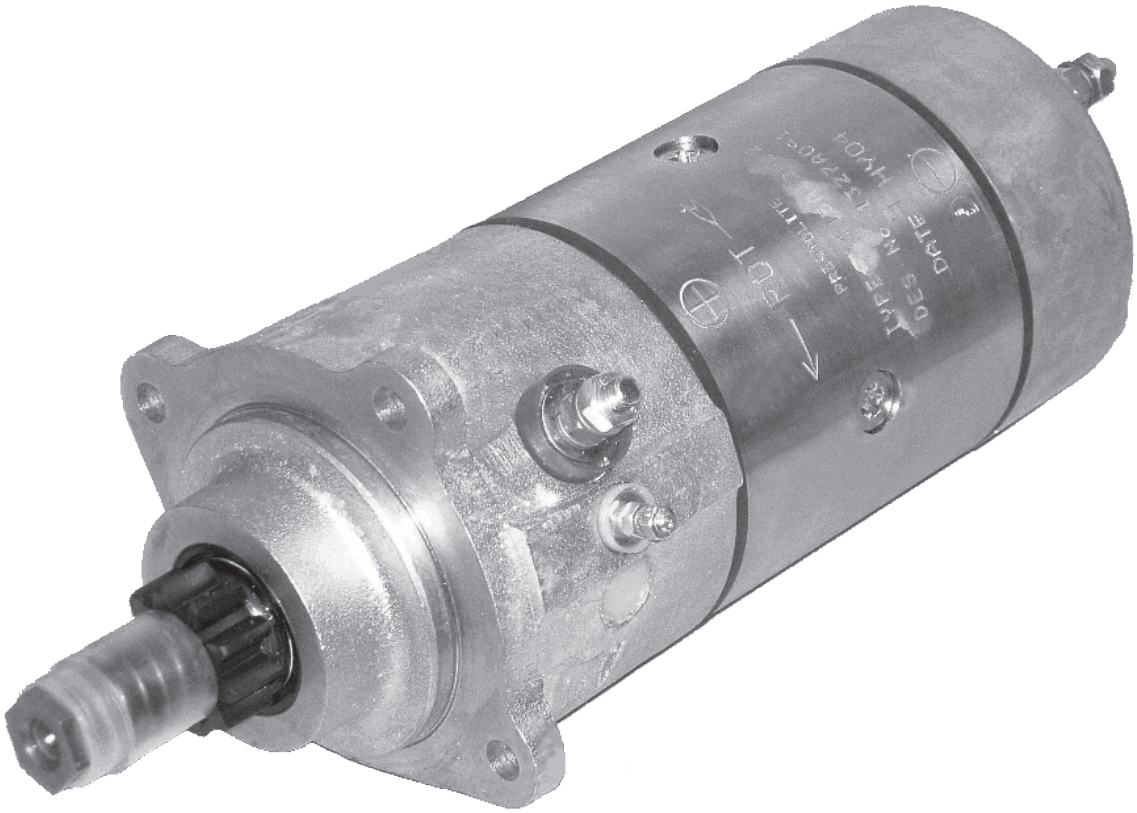
Service Manual for the S115/A Series Starter Motors



Troubleshooting, Diagnostics and Repair

TSM4003

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S115A STARTER MOTOR

1 INTRODUCTION

2 DISMANTLING

3 COMPONENT INSPECTION AND RENEWAL

4 REASSEMBLY

1.1 THE STARTER

The S115A starter motor is capable of starting multi-cylinder diesel engines of up to approximately 7 litres (12 V versions) and 12 litres (24 V versions) capacity.

The flange-mounted starter is nominally 115 mm (4,52 in) diameter and approximately 370 mm (14,6 in) overall length. It is a co-axial design, in which a two-stage operating solenoid is mounted internally around the armature shaft. It is splash-proof and dust-proof and, if required, can be sealed against ingress of oil at the drive end.

The starter is designed so that the pinion engages the flywheel ring-gear under reduced power, thereby minimising the risk of damage to the pinion and/or the ring-gear due to heavy or poor engagement. Full power is applied only when the pinion is fully engaged.

The pinion is mechanically locked in full engagement until either the starter is de-energised or an overspeed protection device operates. This device is fitted to protect the starter if the solenoid circuit remains energised and the engine is allowed to run up to high speed. When the armature reaches a pre-determined speed, the device will operate and allow the pinion to disengage from the flywheel ring-gear.

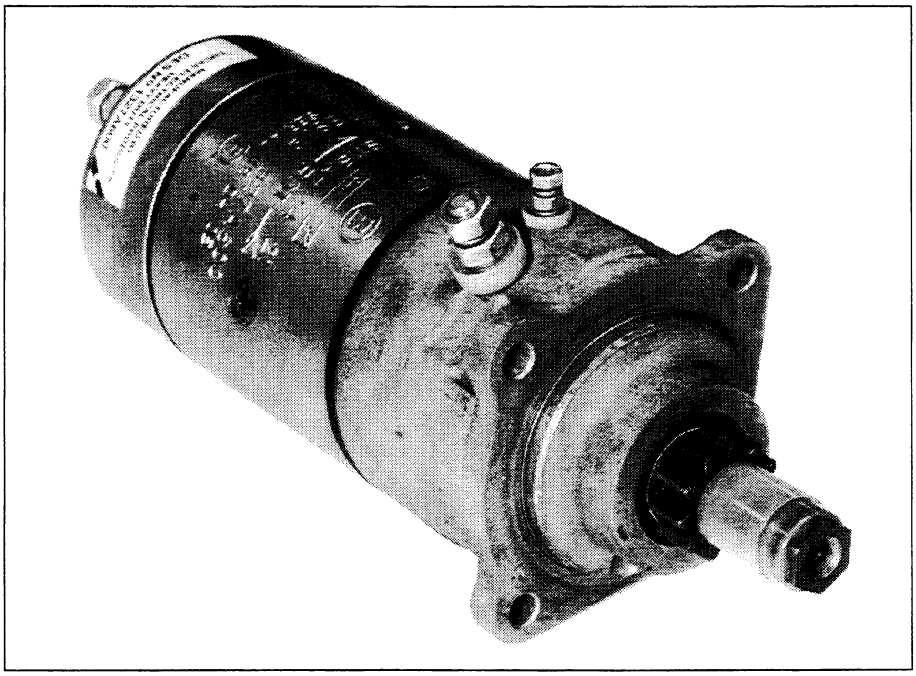


Fig. 1 S115A Starter

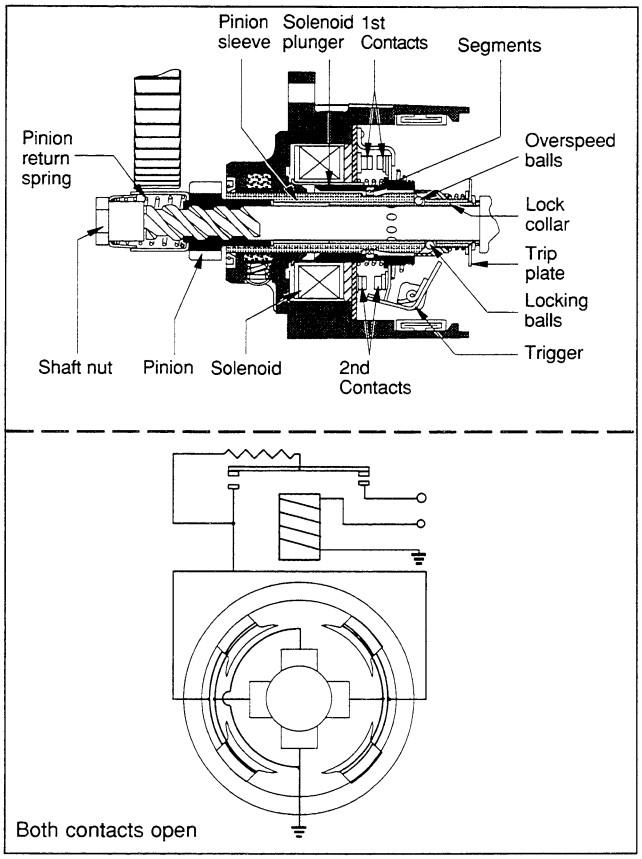


Fig. 2 Rest Position

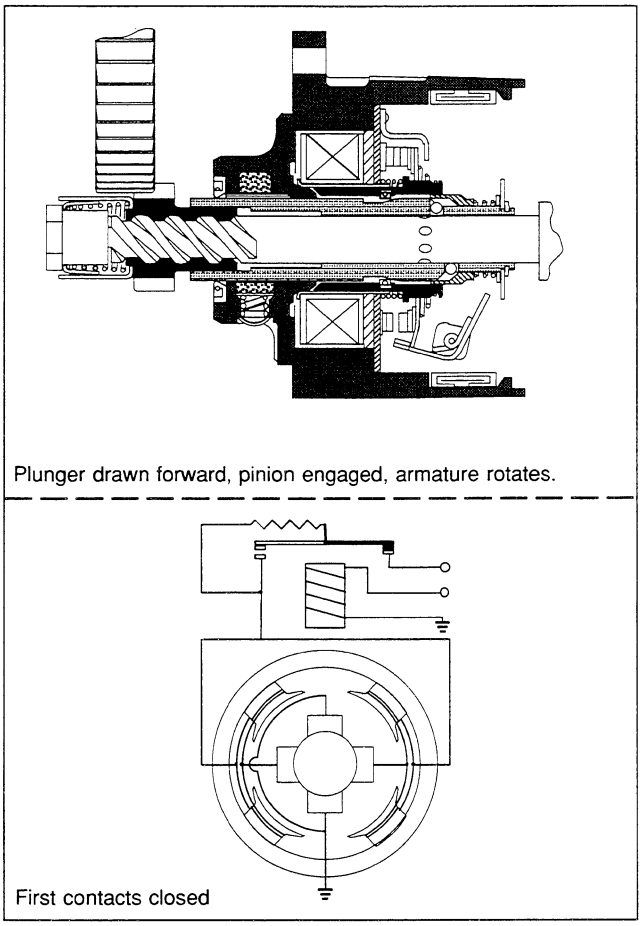


Fig. 3 Engaging Position

1.2 WORKING PRINCIPLE

1.2.1 **Rest position** (see fig. 2)

The pinion is clear of the flywheel and both solenoid contacts are open.

