



Key to Numbers:-

1. Terminal nuts, spring washer, plain washer, nylon bush and rubber sealing ring
2. Solenoid insulators and terminals
3. Leatheroid insulator
4. Main terminal screw, spring washer and plain washer
5. Screw – connection flexible lead from resistor to moving contact switch
6. Switch assembly
7. "Posidrive" screw and spring washer
8. Resistor
9. "Posidrive" screw and spring washer
10. Resistor plate

Fig 28 View of terminal connections and screws locating solenoid switch unit in the drive end shield.

Position the switch unit in the drive end shield see Fig 28, so that the fixed contact connecting arm aligns with the main terminal and insert the two "Posidrive" screws (7)-(9) with spring washers. Tighten the screws to the correct torque value of 2,03 to 2,07 Nm (208 to 277 kgf m or 18 to 20lbf in).

Insert the main terminal screw (4) with spring washer and plain washer see Fig 28. Tighten to the correct torque value of 2,03 to 2,26 Nm (208 to 230 Kgf m or 18 to 20 lbf in).

Position the leatheroid insulator (3) in the resistor groove and then assemble the resistor (8) into it's groove in the drive end shield, see Fig 28.

Fit the solenoid insulators over the terminals (2) and insert the terminals through the resistor plate (10), leatheroid insulator and drive end shield.

> **Note: There are three terminals on machines that employ a starter protection unit for automatic start applications.**

Fit the rubber sealing ring to each terminal (1) followed by the nylon bush, plain washer, spring washer and nuts. Tighten to correct torque value of 2,03 to 2,26 Nm (208 to 230 Kgf m or 18 to 20 lbf in).

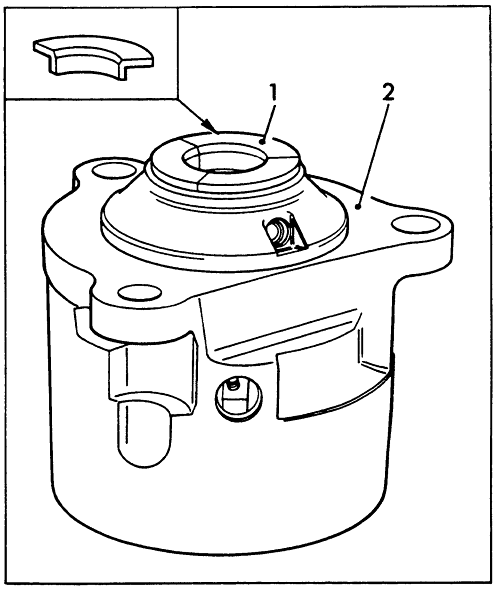
Insert the screw (5) with spring washer and plain washer to connect the flexible lead from resistor to the moving contact switch. Tighten to correct torque value of, 1,69 to 2,03 (173 to 208 kgf m or 15 to 18 lbf in).

PINION SLEEVE

If a new drive end shield is being fitted or the bearing bush has been renewed, then the leatheroid pad (3) Fig 20 must be removed from the bush.

To protect the oil seal in the drive end shield (2) from damage during assembly of the pinion, invert the drive end so that the oil seal is uppermost and fit the three segments of the split collar tool (1), Part No. 6244-43, over the lip of the seal as shown in Fig 29.

Smear the bore of the drive end bearing and also the outside diameter of the pinion sleeve with Shell Tellus T27 oil.



Key to Numbers:-

1. Split collar tool, Part No. 6244-43
2. Drive end shield

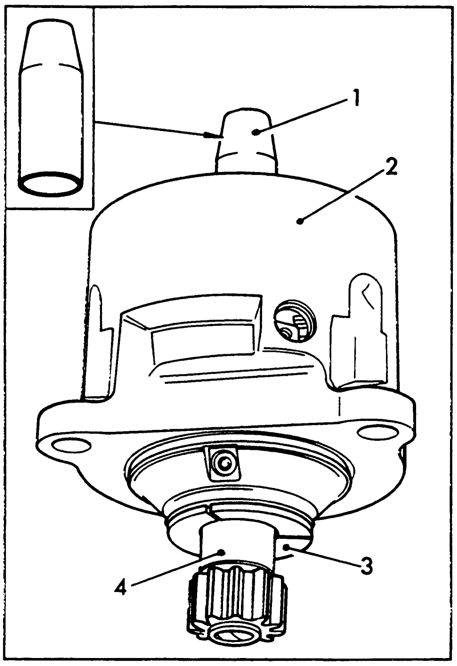
Fig 29 Method of fitting split collar tool, Part No. 6244-43.

Stand the pinion sleeve (4) upright so that the pinion is in contact with the bench and place the pilot tool (1), Part No. 7144-870A on top of the pinion sleeve.

Lower the drive end shield (2) over the pilot tool and pinion sleeve as shown in Fig 30, until the pinion sleeve is through the segments.

Remove the pilot tool from the pinion sleeve.

With a screwdriver, remove the three segments of the split collar tool by prising them from the oil seal.



Key to Numbers:-

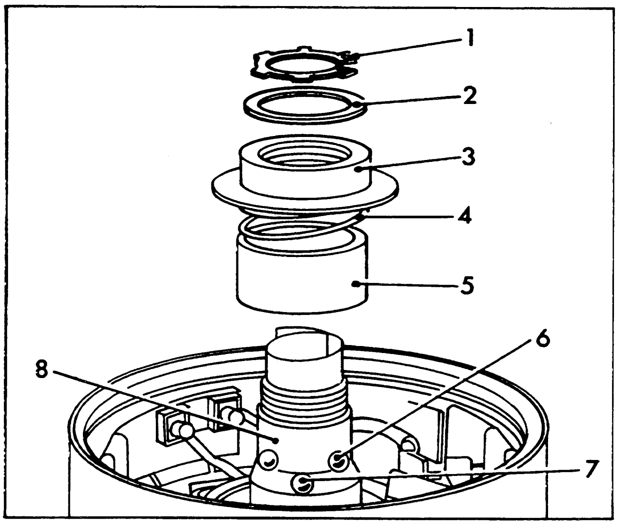
1. Pilot tool, Part No. 7144-870A
2. Drive end shield
3. Split collar tool, Part No. 6244-43
4. Pinion sleeve

Fig 30 Method of fitting pinion sleeve

Clamp the pinion teeth firmly in a soft jawed vice so that the tapered end of the pinion sleeve (8) is uppermost as shown in Fig 31.

Form a small piece of stiff paper into a tube and insert it into the bore of the pinion sleeve as shown; this will prevent the locking (6) and over speed (7) balls from falling into the inside of the pinion sleeve.

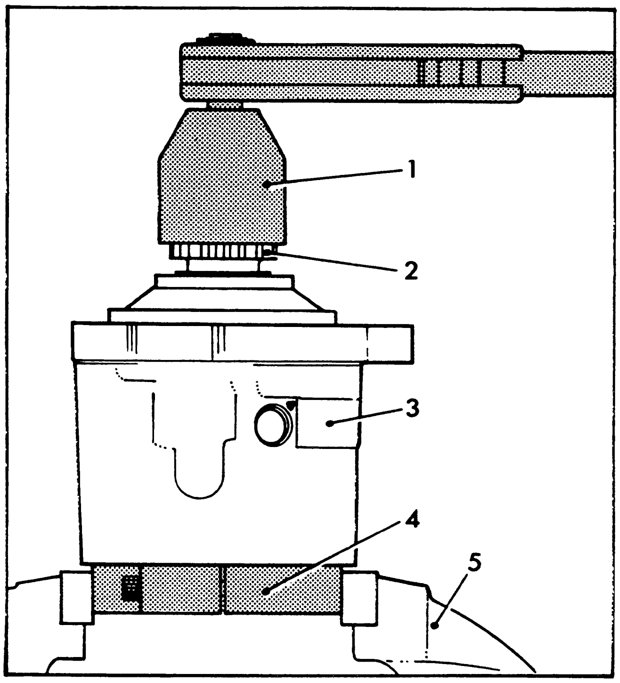
Smear with Aero Shell 16 grease, the bore of the trip plate (3) and corresponding diameter of the pinion sleeve, smear also the four locking balls and four overspeed balls with grease and insert them into the holes in the pinion sleeve. Assemble the locking collar (5) into position over the balls followed by the spring (4) and trip plate (3); secure the assembly with the plain washer (2) and circlip (1).



