## 3.0000
## AIR SYSTEM SPECIFICATIONS

### AIR CLEANER

| Type | Manufacturer |
|---|---|
| Standard - Oil Bath | A.C. |
| Heavy Duty - Centrifugal/Oil Bath | A.C. |
| Marine - Wire Mesh | A.C. |

### TURBOCHARGERS

| Type | Manufacturer |
|---|---|
| FO1 | CAV |
| 3LD | HOLSET |

| | |
|---|---|
| Bearing End Float (CAV) | 0.1 mm - 0.3 mm (0.004" - 0.012") |
| Piston Groove Thrust Wear (CAV) | 0.1778 mm (0.007") maximum clearance |
| Shaft Concentricity Test (CAV) | 0.005 mm (0.0002") maximum eccentricity |
| Clearance Between Turbine Blades and Exhaust Outlet (CAV) | 0.2794 - 0.6096 mm (0.011" - 0.024") |

### TORQUE WRENCH DATA

| | |
|---|---|
| Manifold retaining bolts | 18-20 Nm (13-15 lb ft) |
| Turbocharger Impeller (CAV) | 14 Nm (10 lb ft) |
| Shaft Nose Nut (CAV) | 11 Nm (8 lb ft) |
| Turbine Casing Bolts (CAV) | 8.5 Nm (75 lb in) |
| Compressor Casing Bolts (CAV) | 8.5 Nm (75 lb in) |
| Locknut (Holset) | 17.6 Nm (13 lb ft) |
| Compressor Casing Bolts (Holset) | 6.8 Nm (5 lb ft) |
| V Clamps Locknut (Holset) | 13.6 Nm (10 lb ft) |

# SECTION 4

## LUBRICATION SYSTEM

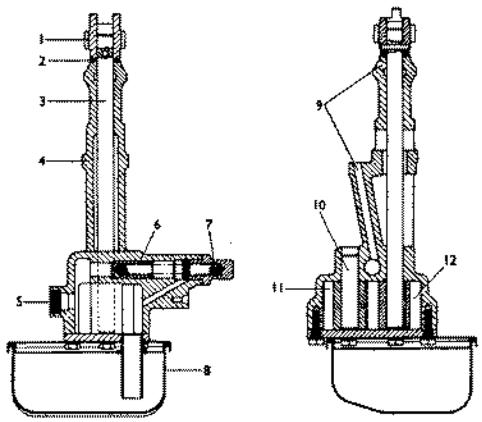
**Contents**

## 4.1000

## OIL PUMP

**Oil Pump (Description)**

1. Lubrication is by forced feed system embodying full flow filtration. Oil is circulated through the system by a gear type pump mounted in a boss on the right hand side of the crankcase.
2. The pump is driven by a skew gear integral with the camshaft. The pump driving spindle is carried direct in the bore of the pump body and has a helical tooth impellor pressed and keyed to its lower end. The driving impellor meshes with the driven impellor, which rotates freely on a spindle pressed into the pump body. A bottom cover bolted to the pump body incorporates a suction pipe and gauze screen.



4.1000-2

1. Driving gear
2. Thrust washer
3. Driving impeller spindle
4. Pump body
5. Delivery port
6. Relief valve plunger
7. Spring
8. Gauze screen
9. Driving gear and spindle oil feed drillings
10. Driven impeller spindle
11. Driven impeller
12. Driving impeller

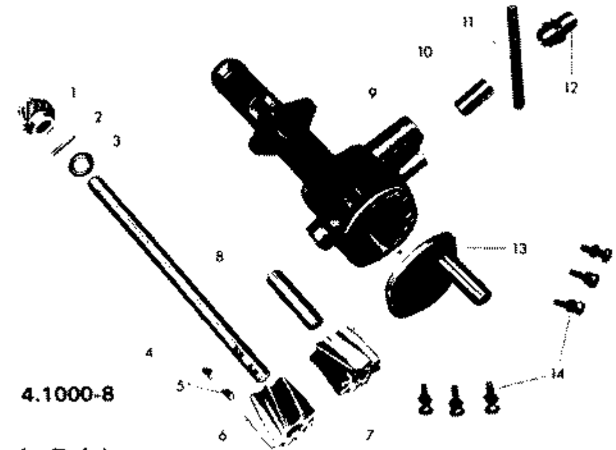
3. A spring loaded oil pressure relief valve is incorporated, and a pipe connects the delivery port to a vertical drilling in the crankcase which leads to the oil filter.

**Oil Pump (Removal)**

4. Remove the oil pan as detailed in 4.7000.
5. Unscrew the delivery pipe from the crankcase.
6. Remove the two fixing bolts and washers and withdraw the complete pump assembly.

**Oil Pump (Inspection and Overhaul)**

7. Remove the oil delivery pipe from the pump body.
8. Prise up the gauze retaining clips and remove the screen. Unscrew the bolts securing the screen retainer, cover the suction tube to the pump body and remove the screen retainer with the screw and suction tube.



4.1000-8

1. Driving gear
2. Gear rivet
3. Thrust washer
4. Driving impeller spindle
5. Driving impeller keys
6. Driving impeller
7. Driven impeller
8. Driven impeller spindle
9. Pump body
10. Relief valve plunger
11. Spring
12. Relief valve plug
13. Cover and suction tube
14. Cover attaching bolts

9. Examine the machined face of the cover for wear or scores. If the wear or depth of scoring is not excessive the cover can be refaced.
10. Using a flat bar and feeler gauges check the end float of the impellers in the body which should be between .002″ and .005″.

4.1000-10

11. With the aid of feeler gauges check the radial clearance of the impellers in the body. This should be between .0015″ and .0035″.


12. Again with the aid of feeler gauges, check the backlash between the impeller teeth which should be between .003″ and .010″.


13. If in any of these checks, the limits are exceeded the pump should be dismantled and parts renewed where necessary.
14. Prior to dismantling the pump, mark the end of the impellers to identify them when reassembling.
15. Withdraw the driven impeller and spindle.
16. Drive out the rivet securing the driving gear to the spindle and using a soft metal drift, tap the spindle out of the gear. This will enable the driving impeller and spindle to be withdrawn from the body.
17. Unscrew the relief valve plug and withdraw the spring and plunger.
18. All components should now be inspected for wear.
19. The driving spindle bores in the body should be examined for wear by checking the clearance of an unworn part of the spindle.
20. Examine the oil pressure relief valve plunger, and the plunger bore in the body for wear or scores. The plunger should slide freely without slackness. The clearance in the bore should be .0007″ to .0025″.
21. The valve spring should be examined for damage and its free length and rate should be checked. The free length should be between 4.42″ and 4.45″, and with a load of 17 to 18 lbs. it should be 2.58 inches.
22. Examine both impeller spindles, impeller teeth and the end faces for wear and scores. The driven impeller spindle should be a press fit on the body. If there is any sign of slackness, renew the spindle and if necessary the pump body.
23. To renew the driven impeller spindle, drive out the old spindle from outside the impeller chamber, then press in the new spindle until its outer end is 1/64 inch below the cover attaching face.
24. To renew the driving spindle or impeller, press out the spindle and transfer the two keys to the new spindle. Align the keys with the keyway in the impeller and press on the impeller until its end face is flush with the end of the spindle. If the existing impeller is being refitted remove any burrs or roughness from the teeth with a fine carborundum stone. After stoning remove all traces of swarf. Ensure that the face previously marked will be towards the bottom of the pump when refitting.
25. Examine the driving gear for worn or chipped teeth and the thrust face for scores. A new thrust washer must be used when refitting the gear.
26. Lubricate the spindles with mineral oil containing colloidal graphite and install the driving impeller spindle into the body.
27. The driving spindle can now be installed, when this operation is being performed the lower end of the spindle must be held against a dolly of lesser diameter than the impeller bore, otherwise the spindle may be pressed further through the impeller. This could cause the spindle to foul the pump cover or create misalignment of the rivet holes, if the original spindle is to be reinstalled.
28. When a new driving impeller spindle is being installed, use a 3/16 inch diameter drill for drilling the rivet hole. Refit the gear rivet, check that the driving spindle end float is within .003″ to .006″ and stake the gear rivet.


29. Ensuring that the previously marked face is towards the bottom of the pump, install the driven impeller.

30. Refit the relief valve plunger, spring and plug. Replace the cover and screen retainer and tighten the six securing bolts to a torque of 6-8 lbs. ft. Refit the screen by pressing the screen retaining clips back into position.
31. Refit the oil delivery pipe.

**Oil Pump (Refitting)**
32. Place the oil pump into position and secure with the two bolts tightening to a torque of 13-15 lbs. ft. Screw the delivery pipe to the crankcase.
33. Replace the oil pan as detailed in 4.7000.

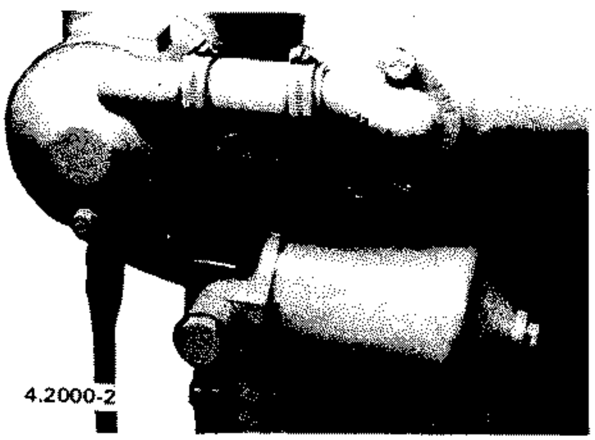
## 4.2000

## LUBRICATING OIL FILTER

**Lubricating Oil Filter (Description)**

1. The AC full flow oil filter is fitted directly to the cylinder block with four screws, the lubricating oil passing through oilways in the cylinder block. However, on engines fitted with a lubricating oil cooler, a cast adaptor is fitted to the block in a position normally occupied by the filter. The filter is fitted to the adaptor and then the whole assembly is fitted to the cylinder block using four longer screws.

2. On marine engines a cast adaptor is fitted to the block in the position normally occupied by the filter. The filter is then fitted to a bracket attached to the front end of the water cooled exhaust manifold. Oil pipes are led from the adaptor block attached to the cylinder block to the filter.



4.2000-2

3. The filter incorporates a spring loaded ball valve in the outlet port which allows oil to by-pass the filter element should it become choked.

4. A hole is tapped into the filter head to accommodate a pressure switch for use with the low oil pressure warning lamp.

**Lubricating Oil Filter (Removal)**

5. Thoroughly clean the area around the oil filter assembly.

6. Disconnect the electrical connections to the pressure switch, if fitted.

7. Remove the four screws which secure the filter to either the cylinder block or the adaptor and lift out the filter from the engine.

Note: On 220 engines prior to serial number P & I 1350 and 330 engines prior to serial number P & I 1900 only two securing screws were used.

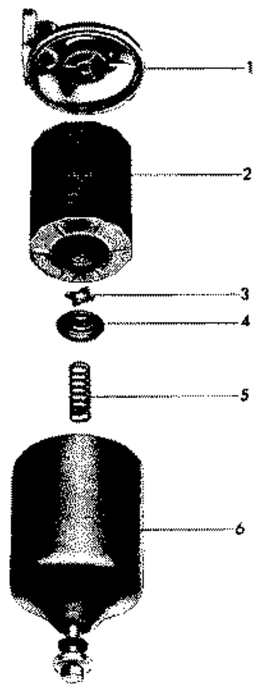
8. On marine engines, the filter inlet and outlet pipes should be disconnected after provision has been made to catch any oil in the system. The two filter retaining nuts, bolts and washers should next be removed and the filter lifted from the engine.

**Lubricating Oil Filter (Inspection and Overhaul)**

9. There are no moving parts in the lubricating oil filter assembly except the relief valve. The inspection, therefore, consists of a visual check for damage caused by knocks, mis-assembly of shell into head or over-torqued centre bolt.

10. The filter element must be changed every 200 hours.

11. Unscrew the filter casing centre bolt and withdraw the casing and element assembly. Hold the casing upright to avoid spilling of oil.




4.2000-11

1. Filter head
2. Filter element
3. Element centralizer
4. Spring retainer
5. Spring
6. Filter casing

12. Drain the oil from the casing and discard the element.

13. Remove the gasket from the filter head.

14. Thoroughly clean the inside of the filter head and casing. Install a new gasket ensuring that it locates correctly and is free from kinks.

15. Install a new element in the casing and bolt the assembly to the filter head. Before tightening the bolt, check that the casing is located correctly on the gasket. Tighten to 1.4 kg/m (10 lbs ft.).

16. Top up the oil pan with the recommended oil and run the engine for two or three minutes to allow oil to circulate. Recheck the oil level and examine for oil leaks.

**Lubricating Oil Filter (Refitting)**

17. Clean all traces of old gaskets from the cylinder block or adaptor and also ensure all parts are clean.

18. Refit the filters using a new gasket, tighten the securing screws to a torque of 36-41 lbs. ft. (48.8-55.6 newton/metres) and 22-27 lbs. ft. (29.8 - 36.6 newton/metres) on marine engines.

19. Reconnect any mechanical or electrical connections to the pressure switch.

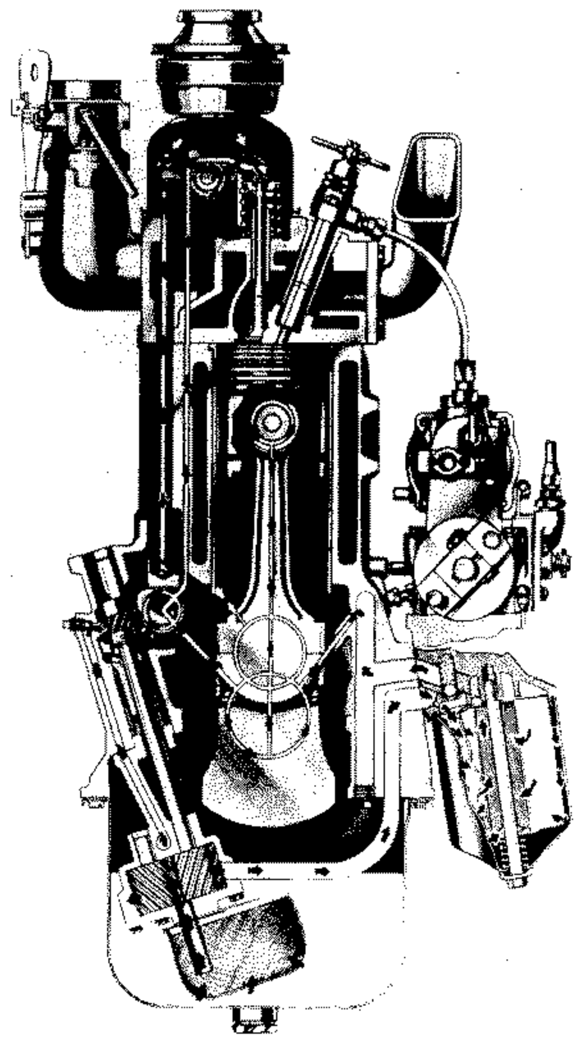
20. On marine engines the oil pipes should be reconnected between the oil cooler and adaptor block and the oil cooler and filter.

4.3000

## OIL DISTRIBUTION

**Oil Distribution (Description)**

1. Oil drawn from the screen into the pump impeller chamber is discharged through the oil filter element to the main oil gallery where it then flows down oilways to the crankshaft main bearings, and thence through oilways in the crankshaft to the connecting rod bearings. A bleed hole in each rod directs oil on the thrust side of the cylinder walls.



4.3000-1

2. The camshaft bearings are lubricated through oilways from the main bearings. An oilway in the front intermediate camshaft journal directs oil at every camshaft revolution through a vertical drilling in the cylinder block and head to the oil pipe connected to the rocker shaft. After lubricating the rockers, surplus oil drains down the push rod tubes and lubricates the rods, tappets and camshaft arms before returning to the oil pan. The camshaft skew gear is lubricated by oil discharged from the oil pump impeller chamber through a drilling in the pump body and crankcase. Surplus oil then lubricates the pump spindle through a drilling in the upper end of the spindle housing.

3. The timing gears are lubricated by a jet of oil fed from the front main bearing through oilways drilled in the main bearing cap and bearing, and the timing gear case. The idler gear hub is separately lubricated from the main gallery, the oil passing through the oilways drilled in the hub and crankcase.

4. When the oil pressure reaches a predetermined figure (3-5 lb/sq. in.), the pressure switch diaphragm flexes and separates its contacts thus extinguishing the warning light. Should the pressure drop below the specified limit whilst the engine is running, the diaphragm, regaining its original position, closes the contacts and illuminates the lamp.

5. The oil pressure is maintained within specified limits by the pressure relief valve. Excess pressure displaces the valve plunger and uncovers the port connecting the oilway to the suction side of the pump. As soon as the excess pressure is relieved the spring returns the plunger to its original position.

**Oil Distribution (Removal)**

6. With the exception of marine engines, the only serviceable parts of the oil distribution system are the rocker feed pipe, oil delivery pipe, oil pump screen and various oil seals.

7. Remove the oil pan as detailed in 4.7000.

8. Unscrew the two sleeve nuts from the ends of the delivery pipe and remove the pipe.

9. Prise up the gauze screen retaining clips and remove the screen.

10. The removal of the rocker feed pipe is described under section 1.7100 and the removal of oil seals are described in the various sections in which they appear.

11. For removal of the oil piping on marine or industrial engines with heat exchangers fitted, the sleeve nuts should be loosened and the pipes withdrawn. It must be remembered that some oil will remain in these pipes and the appropriate action taken to avoid spillage.

**Oil Distribution (Inspection and Overhaul)**

12. Lubricating oil distribution pipes require only a visual inspection for damage, which if found the pipe must be replaced.

**Oil Distribution (Refitting)**

13. Attach the gauze screen to the fuel pump and press down the retaining clips.

14. Refit the delivery pipe between the oil pump and crankcase and tighten the two sleeve nuts.

15. The pipes between the oil filter, heat exchanger and/or crankcase can be repositioned and the sleeves tightened.

## 4.4000

## OIL COOLER

**Oil Cooler (Description)**

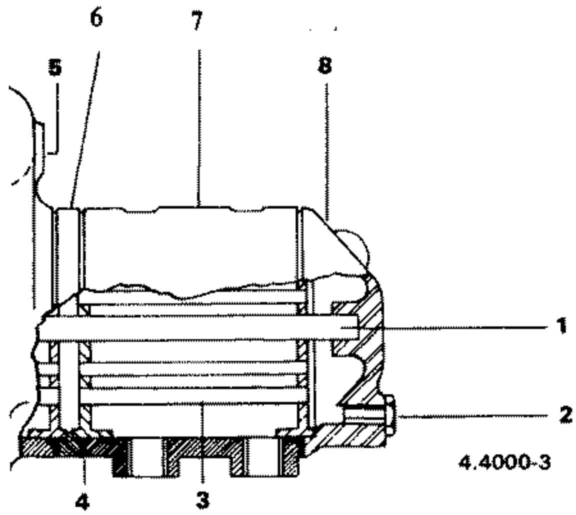
1. Two types of oil cooler are used on 220 and 330 cu. in. engines:
   (a) air blast and
   (b) water cooled
2. The air blast cooler is of light alloy construction and is fitted on the front of the radiator by a bracket assembly. Oil is cooled by air passing between the finned tubes of the oil cooler through which the oil is flowing. The oil is directed to and from the oil cooler by hose assemblies attached to the oil filter adaptor.


4.4000-2

1. Oil cooler
2. Hose assembly
3. Oil filter adaptor
4. Oil filter

3. On engines fitted with a heat exchanger, a small aluminium cylinder attached to the header tank houses the oil cooler. The cooling of the oil is achieved by passing raw water through a series of tubes surrounded by the oil which requires cooling.

4. Hose assemblies allow the flow of oil between the engine and oil cooler.




4.4000-3

1. Tie rod
2. Sea water drain plug
3. Oil cooler tube stack
4. Tube stack seals
5. Heat exchanger drain plug
6. Spacing ring
7. Oil cooler body
8. End cover

**Oil Cooler (Removal)**

5. Place a pan beneath the oil cooler hose assemblies to catch any oil in the system.
6. Remove the air blast oil cooler by unscrewing the two hose connections beneath the oil cooler, then remove the four nuts which attach the cooler to the radiator.
7. Removal, inspection, overhaul and refitting of the combined heat exchanger and oil cooler is described in section 5.5000

**Oil Cooler (Inspection and Overhaul)**

8. To cleanse the oil cooler prepare a solution of one part muriatic acid to nine parts of water. Add one pound of oxalic acid and 0.01 of a gallon of pyridine to every 5 gallons of solution required.

**Note:** The tank used to mix the solution must be of an acid resistant material.

9. Plug the oil inlet and outlet ports, immerse the cooler in the solution. Remove immediately when the bubbling and foaming action has ceased, (approximately 1 to 2 minutes).
10. Flush thoroughly with warm clean water. Repeat the operation if necessary.
11. Remove a plug from either the inlet or outlet port and attach an air hose with a maximum pressure of 170 lb/sq. in. Submerge the cooler in water. Air bubbles indicate any leaks that have occurred which will necessitate replacement of the cooler.

**Oil Cooler (Refitting)**

12. Refit the oil cooler to the radiator bracket assembly by fitting the four retaining nuts and bolts.
13. Reconnect the hose assemblies.

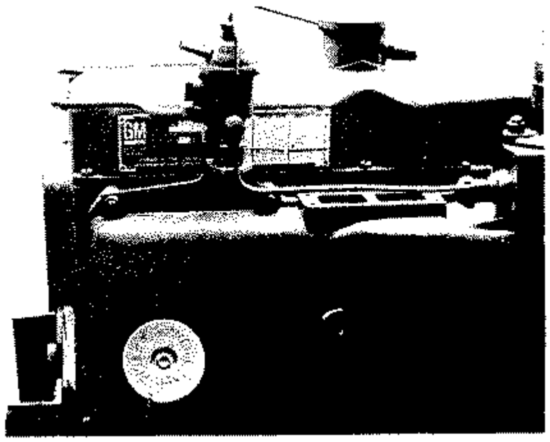
## 4.5000

## OIL FILLER

**Oil Filler (Description)**

1. The oil filler cap is situated on top of the rocker cover although on some engines a second filler tube and cap are fitted to either the oil sump or side cover to enable easier filling.

Standard filler cap



Special filler cap 4.5000-1

**Oil Filler (Removal)**

2. A 90° anticlockwise turn is all that is required to remove the oil filler cap.
3. The filler tube is part of a welded assembly and therefore no further disassembly is necessary.

**Oil Filler (Inspection and Overhaul)**

4. The oil filler tube and cap require only a visual inspection for damage, which if found the cap or tube assembly must be replace.

**Oil Filler (Refitting)**

5. Fill the engine with the correct quantity and grade of oil. The grade of oil is shown under the recommended lubricants at the end of section 1 and the recommended quantities are listed below.

## CAPACITIES

**Engine Oil Sump:**

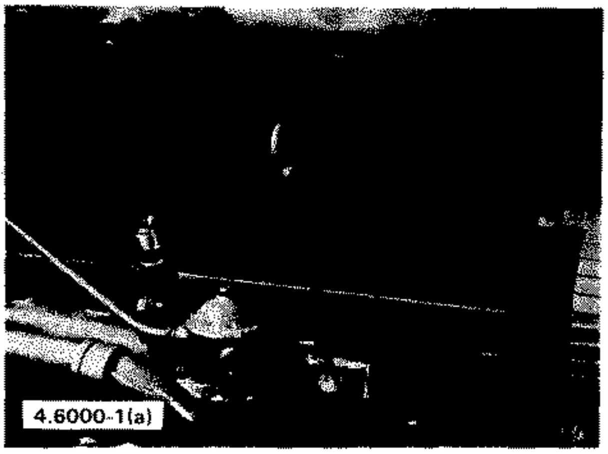
| | |
|---|---|
| Four cylinder, 220 cubic inch, Standard sump: | |
| Total | 14 Imp. Pints ( 8 Litres) |
| Refill | 11 Imp. Pints ( 6 Litres) |
| Refill with filter element change | 13 Imp. Pints ( 7 Litres) |
| Four cylinder, 220 cubic inch, Pressed steel deep sump: | |
| Total | 11 Imp. Pints ( 6 Litres) |
| Refill | 8 Imp. Pints ( 5 Litres) |
| Refill with filter element change | 11 Imp. Pints ( 6 Litres) |
| Six-cylinder, 330 cubic inch, Standard sump: | |
| Total | 17 Imp. Pints (10 Litres) |
| Refill | 14 Imp. Pints ( 8 Litres) |
| Refill with filter element change | 16 Imp. Pints ( 9 Litres) |
| Six-cylinder, 330 cubic inch, Pressed steel deep sump: | |
| Total | 19 Imp. Pints (11 Litres) |
| Refill | 16 Imp. Pints ( 9 Litres) |
| Refill with filter element change | 18 Imp. Pints (10 Litres) |
| Six-cylinder, 330 cubic inch, Cast aluminium deep sump (Off-Highway); | |
| Total | 16 Imp. Pints ( 9 Litres) |
| Refill | 13 Imp. Pints ( 7 Litres) |
| Refill with filter element change | 15 Imp. Pints ( 8 Litres) |

## 4.6000

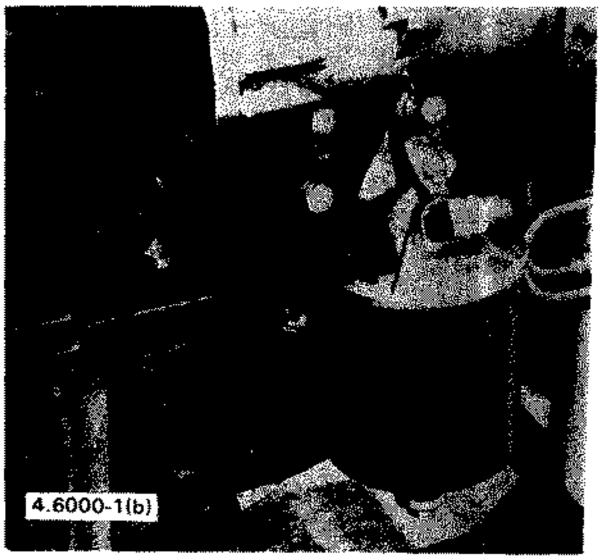
## DIPSTICK

**Dipstick (Description)**

1. The dipstick is used to determine the quantity of oil in the engine oil pan. It is located either (a) on the side cover or (b) a dipstick tube, welded to the oil pan.

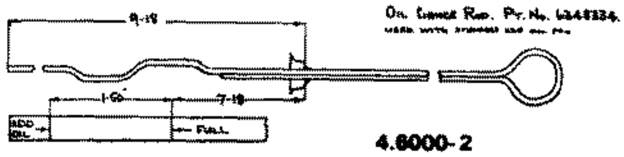


4.6000-1(a)



4.6000-1(b)

2. The dipstick has two marks scribed at the end with oil filling instructions.




4.6000-2

3. The oil should never be allowed to drop below the 'ADD OIL' mark, nor should oil be allowed above the 'FULL' mark.

4. The oil level should be checked daily with the engine stopped. If the engine has been running, ten minutes should be allowed for oil to drain into the sump before taking a reading.

**Dipstick (Inspection and Overhaul)**

5. The dipstick requires only a visual inspection for damage, which if found, must be replaced.

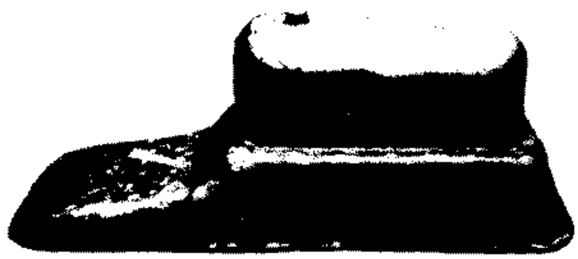
## 4.7000

## OIL PAN

### Oil Pan (Description)

1. The 220 and 330 cu. in. engines may be equipped with either (a) a standard or (b) a deep sump, both of which can be treated for marine use. Dependent on the model application the oil pans may be provided with an inclination angle of 10°, 12°, 15°, 30°, or 45°.

4.7000-1(a)



4.7000-1(b)

2. Some oil pans have an oil filler and/or dipstick tube fitted.

### Oil Pan (Removal)

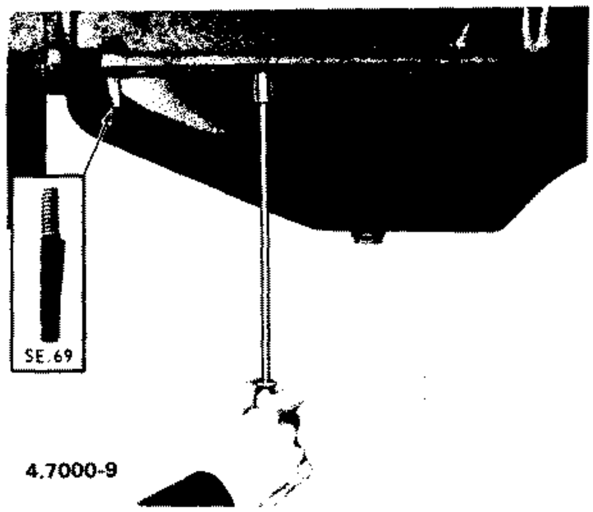
3. Place a tray beneath the sump, remove the drain plug and drain the oil.
4. Replace the drain plug.
5. Remove the securing screws, using screwdriver D1058 and lower the oil pan and gasket.

### Oil Pan (Inspection and Overhaul)

6. There are no moving parts within the oil pan, therefore no wear could take place, however, a visual check for signs of damage or corrosion should be carried out.

### Oil Pan (Refitting)

7. Clean any pieces of the old gasket from the cylinder block and oil pan.
8. Using a new gasket refit the oil pan. To facilitate the assembly of the oil pan, screw two retainers SE69 into the crankcase, one each side, so that the oil pan will locate accurately and prevent displacement of the gasket.
9. Tighten all screws evenly to a torque of 6-8 lbs. ft. (1 kg/m), using screwdriver D1058.




