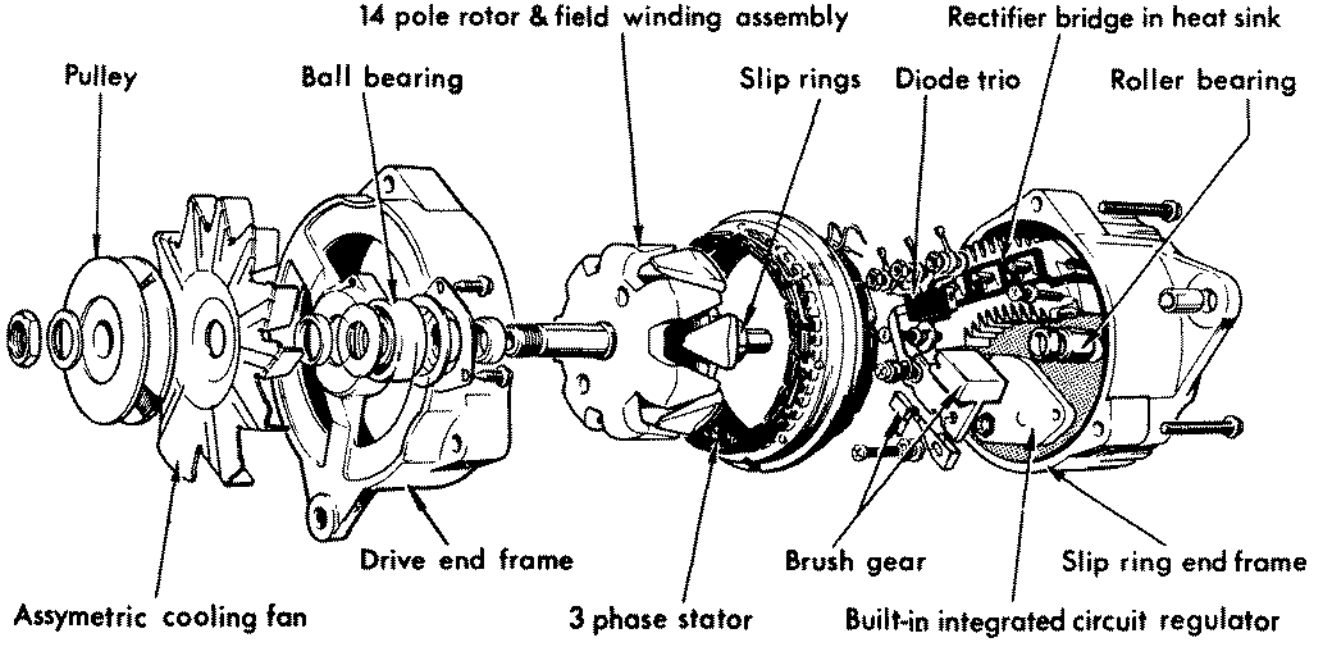
FAULT SYMPTOMS–continued				
Warning Light	Alternator			Probable Fault (Associated Damage)
	Temperature	Noise	Output	
Illuminated at stand-still, dims at cut-in speed (1,500 rev/min) and remains dim, but may be extinguished at very high speeds.	Normal	Excessive	Very low at all speeds above cut-in (1,500 rev/min) Approximately: 7A	Earth side main output diode short circuit or stator winding short circuited to earth.
Illuminated at stand-still, dims at cut-in speed (1,500 rev/min) and remains dim, but may be extinguished at very high speeds	Normal	Excessive	Very low at 6,000 rev/min Approximately: 7A	Field diode short circuit.

AC Delco DN460 Alternators

456. To overhaul the alternator, observe the following procedure in conjunction with the exploded diagram below.

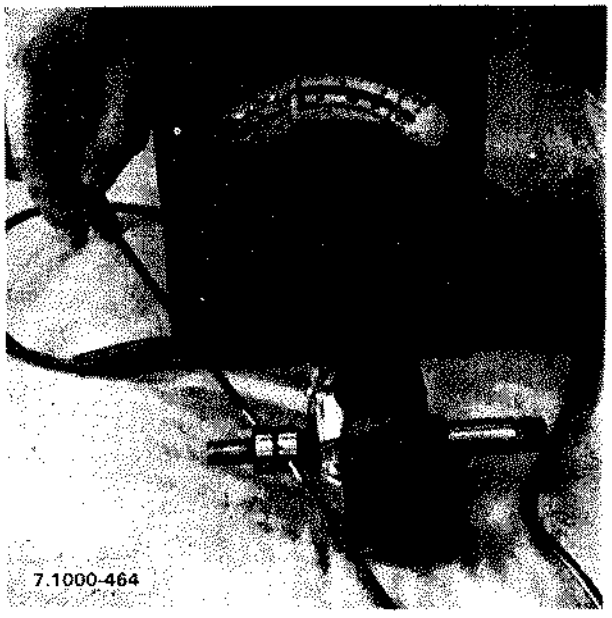
457. To disassemble the alternator, take out the three through bolts, and separate the drive end frame and rotor assembly from the stator assembly by prying apart with a screwdriver at the stator slot.



7.1000-456

458. A scribe mark will help locate the parts in the same position during assembly.
459. After disassembly, place a piece of tape over the slip ring frame bearing to prevent entry of dirt and other foreign material, and also place a piece of tape over the shaft on the slip ring end.
CAUTION: Use tape which will not leave a gummy deposit on the shaft.
460. If the brushes are to be reused, clean with a soft dry cloth.
461. To remove the drive end frame from the rotor, place the rotor in a vice and tighten only enough to permit removal of the shaft nut. Avoid excessive tightening as this may cause distortion of the rotor.
462. Remove the shaft nut, washer, pulley, fan and the collar and then separate the drive end frame from the rotor shaft.

Rotor Field Winding Checks
463. To check for opens, connect the test lamp or ohmmeter to each slip ring. If the lamp fails to light or if the ohmmeter reading is high (infinite) the winding is open.
464. The winding is checked for short circuits or excessive resistance by connecting an ohmmeter to the two slip rings. If the reading is below the specified value, the winding is shorted, if above the specified value, the winding has excessive resistance.



7.1000-464

465. Remember that the winding resistance reading will vary slightly with winding temperature changes.
466. If the rotor is not defective but the generator fails to supply rated output, the defect is in the diode trio, rectifier bridge or stator.

Diode Trio Check
467. Connect an ohmmeter using lowest range scale from brush lead clip to end frame, then reverse lead connections.

7.1000-467

468. If both readings are the same, check for grounded brush lead clip, caused by omission of insulating washer, omission of insulating sleeve over screw, or damaged insulating sleeve. Remove screw to inspect sleeve. If screw assembly is correct, and both ohmmeter readings are the same, replace regulator.
469. To check the diode trio, remove it from the end frame assembly by detaching the three nuts, the attaching screw and removing the stator assembly. Note that the insulating washer on the screw is assembled over the top of the diode trio connector.
470. Connect an ohmmeter having a $1\frac{1}{2}$ volt cell, and using the lowest range scale, to the single connector and to one of the three connectors.

7.1000-470

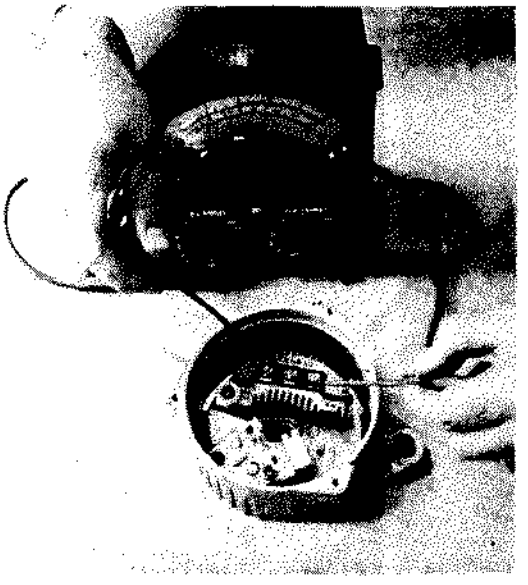
471. Observe the reading. Then reverse the ohmmeter leads to the same two connectors. If both the readings are the same, replace the diode trio. A good diode trio

will give one high and one low reading. Repeat this same test between the single connector and each of the other two connectors.

472. Figures 7.1000-467 and 7.1000-470 illustrate two diode trios differing in appearance. The difference being that on the later models the single connector was made flexible to enable fitment to all models.

Rectifier Bridge Check

473. Note that the rectifier bridge has a grounded heat sink and an insulated heat sink connected to the output terminal. Also note the insulating washer located between the insulated heat sink and end frame.



7.1000-473

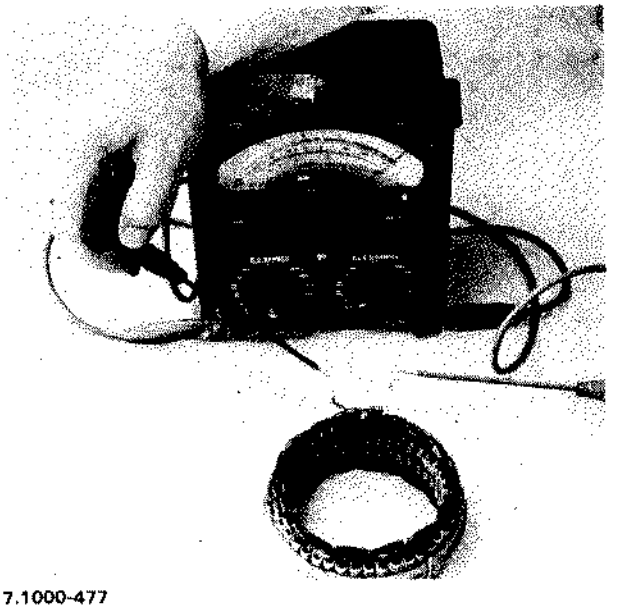
474. To check the rectifier bridge, connect the ohmmeter to the grounded heat sink and one of the three flat metal connectors. Then reverse the lead connections. If both readings are the same, replace the rectifier bridge. A good rectifier bridge will give one high and one low reading. Repeat this same test between the grounded heat sink and the other two terminals, and between the insulated heat sink and each of the three terminals. This makes a total of six checks with two readings taken for each check.

475. The ohmmeter check of the rectifier bridge and of the diode trio as previously covered is a valid and accurate check. Do not replace either unit unless at least one pair of readings is the same. CAUTION: Do not use high voltage to check these units such as a 110 volt test lamp.

476. To replace the rectifier bridge, remove the two attaching screws. Note the insulator between the insulated sink and end frame (7.1000-473). Rectifier bridges may vary in appearance but are completely interchangeable in these generators.

Stator Checks

477. The stator windings may be checked with a 110 volt test lamp or an ohmmeter. If the lamp lights, or if the meter reading is low when connected from any stator lead to the frame, the windings are grounded. If the lamp fails to light or if the meter reading is high when successively connected between each pair of stator leads, the windings are open.



7.1000-477

478. A short circuit in the stator windings is difficult to locate without laboratory test equipment due to the low resistance of the windings. However, if all other electrical checks are normal and the generator fails to supply rated output, shorted stator windings are indicated. Also, a shorted stator can cause the indicator lamp to be on with the engine at low speed.

Brush Holder and Regulator Replacement

479. After removing the three attaching nuts, the stator and diode trio screw, the brush holder and regulator may be removed by removing the two remaining screws. Note the two insulators located over the top of the brush clips in figure 7.1000-467, and that these two screws have special insulating sleeves over the screw body above the threads.

480. The third mounting screw may or may not have an insulating sleeve. If not, this screw must not be interchanged with either of the other two screws, as a ground may result, causing no output or uncontrolled generator output. Regulators may vary in appearance but are completely interchangeable in these generators.

Slip Ring Servicing

481. If the slip rings are dirty, they may be cleaned and finished with 440 grain or finer polishing cloth. Spin the rotor and hold the polishing cloth against the slip rings until they are clean. CAUTION: The rotor must be

rotated in order that the slip rings will be cleaned evenly. Cleaning the slip rings by hand without spinning the rotor may result in flat spots on the slip rings causing brush noise.

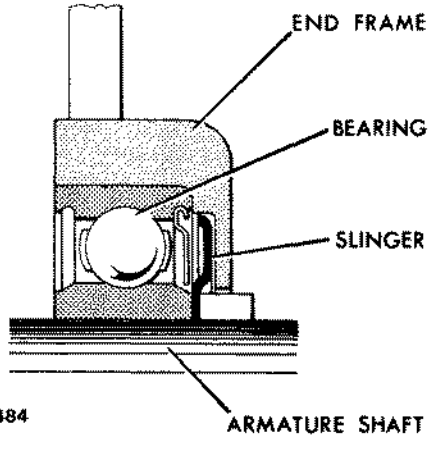
482. Slip rings which are rough or out of round should be trued in a lathe to .002 inch maximum indicator reading. Remove only enough material to make the rings smooth and round. Finish with 400 grain or finer polishing cloth and blow away all dust.

Bearing Replacement and Lubrication

483. The bearing in the drive end frame can be removed by detaching the retainer plate screws and then pressing the bearing from the end frame. If the bearing is in a satisfactory condition, it may be reused and it should be filled one quarter full with specified grease before reassembly. CAUTION: Do not overfill as this may cause the bearing to overheat.

484. To install a new bearing, press in with a tube or collar that just fits over the outer race, with the bearing and slinger assembled into the end frame as shown below.

NOTE: Some models use flat washers instead of a slinger.



485. It is recommended that a new retainer plate be installed if the felt seal in the retainer plate is hardened or excessively worn. Fill the cavity between the retainer plate and bearing with specified grease.

486. The bearing in the slip ring end frame should be replaced if its grease supply is exhausted. No attempt should be made to re-lubricate and reuse the bearing.

487. To remove the bearing from the slip ring end frame, press out with a tube or collar that just fits inside the end frame housing. Press from the outside of the housing towards the inside.

488. To install a new bearing, place a flat plate over the bearing and press in from the outside towards the inside of the frame until the bearing is flush with the outside of the end frame. Support the inside of the frame with a hollow cylinder to prevent breakage of the end frame. Use extreme care to avoid misalignment or otherwise placing undue stress on the bearing.

489. It is recommended that a new seal be installed whenever the bearing is replaced. Press the seal in with the lip of the seal toward the rotor when assembled, that is, away from the bearing. Lightly coat the seal lip with oil to facilitate assembly of the shaft into the bearing.

490. Reassembly of the alternator is the reverse of disassembly but the following points should be noted.

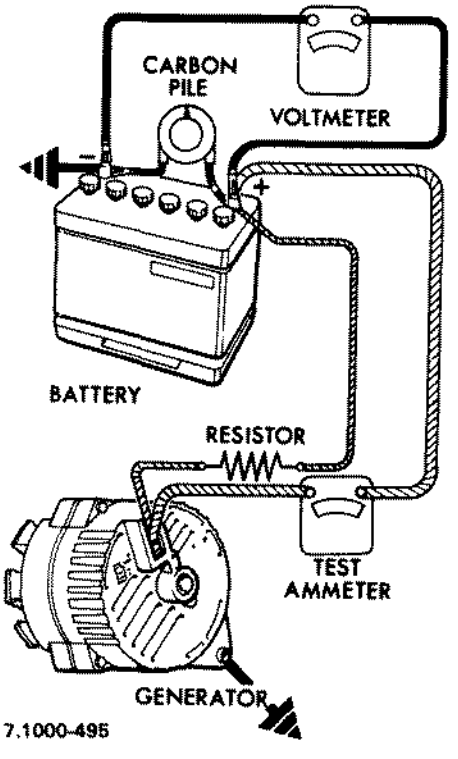
491. Remember when assembling the pulley to secure the rotor in a vice only tight enough to permit tightening the shaft nut to 40-60 lbs. ft. If excessive pressure is applied against the rotor, the assembly may become distorted.

492. To install the slip ring end frame assembly to the rotor and drive end frame assembly, remove the tape over the bearing and shaft and make sure the shaft is perfectly clean after removing the tape. Insert a pin through the holes to hold up the brushes. Carefully install the shaft into the slip ring end frame assembly to avoid damage to the seal.

493. After tightening the through bolts remove the brush retaining pin to allow the brushes to fall down onto the slip rings.

494. When reassembly is complete, the following bench test should be carried out.

495. Make connections as shown in figure 7.1000-495, except leave the carbon pile disconnected. IMPORTANT: Ground polarity of battery and generator must be the same. Use a fully charged battery, and a 10 ohm resistor rated at 6 watts or more between the generator IND terminal and the battery.



496. Slowly increase the generator speed and observe the voltage.
497. If the voltage is uncontrolled with speed and increases above 15.5 volts on a 12 volt system or 31 volts on a 24 volt system, check for grounded brush lead clips. If not grounded replace the regulator and check field winding. NOTE: The battery must be fully charged when making this check.
498. If voltage is below 15.5 volts on a 12 volt system or 31 volts on a 24 volt system, connect the carbon pile as shown in figure 7.1000-495.
499. Operate the generator at moderate speed as required and adjust the carbon pile as required to obtain maximum current output.
500. If output is within 10 per cent of rated output as stamped on generator frame, generator is good.
501. If output is not within 10 per cent of rated output, keep battery loaded with carbon pile and ground generator field.
502. Operate generator at moderate speed and adjust carbon pile as required to obtain maximum output.
503. If output is within 10 per cent of rated output replace regulator as covered in 'Regulator Replacement' section and check field winding.
504. If output is not within 10 per cent of rated output, check the field winding, diode trio, rectifier bridge and stator as previously covered.

Alternators (Refitting)

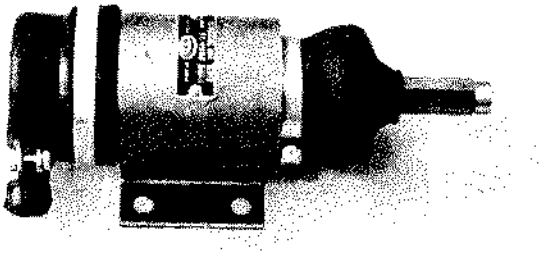
505. Position the alternator into the mounting brackets and install the securing bolts, washers and nuts. Do not fully tighten the bolts.
506. Assemble the slotted brace to the alternator and engine timing cover.
507. Check that the pulleys are clean before fitting the belts and adjust to the correct tension as detailed below.
508. With the alternator attaching bolts and the bolt securing the slotted brace slack, pivot the alternator away from the engine to tighten the belts. It is essential that leverage is applied to the drive end shield and never against the stator or slip ring end shield.
509. The belts can be checked by depressing $\frac{1}{2}$" midway between the fan and generator pulley with a load of 8-10 lbs.
510. When correct tension is obtained, tighten the bolts in the following sequence.
511. Brace to alternator.
512. Drive end shield to mounting bracket.
513. Slip ring end shield to mounting bracket, ensuring that the slotted bush in lug moves to occupy the gap between the lug and bracket. When bolt is pulled up tight, slotted bush is forced to expand in end cover lug.
514. Brace to engine front plate.
515. Recheck the belt tension.
516. Reconnect the wires to the alternator terminals and then reconnect the batteries.

7.2000

SOLENOID SHUTDOWN

Solenoid Shutdown (Description)

1. The solenoid actuator used on Bedford Diesel engines as a fuel shut off is a continuous rated version with removeable coils of the 263 type, manufactured by CAV Limited.



7.2000-1

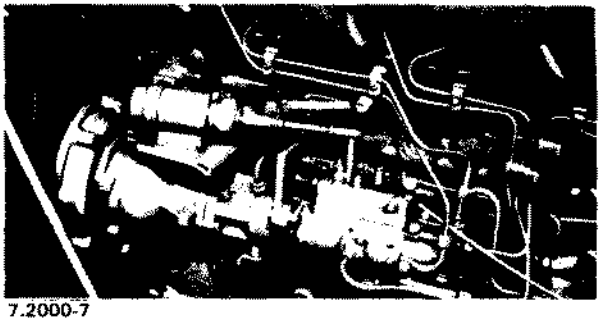
2. This model has a coil (pull in winding) and a plunger housed in a suitable body, in addition a second coil (holding in winding) and a set of non-adjustable contacts which control the operation of the pull in winding.

Operation

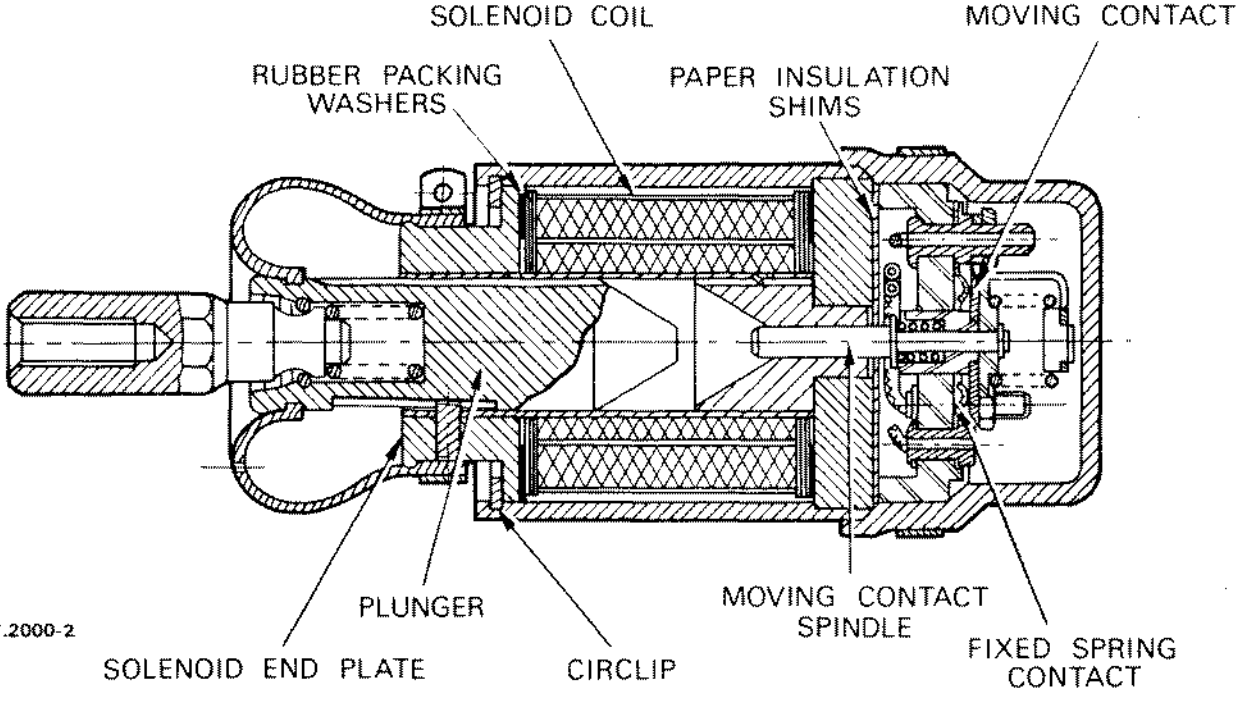
5. Both the pull in winding and the hold in winding are energised when current is supplied, thus drawing the plunger inwards. As the plunger approaches the end of its travel, it operates the moving contact stud, which opens a set of contacts to cut off the supply of current to the pull in winding but leaves the holding-in winding energised to keep the plunger fully drawn in.
6. A return spring is fitted between the operating rod and a bracket attached to the cylinder block.

Solenoid Shutdown (Removal)

7. Detach the clamp securing the rubber end cover and slide the cover off the solenoid body.



7.2000-7



7.2000-2

3. The coils are keyed to the solenoid stop to prevent coil rotation and the coils and end plate are retained by a circlip at the link end to enable the interior to be serviced.
4. The letter 'A' in the type number (263A/) indicated a change in design. This design consists of limiting the plunger travel by means of a stop pin locating in a key way in the plunger.

8. Disconnect the two leads from the rear of the solenoid.
9. Unhook the return spring.
10. Remove the split pin at the end of the operating rod and loosen the retaining screw which will enable the rod to be lifted from the stop control lever.
11. Unscrew the operating rod from the solenoid.

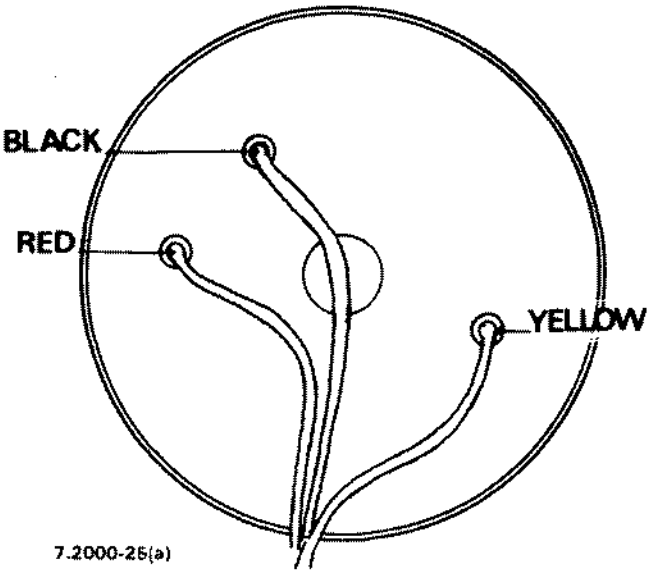
12. Remove the four nuts and bolts and lift the solenoid shutdown assembly from its mounting bracket.

Solenoid Shutdown (Inspection and Overhaul)

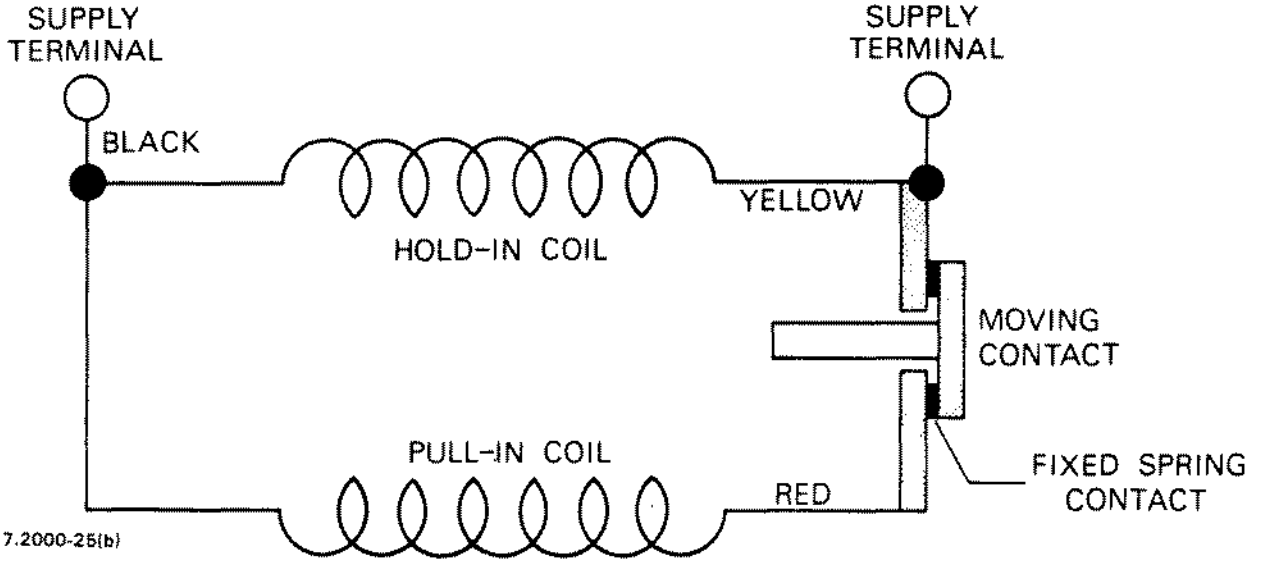
13. Remove all external dirt and grease from the actuator.
14. Detach the clamp securing the rubber bellows and slide the bellows off the solenoid body and the plunger.
15. Remove the plunger stop pin and withdraw the plunger from the solenoid.
16. Remove the screws securing the contact assembly and detach the bridge, contact spring and moving contact.
17. Unsolder the leads from the terminals and remove the terminal block and insulating washer.
18. Release the circlip securing the solenoid end plate and detach the end plate.
19. Pull off the rubber washer and withdraw the solenoid coil from the body.
20. Inspect the rubber bellows and terminal cover for cracks or damage and if faulty replace with new parts.
21. Clean the terminals and contacts with a brush, moistened in petrol or white spirit.

Warning: The moving contact and contact strip are silver plated. **Do not** clean them with emery paper or any other abrasives; if the contacts are pitted or corroded, they must be discarded and replaced by new parts.

25. Fit the insulating washer for the terminal block over the coil leads, insert the leads into the terminals on the terminal block and solder into position. The correct wiring sequence of these leads to the terminals is illustrated below.



7.2000-25(a)



7.2000-25(b)

22. Clean the plunger and core of the solenoid and smear them lightly with Shell Tellus oil No. 11 before reassembly.
23. Insert the solenoid coil, lead end first, into the solenoid body, ensuring that the tag on the coil engages in the keyway in the body and at the same time feed the leads through the hole in the solenoid end.
24. Place the rubber washer in position at the end of the solenoid coil, offer up the solenoid end plate and secure in position with the circlip.

26. Assemble the moving contact, the contact spring and the bridge piece to the terminal block, and screw the complete assembly to the solenoid body with the bridge retaining screws.
27. The recommended contact gap is 0.050 – 0.070 ins. (1.27 – 1.78 mm), this is set during manufacture and should not require re-adjustment. If subsequently the gap becomes too small after long service, it may be increased by removing one of the paper insulation shims, these are indicated in illustration 7.2000-2.

28. Fit the rubber bellows to the plunger and ensure that the breather hole in the bellows will be in line with the base of the solenoid on final assembly. Insert the plunger into the solenoid making certain that the keyway on the plunger is in line with the stop pin hole.
29. Push the stop pin into the hole and slide the rubber bellows over the stop pin.
30. Secure the rubber bellows to the solenoid with the bellows securing clamp.

Solenoid Shutdown (Refitting)

31. Place the actuator assembly onto the mounting bracket and replace the four retaining nuts and bolts. One nut is to be left loose at this stage for refitting earth lead.
32. Screw the operating rod into the solenoid link and place the other end of the operating rod onto the post on the fuel stop lever.
33. Replace the retaining screw and split pin into the operating rod end.
34. Replace the return spring.
35. Reconnect the two leads to the solenoid and earth and tighten remaining nut and bolt.
36. Attach the terminal cover to the terminal block and secure in position with the terminal cover clamp.
37. The following test should then be carried out to ensure correct working of the solenoid.
38. Check the wiring circuit supplying current to the solenoid.
39. Check the plunger for free movement in its bore.
40. Check the solenoid for continuity from the following table.

Type	Voltage	Rating	Pull-In Winding Coil		Hold-In Winding Coil	
			Ohms	Amps	Ohms	Amps
263A – 23	24	Continuous	1.3	18.5	39	0.6
263A – 25	12	Continuous	0.45	27	9.2	1.3

7.3000

STARTING MOTORS

Starting Motors (General Description)

1. Several types of starter motors are used on 220/330 cu. in. Bedford diesel engines. These are listed in the table below and are dealt with separately in the following pages:

Manufacturer	Type	Volt
CAV	CA45'D'	12
CAV	CA45'D'	24
CAV	CA45'F'	12
CAV	CA45'F'	24
SIMMS	55/12/IB3	
LUCAS	M50	12
DELCO REMY	30MT	12
DELCO REMY	35MT	12
DELCO REMY	40MT	12
DELCO REMY	30MT	24

CAV CA45'D' and 'F' (Description)

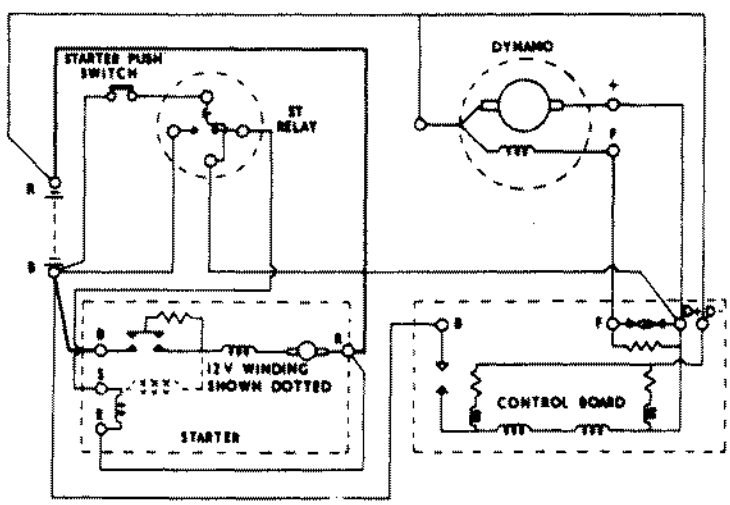
2. The CAV starter type CA45D is a 4.5 inch (114 mm) diameter machine suitable for starting multi-cylinder high compression oil engines. It is designed to provide maximum efficiency with small overall dimensions without awkward protrusions: this is achieved by mounting the two stage operating solenoid and switching mechanism internally and co-axially with the armature shaft. Its principal features are (a) engagement of the pinion with the engine flywheel teeth takes place under reduced power thus avoiding heavy engagement shock and excessive wear and (b) full starting torque is exerted only when the pinion is fully in mesh.

3. When installing a CA45'D' starter it is necessary to include a ST relay and connect it in series with the starter internal solenoid coil. By this means the ampere load on the starter push switch is reduced to that taken by the ST relay coil, also voltage drop in the starter solenoid switch circuit is reduced to a minimum. This relay is also used as part of an overspeed protection device described in paragraph 13.

4. On starters wired for insulated return, (see table below), the return path for the starter internal solenoid is made externally by connecting terminal 'R' on the commutator end shield to the terminal marked 'R' at the drive end, that is, the one next to the 'S' terminal. The cable size should be 065/.012 minimum.

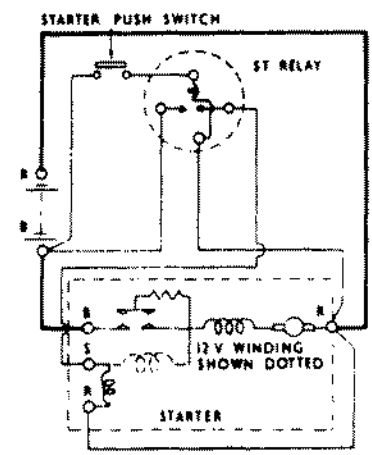
G M Part No.	Model	Despatch No.	
7155925	CA45D12 51	1320513	Earth Return
3352002	CA45F42 Y51	1320F513	Earth Return
3350374	CA45D24 51	1321511	Earth Return
3352003	CA45F24 2	1321F021	Earth Return
3350465	CA45D12 2M	1320028	Earth Return
3352004	CA45F12 Y3M	1320F036	Insulated Return
3350974	CA45D24 51M	1321512	Earth Return
3351814	CA45D12 3M	1320036	Insulated Return
3352239	CA45D24 3M	1321033	Insulated Return
3353252	CA45D24 Y3M	1321F033	Insulated Return
3354064	CA45F12 Y92	1320F902	Earth Return

5. Typical wiring diagrams are shown below for the CA45D. The 12 volt and 24 volt versions are mechanically the same but a dual wound solenoid winding is used in the 12 volt.



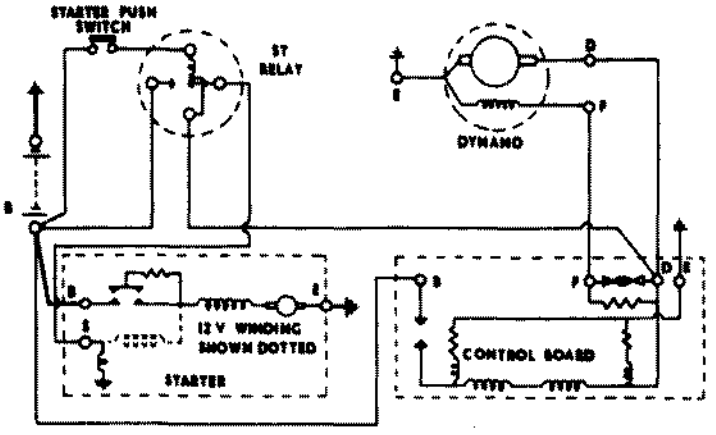
12 VOLT AND 24 VOLT INSULATED RETURN
WITH OVERSPEED PROTECTION

7.3000-5(a)



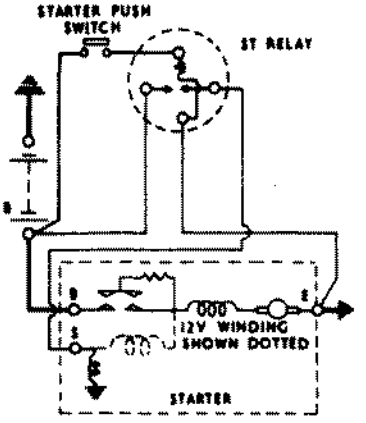
12 VOLT AND 24 VOLT INSULATED RETURN (WITHOUT OVERSPEED PROTECTION)

7.3000 5(b)



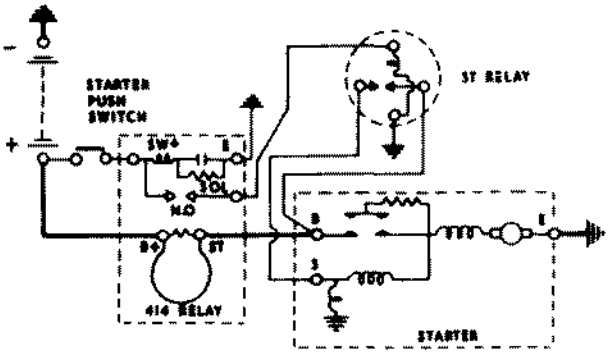
12 VOLT AND 24 VOLT EARTH RETURN WITH OVERSPEED PROTECTION

7.3000-5(c)



12 VOLT AND 24 VOLT EARTH RETURN (WITHOUT OVERSPEED PROTECTION)

7.3000-5(d)



TYPICAL 12VOLT EARTH RETURN CIRCUIT WITH STARTER OVERSPEED PROTECTION WHEN AN ALTERNATOR IS USED

7.3000-5(e)

6. Starters fitted to certain engines, the flywheels of which run in oil or those where extra protection against ingress of water and abrasive dust is required, are provided with additional sealing. The precautions comprise fitting an oil seal in the drive end shield and a rubber sealing ring inside the pinion. A dust cover over the shaft helix at the drive end is fitted to most starters.

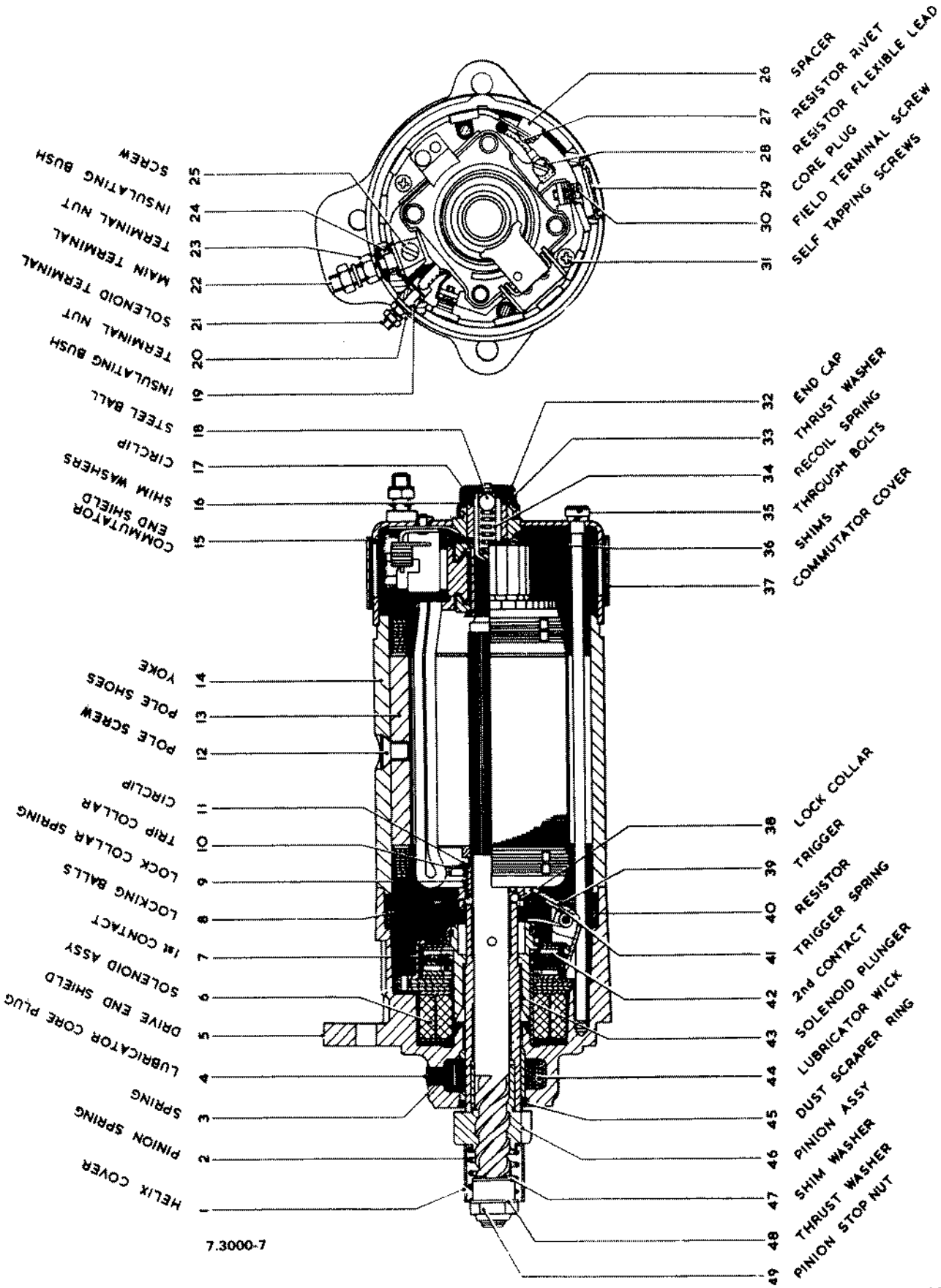
Operation

7. In the following text the figures in brackets refer to the illustration on page 3 unless otherwise stated.

8. When the starter switch is operated current flows through the coil of the ST relay and closes the relay contacts. The solenoid (6) is then energised and its hollow plunger (43) moves forward, pushing pinion (46) towards the engine flywheel teeth. At the same time, the movement of the plunger closes the first stage contacts (7), connecting the battery to the field and armature windings via a heavy duty resistor (40). The resistor reduces the volts to the windings with the result that the armature rotates at low speed.