Key to Numbers:-

1. Circlip
2. Washer
3. Trip plate
4. Spring-locking collar
5. Locking collar
6. Locking ball
7. Overspeed ball
8. Pinion sleeve

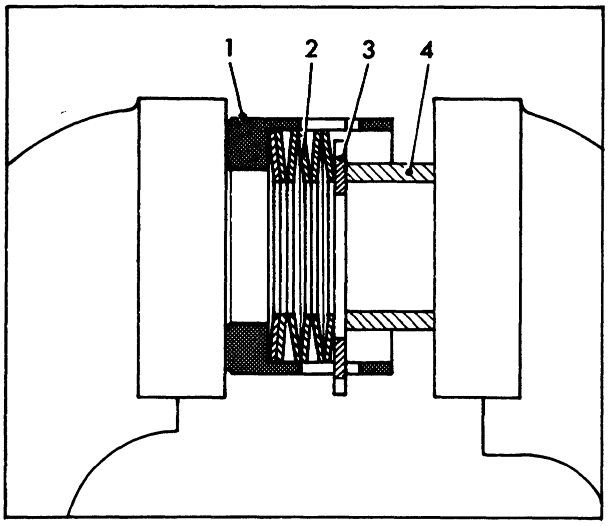
Fig 31 Exploded view of trip plate assembly



Key to Numbers:-

1. Socket tool, see "SPECIAL TOOLS" list for appropriate size
2. Pinion
3. Drive end shield
4. Clamp, tool Part No. 6244-50
5. Bench vice

Fig 32 Method of tightening the trip plate on early type starters.



Key to Numbers:-

1. Recoil housing
2. "Belleville' washers
3. Lock plate
4. Suitable length of tube or bar

Fig 33 Method of compressing "Belleville" washers.

Note: On early type starter motor, the pinion sleeve is threaded and assembly of the trip plate is as follows:

Using a suitable fluid, degrease the threads of the pinion sleeve and trip plate. Smear both the threads of the pinion and trip plate with "Loctite" green retaining compound No. 290.

Fit the clamp tool (4), Part No. 6244-50, over the trip plate boss and tighten the clamping screw to secure the tool in position. Invert the complete assembly and clamp tool in a vice as shown in Fig 32. Using the appropriate sized socket tool and a torque wrench, see "SPECIAL TOOLS" list on page 27, tighten the pinion to a torque value of 54,2 to 67,8 Nm (5,530 to 6,913 kgf m or 40 to 50 lbf ft).

ARMATURE SHAFT

Prior to assembly of the recoil unit, lightly smear the six "Belleville" washers (2) with Aero Shell 16 grease and assemble them into the recoil housing (1) as shown in Fig 33.

Insert one side of the lock plate (3) in the slot in the recoil housing and compress the "Belleville" washers with a suitable length of bar or tube (4) as illustrated until the lock washer can be engaged in the other slot.

Lightly clamp the armature shaft (41) Fig 2 vertically in a soft jawed vice with the threaded end of the shaft downwards.

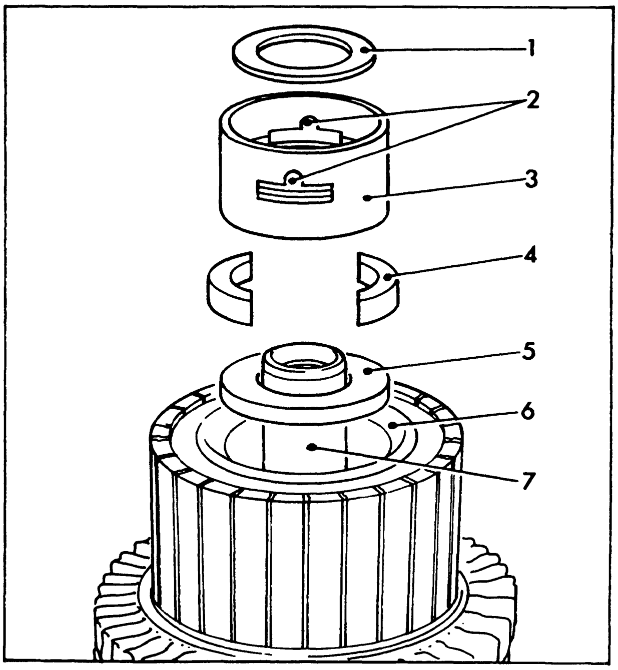
Smear the short shaft helix and thrust washer (40) Fig 2 with Aero Shell 16 grease and slide the thrust washer on to the shaft.

Assemble the armature onto the shaft with a twisting motion to enable the shaft helix to engage with the internal helix in the ratchet sleeve (19) Fig 2.

Smear the spacing washer (5) with Aero Shell 16 grease and insert the washer into the commutator sleeve, see Fig 34.

Apply slight downward pressure on the armature to ensure the shaft helices are fully engaged and place the two collets (4) Fig 34 into the annular groove in the shaft.

To check the end float in the armature shaft, exert sufficient pressure on the shaft to overcome the reaction of the ratchet spring (22) Fig 2 and measure the vertical movement which should be between 0,05 and 0,35 mm (0,002 and 0,014 in). If necessary, fit by selective assembly one spacing washer (5) Fig 34 to obtain the correct end float.



Key to Numbers:-

1. Shims
2. Withdrawal holes
3. Recoil housing
4. Collet
5. Spacing washer
6. Commutator sleeve
7. Armature shaft

Fig 34 Exploded view of recoil unit and collets retaining the armature shaft.

Spacing washers (5) available for adjustment of the armature shaft end float are as follows:-

Part No.	Thickness of Spacing Washers
5986-418A	5,6 mm (0,220 in)
5986-418B	5,4 mm (0,213 in)
5986-418C	5,2 mm (0,198 in)
5986-418D	5,0 mm (0,197 in)
5986-418E	4,8 mm (0,189 in)
5986-418F	4,6 mm (0,181 in)
5986-418G	4,4 mm (0,173 in)
5986-418H	4,2 mm (0,165 in)

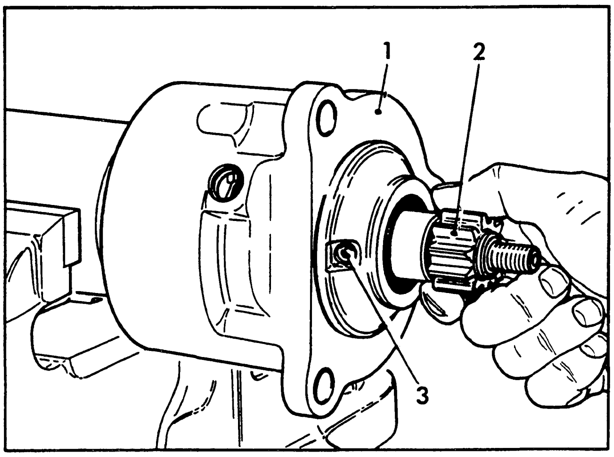
Note: On early type machines, shims are fitted under a thrust washer to obtain end float. Both shims and thrust washer can be discarded and substituted for a spacing washer of suitable thickness. However, if the original shims and thrust washer fitted provides the shaft with the correct end float, always fit the thickest shim next to the collets.

