DIESEL MULTIPLE UNITS

ELECTRICAL

TSU/88/63

MECHANICAL & ELECTRICAL
ENGINEERING
BRITISH RAILWAYS BOARD · HEADQUARTERS

TRAINING

DIESEL MULTIPLE UNITS

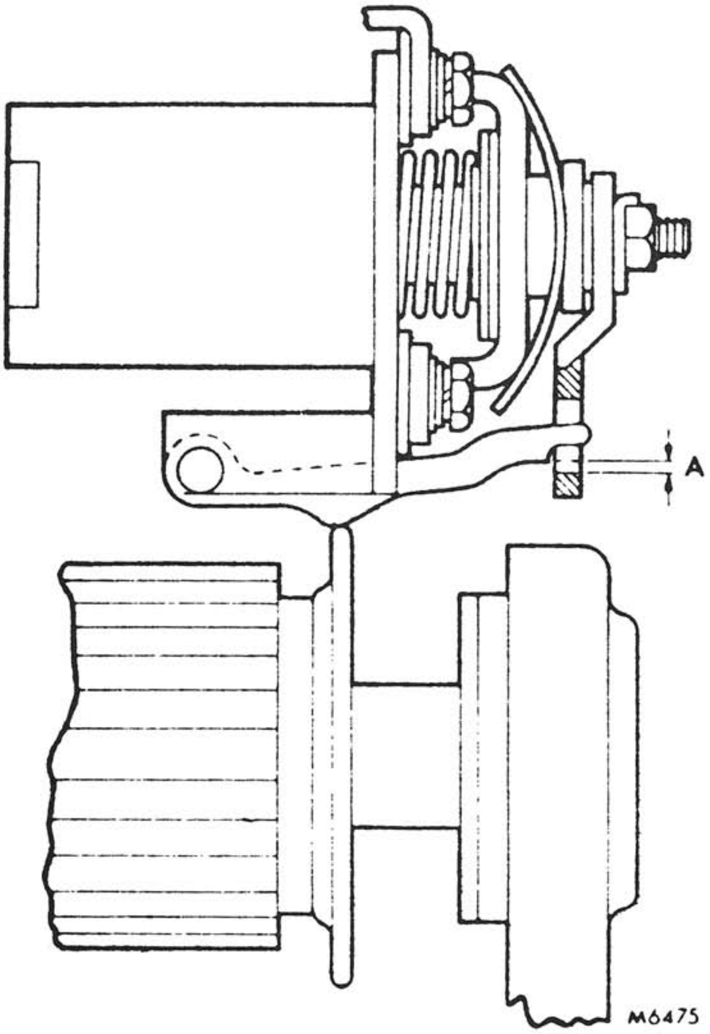
ELECTRICAL

TSU/88/63

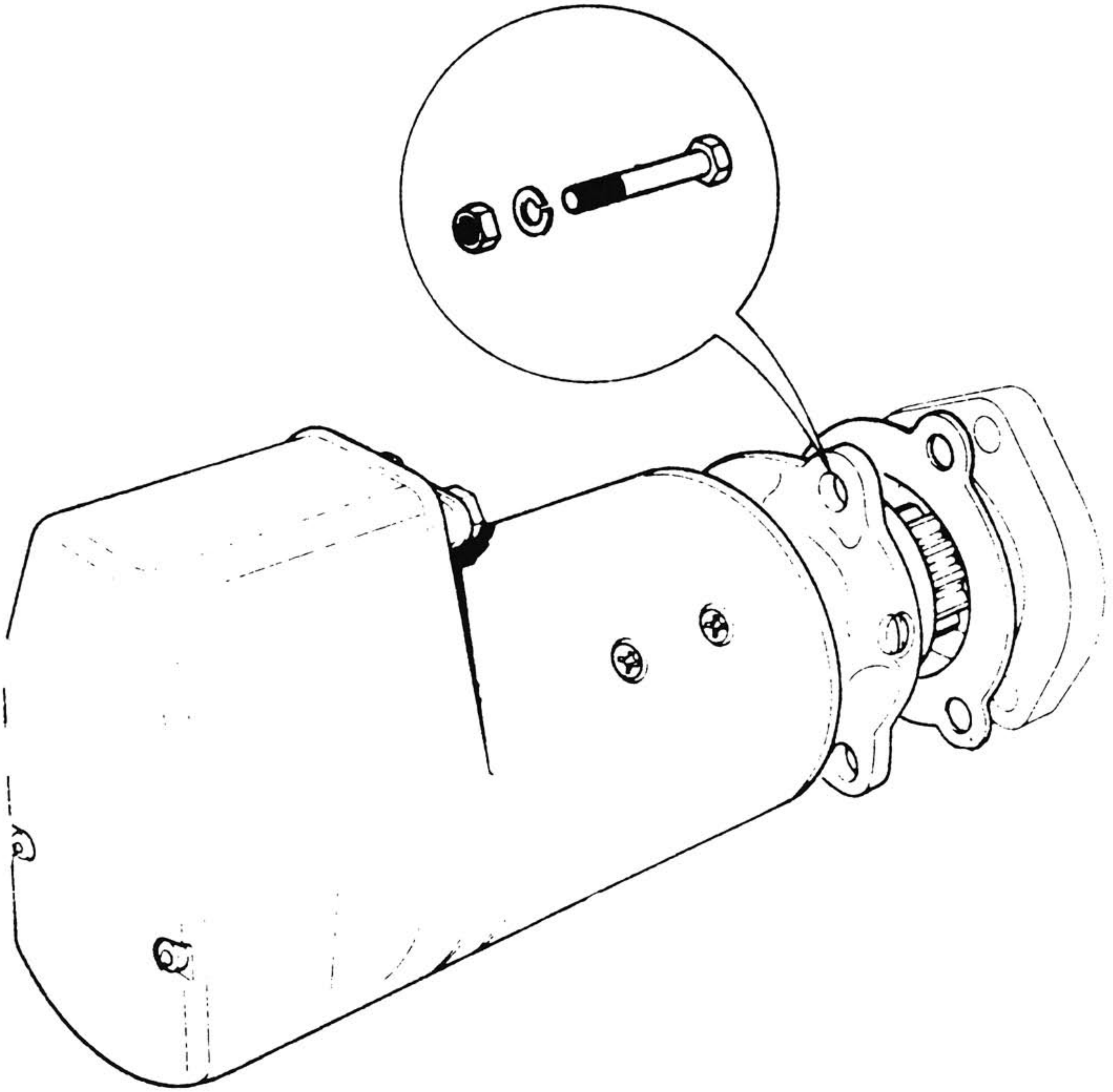
This publication is intended for students attending courses at M. & E.E. Training Units, and is a precis of the lectures given. Subsequently alterations may be made and it entails upon the person concerned to suitably up-date the information.

C.A.V. STARTER MOTOR

TYPE SM143



RELATIONSHIP BETWEEN TRIGGER AND TRIPPING DISC



MAINTENANCE OF STARTER MOTOR

During service, very little attention should be necessary but to ensure maximum life and trouble-free starting, the starter should be examined at regular intervals to check that its mounting bolts or straps are fastened securely and that all electrical connections are clean and tight. The cables should be examined for fractures, particularly at the point where the cables enter the terminal lugs. The cable insulation must be free from signs of chafing, and from deterioration by oil products.

Check that the battery is at least half charged and capable of giving the heavy current required by the starter.

It is also recommended that the maintenance procedures described should be undertaken at a regular interval, the length of which is dependent upon conditions of service.

Brushgear

The brush leads should be clear of any obstruction likely to impede movement, and the brushes should be free in their holders. If a brush is inclined to stick, it should be removed and the inside of the holder cleaned with a clean cloth moistened in white spirit. The brush must be replaced in its original position so that the curvature of its contact surface conforms accurately with the commutator periphery.

Where spiral fibre insulation is provided on the brush leads, ensure that it has not become burnt or charred, thus creating the danger of short circuits.

The brushes should be well 'bedded', that is, worn to the periphery of the commutator over at least 80% of their contact area.

The brush spring pressure should be checked by means of a spring balance hooked under the spring or trigger lip.

The pressure of each spring when taken at the point of contact with the brush should be within 510 to 680 g, (18 to 24 oz).

The brushes must be renewed if they are worn to approximately half their original length or to a point where the springs no longer provide effective pressure. Replacement brushes should be fitted in complete sets. Under no circumstances should brushes of different grades be used together.

It is not practicable to supply replacement brushes already 'bedded', as the diameter of the commutator will vary according to the number of skimming operations performed on the armature. Replacement brushes must therefore be 'bedded' to the commutator prior to use.

Commutator

The surface of the commutator should be clean and entirely free of oil, any trace of which should be removed by pressing a dry, clean cloth against the commutator while the armature is rotated by hand. In the case of starters fitted to engines with oil-immersed flywheels, in excessive amount of oil may indicate a defective oil seal. In these circumstances the starter must be removed from the engine and completely overhauled.

NOTES

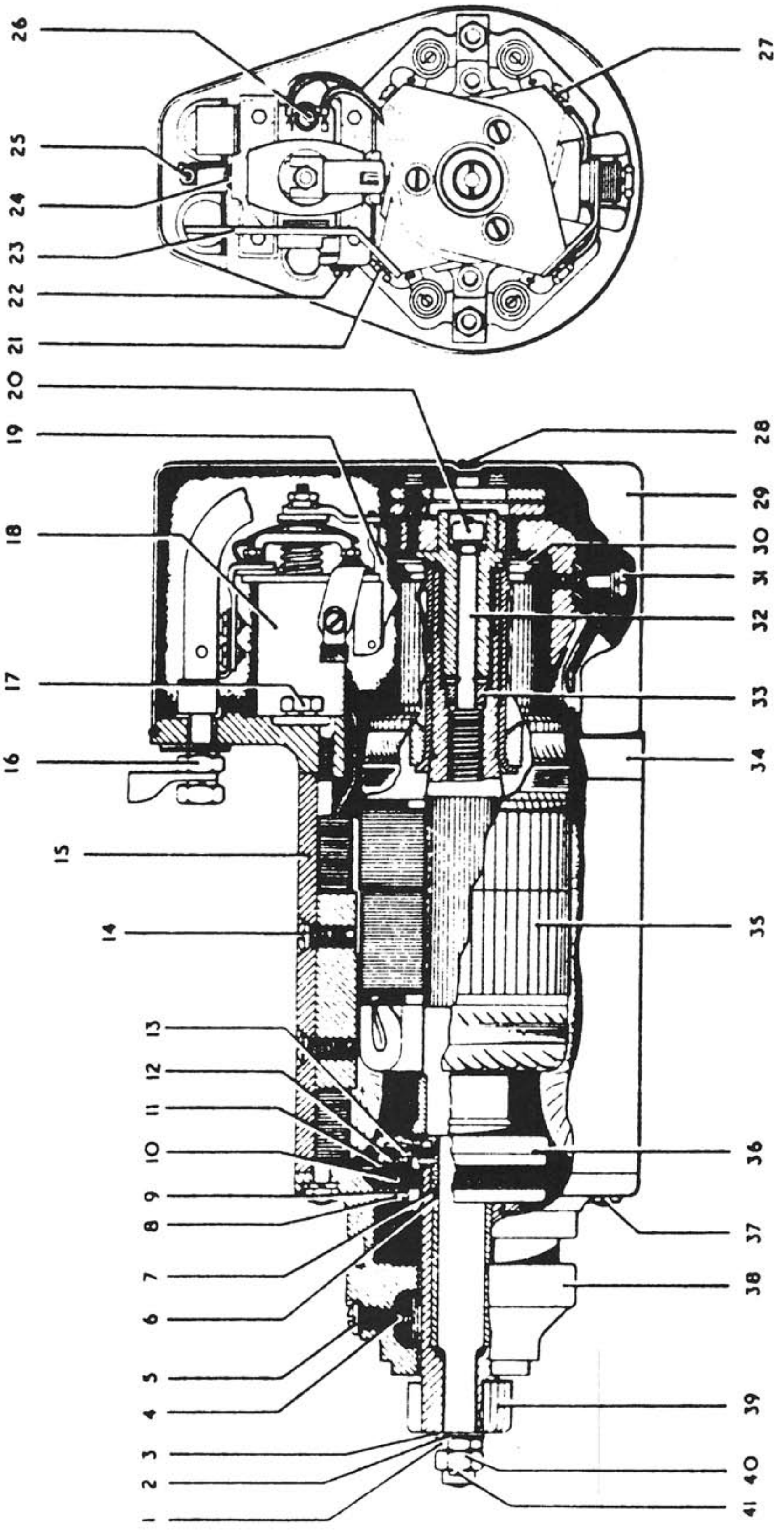

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FIG 13

1. Unscrew nuts (28), and remove the commutator cover (29).

2. Unscrew the brush lead screws (27), lift the brush springs and remove the brushes from their holders. Removal of the brush lead screws also frees the field connections to the brushgear.

Note:- at this stage the leads to the brushgear and solenoid switch should be marked so that they can be identified easily when the starter is assembled.

Remove the nut (20) from the armature plunger by means of tool 5693/45.

Remove the main fixing bolts or screws (37). Tap the drive-end shield (38) gently away from the yoke (15) with a hide or wooden mallet, and withdraw the shield complete with armature (35).

Hold the armature in an armature clamping device, or in a vice fitted with soft metal or wood jaw clamps.

Remove the lubricating plug (5) and the spring (4) from the drive-end shield.

Remove the split pin (41), nuts (40) and (1), and washers (2) and (3) from the front end of the pinion (39), and slide the pinion and drive-end shield off the armature shaft.

Remove the pinion spring (7).

Collect the clutch inner race (8), clutch plates (10), shim washers (11), back plate (12) and pressure plates (13) from the clutch assembly.

Note:- The clutch plates should be tied together in the order of removal so that they can be replaced in their original positions in the clutch when the starter is assembled.

Withdraw the shim(s) (6) from the bore of the pinion.

Unscrew the armature plunger retaining nut (33) by means of tool 5693/103.

Withdraw the armature plunger (32) from the bore of the armature.

Remove screws (24), (22) and (26) securing the positive terminal connector, main field coil ends and auxiliary field connections to the solenoid switch, duly marking them for ease of assembly.

Remove the screw (31) holding the main field connections to the connector at the bottom of the commutator-end shield.

Separate carefully the commutator-end shield from the yoke by tapping with a hide or wooden mallet.

Disconnect the solenoid coil leads, marking them for identification at assembly.

Unscrew the negative terminal nuts (16), and also the screw (21) securing the negative connector to the brushgear. Remove the negative connector.

Unscrew the solenoid fixing screws (17), and remove the solenoid switch.

Inspection and Repair

Commutator

The surface of the commutator should be clean and free from grooves, pits, or uneven discolouration. For moderate surface cleaning, a very fine grade of glass paper (not emery cloth or carborundum paper) may be used. If the surface condition is severe however, the component should be set up on a lathe and the commutator skimmed.

A coarse cut should first be made to remove sufficient copper to clear traces of pitting or distortion. If mica is used as the insulating material between the commutator segments, this insulation should be undercut, that is, it should be removed to a depth not exceeding the width of the insulation. Certain proprietary tools are available for this purpose, but an old hacksaw blade, ground to the width of the insulation, will make a serviceable tool in case of emergency. Where melamine is used as the insulating material no under cutting is normally necessary.

Finally, the component should again be set up on the lathe and a fine finishing cut taken using a diamond or tungsten carbide tipped tool to obtain the desired quality of finish. After machining, the commutator and armature must be cleaned thoroughly preferably by means of compressed air.