9. This combination of forward and rotary movement partially engages the pinion with the engine flywheel. The pinion, being prevented from rotating by the inertia of the flywheel is then pushed fully into mesh by the action of the helix on the slowly rotating armature shaft. Shortly before the fully engaged position is reached, collar (10), carried on the end of the pinion sleeve, trips a trigger (39) on the solenoid. This causes a second set of contacts (42) to close and short circuit the resistor, applying full battery voltage to the windings and full starting torque is exerted.

10. When the pinion is engaged it is locked in position by a special locking device consisting of steel balls (8) located in holes in the pinion sleeve. These balls drop into recesses in the armature shaft when the pinion reaches its fully engaged position, and a spring loaded collar (38) slides over and holds them firmly in position. Hence, the pinion cannot be ejected prematurely **but will remain in mesh until the starter button is released,** or the overspeed device (if fitted) switches out the starter. See paragraph 'Overspeed protection'.


1 HELIX COVER
2 PINION SPRING
3 SPRING
4 LUBRICATOR CORE PLUG
5 DRIVE END SHIELD
6 SOLENOID ASSY
7 1st CONTACT
8 LOCKING BALLS
9 LOCK COLLAR SPRING
10 TRIP COLLAR
11 CIRCLIP
12 POLE SCREW
13 POLE SHOES
14 YOKE
15 COMMUTATOR END SHIELD
16 SHIM WASHERS
17 CIRCLIP
18 STEEL BALL
19 INSULATING BUSH
20 TERMINAL NUT
21 SOLENOID TERMINAL
22 MAIN TERMINAL
23 TERMINAL NUT
24 INSULATING BUSH
25 SCREW
26 SPACER
27 RESISTOR RIVET
28 RESISTOR FLEXIBLE LEAD
29 CORE PLUG
30 FIELD TERMINAL SCREW
31 SELF TAPPING SCREWS
32 END CAP
33 THRUST WASHER
34 RECOIL SPRING
35 THROUGH BOLTS
36 SHIMS
37 COMMUTATOR COVER
38 LOCK COLLAR
39 TRIGGER
40 RESISTOR
41 TRIGGER SPRING
42 2nd CONTACT
43 SOLENOID PLUNGER
44 LUBRICATOR WICK
45 DUST SCRAPER RING
46 PINION ASSY
47 SHIM WASHER
48 THRUST WASHER
49 PINION STOP NUT
7.3000-7

11. On rare occasions, the pinion and flywheel may meet tooth to tooth; this will not affect engagement under normal conditions, as the pinion will continue to rotate until the teeth slide into mesh. If the gear teeth are worn and burrs present, rotation of the pinion may be prevented and the pinion may even be held against the flywheel teeth when the starter button is released. In order to overcome this difficulty, the starter incorporates an armature recoil mechanism comprising a steel ball (18) and recoil spring (34) fitted at the commutator end of the armature shaft.

12. 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, compressing the recoil spring; as soon as the starter button is released, the spring thrusts the armature forward. At the same time, rotary motion, opposite to the normal direction of rotation is imparted to the armature by the helix inside the stationary pinion. When the armature reaches the end of its forward movement, its momentum is sufficient to rotate the pinion slightly, freeing it from the burrs. The pinion then returns to its disengaged position under the influence of the pinion return spring; its radial position will now be slightly retarded, so that there is little likelihood of the gears meeting tooth to tooth during the next engagement.

Overspeed Protection

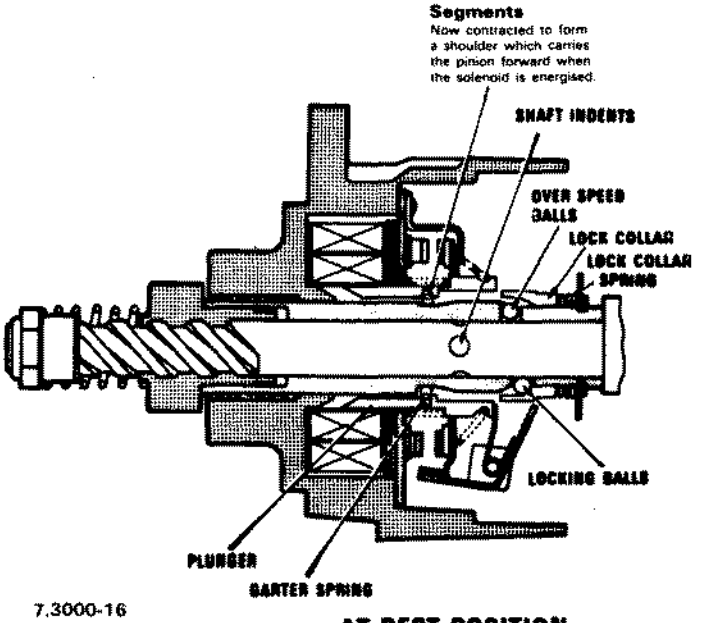
13. The modern diesel engine accelerates quite quickly after starting and on occasions it can easily wind the starter motor round at speeds of 10,000 rpm or more and this can be damaging to the armature bearings and brushes. To prevent this, an overspeed protection device can be incorporated which consists of connecting the battery return circuit from the ST relay to the dynamo output terminal (on the control board) so that the ST relay coil is connected across the cut-out contacts and therefore in series with the dynamo armature. As the dynamo voltage rises with increasing engine speed the voltage across the ST relay falls and its contacts then open to disconnect the starter from the battery. See wiring diagram on pages 1 and 2.

14. When an alternator is used on the vehicle instead of a dynamo an additional 414 relay is required and connected as shown (see wiring diagram on page 2). The unit consists of an L relay with one pair of normally open contacts and a shunt connected 'pull-in' winding in series with an electrolytic capacitor also a heavy series turn which carries all the starter current. It operates as follows: When the starter push switch is closed it connects the battery to the 414 relay unit and its 'pull-in' winding is energised; the return path to earth being completed via the capacitor. The contacts close and the ST relay is then energised and its contacts close. The battery supply is thus fed to the starter solenoid completing the circuit and the starter commences to function. When the second contacts of the starter solenoid close, full current is taken by the starter motor through the heavy series turn of the 414 relay and the engine is cranked. Approximately one second after the 'pull-in' winding is energised the capacitor is fully charged blocking the 'pull-in' winding circuit apart from a small current through the leak resistor. However, sufficient current flows through the heavy series turn to hold the relay closed. After the engine fires the starter speed increases, the current then falls and when it reaches a predetermined value, the current through the series turn is insufficient to hold the relay closed and the contacts open, de-energising the starter solenoid even if the starter switch is held closed. The capacitor is maintained charged by a small current through the 'pull-in' winding and leak resistor. When the starter switch is opened the capacitor discharges through the leak resistor and within 2-3 seconds the unit is ready for a repeat operation.

'F' Design Change

15. The CA45F starter is similar to the CA45D machine in its performance and physical outline. The object of the 'F' design change is to provide mechanical overspeed protection to the starter by means of a centrifugal over-speed mechanism for releasing the pinion from the flywheel on those occasions when excessive rotational speeds are reached. This obviates the necessity of using rising dynamo voltage to cut-out the starter or the additional 'under current' relay when an AC generator is fitted, as is the case with a CA45D starter. However, the inclusion of the ST relay in the circuit is necessary to reduce voltage drop in the starter solenoid switch circuit.

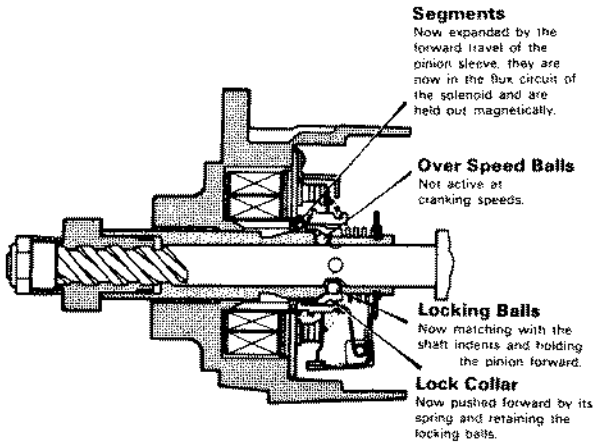
16. The device incorporates four equi-spaced radial holes in the pinion sleeve into which four steel releasing (overspeed balls) locate. The locking collar has an internal cone which encircles these balls. Additionally there are four steel segments held together and against a recess in the pinion sleeve by a garter type spring. The bore of the solenoid also has an annular recess into which the segments become magnetically latched by the magnetic flux of the solenoid during the starting cycle.



7.3000-16

AT REST POSITION

17. When the starter switch is operated the starter solenoid coil is energised and its plunger moves forward carrying with it the four segments and garter spring. These form a shoulder and push the pinion toward the engine flywheel teeth and the starter then functions in the same way as the CA45D machine. During the forward travel of the pinion, a taper on the sleeve forces the segments and garter spring outwards and they become magnetically latched in the recess in the solenoid plunger by the surrounding magnetic flux, thus allowing the uninterrupted movement of pinion and sleeve assembly. The segments remain there until the starter switch is released.

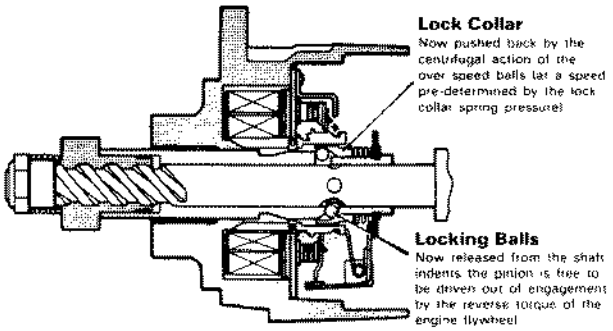


CRANKING POSITION

7.3000-17

18. Once the engine has started, normal function is for the starter button to be released, de-energising the solenoid. The magnetic flux is thus extinguished, the solenoid plunger moves back taking with it the four segments and garter spring. Simultaneously the pinion disengages from the flywheel, the locking collar moves back under force of its return spring, releases the locking balls and the pinion flies back to rest. The garter spring returns the segments to their original position on the pinion sleeve ready for the next start.

19. If the starter is driven by the engine due to quick acceleration and the starter switch is held closed, when the armature reaches a speed of between 9000 – 14000 rpm, the automatic overspeed release mechanism comes into operation. The overspeed balls at this speed exert sufficient centrifugal force to the internal cone of the locking collar to push it backwards until the locking balls are freed from the shaft. The pinion is then able to move out of engagement by the pressure of the pinion return spring and the reverse torque of the flywheel. The armature will continue to rotate at light running speed until the starter switch is released.



OVER SPEED POSITION

7.3000-19

20. The basic wiring circuits for the CA45D starter are applicable to the CA45F. The electrical overspeed protection, where installed, can be left to provide an additional and desirable feature.

CAV CA45'D' and 'F' Removal

21. Disconnect the battery cables.
22. Disconnect the two leads to the ignition switch.
23. Remove the three retaining bolts and washers and remove the starter from the flywheel housing.

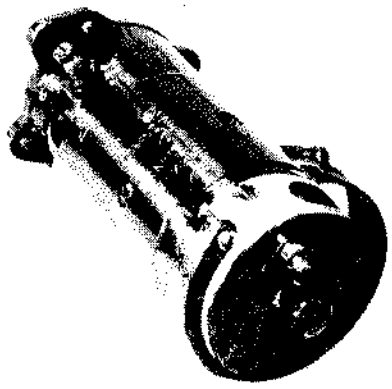
CAV CA45'D' and 'F' (Inspection and Overhaul)

24. The starter should be dismantled and overhauled at regular intervals dependent on operating conditions. For example the starter motor of an engine being continually stopped and started will need overhauling at more frequent intervals than a starter motor on a long running engine, but overhaul periods must not exceed two years.

25. Before overhauling the starter, it is advisable to obtain the special tools listed below. These will reduce the time spent on overhaul and will enable a closer approach to factory standards to be obtained.

CAV Tool No.	Description
5693-222	Setting gauge for machines with a pinion face to mounting flange dimension of 1.875 in. (47.63 mm).
5693-240	Extraction and replacement tool for commutator end bearing.
5693-267	Plug gauge for drive-end bearing.
5693-266	Extractor, drive end bearing.
5693-275	Plug gauge for commutator end bearing.
5693-298	Fitting tool for inspection hole core plugs.
5693-299	Fitting tool for dust scraper ring on drive end shield.
5693-300	Fitting tool for lubricator core plug.
6244-4	End float gauge.
6244-3	Check gauge for circlip on trip collar.
6244-6	Split collar for dust seal protection.

26. In addition to the tools listed above, a compression spring balance scaled 0-50 lbs in 1 lb units is required. A torque spanner with $\frac{1}{2}$ inch square drive and a 7/16 BSF socket with the chamfered lead ground away is required to tighten the pinion nut to the required torque value.
27. The figures in brackets refer to illustration 7.3000-7 unless otherwise stated.
28. Remove the two core plugs (29) in the drive end shield (5) with a sharp pointed instrument.
29. Unscrew the two field terminal screws (30) that are exposed when the core plugs are removed.
30. Remove the commutator cover (37).

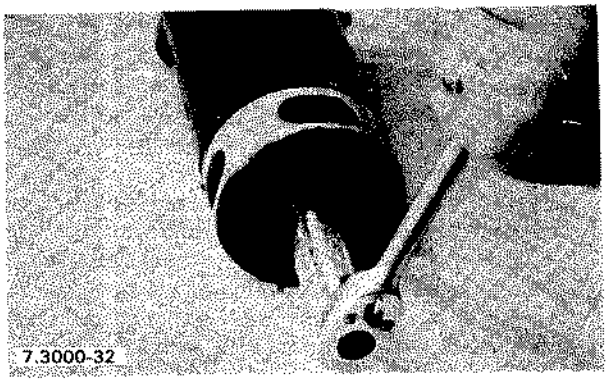


7.3000-30

31. Unscrew the brush lead screws, raise the brush springs and remove the brushes from the holders. It should be noted that removal of the brush lead screws also frees the field coil connections.

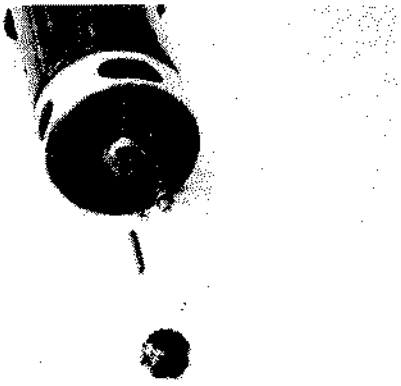
7.3000-31

32. Remove the end cap (32). Early-models have a bayonet type fixing arrangement and should be removed by pushing inwards and twisting in the opposite direction of starter rotation. When removing the cap, care must be taken not to lose steel ball (18) which is under pressure from spring (34). Later models are fitted with a hexagon end cap, internally screwed, together with a thrust pad.



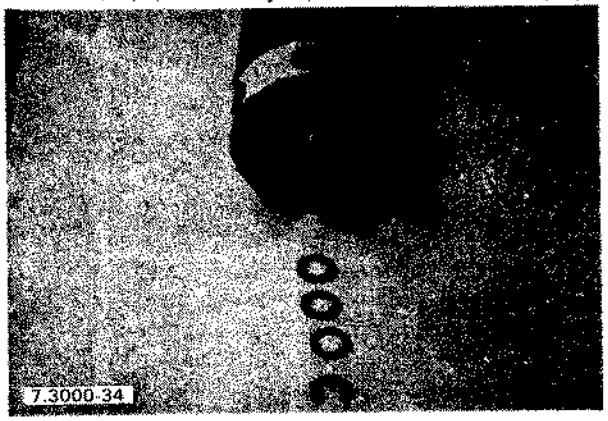
7.3000-32

33. Withdraw spring (34).



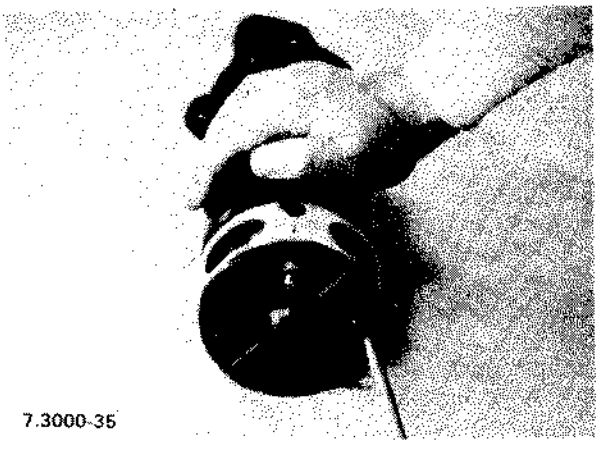
7.3000-33

34. Remove circlip (17) and then withdraw thrust washer (33) (or thrust pad) and shim washers (16).



7.3000-34

35. Unscrew and remove the two through-bolts (35).

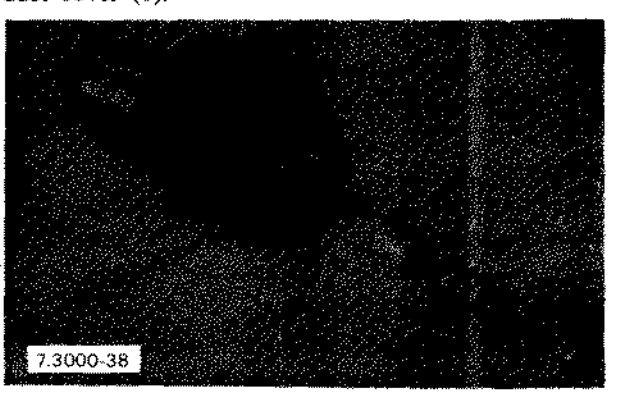


7.3000-35

36. Carefully remove commutator end shield (15) and collect shims (36) from the end of the armature shaft. Keep these shims separately so that if the armature is to be refitted end float adjustment is simplified by refitting the original shims.

37. Tap drive end shield (5) away from yoke (14) with a hide or wooden mallet, and then withdraw end shield complete with armature.

38. Secure the armature in an armature clamp, and, using either a 7/16 in. BSF box spanner or socket with the chamfered lead ground away, unscrew the pinion stop nut (49) left hand thread. Remove the thrust washer (48) shim washer (47) pinion return spring (2) and helix dust cover (1).

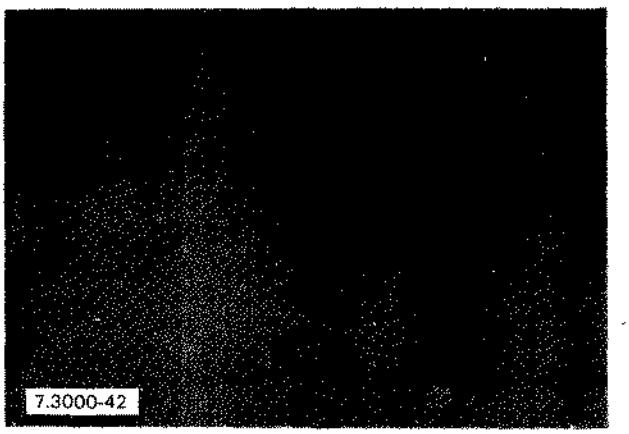


39. Remove core plug (4) and spring (3) from the drive end shield.

40. Release the ball lock mechanism by pushing the end shield towards the armature. 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 four steel balls (8) (six balls on 24 volt models) which may fall through into the inside of the pinion sleeve. Remove the armature from the armature clamp.

41. Using the circlip pliers, remove and discard circlip (11) from the end of the pinion sleeve.

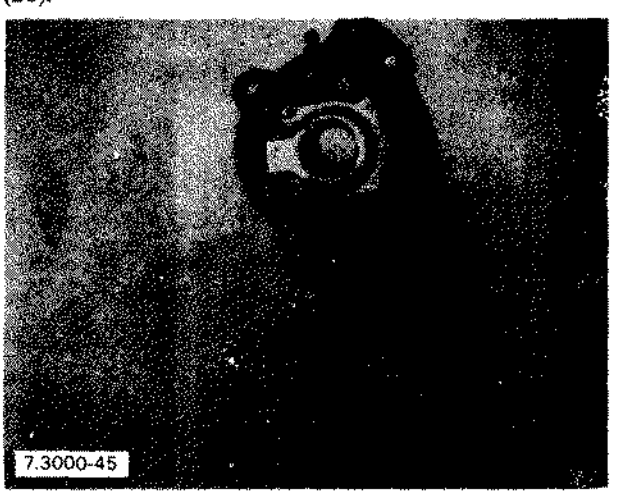
42. Remove trip collar (10) lock collar spring (9) and lock collar (38).



43. Withdraw pinion assembly (46) from the drive end shield. If any burrs can be seen on the pinion, these should carefully be removed by use of a stone before withdrawing the pinion.

44. Detach the resistor flexible lead (28) from the moving contact plate. On insulated return machines, there is a link to a binding post on the moving contact.

45. Free the resistor (40) from the drive end shield by punching out the securing rivet (27) with a suitable punch. Withdraw the resistor and the two nylon bushes (26).



46. Unscrew main terminal nuts (23) and screw (25). Remove washers and insulating bush (24) and then withdraw the main terminal (22) from inside the housing. (Rotating the terminal axially through 180° and compressing the solenoid plunger simplifies this operation).

47. Remove nuts (20) and insulating bush (19) from solenoid terminal (21). Push the terminal well into the drive end shield so that it is clear of its hole.

48. On insulated return starters also remove similar parts from the adjacent 'R' terminal.

48a. Remove two screws and lift out the solenoid assembly.

Inspection and Repair of Components

49. It is essential to remove all brush dust etc., from components by using dry compressed air before making electrical tests.

Armature Windings

50. If the armature windings are suspect, they can be tested for continuity and short circuits by means of a 'growler' armature tester; if such a machine is not available, the armature may be tested by substitution. In the event of a faulty armature, it should be returned direct to C.A.V. depot or Agent.

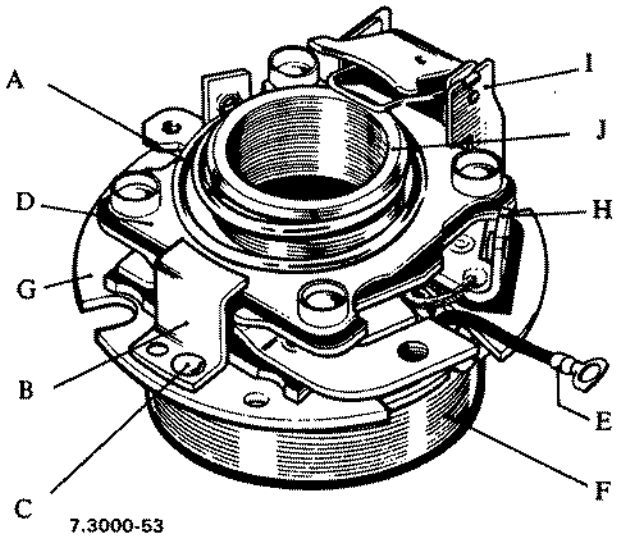
Solenoid Unit

51. Examine the contacts and if necessary clean them with white spirit or very fine carborundum paper. The first stage gap should be 0.083 in. (2.1 mm) with a bottom limit of 0.076 in. (1.93 mm) and a maximum of 0.098 in. (2.5 mm). Press down the plunger and check that the second stage contacts make only after the trigger is tripped.

52. If the contacts are badly burnt or the gap excessive or the coils appear to have overheated the solenoid can be replaced as a complete unit. Service exchange units are available from C.A.V. depots or Agents.

Testing Solenoid Coil Winding

53. The coils can be checked for shorts or open circuits by measuring current consumption at nominal voltage. **12VOLT STARTER SOLENOIDS ONLY** are dual wound and consist of a pull in and a hold in winding. therefore, before testing these, a link should be made between the base of the contact assembly (G) and the terminal lug (H) Fig. 7.3000-53 on EARTH RETURN versions or between the green lead and terminal lug (H) on INSULATED RETURN versions.



7.3000-53

54. On some starter solenoids the green lead is replaced by a yellow lead.

55. If the solenoid is to be dismantled and defective parts replaced the following procedure should be followed:

Dismantling Solenoid

56. Remove the burred over ends of the rivets (C) also the rivets securing the trigger assembly (I) using a 0.187 in (4.75 mm) diameter drill.

57. Carefully punch out the rivets and remove contact stop (B) and trigger assembly. Examine trigger assembly for excessive wear on the pivot points.

58. Withdraw the plunger (J) plunger spring (A) moving contact assembly (D) and inner spring as one assembly.

59. Unsolder the red solenoid lead connected to the fixed contact lug (H) on 12 volt machines also the bare solenoid lead connected to the fixed contact baseplate on all earth return machines.

60. Remove fixed contact assembly (G).

Test Data

Starter type	With ammeter in supply circuit	Read ammeter
CA45D12 Earth Return	Apply 12 volt to black lead and base of fixed contact assembly.	Check current consumption is 39 amp approx.
CA45D12 Insulated Return	Apply 12 volt to black and green leads.	As above.
CA45D24 Earth Return	Apply 24 volt to black lead and base of fixed contact assembly	Check current consumption is 16 amp approx.
CA45D24 Insulated Return	Apply 24 volt to black and green leads	As above.

Assembling Solenoid

61. Locate fixed contact assembly (G) on solenoid coil (F) ensuring that the rivet holes in the fixed contact plate line up with the rivet holes in the solenoid coil plate.
62. Replace the assembly consisting of the plunger, moving contact and springs. The rectangular shaped extension on one side of the moving contact assembly must face the two rivet holes for the trigger.
63. Push the solenoid plunger fully home. With the plunger held in this position replace contact stop (B) and trigger asembly (I) and rivet in position.
64. Solder the red solenoid lead to the fixed contact lug (H) on all 12 volt machines. On all earth return machines solder the other bare solenoid lead to the fixed contact base plate confining the solder to within 0.25 in. (6.3 mm) of the edge of the slot.
65. Check the first stage contact gap is within the limits set down in first paragraph headed 'Solenoid Unit'. Slight adjustment can be made by bending the brass contact stop (B).

Commutator End Bearing

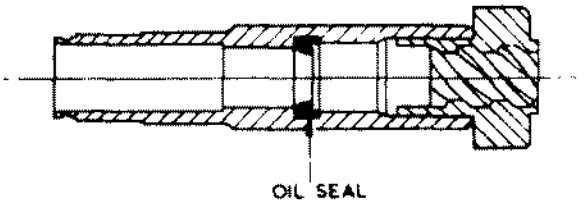
66. Ensure that the commutator end bearing is tight in its housing, and check the side play between armature shaft and bearing. If this is excessive, either a replacement commutator end shield and bearing assembly should be fitted, or the bearing should be renewed as follows:
67. Press the old bearing out of the end shield using tool 5693-240.
68. With the same tool, press the new bearing into the end shield. After assembly, the bearing should not protrude from either end of the housing; no machining should be attempted. A plug gauge, 5693-275 is available for checking the bush bore. The end of the gauge marked 'NOT GO' should not enter the bush.
69. The bearing need not be soaked in oil prior to assembly as it is impregnated with a special lubricant by the manufacturers but a smear of light oil applied will help initially.
70. Under no circumstances should any attempt be made to grease this bearing in service as this may adversely affect its self lubricating properties.

Drive End Shield

71. Check the internal diameter of the drive end bearing with the plug gauge 5693-267. If the bearing is worn the drive end shield should be replaced as an assembly.
72. **IMPORTANT** ON NEW DRIVE END SHIELDS A LEATHEROID RETAINING PAD IS FITTED IN THE OILWAY. THIS **MUST** BE REMOVED TO PREVENT THE BEARING BEING OIL STARVED.
73. Check that the felt pad is free to move under the influence of the spring.
74. If facilities exist for accurate machining the bearing can be renewed as follows:
75. Press the lubricating wick well away from the bore so that it does not get trapped during the pressing operation.
76. Extract the bearing housing using tool 5693-266. If the bearing is loose in its housing the end shield should be renewed.
77. Press the leatheroid retaining pad 5549-608 into the oil hole in the new bearing so that it completely fills the aperture. Cut away any material which projects above the external surface of the bearing.
78. Press the bearing chamfered end leading into the end shield until it reaches the edge of the oil reservoir. Ensure that the lubricating wick is well clear of the bore and then press the bearing fully home.
79. Set up the end shield on a high class lathe in such a manner that when machining of the bore is complete, the bore is perfectly concentric with the internal circumference of the end shield where it registers with the yoke.
80. Turn the bearing bore to $1.127\ ^{+0.0007}_{-0}$ in ($28.63\ ^{+0.02}_{-0}$ mm) diameter ensuring that the finish is of the highest quality. The final diameter of the bore can be checked with plug gauge 5693-267.
81. The diameter of a new pinion is $1.124\ ^{+0.001}_{-0}$ in ($28.55\ ^{+0.025}_{-0}$ mm) therefore a clearance between the bearing bore and pinion diameter of 0.0035 in (0.08 mm) should be maintained even if the existing pinion is used.
82. Clean off all swarf and then remove the leatheroid retaining pad using a pointed instrument, fit felt pad 5933-45.
83. Do not fit the lubricator pad spring (3) and core plug (4) at this stage, as pressure on the felt pad will prevent the pinion sleeve from being fitted.
84. Clean out the groove in the end shield and fit a new dust scraper ring (45) using service tool 5693-299 to press in the new ring.

Pinion

85. If the teeth of the pinion are badly worn or damaged, the pinion should be changed. See that the new pinion has the same number of teeth as the old component and that it is a free sliding fit on the armature shaft. Should it be necessary, the pinion and shaft can be lightly lapped together using a fine lapping paste. Remove all traces of lapping paste, using a bottle brush to ensure absolute cleanliness of the pinion helix. When the pinion is fitted with an oil seal inside, all burrs or sharp edges on the armature shaft and helix must be removed with an abrasive stone otherwise these will tear the oil seal.
86. Fit a new seal with the 'U' channel facing towards the pinion teeth end.



7 3000-86

Springs

87. See that the springs are not damaged and have not lost tension. The tension of the springs when compressed should be as follows:

Spring	Compressed length	Tension
Lock Spring	0·375 in. (9·53mm)	27 to 31 oz. (0.77 to 0.88 kg)
Recoil Spring	1·313 in (33·35 mm)	424 to 472 oz. (12·0 to 13·39 kg)
Pinion Spring	1·250 in. (31·75 mm)	124 to 136 oz. (3·5 to 3·85 kg)
Pinion Spring Oil sealed starter	1·469 in. (37·3 mm)	157 to 163 oz. (4·4 to 4·6 kg)

Commutator

88. 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, the armature should be set up in a lathe and the commutator skimmed. A rough cut should first be made, removing 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 compressed air or hand bellows.

89. The recess in the commutator is required only for initial manufacture, and can therefore be eliminated when skimming is undertaken. Minimum diameter to which the commutator can be reduced is 1.56 in. (39.2 mm) and the radius at the junction of the risers and commutator must not exceed 0.040 in. (1.0 mm). The risers must **not** be skimmed.

90. The commutator must not be undercut otherwise brush dust tracking may occur.

Armature Shaft

91. Examine the recesses in the armature for burrs caused by the steel balls and carefully stone these off.

92. 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 RECOMMENDED LUBRICANTS).**

93. No attempt should be made to machine the armature core.

Field Windings

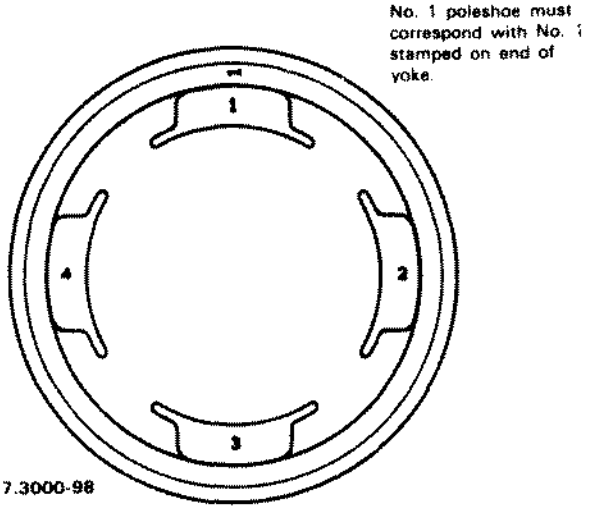
94. Before making electrical tests remove all traces of brush dirt etc., by blowing with dry compressed air.

95. The windings can be tested for earth to the yoke and poles using a 100 volt 'Megger' type tester.

96. There is no easy way of checking for internal shorts in the coils as their resistance is very low. New coils should be tried if the existing ones are suspect. Unserviceable coils should be replaced as follows:

97. Unscrew pole screws (12) and remove the pole shoes (13) and windings, noting the position of the windings and pole shoes in order to facilitate reassembly.

98. Fit the new windings into the yoke and replace the pole shoes. Concentricity is achieved by machining the pole shoes and the pole shoes must therefore be replaced in their original positions, otherwise they may foul the armature. As an aid to correct assembly, the pole shoes are numbered, and must be replaced in the positions shown.



99. Insert and tighten the pole fixing screws (12) to 25-30 lbs. ft. (3.5-4.2 kg m) using a commercial pole shoe screwdriver. Care must be taken that the pole shoes are correctly aligned in the yoke, otherwise they will not bed down fully and may foul the armature.

100. Care must be taken to ensure that the screws are firmly tightened and that no space exists between the mating surfaces of the pole and yoke.

Brushgear

101. Check the brushgear insulation as detailed in paragraphs 102 and 103 using a 100 volt 'Megger' type tester. Ensure that the brush holders are tight.

102. Earth return machines.
Check insulation between insulated brush holders and the frame.
Make sure that the earthed brush boxes are making good electrical contact with the end shield.

103. Insulated return machines.
Check insulation between all brush holders and the frame.

Brushes

104. The brushes should always be renewed at overhaul periods in order to ensure maximum life between overhauls. It is essential that replacement brushes are fitted in complete sets, and under no circumstances should brushes of different grades be used together. To be sure of obtaining the correct grade of brush always specify genuine C.A.V. spares.

105. Replacement brushes must be well 'bedded' that is shaped to the commutator periphery. To do this, wrap a strip of fine glass paper (not emery cloth or carborundum paper) around the commutator with the abrasive side outwards and fasten it in position with an adhesive. Hold the armature in an armature clamping device or in

a vice fitted with soft metal or wood jaw clamps. Slide the commutator end shield on to the armature shaft, fit the brushes and place the brush springs in position. Rotate the end shield in the opposite direction to the normal rotation of the armature until the brushes are bedded over approximately 80% of their contact area. Once this has been done, the brushes should not be interchanged, but should be retained in position in their holders until the end shield is required for use.

106. Remove all traces of dust and abrasive, preferably using compressed air. Examine the brushes to ensure that no particles of abrasive are embedded in their contact surfaces. Do not forget to remove the glass paper and to clean away all traces of adhesive from the commutator surface.

107. The following checks should be made to the brushgear at regular intervals between overhaul periods.

108. Remove the commutator cover. Ensure that the brushes are free in their holders by lifting the brush springs clear of the brushes and pulling gently on the brush leads. If a brush is inclined to stick, remove it from its holder and clean the brush and the inside of the holder with a clean cloth moistened in carbon tetrachloride. Be sure to replace the brush in its original position so that the curvature of its contact surface accurately conforms with the commutator periphery.

109. See that the braided sleeving on the brush leads has not become burnt or charred, thus creating the danger of short circuits.

110. Brushes must be replaced as soon as a minimum length of 0.5 inches (12.0 mm) is reached.

111. Replace the commutator cover, ensuring that the windows are fully covered and that the cover fixing screw is at the bottom of the starter when the starter is mounted on the engine. This is most important, as fuel, oil and water may enter the machine if the cover is not correctly positioned.

Brush Springs

112. The brush spring pressure should be within the range of 6 to 7¼ lb (2.7 to 3.4 Kg). To check the pressure remove the brushes from the holder and with a suitable spring balance hooked under the lip of the spring raise the lip to the height of the brush. If the spring pressure is outside the limits, fit new brush springs.

113. The starter motor should now be reassembled.

114. Fit the split protection collar (Service tool 6244-6) so as to protect the dust scraper ring (45) in the drive end shield and insert the pinion assembly.

115. Detach the split protection collar.

116. Take the assembled solenoid switch and place main terminal insulator under the main terminal lug (H) (7.3000-53) with the end with the hole upright.

117. Insert the solenoid assembly into the drive end shield and fasten it in position with screws (31) and spring washers.

118. Drop the anodized metal strip on the inside face of the main terminal insulator.

119. Place the solenoid terminal tag (E) (73000-53) (black lead) over the solenoid terminal screw (21) and add the shaped insulator bush (19) over the terminal screw and push it through its hole in the end shield. Fit round insulating bush, spring washer and nut (20).

120. On insulated return models there is a further solenoid lead (coloured green or yellow) which must be attached to its terminal screw exactly as above. This is the 'R' terminal.

121. Insert main terminal (22) into position from inside the housing through the anodized metal strip and insulator and into the hole in the end shield. (Pressing down the plunger gives room to insert the main terminal). Replace insulating bush (4) rubber ring, insulating washers, plain washers, spring washers and nut (23). Do not tighten until item 122 has been carried out.

122. Insert spring washer and screw (25) and tighten securely. Now tighten nut (23) to a torque of 5 lbs. ft. (0.7 kg. m.).

123. Fit the lock collar (38) to the pinion sleeve making sure that the 45° chamfer inside the collar is facing towards the solenoid assembly.

124. Replace the spring (9) trip collar (10) and secure in position with circlip (11) dished side downwards. Make sure that the circlip locates in the groove in the locking collar. Check with gauge 6244-3 so that it seats squarely.

125. Insert resistor (40) into its recess in the drive end shield and secure it in position by means of bush and spacer (26) and rivet (27).

126. Connect the resistor flexible lead to the lug on the solenoid assembly moving contact by means of washer and screw (28).

127. On 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 washer and a screw and the other end is attached to a post together with the resistor flexible lead by means of a washer and nut.

128. Insert the lock balls (8) into the pinion sleeve holes from inside the bore, using grease to hold them in position. 12 volt starters have four lock balls and 24 volt starters have six balls.

129. Assemble the pinion and end shield assembly to the armature as follows:

130. Pull the pinion out of the drive end shield until the lock collar (39) is pressed back against its spring by the end of the solenoid plunger (43). Keep it in this position until otherwise stated.

131. Press lock balls (8) fully into their holes to allow free entry of the armature shaft.

132. Slide the pinion and end shield assembly on the armature shaft, taking care not to displace the lock balls.

133. Engage the pinion with the shaft helix, and then release the pull on the pinion. Screw the pinion on to the shaft and check that the pinion locking mechanism engages.

134. Finally support the weight of the drive end shield and rotate the pinion first in one direction and then in

the other to ensure that the pinion is free on the shaft and that the locking mechanism functions correctly. The locking mechanism can be released by pulling lock-collar (38) back against its spring.

135. Mount the armature in an armature clamp. Assemble the helix dust cover (1) the pinion return spring (2) the shim washer (47) and the thrust washer (48) on to the pinion shaft. Screw a NEW pinion stop nut (49) on to the shaft left hand thread. Using a 7/16 in. BSF socket with the chamfered lead ground away, tighten the pinion stop nut to a torque of 40-50 lbs. ft. (5.6-6.9 Kg. m).

136. Assemble the armature and drive end shield assembly to yoke (14) ensuring that the dowel in the end of the yoke locates in the slot in the end shield.

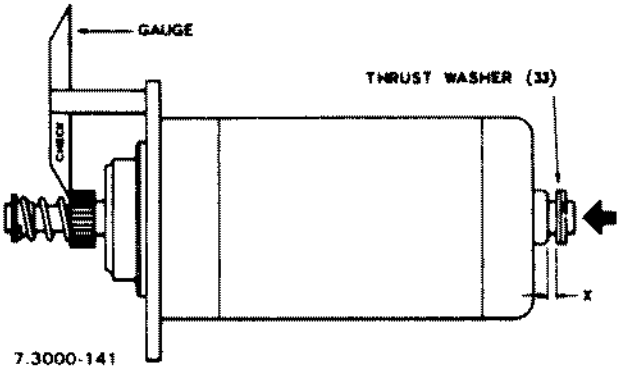
137. The joint between the yoke and each end shield should be sealed with Wellseal Compound.