When the correct end float is obtained, fit the assembled recoil unit into the armature sleeve so that the bore in the bottom of the unit locates over the two collets (4), see Fig 34.

The original shims (1), previously retained during dismantling of the recoil unit or after dismantling the commutator end shield, should be smeared with Aero Shell 16 grease and then inserted into the top of the recoil unit. Fit the thickest shim last, see Fig 34.

Check the operation of the ratchet mechanism by turning the armature. It should turn in one direction only, accompanied by a clicking noise from the ratchet.

Remove the armature assembly from the vice.



Key to Numbers:-

1. Drive end shield
2. Pinion
3. Oiler core plug and spring

Fig 35 Assembling the drive end shield

DRIVE END SHIELD *(See Fig 35)*

Note: When a new drive end shield (1) is being fitted, lubricate the bearing wick through the hole in the boss, as shown in Fig 35, with Shell Tellus T27 oil and fit the spring and new core plug using the punch tool, Part No. 6244-44.

Prior to assembly, lightly smear the drive end helix of the armature shaft (1) Fig 1 and the pinion sleeve internal helix (2) Fig 1 with Aero Shell 16 grease.

Keeping the pinion (2) fully extended as shown in Fig 35, twist the pinion sleeve onto the armature shaft and before the drive end shield is fully in position, remove the paper tube from the pinion sleeve.

On assembly of the drive end shield, check the operation of the locking balls by winding the pinion out until the locking mechanism operates and the pinion is fully locked. Push the drive end shield inwards to release the locking balls then wind the pinion back into the drive end.

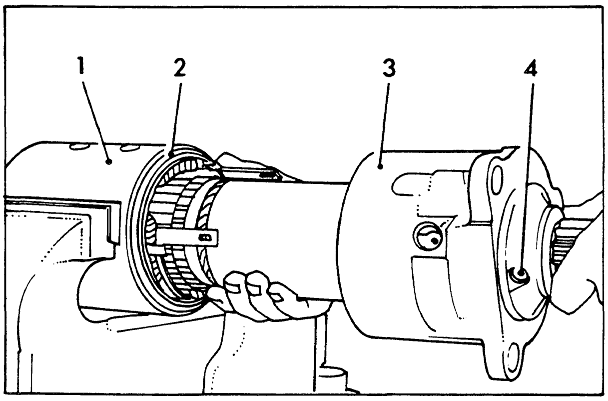
Fit the pinion return spring (3), thrust washer (5) and stop nut (4) to the pinion but leave the nut finger tight, see Fig 8.

Remove the armature and drive end shield from the vice.

ARMATURE AND BRUSHGEAR *(See Figs 24, 36 and 37)*

With the yoke (1) held horizontally in a soft jawed vice as shown in Fig 36, place a new rubber sealing ring (2) on the drive end of the yoke. Insert the armature into the yoke, supporting the assembly as shown to avoid damage to the windings and commutator.

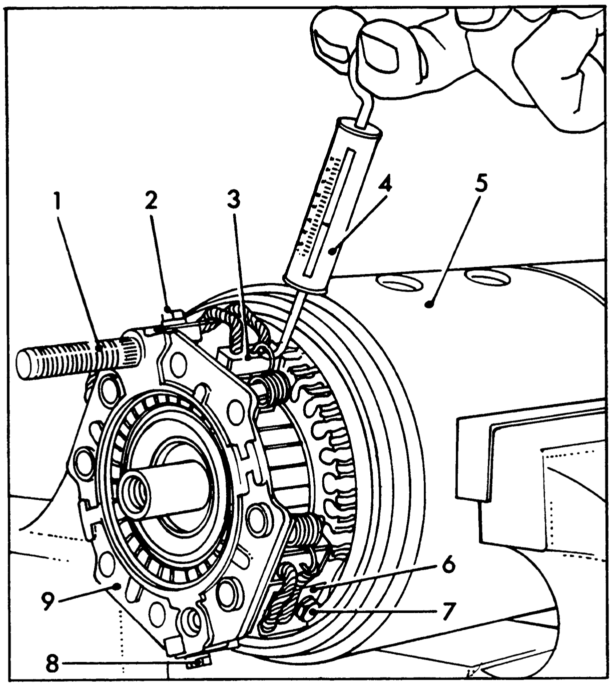
Align the hole in the drive end shield with the dowel (7) Fig 24 in the end of the yoke and using a soft faced mallet, tap the drive end shield into position.



Key to Numbers:-

1. Yoke
2. Rubber sealing ring
3. Drive end shield
4. Oiler core plug and spring

Fig 36 Inserting the armature into the yoke



Key to Numbers:-

1. Return terminal post
2. Screw – field connection
3. Brush
4. Tension gauge
5. Yoke
6. Brush lead tag
7. Screw – brush lead tag
8. Screw – field connection
9. Brushgear assembly plate

Fig 37 Checking brush spring pressure

Fit the brush gear assembly plate (9) onto the commutator end of the yoke so that the return terminal post (1) is approximately in line with the register pip on the end of the yoke, see Fig 37.

Insert the two brush lead tag screws (7) complete with spring washers through each positive brush lead tag (6) and screw them through the field connectors to hold the brush gear assembly plate in position. Do not, at this stage fully tighten the screws (7).

Insert each brush (3) into its holder and secure the remaining two unattached field winding leads with the two field connection screws (2) and spring washers. Tighten both screws (2) to the correct torque value of 1,69 to 2,03 Nm (173 to 208 Kgf m or 15 to 18 lbf in).

Using a tension guage as shown in Fig 37, check each brush spring pressure. The gauge should indicate between 2,38 and 2,49 Kgf (5,25 and 5,50 lbf) when the spring just starts to lift off the brush.

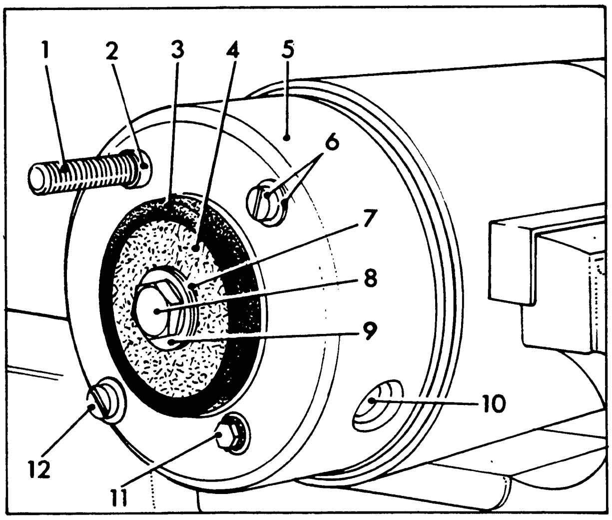
COMMUTATOR END SHIELD *(See Figs 25 and 38).*

Check that both the insulating plate (3) and strip (4) are in position inside the commutator end shield, see Fig 25.

Smear the inside bore of the commutator end shield bearing bush (12) Fig 2 and the end of the armature shaft with "Turbo 41" oil and assemble the end shield onto the yoke as shown in Fig 38.

Ensure that the notch in the end shield locates over the register pip on the yoke and that the brush leads are not trapped.

Insert both the through bolts (6)-(12) with sealing washers and tighten to the correct torque value of 12,9 to 13,6 Nm (1,313 to 1,383 kgf m or 9,5 to 10 lbf ft).



Key to Numbers:-

1. Return terminal
2. Insulating bush
3. Rubber sealing ring
4. Felt lubrication pad
5. Commutator end shield
6. Through bolt and sealing washer (temporarily fitted)
7. Shims – armature shaft end float
8. Bolt
9. Thrust washer
10. Access hole to brush screws
11. Hexagon headed screw, plain washer and insulating bush
12. Through bolt and sealing washer (temporarily fitted)

Fig 38 Fitting the commutator end shield

PINION AND ARMATURE SHAFT END FLOAT ADJUSTMENT

(See Fig 39).