4.7000-9

10. Refill the oil pan with a recommended oil (see recommended lubricants at the end of section 1) to the full mark on the dipstick.
11. Run the engine and check for oil leaks.

## 4.8000

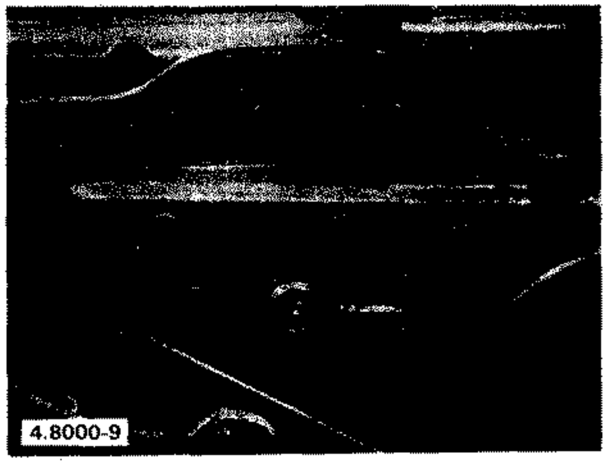
## VENTILATION SYSTEM

**Ventilation System (Description)**

1. The ventilation system is designed to ensure that at all times when the engine is running a depression exists in the crankcase.
2. For maximum depression refer to the following table:

| Inches of Water | | | | |
|---|---|---|---|---|
| Engine | Speed of Engine (rpm) | | | |
| | 1000 | 1500 | 2000 | 2600 |
| 220 cu.in. | 0.5 | 0.8 | 1.1 | 1.3 |
| 330 cu. in. | 0.3 | 0.9 | 1.6 | 3.0 |

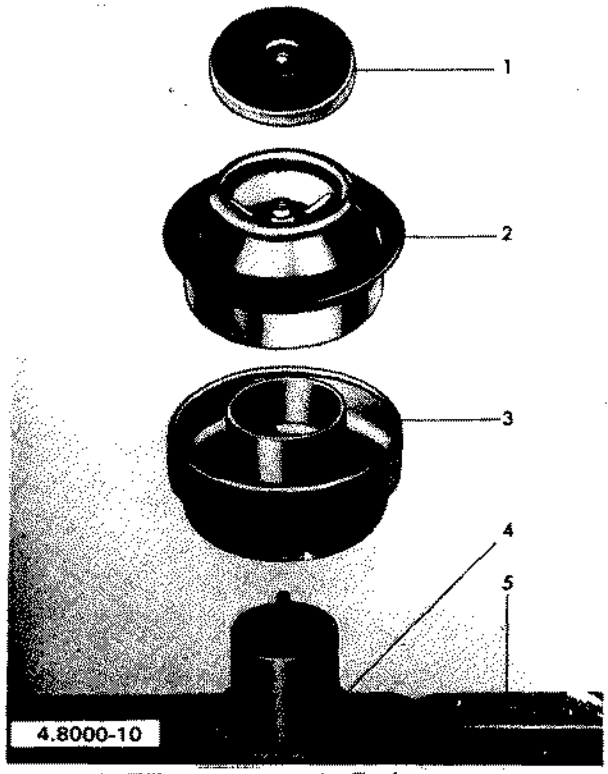
3. Various ventilating systems have been used since the first engines were built. Each system has been described individually in the following paragraphs.
4. Originally on the six cylinder engines the crankcase was ventilated through a pipe connected to an outlet in the push rod cover. On the four cylinder engines the pipe was attached to a baffle chamber which communicated with the crankcase immediately above the oil pump drive gear.
5. The upper end of the pipe on both engines was connected to the air cleaner, and an oil bath type breather was mounted on the rocker cover.
6. The crankcase was ventilated by air drawn through the oil bath breather and after circulating round the crankcase, extracted through the outlet pipe by the air cleaner.
7. At engine serial numbers P & I 0148 on four cylinder engines and P & I 1229 on six cylinder engines, the combined oil filler and oil bath breather was deleted in favour of a plain filler neck with a sealing cap. This was introduced to improve the anti sludging characteristics. The filler neck was interconnected via a pipe between the push rod cover and the engine air cleaner, and had no provision for entry of cold air into the crankcase or rocker cover.
8. The current ventilation system was introduced at serial number P & I 10933 on four cylinder engines, and P & I 7571 on six cylinder engines.
9. This system consists of a vent. valve attached to the push rod cover with a rubber elbow connection to a stub pipe in the underside of the inlet manifold. This system is identical for both four and six cylinder engines.



4.8000-9

**Ventilation System (Removal)**

10. On the original system the crankcase breather can be removed by first lifting away the oil filler cap and then releasing the nut securing the filter element to the rocker cover. The oil bath and element can now be withdrawn.




4.8000-10

1. Filler cap
2. Filter element
3. Oil bath
4. Gasket
5. Rocker cover

11. On all systems unscrew the clips securing the hoses, elbows etc., and remove the pipes.
12. If a baffle chamber is fitted this can be removed by unscrewing the two retaining nuts and lifting the baffle chamber from its seating.
13. To remove the current vent valve, after withdrawing the rubber elbow, unscrew the clip and withdraw the vent valve from the push rod cover outlet.

**Ventilation System (Inspection and Overhaul)**

14. The crankcase breather used on early engines should be inspected for damage and then cleaned prior to reassembly as described in paragraphs 15-17 inclusive.
15. Rinse the element in paraffin/kerosene and blow out with compressed air.
16. Empty the oil bath and clean out any sediment.
17. Install the oil bath and refill to the indicated level with the recommended oil. Install the filter element, retaining nut, and oil filler cap.
18. All other components should be visually inspected for damage, especially rubber hoses.

**Ventilation System (Refitting)**

19. On engines with a baffle chamber apply a sealant on the inside of the connector and press the baffle chamber into position. Add the two retaining nuts and tighten to 6-8 lbs/ft (8.1-10.8 newton/metres).
20. Replace the vent valve, where fitted, onto the push rod cover outlet and tighten the clip.
21. Replace all the pipes and hoses into their respective positions and tighten all the clamps.
22. The crankcase depression should now be checked as follows:
23. Remove the dipstick.
24. Prepare a bung with a short length of tube installed so that a manometer can be connected, this assembly should be installed in the dipstick hole.
25. With the engine running a depression must always be noted within the crankcase, the maximum which should be obtained is shown in the table on page one.
26. To decrease the crankcase depression, the hole into the trunking from the stub pipe should be decreased. Should it be desired to increase the depression the diameter of the hole should be increased.

## 4.0000
## LUBRICATION SYSTEM SPECIFICATIONS

### OIL PUMP

| | |
|---|---|
| Driving Impeller Spindle Diameter | 14.24-14.26 mm (.5607"-.5612") |
| Driving Impeller Spindle End Float | .076-.152 mm (.003"-.006") |
| Driving Impeller Spindle Clearance in Body | .023-.053 mm (.0009"-.0021") |
| Driven Impeller Spindle Diameter | 14.30-14.31 mm (.5629"-.5634") |
| Driven Impeller Spindle Fit in Body | .003-.033 mm (.0001"-.0013") |
| Backlash Between Impeller Teeth | .08-.25 mm (.003"-.010") |
| Driving Impeller Bore Diameter | 14.23-14.24 mm (.5602"-.5607") |
| Driven Impeller Bore Diameter | 14.33-14.34 mm (.5642"-.5647") |
| Driving Impeller Fit on Spindle | Zero-.0254 mm (Zero-.001") Interference |
| Driven Impeller Fit on Spindle | .02-.046 mm (.0008"-.0018") Interference |
| Impeller End Float in Body | .05-.13mm (.002"-.005") |
| Impeller Overall Length | 39.6-39.62 mm (1.559"-1.560") |
| Impeller Radial Clearance in Body | .04-.09 mm (.0015"-.0035") |
| Oil Pressure Relief Valve Plunger Diameter | 15.84-15.86 mm (.6235"-.6243") |
| Oil Pressure Relief Valve Plunger Clearance in Bore | .02-.06 mm (.0007"-.0025") |
| Oil Pressure Relief Valve Spring Free Length | 112-113 mm (4.42"-4.45") |
| Oil Pressure Relief Valve Spring Load at 65.5 mm (2.58") | 7.7-8.2 kg. (17-18 lb) |
| Driving Gear Bore Diameter | 14.24-14.25 mm (.5607"-.5612") |
| Driving Gear Fit on Spindle | 0.0127 mm (.0005") Clearance<br>0.0127 mm (.0005") Interference |
| Driving Gear Thrust Washer Thickness | 2.26-2.39 mm (.089"-.094") |

### OIL FILTER

| | |
|---|---|
| Make and Type | AC 720 - Full Flow |
| Element | AC 72 |
| Element Spring Load at 31.77 mm (1.25") | 7-9 kg. (15-20 lb) |

### OIL DISTRIBUTION

| | |
|---|---|
| Oil Pressure (Hot) | 241-345 KPa (35-50 lb/sq in) |
| Oil Pressure Switch Operating Pressure | 21-34 KPa (3-5 lb/sq in) |

### OIL PAN CAPACITIES

| | |
|---|---|
| **Four-cylinder, 220 cubic inch, standard sump:** | |
| Total | 14 Imp. Pints (8 Litres) |
| Refill | 11 Imp. Pints (6 Litres) |
| Refill With Filter Element Change | 13 Imp. Pints (7 Litres) |
| **Four-Cylinder, 220 cubic inch, pressed steel deep sump:** | |
| Total | 11 Imp. Pints (6 Litres) |
| Refill | 8 Imp. Pints (5 Litres) |
| Refill With Filter Element Change | 11 Imp. Pints (6 Litres) |
| **Six-cylinder, 330 cubic inch, standard sump:** | |
| Total | 17 Imp. Pints (10 Litres) |
| Refill | 14 Imp. Pints ( 8 Litres) |
| Refill With Filter Element Change | 16 Imp. Pints ( 9 Litres) |
| **Six-cylinder, 330 cubic inch, pressed steel deep sump:** | |
| Total | 19 Imp. Pints (11 Litres) |
| Refill | 16 Imp. Pints ( 9 Litres) |
| Refill With Filter Element Change | 18 Imp. Pints (10 Litres) |
| **Six-cylinder, 330 cubic inch, cast aluminium deep sump (off-highway):** | |
| Total | 16 Imp. Pints (9 Litres) |
| Refill | 13 Imp. Pints (7 Litres) |
| Refill With Filter Element Change | 15 Imp. Pints (8 Litres) |

## VENTILATION SYSTEM

### MAXIMUM DEPRESSION IN INCHES OF WATER

| Engine | Speed of Engine (rpm) | | | |
|---|---|---|---|---|
| | 1000 | 1500 | 2000 | 2600 |
| 220 cu in | 0.5 | 0.8 | 1.1 | 1.3 |
| 330 cu in | 0.3 | 0.9 | 1.6 | 3.0 |

### TORQUE WRENCH DATA

| | |
|---|---|
| Oil pump cover retaining bolts | 8-11 Nm (6-8 lb ft) |
| Oil pump retaining bolts | 18-20 Nm (13-15 lb ft) |
| Oil filter centre bolt | 14 Nm (10 lb ft) |
| Oil filter retaining bolts (Industrial) | 49-56 Nm (36-41 lb ft) |
| Oil filter retaining bolts (Marine) | 30-37 Nm (22-27 lb ft) |
| Oil pan retaining screws | 8-11 Nm (6-8 lb ft) |
| Vent system baffle chamber | 8-11 Nm (6-8 lb ft) |

# SECTION 5

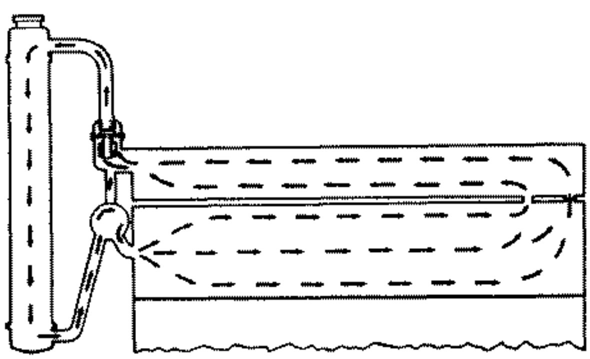
## COOLING SYSTEM

### Contents

## 5.0000

## COOLING SYSTEM

1. The cooling system which is pressurised incorporates a water pump (5.1000), thermostat (5.2000), radiator (5.3000), fan (5.4000), fan guard (5.4100) and some engines utilise a water filter (5.7000).
2. On marine engines a raw water system is also used which includes the heat exchanger (5.5000) and raw water pump (5.6000).
3. Two systems of operation have been used. Prior to serial numbers P & I 1350 on 220 cu in engines, and P.I. 1900 on 330 cu in engines a conventional flow was used, from these points an end to end waterflow has been utilised.
4. With the conventional flow, water entered the pump rotor chamber from the radiator bottom tank, through water passages in the cylinder block and around the valve seats and injector sleeves in the cylinder head. After circulating in the head and cylinder block the water flowed from the head through the open thermostat and into the radiator top tank, where it passed down through the cooling element.



5.0000 - 4

5. The end to end water flow eliminates all waterways at the cylinder head and block gasket faces in favour of an arrangement concentrating the transfer of water through a connection at the rear of the engine. With the elimination of the waterways, the top of the cylinder block, and the lower face of the cylinder head are stronger and less liable to distortion.
6. When the engine of either cooling system is cold, circulation through the radiator is prevented by the thermostat being closed. At the same time a limited circulation in the engine prevails as water is able to flow through the by-pass connection leading to the pump. When the water temperature has risen sufficiently to open the thermostat valve, normal circulation is restored.
7. The pressurised cooling system, by raising the boiling point of water, gives additional protection against overheating for high altitude conditions, tropical temperatures and hard driving. The pressure is limited by the filler cap pressure valve which allows steam and water to escape through the overflow pipe, whenever the pressure exceeds the specified limit. Any depression within the system as the engine cools is relieved by the cap vacuum valve which admits air through the overflow pipe.

### DRAINING THE COOLING SYSTEM

8. The cooling system incorporates two drain taps. One tap is located in the radiator bottom tank and the other in the side of the cylinder block.
9. To prevent the formation of an air lock it is essential to remove the radiator filler cap prior to draining the cooling system.

### CORROSION PREVENTATIVE

10. To prevent corrosion of the interior of the cooling system, and consequent silting up of the radiator and cooling system, a quantity of soluble oil type corrosion preventative is added to the cooling system before leaving the factory. This forms an emulsion with the cooling water and deposits an anticorrosive film. Additions of corrosion preventative should be made at regular intervals of at least once a month or whenever the cooling system is refilled after discarding anti-freeze, to maintain the cooling system in a clean condition.

### ANTI-FREEZE

11. It is most important that a 'permanent' (ethylene glycol) type of anti-freeze is used in the cooling system. The engine is designed to operate at a relatively high temperature which will cause an alcohol type of anti-freeze to evaporate rapidly.
12. The process of protecting the cooling system against frost by adding anti-freeze is well known. What is not so generally known is the degree of frost protection afforded by a specific quantity of anti-freeze.
13. When adding anti-freeze it must be appreciated that the quantity will depend upon the degree of low temperature protection required. The various degrees of protection are classified and explained under the following three headings. In addition, the specified data, at the end of the section, gives the lowest approximate temperature at which each of the various degrees of protection are provided by the different quantities of anti-freeze.

### COMPLETE PROTECTION TEMPERATURE

14. This is the lowest temperature at which the entire cooling system will remain free from ice crystals so that the engine can be operated immediately from cold without risk of freezing or boiling.

### SAFE LIMIT TEMPERATURE

15. This is the lowest temperature at which the coolant, containing ice crystals, will remain mushy. With this condition the engine can be safely rotated but not operated immediately from cold. To prevent any risk of boiling, the engine must be run at a fast idling speed for at least five minutes with the radiator covered before the engine is loaded.
16. When the temperature is below the 'Safe Limit' it will be necessary to raise the temperature of the coolant before the engine can be safely rotated. The method to adopt in raising the coolant temperature will depend on the facilities available, but where possible it is preferable to allow the coolant to thaw naturally.

## LOWER PROTECTION LIMIT TEMPERATURE

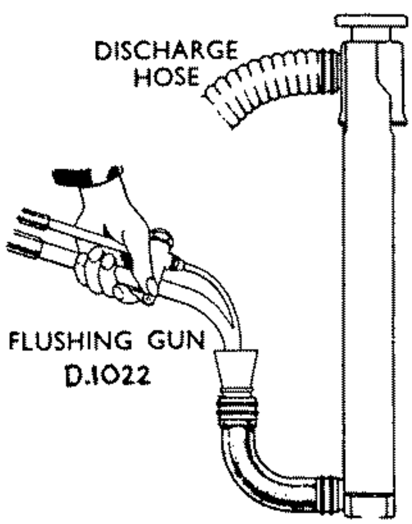
17. This is the lowest temperature which can be withstood without serious risk of cracked castings.

## PRELIMINARY OPERATIONS FOR ANTI-FREEZE

18. Before adding anti-freeze, the cooling system should be checked for cleanliness and if necessary reverse flushed.

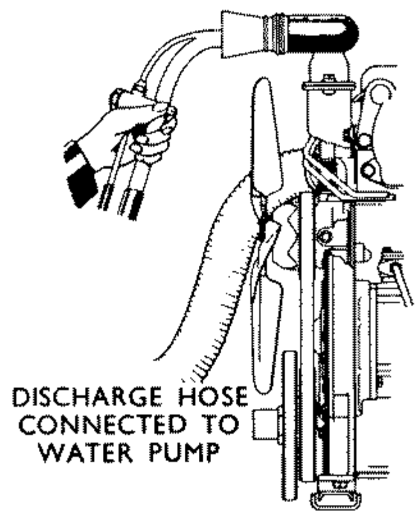
## REVERSE FLUSHING

19. The advantage of reverse flushing is that the cooling system is flushed in the direction contrary to that of the normal circulation, and any sludge or deposits which have lodged in the radiator can be forced out more readily. Similarly, by reverse flushing the cylinder block and head it is possible to remove sludge and deposits from the base of the water jackets.
20. To obtain the best results from reverse flushing, it is necessary to introduce water and compressed air into the cooling system with the aid of Flushing Gun D. 1022.
21. Drain the cooling system.
22. Disconnect the radiator top hose and connect discharge hose to the radiator inlet pipe.
23. Disconnect the bottom hose from the water pump and insert the flushing gun into the hose.
24. Connect the appropriate hoses on the flushing gun to suitable water and air supplies. Always use warm water for flushing a warm engine.
25. Turn on the water, and when the radiator is full, inject air in very short bursts. Keep the water running all the time to enable the radiator to fill between bursts of air. Flush in this manner until the water from the discharge hose runs clean.




5.0000 - 25

26. Inject air very carefully as there is a danger of building up excessive pressure if the radiator element is badly clogged. If it is suspected that the radiator is partially blocked with foreign matter, it should be flow tested as described on Page 00 of Section 5.3000.
27. Remove the water outlet and withdraw the thermostat. Where necessary, disconnect the heater hoses from the engine and plug the hose connections.
28. Refit the outlet and connect the hose for insertion of the flushing gun. Connect the discharge hose to the water pump inlet. Insert the flushing gun and proceed as for the radiator.




5.0000 - 28

29. After reverse flushing and before filling with anti-freeze mixture, inspect the condition of the water hoses, and check the hose connections for tightness. If a water filter is used ensure the correct element is used for anti-freeze solutions.
30. Mix the required quantity of anti-freeze with an equal quantity of clean water, pour the mixture into the cooling system and top up with water. Hard water is preferable, as corrosion is less likely to occur with hard water than with soft water. Over-filling the radiator will cause loss of anti-freeze mixture through the overflow. To avoid this wastage, only enough mixture should be added to bring the coolant level to 1 inch below the bottom of the filler neck.

**NOTE.** Account must be taken for cabin heater circuits when determining the quantity of anti-freeze required.

31. Upon completion, refit the thermostat. Remove the plugs and reconnect the hoses.
32. Refill the cooling system, and check for leaks.
33. A 20% solution of anti-freeze will safeguard the engine against cracking of the engine castings down

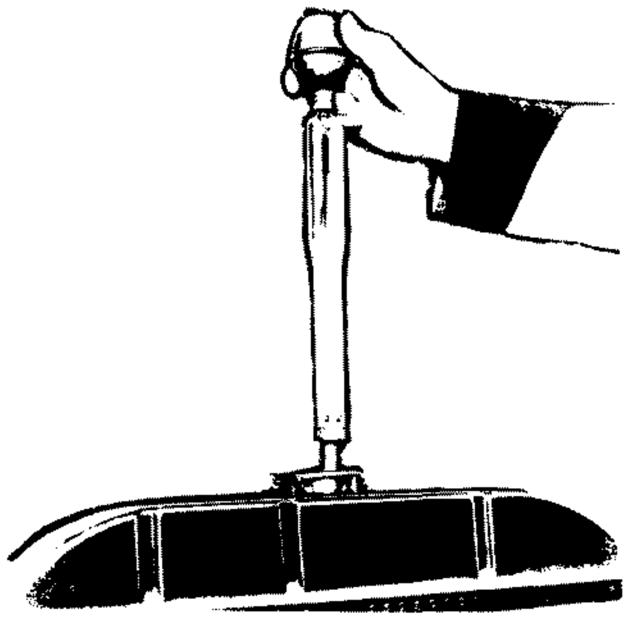
to about 35° of frost (-3°F or -22°C), but the manufacturers' recommendations should be adhered to.

34. When topping up the cooling system, it is essential that only anti-freeze solution of the correct strength should be used. The use of plain water will dilute the solution in the system and reduce the degree of protection.

35. The strength of the anti-freeze solution in the system can be established by means of an anti-freeze tester. The tester records the specific gravity of the solution on a percentage scale and also provides temperature compensation on a thermometer correction scale.

36. When warm weather returns, the anti-freeze mixture should be drained and the process of reverse flushing repeated.

37. When a raw water pump is fitted, it is advisable to drain the system when not in use as this is not protected by the anti-freeze in the engine coolant. To drain, remove the cover plate which is held by six screws, remove drain plugs from the heat exchanger and withdraw the impeller which should be stored in a dark place until required.



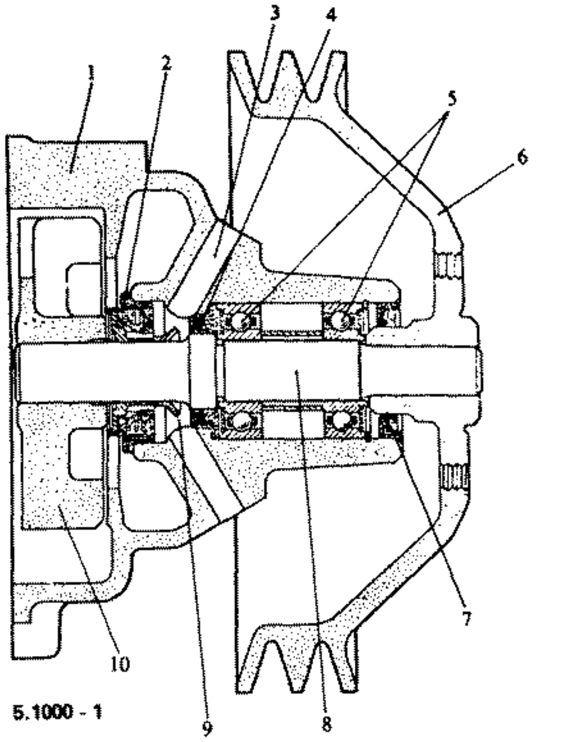
5.0000 - 35

## 5.1000

## FRESH WATER PUMP

### FRESH WATER PUMP (DESCRIPTION)

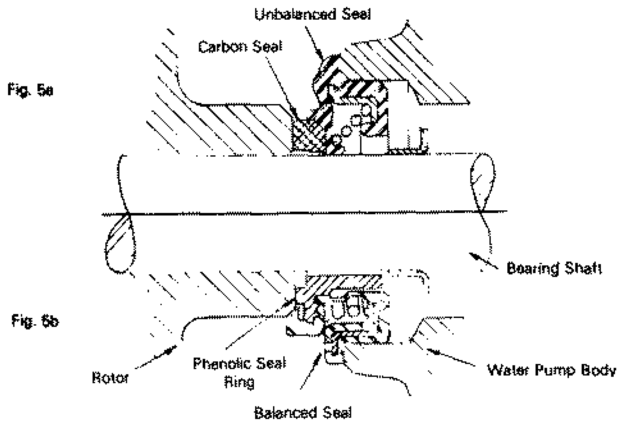
1. The water pump is a belt driven centrifugal type with a self adjusting spring loaded seal.




5.1000 - 1

1. Pump Body
2. Seal Assembly
3. Ventilation Hole
4. Oil Seal
5. Shaft Bearings
6. Pulley
7. Oil Seal
8. Pump Shaft
9. Water Thrower
10. Rotor

2. The pump body is bolted directly to the cylinder block and has a rotor chamber communicating with the water passages in the block and radiator outlet pipe.
3. On early engines a backplate was fitted between the cylinder block and the pump body. The deletion of this backplate had the effect of moving the pulley and fan closer to the engine and a longer spindle, together with a longer alternator mounting stud was necessary to correct the alignment of the pulley belts. This change occurred at serial number P & I 1350 on 220 cu in engines and P & I 1900 on 330 cu in engines. Care should therefore be exercised when ordering spare parts.
4. A rotor pressed onto the rear end of the shaft contacts a balanced self adjusting seal with a phenolic face in the front of which is a water thrower fitted in line with ventilation holes in the pump body.
5. On early engines an unbalanced seal, FIG 5a, with a carbon ring seal was used. The change became effective when the water system pressure was increased to 48 KPa (7 P.S.I.). With the new balanced seal, FIG 5b, the water pressure assists the retention of the seal against the rotor.

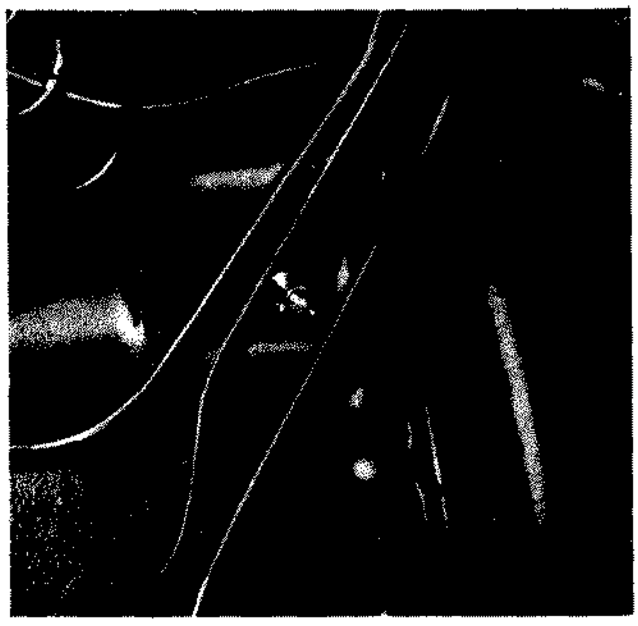



5.1000 - 5

6. The water pump shaft has had various changes to the diameter and from serial number 698239/7066 on 220 cu in engines and 706983/7024 on 330 cu in engines the spindle has been case hardened. Again care is required when ordering parts.
7. The shaft is supported in two single row bearings housed in the front end of the body. The bearings are packed with lubricant during initial assembly and periodic lubrication is unnecessary. The bearing and shaft assembly is retained by a circlip and oil seals protect the outer and inner ends of the respective bearings.

### FRESH WATER PUMP (REMOVAL)

8. Drain the cooling system by first removing the radiator filler cap to prevent an air lock, and then opening the two drain taps. One located in the radiator bottom tank and the other in the side of the cylinder block.



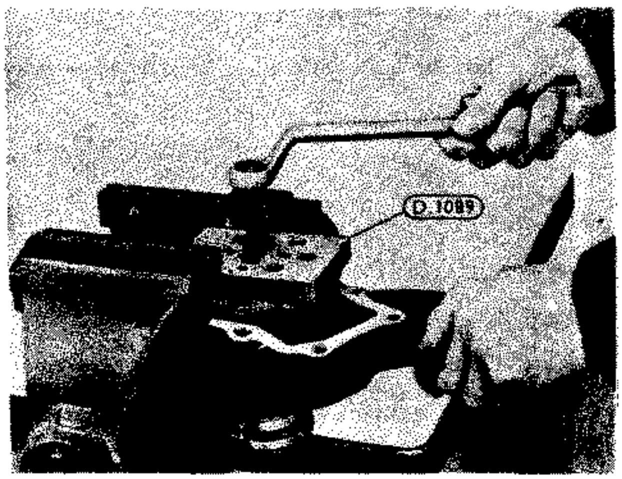
5.1000 - 8

9. Remove the radiator (5.3000), fan (5.4000) and crankshaft pulley belt (1.3320).

10. Disconnect the hose from the water pump, and slacken the clip securing the by-pass hose.
11. Remove the pump securing nuts, release the by-pass pipe from the hose and lift away the pump.