138. Check that shims (36) have all been removed from the armature shaft and then replace commutator end shield (15). Fit through bolts (35) and tighten securely to a torque of 7-7½ lbs. ft. (0.95-1.0 Kg. m).

139. Replace thrust washer (33) and circlips (17) but do not fit shims (16).

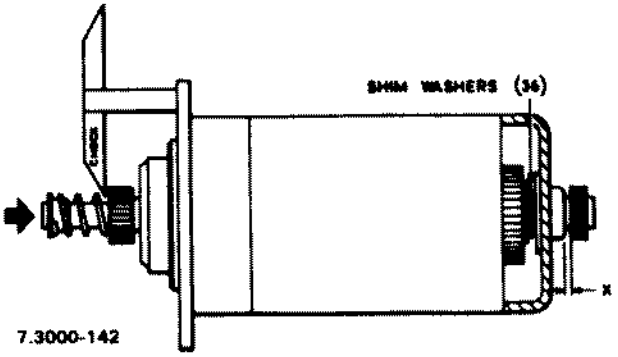
140. The armature end float and the distance between the pinion and mounting flange must now be adjusted as follows using gauge 5693-222.

141. Bolt the gauge on to the mounting flange with the arm marked 'CHECK' towards the pinion as shown below, then 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 thrust washers (33) and the commutator end shield, using feeler gauges. Shim washers, having a total thickness equivalent to the measurement taken by the feeler gauges should then be fitted between the thrust washer and circlip. The shim washers must be well greased before use and are available in two thicknesses 0.008 and 0.004 in. (0.20 and 0.10 mm). A combination of these sizes giving the closest approximation to the required dimension should be used.



7.3000-141

142. When this has been done, push the armature towards the commutator end of the machine as shown below, and again measure gap 'X' which should now be within the limits 0.079 + 0.02 – 0.0 in. (2.03 + 0.50 – 0.0 mm). A GO-NO-GO gauge is available under service tool number 6244-4.



7.3000-142

143. If the gap is outside this limit, remove the commutator end shield and fit shim washers (36) on the armature shaft to the value of the excess. For example, if the gap is 0.120 ins. (3.04 mm) shim washers having a total thickness of 0.030 to 0.040 in. (0.76 to 1.01 mm) should be fitted e.g. nine washers each 0.004 in. thick. These washers also must be smeared with grease before use.

144. Replace commutator end shield, thrust washers, shim washers, (as determined in paragraph 141) and the circlip.

145. Smear steel ball (18) and spring (34) with grease and insert them in the bore in the armature shaft. Replace end cap (32).

146. If a screwed end cap is originally fitted in place of a bayonet type the starter must be held vertically commutator end uppermost and the thrust pad attached to the cap with grease. The cap must be tightened to a torque of 7-10 lbs. ft. (0.967-1.382 Kg.m) and the two thin corners of the hexagon caulked to slots in the bearing collar with a punch.

147. Check that any variation in the relationship of pinion position to check gauge is within the limits of +0.003 –0.002 in.

148. Rectify if necessary by varying the shims as in paragraph 143.

149. Fill the reservoir in the drive end shield with oil, the capacity of this reservoir is such that it requires no attention between overhaul periods. However in cases where the starter is not subjected to regular overhauls the reservoir must be replenished at intervals of not more than two years. This should be done by removing the starter and adding a supply of oil (See RECOMMENDED LUBRICANTS), through the oil filler hole in the drive end shield. The filler hole lies beneath a core plug which must be removed to gain access to the filler hole. Only new plugs must be fitted and care taken to ensure a positive fit in the filler hole.

150. Insert spring (3). Replace core plug (4) using tool 5693-300.

151. Connect the field windings and the free end of the resistor to the solenoid switch lugs by means of screws and washers (30). And refit new core plugs.

152. Fit the brushes and place the brush springs in position. Connect the brush leads and the field winding leads to the brush gear. Check that the brush leads allow free movement of the brushes in their holders. Replace the commutator cover.

'F' Change Starters

153. The only difference in the assembling procedure between the CA45D and CA45F starters is fitting the overspeed balls to the pinion sleeve and the four segments with garter spring to the solenoid plunger. All other operations are the same as detailed previously.

Segments

154. First check that there are no burrs or sharp edges on the segments. Place the garter spring on a clean flat surface and with the fingers position the four segments inside the spring so that they lie end to end in a circle. The garter spring will fit in the outer groove of the segments and hold them together.

155. Place the solenoid switch on the bench, coil end upwards and with the fingers gently push in the garter spring and segment assembly into the bore of the solenoid plunger so that it fits into the recess provided. It will be found easier if one segment is located into the recess first and then the other three can be edged into position.

156. Proceed as for the CA45D starter assembly paragraph 117.

Overspeed Balls

157. The overspeed balls as well as the locking balls can be inserted into the pinion sleeve holes from inside the bore as detailed in paragraph 128 of the CA45D starter assembly. The blade end of a small screw-driver with a spot of grease will be found useful to feed in the balls.

TESTING

Engagement Mechanism

158. **WARNING:** UNDER NO CIRCUMSTANCES SHOULD **BOTH** MAIN TERMINALS BE CONNECTED TO THE SUPPLY DURING THESE TESTS, OTHERWISE THE PINION WILL ROTATE AT HIGH SPEED WHEN PULLED FORWARD, CAUSING INJURY TO THE OPERATOR.

159. With the machine disconnected, pull the pinion forward by hand approximately 0.0625 in. (1.6 mm) and release. The pinion should return to its original position.

160. Energise the solenoid (when cold) by applying a battery voltage of 10 volts for 12 volt starters or 20 volts for 24 volt starters. The battery should be connected between the solenoid terminal 'S' and 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 for a distance of 0.25 in. (6.3 mm) minimum.

161. With the solenoid still energised, pull the pinion forward by hand. The locking mechanism should now come into operation locking the pinion in the forward position.

162. Disconnect the supply to the solenoid. The pinion must return to its disengaged position in one sharp movement.

163. Check the recoil spring action by applying a compression spring balance to the driving end of the armature shaft. The force required before backward movement of the shaft occurs should be 30 to 38 lbs. (13.6 to 17.2 Kg).

Performance Tests

164. For the purpose of these tests, the brushes must be bedded over at least 80% of their contact area.

165. CAUTION: If the starter is allowed to run without engaging a suitable flywheel, 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. Moreover, prolonged running on the first stage contacts may cause grooving of the solenoid trip mechanism. For these reasons, the starter should always be run in conjunction with a flywheel but if this is not possible, the running period must not exceed five seconds.

166. Mount the starter on the starter test bench with a 0.125 in. (3.18 mm) clearance between the face of the pinion and the face of the test bench flywheel.

167. Connect the starter main terminals to a battery of suitable voltage. The solenoid should be energised from a separate battery giving 9-10 volts for a 12 volt starter or 19-20 volts for 24 volt starters at the solenoid terminal when the solenoid current is flowing. The battery should be connected between the solenoid terminal 'S' and earth terminal for machines designed for earth return, and between the solenoid terminal 'S' and solenoid terminal 'R' for insulated return machines.

168. Complete ten engagements into a partly locked flywheel to ensure that the engaging mechanism is operating satisfactorily. Non-engagement may be caused by a tight drive end bearing, or by the pinion binding on the armature shaft.

169. Disconnect the separate supply to the solenoid, and connect the machine for normal operation. Then check the lock torque (LT). the running torque (RT) and the light running torque (LR) of the starter according to the following table.

Test Data

Nominal voltage of starter	Type of test	Battery capacity	Torque	Current (Amps)	Terminal voltage	Speed
12	LT	135AH	35·5 lb ft (4·9 Kg m)	1240 max.	4·5	0
	RT	135AH	15·0 lb ft (2·1 Kg m)	690 max.	8·0	1220 min.
	LR	135AH	0	100-150	12·0	7000
24	LT	78AH	38·0 lb ft (5·2 Kg m)	910 max.	9·2	0
	RT	78AH	17·0 lb ft (2·3 Kg m)	555 max.	15·2	1550 min.
	LR	78AH	0	60-100	24·0	7000

Brush spring tension 6·7·5 lb (2·7-3·4 Kg)
Brush grade 12 volt starter CMIS 24 volt starter DM100
Brush length (new) 12 volt starter 24 mm 24 volt starter 19 mm

170. After the tests have been successfully completed, replace core plugs (29) using tool 5693-298. Finally, replace the commutator cover ensuring that the windows are fully covered and that the cover fixing screw is at the bottom of the starter when the machine is mounted on the engine.

414 Relay Unit Test Procedure

171. The particular relay fitted to the starting system has been chosen to operate satisfactorily with the generator and starter as fitted to the engine. The relay is **not** adjustable and cannot be serviced. If the relay is defective in any way it MUST BE REPLACED BY A NEW ONE OF IDENTICAL TYPE SYMBOL. THIS IS VITAL TO THE PROPER FUNCTION OF THE STARTER MOTOR.

414 – 1 (12 volt)

172. Check continuity between B+ and ST terminals and the insulation to frame all terminals (See wiring diagram on page 2).

173. Connect a variable resistance and milliammeter in series with a 12 volt battery and the relay winding (SW+ terminal and the positive side of the capacitor). Increase the variable resistance and set the relay by adjusting the armature spring tension so that the contacts open between 32 and 34 milliamps.

174. Connect an 8 volt battery between terminals SW+ and E and observe that the relay momentarily closes. Failure to do this indicates a faulty capacitor, loose or broken connections.

175. Connect a 12 volt lamp and battery in series with the relay contacts (SW+ and SOL terminals). Press armature to coil, to close contacts and observe if lamp lights. Failure to light indicates dirty contacts, loose or broken connections.

414 – 2 (24 volt)

176. As 12 volt unit but using a 24 volt battery and lamp, relay contacts open at between 60 and 62 milliamps. Relay to momentarily close at 20 volts.

RECOMMENDED LUBRICANTS

177. The following lubricants are recommended for all CA45D starters and no departure from these should be made without reference to CAV. Alternative greases must not be mixed.

Where used	Recommended lubricants	Alternatives
Drive end bearing (Temperate climates)	Oil to S.A.E. 20W	Castrol 98
Drive end bearing (Sub-zero climates)	Oil to S.A.E. 5W/20W	Castrol 98
Pinion helix, lock balls etc.	Regal Starfak Grease	Mobil Aero 348 Aero Shell 6B
End cap, comm. end and shims	Spheeral EP12	Castrolese LM

CAV CA45'D' and 'F' (Refitting)

178. Place the unit against the flywheel housing and replace the three retaining bolts and washers.

179. Connect the terminal and battery leads to the starter.

180. The starter should be examined to ensure that its mounting bolts are securely fastened and that all cable connections are clean and tight. The cables should also be inspected for fractures, particularly at the point where the cable enters the terminal lug. The cable insulation should be free from chafing or deteriorations due to oil.

181. If the starter does not function or is sluggish in operation, check that the battery is in a satisfactory state of charge and that all connections are clean and tight. A defective starter switch, ST relay or badly worn starter brushes are possible causes of failure.

182. A defective dynamo can also affect operation of the starter (when an overspeed protection device is fitted in the circuit) as the two machines are electrically connected. When this condition exists the starter can be made to operate in emergency only, by temporarily bridging the two main (large) terminals on the ST relay, thereby closing the starter solenoid circuit and eliminating the overspeed protection. The usual precaution of ensuring that the engine gear lever is in neutral MUST be taken before attempting this emergency start. The dynamo trouble must be rectified at the first opportunity. When an alternator is fitted in place of a dynamo the above conditions do not arise as the alternator is not electrically inter-connected. The proper functioning of the 414 and ST relays however, should be checked if any external cause of non-operation of the starters is suspected.

Lucas M50G Starters (Description)

183. The Lucas M50G starter is a four pole brush unit with a solenoid-operated roller clutch drive. The unit has a 5 inch diameter windowless yoke with a parallel connected field.

184. An intermediate bracket incorporating a third armature bush is interposed between the yoke and the drive end bracket which together with the commutator end bracket are clamped together by through bolts.

185. A brake, to stop the armature rotating after pinion disengagement, is incorporated in a bore in the commutator end bracket. The brake comprises a pair of shoes which engage a cross peg in the armature shaft and are centrifuged against the wall of the bore.

186. The brush holders are secured to a plate which in turn is secured to the end bracket by two bolts. Two brushes are grounded to the end bracket and two insulated brushes are connected to the copper field coil assembly. A rubber seal is interposed between the commutator end bracket and the yoke.

187. Engagement and disengagement of the pinion is provided by the solenoid plunger through a lever which pivots about an adjustable eccentric pin housed in the drive end bracket.

188. The M50G unit has a solenoid with two sets of contacts which provides two stage switching of the starter. Thus in the event of tooth-to-tooth abutment, the first stage contacts in the solenoid close so that only one of the field coils comes into operation. This rotates the armature at low speed thus allowing the teeth to clear and the pinion to move into mesh. Upon full pinion engagement the second stage contacts close, and bring the remaining three field coils into operation.

Lucas M50G Starters (Removal)

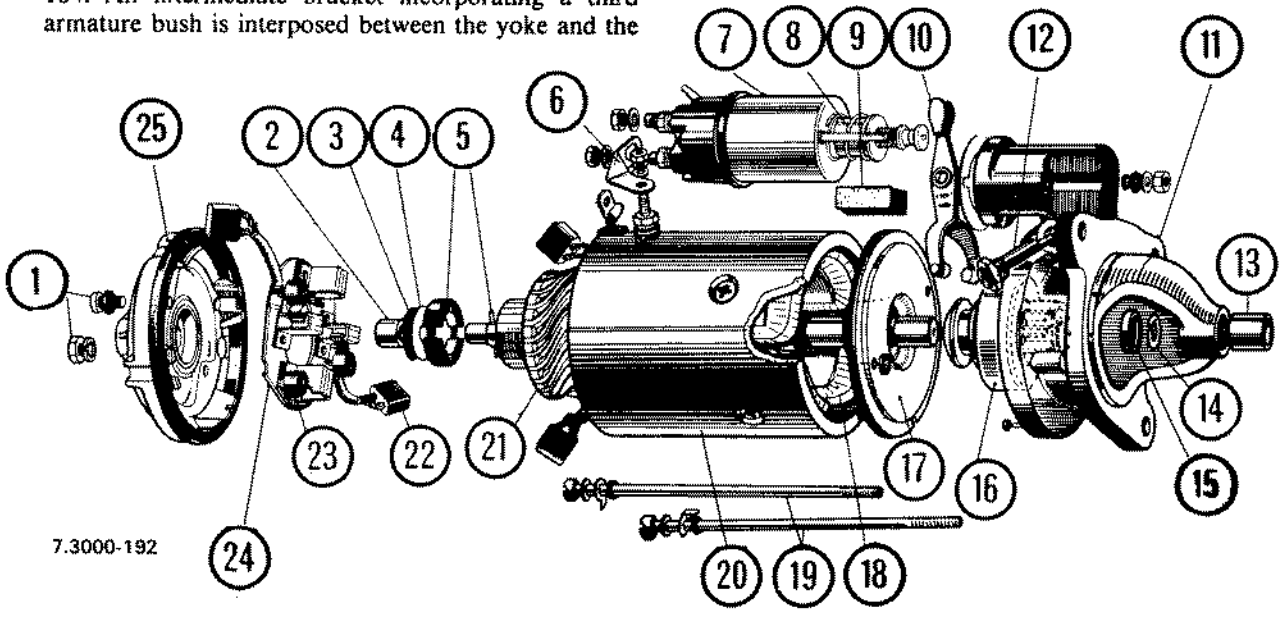
189. Disconnect the battery cables and leads to the solenoid.

190. Supporting the starter remove the three retaining bolts and washers between the starter and flywheel housing.

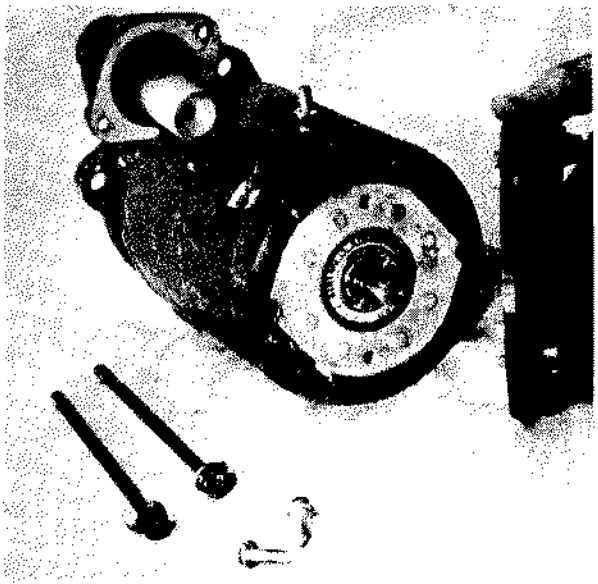
191. Remove the starter.

Lucas M50G Starters (Inspection and Overhaul)

192. A dismantled view of the complete machine is shown below to assist in dismantling. Numbers in brackets in the following text refer to this illustration.

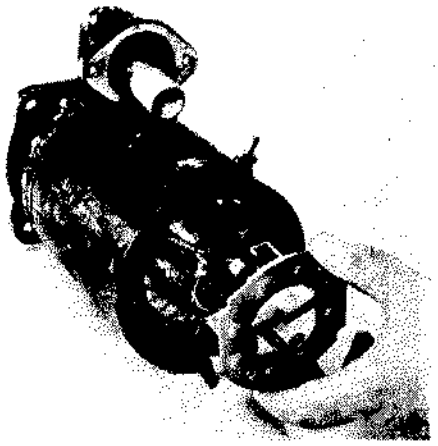


193. The solenoid (7) can be withdrawn after detaching the connecting links (6) and removing the attaching bolts and washers.
194. The solenoid plunger can now be disengaged from the drive engagement lever (10).
195. Remove the two bolts (1) securing the brush gear plate (24), the two through bolts (19) and withdraw the commutator end cover (25).



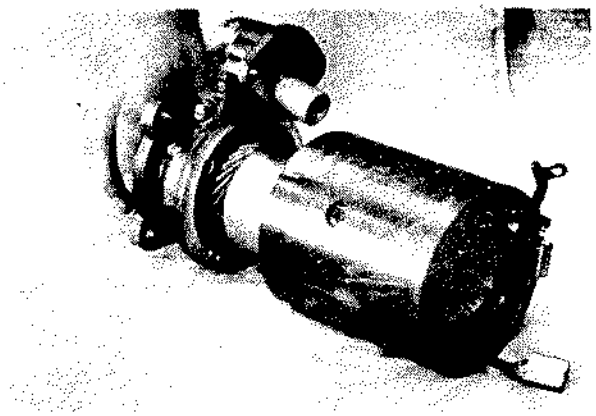
7.3000-195

196. Withdraw the brushes (22) which will then allow the brush gear plate (24) to be removed from the commutator.



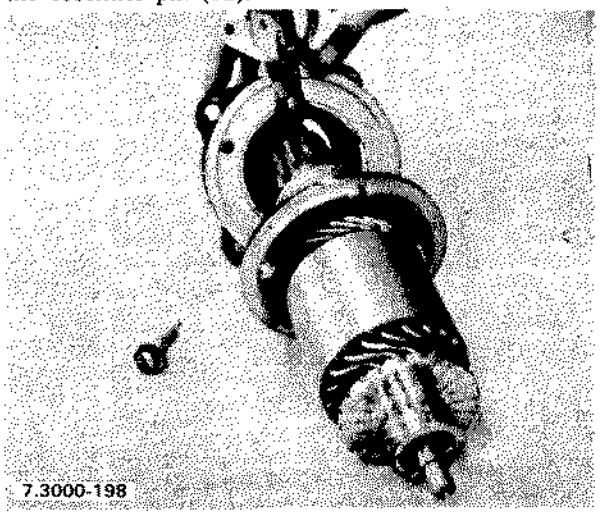
7.3000-196

197. Withdraw the drive end bracket (11) and intermediate bracket (17) complete with armature (21) from the yoke (20).



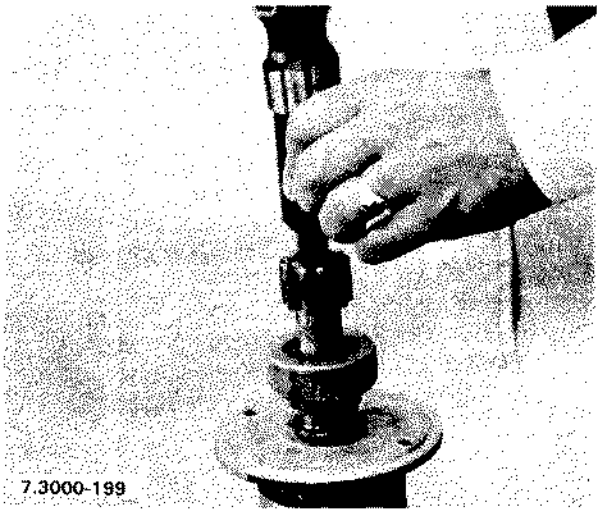
7.3000-197

198. The armature (21), intermediate bracket (17) and drive assembly (16) can be removed from the drive end bracket (11) after releasing the locknut and removing the eccentric pin (12).



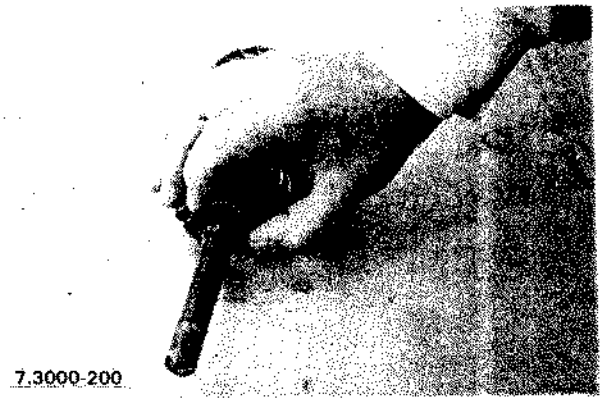
7.3000-198

199. Remove the intermediate bracket (17) and drive assembly (16) from the armature shaft (21) by freeing the thrust collar (15) from the jump ring (14). This can be achieved by tapping the collar down with a tube and then removing the jump ring.



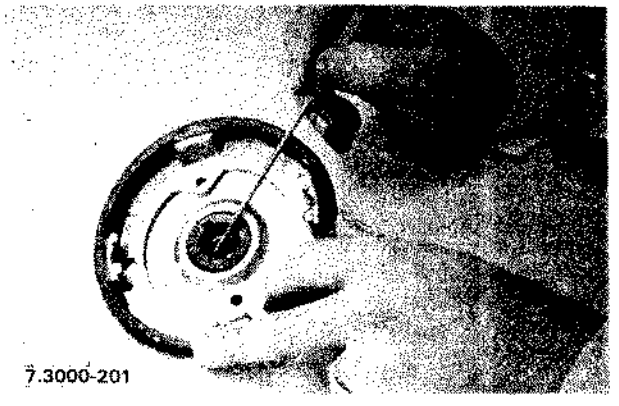
7.3000-199

200. Take care not to lose any shims which may be assembled to the armature shaft between the intermediate bracket and armature core.



7.3000-200

201. The brake shoes and springs (5) can be eased out of the commutator end cover with a small screwdriver, care must be taken not to damage the fibre and steel thrust washers (3 and 4) which are situated behind the brake shoes.



7.3000-201

202. After dismantling the motor each individual item must be examined for wear.

Replacement of Brushes

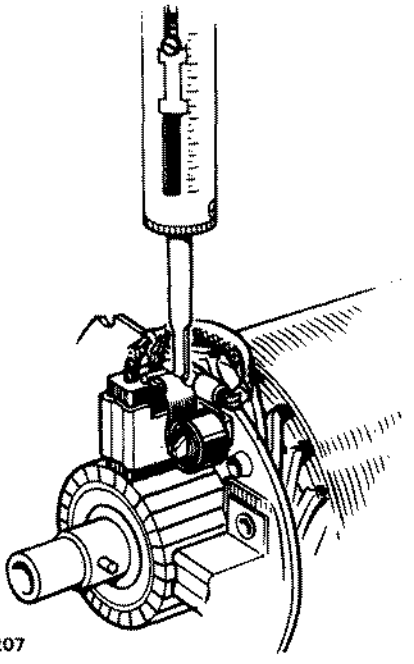
203. The two earth brush flexible connectors are soldered to terminal plates secured by brush box rivets and the two insulated brush flexible connections are hot pressed to free ends of the field coils. Unsolder the earth brush flexibles and solder the connectors of the new brush set in their place.

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

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

206. Check that the new brushes move freely in their boxes.

207. Brush spring tension should be checked with complete brush gear assembled to commutator. Hold assembly firmly centralized whilst checking each spring in turn. Tension should be 42 oz. minimum, with a new brush.



7.3000-207

Commutator

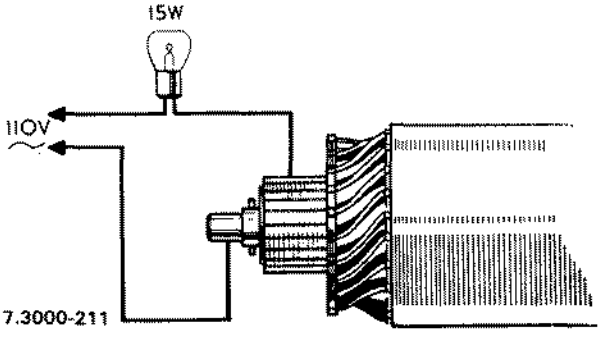
208. A Commutator in good condition will be burnished and free from pits or burned spots. Clean the commutator with a petrol moistened cloth. If the commutator is badly worn, mount the armature between centres in a lathe, rotate at high speed and take a light cut with a very sharp tool. Do not remove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

Armature

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

210. Fouling of the armature core against the pole faces indicates worn bearings or a distorted shaft. A damaged armature must in all cases be replaced and no attempt should be made to machine the armature core or to straighten a distorted armature shaft.

211. To check the insulation of the armature windings use a 110 volt AC 15 watt test lamp.



7.3000-211

212. Before testing, remove all traces of brush dust with a dry air blast.
213. The test lamp must not light when connected between the commutator segment and the armature shaft.
214. If a short circuit in the windings is suspected check the armature on a 'growler'.
215. If the armature failure cannot be remedied, a replacement must be fitted.

Field Coils

216. Ensure that both brushes are clear of the yoke and connect a 110 volt AC test lamp between the field coil eyelet and a clean part of the yoke.
217. If the test lamp lights it indicates that the field coils are earthed to the yoke and must be replaced.
218. Using the same equipment check also the insulated pair of brush boxes on the commutator end bracket. Clean off all traces of brush deposit before testing. Connect the test lamp between each insulated brush box and the bracket.
219. If the test lamp lights this indicates faulty insulation and the end bracket must be replaced.
220. To replace the field coils, remove the nuts, washers and insulation pieces to free the yoke mounted terminal stud.
221. Unscrew the four pole shoe retaining screws, using a wheel operated screwdriver. Remove the insulation piece which is fitted to prevent the intercoil connectors from contacting with the yoke.
222. Draw the pole shoes and coils out of the yoke and lift off the coils. Fit the new field coils over the pole shoes and place them in position inside the yoke. Ensure that the taping of the field coils is not trapped between the mating surfaces of the pole shoes and the yoke. Locate the pole shoes and field coils by lightly tightening the retaining screws.
223. Replace the insulation piece between the field coil connections and the yoke. Tighten the screws by means of the wheel-operated screwdriver while the pole pieces are held in position by a pole shoe expander or a mandrel of suitable size. Finally, remake the soldered connections as before.

Bearing Replacement

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

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

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

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

for Commutator end bracket bush: 0.5005″
for Intermediate bracket bush: 1.123″
for Drive End bracket bush: 0.6705″

227. POROUS BRONZE BUSHES MUST NOT BE REAMED OUT AFTER FITTING or the porosity of the bush will be impaired.

Checking the Roller Clutch Drive Assembly

228. A roller clutch drive assembly in good condition will: (a) Provide instantaneous take-up of the drive in the one direction.
(b) Rotate easily and smoothly in the other.
(c) Be free to move round or along the shaft splines without roughness or tendency to bind.
229. Should the assembly not meet any of these requirements a replacement unit must be fitted.
230. All moving parts should be smeared liberally with Rocol 'Molydest' grease, starting motor grade, or an equivalent alternative.
231. After cleaning all parts, reassembly of the starter motor is the reversal of the dismantling procedure but the following special points should be noted:
232. The thrust shims must be refitted between the intermediate bracket and the armature. These shims are provided to limit the end float to 0.005″ – 0.020″. It is important that after re-assembly the end float be checked and if necessary a further shim added.
233. When installing brake shoes in the commutator end cover, place the fibre washer in the bore first followed by the steel washer and finally the brake shoes.
234. Before installing the end bracket or cover, the brake shoes and the cross peg in the armature must be in the correct relative location so that the peg engages the slots in the shoes.
235. After assembling the brush gear to the commutator, locate the through bolts in the shaft holes of the brush gear plate and temporarily screw the bolts a few threads into the drive end bracket to locate the brush gear plate in the correct assembled position.
236. Position the armature so that the brake shoe cross peg is in line with the two threaded holes in the brush gear plate. Remove the through bolts without disturbing the position of the plate.

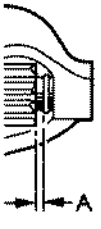
this throws the drive assembly
›sition) and measure dimension
thrust collar on the armature
ure accuracy when taking this
›n lightly towards armature, so
ngagement linkage. For correct
›uld be 0.015" – 0.025".
'A' not be within specified
1) and turn eccentric pivot pin
s obtained. Arc of adjustment is
t be set so that arrow head on
s marked on drive end bracket.
e securing nut to retain the pin
the setting.
and nut with gold size applied
s.

(Refitting)
ainst the flywheel housing and
ing bolts and washers.
minal and battery leads to the

Type SS/1 (Description)
Starter Type SS/1 provides a
diesel engines up to 1 litre
eliminates the normal electric

r is particularly suitable for
g in tropical conditions and
lectrical equipment deteriorates

iple of operation is in the
ored in a compressed spring to
ntly quickly for starting.
starter is in the spring pack
dished spring steel washers
ommon sleeve.
mpressed between the flange on
and the four ears of the inter-
which travels up and down in-
Both nut and sleeve which can
re carried on the ball threaded



mainshaft that is screwed into the nut and locked into the spring sleeve whilst the springs are under a small pre-compression during the assembly process.

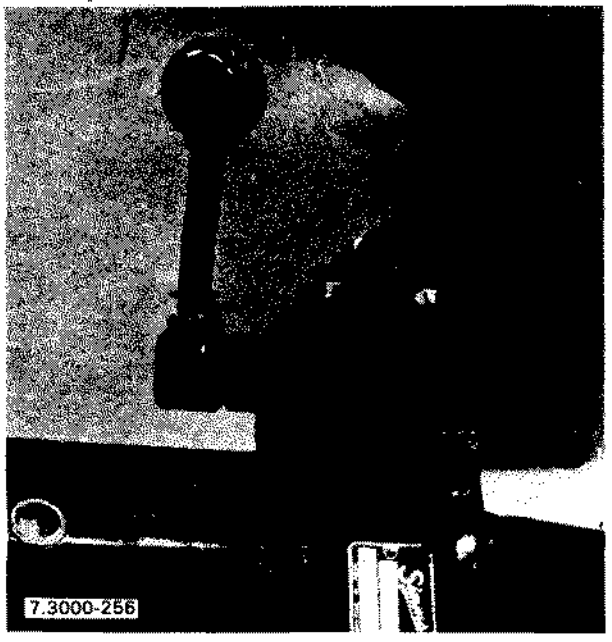
252. By holding the mainshaft stationary and rotating the sleeve the springs are compressed, and conversely when the springs are compressed and the sleeve held stationary, if the mainshaft is released this will rotate as the springs return to their static position.

253. The ratchet mechanism for locking and unlocking the shaft is integral with the bendix drive of the starter pinion and is carried on an extension of the mainshaft.

254. Integral with the spring sleeve is a bevel reduction gear that meshes with the winding shaft which incorporates a ratchet mechanism for locking the spring sleeve.

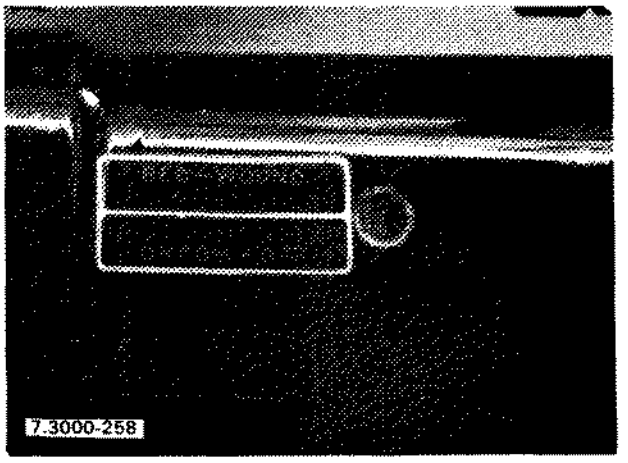
255. The whole mechanism is contained within a three-piece carcase which is both moisture and dustproof.

256. To operate the starter, the trip lever is set in the WIND position.



257. On rotating the hexagonal winding shaft in a clockwise direction, the spring core assembly rotates with the exception of the starter pinion which is restrained from turning by the main ratchet and pawl mechanism. It does, however, move forward into engagement with the flywheel ring gear until it reaches the end of its axial travel, whereupon both pinion and mainshaft are automatically locked. This takes $1\frac{1}{4}$ turns of the winding handle.

258. Further rotation of the winding shaft rotates the spring sleeve and ball nut around the stationary mainshaft which in turn screws the nut into the sleeve thus compressing the disc springs. After approximately $10\frac{1}{4}$ turns (12 total) the starter is fully charged and this is indicated by the appearance of two red springs coinciding with the inspection windows provided in the carcase. The winding shaft is prevented from reverse rotation due to the reaction of the compressed springs by its own ratchet and pawl system.



259. On moving the trip lever into the TRIP position, the pinion and mainshaft are unlocked thus allowing the ball nut to be driven axially along the spring sleeve by the springs until they reach their static position. Axial movement of the nut rotates the mainshaft which in turn rotates the engine flywheel.

260. As soon as the flywheel speed exceeds the mainshaft speed the pinion is thrown out of engagement and returns to its discharged position assisted by a helical return spring.

261. Three other important built-in features should be noted:

a) It is possible to rotate the engine through the starter reduction gear without compressing the springs. This makes tappet adjustment, spill timing and priming the fuel system a simple operation.

b) It is possible to unwind the starter without discharging the stored energy into the engine flywheel.

c) The starter need only be part charged when restarting a hot engine.

Simms Spring Starter Type SS/1 (Removal)

262. Ensure that there is no load on the main spring by checking that the green painted discs can be seen through the inspection windows. If they are not visible the starter must be unwound.

263. Remove the retaining bolts and lift the starter from the engine.

Simms Spring Starter Type SS/1 (Inspection and Overhaul)

264. When overhauling the starter the carcase must not be gripped in a bench vice.

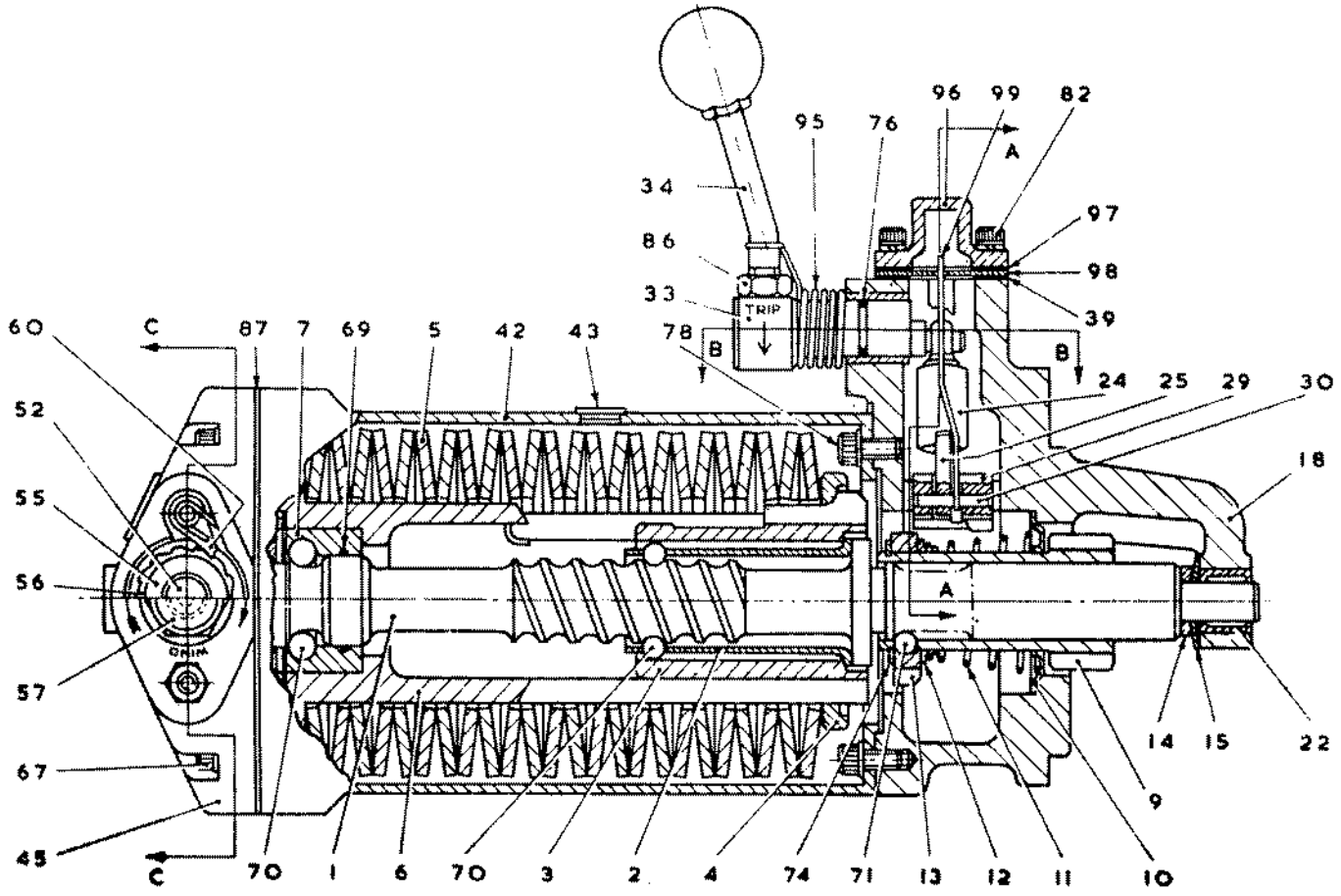
265. To help with overhauling the starter, the numbers in brackets in the following pages refer to the sectional view 7.3000-265 unless otherwise stated.

266. The starter should first be dismantled into three sub-assemblies
End housing assembly
Spring core assembly
Carcase/nosepiece assembly
as follows:

267. Make a note of the starter assembly code position, see page 28, or scribe lines across the end housing/carcase and the nosepiece/carcase joints, this will ensure that these parts can be correctly aligned on reassembly.

268. Turn the winding adaptor anti-clockwise to break the winding ratchet friction.

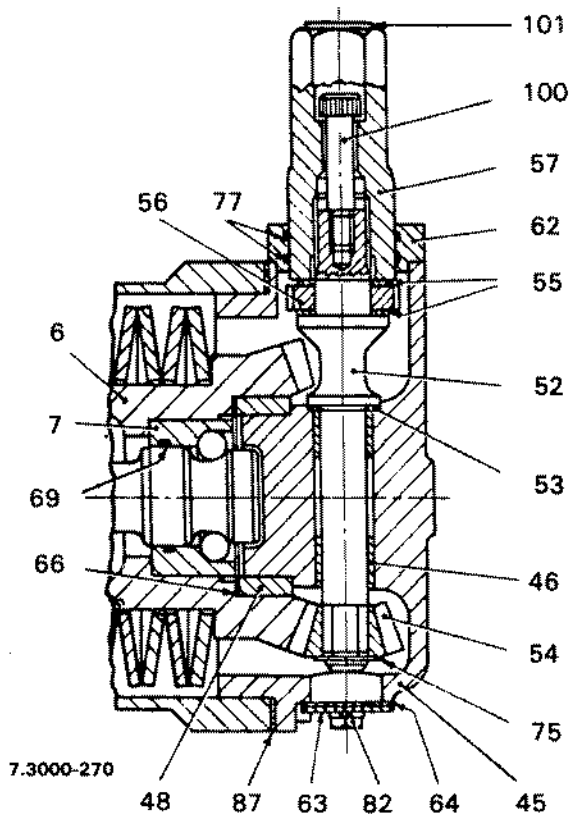
269. Hold the starter vertically on end, with the nosepiece on the bench or on a special stand (Tool No: ST120) and remove the 6 socket cap screws (67) and spring washers.