To obtain the correct position for the pinion (7), measured between the front of the pinion and the mounting flange (9), shims are fitted between the recoil housing and the end shield bearing.

Check the protrusion of the pinion see Fig 39, by using the appropriate gauge tool (8) given in the "SPECIAL TOOLS" List and if necessary adjust as follows:-

Hold the gauge tool (8) firmly against the flange (9) so that the arm on the tool abuts the pinion as shown in Fig 39 and push the pinion lightly inwards towards the drive end. With the pinion lightly loaded, check that the arm on the gauge is just clear of the front face of the pinion.

If this condition is not met, remove the end shield and add or subtract the number of shims (3) fitted between the recoil unit (4) and the end shield bearing (2) until the correct distance is obtained.

To check the end float on the armature shaft, assemble the shims (11) previously retained between the bearing (2) and thrush washer (1) with the thickest shim next to the bearing and fit the thrust washer and bolt (13).

Clamp the starter horizontally in a suitable soft jawed vice gripping the yoke only. Using the pinion holding tool (5), Part No. 6244-39 as shown in Fig 3 to prevent the shaft rotating, tighten the end shield bearing bolt (13) to a torque value of 34,0 to 40,7 Nm (3,46 to 4,15 Kgf m or 25 to 30 lbf ft).

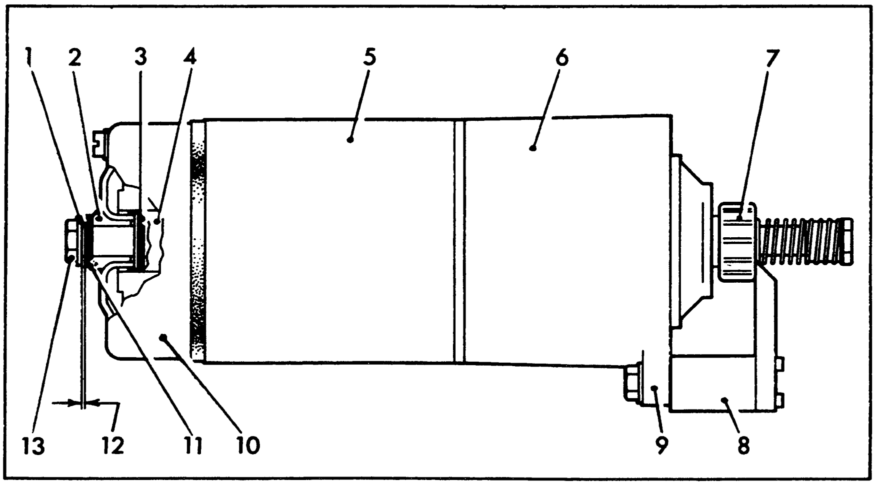
Measure the gap (12) between the thrust washer and shims with a feeler gauge, see Fig 39. The gap should be between 0,1 and 0,3 mm (0,004 and 0,012 in) without compressing the washers in the recoil unit. If necessary, remove the bolt and thrust washer and add or subtract the shims.

Finally, while holding the pinion with tool (5) Part No. 6244-39 as shown in Fig 3, tighten the pinion stop nut (6) to a torque of 54,2 to 67,8 Nm (5,530 to 6,913 Kgf m or 40 to 50 lbf ft).

Shim sizes available to adjust the pinion protrusion and the armature shaft end float are as follows:-

Part No.	Thickness of Shim
5936-329A	1,422mm (0,056 in)
5936-329B	1,219mm (0,048 in)
5936-329C	0,711mm (0,028 in)
5936-329D	0,279mm (0,011 in)
5936-329E	0,229mm (0,009 in)

Fit the small hexagon headed screw (11) into the end shield (5), see Fig 38, with shakeproof washer, plain washer and insulating bush. Tighten the screw to correct torque value of 1,69 to 2,03 Nm (173 to 208 kgf m or 15 to 18 lbf in).



Key to Numbers:-

1. Thrust washer
2. Bearing-end shield
3. Shims – pinion protrusion
4. Recoil unit
5. Yoke
6. Drive end
7. Pinion
8. Gauge tool, see "SPECIAL TOOLS" list
9. Mounting flange
10. Commutator end shield
11. Shims – armature shaft end float
12. Gap 0,1 to 0,3 mm (0,004 to 0,012 in)
13. Bolt – end shield bearing

Fig 39 Cut-away view of shims for pinion and armature shaft end float adjustment with gauge tool in situ for checking pinion protrusion.

Pull on the return terminal and tighten the two brush lead tag screws (7) Fig 37 through the access holes (10) Fig 38 in the commutator end shield. Tighten both brush screws to the correct torque value of 1,69 to 2,03 Nm (173 to 208 kgf m or 15 to 18 lbf in).

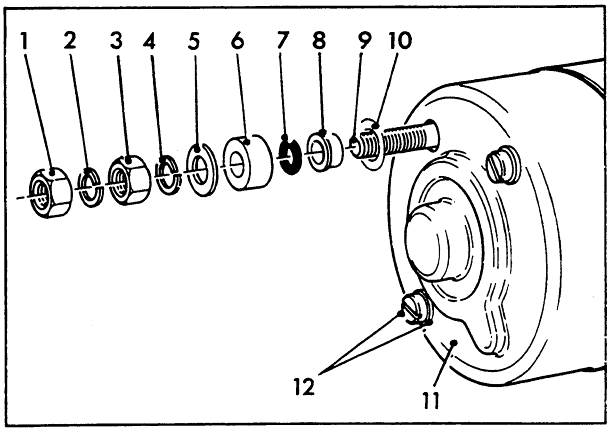
Remove both through bolts (6) and (12) and fit the felt lubrication pad (4) and rubber sealing ring (3) on the end shield, see Fig 38.

Fit the commutator end shield cover in position, see Fig 40. Insert the through bolts complete with their sealing washers (12) and tighten to the correct torque value of 12,9 to 13,6 Nm (1,313 to 1,383 kgf m or 9,5 to 10lbf ft).

Fit the return terminal assembly as shown in Fig 40 in the following order; thin sealing washer (10), insulating bush (8) pressing it fully home, rubber seal (7), seal locator (6), plain washer (5), spring washer (4) and locknut (3). Tighten the nut to the correct torque value of 12,2 to 13,6 Nm (1,244 to 1,383 kgf m or 9 to 10 lbf ft). Place a second spring washer and nut on the return terminal post and tighten by hand.

At the drive end shield, see Fig 3, fit the two field coil, connecting screws (2), spring washers (3) and plain washers (4) through the holes in the end shield. Tighten the screws to the correct torque value of 1,69 to 2,03 Nm (173 to 208 Kgf m or 15 to 18 lbf in). Ensure that this torque loading is not exceeded or the screws will strip the copper threads in the solenoid switch.

Finally, fit a new core plug (1) to each hole in the drive end shield using the tool (5) Part No. 6244-45 as shown in Fig 3.



Key to Numbers:-

1. Locknut
2. Spring washer
3. Locknut
4. Spring washer
5. Plain washer
6. Seal locator
7. Rubber seal
8. Insulating bush
9. Return terminal post
10. Thin sealing washer
11. Commutator end shield cover
12. Through bolt and sealing washer

Fig 40 Exploded view of return terminal assembly with end shield cover fitted.