1.2.2 **Engaging position** (see fig. 3)

When the starter solenoid circuit is closed (by push-button, key switch or automatic repeater) the solenoid is energised and the solenoid plunger is moved forward. The spring-loaded segments, located on the inside of the plunger, move with the plunger and abut the shoulder of the pinion sleeve, moving the pinion forward to just engage the flywheel teeth.

The movement of the plunger closes the first stage contacts and current is then applied to the field windings via the internal resistor. This limits the current so that the armature is only allowed to rotate at low speed.

If correct engagement of the pinion with the flywheel is prevented by tooth-to-tooth abutment, rearward pressure on the armature shaft by the reaction of the helix compresses the recoil spring which is at the commutator end of the shaft. This misengagement should be detected, either by the operator or the repeater and the solenoid circuit de-energised.

This will allow the pinion return spring to assist the shaft to return to the rest position. The recoil spring will relax and cause the pinion to rotate enough to ensure correct engagement the next time the starter is operated.

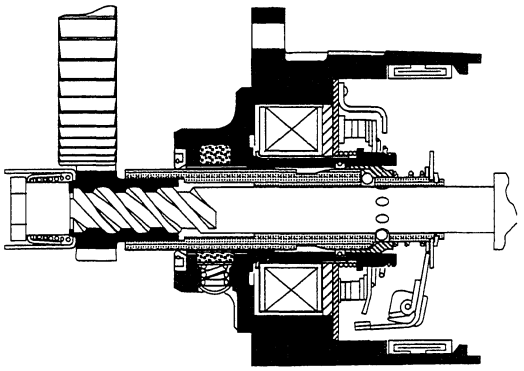
1.2.3 Cranking position (see fig. 4)

When the pinion engages correctly with the stationary flywheel, its rotation is halted; however, the armature shaft continues to turn and, under the action of the helix, the pinion continues to move towards the fully-engaged position until it abuts the shaft nut.

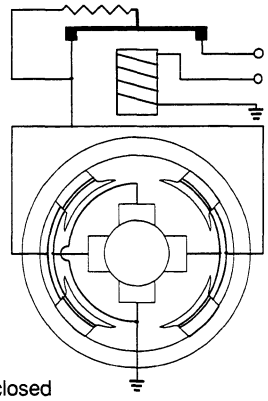
In moving forward, the taper on the pinion sleeve opens the segments, which are then held open by the magnetic flux of the solenoid coil.

As the pinion reaches that position the trip plate at the inner end of the pinion sleeve operates the solenoid trigger allowing the second stage contacts to close. The resistor is thus bypassed, allowing full voltage to be applied to the field windings and therefore full torque to be applied to the pinion.

As the pinion sleeve moves forward it also pushes the lock balls, which are located in holes in the pinion sleeve, inwards into "dimples" in the shaft as the internal cone in the lock collar travels over them. The pinion cannot then be ejected prematurely, but will remain in mesh until the starter control is released, or the overspeed mechanism operates. This is necessary when starting compression ignition engines from cold, as spasmodic engine firing might otherwise cause pinion ejection before the engine is self-sustaining.



Pinion fully engaged, collar holds lock balls.



Second contacts closed

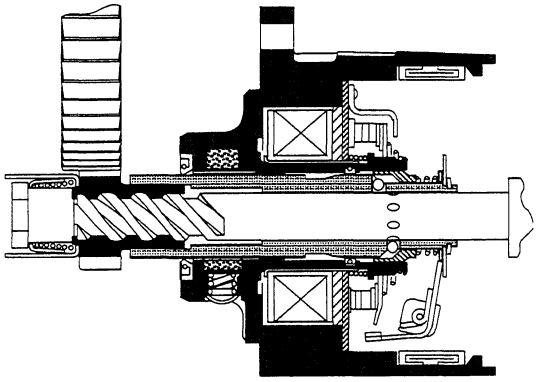
Fig. 4 Cranking Position

1.2.4 Overspeed position (see fig. 5)

If the starter control is held in the "on" position while the engine accelerates to high speed the overspeed balls will, under the action of centrifugal force, push the locking collar back thus releasing the lock balls and allowing them also to move outwards, releasing the pinion.

As the engine drives the starter the pinion will be driven back along the helix until it is fully out of engagement; the return spring then ensures that the pinion will move away from the flywheel and prevents "drift" of the pinion back towards the flywheel.

The starter will continue running, unloaded and at its light running speed, until the solenoid circuit is de-energised.



Overspeed balls push collar back; segments held out by solenoid flux. Pinion free to be driven out of engagement.

Fig. 5 Overspeed Position

1.2.5 Return to rest

Under normal operating conditions the solenoid circuit will be de-energised as soon as the engine is self-sustaining; the solenoid plunger will then be pushed back by its return spring, releasing the lock balls and allowing the pinion to return to the rest position under the action of the helix and its own return spring.

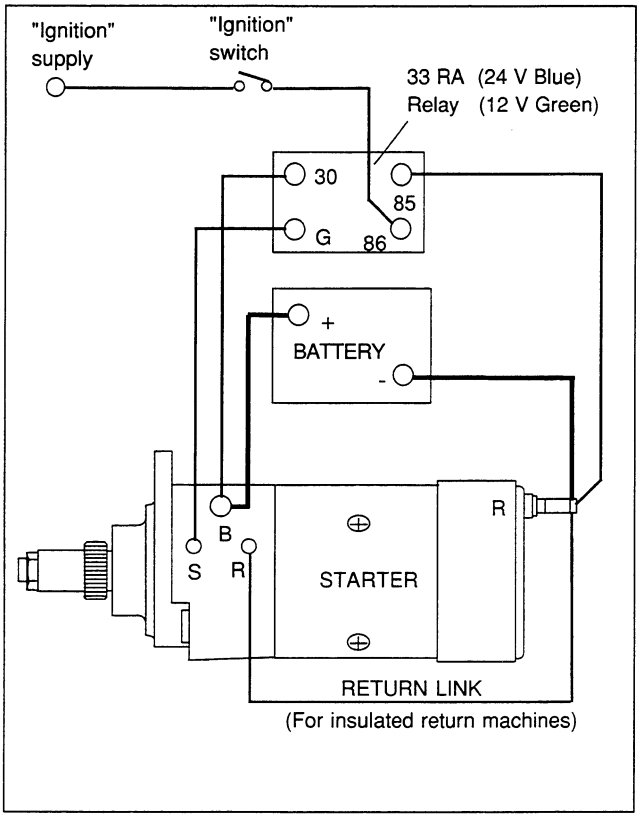


Fig. 6 Electrical Connections

1.3 INSTALLATION INFORMATION

1.3.1 Relay

When installing an S115A starter it is necessary to connect the contacts of a 33RA relay in series with the starter internal solenoid coil and mounted close to the starter (but NOT on the engine). By this means the current through the starter key switch is reduced to that taken by the 33RA relay coil; also voltage drop in the starter solenoid switch circuit is reduced to a minimum.

This particular relay has been chosen to operate satisfactorily with the starter. The relay is NOT adjustable and cannot be serviced.

It is essential that the relay connections are exactly as shown in fig. 6.

Note: If the relay is defective it must be replaced by a new one of identical type symbol. This is vital to the correct functioning of the starter motor.

1.3.2 Cables

See the table in Section 6.2 for details of cable sizes and maximum allowable volt-drops and resistance.

All cables connected to the starter must be terminated with suitable lugs, preferably crimped on, and which must be clean and tight. The cables should also be inspected for fractures, particularly where they enter the terminal lug. The cable insulation should be free from chafing or deterioration.

The main cables supplying the starter should be as short as practicable, but should allow for relative movement between the engine and the chassis or equipment in which it is mounted.

On some starters wired for insulated return (with a second solenoid terminal marked 'R' adjacent to the 'S' terminal on the drive end shield) the return path for the starter solenoid is made externally by connecting this solenoid 'R' terminal to the main 'R' terminal on the commutator end shield, as shown in fig. 6.

However, in some insulated return starters the return link will be internal, thus allowing terminal 'R' to be used to provide a signal from the second contacts to the automatic repeater.

1.4 FITTING AND REMOVAL

Note: Disconnect the battery before any attempt is made to remove the starter.

High-tensile steel bolts and heavy-gauge spring washers must be used for securing the starter; these should be examined to ensure that the mounting bolts are securely fastened.

In the event of apparent malfunction of the starter, check the battery condition and all external cables and connections in both the main and control circuits before removal of the starter.

The voltage across the starter main terminals, under load, should be a minimum of 9 V (12 V starters) or 18 V (24 V starters).

(Reference should be made to the engine or vehicle manufacturer's manual for the correct method of removal and refitting the starter).