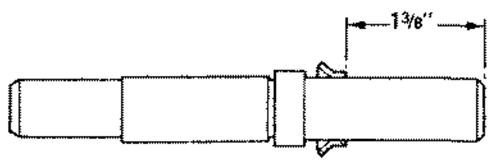
## FRESH WATER PUMP (INSPECTION AND OVERHAUL)

12. Remove the pump backplate if fitted.
13. Using puller D1089, withdraw the rotor.



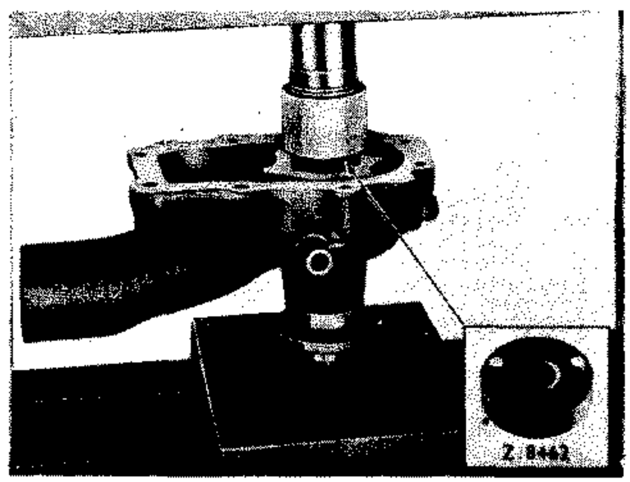

5.1000 - 13

14. Withdraw the pulley flange. On early engines the pulley flange was retained by a nut and plain washer.
15. Prise off the oil seal retainer from the front of the pump body, and remove the bearing circlip.
16. Withdraw the seal from the rotor chamber and tap the bearing and shaft assembly from the body.
17. Withdraw the bearings, distance piece and oil seal from the shaft.
18. Wash and examine the bearings and check the fit of the bearings in the body and on the shaft.
19. Check the water thrower for slackness or damage. If a new thrower is required it should be fitted 1⅜" from the shaft end as illustrated below.




5.1000 - 19

20. Examine the rotor for cracks or corrosion, particularly around the hub and impeller. Examine the seal contact face of the rotor for wear. If worn renew the rotor.
21. Discard the water pump seal assembly and the front and rear oil seals.
22. Moisten the new oil seal felts with engine oil and line up the pips on the seal cup with the location in the bore of the body.
23. Pack the bearings with the recommended grease (see recommended lubricants at rear of section 1). Install the bearings with the shielded ends away from each other and with the distance piece between the two.
24. Install the pulley flange and on earlier engines fit the retaining nut and washer.
25. Smear the seal face and the locating recess in the pump body with the recommended grease.
26. Press on the rotor, using installer Z8462. The installer ensures that the rotor is located to provide the correct clearance between the impellers and the pump body.




5.1000 - 26

27. Refit the backplate if fitted.

## FRESH WATER PUMP (REFITTING)

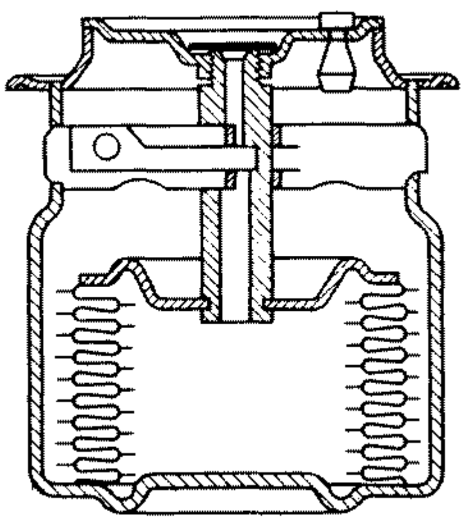
28. Ensure that the pump attaching faces are cleaned, and fit a new gasket smeared each side with jointing compound.
29. Place the pump into position and tighten the retaining nuts to a torque of 30-37 Nm (22-27 lb ft).
30. Reconnect the hoses and tighten the securing clips.
31. Refit the crankshaft pulley belt (1.3320), fan (5.4000) and radiator (5.3000).
32. Refill the cooling system and check for any water leaks.

# 5.2000

## THERMOSTAT

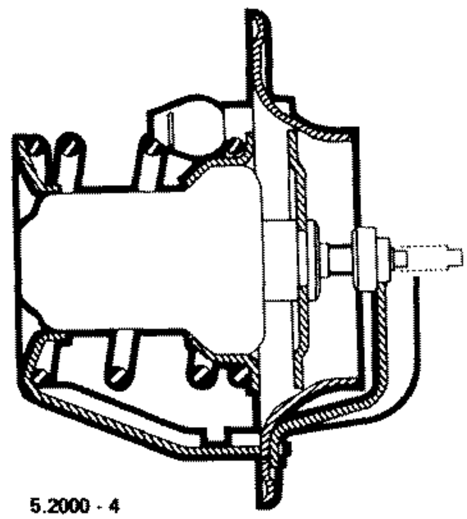
### THERMOSTAT (DESCRIPTION)

1. Two types of thermostats have been used on 220 cu in and 330 cu in engines. Initially a metal-bellows type was used and then at serial numbers P & I 2538 (220 cu in) and P & I 4300 (330 cu in) a wax capsule type was introduced.
2. Both types of thermostats are valves designed to control engine temperature by regulating coolant flow to the radiator.
3. The metal bellows type is a device filled with a volatile liquid which controls a mushroom valve. When the engine is cold this valve is closed and on starting the engine the flow of water to the radiator is temporarily restricted. Due to this, the temperature of the water in the engine will quickly rise, thus ensuring rapid warming up. The heat so generated will gradually expand the bellows so opening the valve, and ultimately permitting a full flow of water to the radiator.



5.2000 - 3

4. The wax capsule type is also motivated by the temperature of the engine coolant. When the engine and coolant are cold the thermostat valve remains closed, restricting the flow of coolant until it reaches a temperature high enough to react off the sensitive wax element. When the pre-determined temperature is reached, the thermoresponsive wax capsule expands and deforms an elastomeric moulding which, in conjunction with the piston, produces an axial force. This causes the element to push away from the static piston and start to open the valve, thus allowing the coolant to flow and circulate through the radiator. If conditions are such that the coolant temperature continues to rise, the valve will open further until the fully open position is reached.



5.2000 - 4

5. Once the engine has reached normal operating temperature the thermostat continues to maintain engine temperatures at a constant level by increasing or decreasing the flow of coolant through the radiator as necessary.
6. When the valve is closed a limited circulation of coolant is allowed to prevent the differential expansion of engine parts due to the formation of local hot spots. A small bleed hole, which is sealed with a jiggle pin when the engine is running, assists in preventing the formation of air locks when filling the cooling system.
7. The thermostat is contained in a housing bolted to the cylinder head and a connection is provided for the radiator inlet hose. A by-pass, communicating with the water pump, is incorporated to relieve the thermostat valve of pressure when closed, and an electrically operated temperature gauge is installed.

### THERMOSTAT (REMOVAL)

8. Drain the radiator.
9. Remove the two bolts securing the water outlet to the thermostat housing.
10. Lift the outlet clear of the housing and withdraw the thermostat.
11. If the engine is fitted with a heat exchanger, the heat exchanger will have to be removed, this is detailed in section 5.5000. The thermostat can be withdrawn immediately upon removal of the heat exchanger.

### THERMOSTAT (INSPECTION & OVERHAUL)

12. To test the efficiency of the thermostat, suspend the thermostat and a thermometer in a container of warm water and heat the water. Agitate the water to ensure uniform temperature. Do not allow the

thermostat or thermometer to rest on the bottom of the container, as this will result in a false reading.

13. Check that the thermostat commences to open at 77° - 82°C (170° - 179°F) and is fully open at 93°C (199°F). The valve lift being 9.14 mm (0.36") minimum.

14. If the thermostat does not coincide with the above readings it should be discarded.

**THERMOSTAT (REFITTING)**

15. Place the thermostat into its housing.

16. Using a new gasket replace the water outlet and tighten the bolts evenly to a torque of 18-20 Nm (13-15 lb ft).

17. Check and refit hose to radiator.

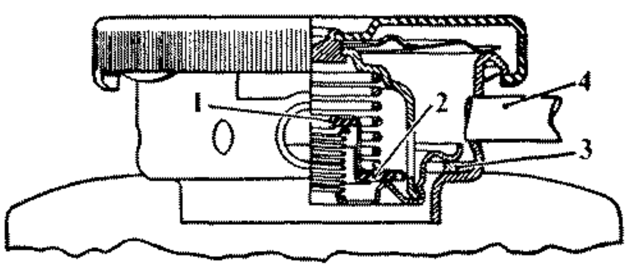
18. Refill the cooling system as described in section 5.0000.

## 5.3000

## RADIATOR

### RADIATOR (DESCRIPTION)

1. Two types of radiator, temperature and tropical, are used on 220 and 330 cu in engines. The radiator consists of a film type cooling element with top and bottom tanks reinforced by side straps.
2. The top tank incorporates the filler neck, overflow and inlet pipes. The bottom tank provides a connection for the outlet pipe and drain tap. The radiator also carries a shroud and is mounted on two bearers supported by two side brackets.
3. The filler cap is of the bayonet fitting pressure/vent type equipped with a vacuum valve and a pressure valve.




1. Vacuum Valve
2. Pressure Valve
3. Filler Cap Seal
4. Overflow Pipe

5.3000 - 3

4. When a temperate or tropical radiator is used on normally aspirated engines, a 457 mm (18") fan must be used, which can be either pusher or puller type depending upon the application. On 330 cu in engines utilising a turbocharger a 508 mm (20") pusher fan must be used with a special distance piece and 95.25 mm (3¾") long bolts.

### RADIATOR (REMOVAL)

5. To remove the radiator the cooling system must be drained. This is described in Section 5.0000.
6. The top and bottom hoses should now be disconnected from the radiator and the securing nuts and bolts removed, which will enable the radiator to be lifted from its mountings.
7. Remove the mounting insulators and ferrules.
8. If during overhaul or repairs to the engine the radiator is left empty and is allowed to dry out, any sediment or deposits will harden and cause an obstruction in the element water passages.
9. Where a radiator is temporarily out of service, reverse flush it as described in Section 5.0000, seal the inlet and outlet pipes with plugs and slowly fill the radiator with water avoiding any air locks.

### RADIATOR (INSPECTION AND OVERHAUL)

10. To locate the source and to effect minor repairs of leaks in the radiator the procedure specified in paragraphs 11 to 16 must be followed.
11. Seal the radiator filler neck and the inlet and outlet pipes with plugs taking care to leave the overflow tube connection unobstructed.
12. Connect the air supply to the radiator overflow pipe, and completely submerge into a test tank of water.
13. Use a hand pump to gradually increase the air pressure in the radiator to within 48-69 KPa (7-10 P.S.I.). Do not exceed the maximum. The use of factory air lines is not encouraged because exceeding the maximum pressure will cause permanent distortion to the radiator.
14. Check carefully for rising air bubbles from the radiator and trace the source of the leakage.
15. Remove the radiator from the tank and seal the leak with solder having a tin content of 33%.
16. Repeat the pressure test.
17. For major repair to cooling elements or tanks, the tanks must be removed, repaired and installed as specified in paragraphs 18-25 inclusive.
18. Remove the overflow pipe and drain tap.
19. Remove the tanks by applying a blow flame to the strap ends soldered to the top tank, and along the seams where the tanks join the cooling elements. Where the top tank has been removed, any deposits which only occur in the top 50 mm (2") of the water channels can be removed, with a feeler strip of suitable thickness. Take care not to damage the element. Invert the radiator and flush out the deposits.
20. Place the bottom tank, open side upwards, on a fixture and position the cooling element on the tank. The tank flanges must be flush with the element.
21. Tack solder the tank to the cooling element at each corner.
22. Use a chisel-shaped gas bit to complete the soldering operation. Do not apply more solder than is necessary for a sound joint, as surplus solder may enter the tank and obstruct water passages in the element.
23. Reverse the cooling element top to bottom and place it in position on the upturned top tank.
24. Re-attach the strap assembly and overflow pipe and replace the drain tap.
25. Test the radiator for leaks as described previously.
26. If the radiator is to be placed in stock, the necessary anti-corrosion precautions must be taken, using Shell Ensus Fluid.

### FILLER CAP

27. A faulty or badly sealed filler cap will allow the coolant to boil at a lower temperature than the desired engine operating temperature.
28. The boiling point of water at atmospheric pressure is 100°C (212°F), but all modern cooling systems are pressurised in order to raise the boiling point of the coolant. The boiling point is raised approximately 1.7°C (3°F) for every 6.89 KPa (1 P.S.I.) of pressurisation but this is affected by the addition of anti-freeze and other additives to the

coolant water. However, for general purposes a 48 KPa (5 P.S.I.) pressure filler cap will raise the boiling point to 112°C (223°F).

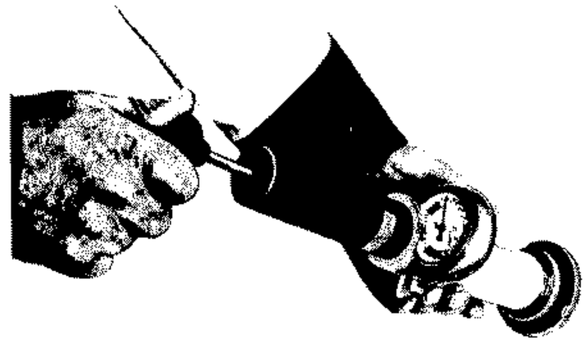
29. The best method of testing a filler cap is to use a pressure cap tester to ensure the pressure valve lifts at the correct pressure, i.e. 22-31 KPa (3.25-4.5 P.S.I.) for a 28 KPa (4 P.S.I.) cap or 43-50 KPa (6.25-7.25 P.S.I.) for a 48 KPa (7 P.S.I.) cap.

## RADIATOR (REFITTING)

30. Place the radiator onto its mountings and tighten the retaining nuts.

31. Connect the top and bottom hoses and secure them with jubilee clips.

32. Refill the cooling system to one inch below the filler neck. Check for leaks from the hose connections and replace any worn or defective hoses.



5.3000 - 29

5.4000

# FAN

## FAN (DESCRIPTION)

1. Except for marine engines a 4 or 6 bladed fan is fitted as standard equipment on 220 cu in and 330 cu in engines.
2. Fans can be of the pusher or puller type and can be of various diameters depending on the application of the engine.
3. The fan is attached to the water pump pulley by four retaining bolts.

## FAN (REMOVAL)

4. Removal of the fan is achieved by removing the four retaining bolts, and lifting the fan and spacers from the water pump pulley.

## FAN (INSPECTION AND OVERHAUL)

5. If a fan blade is damaged in any way, no attempt should be made to repair or re-use the damaged part. A bent or damaged fan should always be replaced with a new assembly.
6. It is essential that fan assemblies remain in proper balance, and proper balance cannot be assured once an assembly has been bent or damaged. A fan that is not in proper balance could fail and fly apart during subsequent use, creating an extremely dangerous condition.

## FAN (REFITTING)

7. Replace the spacers, fan and four retaining bolts and tighten to a torque of 43-52 Nm (32-38 lb ft).

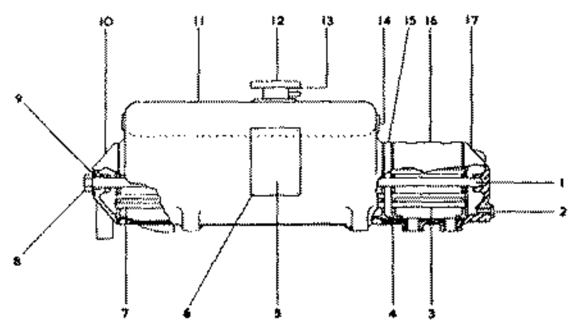
## 5.5000

## HEAT EXCHANGER

### HEAT EXCHANGER (DESCRIPTION)

1. The purpose of the heat exchanger assembly is to provide a header tank, which allows for expansion and de-aeration of the fresh water, also a means of cooling the engine cooling water and engine lubricating oil. The cooling of the water and oil is achieved by passing the raw water through a series of tubes which are surrounded by the liquid which requires cooling.

2. The unit consists of a corrosion resistant aluminium alloy casing providing the header tank and a machined compartment in which the water heat exchanger tube stack is located, also a small aluminium cylinder in which the oil cooler tube stack is located. A tube stack comprises of a series of tubes running between two end plates and a tie bar which passes between the two raw water end covers and joins the whole assembly together.




1. Tie Rod
2. Raw Water Drain Plug
3. Oil Cooler Tube Stack
4. Tube Stack Seals
5. Name Plate
6. Rivet
7. Heat Exchanger Tube Stack
8. Rod Cap Nut
9. Cap Nut Washer
10. End Cover
11. Body Heat Exchanger
12. Filler Cap
13. Filler Neck
14. Drain Plug
15. Spacing Ring
16. Oil Cooler Body
17. End Cover

5.5000 - 2

### HEAT EXCHANGER (REMOVAL)

3. Drain the entire cooling system.
4. Drain the engine oil.
5. Disconnect the three water hoses:
   a. Heat exchanger to raw water pump pipe.
   b. Heat exchanger to exhaust manifold.
   c. Heat exchanger to fresh water pump.
6. Disconnect the two oil pipes from the oil cooler.
7. Remove the two screws attaching the header tank to the engine thermostat housing and the two screws attaching the two stays to the header tank.
8. Lift the heat exchanger from the engine.

### HEAT EXCHANGER (OVERHAUL AND INSPECTION)

9. A thorough cleaning and inspection for leaks caused by ill fitting seals or corrosion comprise the overhaul and inspection procedure. To perform these operations it is necessary to dismantle as follows.

10. Remove the brass cap nut from the end cover, this cover can now be removed.

11. The opposite end cover complete with tie rod can now be withdrawn, care should be taken to support the oil cooler and the spacing ring after the tie rod has been removed, as this is not attached in any way to the main casing.

12. The 'O' seals can now be removed from the end of the tube stacks. This will allow the tube stacks complete to be withdrawn from their respective casings.

13. If the tube stack appears to be badly choked, it should be placed in a solution of 2.5 kg (5.5 lbs) of best brown potash to 22.75 litres (5 UK galls) of water. This will loosen all foreign matter adhering to them. The inside of the tubes which have sea water passing through them are more likely to require cleaning. If these are badly choked, they can be cleaned by pushing a length of 3 mm (⅛ inch) dia brass rod down the tube, so as to dislodge all foreign matter. The end of the brass rod should be free from sharp edges. It is IMPORTANT when doing this to push the rod through the tubes in the opposite direction to that in which the water flows. The other components should be cleaned before assembly, and as these contain no hidden surfaces no special instructions are required.

14. The general procedure for assembly is exactly the opposite to disassembly of the unit. Care should be taken to ensure that the rod cap nut is tightened to a torque of 34 Nm (25 lb ft).

15. All seals should be replaced and care should be taken to ensure that sealing surfaces are clean and free from burrs.

16. The heat exchanger water circuits should be pressure tested at 207 KPa (30 P.S.I.) after major overhauls and the oil cooler tested at 689 KPa (100 P.S.I.). The procedure to follow is detailed below.

17. The fresh water outlet should be plugged and a similar plug with an adaption for connecting an air supply should be fitted to the fresh water inlet.

18. Immerse the unit in hot water 82°-93°C (180°-200°F) and pressurise to 207 KPa (30 P.S.I.). If the heat exchanger is porous, air bubbles will be observed. Great care should be taken when releasing the air pressure.

19. Similar adaptors should be fabricated and the oil cooler tested in the same manner as paragraph 18, but the pressure to be 689 KPa (100 P.S.I.)

### HEAT EXCHANGER (REFITTING)

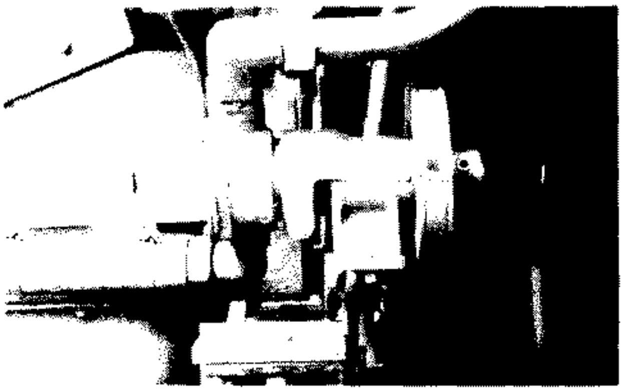
20. Using new thermostat gasket, refit the heat exchanger. Secure the four retaining screws to a torque of 18-20 Nm (13-15 lb ft).
21. Refit the water hoses and oil pipes.
22. Refill the cooling systems and lubricating system.

## 5.6000

## RAW WATER PUMP

### RAW WATER PUMP (DESCRIPTION)

1. The raw water used for lowering the temperature of the engine is circulated through the heat exchanger by a positive displacement pump.



5.6000 - 1

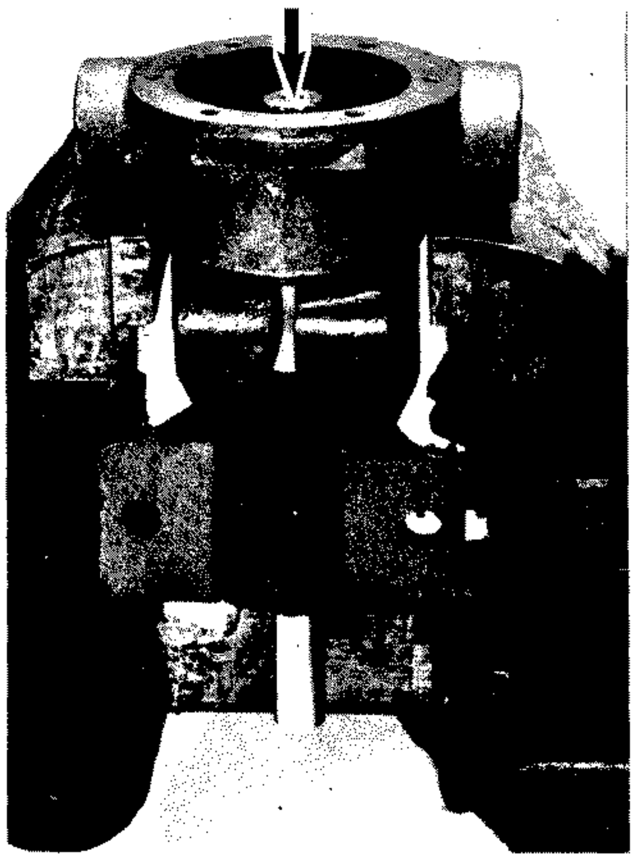
2. The pump drive shaft is supported by prelubricated bearings with a seal at each end to prevent leakage of lubricant and a seal to prevent water leakage along the shaft.
3. An impeller splined to the end of the drive shaft is self lubricated by the water being pumped through and SHOULD NOT BE RUN DRY longer than normally required for the pump to prime itself.
4. A wear plate in the impeller compartment prevents pump housing wear. This plate may be reversed if wear on the impeller side becomes excessive.
5. The pump can be operated in a clockwise or anticlockwise direction. Raw water is drawn into the pump through the inlet opening and discharged through the outlet opening, both openings being located on the top of the pump housing, details of the direction of flow and direction of rotation being given on the pump end cover plate.
6. The pump is driven by a belt which connects the pump to a pulley on the nose of the crankshaft.
7. The pump is not fitted with a drain tap and in freezing conditions the pump must be drained by loosening the end cover and allowing to drain out, retighten the cover before attempting to use the pump.

### RAW WATER PUMP (REMOVAL)

8. Drain the raw water system.
9. Disconnect the two hoses between the pump and oil cooler pipe and pump to heat exchanger.
10. Remove the two screws which secure the pump to the mounting brackets, remove the belt from the pump drive pulley and remove the pump from the engine.

### RAW WATER PUMP (INSPECTION AND OVERHAUL)

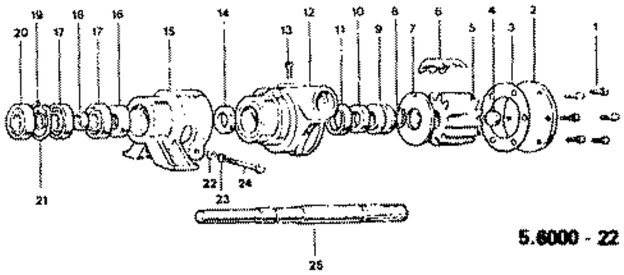
11. No special tools are required for the overhaul of the raw water pump, proceed in the following manner:-
12. Remove the six screws which retain the end cover and gasket, discard the gasket.
13. Withdraw the impeller from the housing by grasping a blade on each side of the impeller with pliers and pulling the impeller off the shaft, care must be taken not to damage the impeller.
14. Remove the cam locking screw and remove the cam. The wear plate which is located with a pin and retained by the cam can now be withdrawn. Place the pump in a position such that the shaft is vertical and remove the circlip which retains the seal.
15. Place the pump in a vice supporting the water outlets, remove the pinch bolt which clamps the pump housing to the bearing housing. Tap the shaft lightly in a downward direction, this will separate the two castings of the assembly and also remove the shaft from the seals in the pump.



5.6000 - 15

16. Remove the remaining seals from the pump housing and the slinger from the shaft.
17. Turn the bearing housing so that the drive pulley is upwards and replace in the vice, remove the driving pulley, the seal may now be prised from the housing and discarded.

18. Remove the large circlip which retains the bearings in the housing.
19. Turn the bearing housing such that the splined end of the drive shaft is uppermost and replace in the vice, the shaft may now be tapped downwards removing the shaft and bearings from the housing.
20. The circlip which retains the bearings on the shaft can now be removed and the bearings and spacer withdrawn with a puller.
21. The remaining seal in the housing can now be removed by tapping from the housing, in the direction away from the pump, and the seal discarded.
22. The pump should be reassembled using new parts where necessary by following the preceding instructions in reverse, it should be noted that a non-hardening sealant must be applied to the cam retaining screw. The exploded view of the water pump can be used as a guide when reassembling.



5.6000 - 22

1. Screw, Cover Retaining
2. Pump, End Cover
3. Gasket, End Cover
4. Spline Seal
5. Impeller
6. Cam
7. Wearplate
8. Retaining Ring
9. Seal
10. Seal Seat
11. Seat Cup-Rubber
12. Body, Water Pump
13. Cam Screw
14. Slinger
15. Bearing Housing
16. Seal
17. Bearings
18. Spacer
19. Retaining Ring-Bearing
20. Seal
21. Retaining Ring-Bearing
22. Nut
23. Washer - Spring Lock
24. Bolt, Hexagon Head
25. Shaft

## RAW WATER PUMP (REFITTING)

23. Fit the raw water pump to the mounting bracket, do not tighten the screws at this stage.
24. Connect the drive belt.
25. Connect the two hoses to the pump inlet and outlet pipes and secure with the clips.
26. Check the alignment of the pulleys with a straight edge across the faces of the pulleys, adjust if necessary, this will prevent excessive wear on the drive belt.
27. Adjust the drive belt to give a deflection of 0.3 mm ($\frac{1}{64}$") per 25 mm (1") of span with a load of 0.9-1.2 kg (2-2¾ lbs) and tighten the pump securing screws to 30-36 Nm (22-27 lb ft.)

5.0000

# COOLING SYSTEM SPECIFICATIONS

| **CAPACITIES** | 220 cu in | 330 cu in |
|---|---|---|
| Cylinder Block | 8 Litres (14 IMP PTS) | 10 Litres (18 IMP PTS) |
| Standard Radiator | 7 Litres (12 IMP PTS) | 7 Litres (12 IMP PTS) |
| Tropical Radiator | 7 Litres (12 IMP PTS) | 11 Litres (20 IMP PTS) |
| Total System Capacity = Cylinder Block + Radiator | | |
| Marine Engine Complete With Heat Exchanger | 11 Litres (19 IMP PTS) | 13 Litres (23 IMP PTS) |

**ANTI-FREEZE**

Type .......... Ethylene Glycol

The following table gives the % of ethylene glycol anti-freeze required for protecting the cooling system within the temperature quoted.

| TOTAL CAPACITY | COMPLETE PROTECTION | | | | SAFE LIMIT | | LOWER PROTECTION LIMIT | |
|---|---|---|---|---|---|---|---|---|
| | -8°C (17°F) | -15°C (5°F) | -23°C (-10°F) | -34°C (-29°F) | -14°C (7°F) | -24°C (-12°F) | -21°C (-5°F) | -40°C (-38°F) |
| 11 Litres (19 IMP PTS) | 3.5 | 5.5 | 7.5 | 9.5 | 5.5 | 8.0 | 6.5 | 10.0 |
| 13 Litres (23 IMP PTS) | 4.0 | 6.5 | 9.0 | 11.5 | 6.5 | 9.5 | 8.0 | 12.0 |
| 15 Litres (26 IMP PTS) | 4.5 | 7.5 | 10.5 | 13.0 | 7.5 | 10.5 | 9.0 | 13.5 |
| 17 Litres (30 IMP PTS) | 5.5 | 8.5 | 12.0 | 15.0 | 9.0 | 12.0 | 10.5 | 15.5 |
| 21 Litres (38 IMP PTS) | 6.5 | 11.0 | 15.0 | 19.0 | 11.0 | 15.5 | 14.5 | 19.5 |

**WATER PUMP**

| | |
|---|---|
| Housing Bore Dia | 34.986 to 35.001 mm (1.3774 to 1.3780 ins) |
| Bearing Dia | 34.9885 to 35.001 mm (1.3775 to 1.3780 ins) |
| Bearing Fit in Body | .0127 mm Clearance to .01524 mm Interference (.0005 in Clearance to .0006 in Interference) |
| Shaft Dia. | 15.9055 to 15.9182 mm (.6262 to .6267 ins) |
| Rotor Bore Dia. | 15.8420 to 15.8674 mm (.6237 to .6247 ins) |
| Rotor Fit on Shaft | .0381 to .0762 mm (.0015 to .0030 in) Interference |
| Rotor Hub Thickness | 21.59 to 21.72 mm (.850 to .855 ins) |
| Pulley Flange Bore Dia. | 13.8252 to 13.8506 mm (.5443 to .5453 ins) |
| Shaft Dia. | 13.8278 to 13.8405 mm (.5444 to .5449 ins) |
| Pulley Flange Fit on Shaft | .0229 mm (.0009 in) Clearance to .0152 mm (.0006 in) Interference |

**THERMOSTAT**

| | |
|---|---|
| Type | Metal Bellows or Wax Capsule |
| Opening Temperature | 77°-82°C (170°-179°F) |
| Fully Open Temperature | 93°C (199°F) |
| Valve Lift | 9.14 mm (0.36 in) Minimum |

**RADIATOR**

Radiator Leak Test Pressure .......... 48-69 KPa (7-10 lb/sq in)

**RADIATOR FILLER CAP**

| | |
|---|---|
| Opening Pressure 28 KPa (4 p.s.i.) Cap | 22 to 31 KPa (3.25 to 4.5 lbs/sq in) |
| Opening Pressure 48 KPa (7 p.s.i.) Cap | 43 to 50 KPa (6.25 to 7.25 lbs/sq in) |

**HEAT EXCHANGER**

| | |
|---|---|
| Water Circuit - Pressure Test | 207 KPa (30 lbs/sq in) |
| Oil Cooler - Pressure Test | 689 KPa (100 lbs/sq in) |

**RAW WATER PUMP**

Drive Belt Adjustment .......... 0.3 mm (1/64") per 25 mm (1") With Load of 0.9-1.2 Kg (2-2¾ lbs)

## TORQUE SPECIFICATIONS

| | |
|---|---|
| Water Pump Retaining Nuts | 30-37 Nm (22-27 lb ft) |
| Thermostat Water Outlet Bolts | 18-20 Nm (13-15 lb ft) |
| Fan Retaining Bolts | 43-52 Nm (32-38 lb ft) |
| Heat Exchanger Retaining Screws | 18-20 Nm (13-15 lb ft) |
| Raw Water Pump Retaining Screws | 30-36 Nm (22-27 lb ft) |

6

# SECTION 6

## EXHAUST SYSTEM

Contents

## 6.1000

## EXHAUST MANIFOLD

### EXHAUST MANIFOLD (DESCRIPTION)

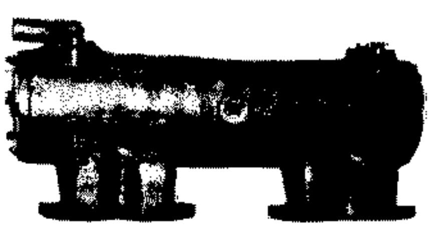
1. The Bedford 220 and 330 cu in engines use either an air cooled or a water cooled exhaust manifold.
2. The air cooled exhaust manifold is a one piece casting secured by four and eight bolts or studs for 220 and 330 cu in engines respectively. A gas tight joint is ensured by the use of gaskets between the cylinder head and exhaust manifold jointing faces, although on early engines the manifold was attached direct to the cylinder head.
3. There are two types of outlet on the air cooled exhaust manifolds, one for automotive engines (a) and a vertical outlet (b) for industrial engines.

a. Automotive

b. Industrial

6.1000 - 3

4. On marine engines a water cooled exhaust manifold is used. The exhaust manifold chamber is surrounded by a casing which retains the coolant. The coolant is the raw water from the heat exchanger unit which passes from the heat exchanger through the outer cavity of the exhaust manifold and is then exhausted.