TESTING

EQUIPMENT

To completely test the starter motor, the following equipment will be required;

1. Starter Test Machine.
2. Variable voltage D.C. supply capable of providing an output of between 14 and 30 volts.
3. Fully charged 24 volt battery of 170 ampere hour capacity.
4. First grade moving coil D.C. ammeter having a range of 0 to 1,500 amperes.
5. First grade moving coil D.C. voltmeter having a range of 0 to 50 volts.
6. Single pole ON/OFF switch.
7. Tachometer with a range of 0 to 8,000 rpm.

Before commencing to test the starter motor, ensure that the pinion is free to be turned easily by hand and that when pulled partly outwards and released, it returns easily to its rest position.

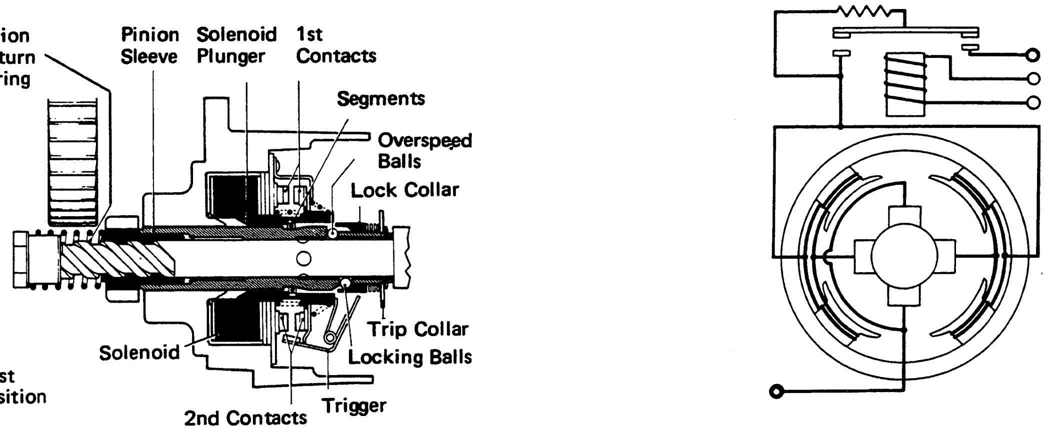
UNDER NO CIRCUMSTANCES SHOULD ANY ATTEMPT BE MADE TO PULL THE PINION OUTWARDS WHILE THE MAIN TERMINALS ARE CONNECTED TO THE POWER SUPPLY. **FAILURE TO OBSERVE THIS PRECAUTION COULD RESULT IN SERIOUS INJURIES BEING SUSTAINED.**

SWITCH AND PINION SLEEVE OPERATION

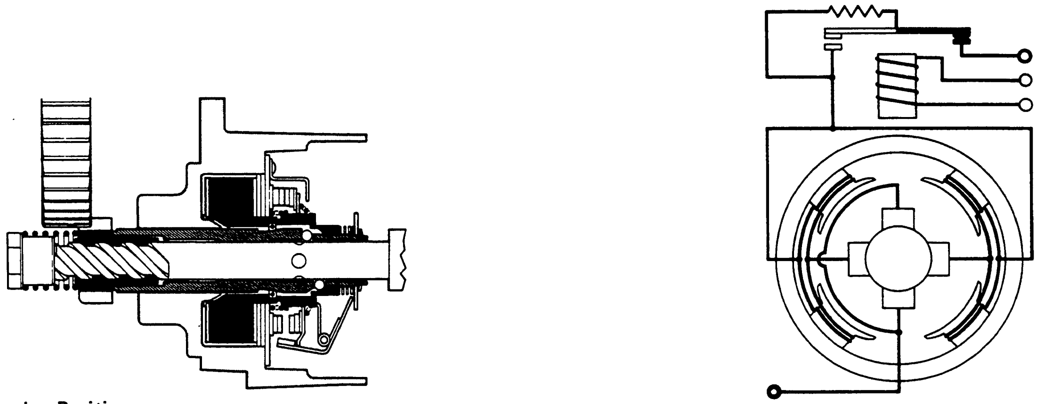
Connect the variable voltage D.C. supply to the solenoid terminals via the ON/OFF switch. Do NOT make any connections to the main terminals at this stage.

Apply 16 volts to the solenoid terminals; the pinion should move forward 7 mm (0,276 in) to give a minimum dimension of 54,6 mm (2,150 in) between the flange and the face of the pinion.

With the solenoid still energised, pull the pinion outwards by hand until it locks in the forward position. The trigger should be heard to operate during this opertaion.

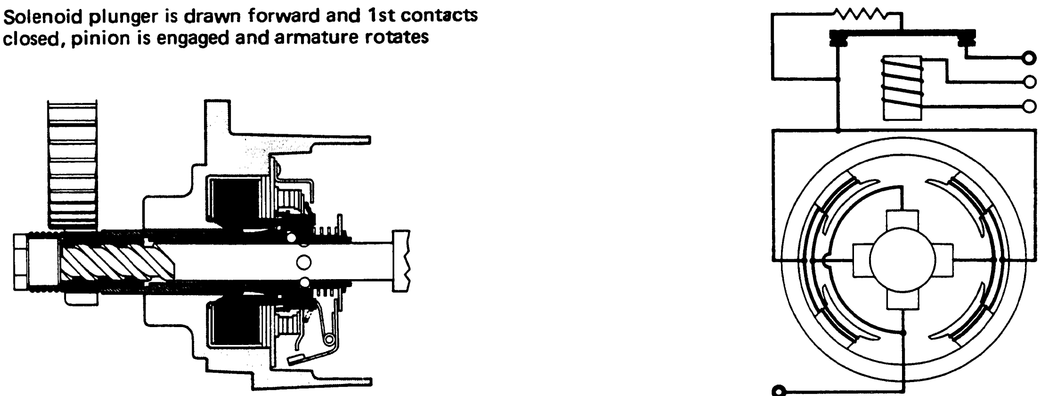


At Rest Position



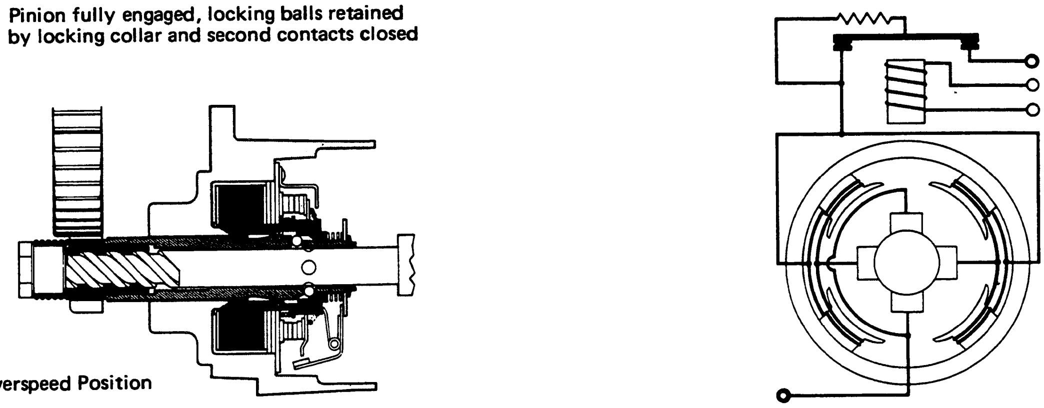
Engaging Position

Solenoid plunger is drawn forward and 1st contacts closed, pinion is engaged and armature rotates



Cranking Position

Pinion fully engaged, locking balls retained by locking collar and second contacts closed



Overspeed Position

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

Operational sequence and internal wiring

With the pinion locked in the forward position, there should be a gap of between 0,10 and 0,67 mm (0,004 to 0,026 in) between the end of the pinion and the pinion stop nut.

Switch OFF the 16 volt supply; the pinion should immediately return to its original de-energised position.