1.5 MAINTENANCE

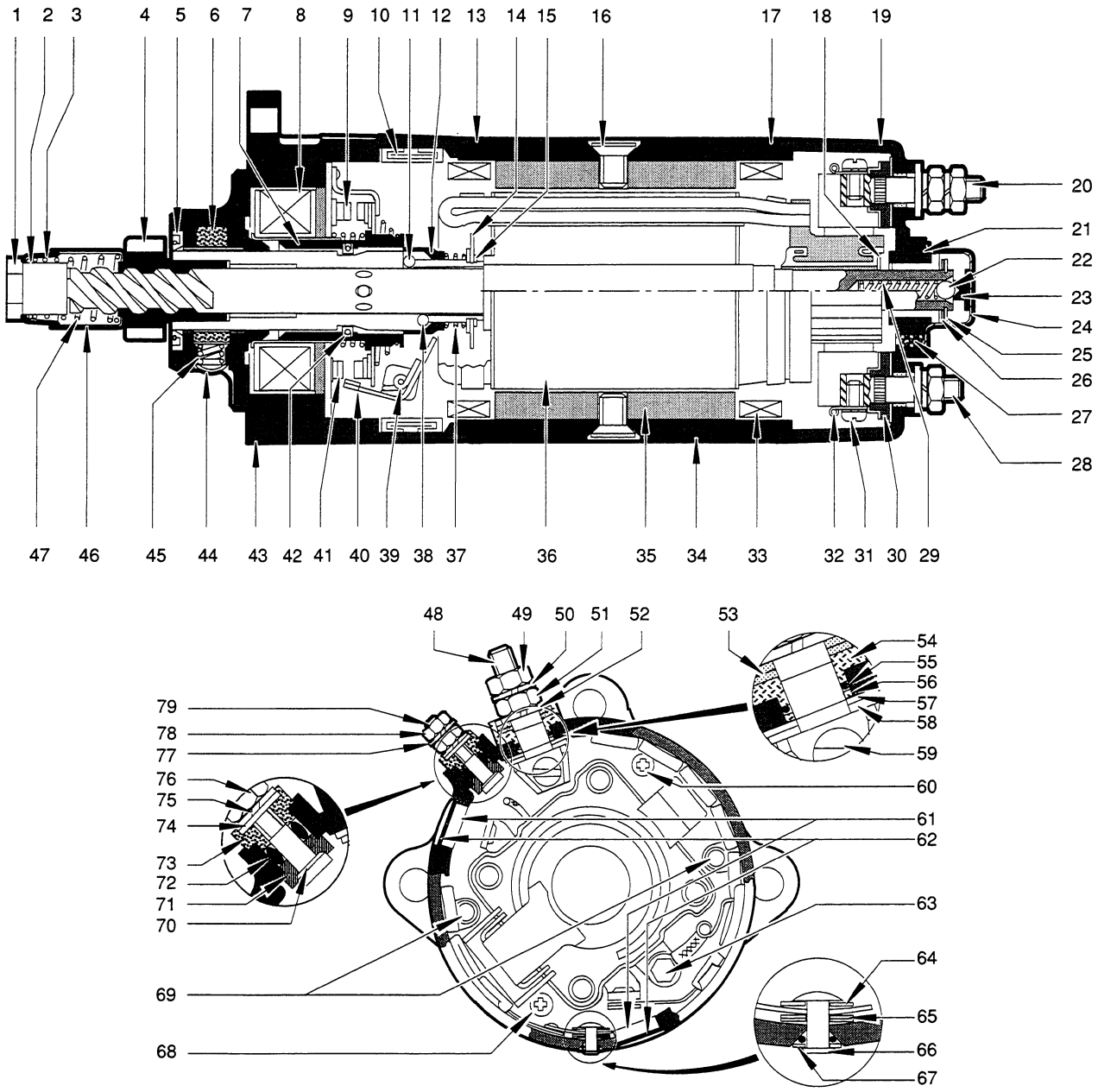
The S115A starters are designed to require no maintenance between major engine overhauls.

1.6 REPAIR

If the starter has been returned under warranty with a claimed fault in performance, an external examination for damage and a full performance test must be carried out before dismantling.

The procedures and components in this manual are based on one variant of the S115A starter as shown in Fig. 7. Other specifications may have differing arrangements; the positions of components must therefore be carefully noted during dismantling.

All special tools required for overhaul are listed in Section 6.1.



1.	Pinion stop nut	21.	O-ring	41.	Switch second contact	61.	Plastic plug
2.	Thrust washers (2 off)	22.	Steel ball	42.	Segments	62.	O-ring
3.	Dust cap	23.	Ball pad	43.	Drive and shield assembly	63.	Screw
4.	Pinion assembly	24.	Recoil cap	44.	Core plug	64.	Insulating washer
5.	Oil seal	25.	Circlip	45.	Spring	65.	Two insulating washers
6.	Felt lubricating wick	26.	Thrust and shim washers	46.	Dust cover	66.	Rivet
7.	Solenoid plunger	27.	Felt pad	47.	Pinion return spring	67.	O-ring and washer
8.	Solenoid assembly	28.	Tie bolt	48.	Main terminal	68.	Self-tapping screw and spring washer
9.	Switch first contact	29.	Recoil spring	49.	Nut		
10.	Resistor	30.	Brush plate assembly	50	Spring washer	69.	Positions of through-bolts
11.	Overspeed balls	31.	Brush tag screw	51.	Nut	70.	Tag
12.	Lock collar	32.	Brush tag	52.	Spring washer	71.	Insulator
13.	Sealing ring	33.	Field coil	53.	Flat washer(s)	72.	O-ring
14.	Trip plate	34.	Yoke	54.	Insulator	73.	Insulator
15.	Circlip	35.	Pole piece	55.	O-ring	74.	Flat washer
16.	Pole screw	36.	Armature	56.	Foam ring	75.	Spring washer
17.	Sealing ring	37.	Lock collar spring	57.	Insulator	76.	Nut
18.	Thrust and shim washers	38.	Lock balls	58.	Back plate	77.	Spring washer
19.	Commutator end shield	39.	Trigger spring	59.	Screw	78.	Nut
20.	Return terminal	40.	Trigger	60.	Self-tapping screw and spring washer	79.	Solenoid terminal

Fig. 7 S115A Main Components

Note (1): If a starter has been returned under warranty with a claimed fault in performance, carry out a full test as described in Section 5.

Note (2): Before removing any components or assembly, make a note of its position relative to adjacent items, either by marking it or making a sketch, to assist in correct positioning during reassembly.

Note (3): Normally, the drive end components will be removed before the commutator end shield. However, some insulated return starters require the commutator end shield to be removed first.

There are three insulated return versions of the S115A starter which may be fitted with a link wire between the two end shields. These are:-

A In which an external link wire is fitted between a second small terminal (marked "R") adjacent to the solenoid "S" terminal and the "R" terminal in the commutator end shield.

B In which an internal link wire connects the return from the solenoid to the "R" terminal in the commutator end shield. The second small terminal in the drive end shield may then be marked "A" and will provide a signal from the solenoid second contacts to an external automatic repeater controller.

C In which an internal link wire connects the return from the solenoid to the "R" terminal in the commutator end shield, but there is no additional external small terminal.

In cases B and C it will be necessary to remove the commutator end shield to gain access to the link wire for disconnection before removing the drive end shield. Follow the procedure in Section 2.2 only up to the point of removal of the end shield.

2.1 REMOVING THE DRIVE END COMPONENTS (See Fig. 7)

Clamp the starter securely in a vice, using soft jaws and gripping the yoke (34) only.

Remove the oiler core plug (44), with a pointed tool, and spring (45) from the drive end shield. Discard the plug.

Remove and discard the plastic plugs (61) and O-rings (62). A thin-bladed screwdriver will assist in removal.

Rotate the starter to position each hole horizontally in turn; unscrew and remove each field coil connection screw, spring washer and flat washer, taking care to avoid dropping components into the end shield.

Fit the pinion holding tool on to the pinion to prevent the shaft rotating. Slit and remove sufficient of the telescopic nylon dust cover (46), if fitted, to allow full fitment of a 22 mm socket (with the chamfered lead-in ground away). Unscrew the pinion stop nut (1) in the direction of starter rotation. Remove the thrust washers (2) and pinion return spring (47), together with any remaining parts of the dust cover and cap.

Straighten the "ears" on the two through-bolt tab washers, using a small chisel or suitable screwdriver blade, and remove the through-bolts.

Tap the drive end shield away from the yoke spigot with a mallet.

Release the ball-lock mechanism by pulling the pinion out from the end shield. With the lock collar held in this position, unscrew the pinion until the helix disengages. Finally, slide the pinion, together with the drive end shield, off the armature shaft, and collect the twelve steel balls (11) and (38) (which may fall through into the inside of the pinion sleeve).

2.2 REMOVING THE COMMUTATOR END SHIELD (See Fig. 7)

Note: The commutator end shield has two grooves in its inner rim, one of which will engage with a "key" formed in the yoke spigot, dependent upon the direction of rotation of the starter. To ensure that the correct groove is used during reassembly, scribe a line across the yoke/end shield joint with an indelible marker or scriber, and approximately in line with the return terminal, before the end shield is removed.

Clamp the starter securely in a vice, using soft jaws and gripping the yoke (34) only.

Slacken and remove the two screws retaining the recoil cap (24); remove the cap, ball (22), ball pad (23), and spring (29). Note that the spring will be under compression.

Unscrew and remove the nut spring washer, nut, spring washer, and flat washer from the return terminal (20).

Remove the nut on the tie-bolt (28), together with the spring washer and flat washer

Remove the shaft circlip (25) by placing a screwdriver blade between the shaft and the clip. Restrain the shaft and rotate the screwdriver until the clip is released. Remove the thrust washers and outer shim washers (26).

Carefully remove the commutator end shield (19) and shims (18) from the end of the armature shaft. Keep the shims in their sets. Do not mix the inner shims and outer shims/thrust washer pack, to simplify re-assembly when replacing these shims in their original positions. Remove the terminal and tie-bolt O-rings.

Raise the brush springs and remove the brushes from the brush boxes. Unscrew the four brush tag fixing screws (31) and remove the brush gear (30)

Remove the armature (36) from the yoke (34).

2.3 DISMANTLING THE DRIVE END SHIELD (See Fig. 7)

Using circlip pliers remove and discard the circlip (15) from the end of the pinion sleeve. Remove the trip plate (14) and shim, lock collar spring (37), and lock collar (12)

Withdraw the pinion assembly (4) from the drive end shield. (Any burrs on the pinion should be carefully removed by the use of a stone before withdrawing the pinion, to avoid damage to the bearing bush).

Remove the screw (63), spring washer and flat washer, and detach the resistor flexible lead screw from the moving contact plate. On 12 V insulated return machines there is a link to a binding-post on the moving contact.