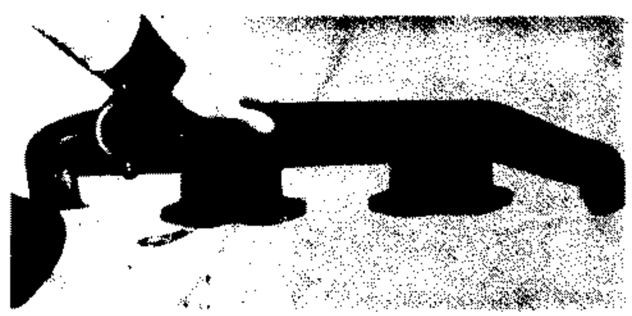
6.1000 - 4

### EXHAUST MANIFOLD (REMOVAL)

5. **Air Cooled.** If the engine is installed in a machine disconnect any exhaust pipe from the manifold. Remove and discard the manifold securing nuts or bolts. The manifold can now be removed from the engine.
6. **Water Cooled.** If the engine is installed in a vessel the raw water coolant must be drained before attempting any removal, this is detailed in 5.6000.
7. Disconnect the exhaust pipe from the manifold by removing the six screws from the rear end of the manifold.
8. Slacken the hose clamps and remove the exhaust water pipe from the rear of the manifold.
9. Slacken the hose clamps, which retain the supply hose, remove hose.
10. Remove the two ⅜" screws which secure the oil filter to the bracket which is fixed to the exhaust manifold. Care must be taken at this stage to remember that on early engines, the oil filter is not firmly fixed to the engine.
11. Support the manifold and remove the screws which secure it to the cylinder head, care must be taken not to damage the fuel pipes from fuel pump to injectors, on some engines the pipe clamps are fitted to the exhaust manifold fixing screws.
12. Remove manifold and manifold gasket, if fitted.

### EXHAUST MANIFOLD (INSPECTION AND OVERHAUL)

13. **Air Cooled.** Examine the manifold for cracks, particularly around the attaching flanges.
14. Check for distortion of the joint face on a surface plate. Slight distortion can be corrected with a fine cut file.



6.1000 - 14

15. **Water Cooled.** Remove the loose scale and carbon that might have accumulated on the internal walls of the exhaust manifold.
16. Clean all traces of the gasket, if fitted, from the exhaust manifold, and also the cylinder head.
17. Examine the manifold for cracks, particularly around the attaching flanges.
18. Make up and fit a plate suitable for sealing the entire exhaust end of the manifold, a rubber gasket is recommended to obtain a seal between the plate and manifold. Remove the water inlet and outlet elbows from the manifold casting, make a plate and fit as above over the water outlet. The water inlet should be covered with a similar plate but with a fitting suitable for connecting an air supply. Do not cover the ports which fit adjacent to the cylinder head.
19. Immerse the exhaust manifold in a container of hot water 82°-88°C (180°-200°F) and pressurise by hand or foot pump (not a works air line) to 207 KPa (30 P.S.I.). It is essential that hot water is used

as this simulates actual operating conditions, if the manifold should have any leaks air will be observed escaping either from the ports or the exterior of the manifold.
20. Remove the manifold from the water tank, remove the fittings and blanking plates. Dry the manifold with compressed air.
21. Check the manifold for distortion of the joint face on a surface plate. Slight distortion can be corrected with a fine cut file.

## EXHAUST MANIFOLD (REFITTING)

22. **Air Cooled.** Ensure that the manifold joint faces are clean and free from burrs.
23. Fit the manifold together with gaskets and secure with the retaining screws. Tighten the screws to a torque of 34 Nm (25 lb ft).
24. **Water Cooled.** Ensure that the manifold joint faces are clean and free from burrs.
25. Fit the manifold gaskets in place, this can be achieved by inserting the fixing screws and spring washers into holes in the manifold and laying the gaskets in place, located by the screws.
26. Offer the manifold to the cylinder head and secure with screws which are not injector pipe bracket attaching points.
27. Refit the injector pipe brackets taking care to refit the clamps in their original positions, this positioning is important in order to prevent the vibration of the pipes.
28. Tighten the manifold securing screws to a torque of 34 Nm (25 lb ft).
29. Refit the oil filter to its mounting bracket on front of the exhaust manifold.
30. Inspect the coolant supply hose and clips and refit, tighten hose clips.
31. Refit after inspection the exhaust water pipe and tighten clips.
32. Refit the exhaust pipe to the manifold.
33. Before starting the engine, check that the end cover has been refitted to the raw water pump, this is detailed in 5.6000. After the engine has been run, check the tightness of all fixings and that no water or exhaust leaks exist.

7

# SECTION 7

## ELECTRICAL EQUIPMENT

### Contents

7.1000

## BATTERY CHARGING GENERATOR

**Battery Charging Generator (General Description)**

1. The generator and alternator charging systems used on 220/330 cu.in. Bedford Diesel Engines use major components produced by different manufacturers. Although the basic principles of operation are similar, they differ sufficiently to require individual attention.
2. The following combinations are used:

| SYSTEM | GENERATOR | CONTROLLER/REGULATOR |
|---|---|---|
| 12 Volt | Lucas CA45 PV6 (Ventilated) | Lucas RB310 (Current Voltage) |
| 12 Volt | Lucas C 45 P 6 (Non-Ventilated) | Lucas RB108 (Compensated Voltage) |
| 12 Volt | Lucas C40L | Lucas RB340 |
| 12 Volt | Lucas C40A (Insulated Return) | Lucas RB108 |
| 12 Volt | Lucas C40A (Enclosed) | Lucas RB108 |
| 12 Volt | C.A.V. GL.45-12-4M | CAV 6GC |
| 24 Volt | C.A.V. GL-45-24-7E (Enclosed) | CAV 6GC |

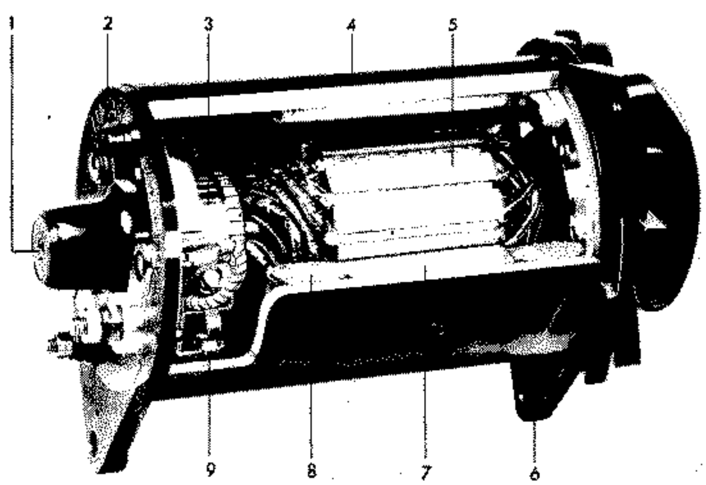
| SYSTEM | ALTERNATOR | CONTROLLER/REGULATOR |
|---|---|---|
| 12 Volt | C.A.V. AC5 | C.A.V. 440/12/2 |
| 24 Volt | CAV AC5 | C.A.V. 440/24/2 |
| 12 Volt | C.A.V. AC5A | C.A.V. 440/12/2 |
| 24 Volt | C.A.V. AC5A | C.A.V. 440/24/2 |
| 12 Volt | Lucas 17ACR (Battery Sensed) | Lucas 8TR |
| 12 Volt | Lucas 17ACR (Machine Sensed) | Lucas 8TR |
| 12 Volt | AC Delco DN460 (Machine Sensed) | AC Delco built in integrated circuit regulator |

3. This section has therefore been sub-divided into three sections i.e. generators, controllers and alternators complete with regulators.

**Generators (Description)**

4. The generators are of the two brush, two pole, shunt type and have the same characteristics in that the voltage rises with an increase of generator speed.
5. The generator comprises a cylindrical frame or yoke containing the pole shoes, field coils, brush gear and an armature with commutator. The field coils are secured to the yoke by screws, the shoes are located 180° apart. One end of the field winding is connected to the yoke and the other to the 'F' terminal. The carbon type brushes are mounted in holders attached to the commutator end bracket, one brush holder is earthed to the bracket whilst the other brush holder is insulated and connected to the 'D' terminal. The armature shaft is supported in a ball bearing carried in the drive end bracket, and a plain porous bronze bush located in the commutator end bracket. The end brackets are clamped to the yoke by through bolts. The ball bearing is packed with grease during initial assembly and requires no attention in service. The bush in the commutator end bracket is lubricated by an oil soaked felt washer at its outer end. An oil hole is provided at the outer end of the bush housing to provide means of lubricating the bush in service.

NOTE: Bush should be lubricated every 700 hours with SAE 30 engine oil.




7.1000-5

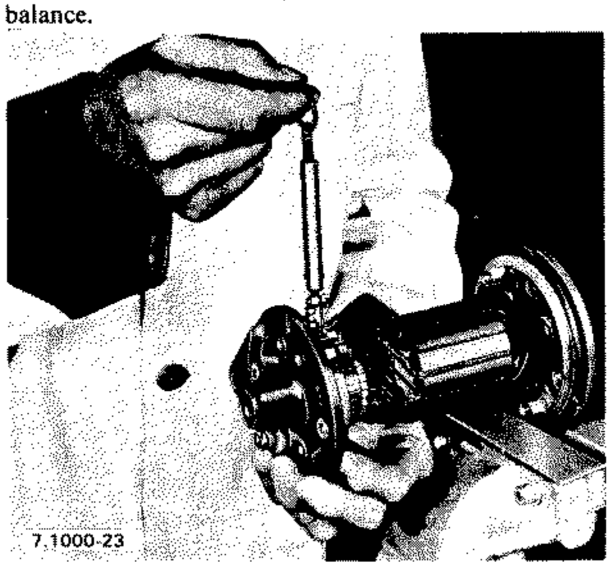
1. Bush lubrication hole
2. Commutator end bracket
3. Commutator
4. Yoke
5. Armature
6. Drive end bracket
7. Pole shoe
8. Field coil
9. Brush spring

6. The end brackets on generators models C45PV-6 and C40L are ventilated and air is circulated by fan blades incorporated in the generator pulley. The pulley, which is driven by a Vee section belt from the crankshaft pulley is keyed to the end of the armature shaft and secured by a nut and lockwasher.
7. The generator is located on the engine crankcase and is supported by three integral lugs, two on the drive end bracket and one on the commutator end bracket. The lug at the commutator end is attached to a bracket bolted to the engine crankcase whilst a slotted brace attached to one of the lugs at the drive end provides means of adjusting the fan belt. The other lug at the drive end is bolted to the engine front plate.

**Operation**
8. Rotation of the armature in the magnetic field produced by the field magnets, induces alternating voltages in the armature windings which are converted into direct current by the action of the brushes and commutator.
9. The output of the generator depends upon the strength of the magnetic field and the speed at which the armature rotates. Normally any variation of speed is accompanied by a change of output, and since the generator is driven at varying speeds, means must be provided to control the output. This is done by varying the strength of the magnetic field, the current value being controlled by either an automatic current or compensated voltage controller or regulator.
10. To test the generator output the following procedure should be adopted:
11. Check the fan belt for correct tension by depressing the belt midway between the fan and generator pulleys and adjust if necessary. Belt tension should be ½'' depression under a load of 8-10 lbs.
12. Check the generator to controller connections to ensure generator terminal 'D' connects to controller terminal 'D' and generator terminal 'F' connects to controller terminal 'F'.
13. Test the generator when cold, by disconnecting the wires from the generator and bridge the two terminals with copper wire.
14. Using a voltmeter with a range of 0-50 volts connect the negative lead to the bridge wire and the positive lead to earth.
15. Start the engine and slowly increase its speed and note the voltmeter reading. This should gradually rise to between 40 and 50 volts if the generator is operating correctly. Do not prolong this test, otherwise serious damage to the generator may result as an open circuit is operating under these conditions and the field windings will quickly overheat.
16. Should the voltmeter reading be low, irrespective of engine speed, an internal fault is indicated and the generator should be removed from the engine and dismantled for rectification.

**Generator (Removal)**
17. Disconnect the cables from the battery and the wires from the generator terminals.
18. Slacken the fan belt adjustment and remove the belts from the generator pulley.
19. Remove the bolts and nuts securing the front of the generator to the engine. With the generator supported, remove the bolt securing the rear end and lift away the unit.

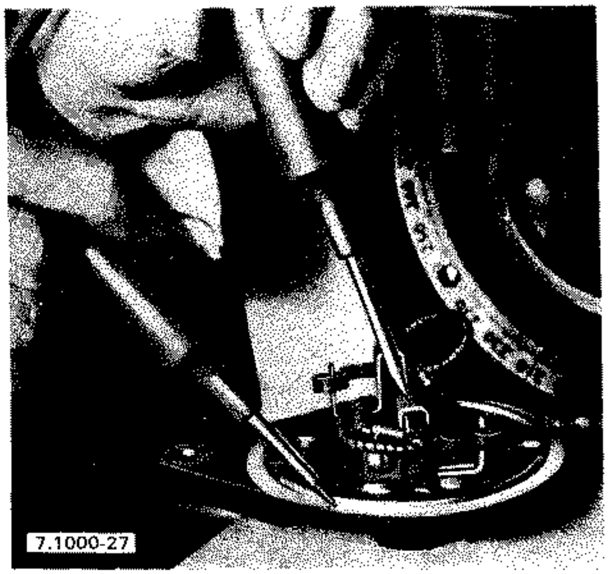
**Generator (Inspection and Overhaul)**
20. Remove the pulley nut and lockwasher and withdraw the pulley.
NOTE: Some generators have a plastic pulley. These pulleys are brittle and when removing the nut restrain the pulley from turning by wrapping a fan belt around the belt groove.
21. Remove the two through bolts securing the drive end and commutator end brackets.
22. Tap the commutator end bracket away from the yoke with a hide mallet taking care not to damage the field post insulating bush. Remove the fibre washer from the armature shaft. Withdraw the drive end bracket and armature shaft from the yoke.
23. Mount the drive end bracket and armature assembly in a vice using soft metal jaw clamps. Assemble the commutator end bracket to the armature with the brushes and springs correctly located. Check the tension of the brush springs with a small spring balance.




24. If the spring load is not within the specified limits, renew the springs during overhaul.
25. Remove the commutator end bracket from the armature shaft.
NOTE: It is not necessary to remove the drive end bracket and bearing assembly from the armature shaft unless the bearing or armature requires renewing. All armature tests can be carried out with the end bracket in position on the shaft.
26. All parts must be cleaned thoroughly but cleaning solvent must not be allowed to contact the field coils or armature, otherwise the insulation may be damaged. In addition, keep the bearings clear of cleaning solvent unless they are to be renewed.

**Brush Gear**

27. Test the insulation of the brush holder mountings using test prods carrying a mains voltage of 200-250 and having a lamp wired in series. With one of the prods on the positive (earthed) brush holder and the other on the commutator end bracket, the series lamp should light up. When testing the negative (insulated) brush holder the lamp will remain unlit if the insulation is in a satisfactory condition.



7.1000-27

28. Check for tightness of the rivets or screws securing the brush holders to the end bracket.
29. Check for sticking of the brushes in their holders, and for excessive brush wear.
30. To free sticking brushes, clean all carbon deposits away with petrol (gasoline) and if necessary ease the brushes by lightly polishing the sides with a swiss file. Ensure that the existing brushes, if satisfactory, are fitted to their original positions.
31. New brushes should be bedded in to the contour of the commutator as follows:
32. Using soft metal jaw clamps, secure the armature in the vice by gripping the drive end bracket.
33. Install the commutator end bracket on the armature shaft so that the brushes locate fully on the commutator.
34. Insert a strip of fine glass paper **(do not use emery cloth)** cut to the width of the commutator, between the commutator and brushes.
35. Whilst holding the end bracket, rotate the armature and glass paper in the normal working direction for about 6 revolutions, then remove the paper and blow out all carbon and glass dust.

**Armature**

36. Examine the commutator for pitting or wear and for evidence of fouling as a result of worn bearings.
37. Using a growler, test the armature for short circuits, open circuits and earthed windings.

**Short Circuits**

38. Place the armature on the growler and move the switch to the 'SERIES' position.
39. Hold a hacksaw blade or steel rule over and in line with the armature core and slowly rotate the armature a complete revolution.
40. If the saw blade or rule does not vibrate the condition of the armature is satisfactory. If however, the saw blade or rule does vibrate a short circuit is indicated.
41. To determine whether the short is in the armature or the commutator, switch off the growler and examine the commutator. Clear any segments which may have burred together, and then retest. If vibration is still evident, the armature is short circuited and should be renewed.
42. Make sure that the armature to commutator leads are securely soldered to the commutator segments.

**Open Circuits**

43. Mount the armature on the growler and move the switch to 'SERIES' position.
44. Place the dual test fingers on adjacent commutator segments. Adjust the ammeter by means of the growler rheostat control knob to obtain the midscale reading, note the reading. Rotate the armature just sufficiently to bring the next gap on the commutator into the checking position. Repeat the test on all segments in turn, maintaining the same point of checking. If from any pair of segments a very low or zero reading is obtained, an open circuit in the winding is indicated. Check for a possible short circuit between the commutator segments and ensure the inter-segments are clear before proceeding.

7.1000-44

45. Retest; if the low reading persists an open circuit is indicated, which should be rectified or the armature renewed.

**Earthed Windings**

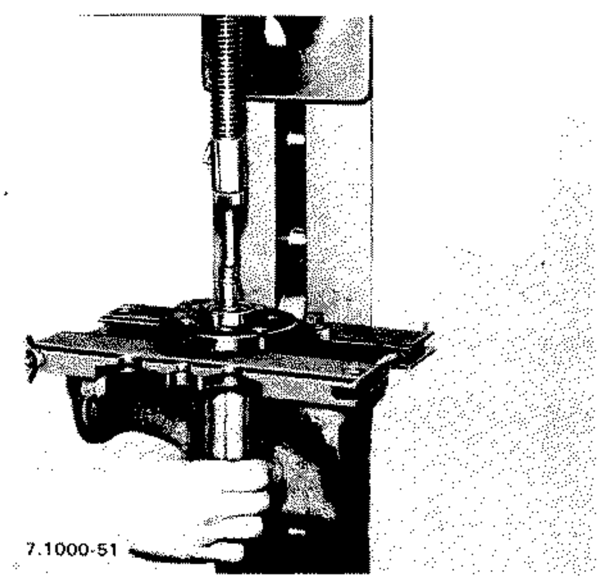
46. For this operation the test prods carrying mains voltage are used in conjunction with the continuity test lamp.
47. Insulate the armature from the growler by placing a strip of insulating material between the mounted armature and growler. Switch on the mains current. Place one test prod on the armature core and the other on each side of the commutator segments in turn.
48. If the test lamp lights, an earth is indicated and should be rectified by repair or renewal of the armature. If the test lamp remains unlit, the armature is satisfactory.
49. To recondition the armature, clean and polish the commutator, using very fine glass paper. **Do not use emery cloth.** Clean out the mica segments, if necessary take a light skim off the commutator (see table below) and undercut to a depth of 1/32″ over the full width of the mica, finish off by polishing the commutator with glass paper. An armature so treated should be given a further growler test as previously described.

**Bearings**

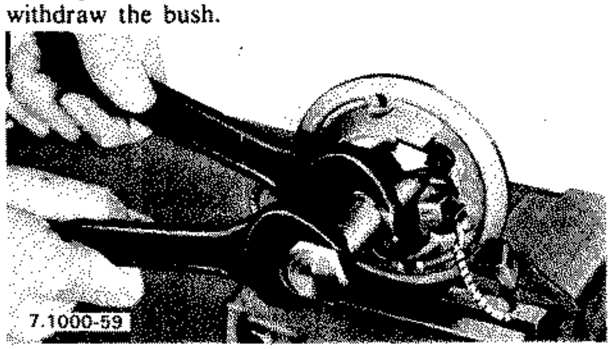
50. Examine the armature ball bearing for roughness or play between the outer and inner races and renew if necessary.
51. Press the armature shaft out of the bearing making sure that the end bracket is supported as close to the bearing as possible. Do not lose the distance collar located over the shaft and behind the bearing.
52. Punch out the rivets securing the bearing retaining plate and remove the plate. On later C40L models a circlip is used in place of the rivets.
53. Push the bearing out of the bracket and remove the corrugated washer, felt seal and retainer.
54. Pack the new bearing with a recommended grease. Assemble the seal retainer, a new felt seal and the corrugated washer to the end bracket.
55. Install the new bearing and retaining plate, and secure in position with new rivets.
56. Make sure that the distance collar is assembled to the shaft and located over the split ring.

| GENERATOR | MINIMUM DIAMETER OF COMMUTATOR |
|---|---|
| Lucas CA45 PV6 | 1.625 inches |
| Lucas CA45 P 6 | 1.625 inches |
| Lucas C40L | 1.450 inches – built prior to October 1964 |
| Lucas C40L | 1.430 inches – October 1964 and later |
| Lucas C40A | 1.430 inches |
| CAV GL45-12-4M | 1.593 inches |
| CAV GL45-24-7E | 1.593 inches |

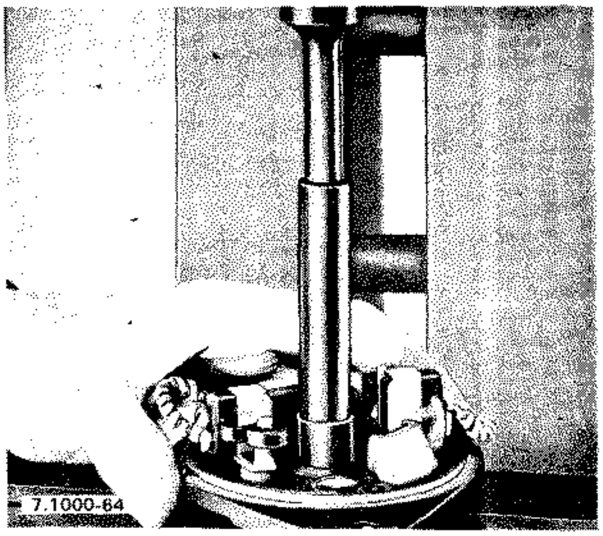
NOTE: The month and year of manufacture are stamped on the armature bearing collar. The month is indicated in alphabetical sequence (omitting the letter I) and each year is denoted by two figures. e.g. K64 is an armature manufactured in October 1964.


7.1000-51

57. Assemble the bracket to the shaft and press into position against the distance collar using a piece of tube to contact the bearing inner race. **On no account must the thrust be taken by the bracket otherwise the corrugated washer or the bearing may be damaged.**
58. Examine the bush in the commutator end bracket and the corresponding end of the armature shaft for wear. To renew the commutator end bush, tap a thread in the bush using an 11/16″ diameter tap. Locate a distance piece 1″ long with a bore diameter of 13/16″ and outside diameter 1¼″ over the end of the bush. Screw a nut on a setscrew or similar thread to the tap and thread the setscrew into the bush.
59. Tighten the nut against the distance piece and withdraw the bush.


7.1000-59

60. Remove the metal disc and felt pad from the bush housing.
61. Thoroughly clean out the housing.
62. Impregnate a new felt pad in clean engine oil and install in the bush housing followed by the metal disc.
63. Saturate the new bush with thin engine oil by placing a forefinger over one end of the bush and fill the bush with oil. Place the thumb over the open end of the bush and apply pressure until oil is observed seeping through the wall of the bush. Refill the bush with oil and repeat the operation to ensure that the bush is completely saturated.
64. Press the bush into the commutator end bracket with drift SE 234/1 or SE 234/2.

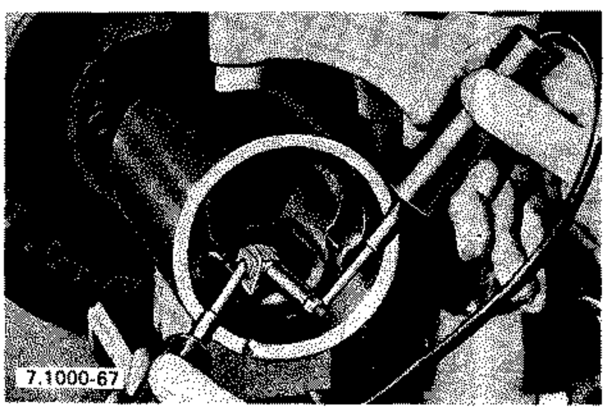

7.1000-64

**Field Coils**

65. Test the field coils for continuity, voltage drop and earth. It is essential that the following tests are carried out whilst the coils are assembled to the yoke. To provide access to the field coil lead, punch out the rivet securing the terminal post to the yoke.

**Continuity**

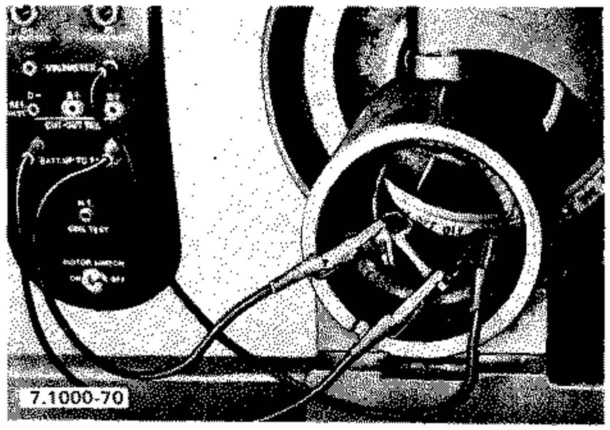
66. For this test use two mains supply test leads fitted with test prods and with a lamp wired in series.
67. Place the two test prods on the field leads as shown below. If the test lamp lights, the field coils are satisfactory.


7.1000-67

68. If the lamp remains unlit, an open circuit is indicated and providing the fault is not in the exposed lead or series connection, the coils should be renewed.

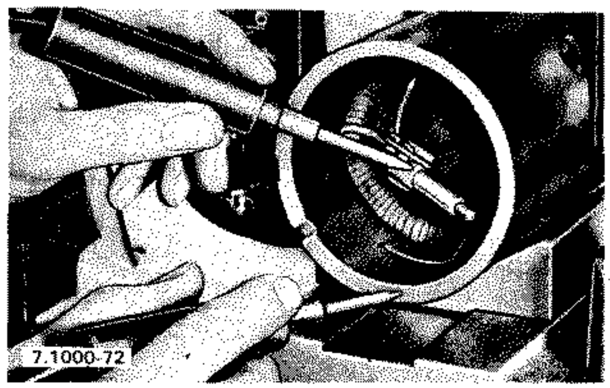
**Voltage Drop**

69. To carry out this test use two leads carrying 12 volts, or 24 volts for C.A.V. generator GL45-24-8E (enclosed).
70. Connect the test leads to the field coil leads. Clean part of the series connection and connect a voltmeter across each coil and note the readings obtained. A reading of 6 volts should be obtained from each coil on Lucas generators, 3 volts on CAV 12 volt generators and 6 volts from CAV 24 volt generators.