Apply 14 volts to the solenoid terminals; the pinion should move forward. Pull pinion almost fully forward but not far enough for the locking device to operate. It should now be possible to push the pinion fully inwards proving that the four segments are being correctly held out by the magnetic field of the solenoid. Switch OFF the 14 volt supply.

Apply 16 volts to the solenoid terminals; the pinion should move partly forward. It should not be possible for the pinion to be returned to the fully de-energised position, thus proving that the segments are still in the correct position. Switch OFF the 30 volt supply.

LIGHT RUNNING TESTS

Energise the solenoid with 24 volts, then connect the main terminals to the 24 volt test battery for a maximum period of five seconds. The pinion should rotate slowly and smoothly with no undue noise or vibration. *DISCONNECT THE TEST BATTERY FROM THE MAIN STARTER TERMINALS.*

MAIN POWER TEST

Apply 24 volts to the solenoid terminals, then pull the pinion fully forward until it locks. Connect the main terminals to the test battery with the ammeter connecter in series with one of the leads. Connect the voltmeter across the main terminals. In this light running condition, the pinion should rotate at a higher speed than before, again with no undue noise or vibration. The current consumption should not exceed 110 amperes at 23 volts when the pinion is revolving at 6,500 rpm.

Switch OFF the supply to the solenoid terminals; the pinion should return to it's de-energised position and stop rotating. *DISCONNECT ALL CONNECTIONS TO THE STARTER.*

ENGAGEMENT AND PERFORMANCE TESTING

Mount the starter on the starter test machine so that when the pinion is fully inwards in the de-energised position, there is a clearance of 3,17 mm (0,125in) between the face of the pinion and the face of the flywheel.

Connect the main terminals to the test battery with the ammeter in series. Connect the voltmeter across the main terminals and connect the variable D.C. supply to the solenoid terminals via the single pole ON/OFF switch.

With the flywheel partly locked, apply 16 volts to the solenoid terminals and check that the pinion engages correctly with the flywheel. Repeat this test ten times to ensure consistent engagement.

LOCKED TORQUE TEST

With the starter running, apply the flywheel brake progressively until the flywheel is fully locked. Quickly note the torque, current and voltage readings, Release the flywheel brake promptly and switch OFF the variable D.C. supply.

Refer to the typical performance figures given against the heading "Locked Torque" in the following table:-

Test	Pinion Torque	Current	Voltage
Locked Torque	108,4 ± 10,2 Nm (11,1 ± 1 kgf m or 80 ± 7,5 lbf ft)	1,250 ± 50A	9,5 ± 1,0V

These figures relate to the torque output measured at the pinion and reference should be made to the test machine instructions to determine the correct torque value applied to the flywheel.

RUNNING TORQUE TEST

With the starter running, apply the flywheel brake progressively until the speed given in the following table is obtained. Quickly note the torque, current and voltage readings.

Release the flywheel brake promptly and switch OFF the variable D.C. supply. Refer to the typical performance figures given against the heading "Running Torque" in the following table:-

Test	Speed	Pinion Torque	Current	Voltage
Running Torque	1,300 rpm	43,4 ± 3,4Nm (4,4 ± 0,3Kgf m or 32 ± 2,5 lbf ft)	660 A max	16,5V min

Follow the test machine instructions and convert the flywheel torque to pinion torque.

PLEASE INSERT IN PUB. No. 2605/1 (En)
S130L STARTER MOTOR

AMENDMENTS & CORRECTIONS

LIST OF TORQUE VALUES

The torque values are correct at the time of printing. Any variations made necessary by modifications or changes in design will be published in relevant Service Instruction Notes; the latest information must be followed.

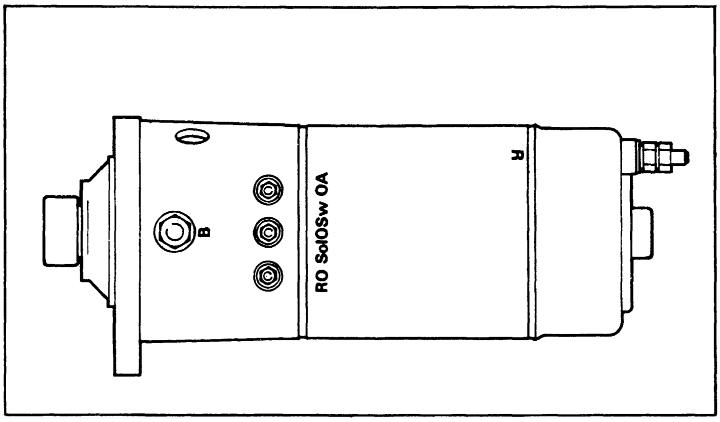
ITEM	TORQUE			REMARKS
	Nm	Kgf m	lbf in	
Main terminal nut	12,2 to 13,6	1,24 to 1,38	108 to 120	Drive end shield (see Fig. 26)
"Posidrive" screws (2 off)	2,03 to 2,71	0,21 to 0,28	18 to 24	connects solenoid switch with drive end shield (see Fig. 28)
Main terminal screw	2,03 to 2,26	0,21 to 0,23	18 to 20	Main terminal post (see Fig. 37)
Terminal nuts (2 off) (3 off on single & dual start machines)	2,03 to 2,26	0,21 to 0,23	18 to 20	Drive end shield (see Fig. 28)
Screw	1,69 to 2,03	0,17 to 0,21	15 to 18	connects flexible lead from resistor to moving contact switch (see Fig. 28)
Trip plate (early type)	54,2 to 67,8	5,53 to 6,91	480 to 600	(see Fig. 32)
Field connection screws (2 off)	1,69 to 2,03	0,17 to 0,21	15 to 18	Brushgear (see Fig. 37)
Through bolts (2 off)	12,9 to 13,6	1,31 to 1,38	114 to 120	Commutator end shield cover (see Fig. 38)
Bolt	34,0 to 40,7	3,46 to 4,15	300 to 360	End shield bearing (see Fig. 39)
Pinion stop nut	54,2 to 67,8	5,53 to 6,91	480 to 600	(see Fig. 8)
Small hexagon screw	1,69 to 2,03	0,17 to 0,21	15 to 18	Commutator end shield (see Fig. 38)
Tag screws (2 off)	1,69 to 2,03	0,17 to 0,21	15 to 18	Brush leads (see Fig. 37)

SPECIAL TOOLS

Description	Part No
HOLDING TOOL for;	
Pinion	6244-39
SOCKET TOOL for;	
Pinion with 10 teeth	6244-30
Pinion with 11 teeth	6244-1
Pinion with 12 teeth	6244-5
CLAMP TOOL for;	
Trip plate	6244-50
TAP TOOL for;	
Drive end bearing bush	6244-32
PIN TOOL for;	
Removing tap, 6244-32 and fitting drive end bearing bush ..	6244-31
Removing and fitting commutator end bearing bush ..	6244-37
GUIDE TOOL (used with 6244-37)	6244-36
BAR TOOL for:	
Removing and fitting drive end bearing bush	6244-41
COLLAR TOOL for;	
Felt wick	6244-42
SPLIT COLLAR TOOL for;	
Drive end shield oil seal	6244-43
PILOT TOOL for;	
Fitting pinion sleeve	7144-870A
PUNCH TCOL for;	
Fitting oil core plug	6244-44
GUAGE TOOL for;	
Setting pinion (1,876 in. gap)	6593-222
Setting pinion (0,813 in. gap)	6593-222A
Setting pinion (1,001 in. gap)	5693-222B
PLUG PUNCH for;	
Fitting core plug	6244-45

AUTOMATIC START APPLICATION USING THE S130L STARTER FOR SINGLE AND DUAL OPERATIONS

INTRODUCTION



Key to Letters:–

TERMINAL IDENTIFICATION	TERMINAL FUNCTION
RO	Negative supply
Sol O Sw	Positive supply
OA	Sensing for 381 repeater relay
B	Main positive supply
R	Main negative supply

Fig 41 Terminal identification for S130L starter Motor used for single and dual automatic start applications.