Carefully drill away the rolled-over end of the rivet (66) securing the resistor (10) and free the resistor from the drive end shield by punching out the rivet. Withdraw the resistor and insulators.

Unscrew the main terminal nut (49), spring washer (50), nut (51) and spring washer (52). Remove the **two** flat washers (53) and the insulating bush (54). Extract and discard the O-ring (55) using a pointed instrument. Remove the screw (59). Press down the switch plunger and withdraw the main terminal (48) from inside the housing. Remove and discard the foam rubber ring (56) from the terminal.

Remove nut (78), spring washer (77), nut (76), spring washer (75), flat washer (74) and insulator (73) from the solenoid terminal (79) . Push the terminal, together with its O-ring (72), insulator (71) and solenoid tag (70), into the drive end shield and ease the assembly out. Remove the O-ring, insulator and tag. Discard the O-ring.

Remove the two solenoid fixing screws (60) and (68) and their spring washers, and the solenoid assembly (8) from the drive end shield.

Note: On insulated return starters remove similar parts from the adjacent 'R' terminal. Some starters will have an additional rivet to retain the resistor.

2.4 DISMANTLING THE SOLENOID SWITCH

Note: This operation will only be necessary if the contacts are severely burnt or damaged.

Component numbers refer to Fig. 8 except where stated.

Use a 4,7 mm drill to remove the rolled-over ends of the rivet (1) which retains the contact stop (2) and the two rivets which retain the trigger assembly (6). Take care to avoid damage to the coil or its spool whilst drilling the rivets.

Carefully punch out the rivets; remove the contact stop and the trigger assembly. Lift out the plunger and moving contact assembly and remove the plunger return spring.

Carefully grip the plunger (7) in a soft-jawed vice and use a suitable screw driver to release the contact spring (5). Separate the plunger and the moving contact assembly (4).

On 12 V machines unsolder the solenoid lead connected to the fixed-contact lug (8) beneath the tapped hole; in the case of earth-return machines unsolder the bare solenoid lead connected to the fixed-contact base plate lug (9). Remove the fixed-contact assembly, taking care to retain the spacer (11).

Remove the four overspeed segments (42) (Fig. 7) from the groove in the plunger bore. They are retained as a group by a "garter" spring.

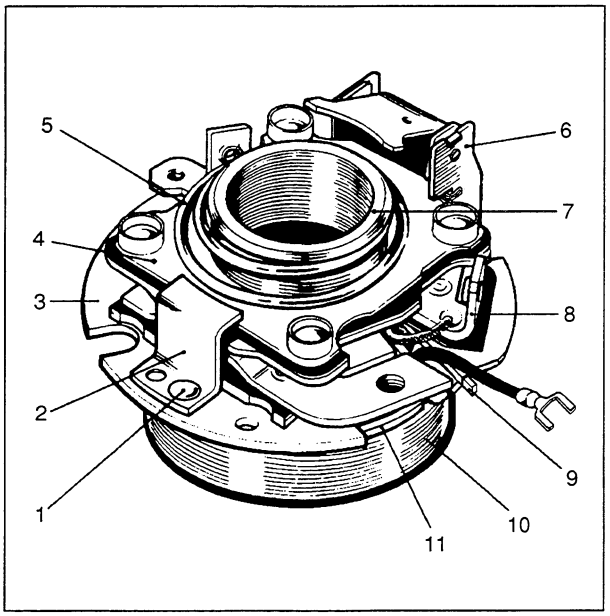


Fig. 8 Solenoid switch

Note: It is essential to remove all brush dust etc. from components by using dry compressed air before making insulation or resistance tests.

3.1 ARMATURE WINDINGS

If the armature windings are suspect e.g. if there is localised burning of adjacent commutator segments, they can be tested for continuity and short circuits by means of a "Growler" or similar armature tester. If such a tester is not available the only alternative is to substitute a new armature in the starter.

Check for insulation to earth by means of a 100 V "Megger"-type Tester between each commutator segment and the armature shaft. Resistance should be at least 1 megohm.

3.2 SOLENOID SWITCH (See fig. 8)

The coils can be checked for short or open circuits by measuring current consumption at nominal voltage. 12 V starter solenoids ONLY are dual-wound and consist of "pull-in" and "hold-on" windings, therefore before testing these a link should be made between the base of the contact assembly (3) and the terminal lug (8) on EARTH RETURN versions, or between the yellow lead and terminal lug (8) on INSULATED RETURN versions.

Examine the contacts and, if necessary, clean them with white spirit or very fine carborundum paper. Press down the plunger and check that the second stage contacts make **only** after the trigger is tripped. See section 6.3 (SOLENOID TEST DATA) for contact clearances.

If the contacts are badly burnt, the gap is excessive, or coils appear to have overheated, the switch should be replaced as a complete unit.

3.3 COMMUTATOR END SHIELD (See fig. 7)

3.3.1 Checking the bearing

The bearing is oil-impregnated and requires no attention. Any attempt to grease the bearing will adversely affect its self-lubricating properties.

Ensure that the bearing is tight in its housing. Check the bearing bore with plug gauge 5693-275. If it is oversize the bearing must be replaced.

3.3.2 Replacing the bearing

Press the old bearing out of the end shield using Tool No. 5693-240 or a suitable alternative "Dolly" and support. Carefully support the alloy end shield on flat surfaces to avoid damage. The bearing must be pressed out from the inside.

Lubricate the outside diameter of the new bearing with a little light engine oil and, with the same tool, press it into the end shield. Do not machine the bore of the bearing, but check it with Plug Gauge 5693-275.

Check that the small felt breather hole plug (27) is in place.

3.4 DRIVE END SHIELD (See fig. 7)

The drive end bearing is lubricated by a wick (6) in the drive end shield oil reservoir. The reservoir should be refilled when the starter is dismantled at a major overhaul. See Section 6.6 (LUBRICANTS). Check the internal diameter of the drive end bearing with Plug Gauge 5693-267. If the bearing is worn, and facilities for accurately machining a new bearing are not available, a new drive end shield assembly must be fitted.

Note: On new drive end shields a leatheroid retaining pad is fitted in the oilway to prevent swarf entering the oil reservoir during factory machining. This must be removed to prevent the bearing being oil-starved. Check that the felt pad is free to move under the influence of the spring (45).

If facilities for accurate machining are available, the bearing can be replaced and machined as follows:-

(i) Ensure that the oiler core plug (44) and spring (45) have been removed.

(ii) Prise out and dispose of the oil seal and press out the bearing with Tool No. 5693-266. Discard the wick (6). Lay a new wick, pre-soaked in oil, around the oil reservoir so that the ends meet 180 degrees from the oiler hole.

(iii) Press a new bearing, chamfered end first, fully home into the end shield and ensure that the bearing "window" is in alignment with the oiler hole.

(iv) Fit the leatheroid pad 5549-608 into the bearing window so that it completely fills the aperture, to prevent swarf entering during machining.

(v) Set up the end shield on a precision lathe in such a manner that the bore is perfectly concentric and square with the internal circumference of the end shield where it registers with the yoke.

(vi) Turn the bearing bore to 28,61-28,63 mm (1,126-1,127 in) ensuring that the finish is of the highest quality. The final diameter of the bore can be checked with Plug Gauge 5693-267.

(vii) Clean off all swarf from the bearing and oil seal bore in the end shield and remove the leatheroid retaining pad.

(viii) Press in a new oil seal using Tool No. 5693-299. Ensure that the oil seal is secure and free from damage.

Note: Do not fit the lubricator pad spring (45) and core plug (44) at this stage, as pressure on the felt pad will prevent the pinion sleeve being fitted.

3.5 PINION

If the pinion teeth or pinion sleeve are worn or damaged, change the pinion. Confirm that the new pinion has the same number of teeth of the correct tooth form, and is a free sliding fit on the armature shaft. The pinion fitted to "oil-sealed" starters will have an oil-seal located in the pinion bore; all burrs or sharp edges on the armature shaft and helix must be removed with a fine abrasive stone otherwise the seal will be torn. Fit a new seal with the 'U' channel facing towards the pinion teeth (see Fig. 9).

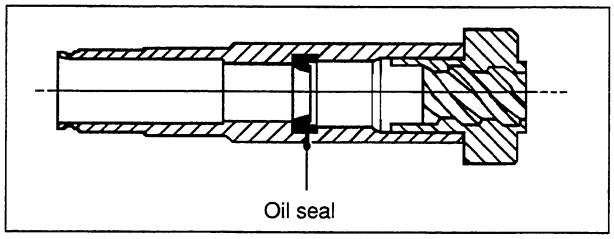


Fig. 9 Pinion Cross-section

3.6 SPRINGS

Ensure that the springs are not damaged and have not lost tension. Check the compressed load of each spring, as listed in Section 6.4 (COIL SPRINGS).

3.7 COMMUTATOR

If the commutator surface is dirty or discoloured, it can be cleaned with a very fine grade of glass paper; **DO NOT** use emery cloth or carborundum paper. In cases where the surface is badly pitted or grooved, set the armature up in a lathe and skim the commutator. With a rough cut remove just sufficient copper to clear traces of grooving or pitting, after which a light cut should be taken, using a diamond- or tungsten carbide- tipped tool to obtain the desired high quality finish. Finally, remove all traces of swarf using dry compressed air.

The minimum diameter to which the commutator can be reduced is 39,6 mm (1,56 in) and the radius at the junction of the risers and commutator must not exceed 1,0 mm (0,040 in).

DO NOT skim the risers.

The full width of the commutator insulators must be undercut to a depth of 0,65 mm (0,026 in).

3.8 ARMATURE SHAFT

Examine the ball recesses in the armature shaft and carefully remove any burrs with a fine stone.

Inspect the shaft helices for signs of damage or excessive wear. Finally, clean the helices with paraffin and smear them with a small quantity of grease. See Section 6.6 (LUBRICANTS).