7.1000-70

**Earth**

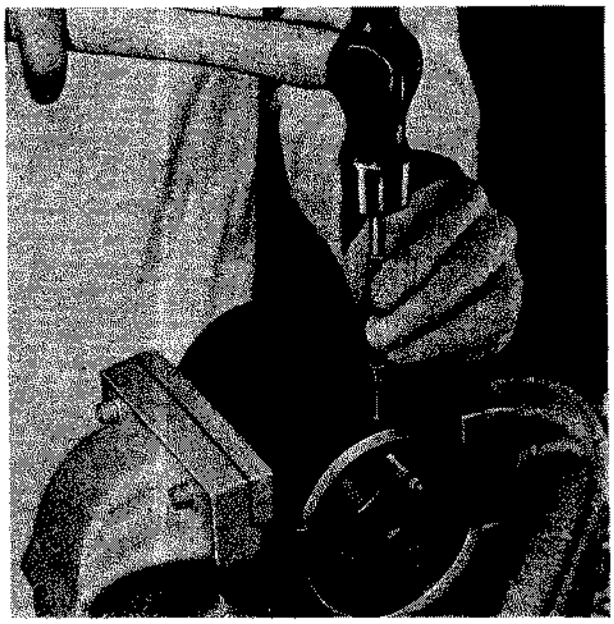
71. For this test use the mains supply test leads with a lamp in series. During this test make sure that the ends of the field coil leads do not touch the generator yoke.
72. Place one of the test prods on the field coil lead and the other on the generator yoke.


7.1000-72

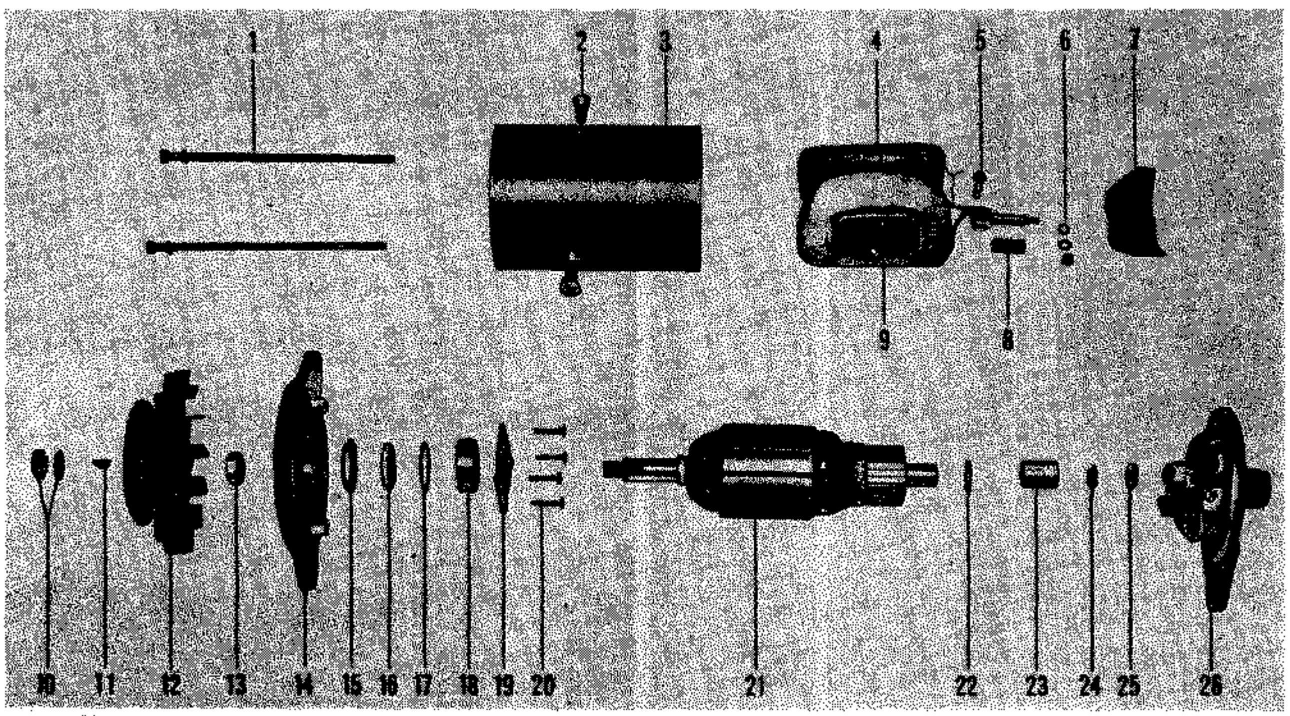
73. If the lamp does not light the coils are satisfactory. If the lamp does light, an earth is indicated and the coils should be renewed.
74. To renew or re-insulate the field coils, the following procedure should be adopted:
75. If not already detached, punch out the rivet securing the field coil terminal post.

76. Mark the pole shoes in relation to the yoke and remove the pole shoe securing screws, using a pole shoe screwdriver.
77. Withdraw the field coils and pole shoes as an assembly from the yoke.
78. Where necessary, insulate the coils, using ½" wide white linen tape, coat the tape with shellac and stove heat until completely dry.
79. When renewing the coils, to avoid the necessity of dismantling the terminal post, use the original lead tags on the post and ensure that the earth (red) lead is connected to the earth tag.
80. Locate the coils and pole shoes in their correct relative positions in the yoke and insert the pole shoe screws.
81. Place the pole shoe expander SE 9 in position and tighten the screws with the pole shoe screwdriver.
82. Secure the terminal post with a new rivet so that the rivet head is on the inside of the yoke.

83. The generator should now be re-assembled.



7.1000-82




7.1000-83

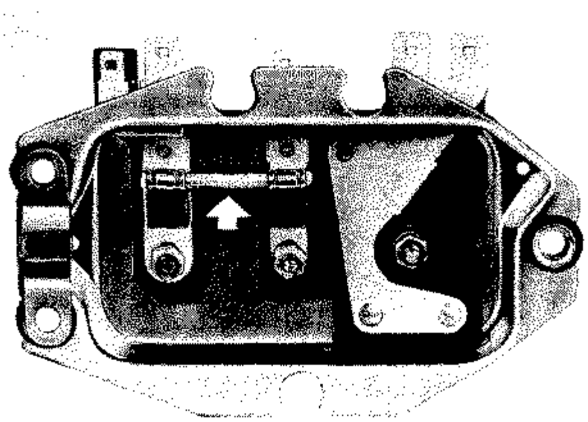
1. Through bolts
2. Pole shoe screw
3. Yoke
4. Field coils
5. Field coil terminal post rivet
6. Washers and terminal nut
7. Insulator
8. Insulating sleeve
9. Pole shoe
10. Pulley nut and lockwasher
11. Woodruff key
12. Drive pulley
13. Distance collar
14. Drive end bracket
15. Felt seal retainer
16. Felt seal
17. Corrugated washer
18. Ball bearing
19. Bearing retainer
20. Bearing retainer rivets
21. Armature
22. Fibre washer
23. Commutator end bush
24. Aluminium washer
25. Felt washer
26. Commutator end bracket and brush gear

84. Install the spacing washer and woodruff key at the drive end of the armature shaft.
85. Press home the generator pulley so that on ventilated generators, the fan blades are towards the drive end bracket. Install the lockwasher and tighten the pulley nut.
86. Install the armature assembly in the yoke and place the fibre washer on the commutator end of the shaft.
87. Lift the brushes and wedge them in the raised position with the springs.
88. Assemble the commutator end bracket to the armature shaft sufficiently to bring part of the brushes over the commutator. Release the brushes ensuring that the springs locate on top of each brush, then push the end pulley home.
89. Line up the dowel in each end bracket with the recesses in the yoke, then insert and tighten the through bolts. Check the armature for free rotation.
90. Before installing the generator in the unit, it should be checked on a bench test, reproducing unit running conditions as closely as possible.

**Generator (Refitting)**
91. Slacken the bolts securing the generator rear mounting bracket to the engine crankcase.
92. Assemble the generator to the bracket and the mounting on the crankcase front plate and temporarily tighten the end bracket bolts and nuts.
93. Securely tighten the bolts attaching the generator rear mounting bracket to the crankcase.
94. Slacken the end bracket bolts and nuts, install the fan belt and assemble the bolt into the slotted brace.
95. Adjust the fan belt. For correct belt tension see page 14 of Section 1.
96. Connect the wires between the generator and controller, ensuring terminal 'D' on the generator connects terminal 'D' on the controller and terminal 'F' on the generator connects to terminal 'F' on the controller.

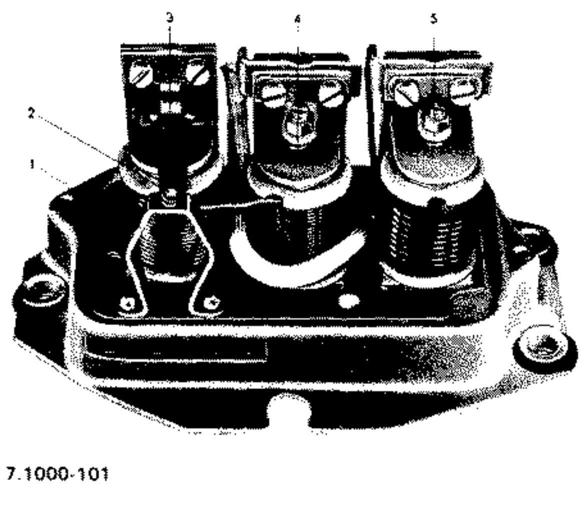
## VOLTAGE CONTROLLERS
97. Lucas RB310, Lucas RB340 and CAV 6GC are all current voltage controllers, while Lucas RB108 is a compensated voltage controller.

**Lucas RB310 (Description)**
98. The current voltage type controller comprises an insulated metal base on which is mounted a cutout, current regulator and voltage regulator. These three units are enclosed by a metal cover, which with a rubber seal is secured to the base by two screws.
99. On all controllers a points resistor bridges the current and voltage regulator frames.



7.1000-99

100. Resistors are of the wire wound (spaghetti) type. The diode is in series with the field parallel resistance and earth. It is of positive earth polarity and this is clearly shown by means of a label on the controller cover.
101. The cut-out, current regulator and voltage regulator are separate units each having a wound core mounted on individual 'L' section frames. An armature is attached to each frame by a flat steel flexible hinge which is riveted to the armature and secured to the 'L' frame by two screws. On the current and voltage regulators, a moving contact is mounted on the top face of each armature and a fixed contact is located in a bracket secured to the top of the 'L' frames.




7.1000-101

1. Cut-out fixed contact post
2. Cut-out moving contact and blade
3. Cut-out armature back stop
4. Current regulator contacts
5. Voltage regulator contacts

102. The cut-out moving contact is attached to the end of a blade which is riveted to the top face of the armature and projects beyond the edge of the armature. The fixed contact is mounted on a post riveted to the insulated base of the controller. A flat steel spring riveted to each armature bears against an adjusting screw threaded into each 'L' frame. These springs hold the current and voltage regulator contacts closed and the cut-out contacts open, until the armatures come into operation. The spring on the voltage regulator and cut-out is the bi-metal type, providing automatic temperature compensations.

103. The cut-out armature is provided with a back stop which is secured, in common with the armature hinge, by two screws.

104. The current regulator core incorporates a single low-resistance series coil. The voltage regulator core carries two coils, a low-resistance bucking coil and a high-resistance shunt coil.

105. The cut-out core carries a shunt coil, and a series coil through which all charging current flows.

**Operation**

106. As the voltage regulator is shunt wound and connected across the generator terminals it is responsive only to variation in the generator voltage, whilst the current regulator, being connected in series with the load, is affected only by changes in current.

107. Under normal conditions when the battery is not discharged, after the generator cut-out reaches the required value and the cut-out contacts close, a further increase in generator speed cause a rise in terminal voltage and subsequently the operating voltage setting of the voltage regulator is attained. When this occurs, the magnetic pull of the voltage regulator core attracts the armature and the voltage regulator contacts open, causing the points resistance located underneath the base to be inserted into the generator field circuit. The effect of inserting this resistance in the field circuit is to reduce the generator output. Consequently the magnetic pull on the armature is reduced and the contacts close and short out the resistance again. This sequence is repeated many times per second and starts the regulator armature vibrating, the effect being to limit the generator voltage to a predetermined value. The bucking coil incorporated in the voltage regulator assists the operation of the armature by increasing the frequency of vibration, and so ensures stability of operation.

108. In cases where the battery is discharged or heavy electrical loads are imposed upon the system, the generator voltage will not rise to the value at which the voltage regulator operates. Therefore another method of controlling the generator output to a safe limit is necessary and this is provided by the current regulator. When the current output of the generator reaches its maximum rated value, the electro-magnetic effect of the current flowing through the current regulator coil attracts the armature and opens the contacts, thus inserting the points resistance in the field circuit as before. Consequently the current regulator armature is set into vibration and a safe limit is imposed on the generator output.

109. When commencing to charge a flat battery, the current regulator allows the maximum safe generator output to pass to the battery and this continues until the battery approaches a charged condition. At this stage the voltage available is sufficient to bring the voltage regulator into operation, the current value falls and the current regulator ceases to operate. During the changeover period, which exists for half a minute, both regulators are in operation.

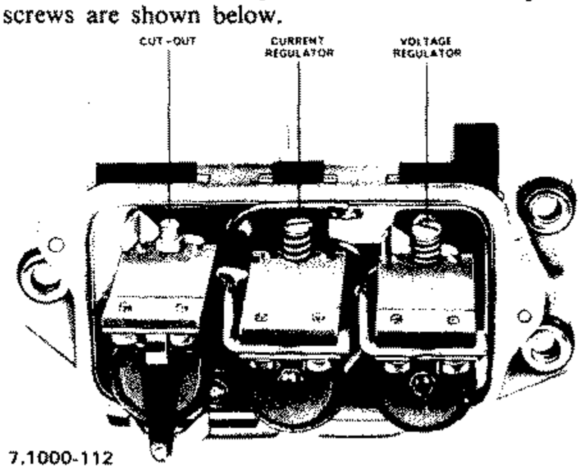
110. After the voltage regulator has been brought into operation, the generator output tapers off until trickle charge conditions are reached.

**Temperature Compensation**

111. With rise in temperature the resistance of the cut-out and voltage regulator shunt coils increases, thus reducing the magnetic pull on the respective armature. To compensate for this reduction in magnetic energy, the tension of the armature bi-metallic spring decreases with the rise in temperature. In this manner the operating voltage of the cut-out remains constant under all temperature conditions. On the voltage regulator, this feature automatically permits the higher voltage required for increasing the battery charging rate in cold weather and the lower voltage required for reducing the charge in warm weather.

**Electrical Settings – To Check and Adjust on Unit**

112. For checking the electrical settings of the controller it is necessary to use a high grade moving coil voltmeter with a range of 0-20 volts, and a high grade moving coil ammeter with a range of 0-40 amperes. The settings on the voltage regulator, cut-out and current regulator should be carried out as a complete sequence. The setting of one unit only is not recommended. The regulator and cut-out adjusting screws are shown below.




7.1000-112

NOTE: The cut-out adjusting screw is secured by a locknut. The adjusting screws on the current and voltage regulators are spring-loaded cheese-head screws.

**Voltage Regulator**

113. When testing and adjusting the voltage regulator the generator is running on open circuit and can therefore build up high voltage, which will cause heating of the regulator shunt coil. The adjustment of the regulator should be completed as quickly as possible, otherwise heating of the shunt coil may cause an inaccurate setting to be made.
114. Remove the controller cover and insert a piece of paper between the cut-out contacts to isolate the generator from the battery.
115. Connect the voltmeter between the controller 'D' terminal and earth.
116. Start the engine and increase engine speed gradually until the voltmeter flicks and steadies. This should occur at the readings specified.
117. If necessary, adjust the regulator by turning the adjusting screw **clockwise** to **increase** the voltage or **anti-clockwise** to **decrease** the voltage, until the setting is within the required limits.
118. Remove the paper from between the cut-out contacts, but leave the voltmeter connected.

**Cut-Out Relay**

119. Connect a load across the battery terminals to draw between 8 to 10 amps.
120. Slowly increase the engine speed from idling and check the cut-in voltage. This should occur between 12·7 to 13·3 volts. Closure of the contacts is indicated by the voltmeter needle flicking back.
121. If necessary adjust the cut-in voltage. Slacken the locknut and turn the cut-out adjusting screw, **clockwise** to **increase** the voltage and **anti-clockwise** to **decrease** the voltage. Retighten the locknut after each adjustment.
122. To check the reverse current, remove the wire from terminal 'B' and connect the ammeter between the terminal and the wire.
123. Run the engine up to charging speed, then gradually decrease the speed and note the ammeter reading. The maximum discharge before the cut-out points open should not exceed 5 amps.
124. If necessary adjust the current value to within the limits by bending the legs of the cut-out fixed contact post to alter the contact gap. **Straightening** the legs will **reduce** the current value and **bowing** them will **raise** it. Repeat the test and if necessary, adjust the legs further until the current value is within the specified limits.
125. Remove the load across the battery terminals.

**Current Regulator**

126. Connect the ammeter between terminal 'B' and the wires removed from the terminal, and bridge the voltage regulator contacts by means of a clip across one of the armature assembly fixing screws and the insulated fixed contact bracket.
127. Run the engine at half throttle and note the ammeter reading. A steady reading of 24 to 26 amperes should be obtained.
128. If necessary adjust the regulator by turning the adjusting screw **clockwise** to **increase** the current or **anti-clockwise** to **decrease** the current.
129. Switch off the engine, remove the clip from the voltage regulator, disconnect the ammeter and reconnect the wires to terminal 'B'. Replace the cover.

**Lucas RB310 (Removal)**

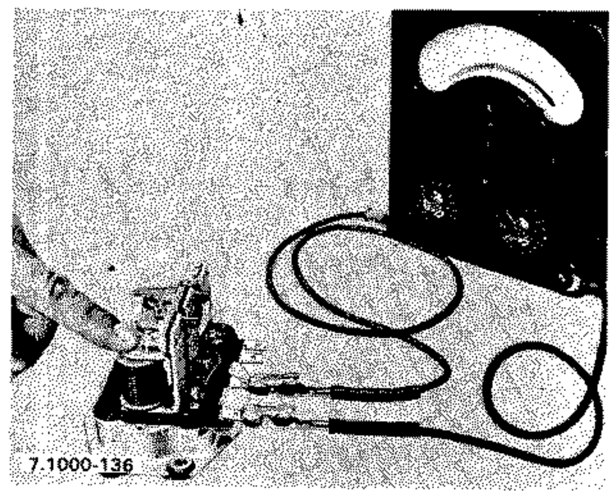
130. Disconnect the cables, from the battery.
131. Disconnect the wires from the controller, remove the three screws securing the controller to the dash panel and lift away.

**Lucas RB310 (Inspection and Overhaul)**
**Shunt Winding Test**

132. Test the cut-out and voltage regulator shunt windings by connecting an ohmmeter across the 'D' terminal and controller base. A reading of approximately 40 ohms will be obtained if both windings are satisfactory.
133. If a reading of approximately 110 ohms is obtained, this will indicate that the cut-out shunt is open circuited. A reading of approximately 60 ohms will mean that the voltage regulator is open circuited.

**Field Resistor Test**

134. Examine the resistor for visual damage.
135. Connect an ohmmeter between terminals 'D' and 'F'.
136. Depress one of the regulator armatures to open the contacts. A reading of 55 to 65 ohms should be obtained.




**Cleaning the Contacts**

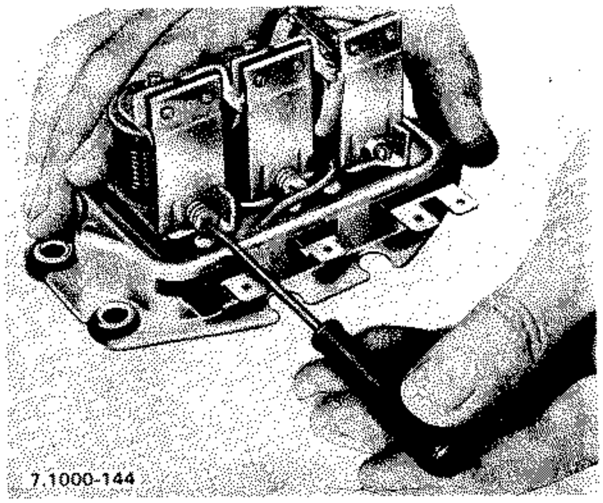
137. Remove the current regulator and voltage regulator adjustable contacts.
138. Remove the armatures from the 'L' frames; these are secured by two screws and lockwashers.
139. Clean the voltage and current regulator contacts with a fine carborundum stone or paper, and wipe over with a cloth moistened with methylated spirits.
140. The cut-out contacts should be cleaned with a strip of fine glass paper. **On no account use carborundum stone or paper, or emery cloth on these contacts.**
141. Reassemble the armatures to the 'L' frames and reset them as described under the following heading.

**Mechanical Settings**

142. **Current and Voltage Regulators** – Dealing with each regulator in turn, proceed as follows:

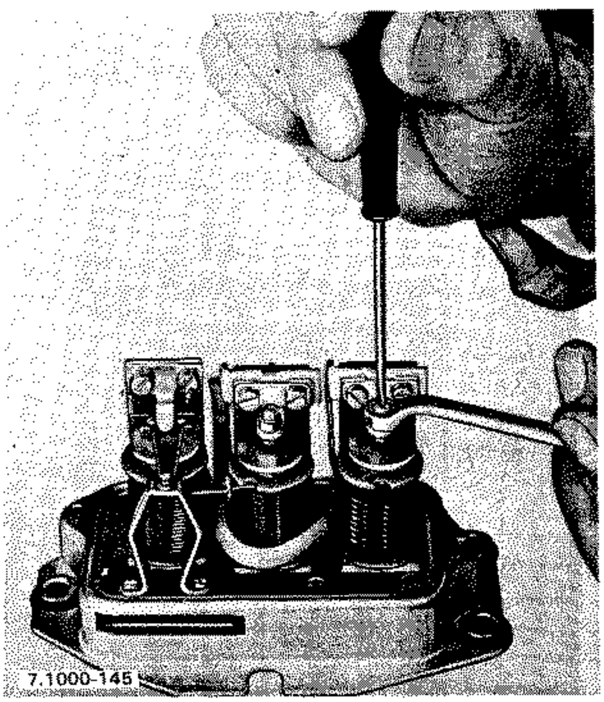
143. Slacken the two screws which secure the armature assembly to the 'L' frame.

144. Slacken the regulator adjusting screw until it is well clear of the armature tension spring.



7.1000-144

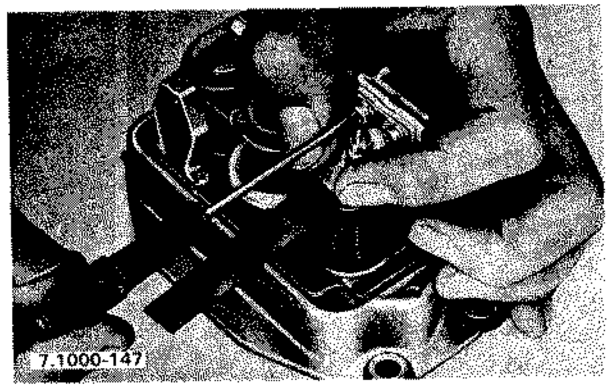
145. Slacken the fixed contact locknut and unscrew the contact until it is well clear of the armature moving contacts.



7.1000-145

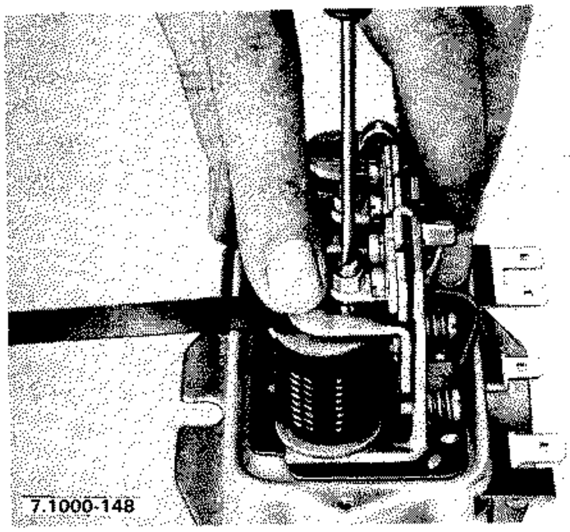
146. Insert a ·018″ feeler gauge between the armature and the core shim **taking care not to turn up or damage the edge of the shim.** The feeler gauge must be wide enough to completely cover the core shim face.

147. Press the armature down squarely on to the feeler gauge and tighten the two armature securing screws.



7.1000-147

148. With the feeler gauge still in position and the armature pressed down, screw down the adjustable contact until it just touches the movable contact in the top of the armature and re-tighten the locknut.

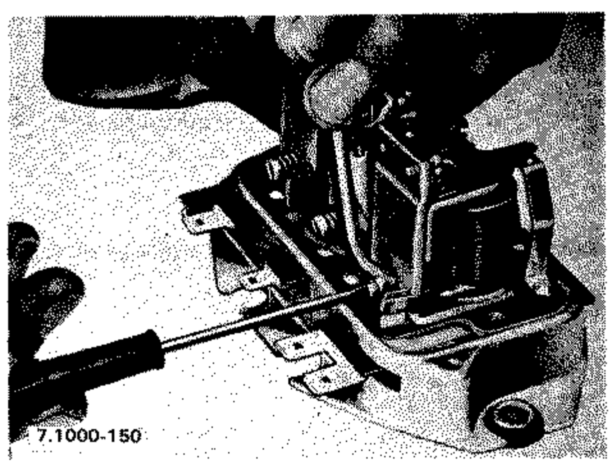


7.1000-148

**Cut-Out Relay**

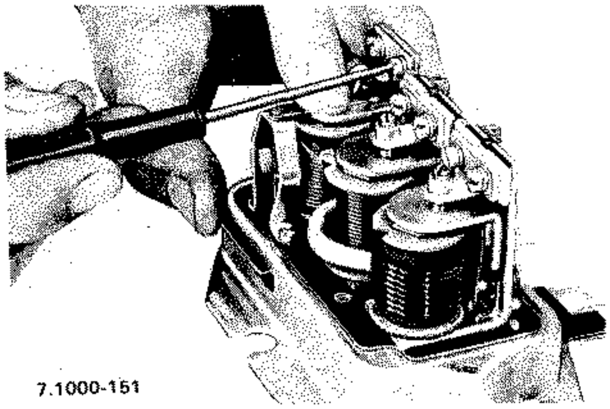
149. Slacken the two screws which secure the cut-out armature to the 'L' frame.

150. Release the adjusting screw locknut, and slacken the screw until it is well clear of the armature tension spring.



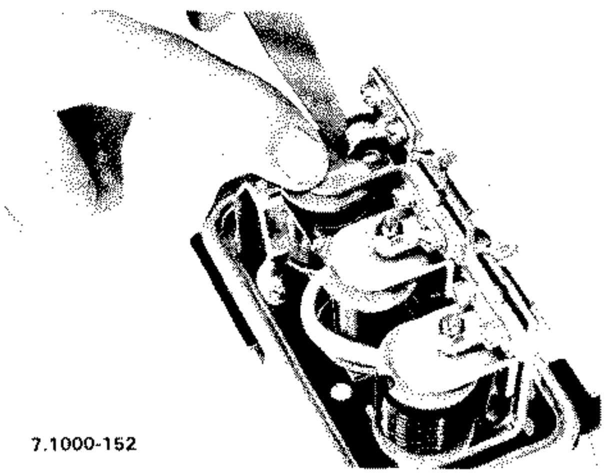
7.1000-150

151. Press the armature down squarely against the core shim face, and tighten the two armature securing screws.



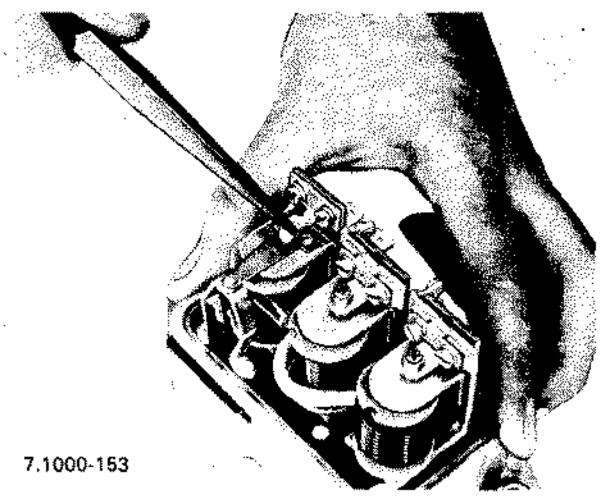
7.1000-151

152. With the armature pressed down squarely against the core shim face, check the gap between the tip of the back stop and the contact blade with a feeler gauge as shown below.



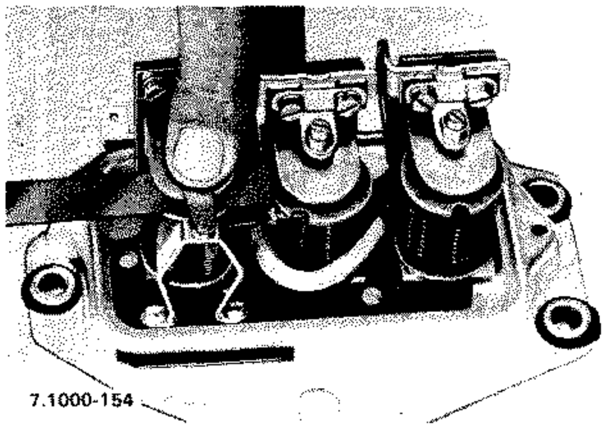
7.1000-152

153. The gap should be ·018″. Adjust if necessary by setting the armature back stop with a pair of thin nosed pliers.



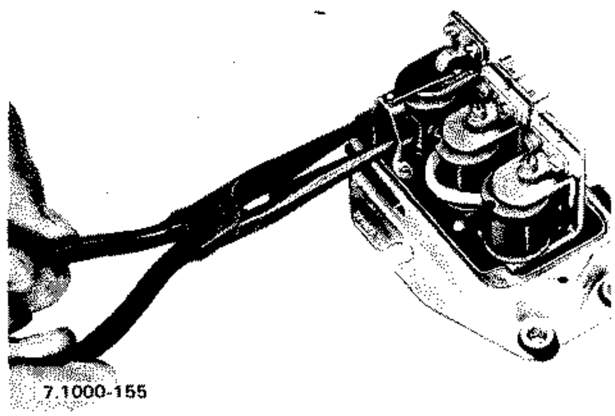
7.1000-153

154 With a ·010″ feeler gauge located under the armature so that it covers the half of the core shim face nearest the contacts, press the armature down against the feeler gauge, when the contacts should be just closed; this can be checked using a cigarette paper between the contacts.



