B.R. 33057/16
D.T.S. 4

BRITISH RAILWAYS - WESTERN REGION

TEMPERATURE CONTROL EQUIPMENT AND LOAD REGULATOR FOR D.1000 CLASS DIESEL HYDRAULIC LOCOMOTIVES

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TEMPERATURE CONTROL EQUIPMENT - D.1000 CLASS D.H.

INTRODUCTION

This equipment is manufactured by Hawker Siddeley Dynamics Ltd. and provides excess temperature protection for:-

(a) Engine Cooling water system

(b) Transmission Oil system

Two sets of equipment are fitted per locomotive, one for each power unit, mounted in the control cubicles under the Drivers Desks.

In both cases the equipment is mounted, in a box approximately 6" x 6" x 4" on top of the termination box, with external connections made by flying leads.

Temperature sensitive probes are installed in the appropriate cooling water and transmission oil temperature circuit.

A reduction in diameter at the end will identify the transmission probe.

The equipment incorporates high temperature trip circuits which operate protection and warning circuits within the locomotive and are set:-

High Cooling water temperature = 93°C

High transmission oil temperature = 127°C

CIRCUIT DESCRIPTION

POWER SUPPLY

In each case power for the relays and modules, available at terminal 9, is obtained from the 110v D.C. auxiliary source.

The 110v line is dropped to 24v through resistors R1, R2 and Zener diode MR 1, to provide power for energising the two relays (RLA and RLB), and is again dropped to 9.1 volts by resistor R3 and Zener diode MR 2 to provide power for the Voltage Sensitive Modules and Thermistor circuits.

Separate diagrams Figs. I, II, III and IV show circuit detail and interconnections for both units.

THERMISTOR CIRCUITS

Thermistor probes CWRT and TORT, for cooling water and transmission oil respectively, are connected between 9.1 volts and 0v lines and each circuit operates in a similar manner. The following description may be read in conjunction with diagram Fig. A which may also be applied to Transmission Oil Temperature Control.

Thermistor resistance is inversely proportional to temperature i.e. as temperature rises resistance decreases, and hence current increases.

At normal temperatures Thermistor resistance will be high and current low, therefore the potential applied to terminal 2 of the voltage sensitive module is low. An increase in temperature resulting in an increase in current will cause this potential at terminal 2 to increase and for test purposes this can be simulated by operation of the CWRT or TORT Test Pushbuttons which will provide the required increase in potential due to the insertion of resistor R6. The rise in potential will be sufficient, at trip temperatures or when the test button is depressed, to operate the associated voltage sensitive module thus causing the related locomotive circuits to revert to a fault condition. Should this not occur when the test button is operated an open-circuit at the probe is indicated since, under this condition, insufficient current would flow via R4, R5 and R6 to raise the potential to trip level.

Should the probe become short-circuited however, high temperature is simulated and the locomotive circuit automatically reverts to fault conditions.

VOLTAGE SENSITIVE SWITCH

This section of the circuit description is based on the cooling water control device but that for transmission oil control is similar.

Transistors VT 1 and VT 3 form a balance detector connected between the arms of a bridge circuit formed by:-

(a) thermistor load resistor

(b) thermistor

(c) resistor R6 and upper part of RV 1

(d) lower part of RV 1 and resistors R 7 and R 8

With this bridge circuit arrangement variation of supply voltage will have only a very limited effect on the balance point.

NORMAL CONDITION

When the input voltage at terminal 2 is below that of the reference voltage (at the wiper of RV 1) transistors VT 1 and VT 2 will be OFF, while VT 3 and VT 4 will be ON. In this condition current will flow via diode MR 3 and resistor R 9, hence raising the reference voltage. This positive feedback drives the circuit into a saturated state and the amount of feedback sets the hysteresis of the circuit.