1	Main Shaft	24	Trip Link	69	'O' Seal
2	Ball Cage	25	Plunger	70	Steel Ball (5/16 in. dia.)
3	Ball Nut	29	Pawl	71	Steel Ball (7 mm. dia.)
4	Ball Nut Ring	30	Link Pin	74	Circlip
5	Main Disc Spring	33	Trip Lever Shaft	76	'O' Seal
6	Spring Sleeve	34	Trip Lever	78	Socket Cap Screw
7	Ball Seat	39	Jointing	82	Screw
9	Main Pinion	42	Carcase	86	Locknut
10	Spring Retainer	43	Inspection Window	87	Shim
11	Return Spring	45	End Housing	95	Return Spring
12	Spacing Ring	52	Winding Shaft	96	Catch Housing
13	Ratchet Ring	55	Friction Disc	97	Jointing
14	Thrust Washer	56	Ratchet Disc	98	Catchplate
15	Nosepiece Disc Ring	57	Winding Adaptor	99	Hook
18	Nosepiece	60	Winding Pawl		
22	Needle Roller Bearing	67	Socket Cap Screw		

7.3000-265

270. Lift the end housing assembly (45 on 7.3000-270) if necessary using a rawhide mallet to loosen it.



6	Spring Sleeve	62	Top Plate
7	Ball Seat	63	Cover Plate
45	End Housing	64	Jointing
46	Bearing Bush	66	Shim
48	Bearing Sleeve	69	'O' Seal
52	Winding Shaft	75	'E' Clip
53	Thrust Washer	77	'O' Seals
54	Bevel Pinion	82	Screw
55	Friction Disc	87	Shim
56	Ratchet Disc	100	Retaining Screw
57	Winding Adaptor	101	Plug

271. Remove the carcase shim (87) if fitted.
272. Remove shims (66) from bevel gear recess.
273. Operate the trip lever (34) through its full travel in order to engage the hook (99) with the catch plate (98).
274. Place hand over the open end of the carcase (42) to hold the spring sleeve bevel gear, then invert the carcase, placing the open end onto the bench. Care must be taken when turning the carcase upside down otherwise the spring core assembly will fall out. Lift the carcase/nosepiece vertically off the mainshaft.

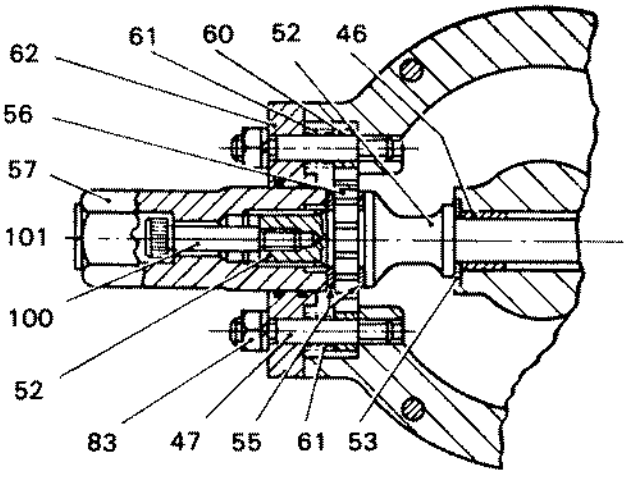
Spring Core Assembly

275. Remove the nosepiece disc spring (15) and thrust washer (14) from end of mainshaft (1).

276. Lay the assembly on its side. Carefully remove the main pinion circlip (74) making sure not to overstretch it. Slide the ratchet ring (13) sideways and remove the five steel balls (71). Slide off the main pinion (9), spring retainer (10), return spring (11), spacing ring (12), ratchet ring (13) and circlip (74) from the mainshaft.
277. Slide the spacing tool (No. ST121) over the pinion end of the shaft and place the main spring assembly vertically in the special press (Tool No. ST138) so that the spring sleeve bevel gear is on top. Place the press tool (No. ST122) in the bevel gear recess and apply sufficient pressure to depress the main spring about $\frac{1}{4}$" (9.5 mm). Whilst the pressure is maintained, lift out the ten steel balls (70). Slowly release the pressure and remove the assembly from the press.
278. Slide the main shaft (1) complete with ball nut (3) and ball nut ring (4) out of the spring sleeve (6). Remove the twenty-four spring discs (5) from the spring sleeve. Examine the 'O' seal (69) for wear or damage. To remove this seal the ball seat insert (7) must be pressed out, an operation which should not be carried out unnecessarily.

End Housing Assembly

279. To dismantle the end housing assembly reference should be made to illustration 7.3000-279 which is section 'CC' of illustration 7.3000-265.



7.3000-279 – Section 'CC' of 7.3000-265

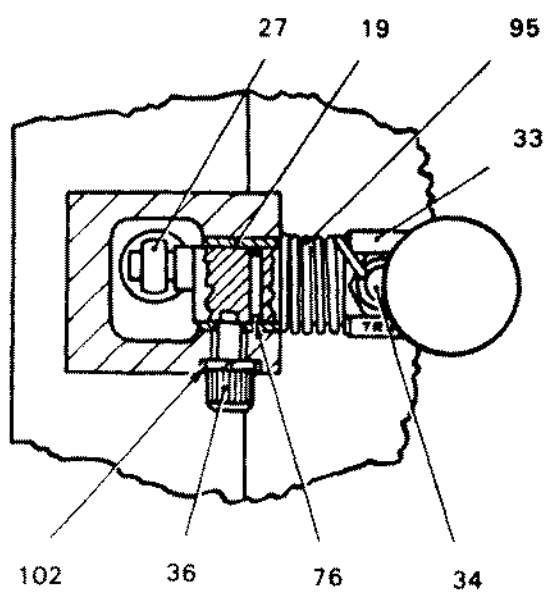
46	Bearing Bush	60	Pawl
47	Stud	61	Spring
52	Winding Shaft	62	Top Plate
53	Thrust Washer	83	Nut
55	Friction Discs	100	Retaining Screw
56	Ratchet Disc	101	Plug
57	Winding Adaptor		

280. Remove the two nuts (83) and spring washers. Remove top plate (62) if necessary tapping it with a rawhide mallet. Remove the two pawls (60) and springs (61).

281. Remove the hexagon screws (82) and spring washers. Lift off cover plate (63) and jointing (64).
282. Remove 'E' clip (75) and withdraw the winding shaft assembly. Place shaft assembly in special tool (No. ST148; PL900) and prise out plastic plug (101).
283. Remove retaining screw (100). Unscrew winding adaptor (57) and remove ratchet disc (56) and the two friction discs (55).
284. Remove thrust washer (53) and bevel pinion (54) from housing.

Carcase and Nosepiece Assembly

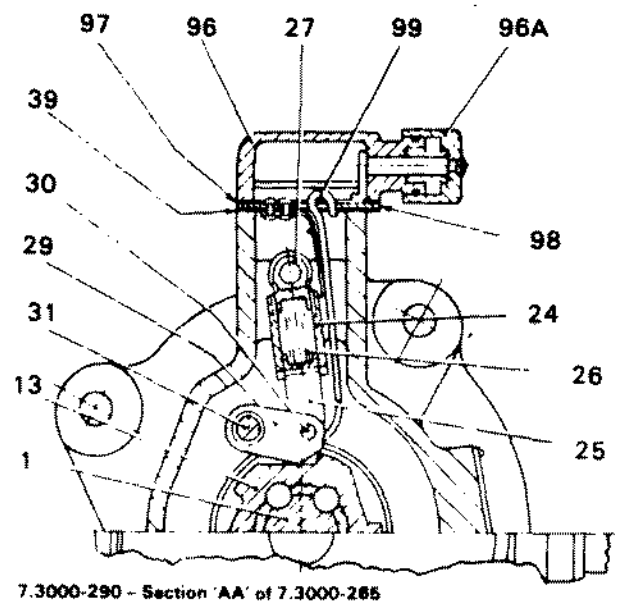
285. Use extended Allen key (Tool No. ST129) to remove the six socket cap screws (78) and shakeproof washers. Separate the carcase (42) from the nose piece assembly (18).
286. Press and release the reset button and remove four screws (82) and spring washers, catch housing (96) and jointing (97).
287. Ensure that hook (99) is freed from catchplate (98). Lift off catchplate assembly, being careful not to damage or bend the leaf spring beneath, and jointing (39).
288. Remove the trip lever stop screw (36 in 7.3000-288) and spring washer.
This illustration is section 'BB' of illustration 7.3000-265.



7.3000-288 – Section 'BB' of 7.3000-265

19	Bush	36	Stop Screw
27	Top Link	76	'O' Seal
33	Shaft	95	Return Spring
34	Trip Lever	102	Washer

289. Withdraw the trip lever shaft (33) complete with trip lever (34), return spring (95) and 'O' seal (76).
290. Use extractor (Tool No. ST136) to remove pawl pin (31 in 7.3000-290); a tapped hole (No. 8-32 UNC) is provided in the end of the pin for this. Lift out the spring loaded plunger assembly complete with hook (99) and main pawl (29).



7.3000-290 – Section 'AA' of 7.3000-265

1	Main Shaft	31	Pawl Pin
13	Ratchet Ring	39	Jointing
24	Spring Link Housing	96	Catch Housing
25	Plunger	96A	Reset Button
26	Spring	97	Jointing
27	Top Link	98	Catchplate
29	Pawl	99	Hook
30	Link Pin		

291. Separate the plunger (25) and the hook (99) from pawl (29) by pressing out the link pin (30) which is a press fit into the wide limb of the pawl.
292. Unscrew the top link (27) and withdraw link spring (26) and plunger (25).
293. Examine needle roller (22) in position. Only press it out from the nosepiece if it must be renewed.
294. Clean all parts for examination and renew any part which is excessively worn or damaged. When ordering spare parts, the starter type number should always be quoted.
295. Particular attention should be given to the two-start thread of the main shaft, the corresponding thread in the ball nut, and the end track of the main shaft. If the main shaft and ball nut are chipped or cracked or badly pitted, they should be replaced. If the spring sleeve ball seat insert is damaged or worn, it must be pressed out and replaced. All these components, including the ratchet ring and ball cage, should also be inspected visually for cracks.
296. The complete pack of twenty-four disc springs (5) should be replaced by new ones if:

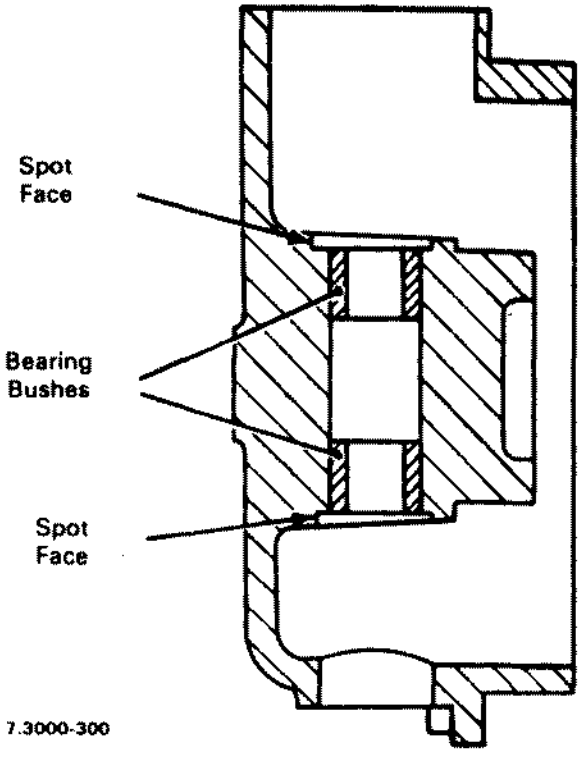
(a) Their surfaces are badly pitted due to atmospheric corrosion
(b) Any of the discs is cracked or broken
(c) The distance from the end of the spring sleeve (6) to the outer edge of the first spring exceeds 0.25" (6.35 mm).

297. If a new ball nut (3) or main shaft (1) have to be fitted, ensure that ball nut, main shaft, balls and ball cage, when assembled as a unit, function smoothly.

298. If a new ball nut is fitted, check that it slides freely in the slots of the spring sleeve.

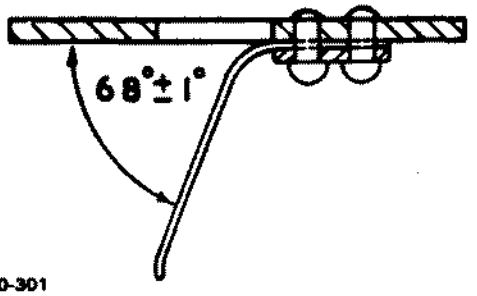
299. Similarly, if either a new ratchet ring (13) or main pinion (9) is fitted, when these components are assembled together with balls (71) on main shaft, check that the main pinion assembly functions smoothly along the whole length of the five start thread.

300. If the two new bearing bushes (46) have to be fitted in the end housing, use a fitting pin 0.5005 in. (12.713 mm) diameter, the winding shaft may be used carefully for this purpose. Press each new bush into the casting, level with its spot face. Check for free running fit of winding shaft.



7.3000-300

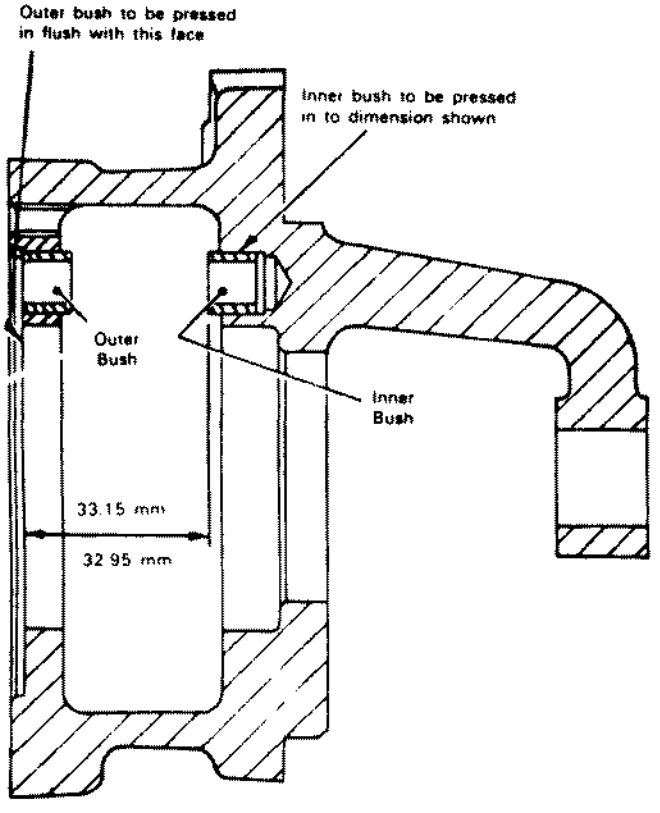
301. The included angle (68°) between the leaf spring and the catchplate should be checked. If this angle exceeds 70° a new catchplate assembly (98) must be fitted.



7.3000-301

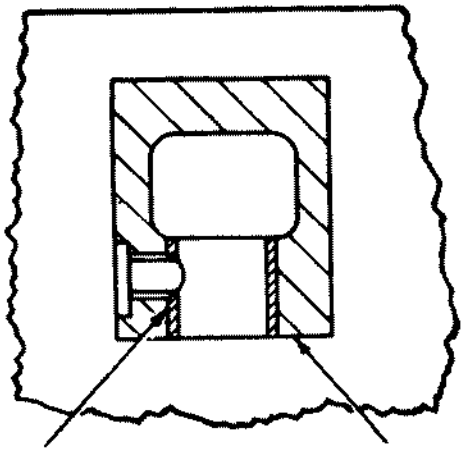
302. The hook (99) must be carefully examined for distortion and cracks inside the hooked end.

303. If two new bushes for pawl pin (31) have to be fitted into nosepiece, use a suitable fitting pin (to maintain alignment and dimension 33.15/32.95 mm) and press in bushes. Check that pawl pin is a free fit in bushes.



7.3000-303

304. Similarly, if a new bush has to be fitted for the trip lever shaft (33), use a suitable fitting pin and press in as shown in illustration 7.3000-304. Afterwards drill and tap (5/16" – 24 UNF – 2A) the bush through the stop screw hole. Remove any internal burrs from bush and check free running fit of trip lever shaft.



7.3000-304

305. The components of the spring starter are lubricated during assembly with grease as indicated in Table 1 (Page 26). The recommended greases are Mobilgrease No. 3 (graphited) and Rocol anti-scuffing paste (Molybdenum disulphide).

306. Lubricate all parts as instructed under 'LUBRICATION' with the exception of the winding bevel pinion teeth (54), the bevel gear of the spring sleeve (6) and the ball seat recess. These parts are lubricated at a later stage, after the gear mesh and the main shaft end float have been adjusted by shims.

307. Reassembling is in the reverse order of dismantling.

308. As a general guide to the tightening of screws and nuts with an adjustable torque spanner, the setting of the spanner is given in lb. ft. (kg. m.).

309. The recommended sealing compound to be used on jointings and face joints (where applicable) is Hylomar SQ32/M.

Carcase and Nosepiece Assembly

310. If a new needle roller bearing is required (22) press it into the nosepiece. The pressure should be applied to the flat end face of the needle bearing assembly.

311. Reassemble the parts of the spring link assembly i.e. plunger (25), spring(26), spring link (24) and top link (27). Preset the new trip link assembly, using the setting tool (No. ST147; PL900). The correctly set link should freely drop over the tool pins.

312. Connect the spring link assembly to the hook (99) and pawl (29) with link pin (30); the link pin is a press fit into the wide limb of the pawl. Assemble the free end of the main pawl sub-assembly into the nosepiece with the pawl pin (31).

313. Locate trip lever return spring (95) into nosepiece (18). Fit 'O' seal (76) in groove of trip lever shaft (33) and fit shaft through the return spring into the nosepiece. At the same time locate the plunger top link (27) on the offset pin of the shaft.

314. Fit stop screw (36) and spring washer (102) so that the screw locates in the slot of the lever shaft. Tighten the screw to 7-9 lbs. ft. (0.97-1.24 Kg. m.). Fit the hooked end of the return spring over the trip lever (34) and ensure that the spring returns the lever to the end of the slot.

NOTE: To adjust the position of trip lever (34) in shaft (33), slacken locknut (86) and turn the trip lever to the position required, then re-tighten locknut.

315. Apply sealing compound to both faces of jointings (39) and (97). Fit jointing (39), catchplate (98), jointing (97) and catch housing assembly (96). Hook (99) locates freely in the catchplate slot. Tighten the catch housing screws (82) to 2-3 lbs. ft. (0.27 0.41 kg. m.).

316. Check the reset trip mechanism as follows:-

(a) The hook should engage in the recess of the catchplate during the full movement of the trip lever and remain there when the trip lever is released.

(b) Pressing the reset button should disengage the hook from the catchplate.

(c) To check that the hook can engage over the button catch (Illustration 7.3000-290) press and hold reset button then manually press pawl upwards until hook engages. Release pressure on pawl and check that hook remains on button catch. Release button and ensure that the hook disengages from button catch and re-engages with the recess in catchplate.

317. Apply sealing compound to the mating faces of nosepiece and carcase, and connect the two parts (in the position marked when dismantling) with the screws (78) and shakeproof washer: tightening torque 7-9 lbs. ft. (0.97-1.24 kg. m.).

Main Shaft and Spring Core Assembly

318. Fit 'O' seal (69) in groove provided in ball seat insert (7).

319. Assemble the twelve pairs of disc springs (5) on spring sleeve (6). Position the painted indicator springs as follows, numbering them from the nosepiece end of the starter:

Spring discs Nos. 1, 2, & 3 (red) abut ball nut ring,
No. 4 (white)
Nos. 11 & 12 (green)

320. If new spring discs are to be fitted, the peripheries of six of them must first be painted with the colours above, so that they may serve as indicator springs.

321. Lubricate the ball tracks of the main shaft (1) with Mobilgrease No. 3 (graphited) to facilitate assembly of the ball cage (2). Slide the ball cage on the main shaft, fit the sixteen balls (70) into the ball cage holes and screw on ball nut (3). Ensure that both the ball nut and ball cage flange abut the main shaft collar. Locate the ball nut ring (4) over the four lugs of ball nut and slide assembly into spring sleeve (6) so that the nut

TABLE 1. LUBRICATION

MOBILGREASE No. 3. (GRAPHITED):-

SPRING CORE ASSEMBLY.

Main Shaft (1)	Roller bearing journal, 5-start screw thread, 2-start screw thread, 'O' seal shoulder and ball track on end of shaft.
Ball Cage (2)	All internal and external surfaces including holes for steel balls.
Ball Nut (3)	Internal 2-start screw thread and external surfaces.
Spring Sleeve (6)	Bevel gear teeth and all internal bores including ball seat track and bearing surface of bevel gear.
Main Pinion (9)	Internal bore and external surface up to gear teeth, including holes for steel balls.
Ratchet Ring (13)	All surfaces including grooves for steel balls.

NOSEPIECE ASSEMBLY

Needle Roller (22)	
Main Pawl (29)	All surfaces.
Link Pin (30)	All surfaces.
Pawl Pin (31)	All surfaces.
Spring Link Assembly (24, 25 & 26)	All surfaces.
Hook (99)	All surfaces.
Trip Lever Shaft (33)	Lever shank and eccentric pin.
Catchplate Assembly (98)	Leaf spring and recess for hook.
Catch Housing Assembly (96)	Button Catch.

END HOUSING ASSEMBLY

End Housing (45)	Bearing sleeve; winding shaft bushes and cavity between them; studs.
Winding Shaft (52)	All surfaces.
Bevel Pin (54)	All surfaces.
Friction Discs (55)	All surfaces.
Ratchet Disc (56)	All surfaces.
Ratchet Pawls (60)	All surfaces.
Ratchet Springs (61)	All surfaces.
Winding Adaptor (57)	Thread and end (friction) face.

Note. Before final assembly of end housing on carcase, fill the ball seat cavity with about ¼ oz. (21 gm.) of Mobilgrease No. 3 (graphited).

ROCOL ANTI-SCUFFING PASTE:-

SPRING CORE ASSEMBLY

Spring Sleeve (6)	Sleeve slots and outer surface.
Ball Nut Ring (4)	Bore.
Spring Discs (5)	The ground mating faces and bore.

END HOUSING ASSEMBLY

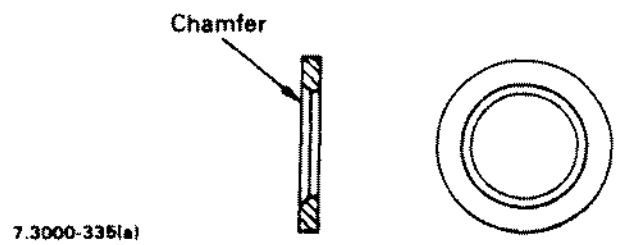
Top Plate (62)	Bore and 'O' seal grooves.
Winding Adaptor (57)	Bearing surface, i.e., the surface which is in contact with the top plate on assembly. It is important that paste must not be allowed on to friction face.

lugs engage the longitudinal slots of sleeve.
322. Slide spacing tool (No. ST121; PL900) on to pinion end of main shaft.
323. Place the whole assembly in press (No. ST138) with bevel gear uppermost. Locate the press tool (No. ST122) in the recess in the spring sleeve and depress the spring sleeve (and springs) about $\frac{1}{4}$ in. (9.5 mm). Distribute the ten steel balls (70) evenly around the main shaft in the undercut portion between the end track and 'O' seal collar. Slowly release the press, ensuring that no steel balls are trapped between the shaft head and edge of ball seat (7). Release the pressure and check that all ten balls are situated between the track in the ball seat and shaft. Remove assembly from press.
324. Assemble the main pinion circlip (74) and ratchet ring (13) on main shaft (1). Assemble spring retainer (10), return spring (11) and spacing ring (12) on main pinion (9). Slide the assembly into position on the main shaft (1) so that the five 7 mm dia. steel balls (71) may be inserted in the five-start thread. Slide ratchet ring over steel balls and fit circlip (74), taking care not to overstretch it. Check that the pinion assembly moves freely up and down the five-start thread.

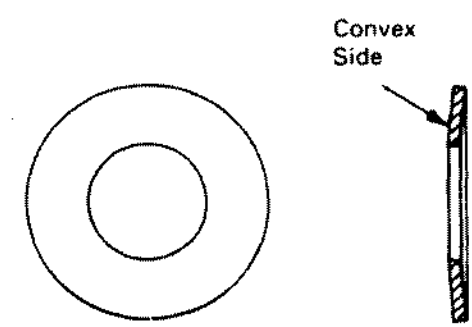
End Housing Assembly
325. Insert winding shaft (52) into new assembly tool (No. ST148; PL900). Assemble (lubricated) friction disc (55), ratchet disc (56), friction disc (55) and winding adaptor (57) in that order, on to shaft. The ratchet-disc rotates clockwise; make sure that its teeth face in the correct direction (see Illustration 7.3000-265). Fit adaptor retaining screw (100) and tighten to 7-9 lbs. ft. (0.97-1.24 kg. m.). Check that, with the winding adaptor turned back against the head of the retaining screw (100), the ratchet disc (56) is free to rotate. Apply sealing compound to flange of plastic plug (101) and press into adaptor.
326. Locate thrust washer (53) in housing seat. Slide the winding shaft assembly into the housing. Fit bevel pinion (54) on to the shaft hexagon and fit retaining 'E' clip (75). Check that winding shaft rotates freely.

Bevel Gear Mesh Adjustment
327. Support the end housing, with its register uppermost, on a bench. A block of wood, shaped to suit the bevelled outer face of the end housing will provide a firm base.
328. Place the thickest shim (66) on the end housing hub, and fit the spring core assembly on to the hub.
329. Rotate the spring core assembly and check that the bevel gears run freely.
330. The shims (66) are supplied in 0.005 in. (0.127 mm) increments from 0.005 in. (0.127 mm) to 0.020 in. (0.508 mm). Add or remove shims until the bevel gears are in full mesh and will just run freely without roughness.
331. The final backlash of the gears should be from 0.10 mm to 0.20 mm. When the correct shim shickness has been determined, keep it with the end housing for final assembly.
332. Fit the two ratchet pawls (60) and springs (61) on to studs (47). Turn the winding adaptor (57) clockwise and check that the ratchet assembly functions correctly.
333. Fit the two 'O' seals (77) into the grooves in the top plate (62). Apply sealing compound to the joint face of the top plate. Fit top plate over winding adaptor and studs (contour of plate matching that of end housing) and secure with nuts (83) and spring washers; tightening torque 5-7 lbs. ft. (0.69-0.97 kg. m.).
334. Apply sealing compound to jointing (64) and cover plate (63). Fit cover plate to end housing with screws (82) and washers; tightening torque 2-3 lbs. ft. (0.27-0.41 kg. m.).

Final Assembly
335. Place the main shaft and spring core assembly vertically on the bench with the nose journal uppermost. Place the thinnest thrust washer (14) and nosepiece disc spring (15) on the end of the mainshaft (1). Ensure that the chamfered side of the thrust washer (Illustration 7.3000-335 (a)) abuts the shoulder of the shaft and that the convex side of disc spring (Illustration 7.3000-335 (b)) abuts the thrust washer.



7.3000-335(a)



7.3000-335(b)

336. Operate the trip lever fully to engage the hook (99) into the catch plate (98) recess. Lower the carcase and nosepiece assembly over the main shaft assembly allowing the shaft journal to enter needle roller in nose. Place one hand under bevel gear and turn the whole assembly through 180° so that the nosepiece rests on bench or on special stand.

337. Fit end housing shim (66) which was selected as detailed in Bevel Gear Mesh Adjustment, into the spring sleeve (6). Place the thickest carcase shim (87) on end housing spigot and assemble end housing on to carcase, engaging bevel pinion (54) with bevel gear. Secure with two cap screws (67) and then slowly rotate the winding adaptor (57), pushing it inwards to seat thrust washer (53) firmly into its seating.

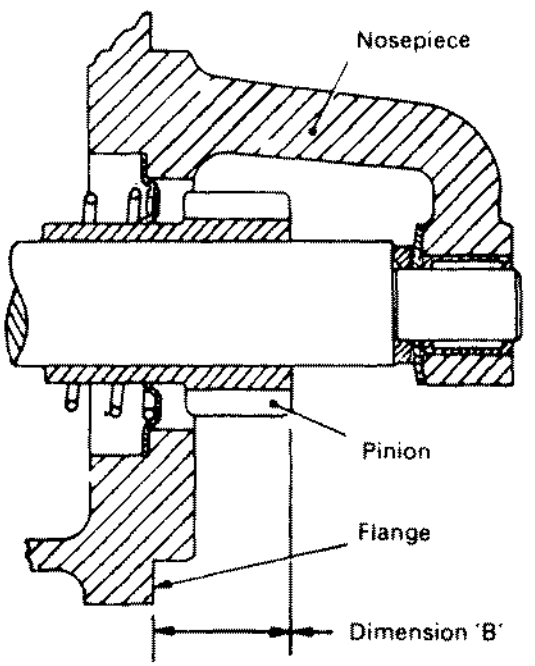
338. Using a dial gauge, measure the shaft end float by lifting the main pinion by its teeth. Tool NO. ST140 (PL900) comprises the dial gauge fixture which bolts to the starter nosepiece, plus a forked lever for lifting the main pinion. Do not exert sufficient force to compress the nose disc spring or an excessive end float figure will be obtained. The pinion face to mounting flange dimension should also be checked at this time.

339. Invert the assembly and place nosepiece on bench or special stand (No. ST120; PL900). Remove end housing and change the carcase shim (87) and thrust washer (14) to obtain the correct pinion face to mounting flange dimension and main shaft end float (0.05-0.21 mm).

340. The dimension 'B' (pinion face to mounting flange) varies for the different types of spring starter.

341. With the thinnest thrust washer (14) and thickest carcase shim (87) the end float is a maximum. A thinner carcase shim will give a larger pinion face to mounting flange dimension but will decrease the end float. The carcase shims are in two sizes 0.5 mm and 1.00 mm thick and the thrust washers vary from 2.4 mm to 3.4 mm in 0.2 mm stages.

342. Fill ball seat cavity with lubricant to the level of the head of the main shaft; see note under 'END HOUSING ASSEMBLY', in table 1. Lubricate also the bevel pinion, bevel gear and bevel gear recess.



7.3000-340

Starter Type No.	'B' Dims. mm.	Normal Assy. Code
SS 10/1	24-25	B3
SS 11/1	20-21	A7
SS 12/1	47-48	B3
SS 13/1	28-29	A1
SS 14/1	26-27	A1
SS 15/1	26-27	F7
SS 16/1	28-29	E5
SS 17/1	47-48	A1
SS 18/1	20-21	B3
SS 19/1	25-26	D5

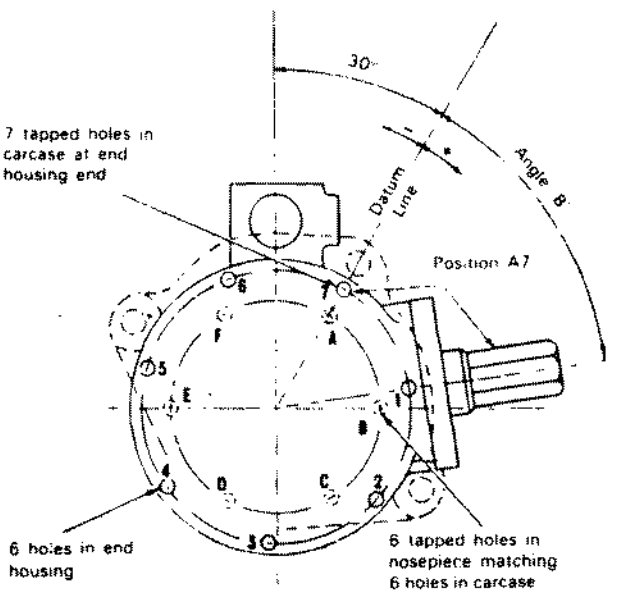
Starter Type No.	'B' Dims. mm.	Normal Assy. Code
SS 20/1	25-26	E5
SS 21/1		
SS 22/1	28-29	A1
SS 23/1	28-29	C3
SS 24/1	47-48	E6
SS 25/1	28-29	B2
SS 26/1	47-48	B3

343. Apply sealing compound to the joint faces of the carcase and end housing, and to both sides of shim (84) if one is to be used. Assemble the housing to the carcase (in the position marked with dismantling) with 6 socket cap screws (67) and spring washers; tightening torque 7-9 lbs. ft. (0.97-1.24 kg. m.).

Starter Assembly Coding

344. The relative angular position between the trip lever and the winding shaft can be varied by equal increments to suit the installation requirements for each starter. An assembly code has been introduced to denote these positions and each starter is normally assembled to a particular code number when manufactured.

345. The illustration and the position code tables show the range of winding shaft positions available. Angle 'B' is measured from a datum line 30° from the trip lever position. This datum coincides with the centre hole of the mounting flange (shown dotted) of the SS . . . /1 Type starter.



7.3000-345

Angle 'B'	Position Code
0	A1
+ 8 4/7°	B2
+17 1/7°	C3
+25 5/7°	D4
+34 2/7°	E5
+42 6/7°	F6
+51 3/7°	A7
+60°	B1
+68 4/7°	C2
+77 1/7°	D3
+85 5/7°	E4
+94 2/7°	F5

Angle 'B'	Position Code
– 8 4/7°	F7
–17 1/7°	E6
–25 5/7°	D5
–34 2/7°	C4
–42 6/7°	B3
–51 3/7°	A2
–60°	F1
–68 4/7°	E7
–77 1/7°	D6
–85 5/7°	C5
–94 2/7°	B4

346. The carcase has 6 holes for the nosepiece screws and 7 tapped holes in the tail end. Two of the carcase holes are in line and are identified by marks 'O' stamped on the outside of the carcase. The starter position codes indicate the holes in the end assemblies which are in line. In Illustration 7.3000-345 nosepiece hole 'A' and end housing hole '7' mate with carcase hole 0-0. The starter Type becomes SS____/1A7.

Delco Remy MT Starters (Description)

347. Delco Remy heavy duty starting motors have a shift lever and solenoid plunger that are totally enclosed to protect them from exposure to dirt, icy conditions and splashing. The nose housing can be rotated to obtain a number of different solenoid positions with respect to the mounting flange.

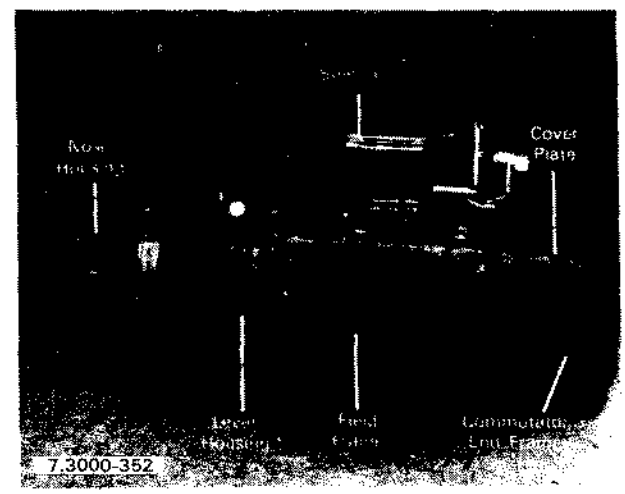
348. Positive lubrication is provided to the bronze bushings by an oil saturated wick that projects through the bushings and contacts the armature shaft. Oil can be added to each wick by removing a pipe plug which is accessible on the outside of the motor. Roller bearings in the lever housing on some models contain a supply of lubricant which will last between engine overhaul periods.

349. Some motors have an oil reservoir for the bronze bearings which makes a larger oil supply available, thereby extending the time required between lubrication periods. Also on some motors, 'O' rings are added to resist entry of dirt and moisture into the assembly. When the oil reservoir and 'O' rings are included in the build the motor is classified as 'long life', which provides long periods of attention free operation.

350. A rubber boot or linkage seal is situated over the solenoid plunger.

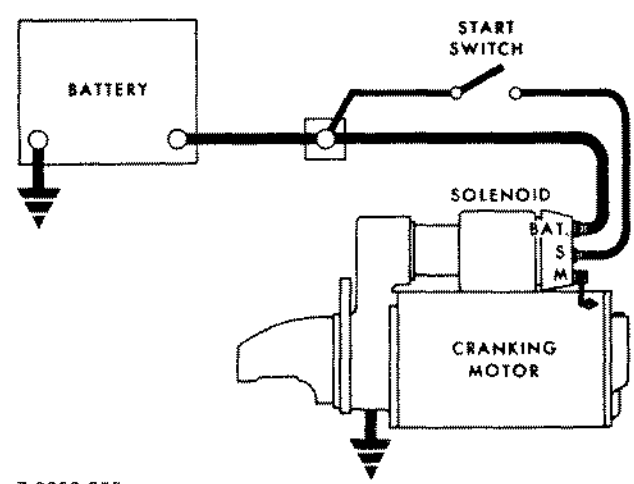
351. A heavy duty sprag type clutch is used which is moved into mesh with the ring gear by the action of the solenoid. The pinion remains engaged until starting is assured and the solenoid circuit is interrupted. In case of a butt engagement with the clutch, the motor will not be energised to prevent damage to the pinion and the gear teeth.

352. The adjustable nose housing is attached by six bolts to the lever housing. To relocate the housing, it is only necessary to remove the bolts, rotate the housing to the desired position, and re-install the bolts, tightening them to a torque of 13-17 lbs. ft. The lever housing and the commutator frame are attached to the field frame independently by bolts entering threaded holes in the field frame.



Operation

353. In the basic circuit shown below the solenoid windings are energised when the switch is closed. The resulting plunger and shift lever movement causes the pinion to engage the engine flywheel ring gear and the solenoid main contacts to close, and cranking takes place. When the engine starts, pinion over-run protects the armature from excessive speed until the switch is opened at which time the return spring causes the pinion to disengage. To prevent excessive over-run and damage to the drive and armature windings, the switch must be opened immediately when the engine starts.

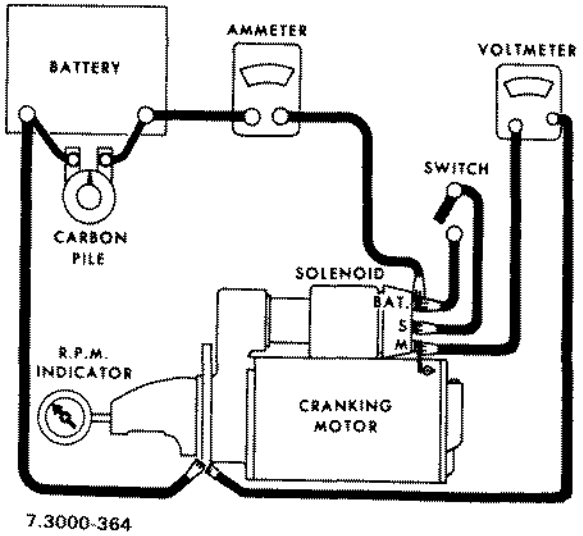


7.3000-353

354. Before removing any unit in the cranking circuit for repair, the tests listed in paragraphs 355 to 358 inclusive, should be carried out.
355. Check the condition of the battery and ensure that it is fully charged.
356. Inspect all wiring for damage. Inspect all connections to the cranking motor, solenoid, magnetic switch, ignition switch or any other control switch and battery, including all ground connections. Clean and tighten connections as required.
357. Inspect all switches, magnetic solenoid and control, to determine their condition. Connect a jumper lead around any switch suspected of being defective. If the system functions properly using this method, repair or replace the by-passed switch.
358. If the battery, wiring and switches are in a satisfactory condition and the engine is known to be functioning properly the motor should be removed and tested.

Delco Remy MT Starters (Removal)
359. Disconnect the battery cables.
360. Disconnect the two leads to the ignition switch.
361. Remove the three retaining bolts and washers and remove the starter from the flywheel housing.

Cranking Motor Tests
362. Regardless of the construction, never operate the cranking motor for more than 30 seconds, without pausing to allow it to cool for two minutes. On some applications 30 seconds may be excessive. Overheating, caused by excessive cranking will seriously damage the motor.
363. With the motor removed from the engine, the armature should be checked for freedom of rotation by prying the pinion with a screwdriver. Tight bearings, a bent armature shaft or a loose pole shoe screw will cause the armature to not turn freely. If the armature does not turn freely, the motor should be disassembled immediately. However, if the armature does rotate freely, the motor should be given a no load test before disassembly as described below.



7.3000-364

364. Connect a voltmeter from the motor terminal to the motor frame, and use an RPM indicator to measure the armature speed. Connect the motor and an armature in series with a fully charged battery of the specified voltage, and a switch in the open position from the solenoid battery terminal to the solenoid switch terminal.
365. Close the switch and compare the rpm current, and voltage reading with the specifications tabulated below.

NO LOAD TEST

Part No.	Volts	Min. Amps	Max. Amps	Min. rpm	Max. rpm
1113202	9·0	50*	70*	3500	5500
1113637	11·6	85*	125*	5900	8100
1114084	11·5	90*	130*	5600	7600

* includes solenoid

366. It is not necessary to obtain the exact voltage specified, as an accurate interpretation can be made by recognising that if the voltage is slightly higher the rpm will be proportionately higher, with the current remaining essentially unchanged.
367. If the exact voltage is required, a carbon pile connected across the battery, see illustration 7.3000-364, can be used to reduce the voltage to the specified value. If the specified current does not include the solenoid, deduct from the ammeter reading the specified current draw of the solenoid hold in winding. Make disconnections only with the switch open.
368. Interpret the test results from paragraphs 369-374 inclusive.
369. Rated current draw and no load speed indicates normal condition of the cranking motor.
370. Low free speed and high current draw indicate:
(a) Too much friction – tight, dirty or worn bearings, bent armature shaft or loose pole shoes allowing armature to drag.
(b) Shorted armature – this can be further checked on a growler after disassembly.
(c) Grounded armature or fields – check further after disassembly.
371. Failure to operate with high current draw indicates: (a) A direct ground in the terminal or fields.
(b) 'Frozen' bearings (this should have been determined by turning the armature by hand).
372. Failure to operate with no current draw indicates:
(a) Open field circuit. This can be checked after disassembly by inspecting internal connections and tracing circuit with a test lamp.
(b) Open armature coils. Inspect the commutator for badly burned bars after disassembly.