7.1000-154

155. If necessary expand or contract the sides of the fixed contact post with a pair of thin nosed pliers to obtain the correct gap setting.



7.1000-155

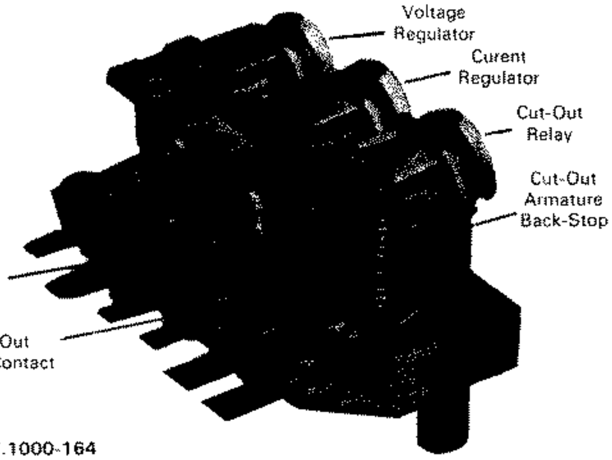
156. After carrying out the mechanical settings, the controller must be bench tested and the electrical settings adjusted before the controller is installed in the unit.

**LUCAS RB310 (Refitting)**

157. Replace the controller and secure with three fixing screws.
158. Connect the wires to the terminals as follows:
159. Wire from the generator 'D' terminal and wire from warning lamp to terminal 'D'.
160. Wire from generator 'F' terminal to terminal 'F'.
161. Wire from ammeter or battery to terminal 'B'.
162. Reconnect the battery cables.
163. Recheck the electrical settings as detailed on page 8 to ensure they are within the specified limits under unit operating conditions.

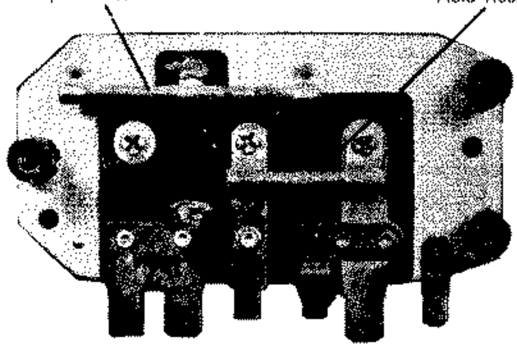
## Lucas RB340 (Description)

164. The RB340 current voltage controller comprises an insulated metal base on which is mounted a cut-out relay, current regulator and voltage regulator.



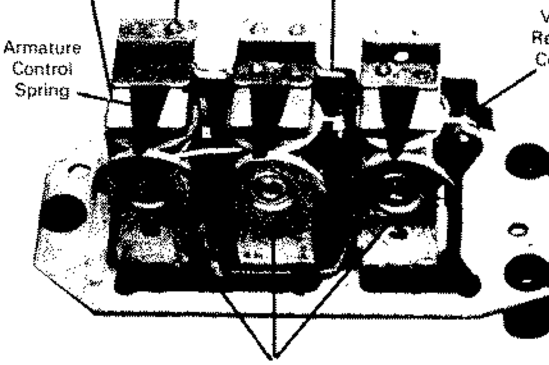

7.1000-164

165. These three units are enclosed by a plastic cover. Bridged between the current and voltage regulator frames is a wire wound type field resistor.




7.1000-165

166. The cut-out moving contact is located at the end of a copper strip spot-welded to the cut-out armature extension. The cut-out fixed contact consists of a copper strip which forms an integral part of terminal 'B'. The armature is provided with a back stop welded to the U-frame.
167. The current regulator moving contact is located at the end of the armature extension. The adjustable fixed contact is located on a metal strip riveted to the U-frame and insulated from it by means of a plastic strip. The arrangement of the contacts for the voltage regulator is similar.
168. The current regulator core incorporates a single low resistance series coil. The voltage regulator incorporates a high resistance shunt coil. The cut-out core carries a shunt coil, and a series coil through which all charging current flows.
169. Each armature hinge spring is riveted to the upper face of the armature. Adjustment of the spring tension is provided by a flat steel (control) spring riveted to the armature bearing against an adjusting cam mounted on the face of the U-frame.




7.1000-169

170. In addition to the bi-metal strip hinge springs, the effects of temperature on the resistance of the cut-out and voltage regulator is minimised by a swamp resistor connected in series with the shunt coils.

### Operation

171. As the voltage regulator is shunt wound and connected across the generator terminals, it is responsive only to variation in the generator voltage, whilst the current regulator, being connected in series with the load, is affected only by changes in current.
172. Under normal conditions when the battery is not discharged, after the generator output reaches the required value and the cut-out relay contacts close, a further increase in generator speed causes a rise in terminal voltage and subsequently the operating voltage setting of the voltage regulator is attained. When this occurs, the magnetic pull of the voltage regulator core attracts the armature and the voltage regulator contacts open, causing the field resistance located underneath the base to be inserted into the generator field circuit. The effect of inserting this resistance in the field circuit is to reduce the generator output. Consequently, the magnetic pull on the armature is reduced and the contacts close and short out the resistance again. This sequence is repeated and starts the regulator armature vibrating, the effect being to limit the generator voltage to a predetermined value.
173. If the battery is discharged or heavy electrical loads are imposed on the system, the generator voltage will not rise to the value at which the voltage regulator operates. Therefore another method of controlling the generator output to a safe limit is necessary and this is provided by the current regulator. When the current output of the generator reaches its maximum rated value, the electro magnetic effect of the current flowing through the current regulator coil attracts the armature and opens the contacts thus inserting the resistance in the field circuit. Consequently the current regulator armature is set into vibration and a safe limit is imposed on the generator output.
174. When commencing to charge a flat battery, the

current regulator allows the maximum safe generator output to pass the battery and this continues until the battery approaches a charged condition. At this stage the voltage available is sufficient to bring the voltage regulator into operation, the current value falls and the current regulator ceases to operate. During the changeover period, which exists for half a minute, both regulators are in operation.

175. After the voltage regulator has been brought into operation, the generator output tapers off until trickle charge conditions are reached.

176. Temperature compensation is provided on the voltage regulator and cut-out relay units by the bi-metal armature tension springs. The spring tension increases with a fall in temperature and decreases with a rise in temperature. This feature in the voltage regulator automatically permits a higher charging rate required in cold weather and a lower charging rate required in warm weather. The springs also compensate for the effect of temperature on the voltage regulator and cut-out relay shunt coils. As the shunt coil warms up, their resistance increases which weakens the magnetic pull on the armature; this reduction in magnetic pull is compensated by corresponding weakening of the bi-metal springs. In addition to the bi-metal springs the effects of temperature are still further minimised by the double swamp resistor.

**Electrical Checking and Setting**

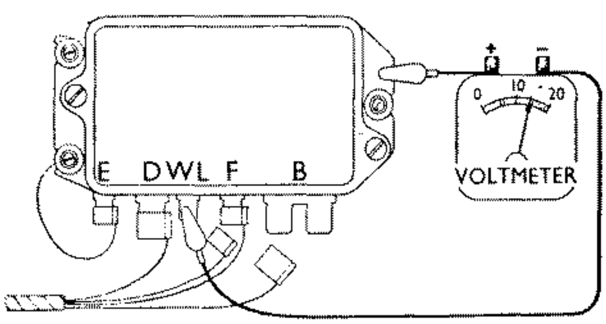
177. The voltage regulator, cut-out relay and current regulator should be checked and adjusted in a complete sequence. The setting of one unit only is not recommended. Use a high grade moving coil voltmeter – scale 0-20 volts and a high grade moving coil ammeter – scale 40-0-40 amperes.

**Voltage Regulator Open Circuit Setting**

178. CAUTION: Checking and adjusting should be completed **as rapidly as possible** to avoid inaccurate readings due to heating of the regulator coil.

179. Disconnect the wire from the controller 'B' terminal. Protect the wire from earthing on adjacent panels.

180. Connect the negative lead of the voltmeter to the controller 'D' terminal. A convenient method of making this connection is to clip the lead to the terminal'WL' which is common with terminal 'D'. This necessitates withdrawing the ignition/generator warning lamp feed wire. Connect the positive lead to earth.




7.1000-180

181. Start the engine and increase speed gradually until the voltmeter flicks and steadies. This should occur at the readings specified below.

| Air Temperature | Volts |
|---|---|
| 10°C (50°F) | 14.4 to 15.0 |
| 20°C (68°F) | 14.2 to 14.8 |
| 30°C (86°F) | 14.0 to 14.6 |
| 40°C (104°F) | 13.8 to 14.4 |

182. An unsteady voltmeter reading (fluctuating more than plus or minus ·3 volts) may be due to dirty points. If the reading is steady but outside the required limits, rotate the adjustment cam to obtain the correct setting using Lucas adjusting tool No. 54381742. To increase the voltage, increase the cam lift.

183. Check the setting by stopping the engine, then re-starting and running the engine again up to the test speed.

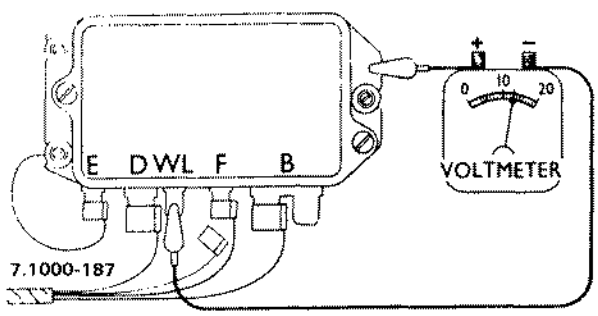
184. Reconnect the wire to the 'B' terminal. Leave the voltmeter connected.

**Cut-Out Relay Cut-In Voltage**

185. CAUTION: Checking and adjusting should be completed **as rapidly as possible** to avoid inaccurate readings due to heating of the relay coil.

186. Connect a lead across the battery terminals to draw between 8-10 amps.

187. Start the engine and increase the engine speed from idling. Check the voltage at the point of contact closure; this should be between 12.6 and 13.4 volts. Closure of the contacts is indicated by the voltmeter needle flicking back.




7.1000-187

188. If necessary adjust the cut in voltage as follows:

189. Reduce the engine speed to below the cut-in speed.

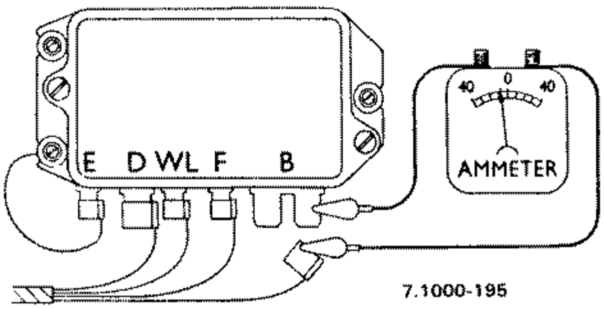
190. Rotate the adjustment cam until the correct voltage is obtained. To increase the voltage, increase the cam lift.

191. Re-check the voltage as previously outlined.

192. Stop the engine and disconnect the load.

193. Disconnect the voltmeter and reconnect the ignition/generator warning lamp wire to the 'WL' terminal.

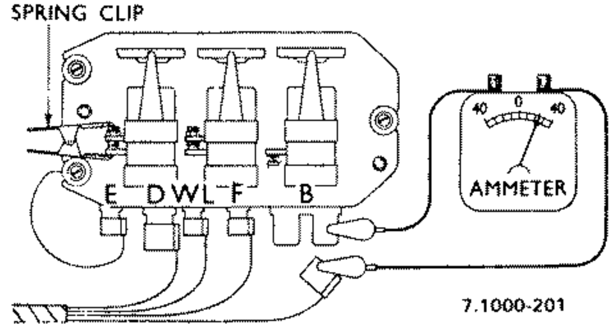
**Cut-Out Relay Reverse Current**
194. Disconnect the wire from the controller 'B' terminal; protect the wire from earthing on adjacent panels.
195. Connect the ammeter between the terminal and the wire.




7.1000-195

196. Connect the load across the battery terminals to draw between 8-10 amps.
197. Start the engine and run up to charging speed, then gradually decrease the speed and note the ammeter reading. The discharge before the cut-out points open should not exceed 8 amperes.
198. Adjust the current to within the limit by bending the relay fixed contact. Close the contact gap to reduce the current and open the gap to increase it.
199. Stop the engine and disconnect the load.

**Current Regulator On-Load Setting**
200. Remove the controller cover.
201. With the ammeter connected between terminal 'B' and the wire removed from the terminal, short circuit the voltage regulator contacts by means of a spring clip across the adjustable contact and the armature limb.

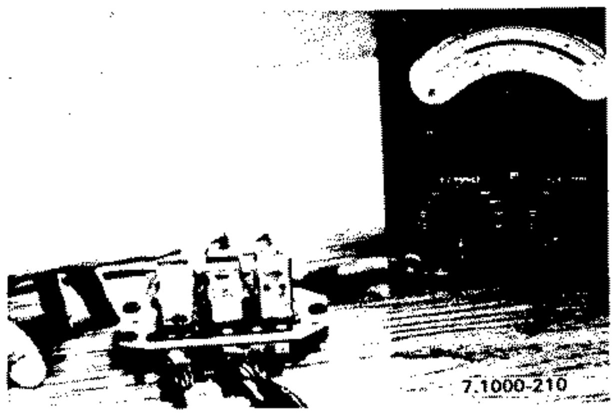



7.1000-201

202. Run the engine at half throttle and note the ammeter reading. A steady reading of 22 amperes should be obtained.
203. If necessary adjust current by rotating the adjustment cam to obtain the correct setting. To increase the current, increase the cam lift.
204. Switch off engine, remove the spring clip from the voltage regulator contacts, disconnect the ammeter and reconnect the wire to terminal 'B'.
205. Replace the controller cover.

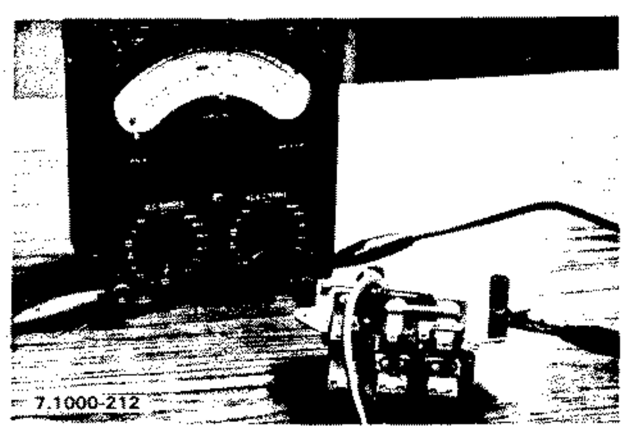
**Lucas RB340 (removal)**
206. Disconnect the battery cables.
207. Disconnect the wires from the controller, remove the three securing screws and lift away.

**Lucas RB340 (Inspection and Overhaul)**
**Field Resistor Test**
208. Examine the resistor for visual damage.
209. Connect an ohmmeter between terminals 'D' and 'F'.
210. Depress one of the regulator armatures to open the contacts. A reading of 55 to 65 ohms should be obtained.



7.1000-210

**Swamp Resistor Test**
211. Examine the resistor for visual damage.
212. Connect an ohmmeter between the centre tag of the resistor and the controller base, when a reading of 13.25 to 14.25 ohms should be obtained.



7.1000-212

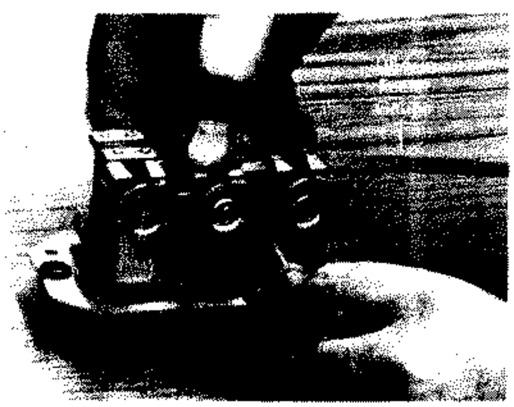
## Cleaning the Contacts

213. Remove the regulator stationary contacts.
214. Clean the regulator contacts with a fine carborundum stone or paper and wipe over with a cloth moistened with methylated spirits.
215. The cut-out contacts should be cleaned with a strip of fine glass paper. **On no account use carborundum stone or paper, or emery cloth on these contacts.**
216. Reassemble the regulator stationary contacts and re-set them as described under the following heading.

## Mechanical Settings

### Current and Voltage Regulators

217. Dealing with each regulator in turn, proceed as follows:
218. Rotate the adjustment cam to reduce the lift on the armature control spring, using Lucas adjusting tool No. 54381742. Allow clearance for a tube wrench on the current regulator stationary contact locknut.
219. Slacken the stationary contact locknut on both regulators.
220. Insert a ·054″ feeler gauge between the current regulator armature and the core face. Position the feeler gauge over the core as far as the rivet heads will allow, then press the armature firmly downwards.
221. Whilst holding the armature down, screw the stationary contacts inwards until it just touches the moving contact and secure by tightening the locknut.



7.1000-221

222. Release the armature and check armature to core air gap which should be within the specified limits.
223. Adjust the core air gap on the voltage regulator in a similar manner.

### Cut-Out Relay

224. The cut-out relay armature to core gap should be ·035″ to ·045″ measured by a feeler gauge inserted as far as the rivet heads will allow. If necessary bend the back stop as required.


7.1000-224

225. Press the armature down until the contacts close and check the clearance between the armature and the core: this should be from ·010 to ·035 inches. Adjust the fixed contact bracket as necessary to give this clearance.

## Lucas RB340 (Refitting)

226. Replace the controller and secure with the three fixing screws.
227. Reconnect the wires to the terminals as follows:
228. Wire from terminal E is earthed to controller securing screw.
229. Wire from Generator D terminal to controller D terminal.
230. Wire from Generator F terminal to controller F terminal.
231. Wire from Warning Light to terminal WL.
232. Wire from Ignition Switch to terminal B.
233. Reconnect the battery.
234. Recheck the electrical settings as detailed on page 13 to ensure that they are in the specified limits under unit operating conditions.

## CAV 6GC (Description)

235. Internally, model 6GC retains the same regulator and cut-out asembly as RB310 mounted on an RB340 type base plate.
236. An extension foot enables model 6GC to be used as a direct replacement for RB310. Terminals are normally of the 'Lucar' type although certain units supplied as service replacements have screw terminals for direct interchangeability.

## CAV 6GC (Inspection and Overhaul)

237. From the foregoing description it will be seen that existing RB310 servicing instructions remain generally applicable to 6GC. However the following table gives the statistical information for the 6GC controller used on Bedford Engines.

| | | VOLTAGE REGULATOR OPEN-CIRCUIT VOLTAGE (AT 20°C) | | | CURRENT REGULATOR | | CUT-OUT | | ARMATURE-TO-CORE AIRGAP SETTING | | RESISTOR VALUE (Ohms) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| C.A.V. Part No. | Voltage | Checking Limits | Reset To | Generator Rev/Min | Setting Amperes | Generator Rev/Min | Cut-In Voltage | Drop-Off Voltage | Voltage Regulator | Current Regulator | Contacts Resistor | Field Parallel | Swamp |
| 37513A | 24 | 28.0–28.5 | 28.0–28.5 | 3000 | 14–15 | 3000 | 26.5–27.0 | 19.0–23.0 | 0.025″–0.028″ | 0.025″–0.028″ | 240 | 30 | 40 |

238. Electrical checking and setting must be carried out with their terminals lowermost.

239. Some units have voltage-regulator open-circuit voltage reset limits which differ from the checking limit figures given in the preceding column. Adjust these units to the closer (reset) limits ONLY IF THE OPEN CIRCUIT VOLTAGE IS FOUND TO BE OUTSIDE THE CHECKING LIMITS. Units that are satisfactorily controlling the output voltage within the checking limits MUST NOT BE DISTURBED.

240. When electrically resetting ANY unit, aim for the mean voltage of the limits given.

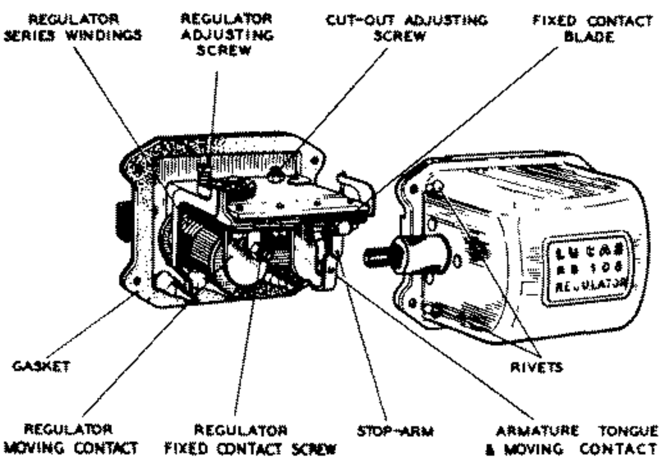
241. For ease of identification, resistors are painted at one end with a particular colour.

The colours, nominal values and duties of the resistors employed with 6GC units are:

| | | |
|---|---|---|
| Blue | 240 ohms | Contact Resistors |
| Orange | 100 ohms | Contact Resistors |
| Red | 60 ohms | Contact Resistors |
| Yellow | 40 ohms | Swamp Resistor |
| Green | 30 ohms | Field Parallel Resistor |

**Lucas RB108 (Description)**

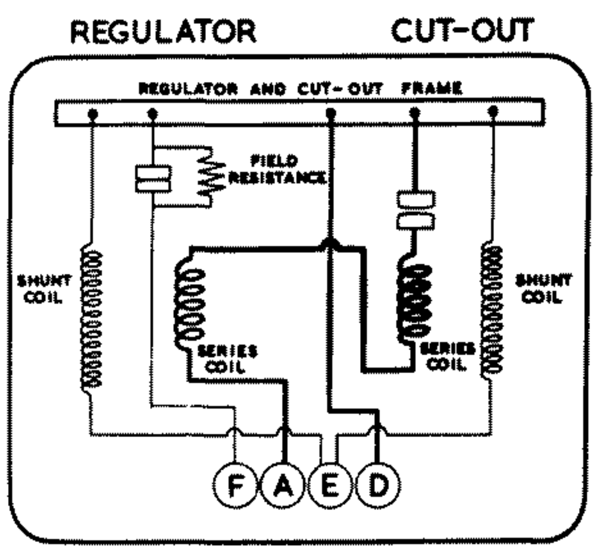
242. The controller comprises a cut-out and compensated-voltage regulator mounted on a moulded base and enclosed by a metal cover. The cover is secured to the base by four rivets and a gasket is interposed between the attaching faces to ensure complete dust sealing of the controller.




7.1000-242

243. The cut-out and voltage regulator form a single unit having two wound cores mounted side by side on a common 'L' shaped frame. These cores operate upon separate armatures which are riveted to flat steel springs forming flexible hinges. Each hinge is secured to the frame by two screws which also secure the regulator and cut-out fixed contacts, insulators, and the cut-out armature stop plate. The regulator moving contact is welded in the centre of the top face of the armature. The cut-out moving contact is riveted to a tongue extension on the armature which aligns with the underside of the stop plate arm. The lower end of each armature also carries a flat spring which bears against an adjusting screw threaded in the frame. The springs maintain the regulator contacts in the close position and the cut-out contacts in the open position. The spring on the voltage regulator is reinforced by a bi-metal strip which provides automatic temperature compensation.

244. The cut-out core incorporates a shunt winding consisting of many turns of fine copper wire, over which is wound a series of windings of heavy gauge copper wire, through which all charging current flows. A similar shunt winding is wound on the regulator core and over this is a compensating winding consisting of a few turns of heavy gauge copper wire in series with the cut-out. The regulator contacts have a resistance connected across them and inserted in the generator field circuit.




7.1000-244

**Operation**

245. The basic function of the cut-out is to connect the generator to the battery when the generator speed is sufficient to provide a voltage higher than that of the battery. It also breaks the circuit when the generator voltage falls below that of the battery and in this manner prevents the battery discharging through the generator.

246. As the voltage regulator is shunt wound and connected across the generator terminals it is responsive only to variation in generator voltage. Under normal conditions when the battery is not discharged, and after the generator out-put reaches the required value and the cut-out contacts close, a further increase in generator speed causes a rise in terminal voltage. A point is reached, therefore, where the magnetic pull of the core is strong enough to overcome the armature spring tension, thus separating the contacts and inserting the resistance in series with the generator field coils. This inserted resistance reduces the field current which in turn causes the generator voltage to fall. The pull of the generator shunt coil is consequently weakened and the spring tension once again becomes the stronger and the contacts are closed again. This operation is repeated so rapidly that the contacts vibrate, alternately inserting and shorting out the resistance in the field circuit. The frequency of vibration is more or less constant but the amplitude of the distance travelled by the contacts becomes greater as the generator speed increases. By this means, the period for which the resistance is in circuit becomes greater as more control is necessary.

247. As the output from the generator depends on the battery voltage, some safeguard is necessary to prevent overloading of the generator and at the same time compensate for the effects of load on the battery. For example, should a battery with an already low terminal voltage be subjected to an increased load, this would further reduce the battery voltage and cause the generator to produce more current than it was designed for. To take care of such conditions compensating series turns are superimposed on the regulator shunt coil and wound to assist the magnetizing effect of the shunt coil. When the generator output is high, the current flowing round the series turns has the effect of supplementing the magnetic pull of the shunt coil, which enables the spring tension holding the contacts together to be overcome at a reduced voltage.

248. Temperature compensation is provided on the voltage regulator by the bi-metal armature tension spring. The spring tension increases with a fall in temperature and decreases with a rise in temperature. This feature automatically permits a higher charging rate required during cold weather and a lower charging rate required in warm weather. The spring also compensates for the effect of temperature on the regulator shunt coil. As the coil warms up its resistance increases, which weakens the magnetic pull on the armature; this reduction in magnetic pull is compensated by corresponding weakening of the bi-metal spring.

**Electrical Settings – To Check and Adjust on Unit**

249. For checking the electrical settings of the controller it is essential to use a high grade moving coil voltmeter with a range of 0-20 volts.

250. Before disturbing any settings check the fan belt tension. The battery should also be checked with a hydrometer and a heavy discharge tester.

251. Checking and adjusting should be completed as rapidly as possible, otherwise heating of the cut-out and regulator shunt coils will give inaccurate readings.

252. Do not remove the controller cover unless the checks indicate the need for adjustment. If this should prove necessary, the cover can be lifted away after removing the four rivets and pushing back the lip of the cover where it is rolled over the edges of the base. When replacing the cover, install a new gasket between the cover and the base.

**Voltage Regulator**

253. Remove the screw securing the terminal retaining plate, ease the plate, insulating strip and rubber seal away from the controller.

254. Disconnect the wire to the 'A' terminal, and insulate to prevent earthing, and connect the voltmeter between the 'D' terminal and earth.

255. Start the engine and gradually increase the engine speed until the voltmeter flicks and steadies. This should occur at the readings shown under 'Specifications', page 2. Where a high reading is obtained, substitute a 'jumper' wire for the controller earth wire. If the reading still remains high, this indicates an open circuit in the regulator shunt winding.

256. If necessary turn the voltage regulator adjusting screw **clockwise** to **increase** the voltage or **anti-clockwise** to **decrease** the voltage until the setting is within the required limits.

257. Re-connect the wire to the 'A' terminal.

**Cut-Out Relay**

258. Connect the voltmeter between the controller 'D' terminal and earth. Connect a load between the controller 'A' and 'E' terminals to draw between 8-10 amps and start the engine.

259. Run the engine up to charging speed. Voltage should rise and the needle will flick back indicating closure of the cut-out contacts. This should occur between 12·7 and 13·3 volts.

260. If necessary adjust the cut-in voltage. Slacken the locknut and turn the adjusting screw **clockwise** to **increase** the voltage, or **anti-clockwise** to **decrease** the voltage. Retighten the locknut and recheck the voltage after each adjustment.

261. To check the reverse current remove the wire from the 'A' terminal and connect the ammeter between the terminal and the wire.

262. Run the engine up to charging speed, then gradually decrease the speed and note the ammeter reading. The maximum discharge before the cut-out points open should not exceed 5 amps.

263. If necessary adjust the current value to within the limits by bending the legs of the cut-out fixed contact ports. Straightening the legs will **reduce** the current value and **bowing** them will **raise** it. Repeat the test and if necessary adjust the legs further until the current value is within the specified limits.
264. Reconnect the wire to the 'A' terminal and relocate the rubber seal, insulating strip and plate, secure with screw.

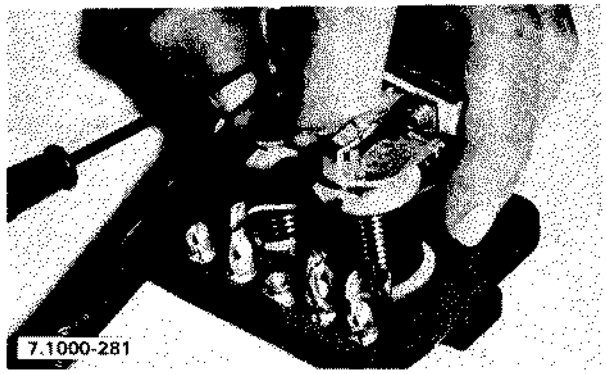
**Lucas RB108 (Removal)**
265. Disconnect the battery cables.
266. Remove the screws securing the terminal retaining plate. Withdraw the plate, insulating strip, rubber seal and the wires from the controller.
267. Remove the controller from its mounting.