No attempt should be made to machine the armature core.

3.9 FIELD WINDINGS (See fig. 7)

Before making electrical tests remove all traces of brush dust etc. by blowing with dry compressed air.

The windings can be tested for earthing to the yoke and poles using a 100 V "Megger" type tester. Insulation resistance to earth must be not less than 1 Megohm.

There is no easy way of checking for initial short-circuits in the coils as their resistance is very low. New coils should be tried if the existing ones are suspect.

If it is necessary to replace the field coils, use the following procedure:

(i) Unscrew the pole fixing screws (16) and remove the pole pieces (35) and windings (33), noting the positions of the windings in order to facilitate reassembly.

(ii) Fit the new windings into the yoke and refit the pole pieces.

(iii) Insert and tighten new pole screws, using a commercial poleshoe screwdriver. Ensure that the pole pieces are correctly aligned in the yoke and that no space exists between the mating surfaces, otherwise they will not bed down fully and may foul the armature.

(iv) Check the new windings for earth-leakage as described above.

3.10 BRUSHGEAR

Check the brushgear insulation by using a 100 V "Megger" type tester between the brush boxes and the mounting plate. Insulation resistance to earth must be not less than 1 Megohm. Ensure that the brush box riveting is tight, that the brushes slide freely in their boxes and that the brush springs are centrally located between the "pigtails". Ensure that the spring fixing posts are not bent out of position.

3.11 BRUSHES

The minimum acceptable brush length is specified in Section 6.5 (BRUSH DETAILS). However, during overhaul always renew the brushes to ensure maximum life between overhaul periods. Replacement brushes must be fitted in complete sets.

3.12 BRUSH SPRINGS

The brush spring force onto a new brush should be within the specified value. This must be checked during reassembly and the method to be used is described in Section 4.8 (v).

3.13 YOKE (See fig. 7)

Examine the yoke for any damage likely to affect correct alignment of the end shields, and hence the armature, and replace the two sealing rings (13) and (17).

4.1 ASSEMBLING THE FIXED CONTACT PLATE TO THE SOLENOID COIL (See Fig. 10)

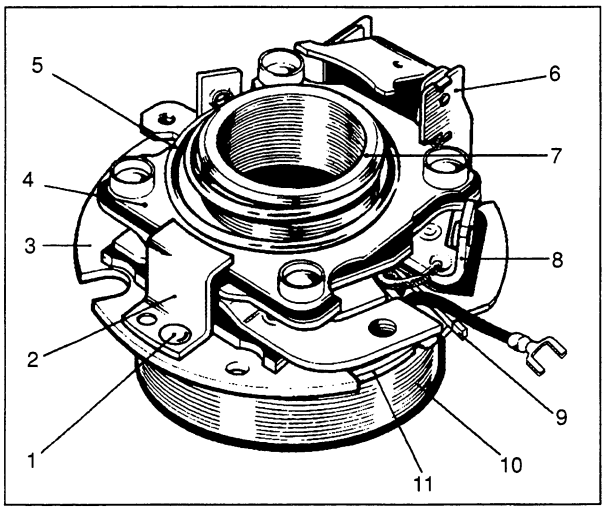


Fig. 10 Solenoid Switch

Locate the fixed contact assembly (3) on the solenoid coil (10). Ensure that the holes for the trigger assembly (6) and the moving contact stop (2) are correctly aligned. Fit the insulator (11) between the solenoid coil plate and the fixed contact, with the blind hole facing upwards and the curved edge aligned with the periphery of the contact plate.

Secure the plunger (7) in a vice (fitted with soft jaws) and place the moving contact assembly (4) over the plunger. Secure the moving contact with the tapered spring (5), with the smaller diameter end retained under the plunger lip.

Remove the plunger assembly from the vice and place the return spring over the plunger, under the moving contact.

Very lightly smear the sliding surfaces with the recommended lubricant (see Section 6.6), ensuring that no lubricant is allowed to contaminate the contact surfaces; place the plunger assembly into the coil and align the larger projection on the plate with the trigger fixing holes.

Push the solenoid plunger fully inwards and retain it in this position with a clamp. Fit the contact stop (2) in place, together with a rivet (1), facing downwards. Close the rivet, and ensure that the components are clamped tightly.

Place the trigger assembly in position and secure it tightly with two rivets, facing downwards.

Note: To gain access to the rivets for closing, it will be necessary to remove the trigger from its stirrup. This can be done by gently spreading the stirrup arms just sufficiently to release the pivot pin, one side at a time, and then releasing the spring ends.

When reassembling the trigger, ensure that the spring legs are correctly located in their notches in the stirrup.

Solder the red solenoid lead to the fixed contact lug (8) on all 12 V machines. On earth-return machines, solder the other bare solenoid lead to the lug (9) on the fixed contact base plate, taking care to minimise spread of the solder. (On insulated return 24 V starters, no soldering is required).

Check that the first stage contact gap is within the limits specified in Section 6.3 (SOLENOID TEST DATA). Slight adjustment, if necessary, can be made by bending the contact stop (2).

4.2 FITTING THE SEGMENTS

It is vital to check that there are no burrs or other damage on the segments which would prevent efficient operation of the overspeed protection device. Place the garter spring on a clean, flat surface and position the four segments inside the spring so that they lie end-to-end in a circle with the sharp edge of all four segments on the same side. The garter spring will fit in the grooves of the segments and hold them together.

Place the solenoid switch assembly on the bench with the coil upwards. Gently push the garter spring and segment assembly, with the sharp edges upwards, into the bore of the solenoid plunger so that it lies close to the recess. Locate one segment in the recess first and then ease the other three into position.

4.3 FITTING THE SWITCH TO THE DRIVE END SHIELD (See fig. 7)

Insert the solenoid assembly into the drive end shield with the trigger assembly over the widest gap in the abutment shoulder. Secure the solenoid assembly in position with the two special self-tapping screws and spring washers.

Place the black solenoid wire tag (70) and the insulator (71) over the terminal (79) and push this assembly through the hole in the drive end shield, with the tag facing upwards. Fit O-ring (72), insulating bush (73), washer (74), spring washer (75) and nut (76), tightened to the specified torque. Fit spring washer (77) and nut (78), leaving the nut finger-tight.

Note: On insulated return models there is a further solenoid lead, coloured yellow, which must be attached to its terminal screw (the " R" terminal) exactly as above.

Place the insulator (57) on to the main terminal (48). Press down the solenoid plunger and insert the terminal into the main hole "B" in the end shield from inside. The widest contact face of the terminal must be towards the fixed contact. Insert the slotted plate (58) between the head of the terminal and the insulator. Fit a new foam rubber ring (56) and O-ring (55). Fit insulator (54), plain washers (53), spring washer (52) and nut (51), finger tight.

Insert screw (59) and spring washer and secure the terminal to the fixed contact; then tighten nut (51) to the specified torque. Ensure that the terminal does turn in the end shield when the nut is tightened.

Fit spring washer (50) and nut (49), finger tight.

4.4 FITTING THE RESISTOR (See fig. 7)

Insert the resistor (10) into its recess in the drive end shield with the anchor point opposite to the fixing hole. Fit a new rivet (66) with one insulating washer (64) under the rivet head and two insulating washers (65) between the resistor and the drive end shield (on 24 V machines). When the rivet is pushed through the end shield from inside, fit the O-ring and washer (67) and close the rivet.

Connect the resistor flexible lead to the lug on the solenoid assembly moving contact with screw (63), spring washer, and flat washer. Ensure that the flexible lead is routed away from the moving contact.

Note: (1) On 12 V insulated-return models there is a link bar between the lug and a corner of the moving contact. The link is secured to the lug by a screw and washer and the other end is attached to a post together with the resistor flexible lead by means of a nut and washer.

Note: (2) On 12 V starters two moulded insulators are used for mounting the resistor instead of three insulating washers.

Note: (3) On insulated-return models, the resistor may be secured by two rivets.

4.5 FITTING THE PINION TO THE DRIVE END SHIELD ASSEMBLY (See fig. 7)

Fit the 3-part split protection collar, Tool No. 6244-6, to protect the oil seal (5), in the drive end shield.

Lightly smear the pinion sleeve with grease (see Section 6.6 LUBRICANTS). Push the pinion carefully into the drive end shield to avoid disturbing the segment group (42). Detach the split protection collar and place the assembly on to the bench with the pinion teeth downwards.

Use a small screwdriver with a little of the specified grease to pick up and place the six overspeed balls (11) and the six lock balls (38) into the holes in the pinion. Retain the balls in position with a little grease. Place the lock collar (12) over the pinion with its larger bore towards the pinion, using a finger in the pinion bore to prevent the balls from being pushed through their holes.

Replace the lock collar spring (37), shim, and trip plate (14) and secure them in position with a new circlip (15), sharp edge outwards. Make sure that the circlip is located properly into its groove.

4.6 FITTING THE DRIVE END SHIELD AND PINION ASSEMBLY TO THE ARMATURE SHAFT (See fig. 7)

Place the armature horizontally in the vice (fitted with soft jaws) using the minimum of force. Fit the pinion and end shield assembly to the shaft as follows:

(i) Pull the pinion out of the drive end shield until the lock collar is pressed back against its spring by the end of the solenoid plunger (7). Keep it in this position until fitment is completed.

(ii) Ensure that the balls are fully into their holes to allow free entry of the shaft.

(iii) Slide the pinion and end shield assembly on to the shaft, taking care not to displace the balls.

(iv) Engage the pinion with the shaft helix. Hold the drive end shield in one hand and rotate the pinion, to match the direction of the helix, on to the shaft and release the pinion.

(v) To check the operation of the lock balls (38), restrain the drive end shield, wind the pinion out until the locking mechanism operates and the pinion is fully locked (a small amount of rotation of the pinion in either direction will be possible). Push the drive end shield inwards away from the pinion to release the locking balls, then wind the pinion back into the drive end shield.