The single and dual start machines employed are similar in design to the standard S130L starter but are provided with an extra terminal marked "OA" as shown in Fig 41. This terminal which, used in conjunction with the type 381 repeater relay unit, is used for sensing that the starter has reached second stage contact with the pinion fully engaged with the flywheel.

In automatic start applications where the cranking of the engine is controlled by a timer, it may be set to enable the engine to be cranked several times, each up to 30 seconds duration. In these circumstances, a tooth to tooth abutment could occur between the pinion and flywheel and if the starter is operated for an excessive time without pinion engagement, it is possible for the resistor (7) Fig 2 in the starter motor to be burnt out. To prevent this occuring in the single automatic start system, the starter is used in conjunction with a 381 repeater relay unit as shown in Figure 42.

When a dual automatic start system is used, two 381 repeater relays are used in conjuction with a 510 control box as shown in Figure 44. Alternatively, in a dual manual system, only a 510 control box is used as shown in Figure 45.

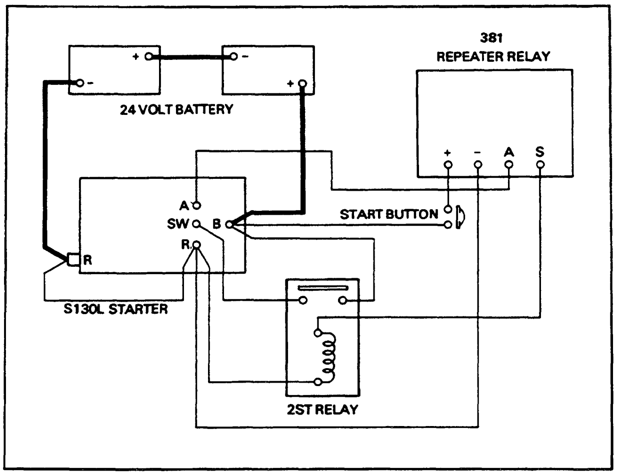


Fig 42 Wiring diagram for single S130L starter used with 381 repeater relay unit and 2ST relay.

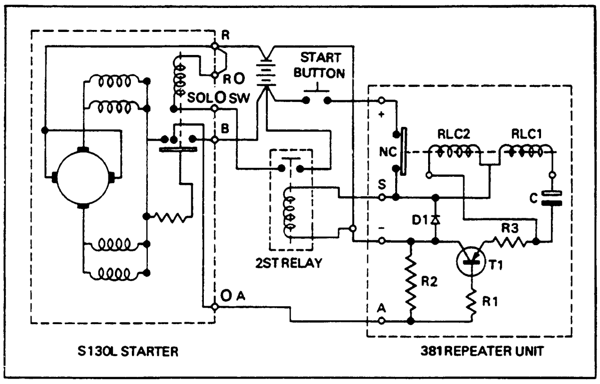


Fig 43 Schematic wiring diagram for single S130L starter with 381 repeater relay unit and 2ST relay.

381 REPEATER RELAY – SINGLE OR DUAL START APPLICATION

The 381 repeater relay unit, as shown in Figure 43, is included in the starter circuit to sense whether the pinion has made a faulty engagement. If more than a brief tooth to tooth abutment occurs with the flywheel ring gear, the starter pinion will return into the rest position. This will permit the pinion to index and then re-engage.

When the start button is operated, current flows from the battery via the normally closed contacts "NC" to the 2ST relay to energise the starter and also through the two relay coils RLC1 and RLC2. The return path for these two coils is provided via transistor T1 to the battery negative, a capacitor "C" is connected in series with RLC1.

The diode D1 is provided to protect the unit by short circuiting reverse polarity voltage spikes which occur when relay 2ST is switched off.

The two coils RLC1 and RLC2 are wound in opposition and the initial effect is for them to cancel each other and the contacts "NC" remain closed, however, as capacitor "C" charges, the current through RLC1 decreases and if the starter does not engage correctly will eventually fall to zero to allow the current through RLC2 to open the contacts "NC" and disconnect the supply to the starter circuit. The capacitor "C" then discharges through the relay coils and near the end of discharge allows the contacts "NC" to close and restart the cycle.

If a faultless engagement occurs, the main contacts inside the starter close and connect the battery positive via starter terminal "OA" to terminal "A" on the repeater relay unit. This current is supplied to the base of transistor T1 via a resistor R1 and causes the transistor to turn off; the current flow through the coils RLC1 and RLC2 is thus interrupted and the relay remains inert. Resistor R2 in conjunction with R1 provides for the correct operation of T1.

510 CONTROL BOX – DUAL START APPLICATION

The system comprises of two S130L starter motors and a 510 control box on a manual start system, with the addition of two 381 repeater relays for an automatic system.

> **Note: 2ST relays are not recommended for use in dual start systems.**

The purpose of the control box is to ensure that both starter pinions are fully engaged with the engine flywheel ring gear before full power is applied to the starter motors.

The 381 repeater relay units as shown in Fig 44, prevents either starter staying in a tooth to tooth abutment situation, which could cause damage to the starter, if used for example, on a mains failure timer circuit.

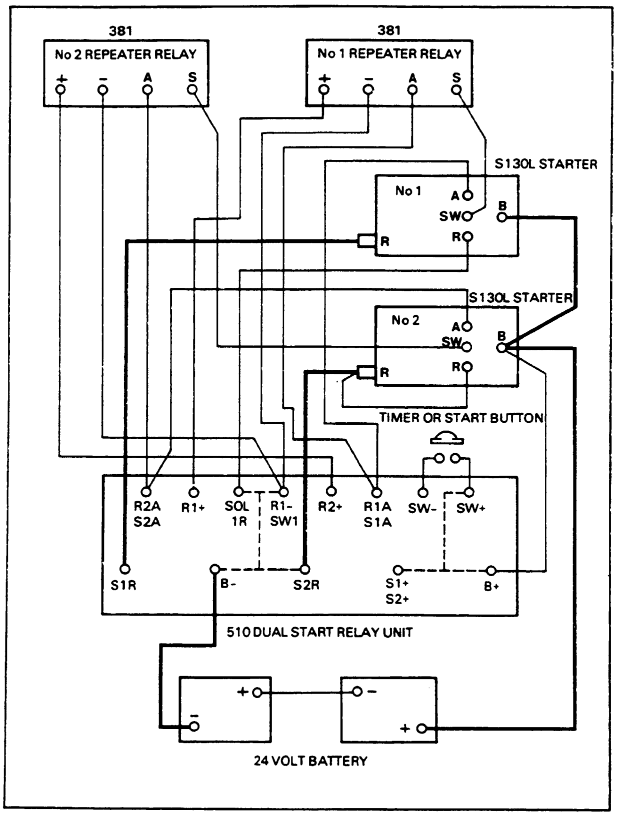


Fig 44 Wiring diagram for dual automatic start system, with two S130L starters using a 510 control box and two 381 repeater relay units.