**Lucas RB108 (Overhaul and Inspection)**
**Shunt Winding Test**
268. Check the cut-out shunt windings for continuity by connecting a lead from the negative side of the battery to the 'E' terminal and applying a positive lead 'ON' and 'OFF' the 'D' terminal. If satisfactory the cut-out core will endeavour to draw in the armature.

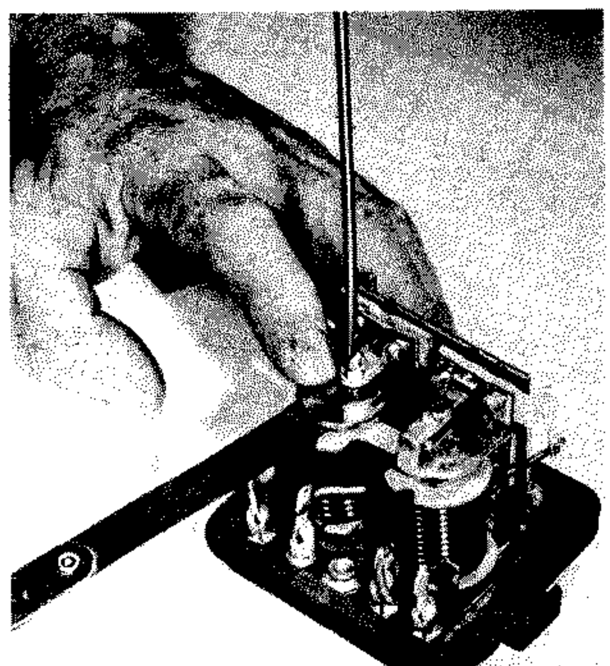
**Field Resistor Test**
269. Connect the ohmmeter between the 'D' and 'F' terminals. There should be a ZERO reading, indicating that the regulator contacts are satisfactory.
270. With the ohmmeter connected as above, depress the regulator armature to open the contacts, when a reading of approximately 63 ohms should be obtained indicating that the resistor connected across the contacts is in order.
271. Connect the ohmmeter between the 'D' and 'E' terminals. A reading of 50 ohms should be obtained. If a reading of approximately 100 ohms is shown, this will indicate that either the cut-out or regulator shunt coils is open-circuited. A 'Zero' reading would indicate that both are open-circuited.

**Cleaning the Contacts**
272. Remove the four rivets securing the cover and ease back the lip of the cover where it is rolled over the edge of the base. Lift off the cover.
273. Remove the armatures from the 'L' frames, these are secured by two screws and lockwashers.
274. Clean the regulator contacts with a fine carborundum stone or paper then wipe off with a cloth moistened with methylated spirits. **Do not use emery cloth.**
275. Clean the cut-out contacts with fine glass paper. **Under no circumstances should a carborundum stone or paper, or emery cloth be used.**
276. Reassemble the armatures to the 'L' frames and reset them as described under the following heading.

**Mechanical Settings**
**Voltage Regulator**
277. Slacken the fixed contact screw locknut and unscrew the contact until it is well clear of the armature moving contact.
278. Slacken the voltage adjusting screw and unscrew the screw until it is well clear of the armature tension spring.
279. Slacken the two screws securing the armature to the 'L' frame.
280. Insert a ·015 inch feeler gauge between the armature and the copper disc attached to the regulator core. Take care not to turn up or damage the disc.
281. Press the armature squarely down against the gauge and re-tighten the armature securing screws.

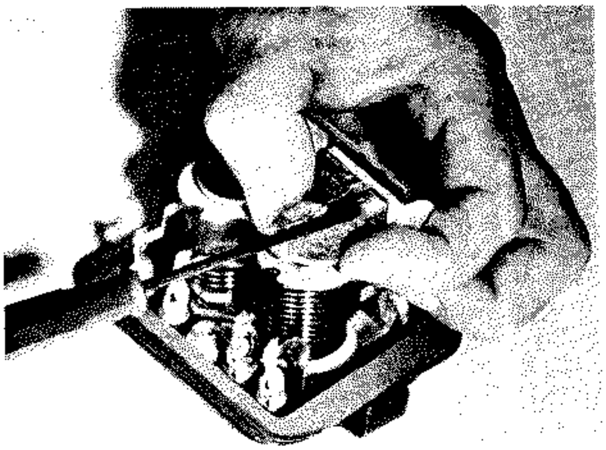

7.1000-281

282. With the feeler gauge still in position, screw down the fixed contact screw until it just touches the armature contact and retighten the locknut.


7.1000-282

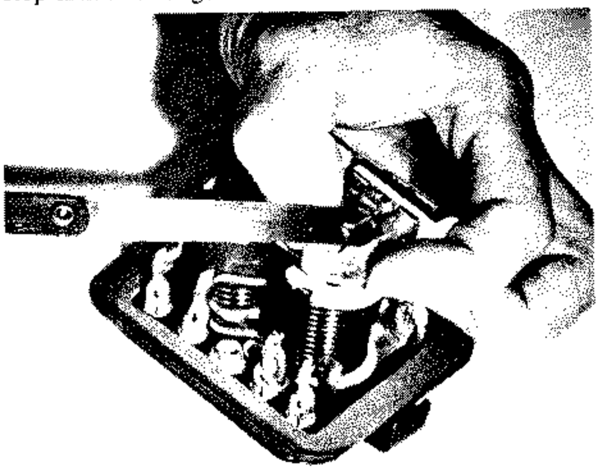
283. Adjust the electrical setting as previously described.

**Cut-Out Relay**
284. Slacken the voltage adjustment screw locknut and unscrew the screw until it is well clear of the armature tension spring.
285. Slacken the two screws securing the armature to the L frame.
286. Press the armature squarely down against the core face and tighten the armature securing screws.



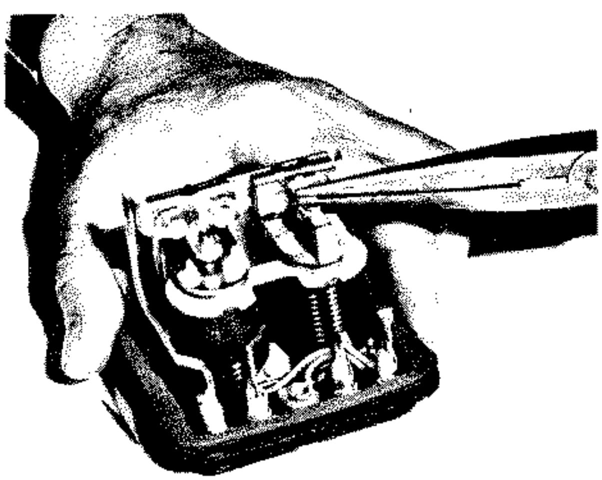
7.1000-286

287. With the armature still held squarely down against the core, check the gap between the armature stop arm and tongue which should be ·025″ to ·040″.



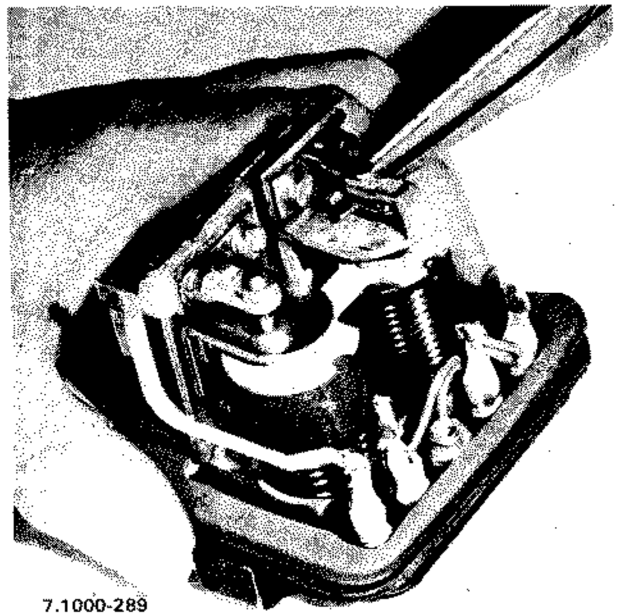
7.1000-287

288. If necessary adjust the gap by carefully bending the stop arm using suitable pliers.



7.1000-288

289. Adjust the fixed contact blade to give a 'follow-through' or blade deflection of ·010″ to ·020″ when the armature is pressed squarely against the core face.



7.1000-289

290. Adjust the electrical setting as previously described.

**Lucas RB108 (Refitting)**
291. Replace the controller in the unit and secure with the two fixing nuts.
292. Connect the wires to the terminals as follows:
293. Wire from generator 'D' terminal to terminal 'D'.
294. Earth wire terminal to terminal 'E'.
295. Wire from ammeter or battery to terminal 'A'.
296. Wire from generator 'F' terminal to terminal 'F'.
297. Reconnect the battery cables.
298. Recheck the electrical settings as detailed on page 17 to ensure they are within the specified limits under unit operating conditions.

**Alternators (Description)**
299. All of the alternators used are three phase units incorporating revolving fields with stationary armatures. In each case the stator and rotor are located between the drive end and slip ring end shields, these shields housing the bearings which support the rotor shaft.
300. Each alternator incorporates six diodes which are connected in a three-phase bridge circuit between the stator and the output and ground terminals. These diodes provide rectification of the generated current.
301. Some of the alternator types have three additional diodes which allow rectified current to route from the stator to the alternator warning lamp and to the regulator.
302. The brush gear for the field system is mounted on the slip ring end shield and uses two brushes which bear against the slip rings incorporated in the rotor assembly.

303. Regulators are self-limiting in current output, therefore the regulator has only to control voltage. All regulators are transistorised and cannot be adjusted in service. The regulator is generally mounted on a bracket separate from the alternator. On 17ACR and DN460 alternators, however, the regulator is located on the alternator slip ring end shield inside the end cover.

**Alternators (Removal)**

304. Disconnect the batteries.

305. Disconnect the wires from the alternator connections.

306. Slacken the mounting and brace bolts and nuts.

307. Disengage the drive belts from the pulleys.

308. Remove the mounting and brace bolts and lift away the alternator.

309. It is essential that the following precautions are taken whilst working on the alternator charging system, otherwise irreparable damage may be caused to the diodes and transistors.

310. All alternator systems employ a NEGATIVE GROUND (EARTH).

311. **Always observe polarity.** If a battery is accidently installed with the leads reversed, the diodes in the alternator will be burned out and possibly the wiring harness between the alternator and the battery will be damaged.

312. Before disconnecting a battery or any of the wires in the charging system, ensure that the engine is not running, thus reducing the likelihood of arcing or short circuiting.

313. Do not polarise the alternator as any attempt to do so may result in damage.

314. Before boost-charging, disconnect the battery. If the battery is not disconnected and the engine is inadvertently started during boost charging, the transistors in the regulator will be damaged.

**Alternators (Inspection and Overhaul)**

315. Normally the Alternator charging system will require very little attention but it should be kept free from build-up of dirt and a check made if it fails to keep the battery charged. This may be due to a slipping drive belt.

316. Inspect the driving belt for wear and correct tension ($\frac{1}{2}$ inch under a load of 11-13 lbs) and see that the alternator is properly aligned with respect to the drive. A slack belt will wear rapidly and because of slip may not drive the alternator at the required speed. Too tight a drive belt will impose a severe side thrust on the alternator bearings and shorten their life.

317. Keep the alternator reasonably clean with a cloth moistened in paraffin or white spirit. Ensure that ventilation slots and air spaces are clear and unobstructed.

318. Remove any dirt accummulated on the regulator housing and ensure that cooling air can pass freely over the casing.

**General Precautions**

319. Although the transistorised regulator offers many advantages such as reliability, long life, accurate regulation, small size, etc., the transistors in the regulator and diodes in the alternator are sensitive to voltage changes and high temperatures. It is essential therefore that certain precautions are taken to avoid irreparable damage to the system when carrying out vehicle maintenance.

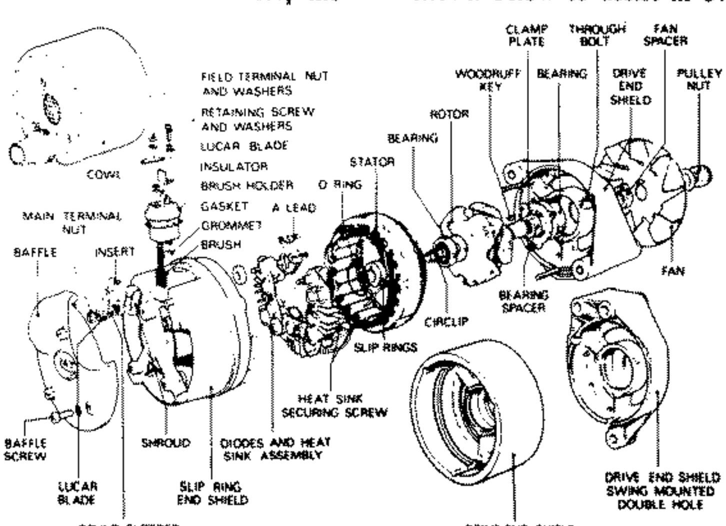
320. Should it be necessary at any time to disconnect a lead from the system it is essential that the engine be shut down to avoid damage to the system.

321. Whenever a lead is disconnected it should be identified in relation to its terminal to facilitate reconnection particularly in regard to regulator connections. **Short circuiting or reverse polarity no matter how brief** will cause immediate and permanent damage to transistors and diodes.

322. The battery must NEVER be disconnected whilst the alternator is running nor should the battery be connected into the system without first checking correct polarity and voltage. Master switches must not be turned whilst the engine is running.

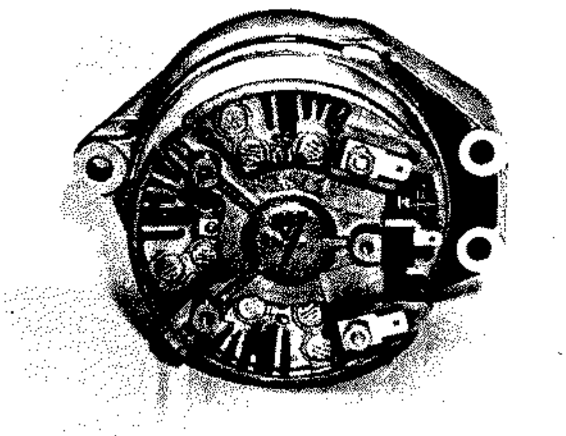
**CAV – AC5 Alternators**

323. An exploded view of a typical AC5 alternator is shown below to assist in overhaul.



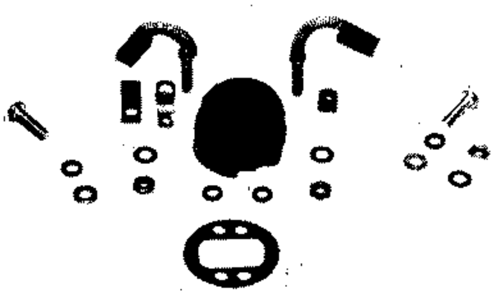

7.1000-323

324. Remove the pulley nut and lockwasher and withdraw the pulley, fan, key and spacer.
325. On later engines the AC5 alternator was replaced with an AC5'A' alternator incorporating a plastic fan moulded on a steel spacer in place of the steel fan. The two fans are not interchangeable.
326. The three screws and washers retaining the baffle should now be removed and the baffle detached from the slip ring end shield. On AC5 'A' alternators the steel baffle plate is thinner than the original and therefore shorter screws must be used.



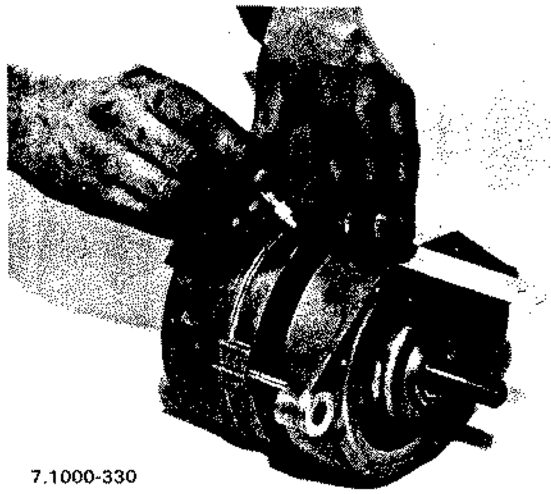
7.1000-326

327. On some alternators a cowl is used in place of the baffle to act as a splash protection.
328. Disconnect the wire from the brush holder 'A' terminal; remove the screws and washers and withdraw the brush holders complete with the brushes.



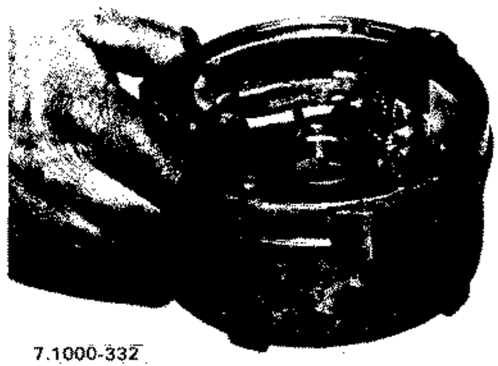
7.1000-328

329. Remove the through bolts securing the drive and slip ring end shields to the stator.
330. Mark the end shields and stator so that they may be located correctly on reassembly.



7.1000-330

331. Withdraw the drive end shield and rotor from the stator. If necessary use a hide mallet to tap the drive end shield away from the stator. The drive end shield and rotor need not be separated unless the drive end bearing requires examination or the rotor is to be renewed. If this is the case, withdraw the rotor using a puller that grips on the bearing housing.
332. With a sharp pointed probe, remove the 'O' ring from the slip ring end shield taking care not to damage the 'O' ring groove.



7.1000-332

333. On AC5 'A' alternators a steel bearing insert is fitted into the slip ring end shield. The 'O' ring is not required.

**Brush Gear**

334. Servicing of the brushes is confined to checking that their length is over the specified minimum of 0.32 inches, and ensuring that they move freely in their housings.
335. To withdraw the brushes, remove the field terminal retaining nuts, washers and insulators from the terminal posts and lift away the brush assemblies from the brush holder. If the brush movement is sluggish, lightly polish the sides of the brush with a smooth file. Remove all traces of dust before refitting the brush to the brush holder.

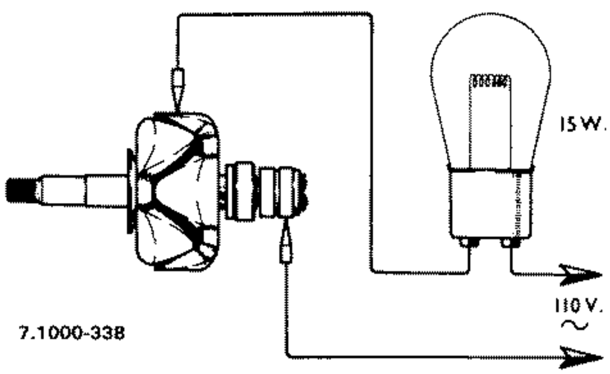
**Slip Rings**

336. The slip rings should be smooth and uncontaminated by oil or other foreign matter. If they require cleaning, this may be done using a petrol moistened cloth, if there are signs of burning or scoring, the slip rings may be skimmed as described in operation 377 under 'Bearings'.

**Rotor**

337. The rotor windings may be checked by connecting an ohmmeter across the slip rings. If a reading lower than 9.6 ohms is obtained, this could mean a short circuit between the coils; a high reading usually indicates that the surfaces of the slip rings need cleaning; and an infinity reading that an open circuit exists in the field.

338. Insulation between the slip rings and rotor poles may be checked by connecting a test circuit as shown, using a 110 volt AC mains supply and a 15 watt test lamp. If the lamp lights, the coil is earthing and a replacement rotor will be required.



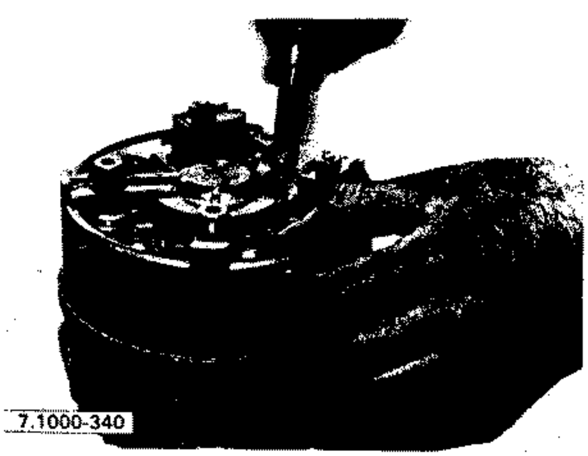

7.1000-338

NOTE: No attempt should be made to machine the rotor poles or to straighten a distorted shaft.

**Stator**

339. The stator winding may be checked for insulation as follows:

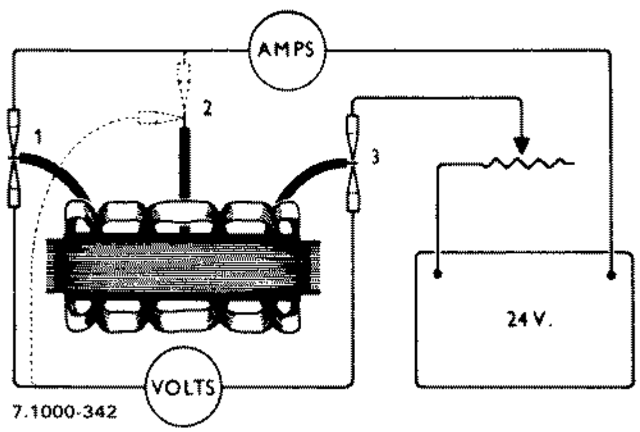
340. Unsolder the three stator wires from the heat sink tags. **Do not remove the tags from the heat sink assembly.**



7.1000-340

341. Separate the stator from the slip ring end shield, using a hide faced mallet if necessary.

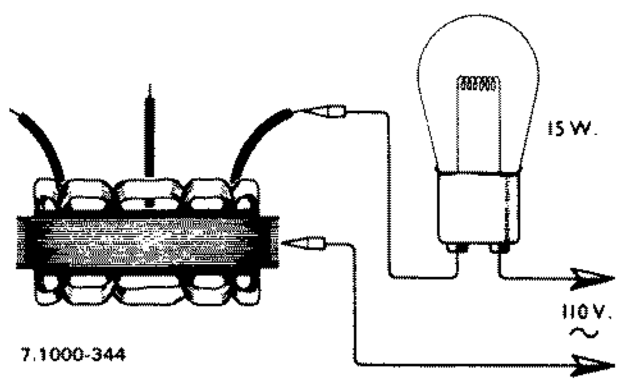
342. Connect a test circuit as shown below using a 24 volt, 20 amp DC supply; positioning the probes in the following sequence: 1-3, 2-3, and 1-2. Check that the voltage drop in each case is 8.4 volts. A low reading indicates a short circuit in the winding, whilst a high reading would probably mean an increase in resistance. In either case a replacement stator would be required.




7.1000-342

343. The insulation between the stator and core may be checked as follows:

344. Connect a test circuit as shown below using a 110 volt AC main supply and a 15 watt test lamp.

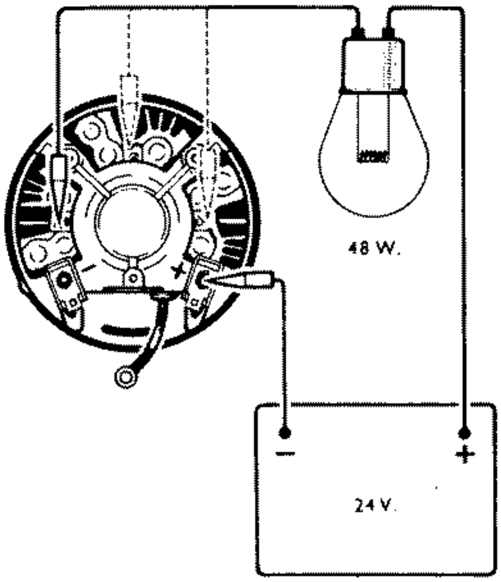



7.1000-344

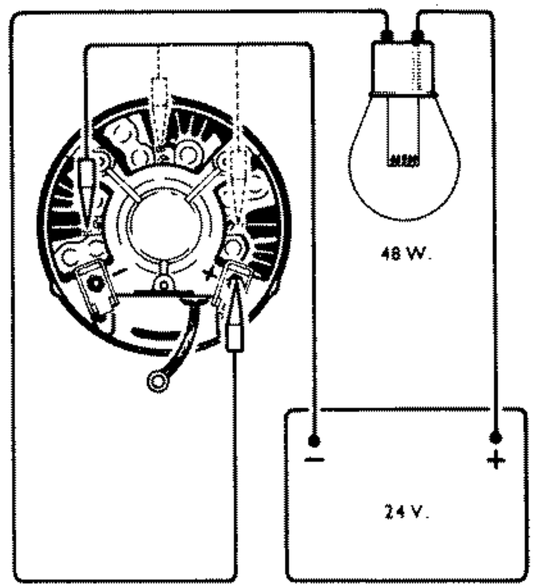
345. Connect the test probes between any one of the three wire ends and the stator core. If the lamp lights, the stator coils are earthing and a replacement stator will be required.

**Heat Sinks and Diodes**

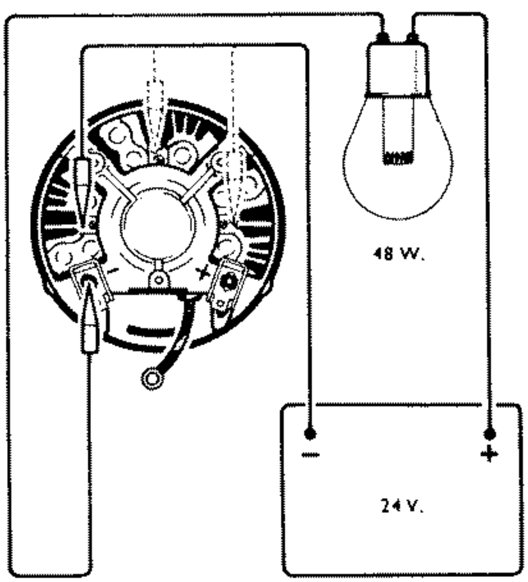
347. Using a 24 volt supply and a 48 watt test lamp, connect a test circuit as shown. The diode test should be connected to each heat sink in turn following the sequence indicated. The opposite result to any of the tests indicates a faulty diode, and will necessitate the renewal of the appropriate heat sink.



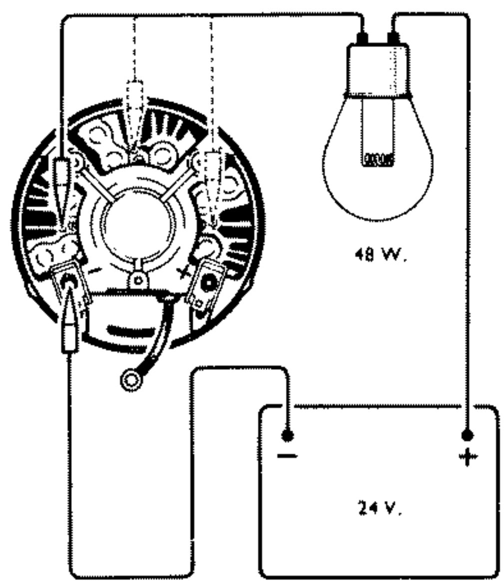

7.1000-347(a) 1. LAMP SHOULD LIGHT




7.1000-347(b) 2. LAMP SHOULD NOT LIGHT

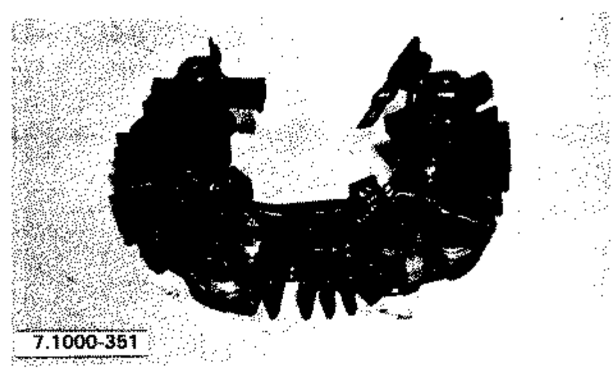



7.1000-347(c) 3. LAMP SHOULD LIGHT




7.1000-347(d) 4. LAMP SHOULD NOT LIGHT

348. The diodes are not serviced individually but are supplied already pressed into the heat sink. The procedure for renewing a heat sink is as follows:
349. Remove the terminal from the end of the 'A' wire and pull the wire through the rubber grommet in the slip ring end shield.
350. Remove the main positive and negative terminal nuts, washers and terminal blades, also the slotted nuts, washers and terminal shrouds.
351. Remove the heat sink securing screws and washers from the slip ring end shields and withdraw the complete heat sink assembly.



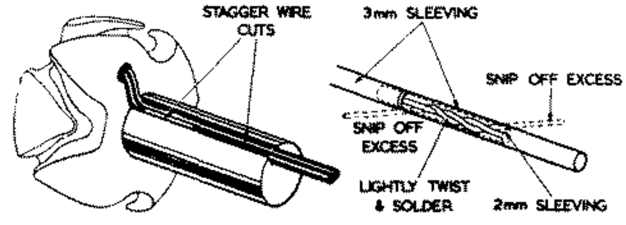
7.1000-351

352. Snip the two copper braids of the faulty heat sink close to the angle terminal tags and unsolder the sleeved wire from the third diode. Remove the appropriate nylon retaining washers and withdraw the heat sink.
353. Assemble the new heat sink ensuring that the nylon insulating washers are interposed between the adjacent heat sinks.
354. Great care must be taken to avoid overheating the diodes. To ensure this, it is recommended that a pair of long nosed pliers should be used as a thermal shunt, and that the soldering be carried out as quickly as possible.