(vi) Fit the larger plastic dust cover (46) over the exposed end of the shaft, against the pinion, open end outwards. Fit the pinion return spring (47), the two shims (2) (with the smaller shim in the outer position) followed by the small plastic cap (3). Screw the stop nut (1) on to the shaft but leave it finger tight.

Note: (1) Some starters will not be fitted with plastic dust covers.

Note: (2) The shaft and nut threads are in opposition to the working direction of rotation of the starter.

4.7 FITTING THE DRIVE END SHIELD AND ARMATURE TO THE YOKE (See fig. 7)

Fit a new seal (13) to the yoke and carefully enter the armature and drive end shield into the yoke, ensuring that the yoke dowel is located in the register in the end shield.

4.8 FITTING THE COMMUTATOR END SHIELD (See fig. 7)

Note: It is necessary to use a jig to pre-align the brush gear to the ends of the field coils so that no strain is imposed on the windings when the connecting screws are tightened. The jig also sets the positions of the brush gear relative to the yoke key and sets the axial dimension from the back of the assembled brush gear to the end-face of the yoke to 36,9 - 37,0 mm (1,45 - 1,46 in).

Modify a spare commutator end cover by machining four slots as shown in fig. 11.

Before using the jig, transfer the scribed mark on the "inner" end of the original commutator end shield to the inner end of the jig by placing the jig on the outer end of the shield and aligning the terminal and tie-bolt holes with those in the jig (the terminal hole has the larger boss). The angular difference

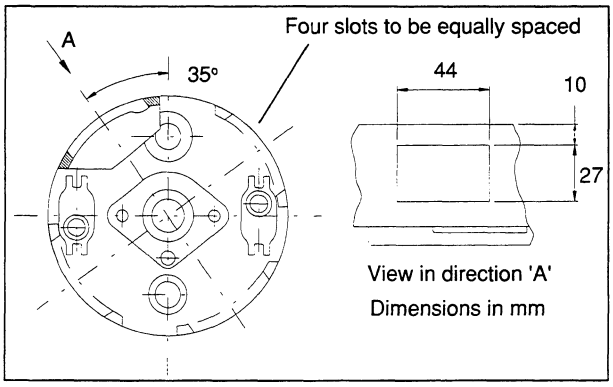


Fig. 11 Brushgear Positioning Jig

between the two locating grooves is 15°, so great accuracy is not needed.

(i) Ensure that the insulating plate, if fitted, is located on the assembled brush gear mounting plate (30) and that an insulating bush and O-ring are fitted to both the terminal (20) and the tie-bolt (28).

(ii) Mount the assembled brush gear plate (30) into the assembly jig, locking the brush gear in position with the terminal and tie-bolt nuts. Ensure that the tie-bolt is adjacent to the felt breather hole.

(iii) Locate the jig on the yoke register ensuring that it is flush with the end of the yoke and that the scribed line on the jig aligns with that on the yoke. Lock the jig in position.

(iv) Use a hook to lift the brush springs and fit the four brushes. Check the spring force by hooking a spring balance at the junction of the two brush leads, where they are soldered to the tag. Raise the brush squarely in its holder until the brush protrusion is 2 mm as shown in fig. 12. Read the force indicated by the spring balance. If the force is outside the limits, fit new brush springs. See Section 6.5 (BRUSH DETAILS).

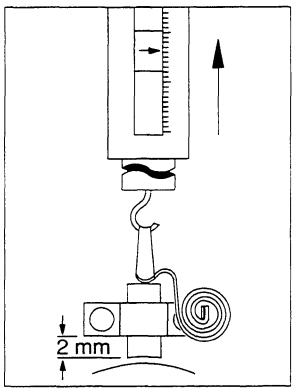


Fig. 12 Measurement of Brush Spring Force

(v) Ensure that the balancing link is in position. The brush tags must be connected in one of the two arrangements shown in Fig. 13, dependent upon the voltage and direction of rotation of the starter. The two screws (31) secure the relevant brush tags to the commutator end terminal and the tie-bolt. Ensure that the field coil terminations are clear of the armature and that the balancing link is clear of the through-bolt position.

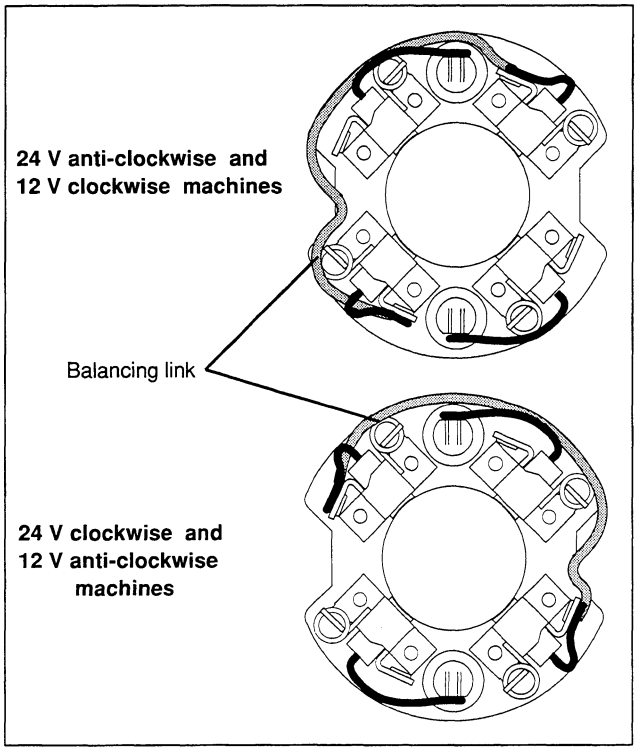


Fig. 13 Brush Connections

(vi) Remove the assembly jig.

4.9 SHIMMING THE ARMATURE (See fig. 7)

There are three options for shimming the armature. Which option is used depends upon whether the original shims and armature are to be refitted or not, and the availability of a pinion-to-flange gauge.

4.9.1 Using the original shims and armature

(i) Fit the original inner shim(s) (18) onto the armature shaft and assemble the commutator end shield (19).

(ii) Place new tab washers and O-rings under the heads of the through bolts and fit the bolts to the machine; locate the tab washers into the recesses in the commutator end shield. Tighten the bolts to the specified torque.

(iii) Replace the outer thrust washers and shim washers, coated with the specified grease. Fit a new circlip (25) in a position where one of the two circlip groove keys is located in the gap between the ends of the circlip (see fig. 14).

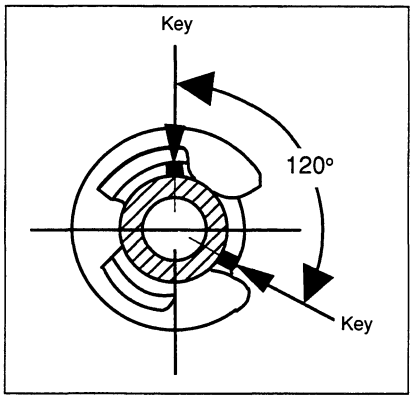


Fig. 14 Circlip Position

(iv) Push the armature shaft towards the commutator end of the machine, pushing the shim and thrust washer pack against the bearing bush flange. Measure the gap 'W' (fig. 15), which should be 2,25 ± 0,25 mm.

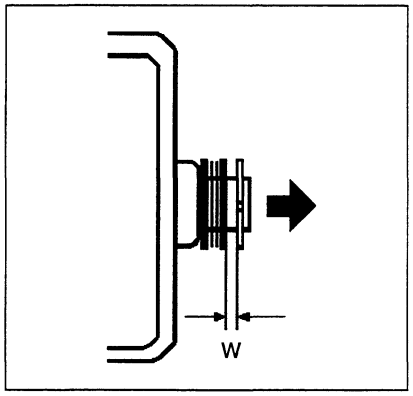


Fig. 15 'W' Dimension

(v) Bolt the relevant setting gauge (see Section 6.1 SPECIAL TOOLS) to the mounting flange as shown in fig. 16. Push the armature towards the drive end of the starter; the pinion face should just touch the gauge as the circlip closes the shims against the bearing bush face i.e. 'X' should be zero. If this does not occur, follow the procedure in Section 4.9.2.

(vi) Finish assembly of the starter as in Section 4.10.

4.9.2 Using new shims and/or a new armature - gauge method

Note: This procedure may also be used if the shims have become mixed after dismantling.

Gap 'X' and the pinion-to-flange dimension may be set as follows, using the appropriate gauge (see Section 6.1 SPECIAL TOOLS).

(i) Remove the inner shim(s) and the thrust washer (18) from the armature shaft and assemble the commutator end shield (19) to the yoke. (It is not necessary to fit the sealing ring (17) yet). Fit the through bolts and tab washers; tighten them to the specified torque. Fit the two outer thrust washers and circlip, ensuring that its sharp edge is facing the thrust washers as illustrated in fig. 14.

(ii) Bolt the gauge on to the mounting flange as shown in fig. 16. Push the armature towards the drive end of the machine until the pinion face just touches the gauge. With the armature held in this position, measure gap 'X' between the thrust washers (26) and the bearing bush flange, using feeler gauges.

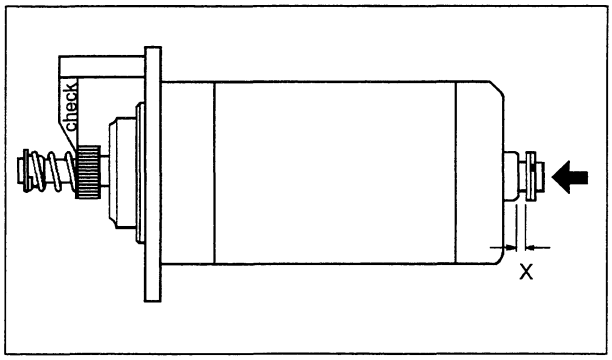


Fig. 16 'X' Dimension

(iii) Fit shim washers, to the same thickness as the feeler gauges, between the two thrust washers. The shim washers are available in two thicknesses, 0,20 and 0,30 mm (0,008 and 0,012 in). A combination of these sizes giving the closest approximation to the required dimension should be used. Replace the circlip.