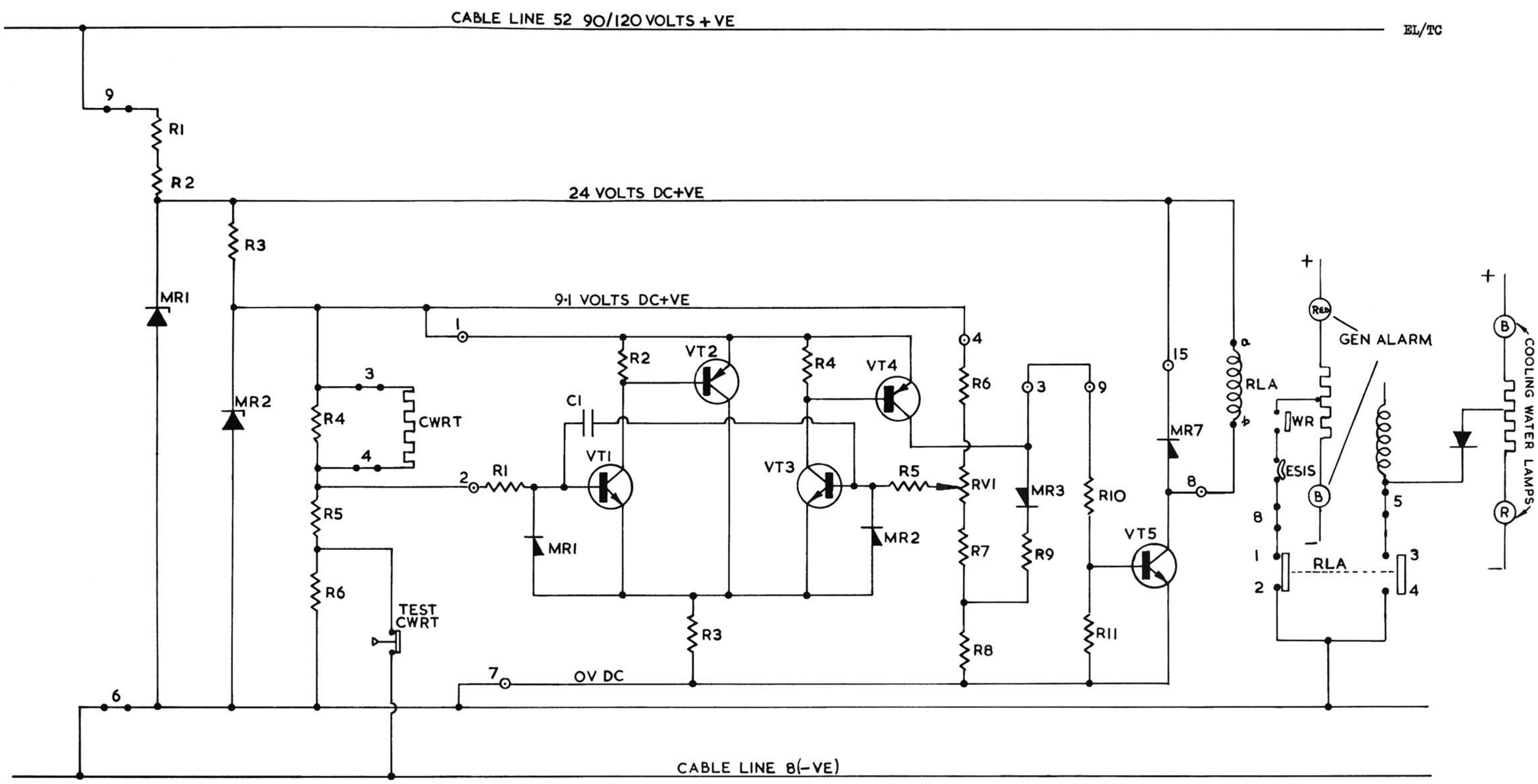
Current flowing via VT 4 and resistors R10 and R11 provides sufficient potential at transistor VT 5 base to allow it to conduct and current is drawn from the 24-volt line to energise relay RLA, the contacts of which take up a normal temperature.

Switch off transients in the relay coil are absorbed by diode MR 7.