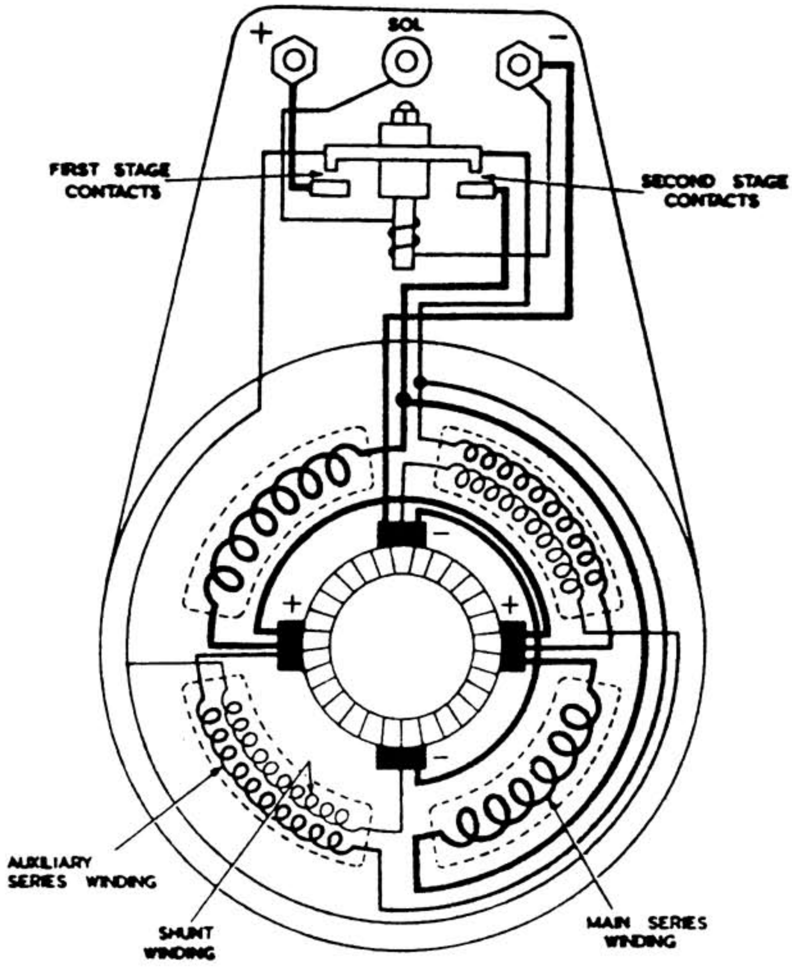
Armature Windings

Armature windings can be tested for continuity and short circuits by means of a 'growler' armature tester. If a 'growler' is not available the armature should be tested by substitution. Should the armature be faulty, the clutch outer race (36) should be pressed off the shaft with the aid of tool 5693/61, and the armature returned to Main Works.

When the clutch outer race is pressed onto the shaft of the new or replacement armature, tool 5693/94 should be inserted into the armature bore so that the press bears upon the tool and not upon the end of the commutator. If this procedure is not followed, the force exerted by the press may distort the commutator segments.

Field Windings

Field windings can be tested for short circuits to the yoke and poles by means of test probes connected to a mains supply not exceeding 110 Volt and in series with a 15 watt lamp of suitable voltage positioned on the live side of the system. One probe should be applied to the yoke at a position where it is free from enamel and insulation, and the other applied to the ends of each of the windings in turn. If the lamp does not light then the insulation is intact. Alternatively a 100 V Megohm meter can be used.



INTERNAL WIRING DIAGRAM

Open circuits can be detected easily be means of an ohmmeter. The instrument should be connected across each of the windings in turn, and, if infinity or maximum ohms is obtained, then an open circuit is indicated in the winding being tested.

Internal short circuits in the coils can best be detected by means of a low reading ohmmeter. If such an instrument is not available and the existing windings are suspect, they should be checked by substitution.

Unserviceable coils should be renewed as follows:-

Unscrew the pole fixing screws (14) and withdraw the poles and windings, noting the position of the windings to facilitate reassembly. Each pole has a small step machined on its surface, and is marked with a number which corresponds with a number stamped on the end of the yoke. When replacing the pole, the steps should all be positioned towards the commutator end of the yoke, and the numbers should correspond.

Fit the new windings to the poles as dismantled, so that they bed down as far as possible on the poleshoe wings.

Assemble the poles and the windings into the yoke, and insert the pole fixing screws.

Apply 'Duralac' sealing compound (specification DTD 369A) to the pole screws and seats and tighten the screws using a proprietary pole screwdriver. The screws should be tightened down firmly to exclude any space between the mating surfaces of the poles and the yoke. This condition can be checked by a thin feeler gauge.

Note:- The windings will bed down more easily if the yoke windings and poles are heated gently in an oven before the pole fixing screws are tightened. If the coils are loose on the pole shoes they must be tightened either by fitting a leatheroid spacer or taping the coils otherwise insulation is liable to break down due to fretting.

Bearings

The pinion should be inserted into its bearing in the drive-end shield, and the commutator end of the armature pushed onto the bearing pin in the commutator-end shield. Both bearings should then be checked for excessive sideplay.

If the bearing pin is worn, it is recommended that the complete commutator-end shield assembly should be replaced, as the shield spigot is machined concentric with the bearing pin after the pin has been assembled.

Provided facilities exist for accurate machining, the drive-end bearing may be removed from its shield and renewed. If such facilities are not available, the complete drive-end shield and bearing assembly should be returned to Main Works for replacement. If the bearing is to be renewed the following procedure should be adopted:-

Push the lubricating wick well away from the bore so that it does not get trapped during the pressing operations.

Press the old bearing out of the shield.

Press in the new bearing from inside the shield, using a split dolly to prevent the lubricating wick from being trapped between the end of the bearing and the edge of the oil reservoir. If the pads have hardened they should be replaced.

Set up the shield in a lathe in such a manner that when machining of the bearing bore is complete, the bore is perfectly concentric with the shield spigot where it registers with the yoke. This can be best done by means of faceplate 5693/93 which is designed to be located in a recess machined in the faceplate of the lathe, and is itself provided with accurately machined recesses for locating the shield spigots of the starter.

Turn the bearing bore to between 35.05 and 35.10 mm diameter, and ensure that the surface finish is of the highest quality.

Turn both ends of the bearing flush with the faces of the castings if necessary.

When fitting a new or used pinion, a clearance between the pinion and bearing should be 0.05 to 0.10 mm.

Brushgear

The brushgear insulation should be checked as detailed below, using a 110 Volt mains supply, test probes and lamp as described under Field Windings. If the lamp lights during any of these tests the insulation is faulty. Alternatively a 100 Volt Megohm meter can be used:-

(a) Between the positive and negative brush holders.

(b) Between the positive brush holder and the frame.

(c) Between the negative brush holder and the frame.

Clutch

If the clutch plates (10) are badly worn or discoloured they must be renewed. Individual new parts should not be inserted unless facilities exist for testing the slipping torque. If such facilities do not exist, and parts of the clutch need renewing, a complete new interior should be fitted, or alternatively, the clutch together with the armature, pinion and drive-end shield should be returned to Main Works for attention.

Pinion

If the teeth of the pinion (39) are badly worn or damaged, the pinion should be changed. Ensure that the new pinion has the same number of teeth and is steel.

Assembly and adjustment

The figures in brackets refer to Fig. 1.

Hold the armature in an armature clamping device, or in a vice fitted with soft metal or wood jaw clamps.

Note:- In all cases where grease is referred to in the following text, use Shell Nerita or B.P. Energrease.

Smear the spring and thrust washer on the armature plunger (32) liberally with grease. Insert the plunger into the bore of the armature, and tighten the plunger retaining nut (33) using the appropriate tool.

Note:- Before assembling the clutch, carefully examine all parts for wear, distortion and the presence of burrs or sharp edges which can cause clutch slip. Burrs or sharp edges should be removed with an abrasive stone from the following parts in working contact leaving a minute radius.

(a) Thread tops on inner race and pinion sleeve.

(b) Slots on inner and outer races.

(c) Edge of clutch plates.

Insert the pressure plates (13), back ring (12) and shim washers (11) into the clutch outer-race (36).

Smear the clutch springs (9) lightly with grease, and place them in their holes in the clutch inner race (8). Each spring should be inserted with its largest diameter first.

Grease the clutch plates (10) lightly and place them on the splines of the clutch inner race, taking car to fit bronze and steel alternately. Fit a steel plate first so that it takes the pressure of the clutch springs.

Assemble the clutch inner race complete with clutch plates.

Grease the pinion spring (7) and slide it onto the armature shaft, together with spacing collar.

Grease the bore of the pinion (39) and insert the shims (6).

Insert the pinion into the drive-end shield (38). To prevent damage to the felt lubricating pad, the pinion should be twisted in the direction of the spiral of the pinion thread whilst the lubricating pad is lifted from inside the casting.

Slide the pinion and the drive-end shield onto the armature shaft. Push the pinion forward and rotate until its thread engages in the internal thread in the clutch inner race. Hold it in this position and replace the shim (3), washer (2), and nut (1). Make sure that the shim locates over the shoulder of the shaft and tighten the nut securely. After the nut has been tightened, the pinion must be capable of a small endways movement on the armature shaft.

Where facilities exist, the slipping torque of the clutch should now be adjusted as follows:-

Remove the existing pinion and temporily fit a pinion of 11 or 13 teeth.

Clamp the armature to the bench using a clamp bracket or in a workshop vice the jaws of which are protected by aluminium, wood or soft brass shields and fit torque socket 6244-1 (for 11 teeth pinions) or socket 6244-2 (for 13 teeth pinions). The original pinion is afterwards replaced. A standard torque spanner calibrated to 150 lb ft with a $\frac{1}{2}$ in square drive shaft should be fitted to the torque socket and the applied torque will be shown on the calibrated scale in the usual manner.

Adjust the clutch to an initial slipping torque of 16.6–19.4 kNm (120–140 lb ft).

Adjustment is made by removing or adding shims (11) Fig. 1 between the clutch plates (10) and back plate (12). The shims are made in two thicknesses 0.1 mm and 0.15 mm. Adding shims will increase the slipping torque and vice versa.

Slip the clutch 10 times and then re-adjust the clutch to slip at a final setting of 13.8–16.6 kNm (100–120 lb/ft).

Replace the castellated (40) tighten securely and insert the split pin.

Pour approximately 12 cc of oil into the oil filler holes in the drive-end shield. Allow sufficient time for the lubricating pad to absorb the oil, and then replace the spring (4) and lubricating plug and washer (5). Wipe off any surplus oil which may have run into the inside of the drive-end shield.

Fit the commutator-end shield to the yoke (15), with 'Durulac' sealing compound ensuring that the dowel in the yoke is correctly located.

Fit the solenoid switch (18) to the commutator-end shield (34) and secure in position with the fixing screws (17), after applying 'Durulac' sealing compound to threads.

Assemble the negative connector (23) to the commutator end shield and replace nuts (16) and screw (21).

Reconnect the solenoid winding leads to their respective terminals.

Replace screws (22), (24) and (26) securing the main field coil ends, positive terminal connector, and auxiliary field connections to the solenoid switch.

Replace the screws and insulating pieces (31) holding the main field connections to the connector at the bottom of the commutator-end shield.

Assemble the armature and drive-end shield to the yoke and apply 'Durulac' sealing compound to spigots and register between yoke and end-shields.

Replace the main fixing bolts or screws (37) together with sealing washers and tighten to 6-8 lb ft.

Spin the armature to ensure that it is not binding and is free to rotate.

Fit the washers and nut (20) to the armature plunger, and tighten.

Replace the brushes, taking care that each brush is replaced in its original position. If new brushes are to be fitted, they must be bedded to the commutator.

Connect the brush leads and field leads to the brush gear with screws (27). On those starters with pressed brush gear do not forget to fit the brush inter-connectors. All these leads should have been duly marked during dismantling as the number and disposition of the leads vary with the starter type.

Check that the relationship between the trigger (19) and the tripping disc (30) is correct, by pulling the armature forward until the trigger is raised to its highest extent by the tripping disc. When the trigger is raised there should be an ample gap between the shoulder on the trigger and the bottom of the slot in the catch plate.

Test Procedure

Engagement Mechanism

The following procedure should be adopted:-

Connect the starter to a battery of suitable voltage.

Insert a strip of insulating material between the moving contact and the second stage contact of the solenoid switch (18) to prevent the second stage contacts from closing.

Press the starter button. The first stage contacts of the solenoid switch should close, and the pinion should revolve in its normal direction of rotation. At the same time, the pinion should move forward a distance of approximately 25.4 mm (1").

Note:- Do not keep the starter button depressed longer than is necessary to check that the starter is functioning satisfactorily, otherwise the auxiliary windings may be damaged by overheating.

Remove the insulating strip from the second stage contacts.

Performance Tests

For the purposes of these tests, the brushes must be bedded over at least 80% of their contact area. The following procedure should be adopted:-

Fit the starter to a starter test rig and connect the power supply. The gap between the starter pinion and the test rig flywheel must be set at 3.175 mm (0.125 in).

Check the lock torque, the running torque, and the light running torque of the starter.

When these tests have been successfully completed, the commutator end cover and sealing ring should be fitted carefully and the machine subjected to insulation tests. Fit nuts (28) and locking washer. Certain starters also have a securing clip.

Insulation Tests

Using test probes connected to a mains supply of 110 Volt maximum and in series with a 15 watt lamp of suitable voltage, check the insulation of the machine as detailed. If the lamp lights during any of the tests the insulation is faulty. Alternatively a 100 Volt megohm meter can be used:-

(a) Between the positive terminal and the frame.

(b) Between the negative terminal and the frame.

Solenoid Switches

Description

Solenoid switch type BBNG, is a simple two-stage unit designed for use with an axial-type starter, and consists of a solenoid operating coil assembly and two pairs of contacts. The switch is mounted inside the starter housing above the commutator, and protected by the commutator end cover.

Operation

When the solenoid operating coil (47), is energised, the magnetic field set up in the winding draws in the solenoid plunger until the first stage contacts are closed, and the catch plate (43) rests on the step in the trigger (44). This position is held until the trigger is raised by the tripping disc on the starter armature, thus allowing the plunger to travel fully home and close the second stage contacts. Both contacts will remain closed until the operating coil is de-energised. The moving contact actuated by the coiled spring (48), will then return to its normally open position.

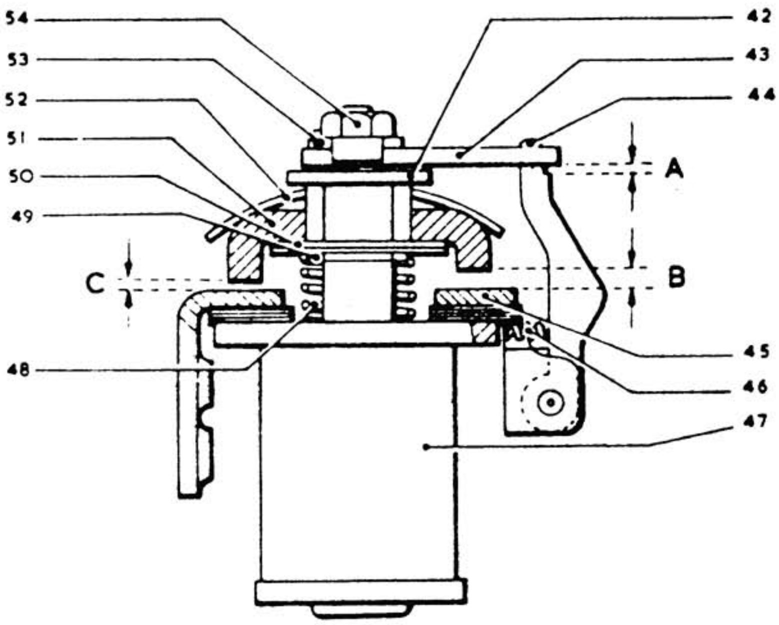


FIG 14

Dismantling Procedure

Dismantling of the units should be carried out as follows:-

Bend back the tags of the lock washer (53) and unscrew the nut (54).