(iv) Push the armature towards the commutator end of the machine as shown in Fig. 17 and measure gap 'Y' which should now be within the limit 2,0 to 2,5 mm (0,080 to 0,100 in). A GO/NO GO gauge is available (see Section 6.1 SPECIAL TOOLS).

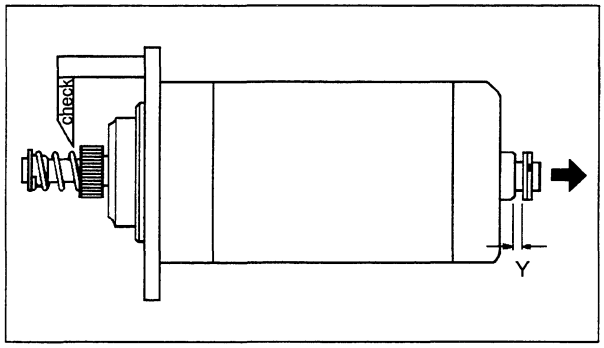


Fig. 17 'Y' Dimension

If the gap is outside this limit, remove the commutator end shield, and fit shim washers (18) on the armature shaft to the value of the excess. For example, if the gap is 3,04 mm (0,120 in) shim washers having a total thickness 0,51 to 1,01 mm (0,020 to 0,040 in) should be fitted i.e. four shims each 0,20 mm (0,008 in) thick. Finally all shims must be smeared with grease.

(v) Fit a new sealing ring (17) and replace the commutator end shield. Fit the through bolts ensuring that the O-rings and tab washers are in place, with the tabs located in the recess cast in the end shield. Ensure that both through bolts have been screwed fully home and that both end shields are correctly located on the yoke spigot. Tighten the bolts to the specified torque.

(vi) Replace the outer thrust washers and shim washers (coated with the specified grease). Fit a new circlip (25) with one of the "keys" in the groove in the shaft located in the gap between the arms of the circlip. See Fig. 14.

(vii) Finish assembly of the starter as in Section 4.10.

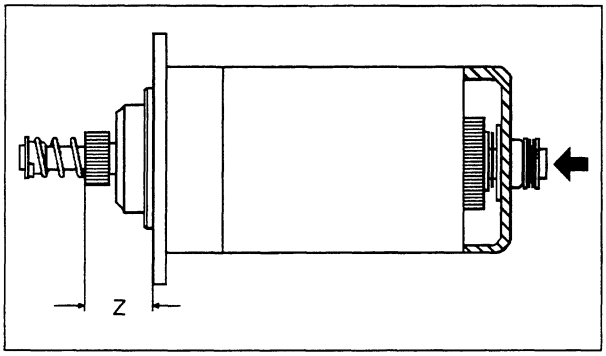


Fig. 18 'Z' Dimension

4.9.3 Using new shims and/or a new armature - direct measurement method

Note: This procedure may also be used if the shims have become mixed after dismantling.

(i) If no gauge is available, push the armature shaft towards the drive end, hard against the pack of shim(s) and thrust washers; measure distance 'Z' by placing a straight-edge across the outer face of the pinion (fig. 18). If this distance is within the specified tolerance (see Section 6.1), renew the circlip (25) ensuring that it is fitted with the sharp edge towards the thrust washer and as shown in Fig. 14. Fit the recoil components as described in Section 4.10.

(ii) If the distance 'Z' is outside the specified tolerance calculate the difference relative to the specified nominal dimension.

a) If 'Z' is larger than the maximum specified, add shims, having a total thickness equal to the calculated difference, to the outer shim pack (26).

b) If 'Z' is smaller than the minimum specified, remove shims, having a total thickness equal to the calculated difference, from the outer shim pack (26).

(iii) Proceed as for Section 4.9.2 parts (iv) to (vii) above.

4.10 FITTING THE END CAP (See fig. 7)

When the end-float and pinion-to-flange clearance are as required, fit the following to terminal (20): washer, spring washer and nut. Fit the following to the tie-bolt (28): washer, spring washer and nut. Tighten both nuts to the specified torque and loosely fit the spring washer and nut to the terminal.

Smear the recoil spring (29) with grease and insert it into the bore in the armature shaft. Pack the recoil cap (24) with grease, using the grease to hold the pad (23) and ball (22) in position.

Check that the felt breather pad (27) and O-ring (21) are in position in the commutator end shield. Fit the recoil cap using the two self-tapping screws and spring washers, ensuring that the small breather hole in the cap flange is in line with the felt pad.

Connect the field windings and the free end of the resistor to the solenoid switch lugs by means of the screws, spring washers and plain washers through the access holes in the drive end shield. Ensure that the screws are tight, the switch lugs are not bent inwards and the terminations are not trapped under the lugs. Fit new plastic plugs with O-ring seals into the two access holes.

Fill the oil reservoir in the drive end shield with the specified oil, and insert the spring (45). Replace the core plug (44) using Tool No. 5693-300, ensuring that the plug is secure.

Remove the stop nut (1). Grease the two thrust washers (2) and fit them into the dust cap (3), the smaller diameter washer first. Ensure that the threads of the armature and stop nut are grease-free and apply Loctite grade 243 to the nut thread. Assemble the cover (46) spring (47), outer dust cover and stop nut on to the shaft. Check that the nut has screwed fully home and that the dust cover is correctly located and rotates smoothly on the pinion register. Use a pinion-holding tool and tighten the nut to the specified torque.

Note: On insulated return starters two washers are fitted to the return terminal and the tie-bolt; and an insulating washer is fitted against the end shield, followed by a steel washer.

5.1 SOLENOID ENGAGEMENT MECHANISM

WARNING:

WHEN TESTING THE SOLENOID ENGAGEMENT MECHANISM, UNDER NO CIRCUMSTANCES SHOULD BOTH MAIN TERMINALS BE CONNECTED TO THE SUPPLY. IF THIS IS DONE, THE PINION WILL ROTATE AT HIGH SPEED WHEN PULLED FORWARD, CAUSING SERIOUS INJURY TO THE OPERATOR.

With the machine disconnected, pull the pinion forward by hand approximately 6 mm (0,25 in) and then release it. The pinion should return briskly to its original position. Repeat this test with the pinion in two other different radial positions, at approximately 120 degrees to the first test position. Check that the armature is not stiff when rotated by hand.

Energise the solenoid, when cold, by applying either 12 V or 24 V, depending upon the voltage of the starter. For ALL tests the battery should be well charged, in good condition and of minimum capacity as indicated in Section 6.7 (STARTER TEST DATA).

The battery should be connected, via a suitable on/off switch or relay, between the solenoid terminal 'S' and the earth terminal (for machines designed for earth return systems), and between the solenoid terminal 'S' and solenoid terminal 'R' for insulated return machines. When the solenoid has been energised, the pinion should move forward briskly for a minimum distance of 6 mm (0,25 in). Repeat this test with the pinion in two other different radial positions, each at approximately 120 degrees to the first position.

With the solenoid only still energised, pull the pinion forward and rotate it by hand against the normal direction of rotation (along the helix) sufficiently to push the plunger segments apart but not enough to engage the ball lock. Release the pinion; it should return fully to the "rest" position, indicating that the segments are held in their "outer" position.

With the solenoid still energised, draw the pinion forward by rotating it in the direction opposite to the normal rotation until the locking mechanism comes into operation, locking the pinion in the forward position. Disconnect the supply to the solenoid. The pinion must return to its disengaged position in one sharp movement.

Check the recoil spring action by applying a compression spring balance to the drive end of the armature shaft. The force required before backward movement of the shaft occurs should be 133 to 169 N (13,6 to 17,2 kgf) (30 to 38 lbf).

5.2 STARTER PERFORMANCE TESTS

CAUTION:

If the starter is allowed to run without engaging a suitable ring gear, the pinion will not be restrained from rotating in the initial stages, and thus will not complete the forward movement necessary to trip the second stage contacts. Under these conditions, the resistor will remain in circuit and may be damaged by overheating. For this reason the starter running period must not exceed five seconds during either of the following tests.

For both of these tests the starter must be securely clamped, or held in a vice.

5.2.1 First contact

Energise the solenoid with either 12 V or 24 V, depending upon the voltage of the starter, then connect the main terminals to the test battery. The pinion should move forward smartly at least 6 mm and rotate smoothly with no undue noise or vibration.

5.2.2 Light running

DISCONNECT THE TEST BATTERY FROM THE MAIN STARTER TERMINALS.

Apply 12 V or 24 V, depending upon the voltage of the starter, to the solenoid terminals **ONLY**, then pull the pinion fully forward by hand; check that it locks in the forward position and back-rock between the pinion and shaft nut does not exceed 0,5 mm (0.020 in.). Connect the main terminals to the test battery, through a suitable switch, with the ammeter connected in series with one of the leads, and connect the voltmeter across the main terminals. In this light-running condition, the pinion should rotate at a higher speed than in 5.2.1 above, again with no noise or vibration. The light-running figures are given Section 6.7.(STARTER TEST DATA).

Switch off the power supply to the solenoid terminals; the pinion should return the its rest position and stop rotating. Remove all connections to the starter.

5.2.3 Engagement and full-load testing

CAUTION:

Before commencing performance testing, ensure that all meters and cables are capable of handling the currents expected to be drawn by the machine under test (see Sections 6.2 and 6.7) and that the bench can absorb the expected torque.

Also, confirm that the tachometer range covers the expected machine no-load speed (see Section 6.7).

Mount the starter on the starter test machine so that when the pinion is fully back in the rest position, there is a clearance of 3,17 mm (0,125 in) between the outer face of the pinion and the face of the ring gear. Ensure that the starter is securely clamped.