FAULT CONDITION

Temperature increase above the pre-set value results in a voltage rise in excess of the reference voltage (at the wiper of RV 1) at terminal 2 and this results in VT 1 conducting followed by VT 2. In turn VT 3 and VT 4 turn OFF and conduction via diode MR 3 and resistor R 9 ceases with a resultant fall in the reference voltage and potential at the base of VT 3.

Similarly, the potential at the base of VT 5 falls and this transistor switches OFF causing RLA to de-energise and its contacts then revert to a temperature fault condition.



COOLING WATER TEMPERATURE CONTROL

FIG 'A'

FAULT LOCATION PROCEDURE FOR TEMPERATURE CONTROL

EQUIPMENT TYPE B00E600031A

These instructions give simple tests for locating a fault in a unit when installed in the D.1000 Class Diesel Hydraulic Locomotive.

An Avometer type 8 or similar and a variable resistance box is required. Resistance test box.

1. Voltage Checks

(a) Check with meter that a supply of +90 to +120 volts D.C. appears on terminal 9 with respect to terminal 6 (-tive).

(b) Check that +20 to +28 volts appears on pin 15 of switch boards with respect to pin 7 (-tive).

(c) Check that +8 to +10.5 volts appears on pins 1 and 4 of switch boards with respect to pin 7 (-tive).

2. Checking Cooling Water Channel

(a) If cooling water temperature is at or below normal running temperature zero volts should appear on terminal 5 with respect to terminal 6 (-tive). Depression of C.W.R.T. test button in the cab, or disconnection of lead to terminal 11, should result in C.W.R.T. over temperature warning in cab and supply voltage appearing on terminal 5. Again the same result should be achieved by short circuiting the thermistor leads on terminals 3 and 4.

(b) If above requirements are not met, connect AVO +tive lead to pin 8 of voltage switch board, when zero volts should appear under normal conditions and 20 to 30 volts when tests as listed in 2(a) are repeated. This test will indicate whether the circuit board or relay is faulty. If board appears faulty check that thermistor circuit has the right voltages and is connected to pin 2 of switch board.

(c) For more accurate checking of the circuit disconnect the thermistor leads to terminals 3 and 4 and connect the Cooling Water resistance test box between terminals 3 and 4. Set resistance to a value of 2000 ohms to simulate low temperature then switch to 380 ohms when circuit should switch to failure condition. Switch in resistance value to 425 ohms and open switch for 380 ohms position, circuit should reset to normal. The resistance values given include tolerances hence particular circuit may operate between the two figures given. If unit does not operate between these values, and unable to adjust by trimmer, unit to be changed.

<u>NOTE</u>: Use meter indication to show relay operation as locomotive circuits are locked once they are tripped.

3. <u>Checking of Transmission Oil Channel</u>

The procedure is identical to that of the cooling water circuit with the following differences:-

(a) At failure supply voltage of 90 - 120 volts appears on terminal 7 with respect to terminal 6 (-tive).

(b) T.O.R.T. test button is connected to terminal 10.

(c) T.O. thermistor leads are connected to terminals 1 and 2.

(d) For testing with Transmission resistance test box, the circuit should switch when resistance value is 220 ohms and reset at 250 ohms.

LOAD REGULATOR - TYPE 100E 6000 45A

NOTE: These notes are supplementary to the description of this unit contained in "Magnetic Amplifiers", B.R. 33057/21, Supplement 'A'.

1. Introduction

The load regulator is a solid state amplifier used in place of the "Torostat" potentiometer on the Brush Type 4 locomotive. It receives a signal from the vane motor in the engine governor and converts this to a P.W.M. (Pulse Width Modulated) output to drive the exciter field. It can also be used to drive a high power unit where no exciter is used.

The output can be cut back by signals indicating wheelslip or generator overtemperature or by the drivers tractive effort control.