Withdraw the catch plate (43), contact guide (42), contact leaf spring (52), moving contact (51), adjusting washers (50), insulating washer (49) and return spring (48).

Remove the trigger spring (46).

Inspection and Repair

Moving Contact

The moving contact (51) can be cleaned with spirit or very fine carborundum paper. If it is very badly burnt or pitted however, it should be set up in a lathe and refaced. The moving contact is machined at an angle, and this angle must be maintained when the contact is refaced. It is important that after machining, the contact surfaces are smooth, flat, and on the same plane. An uneven surface will result in poor contact and the whole operation will have to be repeated. A maximum of 0.5 mm may be removed from the contact faces. If this is insufficient, a new moving contact or moving contact assembly should be fitted.

Fixed Contacts

The fixed contacts (45) can also be cleaned with spirit or very fine carborundum paper. If the contact faces are badly burnt or pitted they should be refaced on a lathe while still in position on the switch. A maximum of 0.5 mm should be removed and if this is insufficient to remove all traces of burning and pitting, the contacts should be renewed. As new contacts are supplied in an unmachined state, they must be assembled to the switch and faced on a lathe before being placed in service.

If machining facilities are not available, the switch should be returned to Main Works for attention.

Solenoid Winding

If the solenoid winding becomes broken or damaged, the complete switch should be returned to Main Works for attention, as the stirrup surround the operating coil is riveted in position and must not be removed.

Catch Plate and Trigger

The catch plate and trigger should be inspected for wear. If the shoulder on the trigger, and the bottom of the slot in the catch plate, show signs of "rounding off" the two components must be renewed.

Assembly and Adjustment

The units should be assembled as follows:-

Smear the solenoid plunger at the point of entry into the switch body lightly with petroleum jelly, and also the leaf spring (52) Fig. 9 at the point of contact with moving contact (51). Apply sparingly to avoid any surplus getting on to the contact faces.

Replace the return spring (48), and ensure that it locates over the lip on the periphery of the switch bore.

Replace the trigger spring (46).

Assemble the insulating washer (49), adjusting washers (50), moving contact (51) contact spring (52), contact guide (42) and catch plate (43).

Locate the end of the trigger in the slot in the catch plate, and then replace the lock washer (53) and nut (54). Tighten the nut securely.

Check that gaps between the contacts 'B' and 'C' are within the limits detailed below. If not, adjusting washers (50) must be added or removed until the correct gap is obtained. The washer (49) must not be removed as it acts as a locating spigot for the return spring. The adjusting washers are made in four thicknesses, 0.1, 0.2, 0.3 and 1.0 mm, and a combination of these sizes should be used to obtain the correct gaps.

Check that gap 'A' between the catch plate and the shoulder on the trigger is within the limits detailed below:-

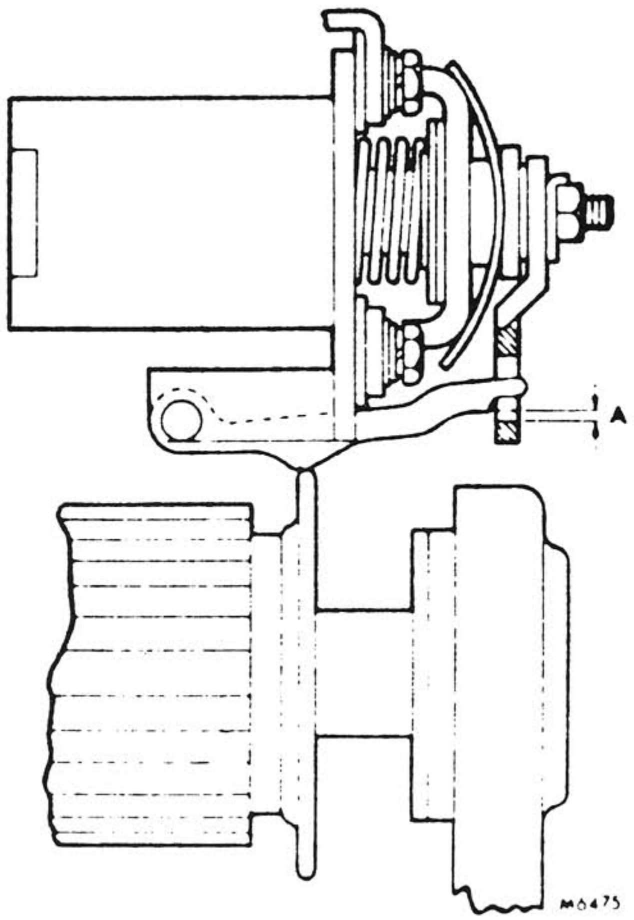
After the adjustments have been successfully completed, lock the nut (54) by means of the tabs on the lock washer (53).

Voltage	Gap A mm	Gap B mm	Cap C mm
12	2.0 ± 0.1	3.8 ± 0.3	1.0 ± 0.1
24	2.0 ± 0.1	3.8 ± 0.3	1.0 ± 0.1
32	5.0 ± 0.1	6.6 ± 0.2	4.0 ± 0.1

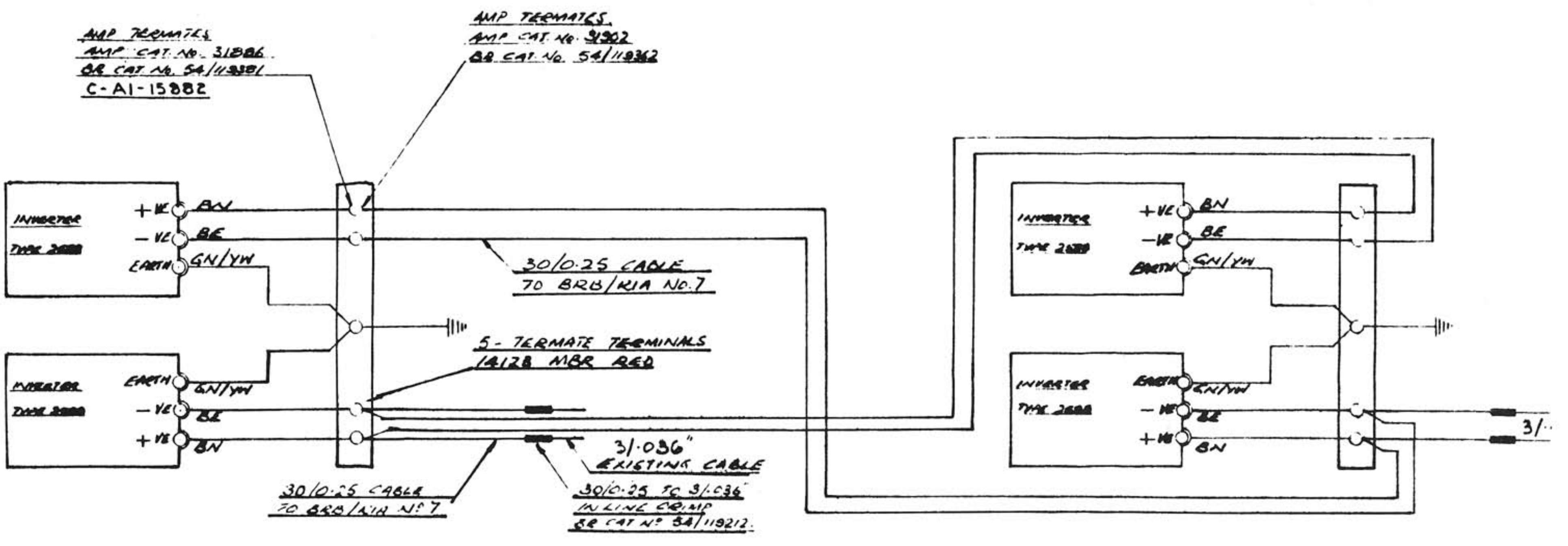
Simple Service Setting

After the machanical settings have been carried out the following check may be made. Push the plunger forward until the first contacts just touch; the gap between the trigger and catch plate should then be approximately 1 mm, that is, the plunger can move a further 1 mm before the catch plate hits the trigger.

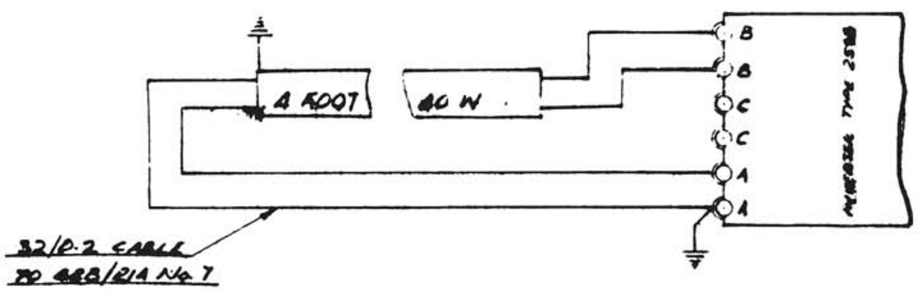
Trip the trigger and push plunger until second contacts just touch, from this point until the plunger completes its travel the distance should be approximately 1 mm.



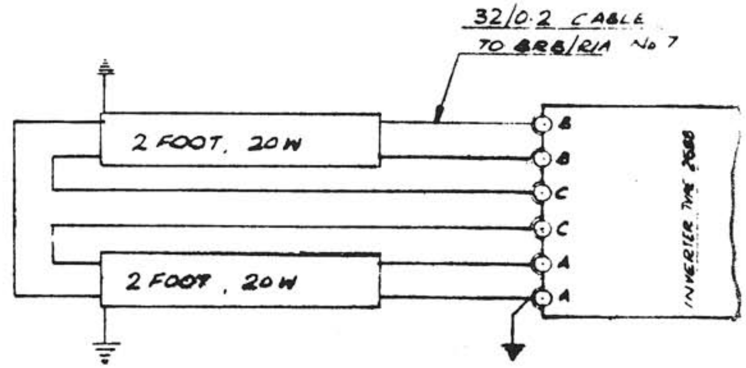
RELATIONSHIP BETWEEN TRIGGER AND TRIPPING DISC



TYPICAL CONNECTIONS OF INVERTERS.



CONNECTIONS FOR SINGLE 40 W TUBE



CONNECTIONS FOR DOUBLE 20 W TUBES

SMITHS COMBUSTION HEATERS.

NOTES ON OPERATION AND MAINTENANCE.

SMITHS COMBUSTION HEATERS.

Introduction.

The Smiths heater used on Diesel Multiple Units functions as an oil fired air heater in which air from the atmosphere flows over a combustion chamber/heat exchanger.

The heater is designed to operate on diesel oil which is delivered by a pump into an atomiser cup which causes the fuel to break up into a fine spray. During the starting cycle this spray is ignited by a Glow Plug, but combustion is self sustaining once the run-up has been completed. Combustion air is drawn into the combustion chamber by an air impeller.

The carriage warming air is forced over the heat exchanger by an electric motor driven fan. The atomiser cup, fuel pump, combustion air impeller are driven from an extension of the motor shaft.

It is a simple system to understand, set up, and maintain provided the operating environment remains reasonably constant. However use on a Diesel Multiple Unit is about as severe a test as could be devised, the heater being exposed to all external weather conditions including varying road speeds from 0 - 70 m.p.h. and tremendous variations in heat loss as passengers open and close doors and windows.

Operation and Maintenance.

In dealing with the operation and maintenance the heater is best considered by splitting the system into its three main functions, i.e. COMBUSTION, HEAT TRANSFER AND DISTRIBUTION AND CONTROL.

(a) Combustion.

The aim is to burn the fuel oil as efficiently as possible under the varying conditions of combustion air flow, combustion chamber temperatures, fuel delivery, and the mixing of air and fuel, while at the same time avoiding the build up of carbon residues in the combustion spaces. To burn the fuel oil efficiently requires an exact amount of air, enough to just complete the combustion and no more. Too little air results in unburnt fuel (soot) while too much increases the volume of flue gas and loss of heat to atmosphere via the exhaust.

The air/fuel ratio must be larger than the minimum value because:-

(1) The mixing of the air and fuel may be incomplete.

(2) The process is taking place rapid-y and excess air must be provided in an attempt to ensure complete combustion.

(b) Heat Transfer and Distribution.

Here the object is to ensure that as much of the heat produced as possible is transferred through the walls of the steel combustion chamber into the air flow passing over the outer surfaces.

It should be noted that the build up of soot etc., has the same thermal insulation effect as a layer of asbestos.

The heating air flow is then forced through the vehicle ducting which has outlets arranged so that the heating air is distributed as evenly as possible. With a particular ducting arrangement the heat is only evenly distributed provided the delivery temperature and air flow are within reasonable limits. This will not be the case if air intake filters and grilles are blocked.

(c) Control.

Most heaters now encountered have an electronic control system which is mounted partly on the heater casing and partly in a separately mounted 'heater relay panel', under normal conditions this control system determines the starting, firing, and shutting down sequences.

Under fault conditions it shuts the heater down in the event of a failure to establish a flame in the combustion chamber, or if there is an excessive temperature rise inside the heater.

In addition there is separate control equipment, i.e. saloon thermostats which automatically start or shut down the heater depending on the internal temperature in the vehicle and control boxes for remote control situated in the drivers and guards compartments, etc.

The main problem with the fault diagnosis is in determining which part of the equipment is defective.

The current position regarding overhaul and maintenance of Smiths automatic heaters is as follows:-

Swindon Overhaul.

All heaters are being overhauled to C.E.P.S.24, with particular attention to:-

1. Conversion to latest equipment (Engineering Instruction MD/86 - combined Flame Detection and Overheat Protestion Unit).

2. Positioning of thermistor (Standard Instruction 2/L/104).

3. Alignment of Fuel Spinner, swan neck fuel pipe etc.

4. Setting up of electronic equipment using voltage method.

5. Renewal of hot thermistor at each overhaul.

6. Fitting of shrouded motor bearings.

7. Fixing of flame ring.

Depot Maintenance.