(c) Broken brush springs, worn brushes, high insulation between the commutator bars or other causes which would prevent good contact between the brushes and commutator.

373. Low no load speed and low current draw indicates: (a) High internal resistance due to poor connections, defective leads, dirty commutator and causes listed under paragraph 372.

374. High free speed and high current draw indicates shorted fields. If shorted fields are suspected, replace the field coil assembly and check for improved performance.

Delco Remy MT Starters (Inspection and Overhaul)

375. Normally the cranking motor should be disassembled only so far as is necessary to make the repair or the replacement of the defective parts. As a precaution, it is suggested that safety glasses be worn when disassembling or assembling the cranking motor.

376. Note the relative position of the solenoid, lever housing and nose housing so that the motor can be reassembled in the same manner.

377. Disconnect field coil connector from solenoid motor terminal, and lead from solenoid ground terminal.

378. On motors which have brush inspection plates, remove the plates and then the brush lead screws. This will disconnect the field leads from the brush holders.

379. Remove the attaching bolts and separate the commutator end frame from the field frame.

380. Separate the nose housing and field frame from the lever housing by removing attaching bolts.

381. Remove armature and clutch assembly from the lever housing.

382. Separate the solenoid from the lever housing by pulling apart.

383. All parts except the drive should be cleaned with mineral spirits and a brush. The drive can be wiped with a clean cloth. The drive, armature and fields should not be cleaned in any degreasing tank, or with grease dissolving solvents, since these would dissolve the lubricant in the drive and damage the insulation in the armature and field coils.

384. If the commutator is dirty it may be cleaned with No. 00 sandpaper. NEVER USE EMERY CLOTH TO CLEAN COMMUTATOR.

Brushes and Holders

385. Inspect the brushes for wear. If they are worn excessively when compared with a new brush, they should be replaced.

386. Ensure the brush holders are clean and the brushes are not binding in the holders. The full brush surface should ride on the commutator to give proper performance.

387. Check by hand to ensure that the brush springs are giving firm contact between the brushes and commutator. If the springs are distorted or discoloured they should be replaced.

Armature

388. If the armature commutator is worn, dirty, out of round or has high insulation, the armature should be put in a lathe so the commutator can be turned down. The insulation should then be undercut (see note) 1/32 of an inch deep and 1/32 of an inch wide, and the slots cleaned out to remove any trace of dirt or copper dust. Finally the commutator should be sanded with No.00 sandpaper to remove any burrs left as a result of the undercutting procedure.

NOTE: The undercut operation must be omitted on part numbers 1113202 and 1113637.

389. The armature should be checked for opens, short circuits and grounds.

390. Opens are normally caused by excessively long cranking periods. The most likely place for an open to occur is at the commutator riser bars. Inspect the points where the conductors are joined to the commutator bars for loose connections. Poor connections cause arcing and burning of the commutator bars as the cranking motor is used. If the bars are not too badly burned, repair can often be effected by resoldering or welding the leads in the riser bars (using rosin flux) and turning down the commutator in a lathe to remove the burned material. The insulation should then be undercut except where noted above.

391. Short circuits in the armature are located by use of a growler. When the armature is revolved in the growler with a steel strip such as a hacksaw blade held above it, the blade will vibrate above the area of the armature core in which the short circuit is located. Shorts between bars are sometimes produced by brush dust or copper between the bars. These shorts can be eliminated by cleaning out the slots.

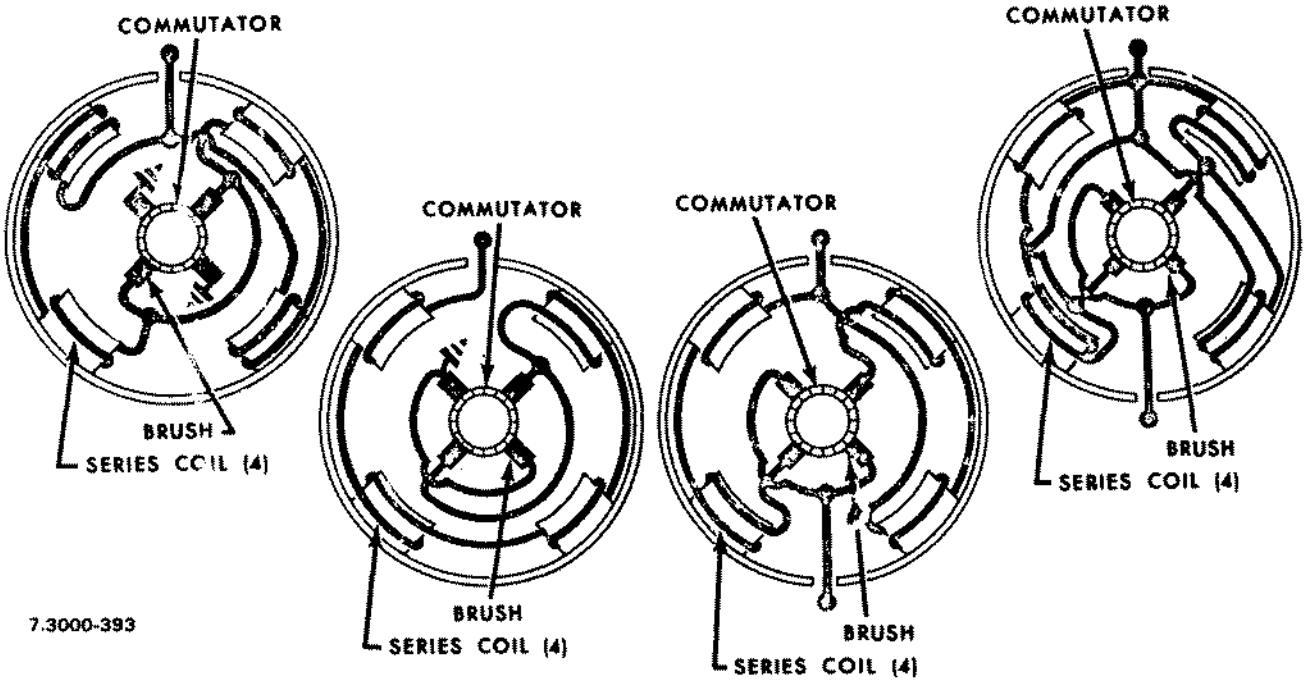
392. Grounds in the armature can be detected by the use of a 110 volt test lamp and test points. If the lamp lights when one test point is placed on the commutator with the other point on the core or shaft, the armature is grounded. Grounds occur as a result of insulation failure which is often brought about by overheating of the cranking motor produced by excessively long cranking periods or by accumulation of brush dust between the commutator bars and the steel commutator ring.

Field Coil

393. The various types or circuits used are shown in the wiring diagram below. The field coils can be checked for grounds and opens by using a test lamp.

394. Grounds: If the motor has one or more coils normally connected to ground, the ground connections must be disconnected during this check. Connect one lead of the 110 volts test lamp to the field frame and the other lead to the field connector. If the lamp lights, at least one field coil is grounded which must be repaired or replaced. This check cannot be made if the ground connection cannot be disconnected.

395. Opens: Connect test lamp leads to ends of field coils. If lamp does not light, the field coils are open.

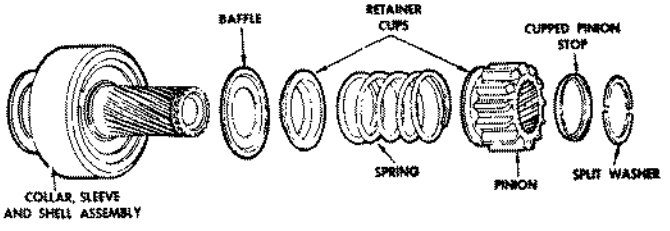


7.3000-393

396. Field coils can be removed from the field frame assembly by using a pole shoe screwdriver. A pole shoe spreader should also be used to prevent distortion of the field frame. Careful installation of the field coils is necessary to prevent shorting or grounding of the field coils as the pole shoes are tightened into place. Where a pole shoe has a long lip on one side and a short lip on the other, the long lip should be assembled in the direction of armature rotation so it becomes the trailing (not leading) edge of the pole shoe.

Clutch

397. Disassembly procedure for the heavy duty sprag clutch, illustrated below, is outlined in the following paragraphs.

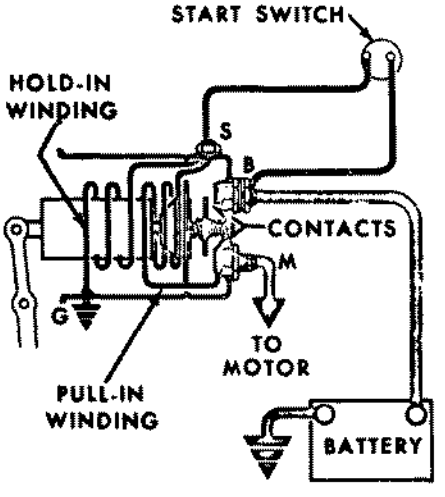


7.3000-397

398. Remove the cupped pinion stop and split washer. In removing the cupped pinion stop, it will probably be damaged, a new one being necessary on reassembly.
399. Remove remaining parts as illustration.
400. Do not lubricate the sprags, as they are lubricated for life with special oil at the factory.
401 Assemble in reverse of disassembly.

Solenoid

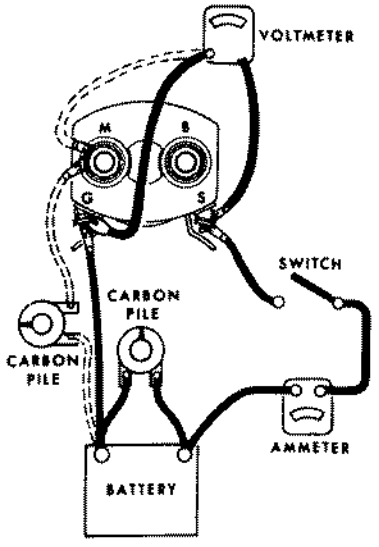
402. A basic solenoid circuit is shown below.



7.3000-402

403. Solenoids may differ in appearance, but can be checked electrically by connecting a battery of the specified voltage, a switch, and an ammeter to the two solenoid windings. With all leads disconnected from the solenoid, make test connections as shown to the solenoid switch (S or SW) terminal and to ground, or to the second switch terminal (G), if present, to check the hold in winding.

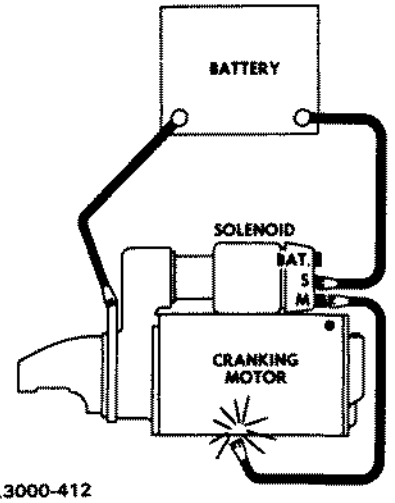
Switch Model	Rated Voltage	Current Consumption			
		Both Windings		Hold-in Windings	
		Amps	Volts	Amps	Volts
1115510	12	26-29	5	18-20	10
1119885	12	70.4-77.8	10	18-20	10
1119879	12	65.3-73.3	10	12.7-14.3	10



7.3000-403

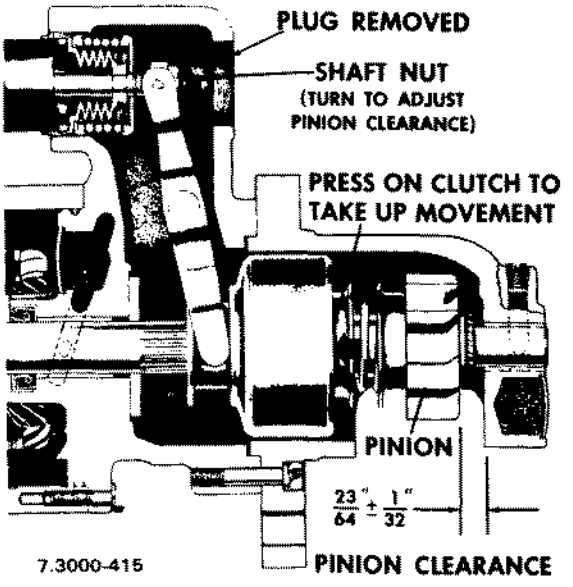
404. Use the carbon pile to decrease the voltage of the battery to the value tabulated above and compare the ammeter reading with the specifications.
405. A high reading indicates a shorted or grounded hold in winding, and a low reading, excessive resistance. To check the pull-in winding connect from the solenoid switch terminal (S) to the solenoid motor (M or MOT) terminal.
406. If needed to reduce the voltage to the specified value, connect the carbon pile between the battery and the 'M' terminal as shown in dotted lines instead of across the battery as shown in solid lines. If the carbon pile is not needed, connect a jumper directly from the battery to the 'M' terminal as shown by the dotted line.
CAUTION: To prevent overheating, do not leave the pull-in winding energised more than 15 seconds. The current draw will decrease as the winding temperature increases.
407. A magnetic switch can be checked in the same way by connecting across its windings.
408. The reassembly procedure is the reverse of disassembly.

409. All wicks and oil reservoirs should be saturated with SAE10 oil, and the splines underneath the clutch should be lubricated with a light coat of SAE 10 oil (Heavier oil may cause failure to mesh at low temperatures). Lever housings having a bearing and seal should have the grease cavity between the bearing and seal filled with Delco Remy No. 1960954.
410. Pinion clearance should be checked after reassembly to ensure it is within specification, this is shown in the following paragraphs.
411. Disconnect the motor field coil connector from the solenoid motor terminal.
412. Connect a battery of the same voltage as the solenoid, from the solenoid switch terminal to the solenoid frame or ground terminal.



7.3000-412

413. MOMENTARILY flash a jumper lead from the solenoid motor terminal to the solenoid frame or ground terminal. The drive will now shift into cranking position and remain so until the battery is disconnected.
414. Push the pinion or drive back towards the commutator end to eliminate slack movement.
415. Measure the distance between the drive and drive stop.

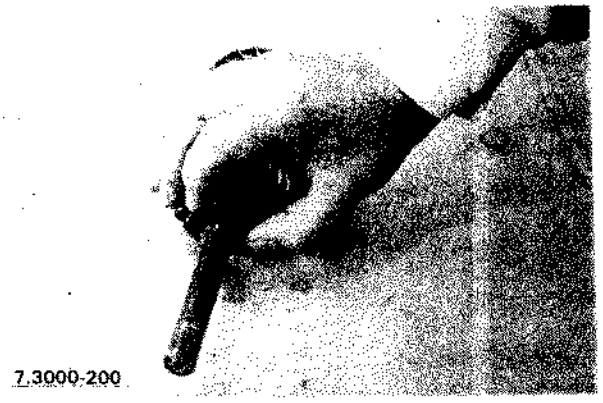


416. Adjust the clearance by removing the plug and turning the shaft nut.

Delco Remy MT Starters (Refitting)

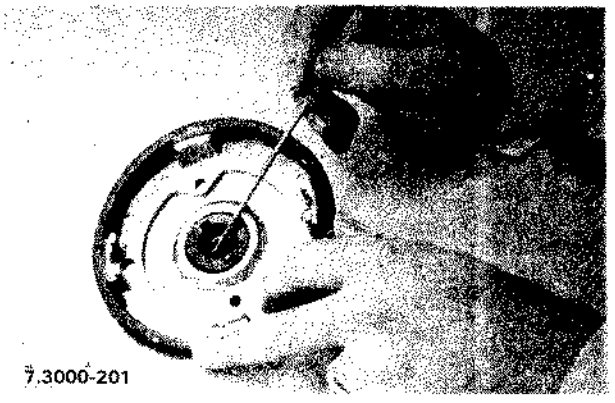
417. Place the motor in position against the flywheel housing and replace the three retaining bolts and washers.
418. Connect the two leads to the ignition switch.
419. Connect the battery cables.

200. Take care not to lose any shims which may be assembled to the armature shaft between the intermediate bracket and armature core.



7.3000-200

201. The brake shoes and springs (5) can be eased out of the commutator end cover with a small screwdriver, care must be taken not to damage the fibre and steel thrust washers (3 and 4) which are situated behind the brake shoes.



7.3000-201

202. After dismantling the motor each individual item must be examined for wear.

Replacement of Brushes

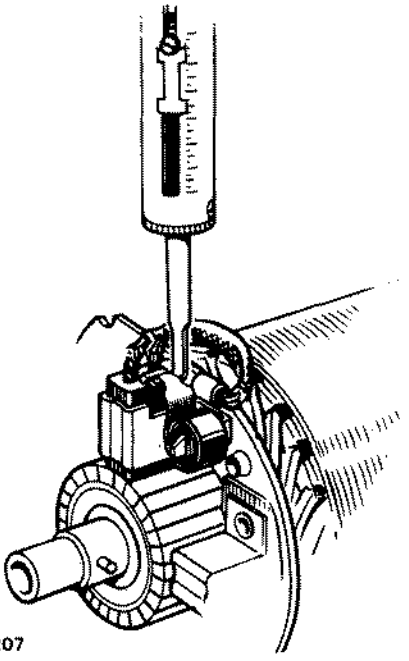
203. The two earth brush flexible connectors are soldered to terminal plates secured by brush box rivets and the two insulated brush flexible connections are hot pressed to free ends of the field coils. Unsolder the earth brush flexibles and solder the connectors of the new brush set in their place.

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

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

206. Check that the new brushes move freely in their boxes.

207. Brush spring tension should be checked with complete brush gear assembled to commutator. Hold assembly firmly centralized whilst checking each spring in turn. Tension should be 42 oz. minimum, with a new brush.



7.3000-207

Commutator

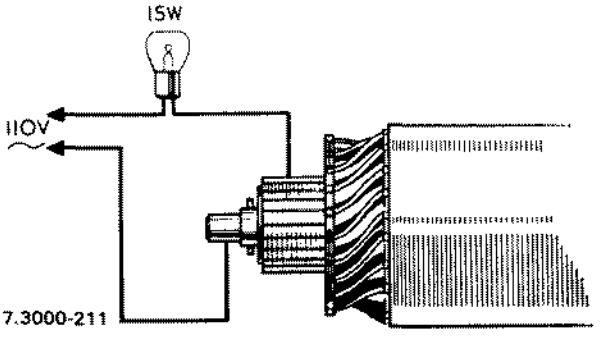
208. A Commutator in good condition will be burnished and free from pits or burned spots. Clean the commutator with a petrol moistened cloth. If the commutator is badly worn, mount the armature between centres in a lathe, rotate at high speed and take a light cut with a very sharp tool. Do not remove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

Armature

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

210. Fouling of the armature core against the pole faces indicates worn bearings or a distorted shaft. A damaged armature must in all cases be replaced and no attempt should be made to machine the armature core or to straighten a distorted armature shaft.

211. To check the insulation of the armature windings use a 110 volt AC 15 watt test lamp.



7.3000-211

212. Before testing, remove all traces of brush dust with a dry air blast.
213. The test lamp must not light when connected between the commutator segment and the armature shaft.
214. If a short circuit in the windings is suspected check the armature on a 'growler'.
215. If the armature failure cannot be remedied, a replacement must be fitted.

Field Coils

216. Ensure that both brushes are clear of the yoke and connect a 110 volt AC test lamp between the field coil eyelet and a clean part of the yoke.
217. If the test lamp lights it indicates that the field coils are earthed to the yoke and must be replaced.
218. Using the same equipment check also the insulated pair of brush boxes on the commutator end bracket. Clean off all traces of brush deposit before testing. Connect the test lamp between each insulated brush box and the bracket.
219. If the test lamp lights this indicates faulty insulation and the end bracket must be replaced.
220. To replace the field coils, remove the nuts, washers and insulation pieces to free the yoke mounted terminal stud.
221. Unscrew the four pole shoe retaining screws, using a wheel operated screwdriver. Remove the insulation piece which is fitted to prevent the intercoil connectors from contacting with the yoke.
222. Draw the pole shoes and coils out of the yoke and lift off the coils. Fit the new field coils over the pole shoes and place them in position inside the yoke. Ensure that the taping of the field coils is not trapped between the mating surfaces of the pole shoes and the yoke. Locate the pole shoes and field coils by lightly tightening the retaining screws.
223. Replace the insulation piece between the field coil connections and the yoke. Tighten the screws by means of the wheel-operated screwdriver while the pole pieces are held in position by a pole shoe expander or a mandrel of suitable size. Finally, remake the soldered connections as before.

Bearing Replacement

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

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

225. The bushes in the intermediate and drive-end brackets can be pressed out, while that in the commutator end bracket is best removed by inserting a 9/16″ tap squarely into the bearing and withdrawing the bush with the tap. Before fitting a new porous bronze bearing bush, immerse it for 24 hours in clean engine oil.
226. Press each new bush into position with a shouldered, highly polished fitting pin of the correct diameter, namely:

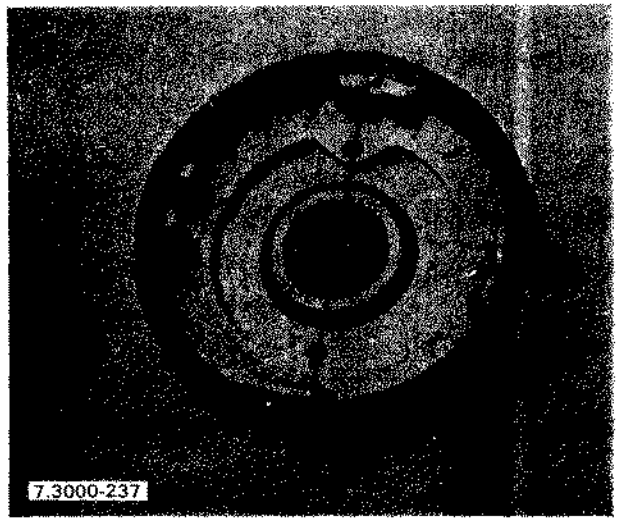
for Commutator end bracket bush: 0.5005″
for Intermediate bracket bush: 1.123″
for Drive End bracket bush: 0.6705″

227. POROUS BRONZE BUSHES MUST NOT BE REAMED OUT AFTER FITTING or the porosity of the bush will be impaired.

Checking the Roller Clutch Drive Assembly

228. A roller clutch drive assembly in good condition will: (a) Provide instantaneous take-up of the drive in the one direction.
(b) Rotate easily and smoothly in the other.
(c) Be free to move round or along the shaft splines without roughness or tendency to bind.
229. Should the assembly not meet any of these requirements a replacement unit must be fitted.
230. All moving parts should be smeared liberally with Rocol 'Molydest' grease, starting motor grade, or an equivalent alternative.
231. After cleaning all parts, reassembly of the starter motor is the reversal of the dismantling procedure but the following special points should be noted:
232. The thrust shims must be refitted between the intermediate bracket and the armature. These shims are provided to limit the end float to 0.005″ – 0.020″. It is important that after re-assembly the end float be checked and if necessary a further shim added.
233. When installing brake shoes in the commutator end cover, place the fibre washer in the bore first followed by the steel washer and finally the brake shoes.
234. Before installing the end bracket or cover, the brake shoes and the cross peg in the armature must be in the correct relative location so that the peg engages the slots in the shoes.
235. After assembling the brush gear to the commutator, locate the through bolts in the shaft holes of the brush gear plate and temporarily screw the bolts a few threads into the drive end bracket to locate the brush gear plate in the correct assembled position.
236. Position the armature so that the brake shoe cross peg is in line with the two threaded holes in the brush gear plate. Remove the through bolts without disturbing the position of the plate.

237. Locate the brake shoes in the commutator end cover so that the cross peg slots are in line with the two smallest of the four holes in the cover. This will correspond with the relative position of the cross peg in the armature shaft.



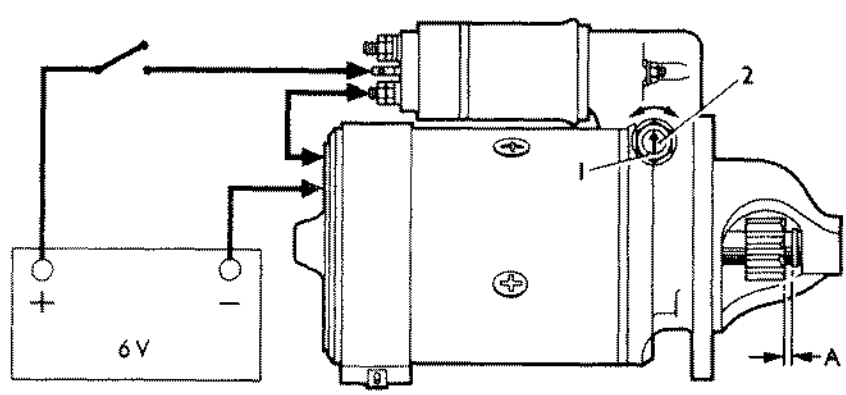
238. With a new sealing ring in position, install the comutator end cover, and screw in the through bolts followed by the brush gear plate screws.
239. The following parts should be tightened to the maximum torques indicated:

Nuts on solenoid terminals:	24 lb in (0.28 kg m)
Solenoid fixing nuts:	4.5 lb ft (0.62 kg m)
Starter motor through bolts ($\frac{1}{4}$" diameter):	8.0 lb ft (1.1 kg m)
Starter motor through bolts (5/16" diameter):	10.0 lb ft (1.38 kg m)

240. After reassembling the starter, pinion movement must be adjusted as follows:
241. Connect the positive terminal of a 6 volt battery through a switch to the blade terminal on the solenoid, and the battery negative terminal to the starter yoke. A 6 volt supply is used as a safety measure to avoid rapid axial movement of the pinion.
242. Close the switch (this throws the drive assembly forward into engaged position) and measure dimension 'A' between pinion and thrust collar on the armature shaft extension. To ensure accuracy when taking this measurement press pinion lightly towards armature, so taking up any slack in engagement linkage. For correct setting this distance should be 0.015" – 0.025".
243. Should dimension 'A' not be within specified limits, slacken locknut (1) and turn eccentric pivot pin (2) until correct setting is obtained. Arc of adjustment is 180° and pivot pin must be set so that arrow head on pin is adjacent to arrows marked on drive end bracket. After setting, tighten the securing nut to retain the pin in position and recheck the setting.
244. Seal the pivot pin and nut with gold size applied to the pivot pin threads.

Lucas M50G Starters (Refitting)
245. Place the unit against the flywheel housing and replace the three retaining bolts and washers.
246. Reconnect the terminal and battery leads to the starter.

Simms Spring Starter Type SS/1 (Description)
247. The Simms Spring Starter Type SS/1 provides a means of hand-starting diesel engines up to 1 litre cylinder capacity, and eliminates the normal electric starting system.
248. The spring starter is particularly suitable for diesel engines operating in tropical conditions and damp climates, where electrical equipment deteriorates quickly.
249. The basic principle of operation is in the application of energy stored in a compressed spring to turn the engine sufficiently quickly for starting.
250. The heart of the starter is in the spring pack which is comprised of dished spring steel washers stacked in pairs on a common sleeve.
251. The springs are compressed between the flange on the slotted spring sleeve and the four ears of the internally threaded ball nut which travels up and down inside the slotted sleeve. Both nut and sleeve which can only rotate as a pair, are carried on the ball threaded



7.3000-242

mainshaft that is screwed into the nut and locked into the spring sleeve whilst the springs are under a small pre-compression during the assembly process.

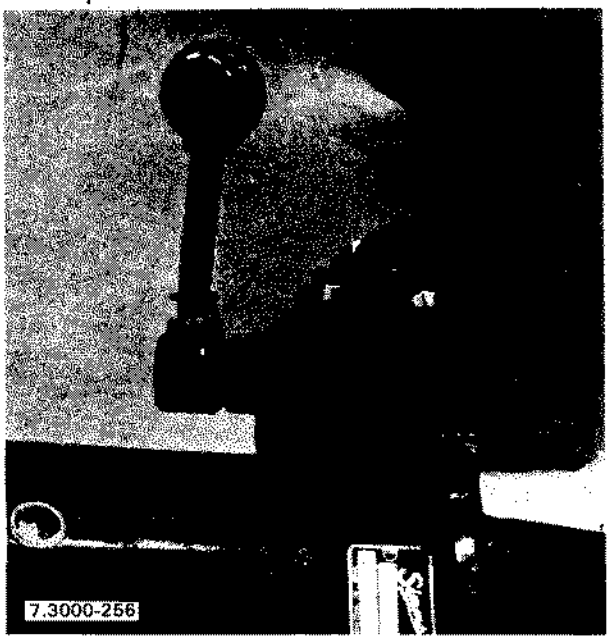
252. By holding the mainshaft stationary and rotating the sleeve the springs are compressed, and conversely when the springs are compressed and the sleeve held stationary, if the mainshaft is released this will rotate as the springs return to their static position.

253. The ratchet mechanism for locking and unlocking the shaft is integral with the bendix drive of the starter pinion and is carried on an extension of the mainshaft.

254. Integral with the spring sleeve is a bevel reduction gear that meshes with the winding shaft which incorporates a ratchet mechanism for locking the spring sleeve.

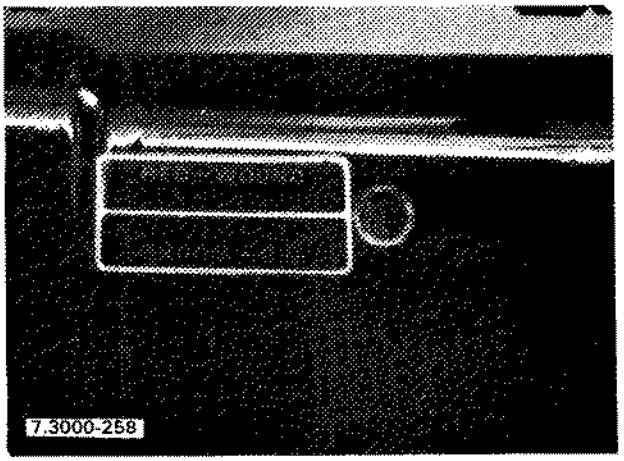
255. The whole mechanism is contained within a three-piece carcase which is both moisture and dustproof.

256. To operate the starter, the trip lever is set in the WIND position.



257. On rotating the hexagonal winding shaft in a clockwise direction, the spring core assembly rotates with the exception of the starter pinion which is restrained from turning by the main ratchet and pawl mechanism. It does, however, move forward into engagement with the flywheel ring gear until it reaches the end of its axial travel, whereupon both pinion and mainshaft are automatically locked. This takes $1\frac{3}{4}$ turns of the winding handle.

258. Further rotation of the winding shaft rotates the spring sleeve and ball nut around the stationary mainshaft which in turn screws the nut into the sleeve thus compressing the disc springs. After approximately $10\frac{1}{4}$ turns (12 total) the starter is fully charged and this is indicated by the appearance of two red springs coinciding with the inspection windows provided in the carcase. The winding shaft is prevented from reverse rotation due to the reaction of the compressed springs by its own ratchet and pawl system.



259. On moving the trip lever into the TRIP position, the pinion and mainshaft are unlocked thus allowing the ball nut to be driven axially along the spring sleeve by the springs until they reach their static position. Axial movement of the nut rotates the mainshaft which in turn rotates the engine flywheel.

260. As soon as the flywheel speed exceeds the mainshaft speed the pinion is thrown out of engagement and returns to its discharged position assisted by a helical return spring.

261. Three other important built-in features should be noted:
a) It is possible to rotate the engine through the starter reduction gear without compressing the springs. This makes tappet adjustment, spill timing and priming the fuel system a simple operation.
b) It is possible to unwind the starter without discharging the stored energy into the engine flywheel.
c) The starter need only be part charged when restarting a hot engine.

Simms Spring Starter Type SS/1 (Removal)

262. Ensure that there is no load on the main spring by checking that the green painted discs can be seen through the inspection windows. If they are not visible the starter must be unwound.

263. Remove the retaining bolts and lift the starter from the engine.

Simms Spring Starter Type SS/1 (Inspection and Overhaul)

264. When overhauling the starter the carcase must not be gripped in a bench vice.

265. To help with overhauling the starter, the numbers in brackets in the following pages refer to the sectional view 7.3000-265 unless otherwise stated.

266. The starter should first be dismantled into three sub-assemblies

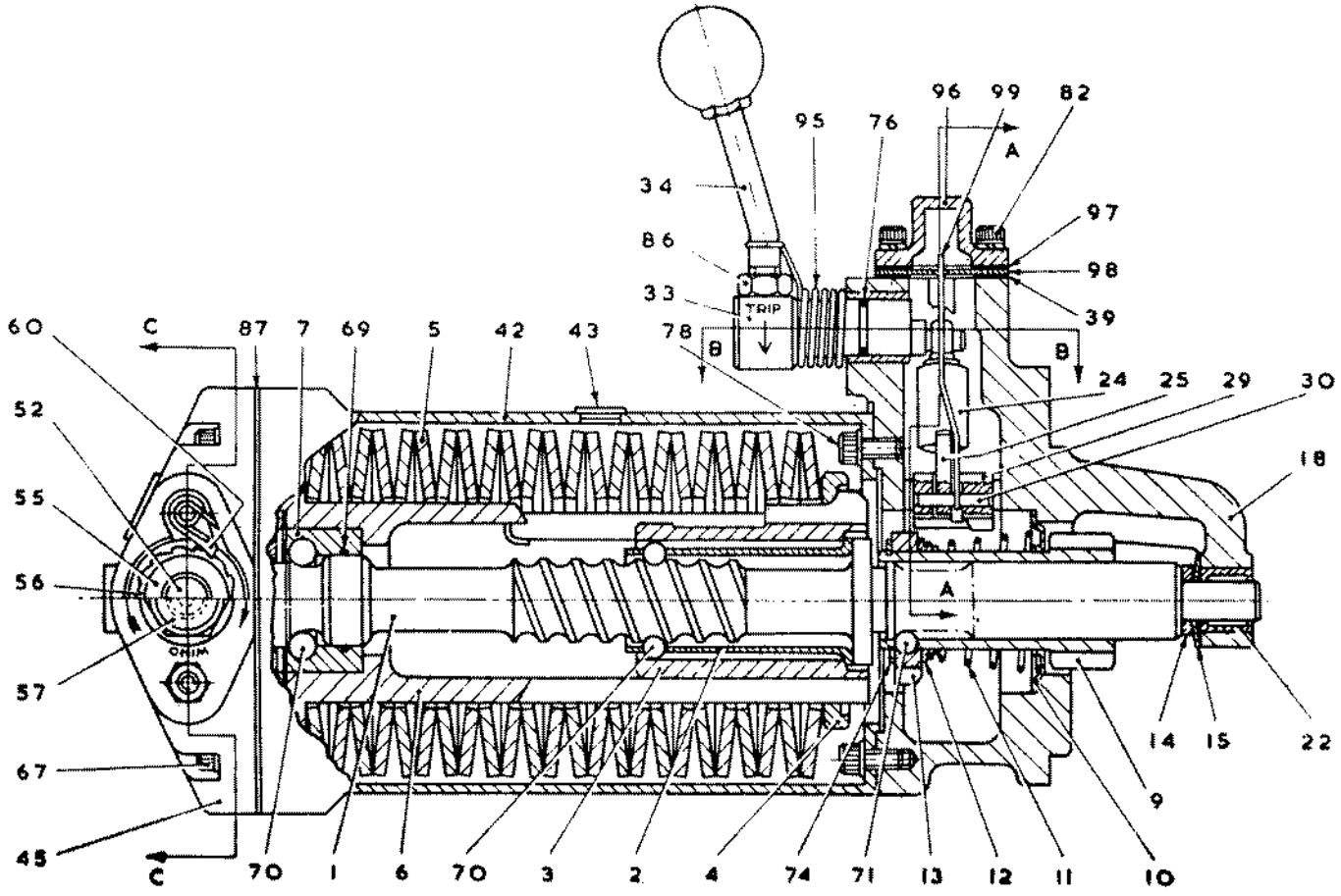
End housing assembly
Spring core assembly
Carcase/nosepiece assembly

as follows:

267. Make a note of the starter assembly code position, see page 28, or scribe lines across the end housing/carcase and the nosepiece/carcase joints, this will ensure that these parts can be correctly aligned on reassembly.

268. Turn the winding adaptor anti-clockwise to break the winding ratchet friction.

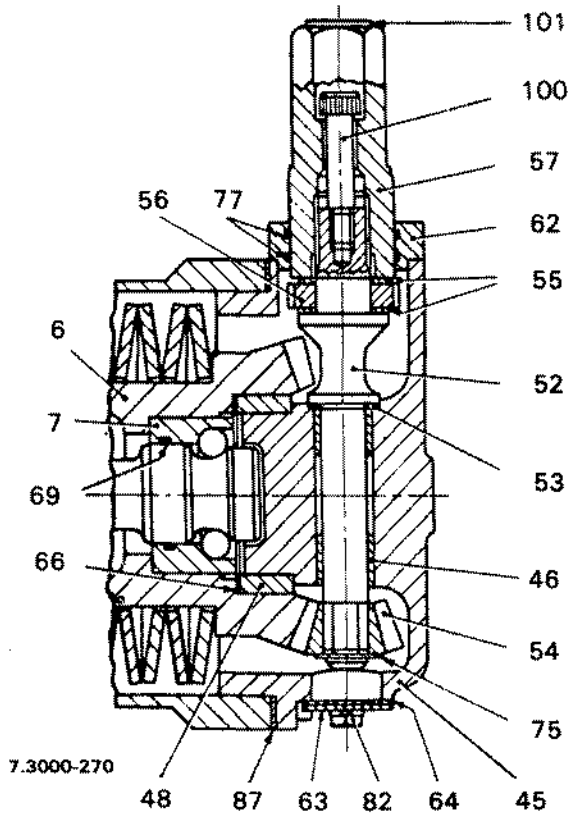
269. Hold the starter vertically on end, with the nosepiece on the bench or on a special stand (Tool No: ST120) and remove the 6 socket cap screws (67) and spring washers.



1	Main Shaft	24	Trip Link	69	'O' Seal
2	Ball Cage	25	Plunger	70	Steel Ball (5/16 in. dia.)
3	Ball Nut	29	Pawl	71	Steel Ball (7 mm. dia.)
4	Ball Nut Ring	30	Link Pin	74	Circlip
5	Main Disc Spring	33	Trip Lever Shaft	76	'O' Seal
6	Spring Sleeve	34	Trip Lever	78	Socket Cap Screw
7	Ball Seat	39	Jointing	82	Screw
9	Main Pinion	42	Carcase	86	Locknut
10	Spring Retainer	43	Inspection Window	87	Shim
11	Return Spring	45	End Housing	95	Return Spring
12	Spacing Ring	52	Winding Shaft	96	Catch Housing
13	Ratchet Ring	55	Friction Disc	97	Jointing
14	Thrust Washer	56	Ratchet Disc	98	Catchplate
15	Nosepiece Disc Ring	57	Winding Adaptor	99	Hook
18	Nosepiece	60	Winding Pawl		
22	Needle Roller Bearing	67	Socket Cap Screw		

7.3000-265

270. Lift the end housing assembly (45 on 7.3000-270) if necessary using a rawhide mallet to loosen it.



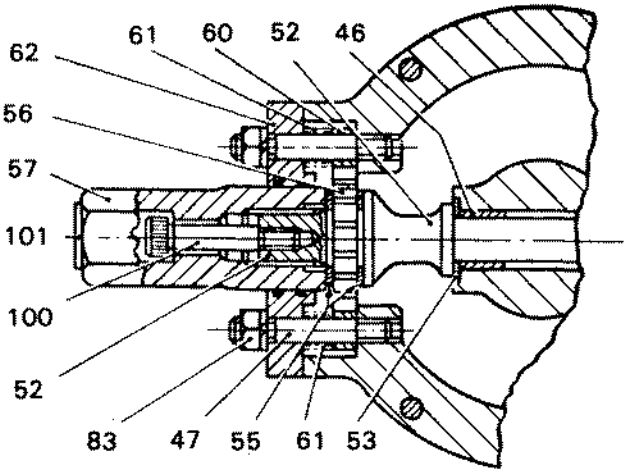
6	Spring Sleeve	62	Top Plate
7	Ball Seat	63	Cover Plate
45	End Housing	64	Jointing
46	Bearing Bush	66	Shim
48	Bearing Sleeve	69	'O' Seal
52	Winding Shaft	75	'E' Clip
53	Thrust Washer	77	'O' Seals
54	Bevel Pinion	82	Screw
55	Friction Disc	87	Shim
56	Ratchet Disc	100	Retaining Screw
57	Winding Adaptor	101	Plug

271. Remove the carcase shim (87) if fitted.
272. Remove shims (66) from bevel gear recess.
273. Operate the trip lever (34) through its full travel in order to engage the hook (99) with the catch plate (98).
274. Place hand over the open end of the carcase (42) to hold the spring sleeve bevel gear, then invert the carcase, placing the open end onto the bench. Care must be taken when turning the carcase upside down otherwise the spring core assembly will fall out. Lift the carcase/nosepiece vertically off the mainshaft.