2. Description of block diagram (For diagrams see "Magnetic Amplifiers")

(a) Oscillator and Demodulator

Load signals from the engine governor are obtained from a transducer which is a linear A.C. pick-off driven by a screw thread to allow a 300° rotary movement to be used. The transducer primary is fed from a multivibrator oscillator at about 900 c/s (terminal 9 and 10). The secondary consists of two windings opposing each other so that the slug (a steel shaft) produces no net output from the secondary when symmetrically placed in the two windings. The slug position varies about ⅛" corresponding to a rotary movement from 20° (0° is zero output position) to 320°. The output from the transducer (terminal 12) is peak rectified and amplified in the demodulator circuit giving an output varying from 3.2 to 8v. RV 1 sets the maximum output to give the correct generator short circuit current.

(b) Pulse Width Modulator

The pulse width modulator consists of a D.C. amplifier and a Schmitt trigger circuit similar to that used in the low speed controller, but without the long term integrator. It provides a pulse width modulated output in which the frequency and the mark space ratio are varied. The frequency reaches a maximum value of about 160 c/s at half power dropping to zero at full power (100%). The latter will only be reached if RV 1 is set to maximum.

(c) Power Switch

The power switch incorporates two thyristors in a D.C. commutation circuit similar to the low speed controller. The main thyristor controls the current drawn through the exciter (terminal 7). Maximum current 2.2A. When the main thyristor is switched off, current continues to flow through the exciter field winding by inductive action, but now passes via terminal 6 through a free wheeling diode in the power switch back to +110v. The power switch also includes two diodes, one in series with SR6 (diode is between terminals 19 and 20), and the other between terminals 20 and 11 (free wheeling diode) to permit SR6 to be used with a P.W.M. signal. This facility is only used with the Brush field divert system.

(d) Filter and Limiter

This circuit takes the P.W.M. signal in at terminal 13, attenuates this and feeds it to the P.W.M. circuit to provide the necessary feedback path. It also inverts and filters the P.W.M. signal to provide a D.C. voltage proportional to the mean voltage across the exciter field.

Three input signals can be fed in to reduce power. Terminal 1 is intended for feeding in a signal from a new wheelslip detector which senses excess acceleration by measuring rate of change of traction motor current, or it can be used with the existing wheelslip system to provide a faster response than that given by the vane motor in the engine governor. Terminal 5 is not used at present, but is intended for a thermistor which senses generator overtemperature. Terminal 23 is used for a tractive effort control in which the resistance of an MDR (magnetic dependent resistor) is compared with a potentiometer set by the driver. The MDR is in a slot in an iron core placed round one of the main generator cables. The transducer senses generator current by giving an increase in resistance with generator current. When the MDR exceeds the potentiometer resistance, power is cut back, reducing the generator current and the MDR resistance until a balance is achieved. 110v is applied to terminal 22 to inhibit the tractive effort control when the first stage of divert comes in.

(e) Voltage Switches

The safety switch compares the signal fed into the P.W.M. with the D.C. output from the filter and limiter. If the latter, which is proportional to output load volts, exceeds the former by more than about 15%, the switch operates a relay. The negative supply to the output transistor on this board is completed via terminal 14. This allows the low speed controller safety circuit to operate PCR with a high power unit without providing an extra high current relay.

The maximum power switch compares the P.W.M. input signal with a pre-set voltage and operates a relay when the P.W.M. signal exceeds this voltage. The pre-set voltage is set by RV 2 to make the relay operate at 95% of the maximum power required. This circuit is only used with the Brush field divert system.

(f) Reed Relays

There are two mercury wetted reed relays on this board together with their respective suppression components. One relay operates SR 5, part of the Brush field divert system and the other one the power control relay. Power is cut off if the safety circuit indicates a failure.

Mercury wetted reed relays must be operated within 30° of the vertical i.e. the back plate of the unit must be nearly vertical if the relays are being used.

3. High Power Unit (35A Power Switch)

This unit is used in the later electric train heating versions of the Brush type 4 to replace the alternator exciter. It contains a thyristor power switch capable of switching up to 35 amps at 134v. The output on terminal 4 follows that from the low power load regulator on the low speed controller. The mean load volts measured across the generator separate field, terminals 4 and 6 will be increased approximately in the ratio $\frac{134}{110}$ relative to the low power input on terminal 3. 134v is only applied to the high power unit when PCR closes. This supply also energises a relay in the high power unit to switch the safety circuit from the low power load regulator output to the high power output.