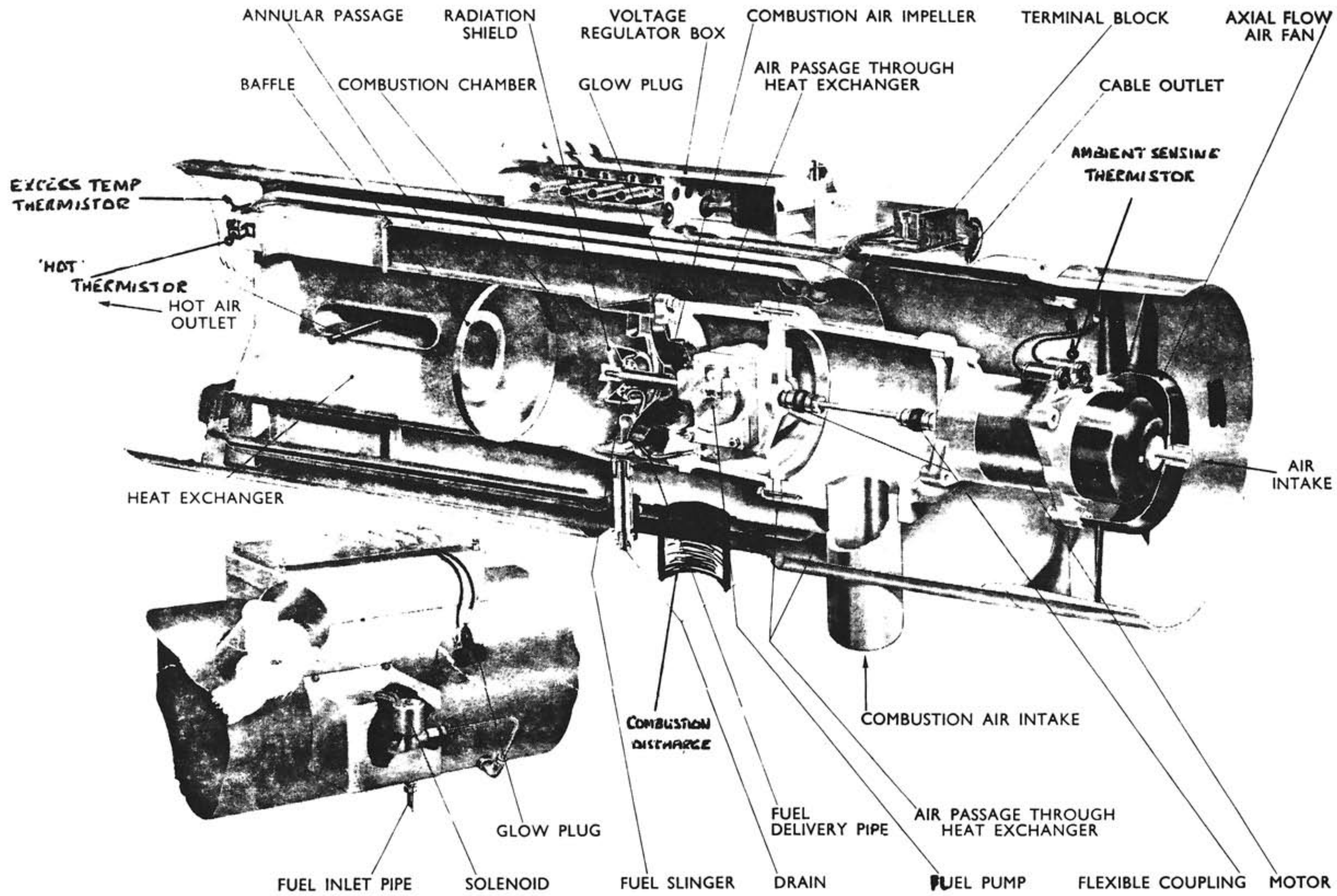
1. Stricter glow plug maintenance and testing (Standard Instruction 2/L/103).

2. Use of portable test unit (Standard Instruction 2/L/105).

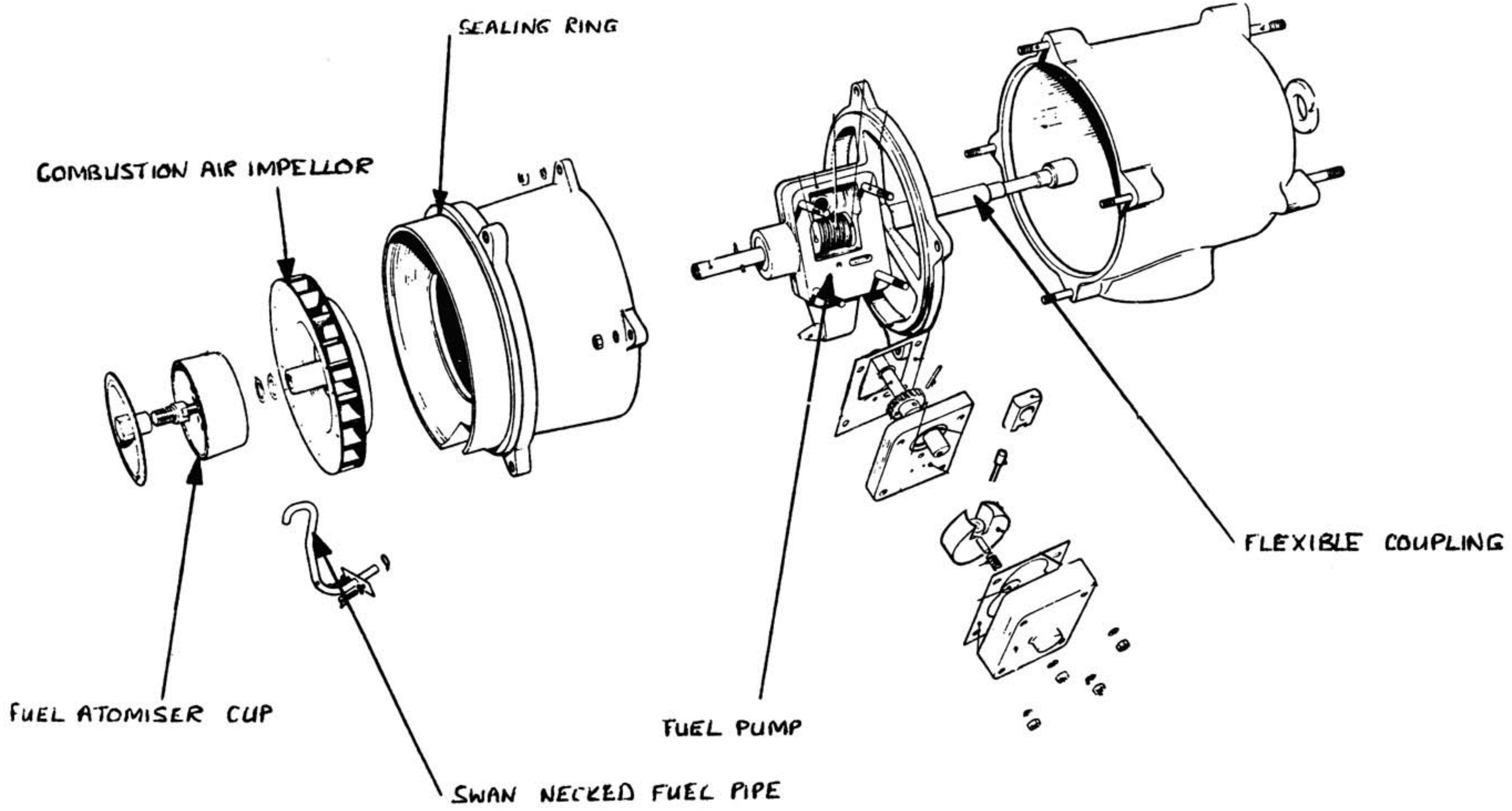
3. Testing of heaters from Swindon before use in service (Standard Instruction 2/L/104).

   Also all heater relay panels passing through Swindon will in future be converted to latest electronic type (Engineering Instruction MD/166, Refurbishing of Automatic Control Boxes, and E.E. Instruction MD/195 Fitting of Protective Diodes) will be applied.