Spring Core Assembly
275. Remove the nosepiece disc spring (15) and thrust washer (14) from end of mainshaft (1).

276. Lay the assembly on its side. Carefully remove the main pinion circlip (74) making sure not to overstretch it. Slide the ratchet ring (13) sideways and remove the five steel balls (71). Slide off the main pinion (9), spring retainer (10), return spring (11), spacing ring (12), ratchet ring (13) and circlip (74) from the mainshaft.
277. Slide the spacing tool (No. ST121) over the pinion end of the shaft and place the main spring assembly vertically in the special press (Tool No. ST138) so that the spring sleeve bevel gear is on top. Place the press tool (No. ST122) in the bevel gear recess and apply sufficient pressure to depress the main spring about $\frac{1}{4}$" (9.5 mm). Whilst the pressure is maintained, lift out the ten steel balls (70). Slowly release the pressure and remove the assembly from the press.
278. Slide the main shaft (1) complete with ball nut (3) and ball nut ring (4) out of the spring sleeve (6). Remove the twenty-four spring discs (5) from the spring sleeve. Examine the 'O' seal (69) for wear or damage. To remove this seal the ball seat insert (7) must be pressed out, an operation which should not be carried out unnecessarily.

End Housing Assembly
279. To dismantle the end housing assembly reference should be made to illustration 7.3000-279 which is section 'CC' of illustration 7.3000-265.



7.3000-279 – Section 'CC' of 7.3000-265

46	Bearing Bush	60	Pawl
47	Stud	61	Spring
52	Winding Shaft	62	Top Plate
53	Thrust Washer	83	Nut
55	Friction Discs	100	Retaining Screw
56	Ratchet Disc	101	Plug
57	Winding Adaptor		

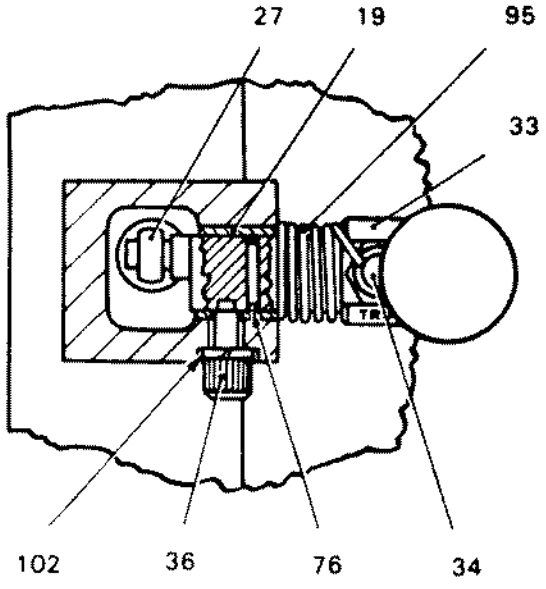
280. Remove the two nuts (83) and spring washers. Remove top plate (62) if necessary tapping it with a rawhide mallet. Remove the two pawls (60) and springs (61).

281. Remove the hexagon screws (82) and spring washers. Lift off cover plate (63) and jointing (64).
282. Remove 'E' clip (75) and withdraw the winding shaft assembly. Place shaft assembly in special tool (No. ST148; PL900) and prise out plastic plug (101).
283. Remove retaining screw (100). Unscrew winding adaptor (57) and remove ratchet disc (56) and the two friction discs (55).
284. Remove thrust washer (53) and bevel pinion (54) from housing.

Carcase and Nosepiece Assembly

285. Use extended Allen key (Tool No. ST129) to remove the six socket cap screws (78) and shakeproof washers. Separate the carcase (42) from the nose piece assembly (18).
286. Press and release the reset button and remove four screws (82) and spring washers, catch housing (96) and jointing (97).
287. Ensure that hook (99) is freed from catchplate (98). Lift off catchplate assembly, being careful not to damage or bend the leaf spring beneath, and jointing (39).
288. Remove the trip lever stop screw (36 in 7.3000-288) and spring washer.

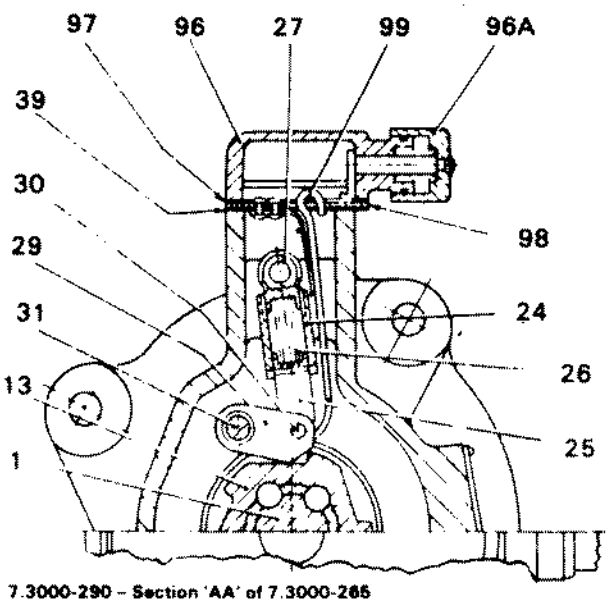
This illustration is section 'BB' of illustration 7.3000-265.



7.3000-288 - Section 'BB' of 7.3000-265

19	Bush	36	Stop Screw
27	Top Link	76	'O' Seal
33	Shaft	95	Return Spring
34	Trip Lever	102	Washer

289. Withdraw the trip lever shaft (33) complete with trip lever (34), return spring (95) and 'O' seal (76).
290. Use extractor (Tool No. ST136) to remove pawl pin (31 in 7.3000-290); a tapped hole (No. 8-32 UNC) is provided in the end of the pin for this. Lift out the spring loaded plunger assembly complete with hook (99) and main pawl (29).



7.3000-290 – Section 'AA' of 7.3000-265

1	Main Shaft	31	Pawl Pin
13	Ratchet Ring	39	Jointing
24	Spring Link Housing	96	Catch Housing
25	Plunger	96A	Reset Button
26	Spring	97	Jointing
27	Top Link	98	Catchplate
29	Pawl	99	Hook
30	Link Pin		

291. Separate the plunger (25) and the hook (99) from pawl (29) by pressing out the link pin (30) which is a press fit into the wide limb of the pawl.
292. Unscrew the top link (27) and withdraw link spring (26) and plunger (25).
293. Examine needle roller (22) in position. Only press it out from the nosepiece if it must be renewed.
294. Clean all parts for examination and renew any part which is excessively worn or damaged. When ordering spare parts, the starter type number should always be quoted.
295. Particular attention should be given to the two-start thread of the main shaft, the corresponding thread in the ball nut, and the end track of the main shaft. If the main shaft and ball nut are chipped or cracked or badly pitted, they should be replaced. If the spring sleeve ball seat insert is damaged or worn, it must be pressed out and replaced. All these components, including the ratchet ring and ball cage, should also be inspected visually for cracks.
296. The complete pack of twenty-four disc springs (5) should be replaced by new ones if:

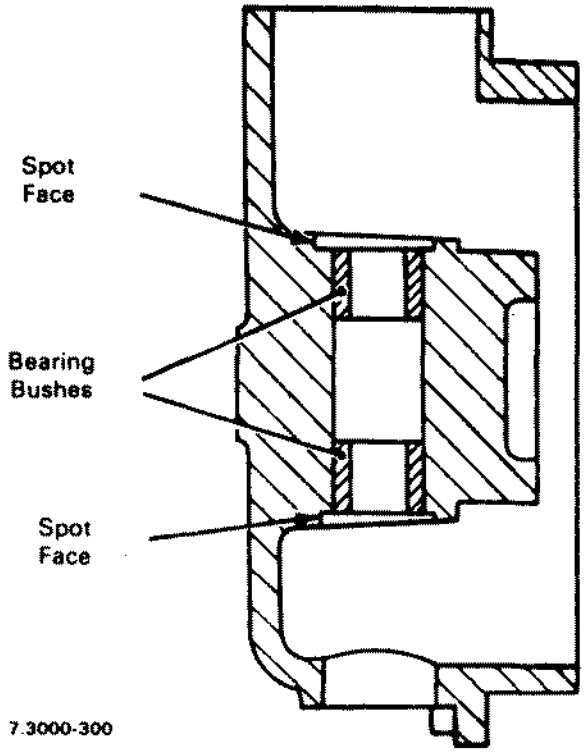
(a) Their surfaces are badly pitted due to atmospheric corrosion
(b) Any of the discs is cracked or broken
(c) The distance from the end of the spring sleeve (6) to the outer edge of the first spring exceeds 0.25" (6.35 mm).

297. If a new ball nut (3) or main shaft (1) have to be fitted, ensure that ball nut, main shaft, balls and ball cage, when assembled as a unit, function smoothly.

298. If a new ball nut is fitted, check that it slides freely in the slots of the spring sleeve.

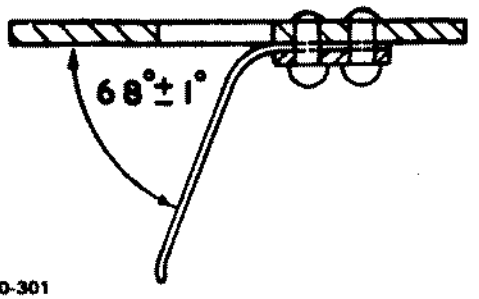
299. Similarly, if either a new ratchet ring (13) or main pinion (9) is fitted, when these components are assembled together with balls (71) on main shaft, check that the main pinion assembly functions smoothly along the whole length of the five start thread.

300. If the two new bearing bushes (46) have to be fitted in the end housing, use a fitting pin 0.5005 in. (12.713 mm) diameter, the winding shaft may be used carefully for this purpose. Press each new bush into the casting, level with its spot face. Check for free running fit of winding shaft.



7.3000-300

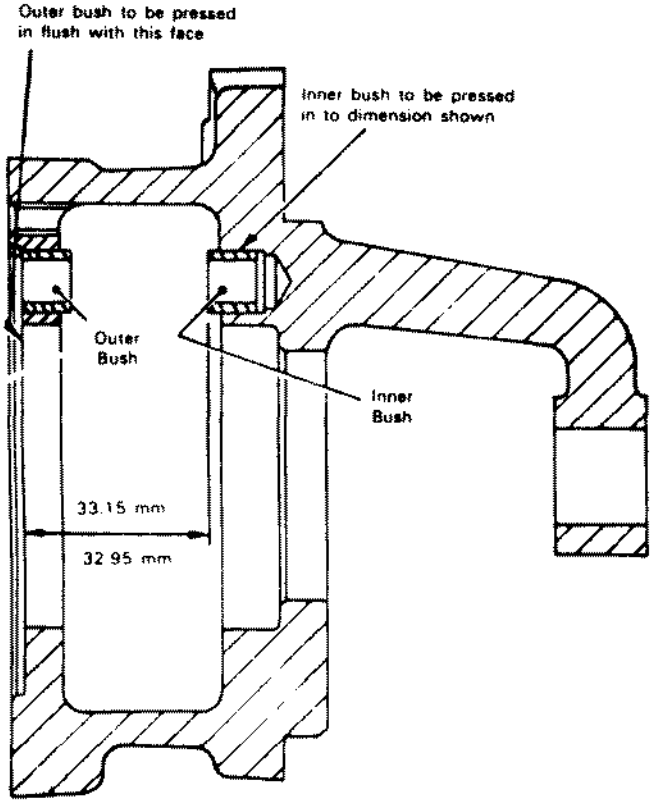
301. The included angle (68°) between the leaf spring and the catchplate should be checked. If this angle exceeds 70° a new catchplate assembly (98) must be fitted.



7.3000-301

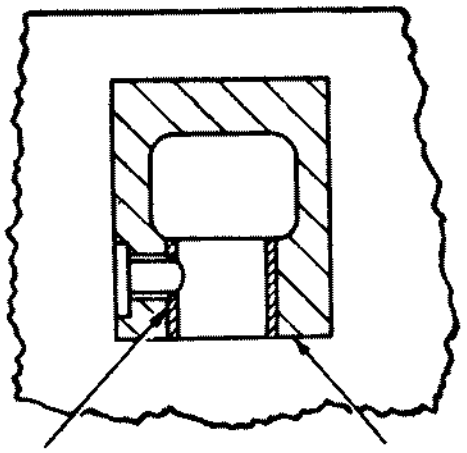
302. The hook (99) must be carefully examined for distortion and cracks inside the hooked end.

303. If two new bushes for pawl pin (31) have to be fitted into nosepiece, use a suitable fitting pin (to maintain alignment and dimension 33.15/32.95 mm) and press in bushes. Check that pawl pin is a free fit in bushes.



7.3000-303

304. Similarly, if a new bush has to be fitted for the trip lever shaft (33), use a suitable fitting pin and press in as shown in illustration 7.3000-304. Afterwards drill and tap (5/16" – 24 UNF – 2A) the bush through the stop screw hole. Remove any internal burrs from bush and check free running fit of trip lever shaft.



7.3000-304

305. The components of the spring starter are lubricated during assembly with grease as indicated in Table 1 (Page 26). The recommended greases are Mobilgrease No. 3 (graphited) and Rocol anti-scuffing paste (Molybdenum disulphide).

306. Lubricate all parts as instructed under 'LUBRICATION' with the exception of the winding bevel pinion teeth (54), the bevel gear of the spring sleeve (6) and the ball seat recess. These parts are lubricated at a later stage, after the gear mesh and the main shaft end float have been adjusted by shims.

307. Reassembling is in the reverse order of dismantling.

308. As a general guide to the tightening of screws and nuts with an adjustable torque spanner, the setting of the spanner is given in lb. ft. (kg. m.).

309. The recommended sealing compound to be used on jointings and face joints (where applicable) is Hylomar SQ32/M.

Carcase and Nosepiece Assembly

310. If a new needle roller bearing is required (22) press it into the nosepiece. The pressure should be applied to the flat end face of the needle bearing assembly.

311. Reassemble the parts of the spring link assembly i.e. plunger (25), spring(26), spring link (24) and top link (27). Preset the new trip link assembly, using the setting tool (No. ST147; PL900). The correctly set link should freely drop over the tool pins.

312. Connect the spring link assembly to the hook (99) and pawl (29) with link pin (30); the link pin is a press fit into the wide limb of the pawl. Assemble the free end of the main pawl sub-assembly into the nosepiece with the pawl pin (31).

313. Locate trip lever return spring (95) into nosepiece (18). Fit 'O' seal (76) in groove of trip lever shaft (33) and fit shaft through the return spring into the nosepiece. At the same time locate the plunger top link (27) on the offset pin of the shaft.

314. Fit stop screw (36) and spring washer (102) so that the screw locates in the slot of the lever shaft. Tighten the screw to 7-9 lbs. ft. (0.97-1.24 Kg. m.). Fit the hooked end of the return spring over the trip lever (34) and ensure that the spring returns the lever to the end of the slot.

NOTE: To adjust the position of trip lever (34) in shaft (33), slacken locknut (86) and turn the trip lever to the position required, then re-tighten locknut.

315. Apply sealing compound to both faces of jointings (39) and (97). Fit jointing (39), catchplate (98), jointing (97) and catch housing assembly (96). Hook (99) locates freely in the catchplate slot. Tighten the catch housing screws (82) to 2-3 lbs. ft. (0.27 0.41 kg. m.).

316. Check the reset trip mechanism as follows:-

(a) The hook should engage in the recess of the catchplate during the full movement of the trip lever and remain there when the trip lever is released.

(b) Pressing the reset button should disengage the hook from the catchplate.

(c) To check that the hook can engage over the button catch (Illustration 7.3000-290) press and hold reset button then manually press pawl upwards until hook engages. Release pressure on pawl and check that hook remains on button catch. Release button and ensure that the hook disengages from button catch and re-engages with the recess in catchplate.

317. Apply sealing compound to the mating faces of nosepiece and carcase, and connect the two parts (in the position marked when dismantling) with the screws (78) and shakeproof washer: tightening torque 7-9 lbs. ft. (0.97-1.24 kg. m.).

Main Shaft and Spring Core Assembly

318. Fit 'O' seal (69) in groove provided in ball seat insert (7).

319. Assemble the twelve pairs of disc springs (5) on spring sleeve (6). Position the painted indicator springs as follows, numbering them from the nosepiece end of the starter:

Spring discs Nos. 1, 2, & 3 (red) abut ball nut ring.
No. 4 (white)
Nos. 11 & 12 (green)

320. If new spring discs are to be fitted, the peripheries of six of them must first be painted with the colours above, so that they may serve as indicator springs.

321. Lubricate the ball tracks of the main shaft (1) with Mobilgrease No. 3 (graphited) to facilitate assembly of the ball cage (2). Slide the ball cage on the main shaft, fit the sixteen balls (70) into the ball cage holes and screw on ball nut (3). Ensure that both the ball nut and ball cage flange abut the main shaft collar. Locate the ball nut ring (4) over the four lugs of ball nut and slide assembly into spring sleeve (6) so that the nut

TABLE 1. LUBRICATION

MOBILGREASE No. 3. (GRAPHITED):-

SPRING CORE ASSEMBLY.

Main Shaft (1)	Roller bearing journal, 5-start screw thread, 2-start screw thread, 'O' seal shoulder and ball track on end of shaft.
Ball Cage (2)	All internal and external surfaces including holes for steel balls.
Ball Nut (3)	Internal 2-start screw thread and external surfaces.
Spring Sleeve (6)	Bevel gear teeth and all internal bores including ball seat track and bearing surface of bevel gear.
Main Pinion (9)	Internal bore and external surface up to gear teeth, including holes for steel balls.
Ratchet Ring (13)	All surfaces including grooves for steel balls.

NOSEPIECE ASSEMBLY

Needle Roller (22)	
Main Pawl (29)	All surfaces.
Link Pin (30)	All surfaces.
Pawl Pin (31)	All surfaces.
Spring Link Assembly (24, 25 & 26)	All surfaces.
Hook (99)	All surfaces.
Trip Lever Shaft (33)	Lever shank and eccentric pin.
Catchplate Assembly (98)	Leaf spring and recess for hook.
Catch Housing Assembly (96)	Button Catch.

END HOUSING ASSEMBLY

End Housing (45)	Bearing sleeve; winding shaft bushes and cavity between them; studs.
Winding Shaft (52)	All surfaces.
Bevel Pin (54)	All surfaces.
Friction Discs (55)	All surfaces.
Ratchet Disc (56)	All surfaces.
Ratchet Pawls (60)	All surfaces.
Ratchet Springs (61)	All surfaces.
Winding Adaptor (57)	Thread and end (friction) face.

Note. Before final assembly of end housing on carcase, fill the ball seat cavity with about ¼ oz. (21 gm.) of Mobilgrease No. 3 (graphited).

ROCOL ANTI-SCUFFING PASTE:-

SPRING CORE ASSEMBLY

Spring Sleeve (6)	Sleeve slots and outer surface.
Ball Nut Ring (4)	Bore.
Spring Discs (5)	The ground mating faces and bore.

END HOUSING ASSEMBLY

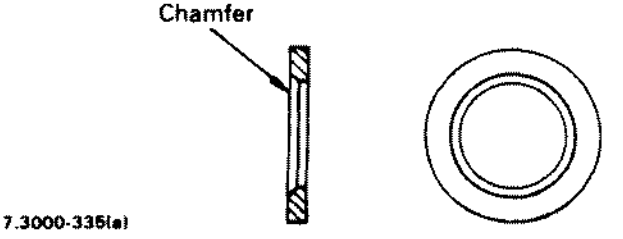
Top Plate (62)	Bore and 'O' seal grooves.
Winding Adaptor (57)	Bearing surface, i.e., the surface which is in contact with the top plate on assembly. It is important that paste must not be allowed on to friction face.

lugs engage the longitudinal slots of sleeve.
322. Slide spacing tool (No. ST121; PL900) on to pinion end of main shaft.
323. Place the whole assembly in press (No. ST138) with bevel gear uppermost. Locate the press tool (No. ST122) in the recess in the spring sleeve and depress the spring sleeve (and springs) about $\frac{1}{4}$ in. (9.5 mm). Distribute the ten steel balls (70) evenly around the main shaft in the undercut portion between the end track and 'O' seal collar. Slowly release the press, ensuring that no steel balls are trapped between the shaft head and edge of ball seat (7). Release the pressure and check that all ten balls are situated between the track in the ball seat and shaft. Remove assembly from press.
324. Assemble the main pinion circlip (74) and ratchet ring (13) on main shaft (1). Assemble spring retainer (10), return spring (11) and spacing ring (12) on main pinion (9). Slide the assembly into position on the main shaft (1) so that the five 7 mm dia. steel balls (71) may be inserted in the five-start thread. Slide ratchet ring over steel balls and fit circlip (74), taking care not to overstretch it. Check that the pinion assembly moves freely up and down the five-start thread.

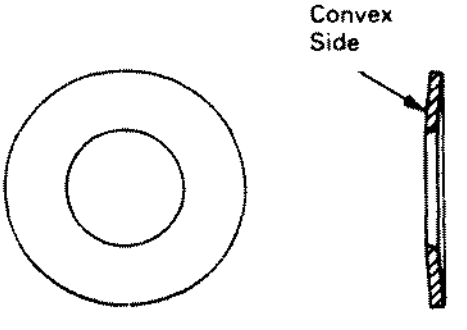
End Housing Assembly
325. Insert winding shaft (52) into new assembly tool (No. ST148; PL900). Assemble (lubricated) friction disc (55), ratchet disc (56), friction disc (55) and winding adaptor (57) in that order, on to shaft. The ratchet-disc rotates clockwise; make sure that its teeth face in the correct direction (see Illustration 7.3000-265). Fit adaptor retaining screw (100) and tighten to 7-9 lbs. ft. (0.97-1.24 kg. m.). Check that, with the winding adaptor turned back against the head of the retaining screw (100), the ratchet disc (56) is free to rotate. Apply sealing compound to flange of plastic plug (101) and press into adaptor.
326. Locate thrust washer (53) in housing seat. Slide the winding shaft assembly into the housing. Fit bevel pinion (54) on to the shaft hexagon and fit retaining 'E' clip (75). Check that winding shaft rotates freely.

Bevel Gear Mesh Adjustment
327. Support the end housing, with its register uppermost, on a bench. A block of wood, shaped to suit the bevelled outer face of the end housing will provide a firm base.
328. Place the thickest shim (66) on the end housing hub, and fit the spring core assembly on to the hub.
329. Rotate the spring core assembly and check that the bevel gears run freely.
330. The shims (66) are supplied in 0.005 in. (0.127 mm) increments from 0.005 in. (0.127 mm) to 0.020 in. (0.508 mm). Add or remove shims until the bevel gears are in full mesh and will just run freely without roughness.
331. The final backlash of the gears should be from 0.10 mm to 0.20 mm. When the correct shim shickness has been determined, keep it with the end housing for final assembly.
332. Fit the two ratchet pawls (60) and springs (61) on to studs (47). Turn the winding adaptor (57) clockwise and check that the ratchet assembly functions correctly.
333. Fit the two 'O' seals (77) into the grooves in the top plate (62). Apply sealing compound to the joint face of the top plate. Fit top plate over winding adaptor and studs (contour of plate matching that of end housing) and secure with nuts (83) and spring washers; tightening torque 5-7 lbs. ft. (0.69-0.97 kg. m.).
334. Apply sealing compound to jointing (64) and cover plate (63). Fit cover plate to end housing with screws (82) and washers; tightening torque 2-3 lbs. ft. (0.27-0.41 kg. m.).

Final Assembly
335. Place the main shaft and spring core assembly vertically on the bench with the nose journal uppermost. Place the thinnest thrust washer (14) and nosepiece disc spring (15) on the end of the mainshaft (1). Ensure that the chamfered side of the thrust washer (Illustration 7.3000-335 (a)) abuts the shoulder of the shaft and that the convex side of disc spring (Illustration 7.3000-335 (b)) abuts the thrust washer.



7.3000-335(a)



7.3000-335(b)

336. Operate the trip lever fully to engage the hook (99) into the catch plate (98) recess. Lower the carcase and nosepiece assembly over the main shaft assembly allowing the shaft journal to enter needle roller in nose. Place one hand under bevel gear and turn the whole assembly through 180° so that the nosepiece rests on bench or on special stand.

337. Fit end housing shim (66) which was selected as detailed in Bevel Gear Mesh Adjustment, into the spring sleeve (6). Place the thickest carcase shim (87) on end housing spigot and assemble end housing on to carcase, engaging bevel pinion (54) with bevel gear. Secure with two cap screws (67) and then slowly rotate the winding adaptor (57), pushing it inwards to seat thrust washer (53) firmly into its seating.

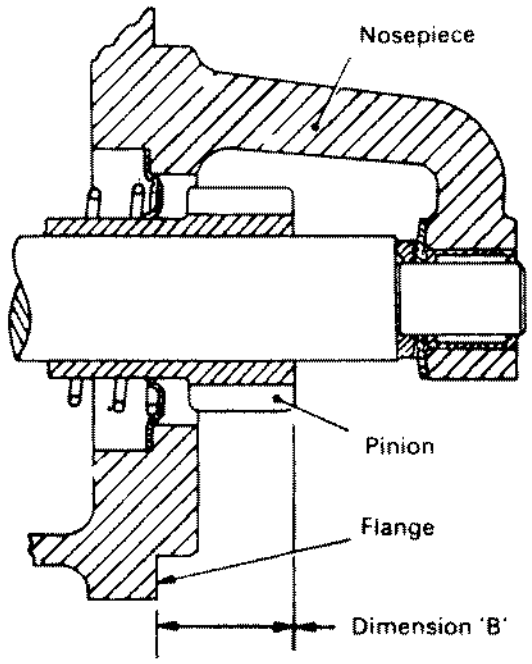
338. Using a dial gauge, measure the shaft end float by lifting the main pinion by its teeth. Tool NO. ST140 (PL900) comprises the dial gauge fixture which bolts to the starter nosepiece, plus a forked lever for lifting the main pinion. Do not exert sufficient force to compress the nose disc spring or an excessive end float figure will be obtained. The pinion face to mounting flange dimension should also be checked at this time.

339. Invert the assembly and place nosepiece on bench or special stand (No. ST120; PL900). Remove end housing and change the carcase shim (87) and thrust washer (14) to obtain the correct pinion face to mounting flange dimension and main shaft end float (0.05-0.21 mm).

340. The dimension 'B' (pinion face to mounting flange) varies for the different types of spring starter.

341. With the thinnest thrust washer (14) and thickest carcase shim (87) the end float is a maximum. A thinner carcase shim will give a larger pinion face to mounting flange dimension but will decrease the end float. The carcase shims are in two sizes 0.5 mm and 1.00 mm thick and the thrust washers vary from 2.4 mm to 3.4 mm in 0.2 mm stages.

342. Fill ball seat cavity with lubricant to the level of the head of the main shaft; see note under 'END HOUSING ASSEMBLY', in table 1. Lubricate also the bevel pinion, bevel gear and bevel gear recess.



7.3000-340

Starter Type No.	'B' Dims. mm.	Normal Assy. Code
SS 10/1	24-25	B3
SS 11/1	20-21	A7
SS 12/1	47-48	B3
SS 13/1	28-29	A1
SS 14/1	26-27	A1
SS 15/1	26-27	F7
SS 16/1	28-29	E5
SS 17/1	47-48	A1
SS 18/1	20-21	B3
SS 19/1	25-26	D5

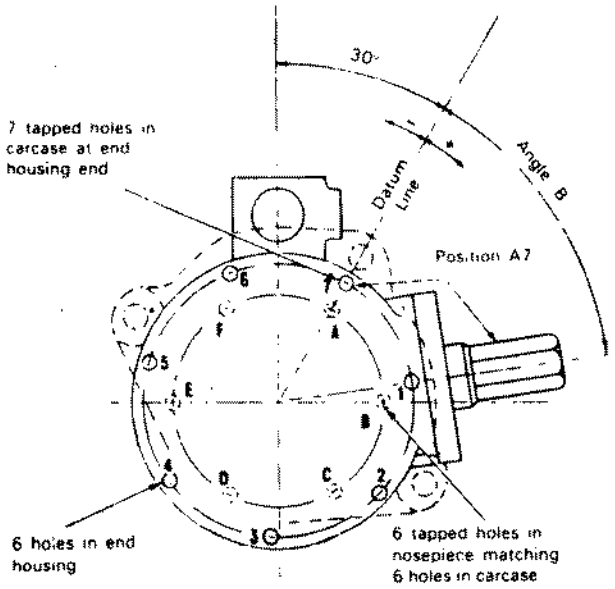
Starter Type No.	'B' Dims. mm.	Normal Assy. Code
SS 20/1	25-26	E5
SS 21/1		
SS 22/1	28-29	A1
SS 23/1	28-29	C3
SS 24/1	47-48	E6
SS 25/1	28-29	B2
SS 26/1	47-48	B3

343. Apply sealing compound to the joint faces of the carcase and end housing, and to both sides of shim (84) if one is to be used. Assemble the housing to the carcase (in the position marked with dismantling) with 6 socket cap screws (67) and spring washers; tightening torque 7-9 lbs. ft. (0.97-1.24 kg. m.).

Starter Assembly Coding

344. The relative angular position between the trip lever and the winding shaft can be varied by equal increments to suit the installation requirements for each starter. An assembly code has been introduced to denote these positions and each starter is normally assembled to a particular code number when manufactured.

345. The illustration and the position code tables show the range of winding shaft positions available. Angle 'B' is measured from a datum line 30° from the trip lever position. This datum coincides with the centre hole of the mounting flange (shown dotted) of the SS . . . /1 Type starter.



7.3000-345

Angle 'B'	Position Code
0	A1
+ 8 4/7°	B2
+17 1/7°	C3
+25 5/7°	D4
+34 2/7°	E5
+42 6/7°	F6
+51 3/7°	A7
+60°	B1
+68 4/7°	C2
+77 1/7°	D3
+85 5/7°	E4
+94 2/7°	F5

Angle 'B'	Position Code
– 8 4/7°	F7
–17 1/7°	E6
–25 5/7°	D5
–34 2/7°	C4
–42 6/7°	B3
–51 3/7°	A2
–60°	F1
–68 4/7°	E7
–77 1/7°	D6
–85 5/7°	C5
–94 2/7°	B4

346. The carcase has 6 holes for the nosepiece screws and 7 tapped holes in the tail end. Two of the carcase holes are in line and are identified by marks 'O' stamped on the outside of the carcase. The starter position codes indicate the holes in the end assemblies which are in line. In Illustration 7.3000-345 nosepiece hole 'A' and end housing hole '7' mate with carcase hole 0-0. The starter Type becomes SS____/1A7.

Delco Remy MT Starters (Description)

347. Delco Remy heavy duty starting motors have a shift lever and solenoid plunger that are totally enclosed to protect them from exposure to dirt, icy conditions and splashing. The nose housing can be rotated to obtain a number of different solenoid positions with respect to the mounting flange.

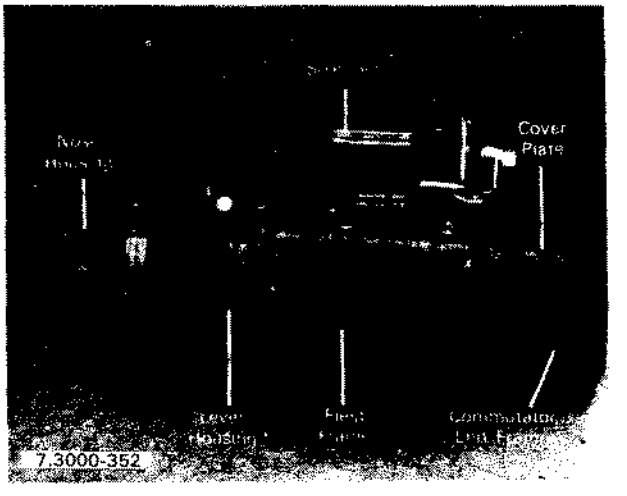
348. Positive lubrication is provided to the bronze bushings by an oil saturated wick that projects through the bushings and contacts the armature shaft. Oil can be added to each wick by removing a pipe plug which is accessible on the outside of the motor. Roller bearings in the lever housing on some models contain a supply of lubricant which will last between engine overhaul periods.

349. Some motors have an oil reservoir for the bronze bearings which makes a larger oil supply available, thereby extending the time required between lubrication periods. Also on some motors, 'O' rings are added to resist entry of dirt and moisture into the assembly. When the oil reservoir and 'O' rings are included in the build the motor is classified as 'long life', which provides long periods of attention free operation.

350. A rubber boot or linkage seal is situated over the solenoid plunger.

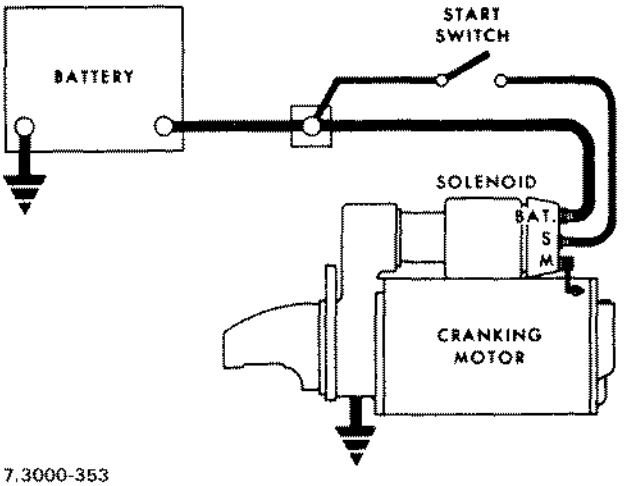
351. A heavy duty sprag type clutch is used which is moved into mesh with the ring gear by the action of the solenoid. The pinion remains engaged until starting is assured and the solenoid circuit is interrupted. In case of a butt engagement with the clutch, the motor will not be energised to prevent damage to the pinion and the gear teeth.

352. The adjustable nose housing is attached by six bolts to the lever housing. To relocate the housing, it is only necessary to remove the bolts, rotate the housing to the desired position, and re-install the bolts, tightening them to a torque of 13-17 lbs. ft. The lever housing and the commutator frame are attached to the field frame independently by bolts entering threaded holes in the field frame.



Operation

353. In the basic circuit shown below the solenoid windings are energised when the switch is closed. The resulting plunger and shift lever movement causes the pinion to engage the engine flywheel ring gear and the solenoid main contacts to close, and cranking takes place. When the engine starts, pinion over-run protects the armature from excessive speed until the switch is opened at which time the return spring causes the pinion to disengage. To prevent excessive over-run and damage to the drive and armature windings, the switch must be opened immediately when the engine starts.

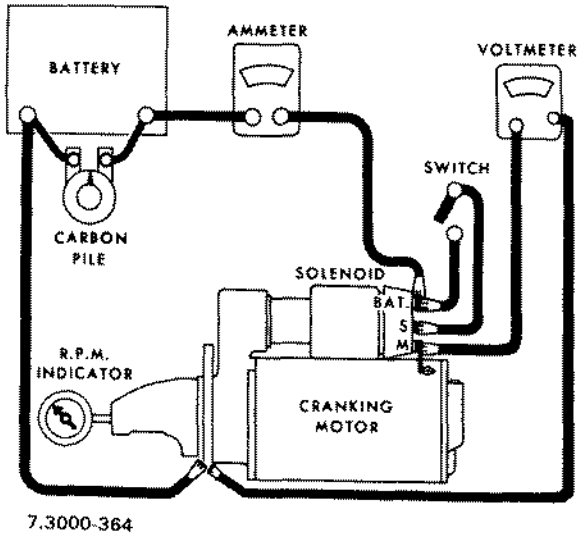


7.3000-353

354. Before removing any unit in the cranking circuit for repair, the tests listed in paragraphs 355 to 358 inclusive, should be carried out.
355. Check the condition of the battery and ensure that it is fully charged.
356. Inspect all wiring for damage. Inspect all connections to the cranking motor, solenoid, magnetic switch, ignition switch or any other control switch and battery, including all ground connections. Clean and tighten connections as required.
357. Inspect all switches, magnetic solenoid and control, to determine their condition. Connect a jumper lead around any switch suspected of being defective. If the system functions properly using this method, repair or replace the by-passed switch.
358. If the battery, wiring and switches are in a satisfactory condition and the engine is known to be functioning properly the motor should be removed and tested.

Delco Remy MT Starters (Removal)
359. Disconnect the battery cables.
360. Disconnect the two leads to the ignition switch.
361. Remove the three retaining bolts and washers and remove the starter from the flywheel housing.

Cranking Motor Tests
362. Regardless of the construction, never operate the cranking motor for more than 30 seconds, without pausing to allow it to cool for two minutes. On some applications 30 seconds may be excessive. Overheating, caused by excessive cranking will seriously damage the motor.
363. With the motor removed from the engine, the armature should be checked for freedom of rotation by prying the pinion with a screwdriver. Tight bearings, a bent armature shaft or a loose pole shoe screw will cause the armature to not turn freely. If the armature does not turn freely, the motor should be disassembled immediately. However, if the armature does rotate freely, the motor should be given a no load test before disassembly as described below.



7.3000-364

364. Connect a voltmeter from the motor terminal to the motor frame, and use an RPM indicator to measure the armature speed. Connect the motor and an armature in series with a fully charged battery of the specified voltage, and a switch in the open position from the solenoid battery terminal to the solenoid switch terminal.
365. Close the switch and compare the rpm current, and voltage reading with the specifications tabulated below.

NO LOAD TEST

Part No.	Volts	Min. Amps	Max. Amps	Min. rpm	Max. rpm
1113202	9·0	50*	70*	3500	5500
1113637	11·6	85*	125*	5900	8100
1114084	11·5	90*	130*	5600	7600

* includes solenoid

366. It is not necessary to obtain the exact voltage specified, as an accurate interpretation can be made by recognising that if the voltage is slightly higher the rpm will be proportionately higher, with the current remaining essentially unchanged.
367. If the exact voltage is required, a carbon pile connected across the battery, see illustration 7.3000-364, can be used to reduce the voltage to the specified value. If the specified current does not include the solenoid, deduct from the ammeter reading the specified current draw of the solenoid hold in winding. Make disconnections only with the switch open.
368. Interpret the test results from paragraphs 369-374 inclusive.
369. Rated current draw and no load speed indicates normal condition of the cranking motor.
370. Low free speed and high current draw indicate:
(a) Too much friction – tight, dirty or worn bearings, bent armature shaft or loose pole shoes allowing armature to drag.
(b) Shorted armature – this can be further checked on a growler after disassembly.
(c) Grounded armature or fields – check further after disassembly.
371. Failure to operate with high current draw indicates: (a) A direct ground in the terminal or fields.
(b) 'Frozen' bearings (this should have been determined by turning the armature by hand).
372. Failure to operate with no current draw indicates:
(a) Open field circuit. This can be checked after disassembly by inspecting internal connections and tracing circuit with a test lamp.
(b) Open armature coils. Inspect the commutator for badly burned bars after disassembly.

(c) Broken brush springs, worn brushes, high insulation between the commutator bars or other causes which would prevent good contact between the brushes and commutator.

373. Low no load speed and low current draw indicates: (a) High internal resistance due to poor connections, defective leads, dirty commutator and causes listed under paragraph 372.

374. High free speed and high current draw indicates shorted fields. If shorted fields are suspected, replace the field coil assembly and check for improved performance.

Delco Remy MT Starters (Inspection and Overhaul)

375. Normally the cranking motor should be disassembled only so far as is necessary to make the repair or the replacement of the defective parts. As a precaution, it is suggested that safety glasses be worn when disassembling or assembling the cranking motor.

376. Note the relative position of the solenoid, lever housing and nose housing so that the motor can be reassembled in the same manner.

377. Disconnect field coil connector from solenoid motor terminal, and lead from solenoid ground terminal.

378. On motors which have brush inspection plates, remove the plates and then the brush lead screws. This will disconnect the field leads from the brush holders.

379. Remove the attaching bolts and separate the commutator end frame from the field frame.

380. Separate the nose housing and field frame from the lever housing by removing attaching bolts.

381. Remove armature and clutch assembly from the lever housing.

382. Separate the solenoid from the lever housing by pulling apart.

383. All parts except the drive should be cleaned with mineral spirits and a brush. The drive can be wiped with a clean cloth. The drive, armature and fields should not be cleaned in any degreasing tank, or with grease dissolving solvents, since these would dissolve the lubricant in the drive and damage the insulation in the armature and field coils.

384. If the commutator is dirty it may be cleaned with No. 00 sandpaper. NEVER USE EMERY CLOTH TO CLEAN COMMUTATOR.

Brushes and Holders

385. Inspect the brushes for wear. If they are worn excessively when compared with a new brush, they should be replaced.

386. Ensure the brush holders are clean and the brushes are not binding in the holders. The full brush surface should ride on the commutator to give proper performance.

387. Check by hand to ensure that the brush springs are giving firm contact between the brushes and commutator. If the springs are distorted or discoloured they should be replaced.

Armature

388. If the armature commutator is worn, dirty, out of round or has high insulation, the armature should be put in a lathe so the commutator can be turned down. The insulation should then be undercut (see note) 1/32 of an inch deep and 1/32 of an inch wide, and the slots cleaned out to remove any trace of dirt or copper dust. Finally the commutator should be sanded with No.00 sandpaper to remove any burrs left as a result of the undercutting procedure.