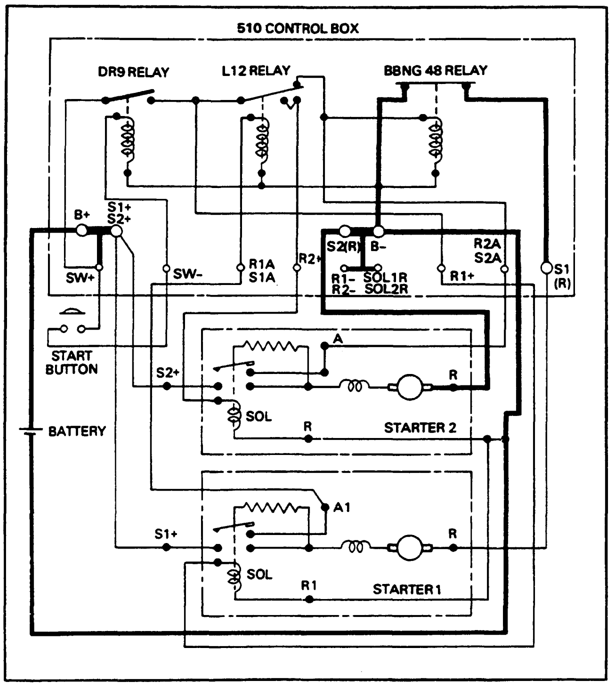


Fig 45 Schematic wiring diagrams for dual manual start system with two S130L starters using a 510 control box.

As the 381 repeater relay units are equivalent in operation to that described in the single automatic start system they have been omitted from the wiring diagram depicted in Fig 45. The diagram is schematic and should not therefore be used as a system wiring diagram.

When the start button is pressed or an auto start contact closes, a positive supply is connected to terminal SW–. this energises the coil of the DR9 relay and its normally open contact closes. This contact closes energises the coil of BBNG relay and also puts a positive feed onto terminal R1+ which energises the solenoid in starter No. 1.

Since the BBNG relay is already energised, its contact puts a feed through S1 terminal to the main negative terminal of the starter No. 1 enabling the pinion to rotate and engage with the engine flywheel. When starter No. 1 is fully engaged, a positive feed is supplied to terminal OA of the starter, which is connected to terminal R1A, S1A of the 510 control box. The L12 relay is subsequently energised, and its change over contacts operate. The normally closed contact of the L12 relay opens, de-energising the BBNG relay, leaving starter No. 1 fully engaged, but with no power to its main windings, so rotation cannot occur.

The normally open contact of the L12 relay closes feeding terminal R2+ which energises the solenoid of starter No. 2. This starter has its main terminals already connected to the battery supply so its pinion rotates and engages with the engine fly wheel.

When starter No 2 is fully engaged, a positive feed is supplied to its terminal. "OA" which is connected to terminal R2A, S2A of the 510 control box. This allows the BBNG relay contacts to close, providing full power to starter No. 1. Both starters are now fully in mesh and rotate together on full power to crank the engine.

ADJUSTING

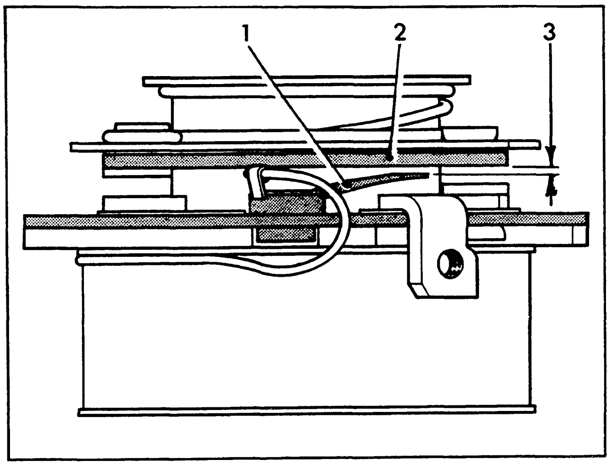
SETTING SOLENOID INTEGRAL LEAF RELAY

Note: In the single start system, the integral leaf spring relay see Fig 46, is situated on the starter internal solenoid switch for repeater relay "A" line sensing.

On the dual start system, the starter "A" terminal is wired to the 510 control box.

When the starter motor is dismantled and the solenoid switch removed, check the setting of the integral leaf relay of the solenoid as follows:-

Lift the moving contact (2) into the trigger catch manually and make first contact, using a feeler gauge check that the gap (3) between the lip of the leaf spring (1) and the adjacent top plate of the moving contact measures 0,3 to 0,4 mm (0,0118 to 0,0157 in). If necessary, lift or lower the leaf spring with the blade of a screw driver to obtain the correct gap.



Key to Numbers:—

1. Leaf spring
2. Moving contact
3. Gap measurement 0,3 to 0,4 mm (0,0118 to 0,0157 in)

Fig 46 Setting gap of the integral leaf relay

SOLENOID LEAF SPRING ADJUSTMENT

When the starter motor is partially assembled, at the stage where the drive end shield and pinion is fitted to the armature, test the operation of the leaf spring adjustment as follows:-

Connect a 24 volt lamp across the small terminal 'OA', see Fig 47, and push button Sol O Sw terminal. The positive lead of a 24 volt D.C. supply should be connected via a push button switch rated at 20 amps to the Sol O Sw terminal.

Connect a negative lead from the battery to the "OR" terminal with a link connected to the fixed second contact through the hole (marked 'X') in the drive end shield as shown in Fig 47.

Depress the push button and first contact of the solenoid switch should be made, then pull the pinion forward to make second contact. If the leaf spring has been correctly adjusted, a 'click' will be heard on second contact followed by illumination of the test lamp. If this does not occur the leaf spring must be re-adjusted.

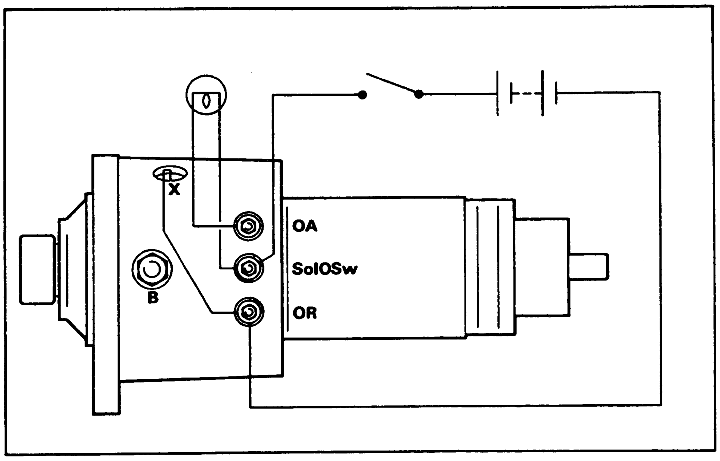


Fig 47 Initial test to check leaf spring adjustment, during partial assembly of starter.

When the starter is completely assembled, the starter must be tested again using a lamp and battery as shown in Fig 48.

During this test, do not connect the cable to the "B" terminal on the starter. This will preclude the possibility of the pinion being rotated on full power when it is pulled by hand.

Repeat the procedure as described under TESTING as a final check for correct operation of the leaf relay contact.

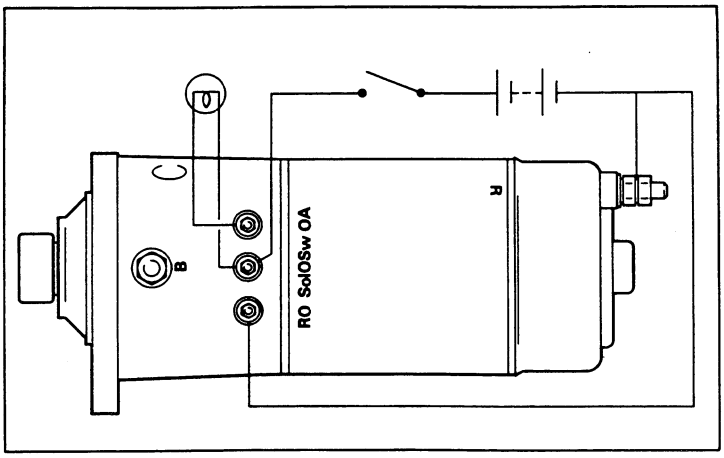


Fig 48 Final test to check leaf spring adjustment, after assembly of starter.

NOTES