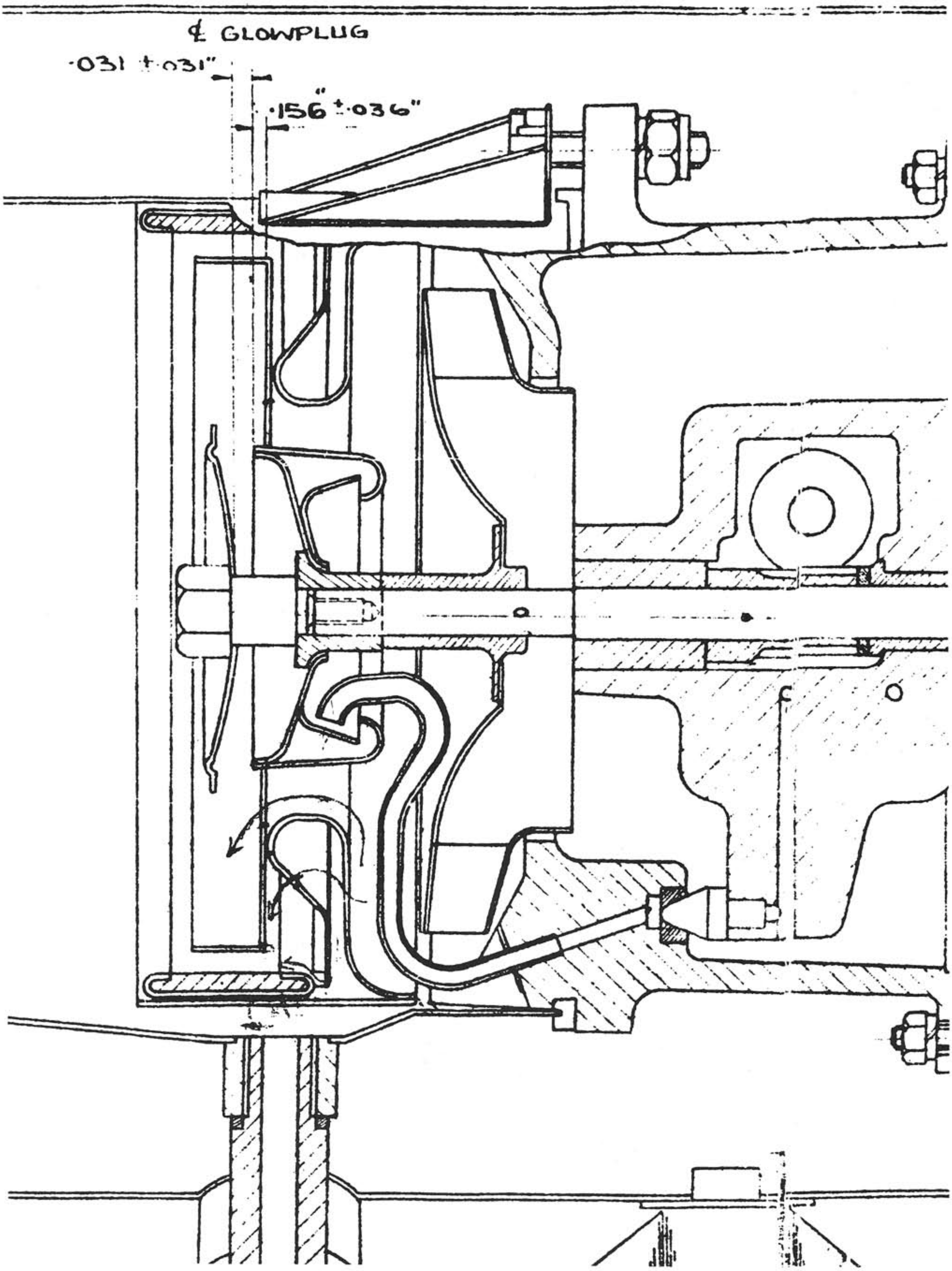
SMITHS HEATER APPENDIX A



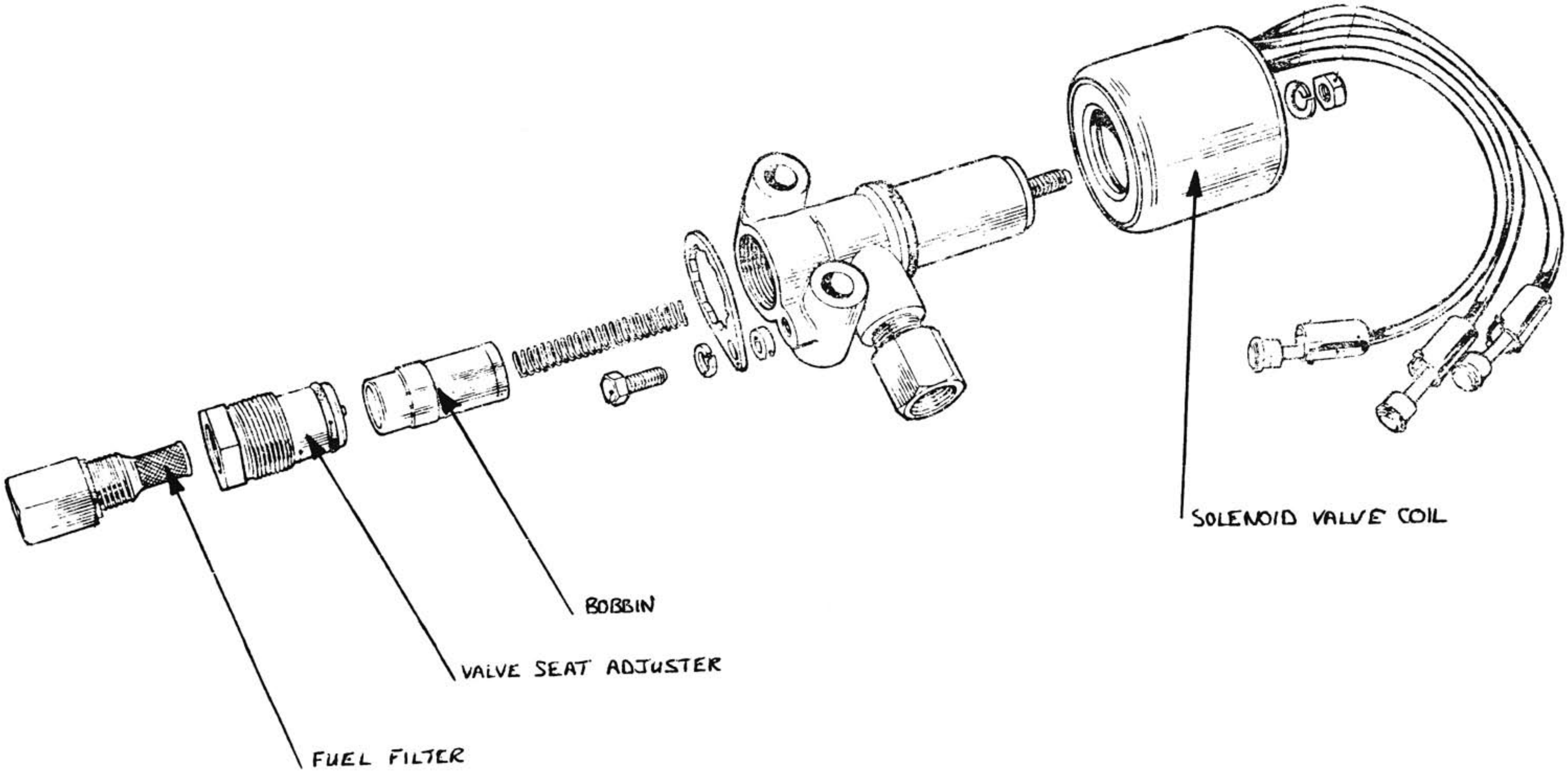
FUEL PUMP / ATOMISER / COMBUSTION AIR IMPELLOR SUB-ASSEMBLY

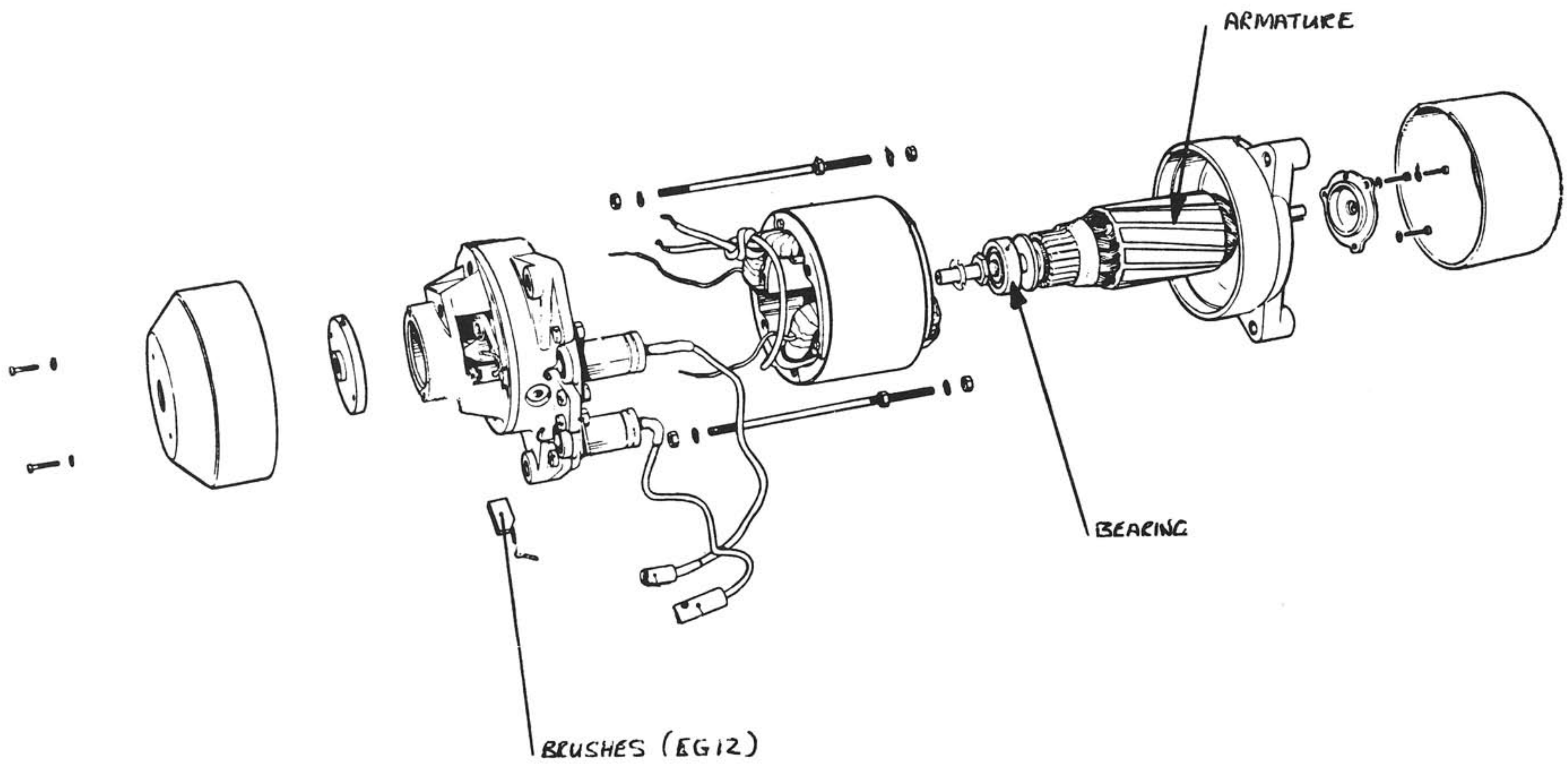


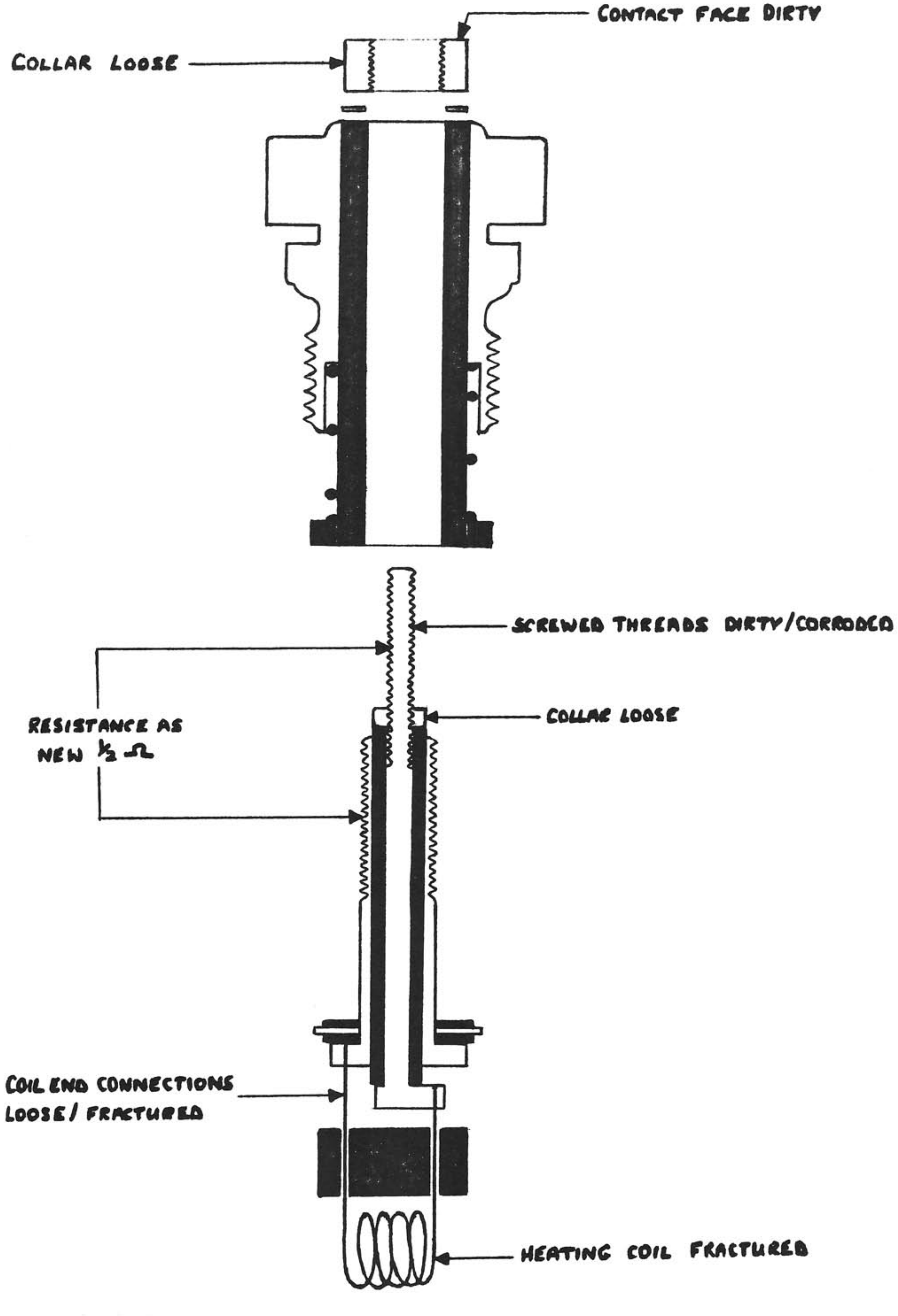
APPENDIX C



FUEL SOLENOID VALVE

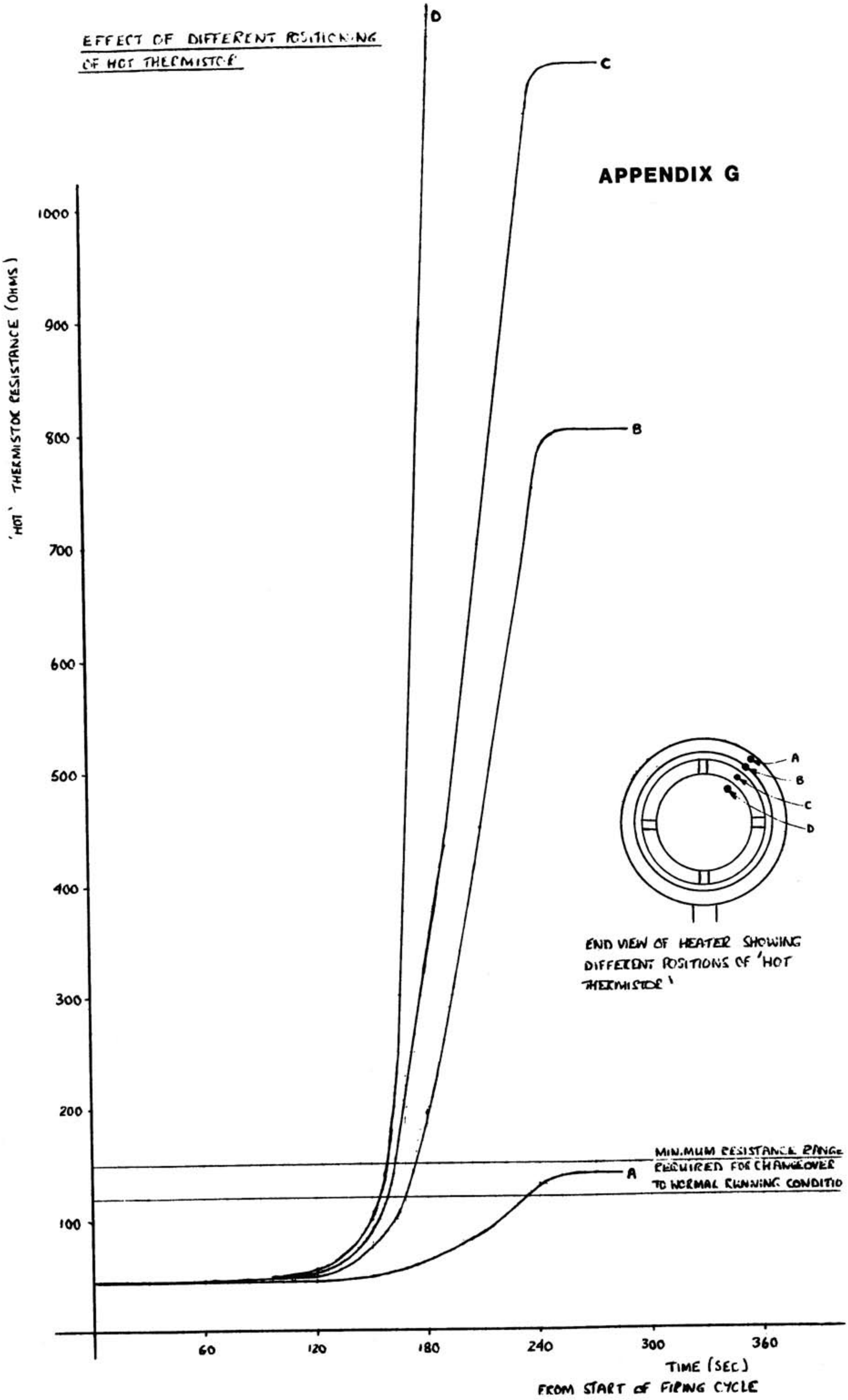



ARMATURE
BEARING
BRUSHES (EG12)



SMITH HEATER GLOWPLUG - COMMON FAULTS **APPENDIX F**

APPENDIX G



EFFECT OF DIFFERENT POSITIONING
OF HOT THERMISTOR
'HOT' THERMISTOR RESISTANCE (OHMS)
1000
900
800
700
600
500
400
300
200
100
60
120
180
240
300
360
TIME (SEC)
FROM START OF FIRING CYCLE
A
B
C
D
MINIMUM RESISTANCE RANGE
REQUIRED FOR CHANGEOVER
TO NORMAL RUNNING CONDITIO
END VIEW OF HEATER SHOWING
DIFFERENT POSITIONS OF 'HOT
THERMISTOR'

Smiths Heaters: Electronic Flame Detection and Overheat Protection Units, Series II.

1. Description of Operation of Series II Unit.

1.1. Foreward.

The Series II circuit detects the temperature rise by comparing the resistance change of a thermistor in the hot air putlet with a thermistor in the cold air inlet. Thus the equipment is not affected by the ambient temperature and should detect heat as easily in winter as in summer.

1.2 Setting up the Flame Detection Circuit.

Before any heater is put into service it should be set up to the following standards:-

(a) The two thermistors TH1 and TH3 should be a matched pair with no more than 10 ohms difference between them.

(b) The heater is run in the VENT position and the voltage (X) between the junction TH1/3 and the negative rail is measured. Then the voltage (Y) between the RP1 slider and the negative rail is set to be 0.3 volts higher than the (X) voltage.

The heater is now ready to run.

1.3 Flame Detection Circuit Operation.

A 24 volt supply is present across terminals (+ ve) and 8 (- ve). This supplies the flame detection circuit via a dropping resistance R1 and a stabilizing zener diode (10 volts) ZD1. Resistors R2 and R5 and ZD2 stabilise the supply to the thermistors at 3.3 volts.

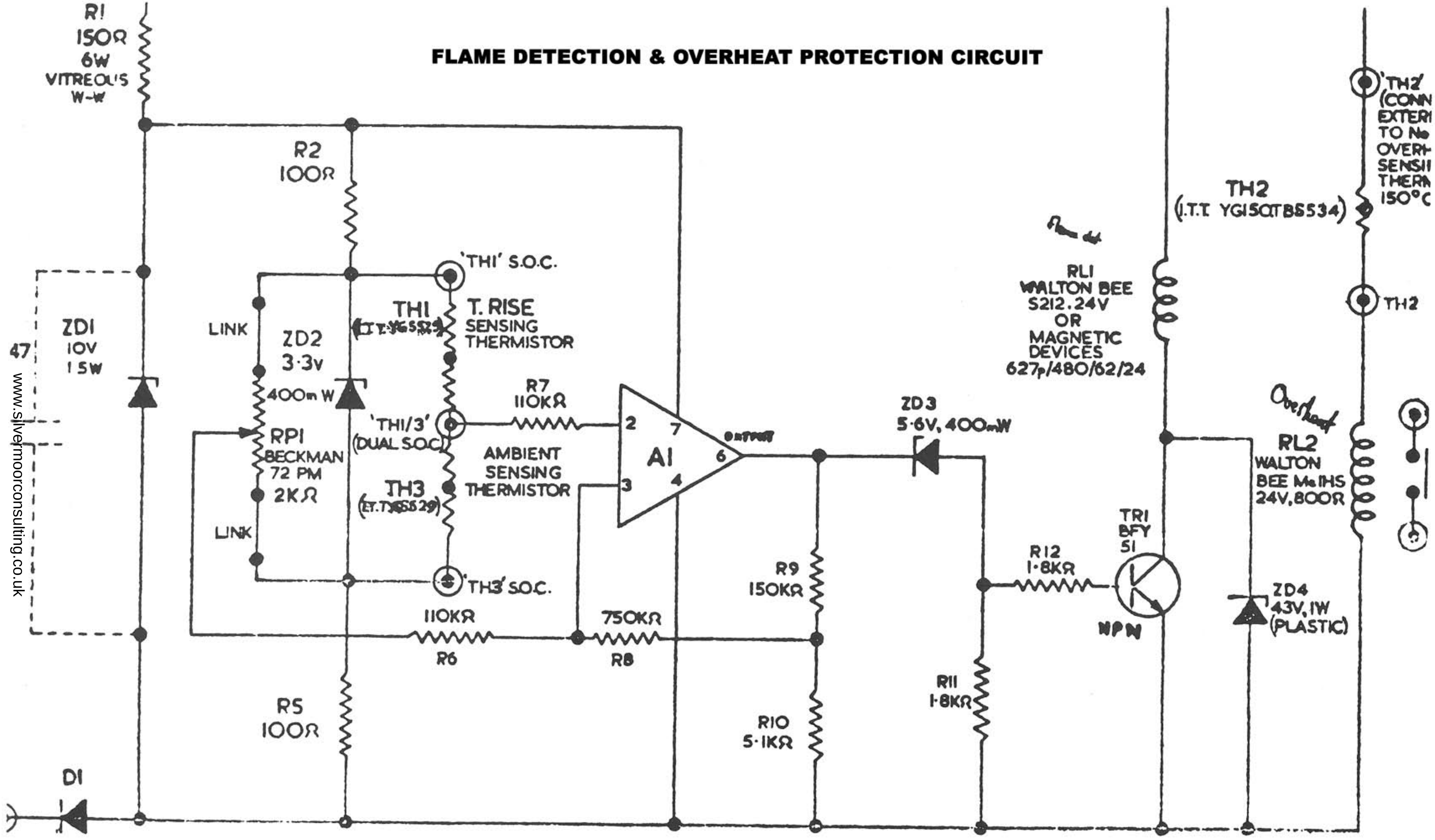
Before starting the heater the thermistors are cold and at the junction TH1/3 the voltage (X) will be approximately 5 volts above the negative rail. The output from RP1(Y) has been set 0.3 volts above (X) and the amplifier A1 will be switched 'OFF'.