NOTE: The undercut operation must be omitted on part numbers 1113202 and 1113637.

389. The armature should be checked for opens, short circuits and grounds.

390. Opens are normally caused by excessively long cranking periods. The most likely place for an open to occur is at the commutator riser bars. Inspect the points where the conductors are joined to the commutator bars for loose connections. Poor connections cause arcing and burning of the commutator bars as the cranking motor is used. If the bars are not too badly burned, repair can often be effected by resoldering or welding the leads in the riser bars (using rosin flux) and turning down the commutator in a lathe to remove the burned material. The insulation should then be undercut except where noted above.

391. Short circuits in the armature are located by use of a growler. When the armature is revolved in the growler with a steel strip such as a hacksaw blade held above it, the blade will vibrate above the area of the armature core in which the short circuit is located. Shorts between bars are sometimes produced by brush dust or copper between the bars. These shorts can be eliminated by cleaning out the slots.

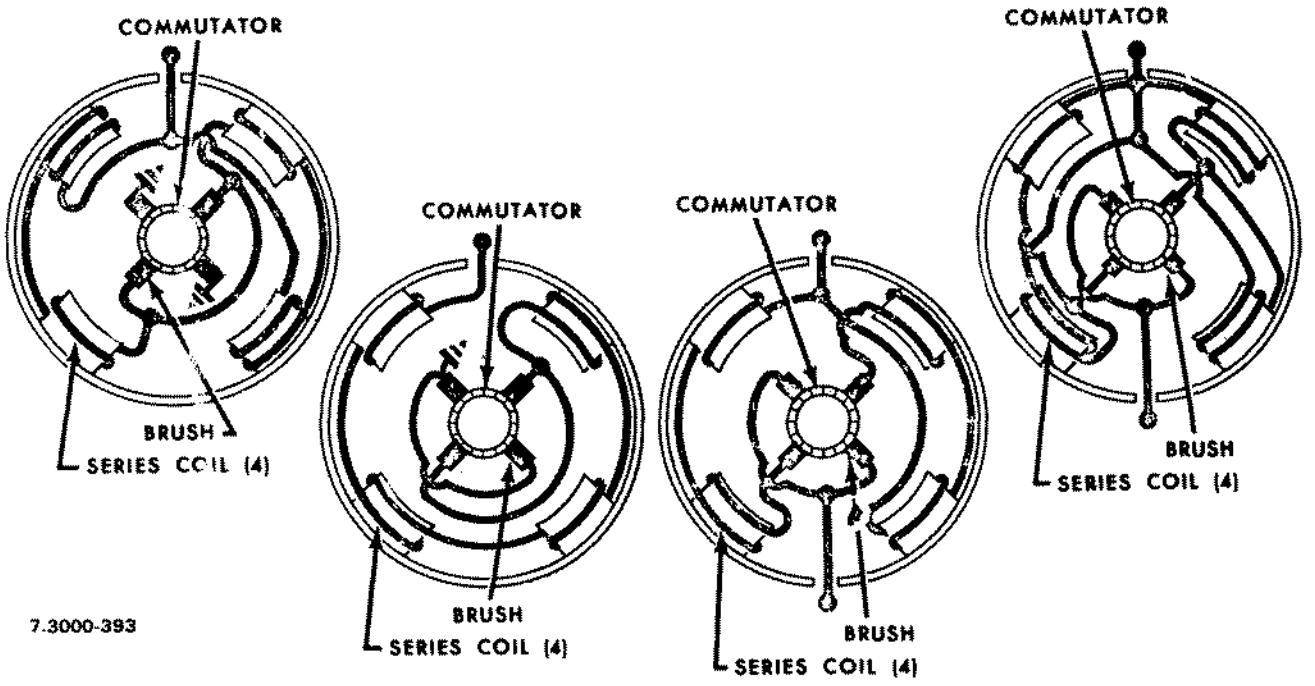
392. Grounds in the armature can be detected by the use of a 110 volt test lamp and test points. If the lamp lights when one test point is placed on the commutator with the other point on the core or shaft, the armature is grounded. Grounds occur as a result of insulation failure which is often brought about by overheating of the cranking motor produced by excessively long cranking periods or by accumulation of brush dust between the commutator bars and the steel commutator ring.

Field Coil

393. The various types or circuits used are shown in the wiring diagram below. The field coils can be checked for grounds and opens by using a test lamp.

394. Grounds: If the motor has one or more coils normally connected to ground, the ground connections must be disconnected during this check. Connect one lead of the 110 volts test lamp to the field frame and the other lead to the field connector. If the lamp lights, at least one field coil is grounded which must be repaired or replaced. This check cannot be made if the ground connection cannot be disconnected.

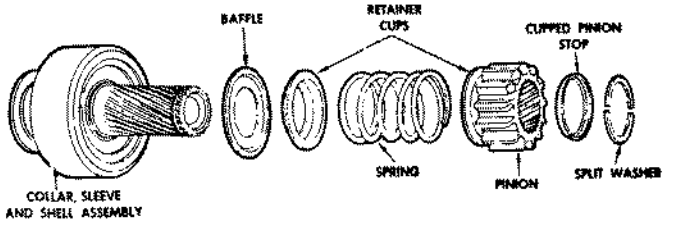
395. Opens: Connect test lamp leads to ends of field coils. If lamp does not light, the field coils are open.



396. Field coils can be removed from the field frame assembly by using a pole shoe screwdriver. A pole shoe spreader should also be used to prevent distortion of the field frame. Careful installation of the field coils is necessary to prevent shorting or grounding of the field coils as the pole shoes are tightened into place. Where a pole shoe has a long lip on one side and a short lip on the other, the long lip should be assembled in the direction of armature rotation so it becomes the trailing (not leading) edge of the pole shoe.

Clutch

397. Disassembly procedure for the heavy duty sprag clutch, illustrated below, is outlined in the following paragraphs.



398. Remove the cupped pinion stop and split washer. In removing the cupped pinion stop, it will probably be damaged, a new one being necessary on reassembly.

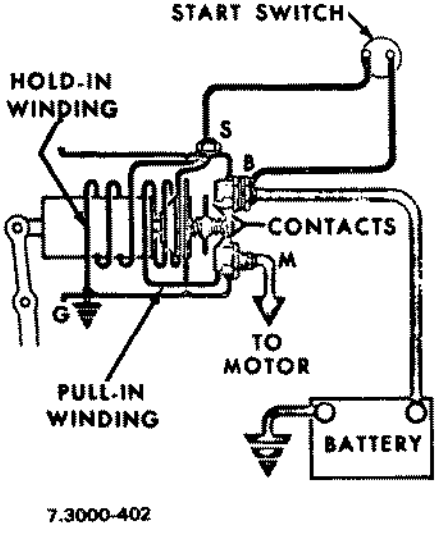
399. Remove remaining parts as illustration.

400. Do not lubricate the sprags, as they are lubricated for life with special oil at the factory.

401 Assemble in reverse of disassembly.

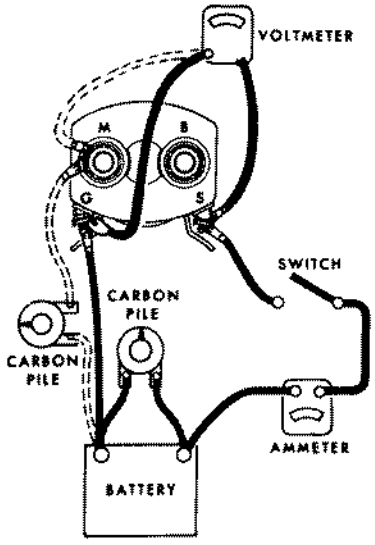
Solenoid

402. A basic solenoid circuit is shown below.



403. Solenoids may differ in appearance, but can be checked electrically by connecting a battery of the specified voltage, a switch, and an ammeter to the two solenoid windings. With all leads disconnected from the solenoid, make test connections as shown to the solenoid switch (S or SW) terminal and to ground, or to the second switch terminal (G), if present, to check the hold in winding.

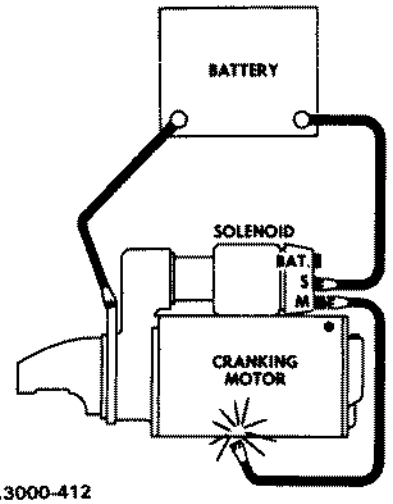
Switch Model	Rated Voltage	Current Consumption			
		Both Windings		Hold-in Windings	
		Amps	Volts	Amps	Volts
1115510	12	26-29	5	18-20	10
1119885	12	70.4-77.8	10	18-20	10
1119879	12	65.3-73.3	10	12.7-14.3	10



7.3000-403

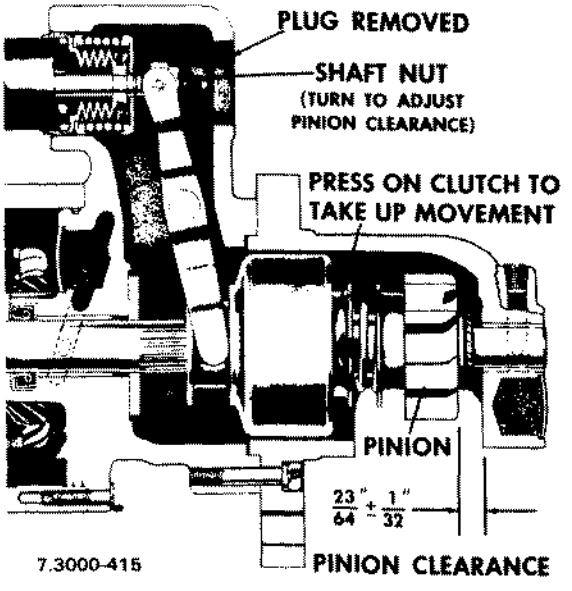
404. Use the carbon pile to decrease the voltage of the battery to the value tabulated above and compare the ammeter reading with the specifications.
405. A high reading indicates a shorted or grounded hold in winding, and a low reading, excessive resistance. To check the pull-in winding connect from the solenoid switch terminal (S) to the solenoid motor (M or MOT) terminal.
406. If needed to reduce the voltage to the specified value, connect the carbon pile between the battery and the 'M' terminal as shown in dotted lines instead of across the battery as shown in solid lines. If the carbon pile is not needed, connect a jumper directly from the battery to the 'M' terminal as shown by the dotted line.
CAUTION: To prevent overheating, do not leave the pull-in winding energised more than 15 seconds. The current draw will decrease as the winding temperature increases.
407. A magnetic switch can be checked in the same way by connecting across its windings.
408. The reassembly procedure is the reverse of disassembly.

409. All wicks and oil reservoirs should be saturated with SAE10 oil, and the splines underneath the clutch should be lubricated with a light coat of SAE 10 oil (Heavier oil may cause failure to mesh at low temperatures). Lever housings having a bearing and seal should have the grease cavity between the bearing and seal filled with Delco Remy No. 1960954.
410. Pinion clearance should be checked after reassembly to ensure it is within specification, this is shown in the following paragraphs.
411. Disconnect the motor field coil connector from the solenoid motor terminal.
412. Connect a battery of the same voltage as the solenoid, from the solenoid switch terminal to the solenoid frame or ground terminal.



7.3000-412

413. MOMENTARILY flash a jumper lead from the solenoid motor terminal to the solenoid frame or ground terminal. The drive will now shift into cranking position and remain so until the battery is disconnected.
414. Push the pinion or drive back towards the commutator end to eliminate slack movement.
415. Measure the distance between the drive and drive stop.



416. Adjust the clearance by removing the plug and turning the shaft nut.

Delco Remy MT Starters (Refitting)

417. Place the motor in position against the flywheel housing and replace the three retaining bolts and washers.
418. Connect the two leads to the ignition switch.
419. Connect the battery cables.

7.5000

POWER GENERATOR

POWER GENERATOR (DESCRIPTION)

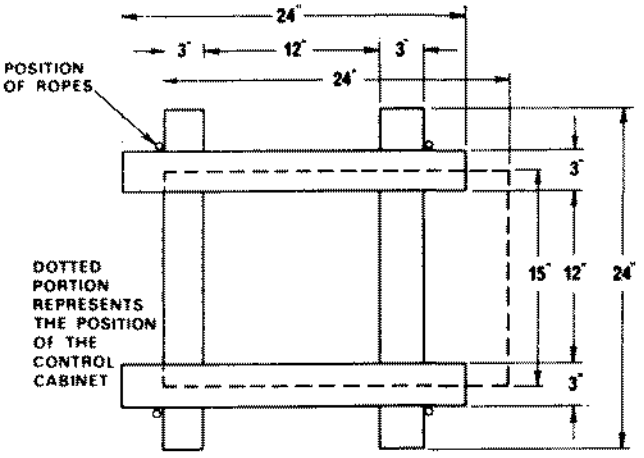
1. The alternator fitted on to the 220/330 cu in Bedford engines is rated as shown in the following table.

	RATINGS							
	50 HZ.				60 HZ			
	Stand By Output		Continuous Output		Stand By Output		Continuous Output	
	KW	KVA	KW	KVA	KW	KVA	KW	KVA
220	27	34	25	31.25	32	40	30	37.5
330	41	51.5	38	47.5	50	62.5	44	55

2. The machine is a brushless, self-exciting, ten wire, dual output, dual frequency which provides tappings for either high or low voltage, and by change to the engine governor can be operated at 50 or 60 Hertz.
3. The exciter section produces alternating current and the initial excitation is by residual magnetism retained in the stator of the exciter. The exciter field strength is controlled by an automatic voltage regulator.
4. The output from the exciter is rectified by silicon diodes mounted on a plate between the exciter rotor and the rear bearing, the resultant direct current excites the rotating fields of which there are four poles on the main rotor.
5. The voltage regulator employs semi-conductors, this includes a thyristor, transistors and silicon diodes to sense, compare and relate the output voltage to provide correct excitation for the exciter field.
6. This voltage is sensed from two phases, phase to phase, and the comparison voltage is set up by adjustment to the rheostat controlling the voltage regulator.
7. The main casing of the electrical machine is attached to the engine flywheel housing and the rotor is attached by flexible plates to the engine flywheel, whilst the rear end is supported in a ball bearing. Therefore the only moving part is the rotor within the casing, the excitation and rectification being completed within the rotor without any brushes or slip rings. The voltage regulator also has no moving parts and therefore the complete unit should be free from maintenance over a very long period.
8. Parallel operation can be simply achieved with the sets providing they were initially supplied or since modified to accept parallel operation. For parallel operation a small sub-panel including switches, fuses and synchronizing lamps are housed, together with additional parts for reactive cross current compensation which are installed in the main cabinet when required.

POWER GENERATOR (REMOVAL)

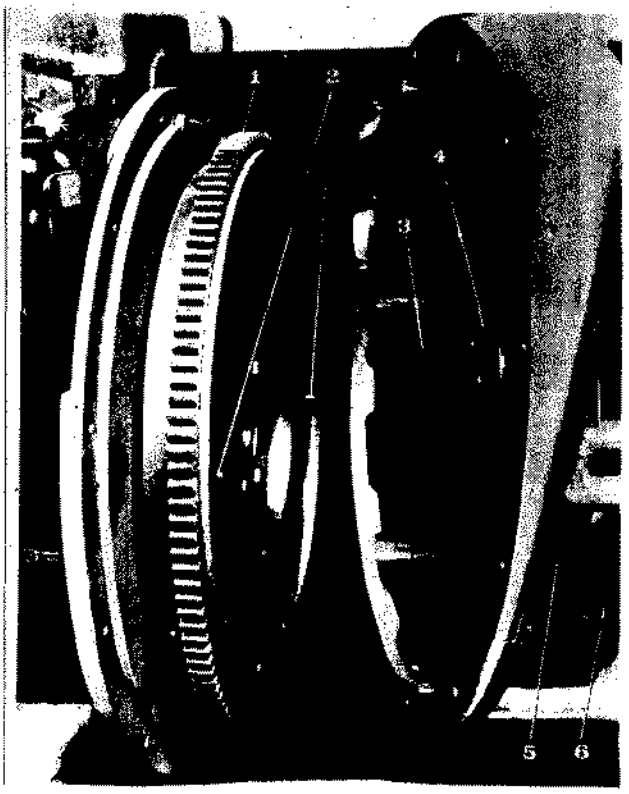
9. Ensure cables to load are not coupled to live source.
10. Remove control cabinet cover.
11. Disconnect the power cables from the cabinet.
12. Disconnect battery charging generator cables, engine throttle, oil pressure gauge pipe, engine stop control cable, starter motor, tachometer drive cable from engine end and all cables connected to the alternator terminal board.
13. Due to a change in mounting the control panel onto the alternator the removal sequence differs at this point. For engines built prior to serial number P & I 11299 on 220 cu in engines and P & I 7911 on 330 cu in engines, paragraphs 14 and 15 are applicable while for engines built after these serial numbers paragraphs 16 to 19 are applicable.
14. Remove the alternator mounting bolt nuts from beneath the skid flange.
15. Carefully position slings around the alternator frame, well spaced, and use a wooden spreader as illustrated below to keep the slings spaced clear of the cabinet.



7.5000 - 15

16. Remove the four nuts connecting the control panel plinth and remove the control panel.
17. Remove the nuts connecting the control panel plinth to the underbase and remove the plinth.
18. Insert the two lifting eyes, supplied loose with each unit, into the two lifting orifices on the sides of the alternator.
19. Attach lifting tackle on the alternator and also the rear engine lifting hook.
20. Lift the alternator carefully, approximately 40 mm (1½") until the mounting bolts, cushions and spacers can be removed. Take care to ensure no damage is done to the radiator connections and that the fan does not touch the radiator core during this operation.
21. Place wooden blocks of suitable thickness below the engine at the rear of sump. A metre length of 100×50 mm (3' 3"×4"×2") will span the skid and an additional block approximately 40 mm (1½") thick under the sump should be ideal. Lower the engine and alternator very carefully and support the weight of the alternator.

22. Remove the drive end and non drive end grill bands.
23. Remove the eight ⅜" bolts which attach the alternator fan and flexplates to the engine flywheel.
24. Slacken the twelve ⅜" bolts which secure the alternator frame to the engine back plate keeping careful watch on the weight transfer as this is done. When the engine is resting on the wood blocks and the weight of the alternator is supported on the lifting equipment remove the bolts. (Note on the early type of generator and control panels the top two bolts cannot be completely removed, due to the cabinet being still attached to the alternator.)
25. Carefully move the alternator from the engine ensuring that the flexplates come from the flywheel dowels cleanly.



7.5000 - 25

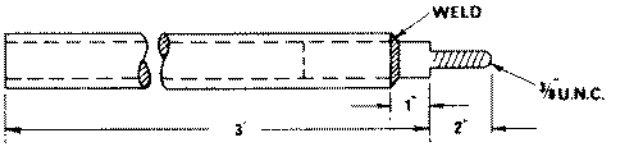
1. Engine Flywheel Assy
2. Dowel Pins
3. Dowel Hole
4. Flex Plates and Fan Retaining Bolts
5. Flex Plates
6. Fan

POWER GENERATOR (INSPECTION AND OVERHAUL)

26. During servicing of the alternator the following points should be adhered to.
27. The alternator and the exciter should be kept as clean as possible. Most electrical faults occur due to accumulation of dirt and this can easily be avoided by periodic blowing out of the dirt and dust which may gather inside the machine. If compressed air is used, care must be taken to ensure that the dust is not blown into the windings. The interior and exterior ports should always be kept free from water, oil and dirt.
28. All connections should be checked to see that none has worked loose or fractured. Examine all fuse and switch contacts and clean with fine emery cloth. Examine all fuses.
29. It should normally only be necessary to check the main stator winding at the output phase terminals, but if a fault condition should make it necessary to check the insulation resistance of other windings, the winding to be checked should be disconnected from its associated rectifier and checked separately, otherwise under certain fault conditions the transistors or rectifying diodes may be damaged.
30. The bearing is grease lubricated and packed with the correct quantity of grease by the alternator manufacturer. The bearing is packed with Shell Alvania RA, unless otherwise stated on the machine. Where the machine is to be operated in ambient temperatures below freezing point, or above their rated ambient temperatures, the grease manufacturers should be consulted.
31. The automatic voltage regulator unit is fitted in the control panel on early engines and at the rear of the frame on later engines, this coupled with the fact that the components are liberally rated, provides a unit which should give trouble free operation and require no maintenance other than an occasional check to ensure that all connections are tight and serviceable. The hand regulator is of the torroidal slide wire type and an occasional wipe over with petroleum jelly will keep it in good condition.

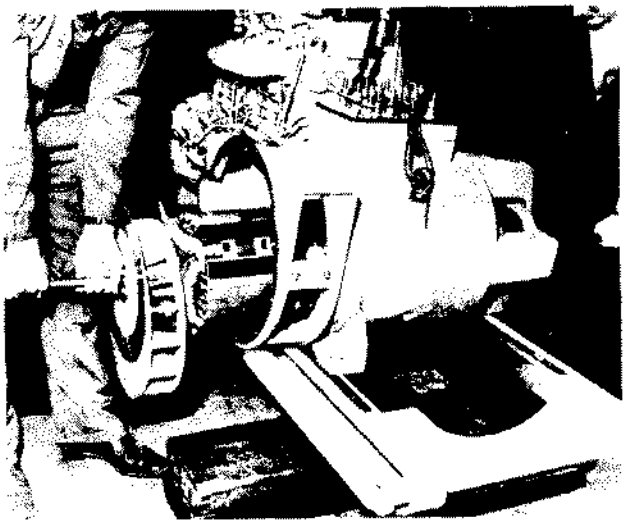
DISMANTLING

32. Remove the end cover plate located at the extreme end from the engine. Insert lifting bars into the tapped holes in the rotor shaft, the lifting bar (PI ST 1) should be manufactured locally to the dimensions given below.



7.5000 - 32

33. Lift the rotor at the fan end and pull out of the stator frame until the bearing is free of its housing.
34. Support the weight of the rotor with the lifting bar and then pull the rotor out clear of the stator frame taking care that the rotor cores do not rub on the stator windings or the rotating rectifier is not damaged whilst doing so.
35. Failure to support the rotor during dismantling and reassembly may cause serious damage to windings. Care should be taken to avoid damage to the rotating rectifier which is mounted on the rotor shaft.



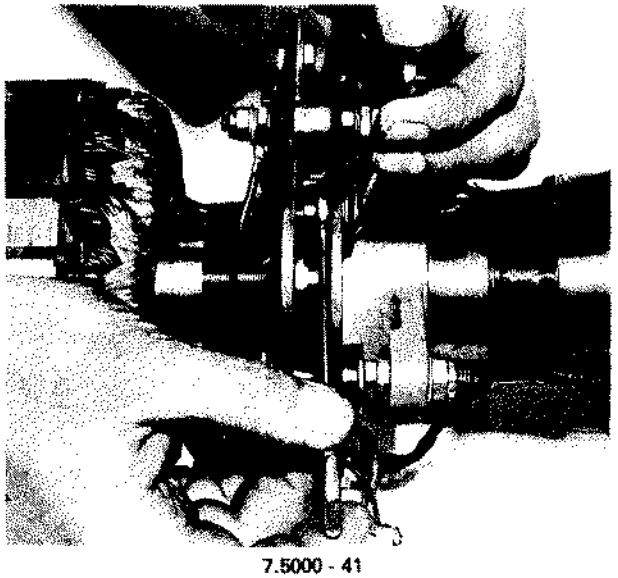
7.5000 - 34

ALTERNATIVE METHOD OF REMOVING ROTOR (PARAGRAPHS 36, 37 & 38)

36. Carefully lift alternator to rest on its rear end with wedges to ensure it does not tip.
37. Fit lifting eye with a ⅜" UNC thread in the drive end and carefully lift the rotor out of the frame.
38. Extreme care is necessary to ensure that the frame does not tilt during this operation.

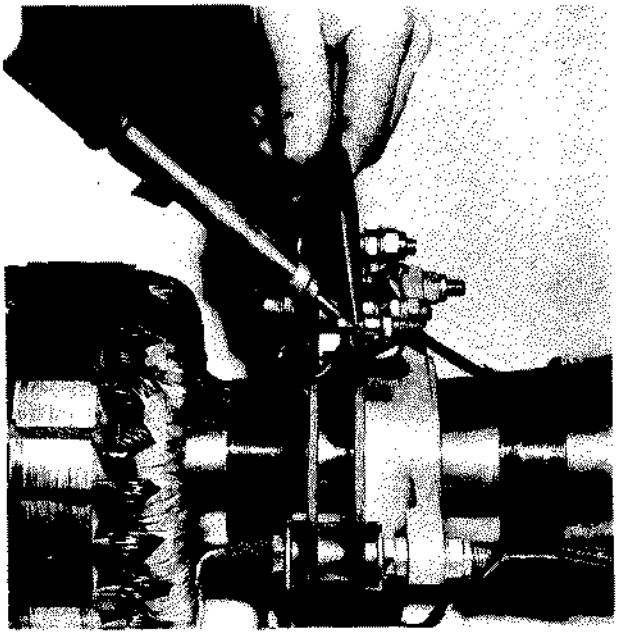
INSPECTION

39. Check the bearing for wear and replace if necessary.
40. A faulty diode in the rotating rectifier assembly can be removed and tested as follows:
41. Using two open ended spanners, remove the retaining nut.



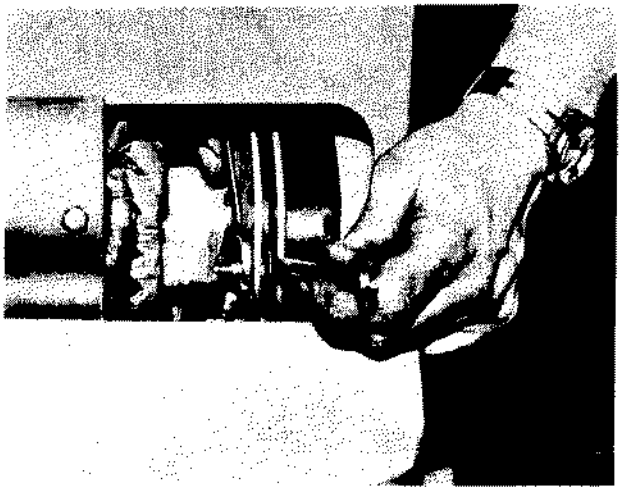
7.5000 - 41

42. Pull the diode clear from the rotating rectifier.
43. Holding the diode with a pair of long nose pliers unsolder the connection. The pliers should act as a "heat sink" during this operation.



7.5000 - 43

44. Using a "Multimeter" check the resistance as described under AVR static tests, and replace where necessary.
45. Diodes can be replaced without removing the rotor assembly from the alternator, by removing the non drive end grill.



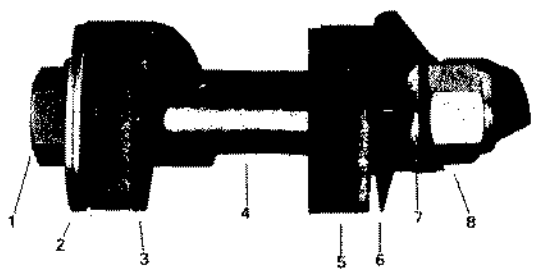
7.5000 - 45

REASSEMBLY

46. Attach the lifting bar to the rotor and lift into the alternator. Two persons are required for this operation. Care should be taken to avoid damage to the rotating rectifier which is mounted on the rotor shaft.
47. Remove the lifting bar.
48. Refit the end cover and grill band.
49. Secure the flexplates to the rotor with the six securing lock bolts and tighten to a torque of 54 Nm (40 lb ft).

POWER GENERATOR (REFITTING)

50. Ensure engine is securely blocked slightly up at rear to running attitude relative to the skid frame.
51. Lift the alternator onto the skid frame. On the earlier engines do not attempt to lift with slings passed underneath the control cabinet. Slings must only be placed underneath the alternator and the wooden spreader placed above the cabinet between the slings to prevent crushing the control cabinet. Line up alternator flex disc to engine flywheel, do not remove slings from alternator.
52. Align dowel holes in the flex discs to the dowels on the flywheel, care should be taken at this point as it must be remembered that the dowels differ in size, should the flex discs fail to engage with the flywheel dowels, it may prove necessary to rotate the engine 180°, ensuring first that the stop control is in the stop position, also ensure that none of the flex discs are engaged with dowels on the flywheel.
53. Fit the alternator to the rear engine plate and secure with the twelve ⅜" bolts, tighten to a torque of 48 Nm (35 lb ft).



7.5000 - 53

Alternator Mounting Bolt Assembly.

1. Bolt
2. Two Spacers
3. Rubber Washer
4. Tube Spacer
5. Rubber Washer
6. Wedge Shaped Washer
7. Spring Washer
8. Nut

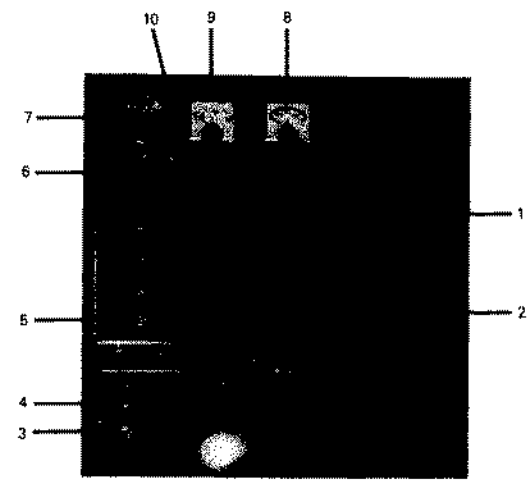
54. Fit the rubber washers under the base of the alternator feet, place the other rubber washers above the feet. Assemble the bolts, washers and spacers and position through the rubber washers, alternator feet and skid base. Fit the remaining washers and nut and tighten until the washers touch the tube spacers.

NOTE. On later engines item 6, the wedge shaped washer, has been deleted.

55. Tighten the bolts which secure the flex discs to the flywheel to a torque of 48 Nm (35 lb ft).
56. Check the air gap between the rotor and stator conforms with the table below, using long feeler gauges.

ENGINE	MAIN	EXCITER
220 cu in	0.025" NOMINAL	0.025" (0.018 MINIMUM)
330 cu in	0.042" NOMINAL	0.025" (0.018 MINIMUM)

57. On later engines refit the control cabinet and plinth as described under section 7.6000.
58. Inspect all internal fittings and rotating rectifier for possible damage, reinstall grill bands and bearing cover.
59. Before applying the set to a job it is essential to ensure that the correct frequency will be provided by the engine governor so that the engine can operate satisfactorily at synchronous speed, ie 1500 RPM = 50 Hertz, 1800 RPM = 60 Hertz. Secondly, it is essential that the terminal linkage within the cabinet be connected to provide the correct voltage since the machine stator has star windings with centre taps, which permits the windings to be individually run in series or parallel.
60. Before connecting driven equipment or buss bars it is essential to ensure that phase rotation is correct, normally these are numbered 1, 2, 3 or in colour coding, red, yellow or white, blue. The correct phase rotation is essential if motors connected are to be driven in the correct direction, also it is the first essential of enabling the set to be paralleled with any other set. For instructions on changing frequency or voltage see pages 00 to 00 of 7.6000.
61. If extended storage is unavoidable, the unit should be kept in a dry, warm atmosphere and to prevent the grease pitting within the bearing an occasional rotation should be made. Should it be suspected that the unit has been subjected to damp the insulation resistance of the main stator winding should be checked and if this is less than 1 Megohm (1,000,000 ohms) the equipment should be slowly dried out until this insulation resistance is achieved. The other windings within the equipment operate at low voltage, therefore it should not normally be necessary to check the insulation resistance of these.
62. **WARNING.** Before putting the engine into operation the earthing arrangements should be checked and the neutral lead properly attached. Should a large proportion of the load to be driven be of single phase it would be necessary to ensure equal sharing between the three phases of the machine since out of balance loads will create overloading at below the rated output of the equipment.
63. **STARTING.** Once the initial installation has been checked and the correct connections made preparation to run the prime mover can be made.
64. Annotations in the following paragraphs refer to illustration 7.5000 - 64.



7.5000 - 64

65. Ensure main breaker switch, item (1) is in the off position.
66. If this is the initial start, turn voltage regulator control (2) to a minimum position, fully anti-clockwise.
67. Set engine governor stop control (3) to "run" position.
68. If initial start, set throttle control (4) to midway position. Depress knob in centre of control, pull outer knob to desired position and release centre. Fine adjustment can now be made by turning knob anticlockwise to increase speed and clockwise to decrease speed.
69. Operate the key switch (5) to crank engine and when it fires check that oil pressure (6) is present.
70. If this is the initial start of the unit, leave engine operating at approximately 1500 RPM for a few moments and check for coolant, lube oil, or fuel oil leaks.
71. Run engine to synchronous speed as indicated on frequency tachometer (7) and if time permits allow speed to settle to remove the chill from the cooling system.
72. Set voltage 2% over required load voltage and frequency at 2 C.P.S. above that required if it is intended to take over more than ¾ load on switching in, proportionally lower setting for ½ and ¼ load and exactly on frequency and voltage for loads of less than ¼.
73. Ensure that no personnel are engaged on lines and switch main breaker (1) to "on" position, check voltage and frequency and adjust as necessary by use of voltmeter (8) and frequency meter (7), the load in amperes should be checked by reference to ammeter (9) and each phase should be checked in turn by use of the selector (10). (No attempt should be made to operate in parallel without the necessary additional apparatus.)
74. Further slight adjustment may be required when the engine alternator and regulator have achieved normal working temperatures.

STOPPING

75. Open the main breaker and shut engine down (3). It can be harmful to operate loads at lower than correct synchronous speed, on engines built prior to serial number 893. This is due to the voltage regulator attempting to provide sufficient excitation to maintain the voltage whilst the speed may be low and the iron laminations within the unit will be unable to provide the necessary magnetic field under these conditions and heavy current will flow and cause overheating quite rapidly.

PARELLELING

76. Successful parallel operation can only be achieved if all of the engine governors are of the same characteristic, and it is advantageous to utilise sets of similar alternators and voltage regulators. It is necessary with the GM Bedford Alternator Set to request paralleling equipment which aids synchronisation and is capable of sharing reactive loads equally between alternators.
77. All sets being paralleled require this equipment which can be provided for an existing set.
78. Check phase rotation of buss to which set is to be connected. Various terms are used but phase 1-2-3 or A-B-C or red, yellow or white, blue, are often the local standard. If in doubt connect a 3 phase induction motor to the output and check its direction of rotation relative to a known set of leads.
79. Follow the starting instructions, paragraphs 62 to 70.
80. Switch all units to parallel run.
81. Close the synchronising lamp switches.
82. Units under load - check frequency of units running on load at 50 or 60 C.P.S. whichever is applicable.
83. Adjust voltage on coming set to correct level.
84. Observe the synchronising lamps alternating bright and dim in rotating pattern, adjust engine governor control to slow the rate of change to minimum and when a steady period of darkness exceeding ten seconds has been repeated three times, place hand on breaker (1) and at commencement of next dark period on upper lamp, count five seconds, close breaker.
85. Switch off synchronising lamps.
86. Adjust engine governor control (4) to indicate each set providing proportional share of load by ammeter (9).
WARNING. On no account should the voltage regulator control be varied whilst parallel operating sets.
87. To shut down, open main breaker (1) and stop engine with stop control (3).
88. **NOTE.** The foregoing instructions should enable anyone to put the machine on the line but individual circumstances and operating techniques may vary and providing the operator is familiar with the type of equipment concerned no harm will result.
89. For the ultimate in efficiency it is essential that each phase carries equal load and if practicable the single phase loads should be as similar as possible including reactive content.
90. For parallel operation each machine should be operated on the proposed load separately to obtain the best reactive droop resistor setting and ensure that engine governors behave similarly.
91. Should a fault appear during the starting and switching procedure refer to trouble shooting on page 0 of section 7.6000.
92. **WARNING.** The voltage occurring within the cabinet can in certain circumstances be lethal, therefore, due precautions should be observed. If it is necessary to work within the cabinet whilst it is "live", it is suggested that one hand only should be used to reduce accidental contact risks from affecting the respiratory nervous system. Remember voltage from line to earth or neutral can be dangerous in addition to line to line voltage.

7.6000

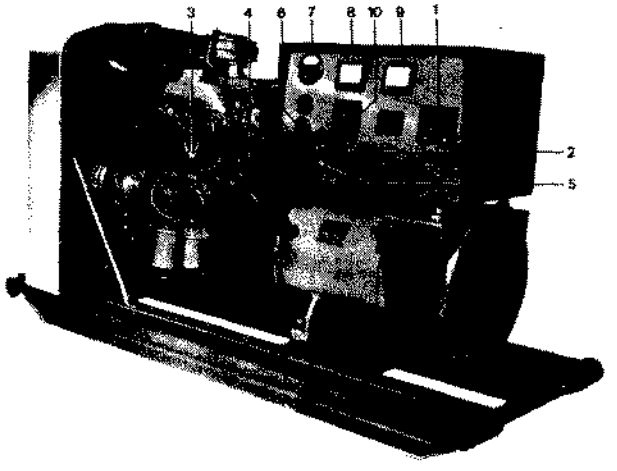
CONTROL PANEL

CONTROL PANEL (DESCRIPTION)

1. A drip proof sheet steel cabinet is mounted on vibration absorbing feet to a sheet steel plinth which in turn is attached to the skid base. The sides of the control panel are interchangeable, enabling the instruments to face either left, right or to the non-drive end of the alternator. On engines prior to P & I 11299 (220 cu in) and P & I 7911 (330 cu in) the cabinet vibration absorbing feet were mounted directly onto the alternator and the sides were not interchangeable but it could be mounted with the instruments facing left or right.

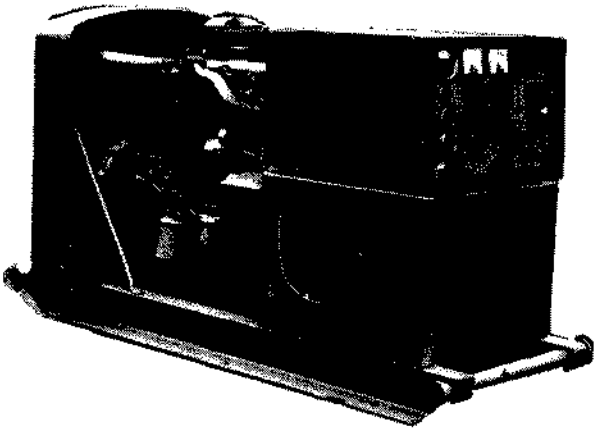
2. The engine and alternator controls, voltage selector and instruments are mounted within the cabinet, on the earlier engines, current transformers and the AVR printed circuit board were also mounted inside the cabinet. The early design is shown in 7.6000 - 2(a) and the later one is shown in 7.6000 - 2(b).

3. **The cabinet houses four distinct electrical circuits:-**
   a. Battery charging generator, voltage regulator and engine instruments.

