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Chapter 60

VOLTAGE CONTROL PANEL TYPE 50A

(E.E. TYPE A.E.7307 STYLE 2)

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LEADING PARTICULARS

Voltage control panel Type 50A	*Ref. No. 5UC/7601*
Bus-bar voltage	*28V d.c.*
Regulator voltage setting at 20°C	... 29·2 ± 0·05*V d.c.*

Regulation (over full environmental and load range)	$\pm$*0·28V d.c. with an additional 1V d.c. drop (with 400A load on main bus-bar)*
Ripple (maximum)	*2·24 p to p at bus-bars with battery connected*
Rating	... ... *Continuous*
Cooling	... ... *Natural air circulation*
Ambient Temperature Range (at all altitudes)	
Operational	... ... *−30°C to +45°C*
Storage	... ... *−40°C to +70°C*
Altitude range	... ... *0 to 25000 ft.*
Weight	... ... *6½ lb.*
Associate generator	*Type 527A (E.E. Type AE2505/3 Ref. No. 5UA/8330)*

Introduction

1. The voltage control panel Type 50A (E.E. Type AE7307 Style 2) controls the output of a d.c. generator Type 527A (E.E. Type AE2505 Style 3) which forms part of a multi-generator system.

DESCRIPTION

General

2. The unit employs printed circuit techniques, and the components are housed within a light alloy case assembly. Metal tubes positioned in each corner of the case locate the four fixing bolts, whilst perforated cut-outs in the sides of the case permit free circulation of cooling air, through the unit. The components are secured to the case by anchor plate nut assemblies and support plates. The cover has a cut-out which gives access to potentiometers, RV1 and RV3.

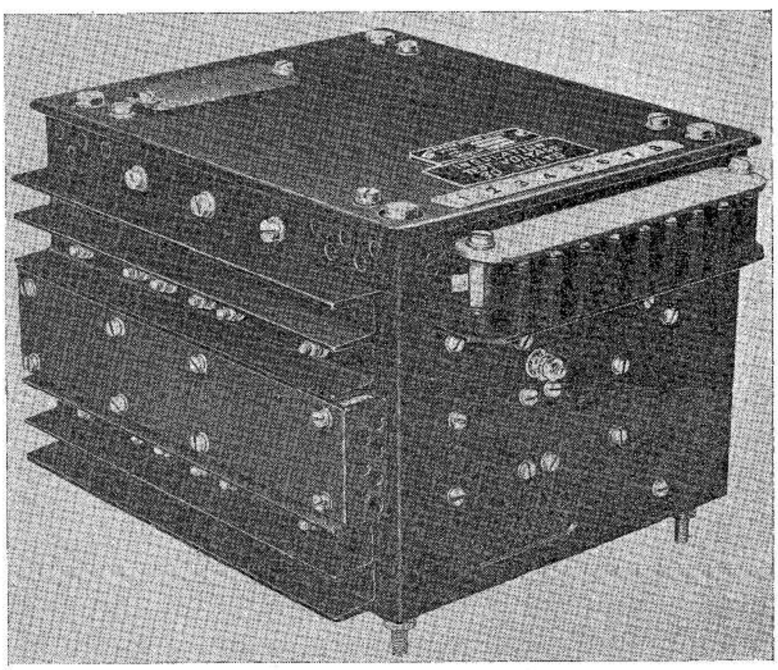

Fig. 1. Voltage control panel, Type 50A

3. Housed within the fabricated case are the capacitor and clamp assembly (C8), capacitor and block assembly (C13, C14, C15), transformer assembly (T3), diode assembly (ZD4, ZD5), diode assembly large (D11), choke assembly (L1, L2), potentiometer and bracket assembly (RV1, RV3), printed circuit board No. 1, terminal assembly, printed circuit board No. 2, silicon control rectifier (SCR1), silicon control rectifier (SCR2), silicon power rectifier (D8), silicon power rectifier (D9), resistors, (R15, R16, R17), and diode assembly (D10).

4. Attached to the outer side of the case is a heat sink through which the studs of the diodes protrude. The nuts and washers securing the diodes in place are enclosed by a cover which is secured to the heat sink. A bracket attached to the case supports the terminal block, which connects the unit in circuit to associated equipment. Earth connection to the unit is via a stud and nut assembly which is located in the case under the terminal block.