When the heater fires and combustion takes place the sensing thermistor TH1 detects the rise in air temperature and increases its resistance. Thus the voltage at the junction TH1/3 will gradually drop. When this voltage has dropped to 0.6 volts below (Y), the amplifier A1 will switch 'ON'. When A1 switches 'ON' the output voltage breaks down ZD3 andbias on the base of TR1. Relay RL1 will then energise as TR1 conducts and flame detection will have taken place.

When the heater shuts down a similar procedure takes place. The temperature detected at TH1 decreases and this causes the voltage at TH1/3 to rise. When this voltage reaches 0.6 volts below (Y) then the heater switches off.

This circuit has a 24 volt supply across an overheat thermistor TH2 and a relay RL2. The thermistor (150 degree C knee type) has a normal resistance of approximately 100 ohms. and is in series with the 800 ohms. coil of RL2. With only about 3 volts dropped across the thermistor the relay is normally energised with 21 volts across it.

FLAME DETECTION & OVERHEAT PROTECTION CIRCUIT



NOTE:- (1) RL1 RELAYS OF WALTON BEE OR MAGNETIC DEVICES MANUFACTURE ARE NOT INTERCHANGEABLE.

(2) RINGED NUMBERS DENOTE 2BA RING TERMINALS.

(3) S.O.C. DENOTES 1/4" FASTON CONNECTORS.

The overheat thermistor positioned in the hot air outlet will rapidly increase its resistance when the temperature increases above 150° C. The resistance will rise to 2000 ohms plus and de-energise the relay coil. The contacts on RL2 will open and immediately shut down the heater.

2. Description of Electronic Relay Panel.

2.1 Forward.

The electronic relay panel replaces the original timing motor and can operate relays with electronic timing and relay switching.

2.2 Setting up the Relay Panel.

Before putting a relay panel in service it is necessary to set up the glow plug cycle and the motor relay cycle. The normal procedure when setting up the panel is to:-

(a) Switch on the glow plug by pushing the start button.

(b) After 45-60 seconds the electronic control switches on the motor relay.

(c) The relay panel switches off after 4 minutes if combustion has not taken place and been detected by the heater.

Variable resistance RP1 is used to set the total relay panel cycle (4 minutes) and RP2 is used to set the initial glow plug cycle (45 - 60 seconds) before the motor relay energises.

2.3 Operation of the Relay Panel.

Stage 1.

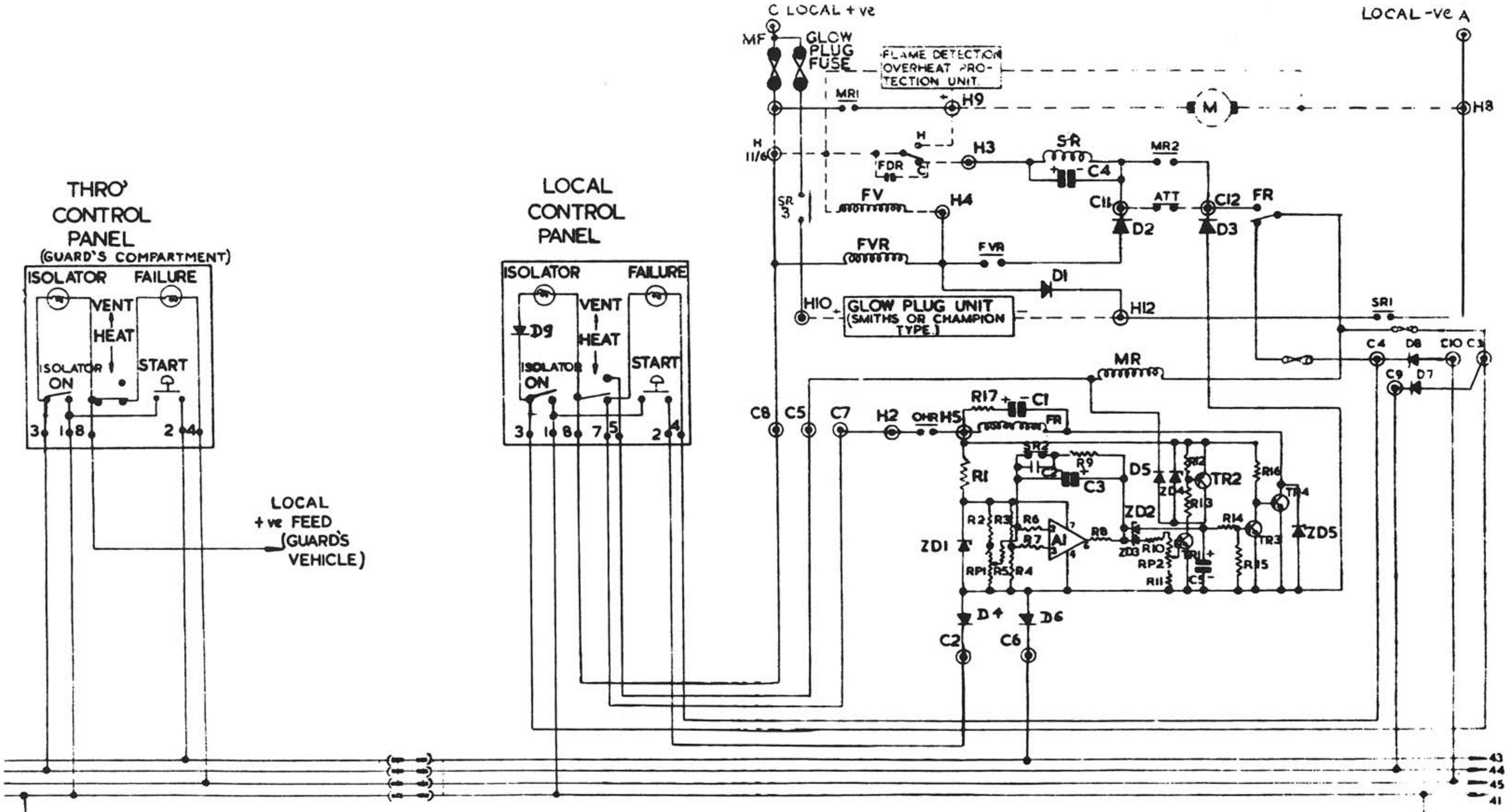
The heating system obtains its positive and negative local supply from C & A respectively and uses a common negative through train wire 41.

(a) Put the isolator switch in the Guard's compartment to the 'ON' position. The isolator light will be bright (Circuit: C - M. Fuse - C8 - Isol. Lamp - Isol. Sw. - 41 wire).

(b) Select 'HEATING' on the Guard's control panel. The failure indicator light should be bright. (Circuit: C - M. Fuse - C8 - H.V. Switch - Failure Lamp - C4 - FR interlock - C3 - Isol. Sw. - 41 wire).

(c) Press the start button. The failure light goes out as the fault relay operates. (Circuit: C - C8 - H.V. Switch - OHR interlock - FR - TR4 - D4 - Start Button - 41 wire).

TR4 is switched on by positive feed (Circuit: C - OHR interlock -H5 - R16 - Base of TR4).



C3 -ve Fuse.

Local VE Fuse Guards Vehicle

ELECTRONIC CONTROL PANEL: SMITHS HEATERS (THROUGH CONTROL SYSTEM).

⊙ ALL CONNECTIONS TO PANEL CONTROL SOCKET PREFIX 'C'.

⊚ ALL CONNECTIONS TO PANEL HEATER SOCKET PREFIX 'H'.

SEE DRG C-A2-14952. COMPONENT LIST DRG C-A4-10517.

C3VE FUSE

LOCAL ve FEED

33

Stage 2.

(a) When FR energises the start relay SR becomes energised. (Circuit: C - H11 - F.D.R. (cold position) - H3 - SR - Saloon stat - F.R. interlock - C3 - 41 wire).

F. Relay is kept energised by its own interlock FR maintaining the negative after the start button is released.

(b) The operation of S.R. brings in the glow plug. (Circuit: C - G.P. Fuse - H10 - Glow Plug - H12 - SR1 - A).

(c) The fuel valve and the fuel valve relay are also energised by the closing of SR1 interlock. (Circuit: C - H11 - FV and FV4 - D1 - SR1 - A).

Stage 3.

After starting the timing circuit operates and gradually builds up an output voltage from A1 until it reaches the break over voltage of ZD3 (6.2 volts). (Circuit: C - H5 - R1 - R2 -RP1 - R5 - R6 - A1 and a fixed voltage on the other integrated circuit input R1 - R3 - R7 - A1). The voltage builds up across capacitor C3 until it reaches 6.2 volts when ZD3 break down and puts a positive voltage on the base of TR1. The time taken until ZD3 breaks down is adjustable using the RP1 and the RP2 potentiometers. This time is set to 45 - 60 seconds.

When TR1 has a positive voltage on its base it conducts and applies a voltage to the base of TR2 and switches this on. (Circuit: C - HVS - H5 - R12 - Vase TR2 - R13 - TR1 - FR - wire 41).

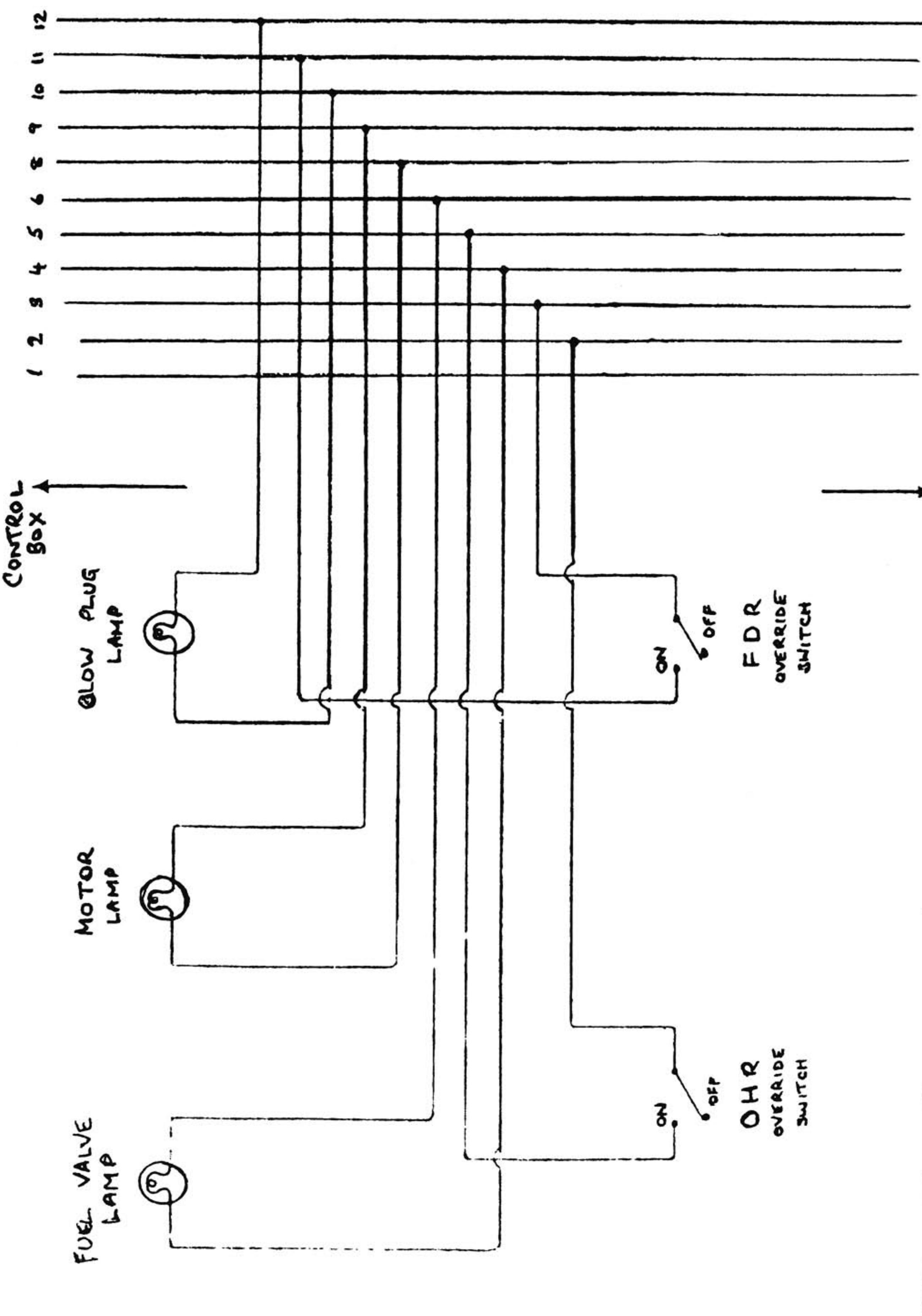
When TR2 switches on MR is energised. (Circuit: C - HVS - H5 - TR2 - C3 - wire 41).

Stage 4.

When MR energises MR1 closes and the motor starts running. (Circuit: C - MF - MR1 - M - H8 - A).

The interlock MR closes and shorts out the saloon thermostat allowing SR to remain energised as the temperature rises.

The second stage of the timing circuit now comes into operation. After A1 has built up voltage to 6.2 volts and ZD3 breaks down, the voltage continues to increase up to 12 volts when ZD2 breaks down. This will take a total time of 4 minutes and will only occur if combustion and flame detection have not taken place. If combustion does not take place then ZD2 will break down at 12 volts and put a positive voltage onto the base of TR3, switching it on. When TR3 is on the base voltage of TR4 is reduced to zero and it switches off FR and brings up the failure light. SR de-energises and switches off the glow plug, FVR, and MR. (The closing of SR2 interlock shorts out capacitor C3 and reduces the standing voltage on A1 to approximately 5 volts. This switches off ZD2 and ZD3 and thus TR1 and TR2 switch off. When TR2 switches off MR de-energises and the motor stops).



TEST BOX SCHEMATIC

Stage 5.

If the flame detection relay operates the positive feed to run the motor is supplied through F.D.R. interlocks. (Circuit: C - MF - H11 - FDR - H9 - M - A).

The feed to SR is cut off, thus de-energising the start relay. When SRL opens the glow plug is switched off. When SR2 closes it dissipates the charge on C3 and reduces the standing voltage at R8 to 5 volts. The positive feed to the base of TR1 is shut off by ZD3 and TR1 switches off. When TR1 stops conducting TR2 is switched off thus de-energising MR.

The FV and FVR remain energised through the saloon thermostat. (Circuit: C - MF - FVR - FVR1 - DZ - ATT - FR - C3 - Wire 41).

3. Heater Test Unit.

3.1 Foreward.

The test unit is designed to prove whether the heater or the relay panel is at fault.

3.2 Use of Test Unit.

The unit should be plugged into the relay panel (heater connection) and the heater connection plugged into the test box.

(a) Start the heater from the local control panel.

(b) Firstly the glow plug light and fuel valve light on the test unit should be illuminated and then after 45-60 seconds the motor light should illuminate and the motor should run.

(c) The lights only prove that the glow plug and fuel valve have electrical feeds to them - a physical check that the glow plug is energised and that the fuel valve is open should be made if the heater runs but combustion does not take place.

(d) If the lamps do not light operate the OHR and FDR switches. Try starting the heater again. If the heater now operates correctly the fault lies with the heater. Individual operation of the fault switches OHR and FDR will prove which circuit is defective and a visual investigation of the heater electronic panel may show up the fault).

(e) If after OHR and FDR have been operated the heater is still dead, check all fuses and then change the relay panel.

D.M.U. A.C. & D.C. GENERATING EQUIPMENT

REQUIREMENT

To ensure correct fitting of:-

1) Alternator and rectifier/regulator units
2) Generator and regulator units

REASON

Incorrect fitting will cause failures and poor battery condition.