FAULT LOCATION GUIDE FOR STATIC LOAD REGULATOR

This instruction sheet gives simple tests for locating a faulty unit when installed in a locomotive. If requires a multi-range meter, preferably AVO 8, and a 1000 ohm potentiometer, preferably 5% wire wound.

If a high power unit (35A power switch) is installed, it will have a load of 560 ohms connected so that the load regulator can be checked without the engine running. With a 560 ohm load the volts between terminals 7 and 8 in tests 1, 4 and 7 at minimum power should be 25 - 32v. The resistor can be any value between 50 and 600 ohms provided it can handle up to 110v across it for the duration of the tests. Lower values will reduce the minimum power reading down to a minimum figure of 15v.

High Power Unit (35A Power Switch)

If test 5 indicates a fault in this unit, check the resistance between terminal 4 (main thyristor anode) and terminal 5 (0v). This should be more than 3K ohm with the locomotive wires disconnected (stop engine and open B.I.S. for this test).

Test	Symptom	Action	Meter Across	Correct meter reading	Remarks
1	Generator current less than 500A.	Connect terminals 11 & 12 together. Disconnect these after test.	Terminals 7 & 8 (+ve)	15-22v D.C.	Meter reading - do tests 3 & 5. Meter reads supply volts load regulator faulty. Meter reads less than 2v - do test 2.
2	" " "	Stop engine, open B.I.S. Remove wires to terminal 7. Replace wires after test.	Terminals 7 & 11.	More than 10K ohms.	If meter reading is less than 10K ohms, load regulator is faulty. If more than this, do test 3.
3	" " "		Terminals 7 & 13. Terminals 11 & 14.	Less than 1 ohm. " "	Safety circuit will trip, preventing P.C.R. picking up if the P.W.M. signal does not appear at 13. Check wiring. If a high power unit is used, terminals 2 & 3 on this unit should be joined by a relay. If readings are correct, do test 4 unless test 1 was correct.
4	" " "	Disconnect wires to terminals 1,5 & 23, close B.I.S. Start engine. Connect terminals 11 & 12. Disconnect after test.	Terminals 7 & 8 (+ve)	15-22v D.C.	If correct reading is not obtained, load regulator is faulty. If reading is correct, connect wires to terminals 1,5 & 23 in turn and then check the circuit which is faulty. When the tractive effort control is not used, there should be a 470 resistor between terminals 21 & 23.

Test	Symptom	Action	Meter Across	Correct meter reading	Remarks
5	Generator current less than 500A.	Connect terminals 17 & 18. Apply power.			If normal generator current is now obtained, load regulator safety circuit is faulty. If current increases rapidly and a high power unit is installed, the fault will be in the high power unit. Switch off power immediately.
6	Generator current 1400 - 2500A i.e. current does not increase beyond normal minimum power.	(a) Check F.D.unit (b) Check transducer circuit Engine must be running.	Terminals 9 & 11 Terminals 10 & 11 Terminals 11 & 12	7 - 9v D.C. 7 - 9v D.C. 0 - 0.5v A.C. (10v A.C. range Avo 8) Transducer at max.for 0.5v.	If these readings are not obtained disconnect wire to terminal 9 and check resistances of transducer primary and secondary. If these checks are satisfactory do test 7. Transducer should reach max. power position if power handle is put to full power.
7	Generator current 1400 - 2500A.	Replace links across terminals 2,3 & 4 with 1000 ohm potentiometer, wiper to terminal 4 connect terminals 11 & 12. Disconnect after test.	7 & 8 (+ve)	15-22v D.C. with potentiometer at min. Max. volts up to supply volts depending on setting of RV 1.	If the minimum volts reading is correct, but the volts cannot be increased by turning the 1000 ohm potentiometer, then the load regulator is faulty.