7.1000-354

355. Solder the diode braids to the appropriate angle tags. The length of the braids is such that it is impossible to connect them incorrectly.
356. Solder the sleeved wire to the remaining diode.
357. After soldering the connections, check the diodes for correct operation.
358. Thread the 'A' wire through the rubber grommet in the slip ring end shield.
359. Install the heat sink assembly in the slip ring end shield, ensuring that the nylon insulating washers are assembled between the heat sink and the end shield. Install the securing screws and 'D' terminal.
360. Install the nylon terminal shrouds, washer and slotted nuts and terminal blades, washers and nuts.

**Bearings**
361. Access to the bearings in the drive end shield is obtained by removing the bearing retainer. Care must be taken during removal and installation of the bearing to ensure that the end shield is supported on the bearing housing, so that no undue strain is placed on the support webs.
362. Renew the slip ring end shield as follows:
363. Unsolder the ends of the field wires from the slip ring, taking care not to break the wires.
364. Using an extractor, withdraw the slip ring assembly from the rotor. Removal of the slip ring renders it unserviceable therefore a new one must be fitted.
365. Remove the bearing circlip, and withdraw the bearing and bearing spacer.
366. Before installing a new bearing, check that the field wires are serviceable and of sufficient length. Should the wires break whilst re-soldering to the slip ring terminal, it will be necessary to renew the slip ring assembly. If the wires are unserviceable they should be renewed as follows:
367. If both wires need renewal, the joints should be staggered as shown.




7.1000-367

368. Trim back the sleeving and lightly twist a new length of 23.5 S.W.G. (or alternatively 0.6 mm dia.) copper wire to the existing wire and solder. Snip off the excess wire.
369. Apply a coating of shellac and slide a short length of 2 mm sleeving over the join so that it fits inside the existing sleeve.
370. Apply a further coating of shellac and slide on a new length of 3 mm sleeving to abut the original sleeve. Apply a final coat of shellac to the outside.
371. Refit the bearing spacer so that the groove is correctly located to contain the field wires.
372. Press the new bearing on to the shaft and refit the circlip.
373. Plug with Silcoset 151 any gap that appears where the wires enter the spacer, between the spacer and the rotor poles.
374. Place the rotor, drive end downwards in a press so that the weight is supported by the rotor poles.
375. Pass the field wires through the bore of a new slip ring, and locate the slip ring on the shaft so that the terminal posts are positioned at 90° relative to the shaft slot.
376. Press the slip ring onto the rotor shaft using Installer SE838, until the slip ring centre sleeve is flush with the end of the rotor shaft. Resolder the field wires to the terminal posts.
377. After assembly, the slip ring should be concentric with the slip ring end bearing to within 0.002 inches limit, and may be skimmed to the minimum diameter of 1.136 inches.
378. To obtain the required degree of finish, a diamond cutting tool should be used for this operation.
379. Normal workshop practice should be taken when assembling the alternator, for cleanliness to working surfaces and tools.
380. Lay the stator on the bench with the three stator phase leads facing upwards.
381. Invert the end shield and locate it over the stator, so that the three wide spaces on the heat sink finning coincide with the three stator phase leads. Carefully lower the slip ring end shield to the stator and align the scribe marks. Twist stator phase leads once only around heat sink tags and solder.

382. Fit spacer over the rotor drive shaft and insert drive shaft through the bore of the drive end shield ballrace.

NOTE: The original short spacer (0.368") was used when the rotor had a dust thrower. The dust thrower is no longer used and a longer spacer (0.422") is necessary when a new rotor is fitted. The longer spacer must not be used with the old rotor and vice versa.

383. Support the rotor, slip rings downwards, between a pair of parallel blocks on a suitable handpress table (great care must be exercised at this stage not to damage the rotor field leads with the blocks). Gently press the drive end shield into place with a suitable piece of tube pressing on the bearing housing.

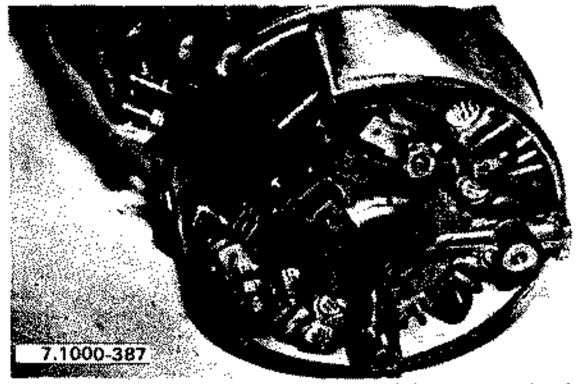
384. Assemble the rotor and slip ring end shield assembly to the drive end ensuring again that the scribed lines are in alignment. Insert the three through bolts with 'Loctite' grade A applied to the threads and tighten them evenly and progressively whilst gently tapping the slip ring end shield with a hide faced mallet to draw end shields squarely into position. Finally tighten the through bolts to a maximum torque of 45 lbs. in. (0.52 Kg. m.).

NOTE: Alternators manufactured prior to serial number UH 1001 of having three digits in the serial number, must have the through bolts changed as there is a danger of breakage. New through bolts now available (Having the same part number) are made of stronger material. To indicate the change scribe a line on the new bolt head at 90° to the screw driver slot BEFORE fitting.

385. Refit brushes to brush box making sure that the terminals are fully seated.

386. Thread 'O' sealing rings (supplied in seal and gasket set) over both the terminal posts and assemble insulator to one of the terminals. Fit terminal blades and crinkle washers to both terminals and secure with terminal nuts. Marine versions have one terminal blade and one threaded stud.

387. Fit a new gasket (supplied in seal and gasket set) to the brush box moulding and assemble brush gear to the slip ring end shield. Correct positioning is ensured by the locating dowel. Secure with retaining screws, plain and spring washers. Reconnect 'A' lead to terminal post marked 'A', secure with crinkle washers, plain washer and terminal nut.




388. Fit baffle to slip ring end shield (or cowl, gland and ferrule to marine versions) and secure with screws and spring washers.

389. Fit fan spacer machined slot outwards and aligned with keyway. Fit woodruff key, fan pulley and pulley nut. Tighten pulley nut to a torque of 40 lbs. ft. (5.3 kg. m.).

390. Finally carry out the following bench tests:

391. Before making connections, test the alternator for earths with non-destructive flash test with voltage rating of 110 volts. Connect instrument between D+ and earth, D– and earth and 'A' terminal and earth. Make sure always to keep the one probe on the frame so as not to apply full test voltage between any two terminals on the alternator.

392. Mount the alternator on the test machine drive and make all connections to the battery and regulator. Make sure that the correct warning light bulb in series with a switch is connected in the circuit. Connect the ammeter in the positive line. The variable load of at least 60 amp maximum capacity with a switch in series should be connected straight across the battery so as to discharge the battery when required by conditions of test indicated overleaf.

393. Close the switch and observe that the bulb illuminates.

394. Start the drive and increase speed until warning light is extinguished, which indicates that the alternator is charging. This should be below 1500 rpm.

| Model | Load Applied | Speed | Ammeter reading | Voltage |
|---|---|---|---|---|
| 24 volt | 20 – 30 amp | 3200 rpm | 28 – 31 amp @ 26 – 27 | |
| 12 volt | 40 – 50 amp | 3200 rpm | 50 – 55 amp @ 13–13.6 | |
| 12 volt (low c.i.s.) | 25 – 35 amp | 2000 rpm | 32 – 35 amp @ 13–13.7 | |

395. Reduce speed 1125 rpm (826 rpm for low cutting in speed versions) and measure DC voltage between warning light/negative on the 440 regulator. The voltage should be between 24-28 volts (24 volt model) or 12-14 volts (12 volt model).
396. Connect the voltmeter across B+ and B–. Apply load (see table below) to the battery and increase alternator speed to 3200 rpm (2000 rpm on low c.i.s. version). Observe ammeter reading which should be as follows:
397. Increase speed to 10,000 rpm and again observe ammeter reading which should be as follows:

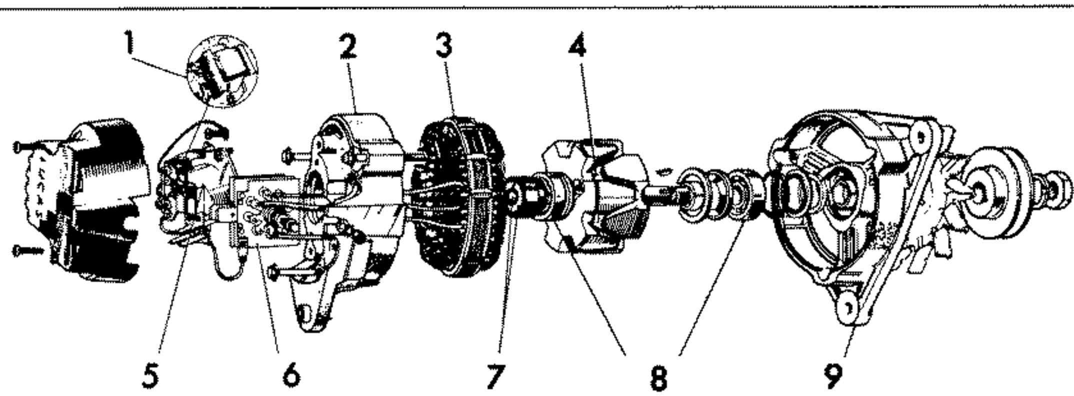
| Model | Ammeter reading | Voltage |
|---|---|---|
| 24 volt | 30 – 35 amp @ | 26 – 27 |
| 12 volt | 60 – 65 amp @ | 13 – 14 |
| 12 volt (low c.i.s.) | 40 – 45 amp @ | 13 – 14 |

398. Adjust battery load as necessary. Run at top speed of 10,000 rpm for 1 minute.
399. Decrease speed to 3000 rpm and switch off loads connected across the battery. Depending on the connections selected for the positive sensing wire (LO, MED, HI) the voltage should rise to between 26-28 volts (13-14 volt on 12 volt models) and then remain constant. At the same time the current reading should drop appreciably. This test indicates that the regulator is working correctly. With sensing wire connected to + Med and load adjusted to 15 amp the voltage reading should be 27.5 + 0.25 volt (13.75 + 0.25 volt for the 12 volt model).

**Stage 1**
401. Remove the moulded plastic cover. Disconnect the yellow wire from the field diode heat sink and the black wire of the capacitor from the diode positive heat sink where used.
402. Remove the screws securing the brush housing and regulator to the slip ring end shield.
403. Unsolder the three wires connecting the stator to the diodes, noting the wire to the diode relationship. A pair of long nosed pliers should be used to grip the diode pin during this operation to act as a thermal shunt.
404. Slacken the nut securing the rectifier and remove the assembly from the end shield.

**Brush Gear**
405. The brushes should be examined to ensure that they move freely in their guides and that the free length of the brush protruding beyond the brush housing are not less than 0.20 inches.
406. If the brush movement is sluggish, lightly polish the brush sides with a smooth file.
407. Check that the brush spring pressures are between 7-10 ozs. This pressure is measured when the brush is pushed against the spring until the brush face is flush with the housing.

**Slip Rings**
408. The surfaces of the slip rings should be smooth and uncontaminated by oil or other foreign matter. If they require cleaning this may be done using a cloth moistened with white spirit or, if there is any evidence of burning, use a very fine glasspaper.
409. Under no circumstances should the slip rings be machined.

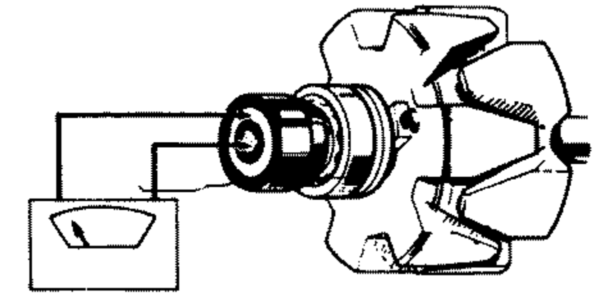



1. Regulator
2. Slip ring end shield
3. Stator
4. Rotor
5. Brush housing
6. Rectifier
7. Slip rings
8. Bearings
9. Drive end shield

7.1000-400

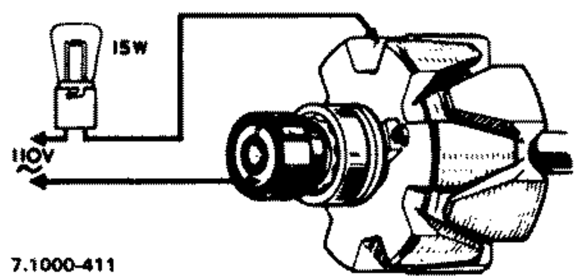
**Lucas 17ACR Alternators**
400. The 17ACR alternator can be dismantled in two stages, the first stage will enable tests to be made of the rotor, stator and diodes. The second stage will only be necessary in order to replace a component part. An exploded view is shown below to assist in overhaul.

**Rotor**
410. The rotor windings may be checked by connecting an ohmmeter across the slip rings. If a reading lower than 4.16 ohms (±5%) is obtained, this could mean a short circuiting between the coils; a high reading usually indicates that the surfaces of the slip rings need cleaning; and an infinity reading indicates an open circuit.



7.1000-410

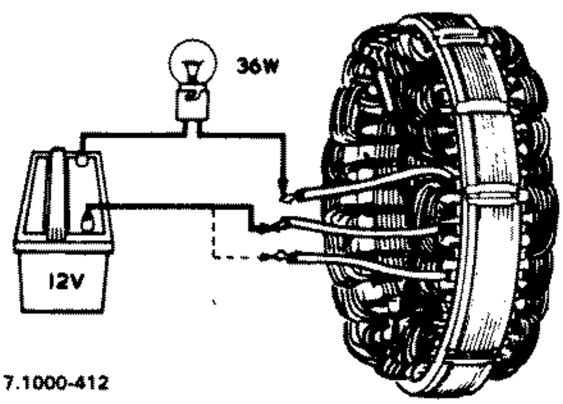
411. The insulation between the slip ring and rotor poles may be checked by connecting a test circuit using a 110 volt AC main supply, and a 15 watt test lamp. If the lamp lights, the coil is grounding and a replacement rotor will be required. No attempt should be made to machine the rotor poles or to straighten a distorted shaft.




7.1000-411

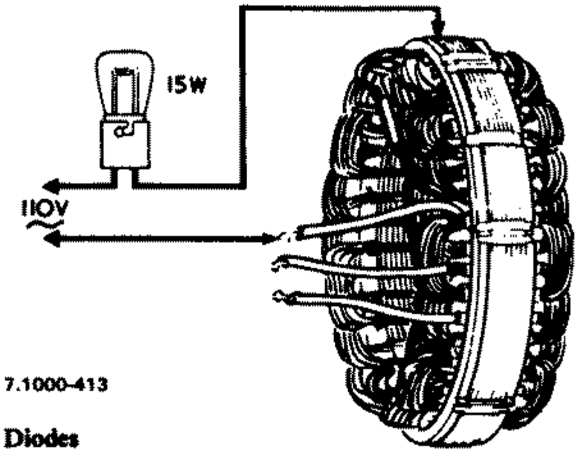
**Stator**

412. The stator winding may be checked for continuity by connecting any two of three stator wires in series with a 36 watt bulb and a 12 volt battery. Repeat the test, replacing one of the two wires by the third wire. Failure of the test lamp to light on either occasion means an open circuit in part of the stator windings and a replacement will be required.




7.1000-412

413. The insulation between the stator coil and core may be checked by using a 110 volt AC mains supply and a 15 watt test lamp. Connect the test probe between any one of the three cable ends and the stator core. If the lamp lights, the stator coils are grounding and a replacement stator will be required.

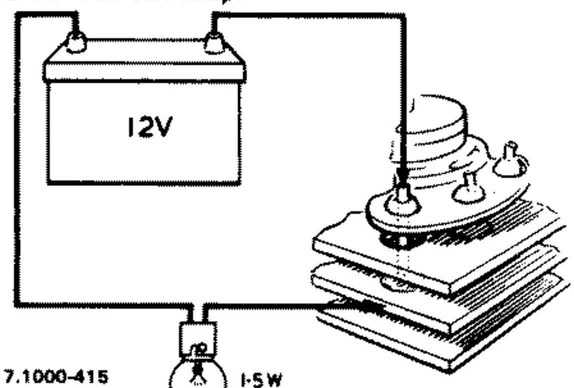



7.1000-413

**Diodes**

414. When checking the diodes, the three stator wires must be disconnected.

415. Connect a test circuit using a 12 volt battery and a 1.5 watt test lamp.




7.1000-415

416. Connect one test probe to each of the nine diode pins in turn while holding the other probe in contact with the associated heat sink.

417. Reverse the connections to the diode pin and heat sink. The bulb should light in one test only.

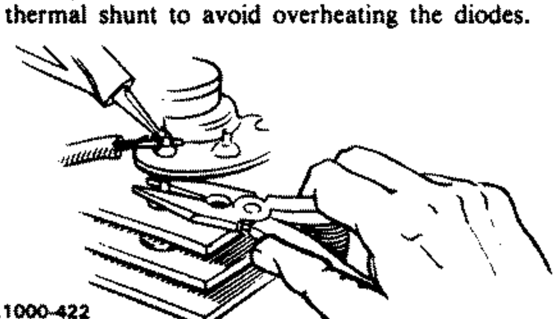
418. Should the lamp light in both tests, or not light in either test, the diode is defective and a new rectifier assembly must be installed.

419. This procedure is adequate for all service purposes. However, should a battery ohmmeter be used, a serviceable diode will indicate infinity in one direction and a much lower reading in the other.

420. Ohmmeter incorporating a hand driven generator must NEVER be used for checking diodes.

421. When resoldering the stator wires to the diode pin, use only 'M' grade 45:55 tin/lead solder.

422. A pair of long nosed pliers must be used to act as a thermal shunt to avoid overheating the diodes.



7.1000-422

**Stage 2**

423. If from the tests a new component is found to be required, the three bolts securing the end shields to the stator should be removed.

424. Hold the alternator vertically with the fan underneath.

425. Place a 3 inch long steel sleeve, having an outside diameter of 1.32 inches and an inside diameter of 1.24 inches, over the slip ring moulding to engage the outer race of the slip ring end bearing. It may be necessary to remove some surplus solder from the slip ring field winding terminals to clear the sleeve.

426. Hold the alternator by the drive end shield and carefully drive the sleeve against the bearing until it is clear of the housing.

427. In some cases, it is possible to separate the slip ring end shield and stator from the rotor and drive end shield by using a wood lever between the through bolt bosses on the end shields.

**Bearings**

428. To gain access to the drive end bearings, the rotor shaft must be pressed out from the drive end shield after the shaft nut, washer, pulley, fan and key have been removed.

429. When removing the slip ring end bearing, unsolder the field winding wires from the slip ring moulding, noting the original connections. Prise the slip ring moulding from the rotor shaft, using two wooden levers between the bearing and the slip ring mounting.

430. The alternators have heavy duty bearings that are packed with grease and sealed for life.

431. The slip ring end bearing kits incorporate a black moulded spacer.

432. It is essential that the slip ring end shield is pressed on the rotor shaft to connect its abutment. If the rotor and drive end shield have been separated, the inner race of the drive end bearing must be supported with a tube whilst the rotor shaft is being pressed into the drive end shield.

433. Remake the field to slip ring connections, using a 95:5 tin/antimony solder.

434. Reassembly of the alternator is a reversal of the dismantling procedure but the following should be noted.

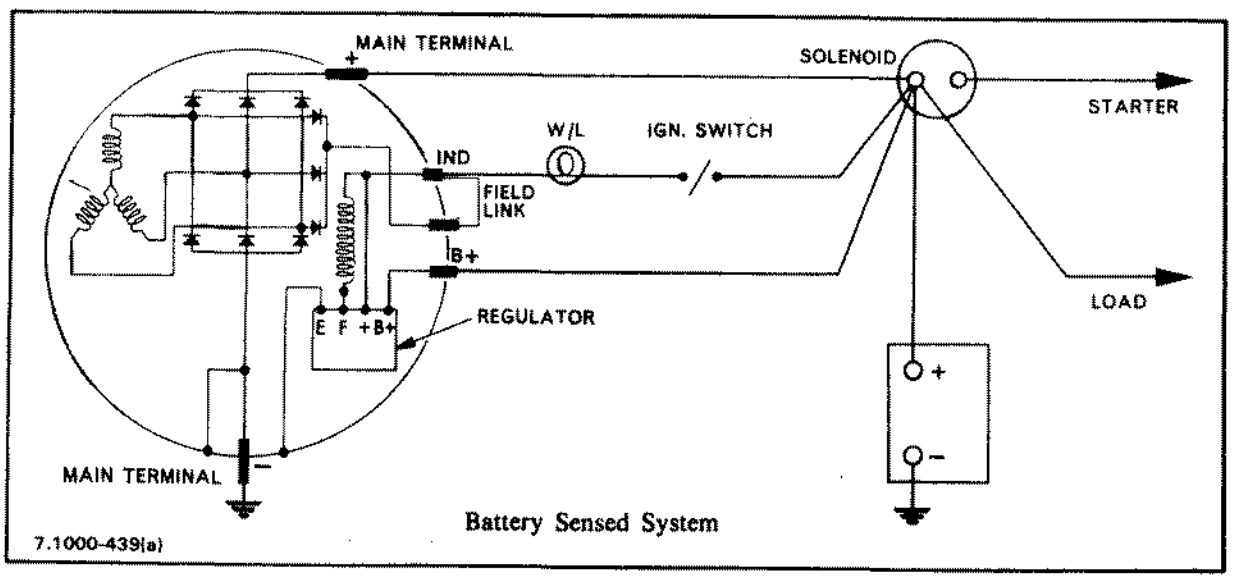
435. When assembling the end shields, ensure that the location marks made before disassembly are in alignment.

436. Do not exceed 47 lbs. in. torque when tightening the alternator through bolts or 37 lbs. in. on the rectifier securing nuts.

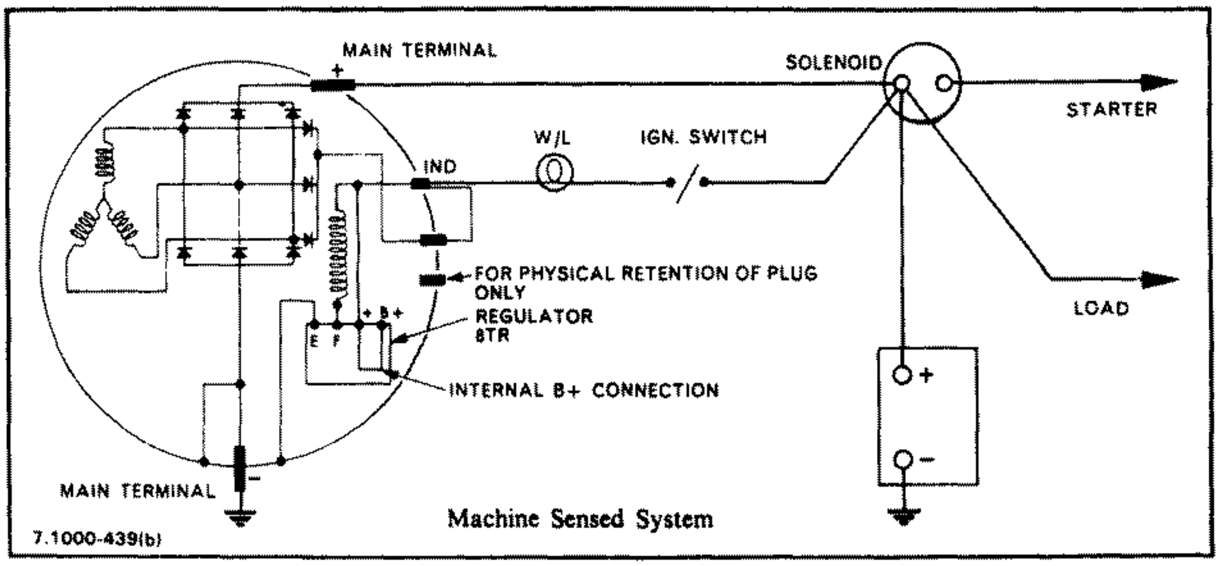
437. When the alternator is completely assembled, check that the rotor can be turned freely by hand. It should turn noiselessly.

438. The alternator should next be tested on the bench using a test rig capable of varying the alternator speed from zero to 6000 rpm. To avoid overheating of the alternator, it should be fitted with a fan and driven in the correct direction of rotation. Correct rotation can be determined by an arrow marking on the face of the fan, or alternatively, by the angle of the fan blades which are inclined in the opposite direction to that in which the alternator must be rotated when viewed from the drive end. Wiring used in the test circuit must be of an equivalent grade to that used in the engine alternator installations 14/010 (14/0.25 mm) grade for the 'IND' field circuit cables and 120/012 (120/0.30 mm) grade for the main terminals and earth cables.

439. Clamp the alternator in the test rig, with the alternator moulded slip-ring end cover removed to expose the regulator connections. Connect a test circuit, simnilar to one of the applicable circuits shown below, but using direct connections between the alternator, warning light (12V 2.2W) and the test battery.




Battery Sensed System




Machine Sensed System

440. Include in the test circuit: a 0-60A moving coil ammeter in series with the alternator main output '+' cables and connect in parallel across the battery terminals a 0-20V moving coil voltmeter and a 15 ohm 35A variable load resistor. The warning light should be illuminated, in which case proceed direct to the first test paragraph 447 'Alternator Output Test with Regulator Inoperative'.

441. If the warning light is not illuminated (providing warning light bulb is known to be good), non-continuity of the rotor field winding circuit is indicated. Check in the following order: regulator, brushes and springs, and rotor slip-rings, rotor field-winding continuity.

**Regulator**
442. Connect the regulator 'F' terminal (green) to the alternator frame. If this results in the warning light now being illuminated, the regulator is faulty and it must be renewed.

**Brushes and Springs and Rotor Slip-rings**
443. Remove the brush box moulding. Check whether brushes and slip rings are free of oil or grease. If necessary, the brushes and springs can be cleaned with a petrol moistened cloth. Check brush and spring assemblies for freedom of movement in the brush box moulding. If the visible length of the brushes in the free position is less than ¼" (0.25" or 6 mm), this is the probable cause of non continuity of the field circuit. The brush and spring assemblies should be renewed.
444. While the brush box moulding is removed, check the rotor field winding continuity.

**Rotor Field Winding Continuity**
445. Check the rotor field winding continuity by connecting a battery operated ohmmeter or a 12 volt battery test lamp between each of the rotor slip rings. The ohmmeter should register a reading or the test lamp should light.
446. If the test is unsatisfactory, renew the rotor before proceeding with the following tests.

**Alternator Output Test with Regulator Inoperative**
447. Make the regulator inoperative, by linking its green lead ('F' terminal) to alternator frame.
448. Run the alternator in the test rig at a slowly increasing speed. The warning light should be extinguished at the cutting in speed 1550 (max.).
449. If the warning light is not extinguished, the suppression capacitor and/or surge protection device (when fitted) should be proved by repeating the test with each of these items disconnected in turn. If the result is still unsatisfactory, the alternator is faulty and must be dismantled, as described previously, to determine and rectify the fault.
450. Providing the first half of the test is satisfactory, (warning light extinguished), increase alternator speed to 6000 rpm and adjust the variable load resistor until the voltmeter registers 13.6V. The ammeter should register 36A the maximum rated output of the alternator.
451. If the second half of the test is unsatisfactory, the suppression capacitor and/or surge protection device (when fitted) should be proved by repeating the test with each of these items disconnected in turn. If the result is still unsatisfactory, the alternator is faulty and must be dismantled for a detailed inspection to determine and rectify the fault.
452. Failure of one or more of the diodes will be indicated by the effect on alternator output, and in some

instances by abnormally high alternator temperature and noise level. The fault symptom table shows how diode failure will influence alternator output test results, and paragraph 414 gives information on testing the diodes.

**Regulator Test (In Situ)**

453. This test assumes the alternator output test has been carried out and found to be satisfactory.

454. Remove the variable load resistor from the battery terminals, and also the test link connecting the regulator 'F' terminal connection to alternator frame.

455. Run the alternator at 6000 rpm until the ammeter registers less than 10A. If the voltmeter is registering 13.6-14.4V, the regulator is working normally. If the voltmeter is reading outside these limits, the regulator must be renewed.

**FAULT SYMPTOMS**

| Warning Light | Alternator | | | Probable Fault (Associated Damage) |
|---|---|---|---|---|
| | Temperature | Noise | Output | |
| Illuminated at stand-still, extinguished at cut-in speed (1,500 rev/min) but at higher speeds becomes partially illuminated and gets progressively brighter. | High | Normal | Higher than normal at 6,000 rev/min. Approximately: 38A | Live-side main output diode open-circuit (May damage rotor field winding and regulator, over heat brushboxes, and fuse warning light bulb). |
| Not illuminated between zero and 1,500 rev/min. | High | Excessive | Very low at 6,000 rev/min Approximately: 10A | Live side main output diode short-circuit. (May damage associate 'field' diode). |
| Illuminated at stand-still, dims appreciably at cut-in speed (1,500 rev/min) and gets progressively dimmer or may be extinguished at higher speeds. | Normal | Excessive | Poor at low speed. Slightly below normal at 6,000 rev/min Approximately: 30A | Earth side main output diode open circuit. |
| Illuminated at stand-still, dims appreciably at cut-in speed (1,500 rev/min) and gets progressively dimmer or may be extinguished at higher speeds. | Normal | Normal | Lower than normal at 6,000 rev/min. Approximately: 30A | Field diode open circuit. |