PERIODICITY

When replacing or checking alternators and rectifer/regulator units, and generator and regulator units.

METHOD

CHANGING OF CAV 460 REGULATORS AT DEPOTS (Figure 1)

These regulators are fitted to Power Cars with AC203 60 amp alternators. (See Appendix 'A' for detailed description).

On receipt of the regulator from Stores (B.R. Cat No. 15/11417), remove the steel backing cover and select the setting required by moving the flying lead to suit the vehicle battery (i.e. Lead Acid or NIFE). The middle position is reserved for Class 140 vehicles only. (See Figure 1).

Regulators modified to the latest standard have a yellow stripe painted beneath the 'CAV' plate, and the box housing the two regulators should be painted with a yellow rectangle on its cover. BOTH REGULATORS MUST BE TO THE LATEST STANDARD.

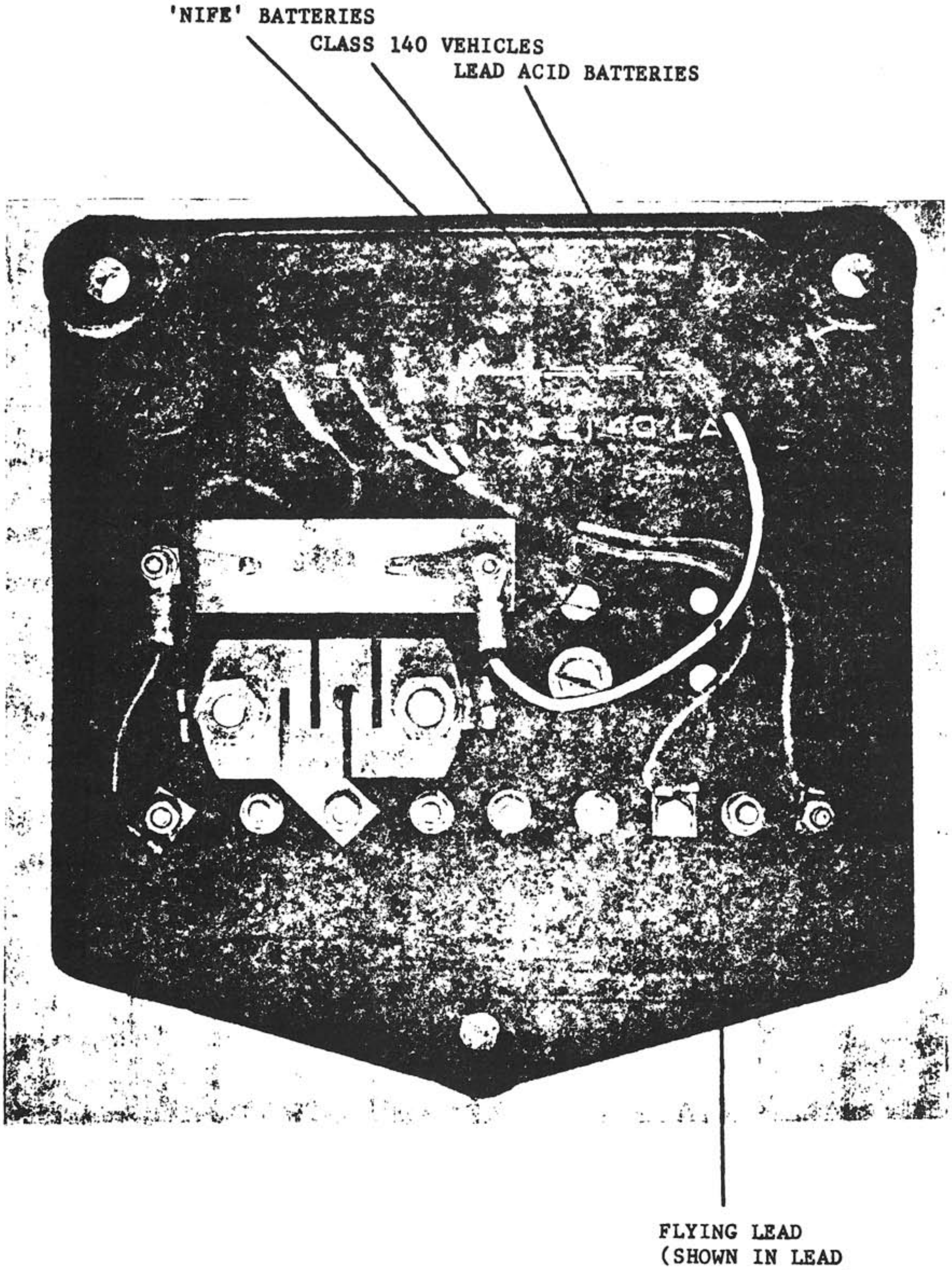


Figure 1 CAV 460C-24-3 regulator (Rear view)

CHANGING OF RUG RECTIFIER/REGULATOR UNITS AT DEPOTS

These regulators are fitted to Power Cars with AC8 50 or 75 amp alternators. (See Appendix 'B' for detailed description).

RUG units modified to the latest standard are designated by the suffix 'A' (i.e. RUG 11 becomes RUG 11A, etc.)

Modified units are identified by the removal of the protection unit (including the test button and indicator lamp).

During modification, terminals 1 & 2 (between B+ and B- in the D.C. connection block) have been rewired to allow for toilet water heating to be installed on certain Power Cars at Works overhaul. It is therefore not always possible to interchange unmodified and modified RUG units.

The following connections are correct:-

A Refurbished Class 101 DMC (L) vehicles with toilet water heating

These vehicles are identified by a toilet water heater control panel mounted next to the RUG unit.

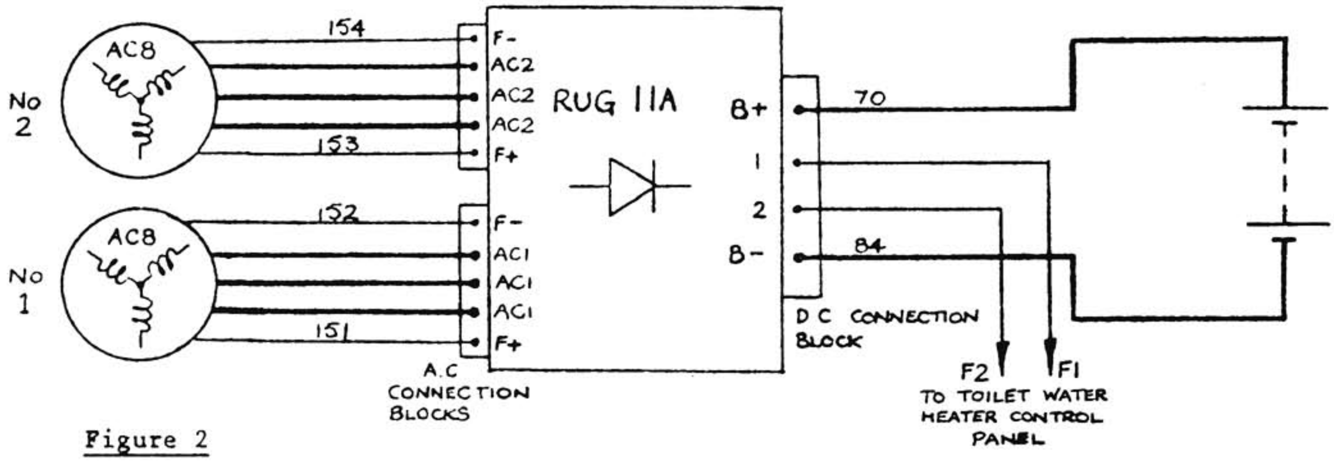


Figure 2

NOTE - ONLY RUG 11A UNITS MUST BE FITTED

Terminals 1 and 2 to be connected up.

(A full description of toilet water heating is in W.R. Standing Order 2/H/104).

B **All other RUG - fitted Power Cars**

Modified and un-modified RUG units are interchangeable on these vehicles providing the following connections are made.

Either

a) For an unmodified unit

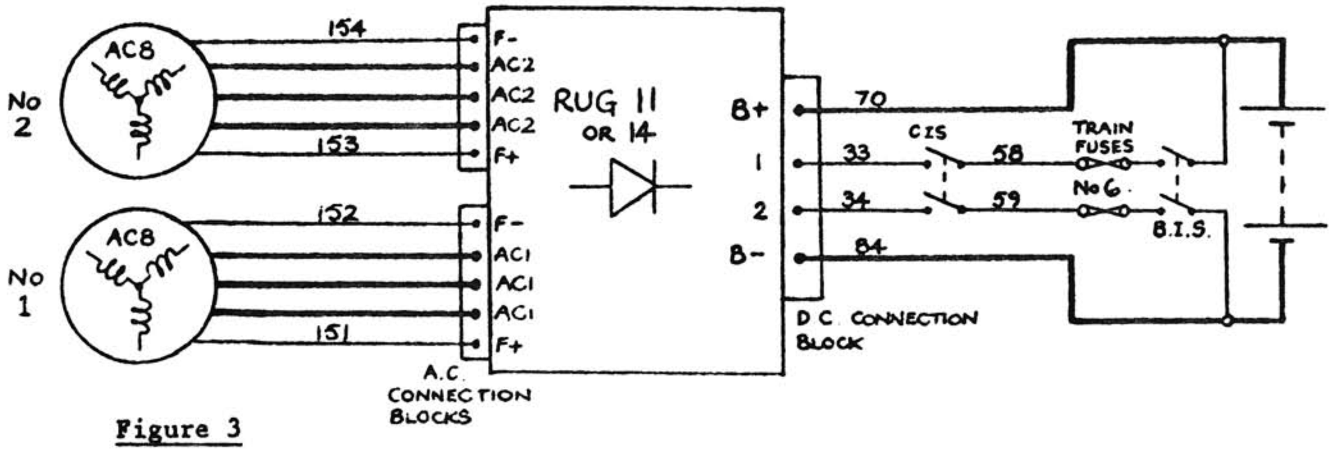


Figure 3

Cables 33 and 34 to be connected up to terminals 1 and 2.

or

b) For a modified unit

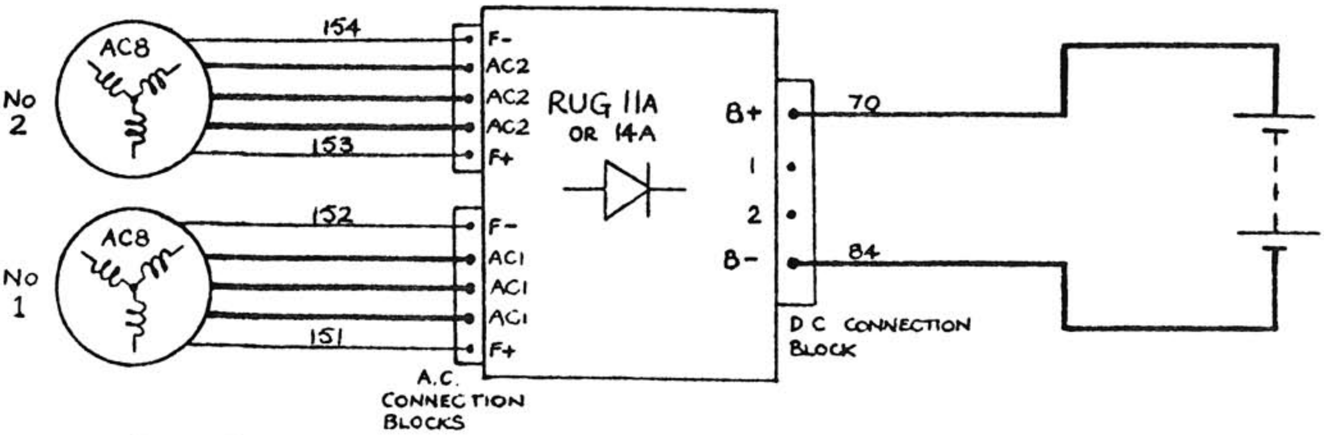


Figure 4

Cables 33 and 34 to be left disconnected and taped up.

FAILURE TO DO THIS WILL DAMAGE THE ALTERNATOR FIELD DIODES AND CABLES

DEPOT MAINTENANCE

Alternator-fitted Vehicles

If current is unobtainable following an alternator or regulator change:

1. Check that the relevant fast fuse is intact.

2. If the fuse is blown, check the polarity of the connections before renewing the fuse.

3. Check the rotor field of both alternators by disconnecting the rotor field and measuring its resistance. (Rotate alternator through one revolution as the field is measured).

   Field resistance should be between:

   16-20 Ohms AC8 alternator
   10-15 Ohms AC203 alternator

4. If the fuse is intact, the alternator field must be externally energised by connecting a resistor of approximately 200 Ohms, 6 Watt capacity for a few seconds, with the engines running, between terminals

   B+ and F+ for the affected AC8 alternator
   B+ and F+A for the affected AC203 alternator

Generator-fitted vehicles

If current is unobtainable following a generator or regulator change.

1. Check the relevant fuses are intact (i.e. in the regulator panel, generator coupling box and battery box).

2. If fuses are blown, check polarity of connections and renew fuses.

3. To re-magnetise or to correct a reversed field, remove one of the main generator fuses in the coupling box. Connect a resistor of approximately 200 Ohms 6 Watt capacity for a few seconds between terminals B+ and F+ in the regulator panel.

   Replace main generator fuse.

AC203 ALTERNATORS AND CAV 460C REGULATORS

The latest CAV Alternator type AC203 and associated regulator are being fitted on certain vehicles formerly equipped with CAV AC8 alternators and RUG regulator units. This conversion is being carried out in Main Works on selected Power Cars and is detailed in Engineering Instruction MD199 issued to B.R.E.L.

Additionally, certain vehicles originally equipped with Stones D.C. generators are being fitted with AC203 Alternators as part of the D.M.U. refurbishing programme. Engineering Instruction MD305 has been issued to B.R.E.L. to cover the necessary alterations.