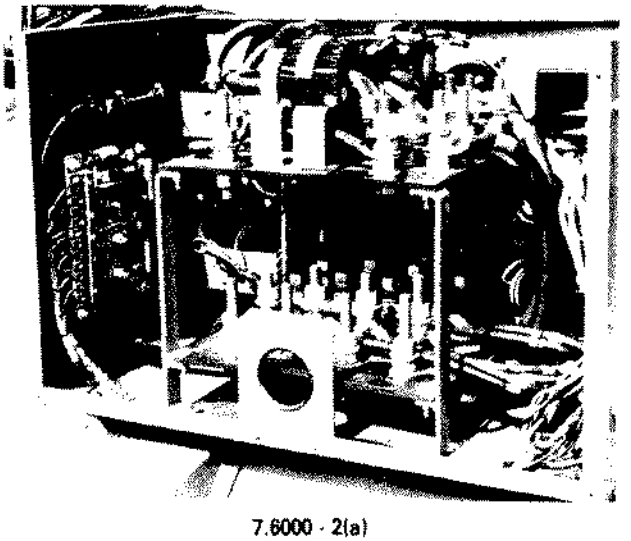


1 MAIN BREAKER
2 REGULATOR CONTROL
3 ENGINE STOP / RUN
4 ENGINE SPEED CONTROL
5 ENGINE START SWITCH
6 OIL PRESSURE GAUGE
7 FREQUENCY METER
8 VOLTMETER
9 AMMETER
10 AMMETER SELECTOR

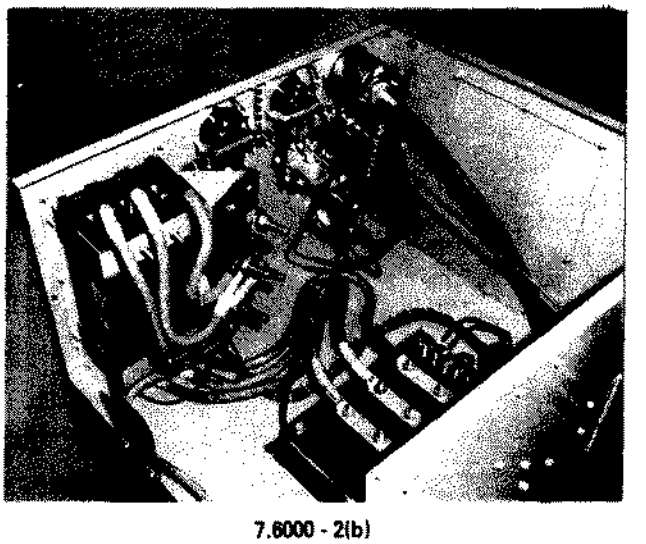
7.6000 - 1(a)



7.6000 - 1(b)



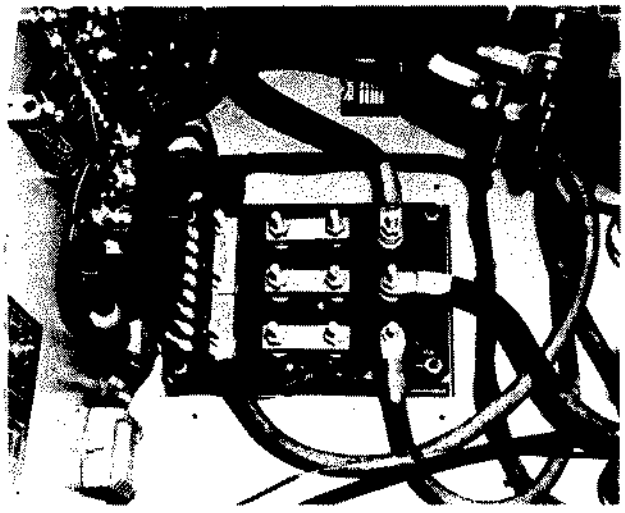
7.6000 - 2(a)



7.6000 - 2(b)

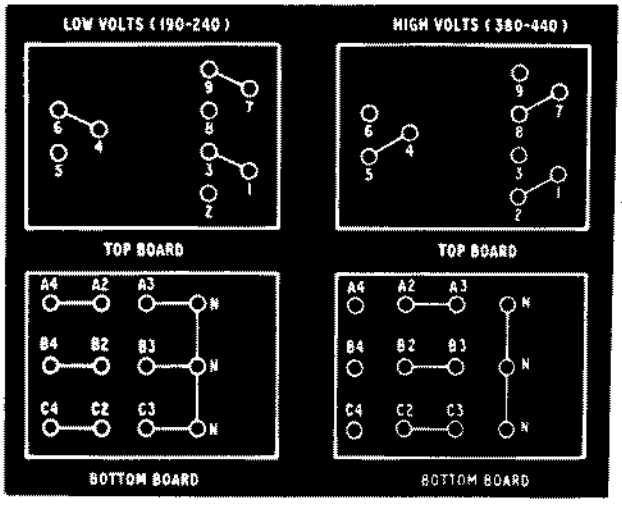
b. Alternator terminal board for voltage selection and output.
c. Alternator voltage regulator, controls and instrumentation.
d. Output switching and overload protection.

4. The four electrical circuits are described in detail in the following pages.
5. The battery charging generator, voltage regulator and engine instruments. For the description and servicing of these components refer to sections 7.1000 and 7.4000 of this manual.
6. Alternator terminal board for voltage selection and output. Earlier units utilised two terminal link boards, one above the other, with copper links connecting the terminals. The top board was for current transformer selection while the lower was for voltage selection. On the later units only the voltage selection board is used, illustrated below.



7.6000 - 6

7. To change from high to low voltage or vice-versa the procedure in paragraphs 8 to 12 should be followed. The terminal links for high and low voltage are shown below.



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REWORKING THE LOWER PANEL (ALL UNITS)

8. Ensure the engine cannot be started.
9. Remove the cabinet cover which is secured by eight screws.
10. Remove the nuts and washers from the terminals and move the straps to the setting required.
11. Replace the nuts and washers.
12. This change connects the alternator stator windings in the appropriate manner.

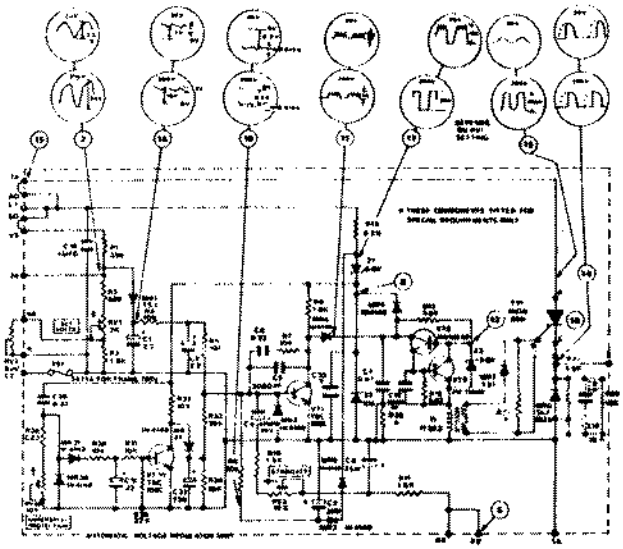
REWORKING THE UPPER PANEL (EARLY UNITS ONLY)

13. The procedure is the same as for the lower panel except for the position of the straps. This change ensures that the current transformers for ammeter and overload trip have the correct number of primary turns, ie one or two turns.

AUTOMATIC VOLTAGE REGULATOR

14. The automatic voltage regulator is of the phase-controlled thyristor type. For the purpose of description, it will be considered under the following headings:
a. Voltage sensing and comparison circuit.
b. Trigger pulse timing circuit.
c. Power switching circuit.
d. Stability feedback.
e. Underspeed protection.

15. Annotations in the following paragraphs refer to illustration 7.6000 - 15.



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VOLTAGE SENSING AND COMPARISON CIRCUIT

16. The line-to-line voltage of the alternator under control is sampled, from the lower voltage tap, via the potential divider network, R1, R2, RV1, RV2 and R3. The potential divider ratio, and hence the voltage at point A, is varied by means of RV1 and RV2, R3 limits the range of voltage setting available at RV2. The voltage at point A, which is proportional to alternator voltage is half wave rectified by MR1 and smoothed by the two stage filter C1, R4 and C2.

17. The voltage across C2 is compared, via R5 with a fixed negative reference voltage across C3, injected via R6, any voltage difference at the point is the "error" voltage which is used to control the alternator voltage level. The fixed reference voltage is obtained from Z1, the supply to Z1 and Z2 is obtained via the dropper resistor R13 from the same AC line as feeds the thyristor TY1 for correct phasing. The resultant wave form is an approximate negative - going square wave across Z1 and a positive-going square wave across Z2. The negative voltage across Z1, plus the forward voltage drop across Z2 (which provides temperature compensation of the total voltage) is smoothed by C3, MR3 preventing discharge of C3 when the zener voltage reverses.

TRIGGER PULSE TIMING CIRCUIT

18. The positive going square wave across Z2 is used to charge capacitor C7 via R8 and MR4 and also via R9. Transistor VT1 controls the rate of charge C7 by acting as a shunt path for the charging current, the current flow through VT1 being controlled in turn by the "error" voltage supplied to its base from the comparison circuit.

19. The configuration of R8, R9, MR4 and VT1 helps to improve the linearity of the charging rate on C7, and the network C5, C6, R7 provides negative AC feedback which reduces the gain of VT1 particularly at high frequencies, in order to eliminate exaggeration of ripple appearing on its base. MR5 allows discharge of C7 at the end of each positive half-cycle. The voltage across C7 has, therefore, a positively sloping ramp waveform over the positive half-cycle of the supply, followed by a quick discharge of approximately zero over the negative half-cycle. This voltage is applied to an avalanche connected transistor pair, VT2 and VT3, the break-over voltage being set approximately by the zener diode Z3. When the avalanche voltage is reached, capacitor C7 is discharged rapidly through T1, giving a pulse at the secondary of T1 which occurs at a point in the half cycle determined by the time taken to charge C7 to the avalanche voltage, which in turn depends on the error voltage of the comparison network and hence on the machine voltage. Thus, a high machine voltage will retard the firing angle of the thyristor and a low machine voltage will advance the thyristor firing angle giving a low and high mean field voltage respectively. Hence, for any setting of RV1 and RV2 and equilibrium position will be reached at which the field current supplied by the thyristor maintains the alternator output voltage at that pre-set voltage in spite of loading and heating effects.

Power-Switching Circuit

20. The main power control element of the AVR is a Controlled Rectifier or Thyristor TY1, operating in single phase, line-to-line, half-wave configuration in series with the field. It is fed direct from the same line as R13 for correct phasing, in this case A phase. The cathode is connected to the positive end of the field, the negative end being connected to B phase via R14. A flywheel path round the field and R14 is provided by MR6 which allows current to flow when TY1 is in its blocking state.

Stability Feedback

21. The voltage appearing across R14 is directly proportional to the current flowing in the field. Ripple is reduced by the filter R11, C8 and the resultant D.C. voltage is fed through R10, RV3 on to the base of the control transistor VT1 via C4. Thus, when the field current increases the voltage on the base of VT1 will increase transiently, retard the firing angle and reduce the rate of increase of field current, conversely a decrease in field current is also limited transiently. This negative A.C. feedback has no effect on steady state conditions.

Underspeed Protection

22. In order to cater for special conditions a low frequency unloading circuit is used. This senses drop in the engine speed below a pre-set minimum and droops the alternator voltages with falling speed below this pre-set value. This drooping voltage is proportioned so that the alternator is not provided with sufficient excitation to damage it when run below the rated speed.

23. Normal governing for the alternator sets will be 4% speed droop from no load with transient speed excursions during run up and full load switching of approximately ±10% of rated speed. If the low frequency unloading circuit is energised by transient speed changes by switching load on the alternator it will worsen the transient voltage excursions produced by the alternator for normal load switching. To prevent this, the low frequency unloading circuit (frequency droop) is provided with a built-in, time constant, time delay so that it will not adversely affect the alternator voltage transient performance for load switching up to full load.

24. It is possible for the set operator to override the frequency droop circuit, by a small amount, by turning up the external panel mounted, voltage trimming potentiometer RV2, available under normal operations. The main voltage setting potentiometer RV1 which is mounted on the printed circuit board should be carefully pre-set as per the instructions below.

SETTING UP THE LOW FREQUENCY UNLOADING CIRCUIT

25. Turn Low Frequency Unloading Circuit Potentiometer (RV30) fully anticlockwise. This ensures that the frequency droop equipment is out of circuit.

26. With the governor set for rated speed and with the AVR in circuit (that is, AVR fuse in) do a normal (not slow) run up of the Alternator to rated voltage. (If a slow run up or operation at low speed governor setting is required, the AVR should first be disconnected by removing the AVR fuse.)

27. Set the panel voltage control (RV2) to give maximum Alternator voltage; then adjust back this voltage on the coarse voltage setting potentiometer on the AVR printed circuit card (RV1) so that the maximum voltage is within the voltage rating on the machine nameplate for the particular frequency in use. Do not allow the machine voltage to rise by more than 5% above maximum nameplate voltage for frequency used during the setting up procedure. Use RV2 and RV1 in sequence and in small steps to

prevent this. For normal operation the maximum voltage available on the panel control RV2 should not be more than 5% above nominal running voltage.
28. Set Alternator speed for 2% below rated full load speed and Alternator voltage to rated, turn low frequency unloading circuit potentiometer RV30 slowly clockwise till the Alternator voltage falls by 1%. Remember the Low Frequency Unloading Circuit will take about 2 seconds to respond to the adjustment of RV30. Allow the Alternator voltage to settle for 10 seconds to ensure that the setting is correct.
29. Reduce engine speed to 90% of its full load rated speed to check that the setting of the L.F.U. unit is correct. The Alternator voltage should fall to approximately 90% of the set voltage at rated speed if the setting is in order.

AVR 6 TROUBLE SHOOTING

30. **AVR 6 Ratings**

30.1 Maximum ambient temperature 52°C (125.6°F).
30.2 Maximum continuous DC exciter current 3.5 amps.
30.3 Maximum overload forcing current in exciter field 6 amps DC 1 minute rating.
30.4 Maximum continuous AC input voltage to AVR 264 rms.
30.5 Maximum continuous AC input voltage to comply to Canadian Standards Association specifications 250 volts AC rms.
30.6 Maximum field voltage output for 264 volts AC rms output 117 volts DC 1 minute rating.

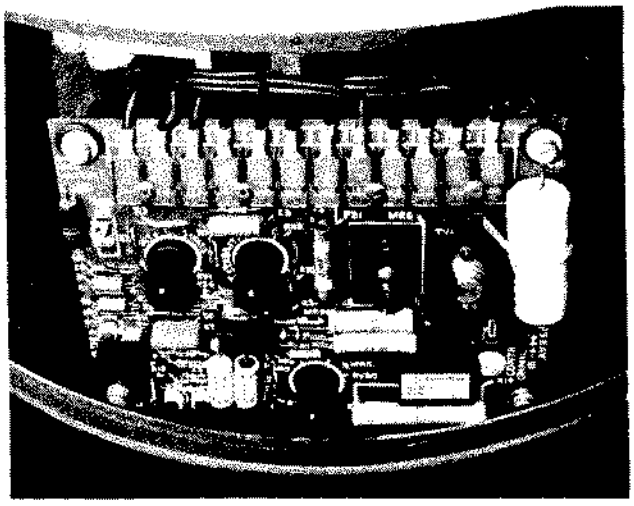
FAULT FINDING CHART

SYMPTOM	POSSIBLE CAUSE	ACTION
Alternator will not generate	a. Alternator Faulty	Check alternator excitation against test sheet
	b. AVR Fuse Blown	Remove AVR from machine and test on jig
	c. Wiring to AVR Faulty	Check against schematic and wiring diagrams
	d. Machine Residual Voltage too low	Check against test sheet
Alternator Voltage too high	a. RV1 or RV2 Wrongly Set	Adjust RV1 or RV2
	b. AVR Faulty	Remove AVR from machine and test on jig
	c. AVR Wiring Faulty	Check and repair
Alternator Regulator Poor	a. Alternator Faulty	Check Excitation against test sheet
	b. AVR Faulty	Remove AVR from machine and test on jig
	c. R23 Wrongly Set	Reset R23
	(Machines fitted with short circuit maintenance unit)	
Fuse FS1 Blown	a. RV1 or RV2 set too high for Alternator Voltage	Reset RV1 or RV2
	b. MR6 Faulty	Replace MR6
	c. TY1 Faulty	Replace TY1
	d. Alternator Faulty causing Alternator to require too much excitation	Check Alternator excitation against test sheet
	e. C9 Short Circuit	Replace C9
Req. Voltage Setting Not Available from RV1	a. Fault in C1, C2, C4, Z1 or Z2	Replace faulty components
Alternator Unstable	a. RV3 Wrongly Set	Reset RV3
	b. RV3 Open Circuit	Replace RV3
	c. C4 Open Circuit	Replace C4
	d. C8 Leaking	Replace C8

31. From (30.3) above it can be seen that AVR 6 is only rated to provide full output for 1 minute. This 1 minute forcing rating provides the alternator with overload capacity in excess of full load for motor starting.
It also ensures good forcing levels to give fast transient response to load switching. When testing AVR 6 on the test rig this should be borne in mind. If full conduction is maintained on AVR 6 for more than 1 minute the voltage across the MR6 diode will be equivalent to that occurring, on the machine, during peak forcing. This means that resistor R14 (if fitted) will be subject to about twice the voltage that would normally appear across it in the machine, with the machine loaded to full load current. If the voltage across R24 is 2 times normal, the watts in it will be 4 times normal. It will, therefore, overheat very rapidly if the AVR is held at full conduction for more than 1 minute.
32. The test rig artificial field load (R41 + L1) is approximately 2 times the field resistance of the alternator on which the AVR will work. The AVR test rig output current is, therefore, limited to approximately the maximum continuous rating of the exciter field current (30-2) 3.5 amps DC. This is done intentionally to prevent FS1 blowing during test rig working.
33. Therefore, on test rig testing the DC current output of the AVR is limited but the voltage is not. Hence full output should not be maintained on the AVR on the test rig for more than 1 minute or R24 will overheat.
34. The AVR fuse is in the AC input line to the AVR. It is rated at 2.5 amps AC. This may appear strange since it is less than the continuous rating of the exciter field current. The reason is that the thyristor TY1 rectifies the AC current and the resultant DC current is smoothed by the exciter field inductance to give a DC field current which is larger than the rms current in fuse FS1. With 2.5 amps AC rms in FS1 the DC field current is over 3.5 amps.
35. Fuse FS1 will blow if the alternator demands too much excitation or is given too much excitation.
36. If (a) the voltage setting potentiometer RV1 and/or external trimmer RV2 have been set correctly so that the alternator gives the rated voltage (or less) at rated speed, and if (b) RV3 has been set correctly to provide under-speed protection by automatically lowering the alternator voltage as the speed falls, then the excitation current will fall as the speed falls (except, for a small rise at speeds just below the rated value) and the alternator can be run at low speeds without any adverse effects and without blowing FS1. However, if RV3 is not set correctly to give this under-speed protection, the excitation current will increase excessively at low speeds and the fuse FS1 will blow. Also, if RV1 and RV2 are set to give too high voltage, the machine will demand too high an excitation and the fuse will blow. In either case, the blowing of the fuse FS1 prevents the overheating of R24 in normal service.
37. The fuse will also blow if the AVR fails to a full conduction condition or a short circuit develops in TY1, T1, MR6, R24, C9 or C10.
38. The fuse is not intended as a complete protection for the semi-conductors used in the AVR. However, it does protect the machine against over-excitation due to an AVR fault, and also limits the damage on the AVR board, by disconnecting the faulty AVR from the machine.
39. Overload protection for the machine is provided by over-current devices at the machine output in the cabinet.
40. If the machine is to be run at low speed for engine adjustment or test, please ensure that the under-speed protection is in operation so that as the speed falls the alternator voltage is not in operation or is not effective enough, under-speed potentiometer RV30 should be set correctly according to the method described in paragraph 28.
41. The under speed protection is provided by a circuit built into the AVR. This circuit has an overriding control of the AVR so as to automatically reduce alternator voltage with falling speed, and this prevents saturation and the resulting dangerously high excitation.
42. When changing alternator winding connections or operating frequency, it is important to remember that the AVR operating voltage setting is changed. When such changes are made or when a new AVR is fitted always turn down the RV1 control of the AVR to minimum voltage before running the machine. (RV1 fully counterclockwise.) When the machine is running at rated speed RV1 should be turned slowly clockwise to give the required operating voltage. Failure to do this may cause the machine to run at too high a voltage and FS1 may be blown by the high field current at high voltage.

AVR Static Tests

43. The following equipment will be required when conducting these static tests:-
    a. Cathode ray oscilloscope DC coupled vertical amplifer DC - IM c/s band width capable of withstanding signal input voltages up to 290 volts AC rms.
    b. 20,000 ohm/volt multimeter, Avometer model 8 or similar.
44. Whilst these tests are being conducted the alternator can still be operated manually by supplying the exciter field via a series resistor and half wave rectifier. See section "Emergency Voltage Control".
45. The AVR forms a separate part of the cabinet assembly and should a fault develop in this unit the performance of the machine will be greatly impaired. To determine whether or not the unit is operating correctly the following static tests should be carried out.
46. Disconnect and remove the printed circuit board assembly from either the cabinet or the alternator frame.
47. Check the resistance values of the internal volts set potentiometer (RV1) and stability potentiometer RV3. These should be 2 kilohms and 10 kilohms respectively.
48. The resistance of the external volts set potentiometer (RV2) should be checked, if fitted, to be the value marked on the back. Using an Avometer Model 8, the forward and reverse resistance of the flywheel



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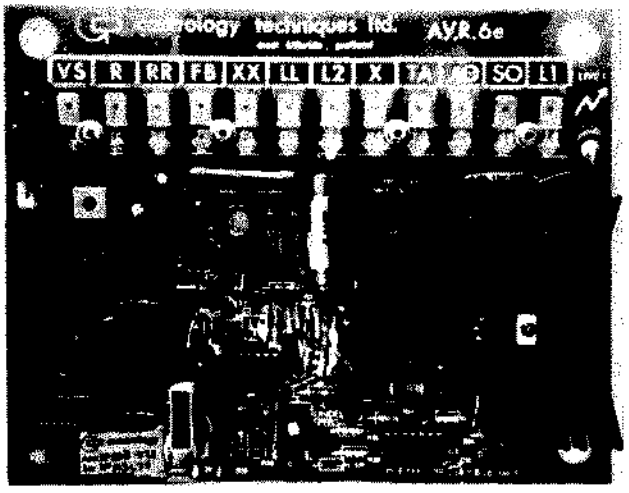
TEST APPARATUS COMPONENTS LIST	
Schematic Ref.	Description
V1	A.C. voltmeter 0.300 volt rectified moving coil type.
A1 & SH1	0-5 amp DC shunt with suitable meter, Avometer or similar, 20,000 ohms per volt.
SW5	Single pole on-off switch 5 amp 300 volts A.C.
R40	1-5 ohms ± 10% 60 watt resistor (Berco type VWHK3)
R41 + L1	L1 100 MH D.C. choke rated 3 amp D.C. the total D.C. resistance of L1 + R41 to be 30 ohms R41 to be rated to carry 3 amps D.C. continuous.
TV1	Variac transformer - 230 volt 2.5 amp for 230 volt supply or 115 volt 5 amp for 115 volt supply.
T4	Isolating transformer primary to suit. Supply voltage secondary rated 280 volt 2.5 amp A.C. for half wave rectified supply (D.C. in transformer). No load to full load regulation to be 7% electrostatic screen required between primary and secondary.
F2 & F4	2.5 amp H.R.C. fuse for 230 volt A.C. supply. 5 amp H.R.C. fuse for 115 volt A.C. supply.
F3	2.5 amp H.R.C. fuse.
SW4	2 pole single throw switch rating 250 volt A.C. 10 amps.
K1	Int rectifier Selenium Klipsel type KSA10DBF.

diode (MR6) and the thyristor (TY1) should be checked. These can be measured on terminals LL (MR6 anode), X (MR6 cathode), TA (TY1 anode) and X (TY1 cathode). The diode should have a low forward resistance (about 1000 ohms) and a high reverse resistance (greater than 100 kilohms) and the thyristor a high resistance (greater than 100 kilohms) in both directions. These values may be different when use is made of ohmmeters of different makes. If these values are not closely obtained the device(s) should be replaced.

49. Check the fuse FS1 (12 LL) when fitted. If no fuse is fitted check the foil pattern for damage. If damage has occurred, the board must be replaced.

50. Check the AVR resistances in order as shown in fig 7.6000 - 50 and repair where fault is in evidence.

NOTE. The resistance readings are obtained with all external leads to the AVR terminal board removed. The readings being made using Avometer Model 8 multimeter on the "ohms" range.



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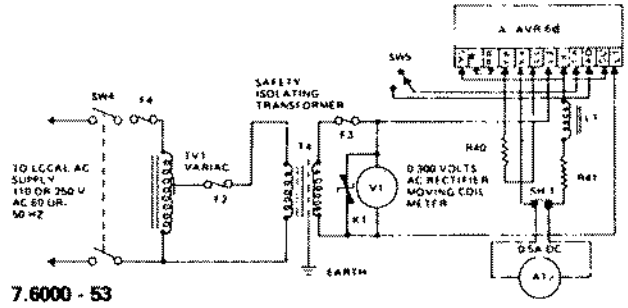
51. The resistance readings given are subject to at least ± 10% variation with unit life and component tolerance.

52. The red avometer lead is connected to the numbered terminals to obtain these resistance readings.

53. Connect the AVR to a test rig (7.6000 - 53). Open SW5 and connect the oscilloscope between terminal 12 and the cathode of MR4 (test point 11 of 7.6000 - 50). Set TY1 to zero and check FS1.



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54. Switch on SW4 (mains supply) and turn up "Variac" TV1 to give 20 volts on V1, check waveform on oscilloscope as shown in 7.6000 - 15. If this is not correct check the waveform at test points (2), (10), (16) and (17) to locate the fault. If the fault is still not located remove the board from the test rig and measure the corresponding resistances.
55. When the waveform at test point (11) is as 7.6000 - 15, turn up TV1 to give 200 volts on V1 and check the waveform again is as 7.6000 - 15. This waveform should be controllable in phase by RV1 and should be as below.

56. Check that the waveform as B can be obtained at V1 voltages of 170 volts and 260 volts A.C. by adjustment of RV1. If not check or replace Z1 and Z2.
57. Set TY1 to zero. Close SW5 and connect the oscilloscope between L2 and test point (14). Set variac at 20 volts and check that waveform is as 7.6000 - 15. If not check back to test point (11) and check, or replace T1, MR7, R24 and TY1.
58. Note that the waveform at TY1 should be D, and not E. If the waveform is as E, fit R24 if not already fitted or select a TY1. Set TY1 down in voltage and make sure the waveform of D is obtained between 12 and 16 volts. This may require a selection of TY1 for low holding current.
59. Take a condition of 30° conduction on thyristor TY1.

60. Set TY1 to 120 volts on V1 then to 260 volts. Ensure that under both conditions the waveform of F can be obtained by adjustment of RV1.
61. Remove AVR board from test rig as components C4, R10, RV3, C8 and R11, cannot be properly tested on the test rig. Check these carefully by resistance. Give any new components and newly soldered areas of the printed circuit board a coat of clear polyurethane varnish for protection.
62. The stability must now be set on the alternator as described below:-
63. RV3 can only be optimised in setting on the alternator. It is a stability control and affects the type of transient voltage response that the alternator gives to load switching. With RV3 fully anti-clockwise, the alternator will go into a continual hunting oscillation. With RV3 fully clockwise the machine may be over-damped in response. For most machines a setting of RV3 approximately 10° back from the fully clockwise condition will be sufficiently close to optimum.
64. If difficulty is experienced on site, it is suggested that a D.C. voltmeter be connected between terminals X and LL of the AVR to monitor exciter field voltage. This voltage should be monitored when the machine has a 1 P.F. load of at least 30% of its rating switched off. A flicker on this meter will indicate continuous servo oscillation. On throwing off load, the voltmeter reading will dip then rise again to the new value of excitation required by the alternator on no load. If the alternator is under-damped the meter could take 2 or 3 swings to stabilise out. RV3 should be adjusted to give recovery in the minimum number of swings without a continuous flicker indicating system servo oscillation.
65. **WARNING.** During site tests of the type described above, it may be possible, with gross mis-setting of RV3 to produce alternator output voltage swings that could be dangerously high for electronic loads, incandescent bulbs and similar voltage sensitive loads. Such tests, therefore must be performed on loads which will not be damaged by voltage surges.
66. It is also essential that the meter used to monitor exciter field voltage has a sensitivity of at least 1 k.ohm per volt and is not in itself under-damped. If it is under-damped, it's swings when settling can be confused for field voltage swings.
67. On units built after June 1977, AVR6e replaced AVR6d. The main features of the new AVR are the use of improved components to give greater overall reliability and improved voltage stability over a wider temperature range and the removal of high powered resistors from the printed circuit board. In addition the feedback resistor is not required, a signal is fed from a component on the printed circuit board.
68. The AVR6e may be used as a spare part to replace any earlier AVR6 models. The underspeed setting-up procedure, however, differs slightly and should be carried out as described in paragraphs 69 to 74 inclusive.
69. Set the underspeed potentiometer fully anti-clockwise.
70. Set the engine to rated full load speed to give nominal frequency, ie 1500 RPM for 50 HZ and 1800 RPM for 60 HZ machines.
71. Turn the underspeed potentiometer slowly clockwise until the light emitting diode (LED1) lights.
72. Turn underspeed potentiometer very carefully anticlockwise until LED1 just goes off.
73. Set volts and stability controls can be adjusted as for earlier engines.
74. When fitting AVR6e in place of earlier models it is not necessary to remove the 1.5 ohm feedback resistor R14 connected across terminals FB and LL.

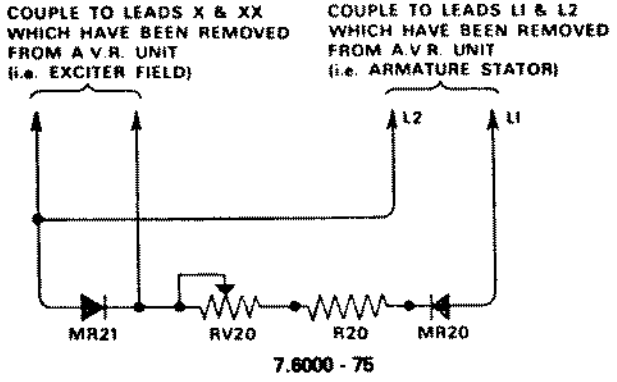
Emergency Voltage Control Equipment

75. In using this equipment it must be ensured that the AVR is completely disconnected and all unused AVR connection leads are thoroughly isolated from each other. Also that they are carefully supported clear of the windings and rotating members of the Alternator.

a. MR20 and MR21 (3354159) are 6 amp 800 volt PIV silicon diodes mounted on suitable heat-sink.

b. R20 (3354160) rating 10 ohm 3 amp Ballast resistor.

c. RV20 (3354161) rating 400 ohm. Variable resistor graded 3 amp to 0.2 amp.



76. N.B. This excitation scheme is manual and RV20 must be used to make manual adjustment of excitation each time the load is changed.
77. Standard generator sets fitted with "Murphy" shutdown equipment and/or synchronising cross current compensating and reverse power protection equipment should have the following additional tests.

Murphy Shutdown

78. **Low Oil Pressure.** Test by "shorting" the gauge pointer contact to the low contact. Generator Set must shutdown.
79. **High Water Temperature.** Test by "shorting" the gauge pointer contact to the high contact. Generator set must shutdown.
80. **Overspeed.** Test by "shorting" the tachometer pointer contact to the high contact. Generator Set must shutdown.
81. **Circuit Reset.** Must be operative by depressing lub oil gauge reset and Murphy 117 relay reset buttons in sequence.
82. **Switching Off** of key switch must de-energise shutdown solenoid and shutdown engine.

Cross Current Compensating Equipment

83. Equipment should be tested for correct polarity of current transformer as follows:-
84. An inductive load must be connected to alternator set and set should be run up to normal voltage and frequency. With Single/Parallel Switch in "Single" position close breaker and record volts. Then throw Single/Parallel Switch to "Parallel" position and record volts. Voltage should droop 3 to 4% of initial recorded levels.
85. If volts rise reverse secondary connections to current transformer.
86. Adjust droop resistor centre tap to obtain correct voltage droop.
87. Test voltages for the above should be as follows:

Frequency	Initial Voltage Setting ("Series" Position)	Final Voltage ("Parallel" Position)
50 Hz	220 V Line to Line	211/214 V Line to Line
	or 440 V Line to Line	422/428 V Line to Line
60 Hz	240 V Line to Line	230/233 V Line to Line
	or 480 V Line to Line	460/466 V Line to Line

Synchronising Equipment

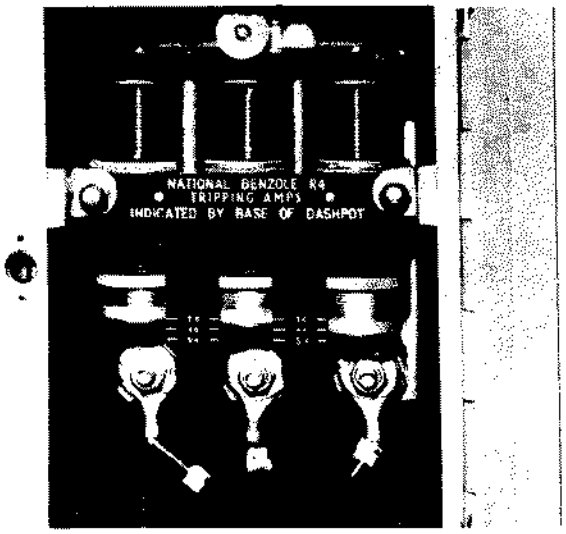
88. Equipment must be tested by the operation of two generator sets connected in parallel on the load bank. The following procedure applies:-
89. With breakers open run up Sets 1 and 2 and ensure normal operating temperature.
90. Set nominal load of 20 kW on load bank and close breaker of Set 1. Then adjust line to line voltage to that specified on Sales/Work Order. Record voltage and frequency. Open breaker.
91. Repeat paragraph 90 for Set 2 ensuring that on the load voltage and frequency are the same as for Set 1.
92. Throw both single/parallel switches to "parallel" position.
93. With Set 2 only on load switch on synchronising lamps of Set 1. A revolving pattern of flashing lights should be observed. Adjust throttle control of Set 1 until the rotating sequence of lights slows down to the point when the upper lamp is extinguished. When the upper lamp remains dark for a period of 10 seconds each cycle wait for the next dark period, count 5 seconds and close breaker. Load sharing can now be adjusted by small adjustments of the throttle controls.
94. Load should now be increased to full to check performance and load share.
95. Repeat 93 and 94 with Set 1 initially running and synchronising in Set 2.
96. **NOTE.** If during initial parallel load testing one or both sets trip shortly after being put onto load this may be due to incorrect polarity connections to the reverse power relay current transformer (RPRCT). In the event of this try reversing the connections S1 and S2 to this transformer.
97. **IMPORTANT.** Under no circumstances should either generator set circuit breaker be opened whilst they are running in parallel on full load.

Reverse Power Protection Equipment

98. Set percentage (%) reverse power to 10%.
99. Set time delay TC to 5 seconds. (Full scale represents 20 secs.)
100. The next steps are to check the operation of the reverse power relay.
101. Set the load on the load bank so that it does not exceed the full load capacity of one generator set only.
102. Reverse the secondary connections of the reverse power relay current transformer (RPR CT) S1 and S2 on Set 2 only.
103. Repeat procedure for paralleling given under "Synchronising Equipment" beginning by putting Set 1 on load. After the breaker of Set 2 is closed the set should stay on load for only the time set on Tc, ie about 5 seconds and the breaker will trip. Nominal adjustments can be made of Tc if necessary.
104. The reversing of the secondary terminals S1 and S2 or the RPR CT simulates a reverse power condition. The load must be restricted to less than the capacity of one set so that set is not overloaded at any time.
105. Change the terminal connections back on Set 2 and repeat the procedure on Set 1. (Thus making Set 1 become Set 2 and vice-versa.)

Output Switching and Overload Protection

106. Output switching and overload protection comprise of a triple pole unit with 3.6 amp to 5.4 amp coils and changeover contacts, hand reset.



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107. It is necessary to arrange for current to pass once or twice through the current transformers so that the current sensed by the ammeter and overload trip is equivalent to the high and low voltage selections. This means that at high voltage the current is directed through the current transformers twice whilst at low voltage only once.

108. The following data gives the oil dashpot overload settings corresponding to the standby outputs. The figures assume a standby load at 0.8 power factor.

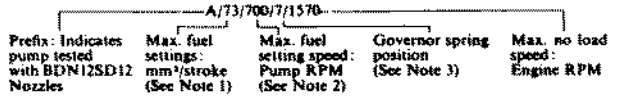
MODEL	KVL (Standby)	VL (Volts)	FLC (Amps)	CT Ratio	O/L Setting Current (Amps)
220G	40	480	48	100:5	4.8
	10	416	55.5		5.4
	40 40	203 240	111 95		5.4 4.8
	34 34	380 440	51.5 44.5		5.1 4.4
	34 34	220 190	89 103		4.4 5.1
330G	62.5 62.5	480 416	75 86	150:5	5.0 5.4
	62.5 62.5	208 240	173 150		5.4 5.0
	51.5 51.5	380 440	78.5 68		5.2 4.5
	51.5 51.5	220 190	135 156		4.5 5.2

CHANGE OF FREQUENCY

109. The frequency at which the current alternates is governed by the speed of rotation of the field which is coupled directly to the flywheel of the engine, no reduction gears being employed. For a 4 pole rotor used in the alternators a driving speed of 1500 RPM will result in 50 hertz or an input speed of 1800 RPM will result in 60 hertz. It will now be realised that the frequency output is relative to engine speed, therefore adjustment to the engine governing is required.

110. On mechanically governed DPA pumps, as fitted on Bedford engines, the setting data must be obtained from the pump nameplate.

Example of Setting Code:



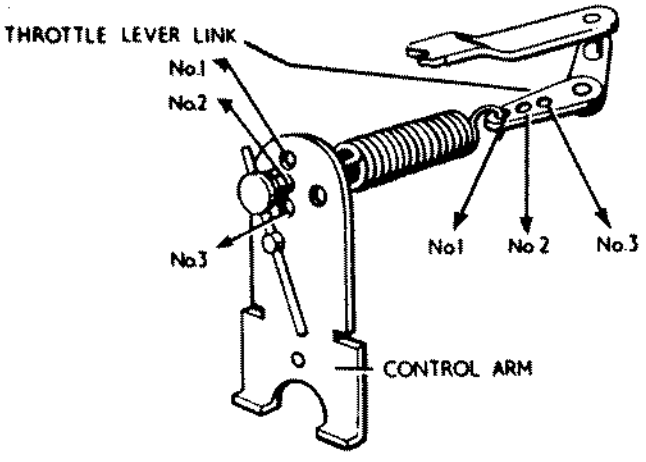
111. Note: 1 (Max fuel setting). The maximum fuel setting code is given in mm^3/stroke and must be divided by 5 to obtain the setting value in c.c./200 strokes.

112. Note: 2 (Max fuel setting speed). The figure given in the code indicates pump RPM which must be used for setting the maximum fuel above.

113. Note: 3 (Governor spring position). The numbers 1 to 9 will be used to indicate the various spring positions as shown in the following table.

Code	Control Arm	Throttle Arm
1	1	1
2	1	2
3	1	3
4	2	1
5	2	2
6	2	3
7	3	1
8	3	2
9	3	3

114. An example of the governor main spring positions is shown below. The example shows the governor spring in position 4 of the table.



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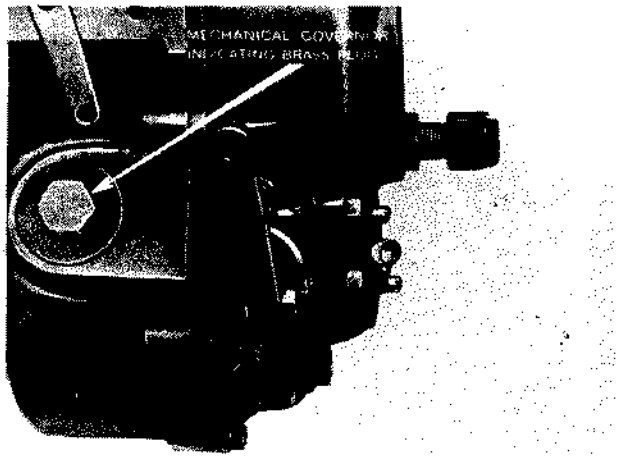
115. The procedure for re-working the governor is as follows:
116. Remove the shut-off lever, throttle lever and the two governor cover retaining nuts and washers.
117. Carefully lift the cover from the pump.
118. Adjust the governor spring position to the required setting from the governor spring setting chart.
119. Using a new gasket, replace the governor cover, and refit the two retaining nuts and washers. Tighten to a torque of 4.5 Nm (40 lb in) if a permanite gasket is used or 3.4 Nm (30 lb in) if a cork gasket is used.
120. Replace the throttle lever and shut-off lever and tighten the retaining nuts to a torque of 3.4 Nm (30 lb in).
121. Check the engine RPM.
122. Remove and discard the governor identification plates and fit a new plate giving the relevant details.
123. On early 330 cu in engines, inline fuel injection pumps with mechanical governors were fitted. The procedure for reworking these governors is as follows.
NOTE. It is not sufficient to adjust the throttle lever vernier control from 1800 RPM down to 1500 RPM, since the 1800 RPM springs will not provide adequate governing at 1500 RPM.
124. Remove the brass plug from the governor housing, this will permit access to the governor springs.



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125. Rotate the fuel pump until the governor spring retaining nut is in a direct line with the aperture in the governor housing.
126. Remove the retaining nut using CAV key part number 7044-65. Care must be taken that the springs do not fly out when removing the retaining nut. Remove the upper spring plate, also the outer spring, inner spring support and lower plate from the governor weight, with the exception of spring support (inner spring), these parts can be discarded. The spring support can be identified by virtue of the fact that it is manufactured from the thinnest gauge of material, also it is the spring of the smallest diameter.

GOVERNOR RE-WORK CHART

	60 C.P.S. 1800 r.p.m. 4%	50 C.P.S. 1500 r.p.m. 4%
Retaining Nut Setting	Flush + ½ Turn Down	Flush + 1 Turn Down
Governor Rework Kit	6397412	6397414
Plate, Lower (2)	6334230	6334230
Plate, Upper (2)	6371728	6371730
Spring, Inner (2)	6371732	6371726
Spring, Outer (2)	6361175	6361175
Plate, Governor Identification (1)	6380525	6380530
Rivet, Plate (2)	6380521	6380521

127. Select the replacement spring set from the chart and refit to the governor weight, assemble the new components in the reverse order to that in which the original springs were removed. Take care that the upper spring plate is correctly located on the flats of the threaded portion of the stud which is fitted to the governor.
128. Fit the retaining nut and tighten according to the instructions given on the spring selection chart.
129. Rotate the governor weights until such time as the unmodified governor weight spring is opposite the hole in the housing and repeat the steps detailed in paragraphs 125, 126, 127 and 128.
130. Check the engine R.P.M.
131. Remove and discard the governor identification plates, fit a new plate giving the relevant details.