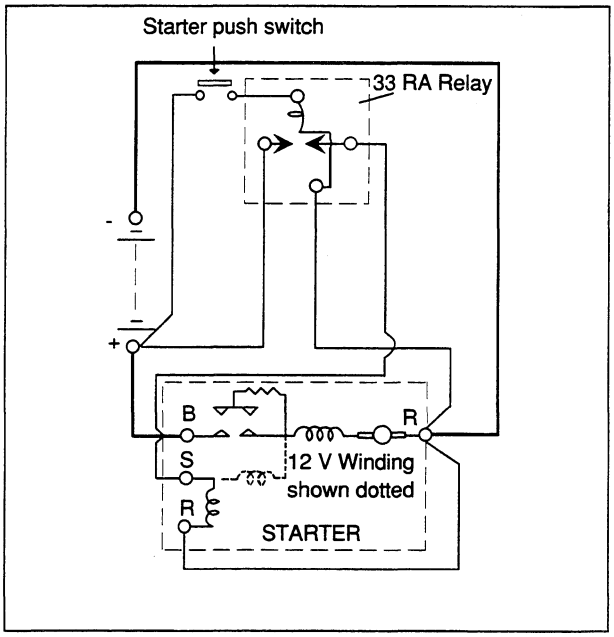


Fig. 19 Insulated Return Test Circuit

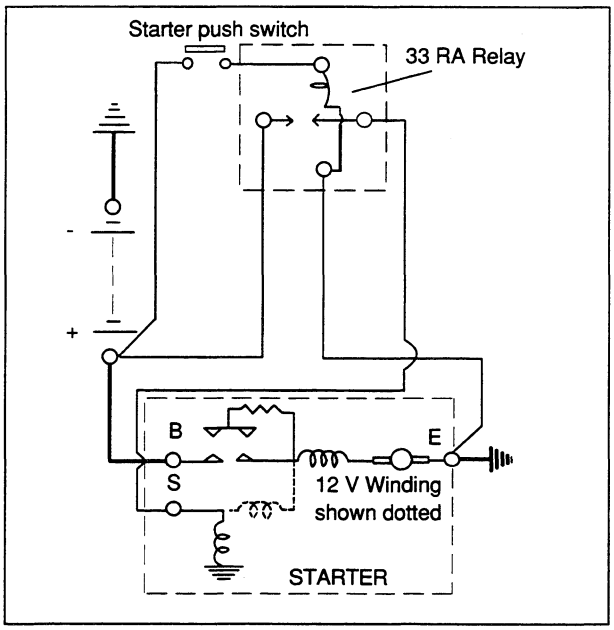


Fig. 20 Earth Return Test Circuit

Connect the starter terminals to a fully charged battery of the correct voltage, as shown in Test Circuits Fig's 19 and 20.

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

With the flywheel brake partially applied, apply 12 V or 24 V, dependent upon the voltage of the starter, to the solenoid terminals and check that the pinion engages correctly with the flywheel. Repeat this test ten times to ensure consistent engagement.

5.2.4 Locked torque test

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

Refer to the typical performance figures given against the heading "Locked Torque" in the table in Section 6.7 (STARTER TEST DATA).

The figures in the table refer to torque output measured at the pinion; refer to the test machine instructions for conversion of the torque at the flywheel shaft (indicated by the test machine) to the equivalent at the pinion.

5.2.5 Running torque test

With the starter running and driving the flywheel, apply the brake progressively until the torque given in the table is obtained. Quickly note the torque, current and voltage readings. Again, the test machine instructions will give the conversion factor to be applied.

Release the flywheel brake promptly and switch the starter OFF. Refer to the typical performance figures given against the heading "Running Torque" in the Section 6.7. (STARTER TEST DATA).

Remove the starter from the test machine and replace the terminal spring washers and nuts.

6.1 SPECIAL TOOLS

Before overhaul it is advisable to obtain the following special Lucas Hartridge tools. These will reduce the time spent on overhaul and enable a closer approach to factory standards to be achieved.

Tool Number	Description
5693-222	Setting gauge for machines with a pinion-face to mounting- flange dimension of 47,6 mm (1,875 in).
5693-222A	Setting gauge for machines with a pinion-face to mounting-flange dimension of 20,65 mm (0,8125 in).
5693-240	Extraction and replacement tool for commutator end bearing.
5693-267	Plug gauge for drive end bearing
5693-266	Extractor for drive end bearing
5693-275	Plug gauge for commutator end bearing
5693-299	Fitting tool for drive end shield oil seal
5693-300	Fitting tool for lubricator core plug
6244-4	End float gauge (GO/NO-GO)
6244-6	Split collar for oil seal protection
6244-39	Pinion holding tool

Note: If no gauge is available the pinion-to-mounting flange dimension, as indicated in the table above, may be measured as described in Section 4.9.3 ; the tolerance allowed on the nominal dimension is ± 0,15 mm.

In addition to the two dimensions listed, there is a further possible dimension of 40,50 mm (1,594 in).

In addition to the tools listed in the table above, a tension/ compression spring tester of range 0 to 20 kg (44 lbf) is required. A suitable instrument can be purchased from Salter Industrial Instruments, George Street, West Bromwich, West Midlands, B70 6AD, England. Also, a torque wrench with ½ in square drive and a 22 mm socket with the chamfered lead-in ground away is required to tighten the pinion nut to the required torque.

6.2 RECOMMENDED MINIMUM CABLE SIZES

Cable Area (mm^2)	Main	Solenoid
12 V starters	55	4.5
24 V Starters	55	2.0

The overall resistance of the main cables should not exceed 0,0017 ohms at 20°C.

The maximum volt drop in the solenoid circuit must not exceed 0.5 V in 12 V systems or 1.0 V in 24 V systems.

Note: The total volt-drop must include any losses in associated switchgear.

6.3 SOLENOID TEST DATA

Starter Type	With Ammeter In Supply Circuit	Read Ammeter
S115A-12 Earth return	Apply 12 V to black lead and base of fixed contact assembly	Check that current consumption is approx. 39 amp
S115A-12 Insulated return	Apply 12 V to black and yellow leads	as above
S115A-24 Earth return	Apply 24 V to black lead and base of fixed contact assembly	Check that current consumption is approx. 19 amp
S115A-24 Insulated return	Apply 24 V to black and yellow leads	as above

First contact gap - 2,10 mm (0,083 in) nominal
Bottom limit - 1,93 mm (0,076 in)
Upper limit - 2,50 mm (0,098 in)

6.4 COIL SPRINGS

Spring		Compressed Length	Compression
Lock collar spring		13,3 mm (0,525 in)	1,00 to 1,09 kgf (2,22 to 2,41 lb)
Recoil spring		33,35 mm (1,313 in)	12,0 to 13,39 kgf (26,5 to 29,5 lbf)
Pinion spring	A	37,3 mm (1,469 in)	4,4 to 4,6 kgf (9,81 to 10,19 lbf)
	B	31,7 mm (1,25 in)	3,2 to 3,6 kgf (7,1 to 7,9 lbf)

Note: The pinion spring can be identified as below:-

Spring	Part No.	Ident. Colour	No. of Turns	Free Length(New) mm	Free Length(New) in
A	6211-227A	Black	8	66-68	2.6-2.7
B	6211-70A	Brown	6	51-53	2.0-2.1

6.5 BRUSH DETAILS

Brush grade (12 V starters) 9198

Brush grade (24 V starters) 6836, 8389, DM100

Brush spring tension with new brush 13,7 - 16,7 N (3,05 - 3,75 lbf) (1,4 - 1,7 kgf)

Brush length (new) 20 mm (0,8 in)

Minimum brush length 12,7 mm (0,5 in)

6.6 LUBRICANTS

The following lubricants are recommended for S115A starters. No departures from these should be made without reference to Lucas Automotive Ltd, Lucas Aftermarket Operations.

Where Used	Recommended Lubricants	Alternative
Drive end bearing	Castrol AWH 150 with 10% (by volume) Acheson anti-wear oil additive	
Switch plunger and segments	Regal Starfax DTD 900-4363	BP Energrease RBB3
Pinion sleeve, lock collar, balls and helix	Aeroshell 16	
End cap and ball, commutator end shims, O-rings and seal	Castrol Spherol EPL2	BP Energrease LS/EP2
Lip of helix dust cover	Molybdenum Disulphide MP7	
Switch trigger pin	Coltex Thuban 90 oil	
Shaft nut thrust washers	Molycote "G" rapid paste	

6.7 STARTER TEST DATA

Nominal Voltage of Starter	Type of test	Minimum battery capacity (Ah)	Torque		Current amperes	Terminal voltage	Speed (rev/min)
			Nm	lbf ft			
12 V	Locked torque	135	48.1	35,5	1240 max.	4,5	-
	Running torque	135	20,3	15,0	690 max.	8,0	1220 minimum
	Light running	135	nil		100-150	12,0	7000 minimum
24 V	Locked torque	78	51.5	38,0	910 max.	9,2	-
	Running torque	78	23.1	17,0	550 max.	15,2	1550 minimum
	Light running	78	nil		60-100	24,0	7000 minimum

6.8 TIGHTENING TORQUE FIGURES

Item	N m	lbf ft	Item	N m	lbf ft
Pinion stop nut	54 - 68	40 - 50	M8 commutator end terminal nut	12 - 13	8,9 - 9,6
Through bolts	12 - 13	8,9 - 9,6	M10 commutator end terminal nut	27 - 29	19,9 - 21,4
M8 main terminal nut	12 - 13	8,9 - 9,6	Resistor flexible fixing screw	1,5 - 1,7	1,1 - 1,3
M10 main terminal nut	27 - 29	19,9 - 21,4	Field coil to switch screw	1,5 - 1,7	1,1 - 1,3
M12 main terminal nut	35 - 37	25,8 - 27,3	Main terminal switch screw	3,0 - 3,6	2,2 - 2,7
M5 solenoid terminal nut	2,5 - 3,0	1,8 - 2,2	Pole fixing screws	30 - 34	22 - 25
M6 solenoid terminal nut	4,5 - 5,5	3,3 - 4,1			