The system consists of:-

2 CAV AC203 60 Amp Alternators (BR Cat No. 15/11118)
2 CAV regulators, type 460C-24-3 (BR Cat No. 15/11417)
2 Fast fuses

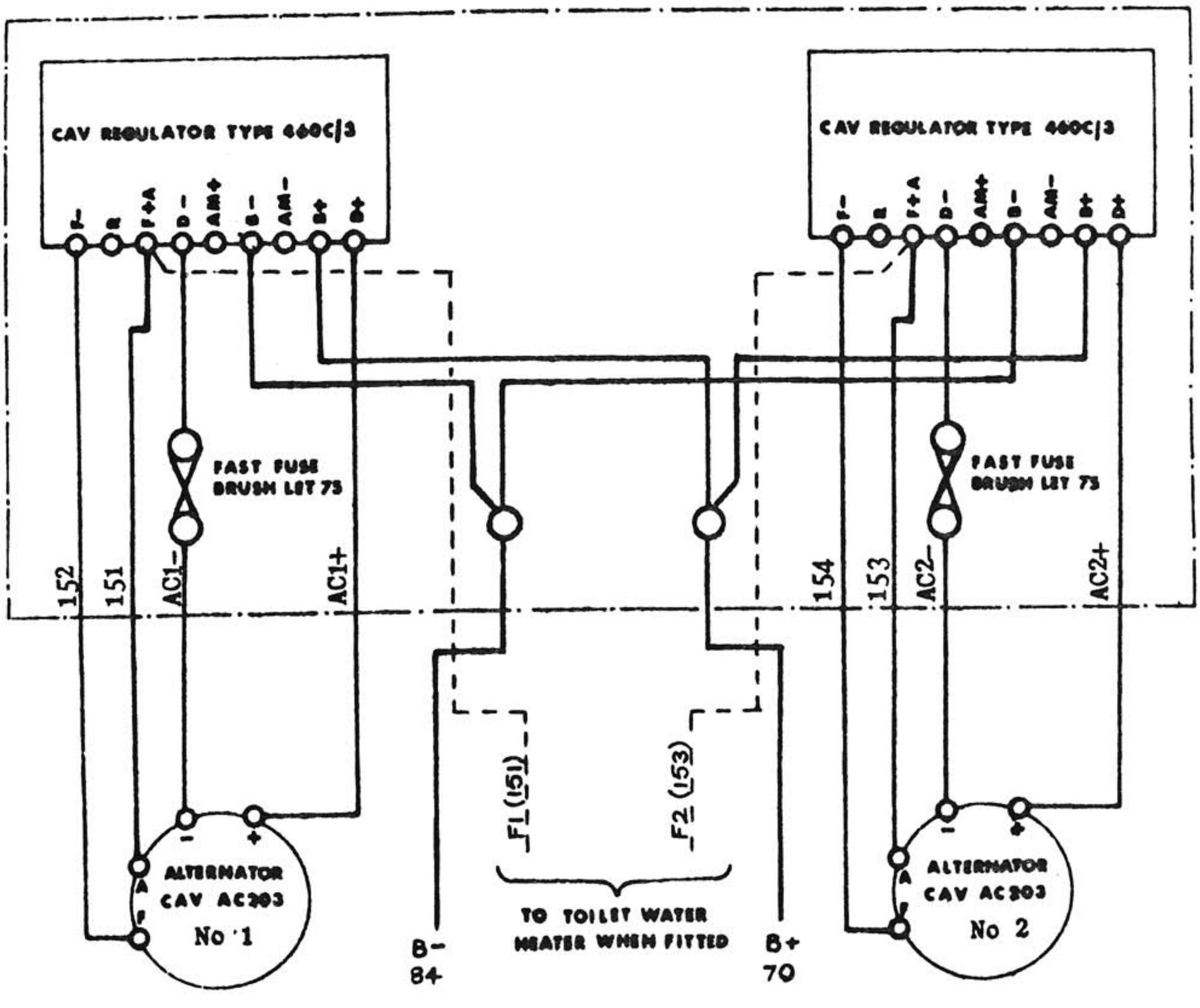


Figure 5 CAV AC203 ALTERNATOR SYSTEM

The AC203 is a self-excited machine which differs from the AC8 alternator in that the rectifying diodes are built into the machine. The output is therefore D.C. which is fed to the regulator.

The CAV 460C regulator is a solid-state unit sealed within an aluminium case. On Power Cars previously fitted with AC8 alternators, the regulators (and fast fuses) are housed in the same location as the displaced RUG unit. On Power Cars originally equipped with generators, the regulators are mounted in the box which contained the Tonum regulator panel.

To prevent the alternator diodes being destroyed by reverse polarity connection of the vehicle battery, a 'fast' fuse is fitted in the negative line from each alternator.

The regulator is set for a maximum voltage of

29.5 Volts - Lead Acid batteries
31.5 Volts - NIFE batteries

AC8 ALTERNATORS AND RUG RECTIFIER/REGULATORS

The CAV AC8 Alternator (both 50 Amp - BR Cat No. 15/58501, and 75 Amp - BR Cat No. 14/94221) and their associated RUG units are now obsolete. They will be gradually phased out when more than mimimum repair is required at Works.

RUG units considered repairable are being modified at Works to help reduce maintenance and improve battery charging at engine idling.

The modification consists of fitting a new diode assembly making the alternator self-excited (similar to the AC203). This eliminates the alternator field relay (energised via train wires 33 and 34 and the drivers key switch - figure 3). Battery charging can then take place with the engines idling without the need for the drivers key to be 'ON'.

Additionally, the main rectifying diodes (Germanium type) are being replaced by the more reliable Silicon type with the removal of the two protection relays, test button and indicator lamp.

The modification is covered in Engineering Instruction MD321 issued to B.R.E.L. All modified units are designated by the suffix 'A' as follows:-

	TYPE	BR Cat No.	Battery Type	Voltage Setting
Original Modified	RUG 11 RUG 11A	14/94904 15/11281	Lead Acid	29.5V
Original Modified	RUG 14 RUG 14A	14/98412 15/11285	Lead Acid	29.5V
Original Modified	RUG 15 RUG 15A	14/94812 15/11286	NIFE	31.5V

Stones Tonum Regulator Panels

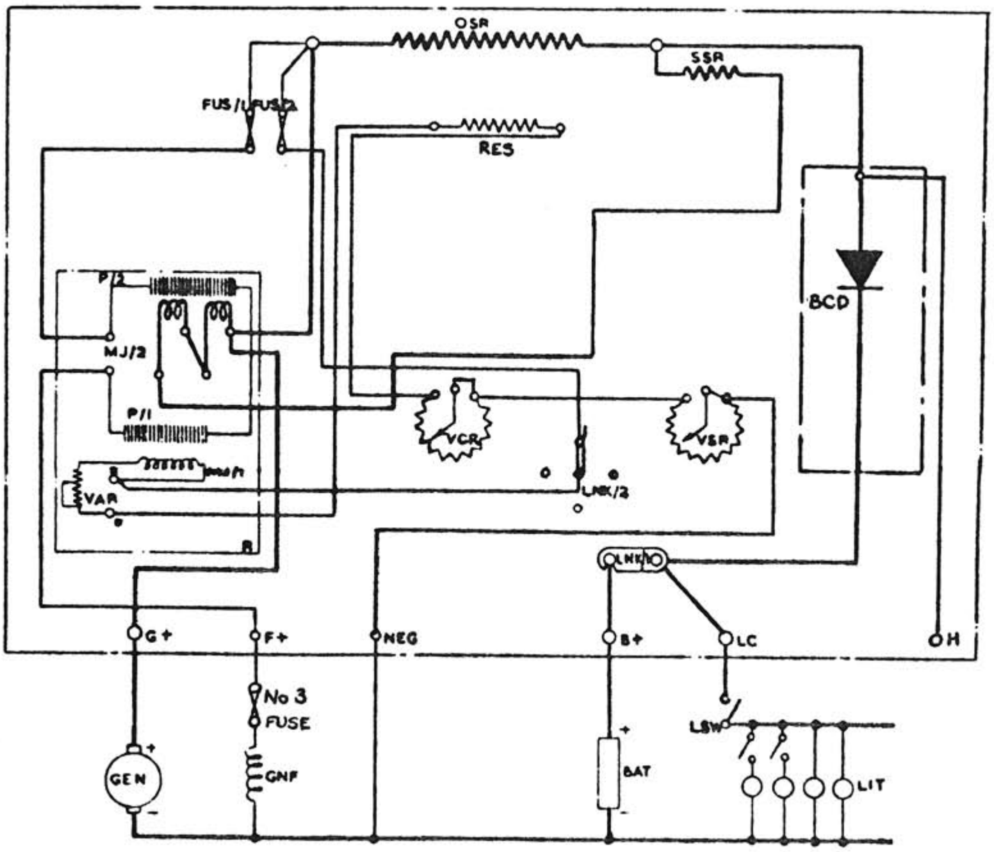
When the above regulators are overhauled in B.R.E.L. the battery charge contactor (CTR) and the associated cut-in relay (CIR) and regulator relay (REL) are being replaced by a battery charge diode (BCD). This alteration is detailed in Engineering Instruction MD 328 issued to B.R.E.L.

The adjustable settings for a modified regulator (BCD fitted - see figure 6) are:-

VSR 30.5 Volts (Lead Acid Batteries)
32.5 Volts (NIFE Batteries)

VDR LNK/2 position 1 permanently

Terminals LT (between B+ and NEG) and LR (between LC and H) are now removed.



BAT	BATTERY
BCD	BATTERY CHARGE DIODE
FUS/1	FIELD FUSE
FUS/2	VOLTAGE DIVIDING FUSE
GEN	GENERATOR
GNF	GENERATOR FIELD
LIT	LIGHTS
LNK/1	BATTERY ISOLATING LINK
LNK/2	VOLTAGE DIVIDING LINK
MJ/1	REG. EXCITATION COIL (VOLTAGE SIDE)
MJ/2	REG. EXCITATION COIL (CURRENT SIDE)
OSR	OUTPUT SELECTING RESISTANCE
P/1	CARBON PILE OF REG. (VOLTAGE)
P/2	CARBON PILE OF REG. (CURRENT)
R	LILIPUT DUAL REGULATOR
RES	FIXED RESISTANCE
SSR	SERIES SWAMP RESISTANCE
VAR	VOLTAGE ADJUSTING RESISTANCE
VCR	VOLTAGE CALIBRATING RESISTANCE
VSR	VOLTAGE SELECTING RESISTANCE

Figure 6 modified Tonum Regulator Panel (BCD fitted)

All currently overhauled panels are supplied as above.

Unmodified Regulators (Battery Charge Contactor fitted)

The settings for an unmodified regulator (see figure 7) are:-

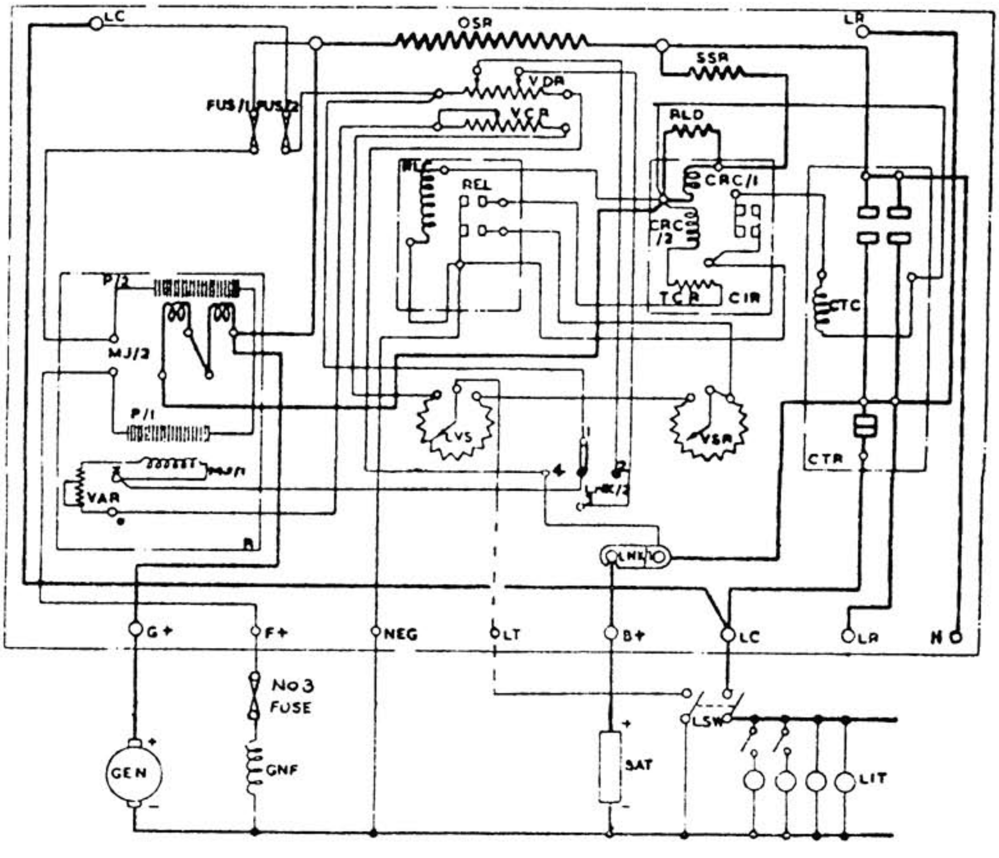
VSR 30.5V CLASS 116 VEHICLES ONLY

29.5V Lead Acid Batteries) All other generator
31.5V NIFE Batteries) fitted vehicles

VDR LNK/2 position 1 permanently

LVS 27V, Cut-in Relay (CIR) 28V - Lead Acid
LVS 28V, Cut-in Relay (CIR) 29 V or MAX - NIFE

The LT terminal to be left disconnected and the wire taped back.



BAT	BATTERY
CIR	CUT-IN RELAY
CRC	CUT-IN RELAY COIL
CTC	CONTACTOR COIL
CTR	CONTACTOR
FUS/1	FIELD FUSE
FUS/2	VOLTAGE DIVIDING FUSE
GEN	GENERATOR
GNF	GENERATOR FIELD
LIT	LIGHTS
LNK/1	BATTERY ISOLATING LINK
LNK/2	VOLTAGE DIVIDING LINK
LVS	LAMP VOLTAGE SELECTOR
MJ/1	REG. EXCITATION COIL (VOLTAGE SIDE)
MJ/2	REG. EXCITATION COIL (CURRENT SIDE)
OSR	OUTPUT SELECTING RESISTANCE
P/1	CARBON PILE OF REG. (VOLTAGE)
P/2	CARBON PILE OF REG. (CURRENT)
R	LILIPUT DUAL REGULATOR
REL	REGULATOR RELAY
RLC	REGULATOR RELAY COIL
RLD	RELAY DIVERTER
SSR	SERIES SWAMP RESISTANCE
TCR	TEMPERATURE COMPENSATING RES.
VAR	VOLTAGE ADJUSTING RESISTANCE
VCR	VOLTAGE CALIBRATING RESISTANCE
VDR	VOLTAGE DIVIDING RESISTANCE
VSR	VOLTAGE SELECTING RESISTANCE

Figure 7 Un-modified Tonum Regulator Panel (Contactor fitted)

APPENDIX 'D'

SUMMARY OF GENERATING EQUIPMENT FITTED TO W.R. DMU's (as at June 1983)

Catalogue Numbers in Brackets

CLASS	SET NUMBERS	POWER CAR	TRAILER CAR
101 Metro-Cammell	800-805, 810-812 820-823	AC8 50 Amp Alternator (15/58501) RUG 11A Regulator (15/11281)	Stones Generator TD 1255 (52/18831) Tonum Regulator T3400H (52/26271)
	813, 814	AC203 60 Amp Alternator (15/11118) CAV 460C Regulator (15/11417)	
116 Derby Suburban	300-307 312-320 330-335	Stones Generator TD 1269(52/18837) Tonum Regulator T3400H (52/26271)	As above
117 Pressed Steel Suburban	404,407,410,416 424,430 (51410) 432,436,438,439	AC8 50 Amp Alternator (15/58501) RUG 11A Regulator (15/11281)	As above
	400-403,405, 406, 408,409,411-415, 417-423,425-429 430(51368),431 433-5,437,450	AC203 60 Amp Alternator (15/11118) CAV 460C Regulator (15/11417)	
118 BRCW Suburban	460-473 & 480	AC8 50 Amp Alternator (15/58501) RUG 11A Regulator (15/11281)	As above
119 Gloucester Cross Country	571-596	AC203 60 Amp Alternator (15/11118) CAV 460C Regulator (15/11417)	As above (except 59282 (571 Set) which is a Class 120 trailer and fitted as below).
120 Swindon Cross-Country (Mark 1)	615,616	AC203 60 Amp Alternator (15/11118) CAV 460C Regulator (15/11417)	Stones Generator TD 1364 (52/426) Tonum Regulator T3473 (52/26272)

CLASS	SET NUMBERS	POWER CAR	TRAILER CAR
121 & 122 Pressed Steel (Single Power Cars) & Route Learning Cars	101-103 120-134	AC8 50 Amp Alternator (15/58501) RUG 11A Regulator (15/11281)	
128 Gloucester Parcels Cars	55991,55992	AC8 75 Amp Alternator (14/94221) RUG 14A Regulator (15/11285)	
149 Pressed Steel (Drive End Trailers)	280,281, 283-287, 289		Stones Generator TD 1255 (52/18831) Tonum Regulator T3 400H (52/26271)

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