Power and silicon diode assemblies (SCR1, SCR2, D8, D9)

5. The power and silicon diodes are secured to mounting plates which have

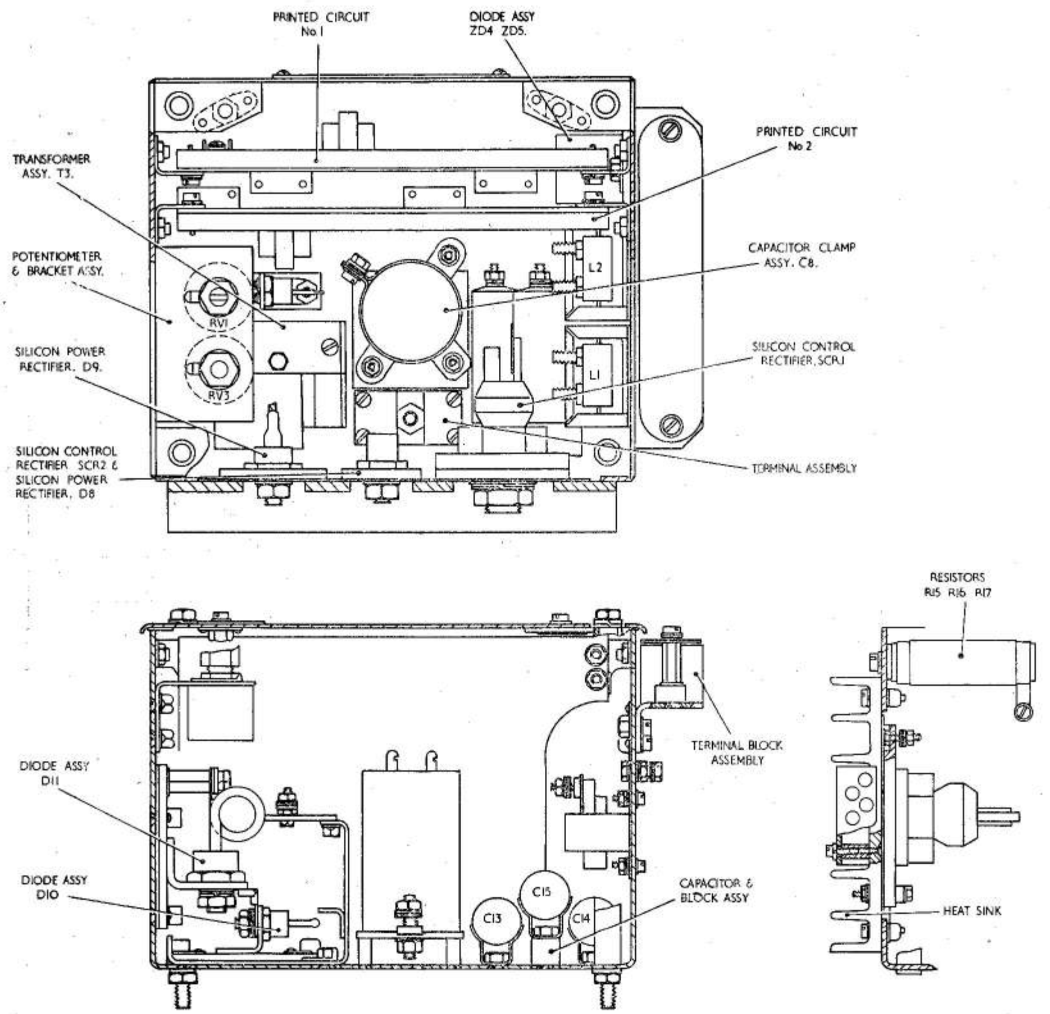

Fig. 2. Sectional plan and side view

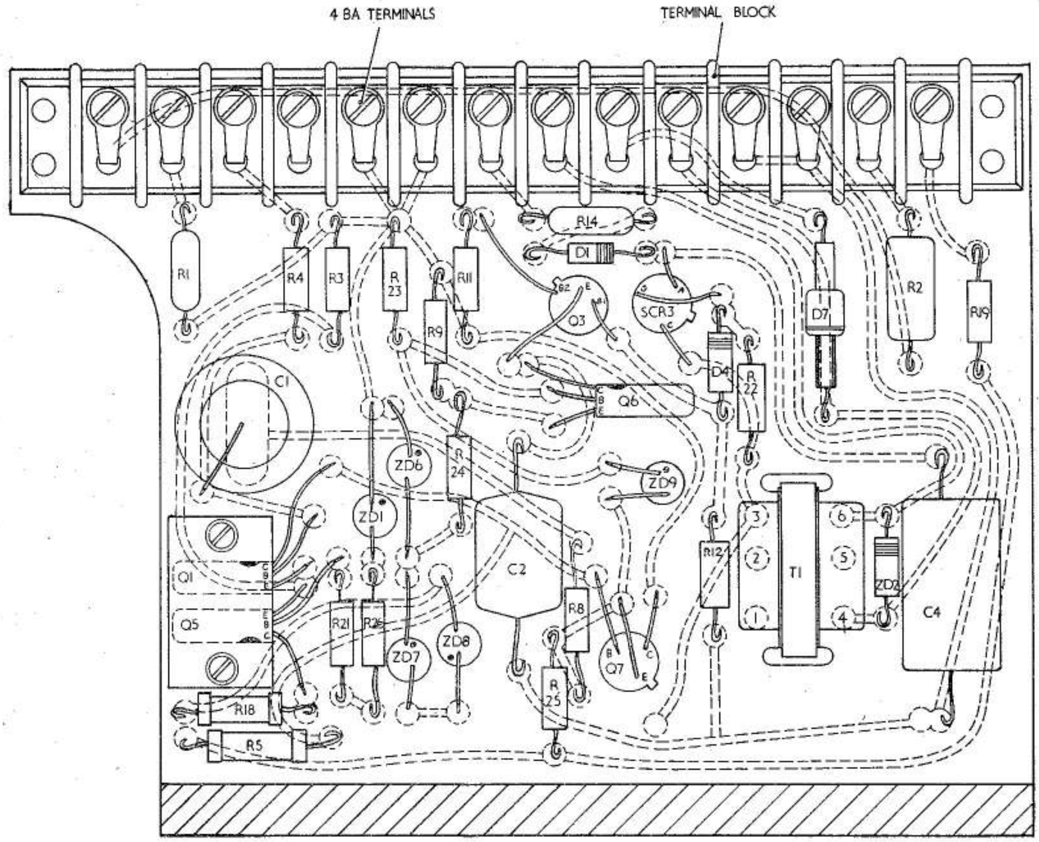

Fig. 3. Board assembly—printed circuit No. 1

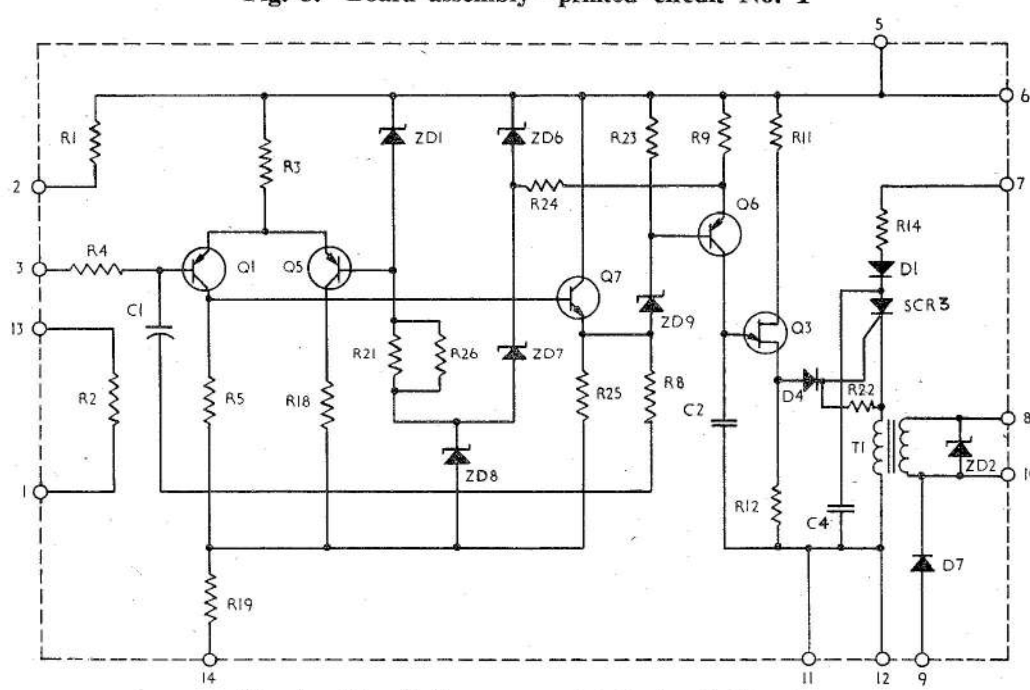

Fig. 4. Circuit diagram—printed circuit No. 1

leads attached to screw and nut assemblies anchored in each plate. The plates act as a positive feed to the diode during the operation of the unit. Each plate is attached to the heat sink and insulated from it by sheet glass-mica and insulated bushes.

Potentiometer and bracket assembly (RV1, RV3)

6. The potentiometers are locked on the brackets with nuts and tab washers; a control lock device positioned on the spindles of the potentiometers prevents variance of potentiometer setting.

Diode assemblies D10, D11, ZD4, ZD5

7. Brackets attached to insulated bases are used to mount the diode assemblies. Diode D11 is secured by its anode terminal to its bracket and the cathode lead is connected to a terminal assembly positioned on the insulated base. Diodes ZD4, ZD5, D10, are secured by their cathode terminals to the respective brackets, the anode terminals being connected to the various components.

Terminal assembly

8. An insulated plate supports a stud locked in place with a nut and washer. Leads from printed circuit board No. 1, silicon control rectifier No. 1, silicon control rectifier No. 2 and transformer T3 are attached to the stud. The assembly is secured to screwed pillars which are anchored to the case with c'sk. hd. screws.

Printed circuit boards No. 1 and No. 2

9. The printed circuit boards shown in fig. 3 and 5 have components which are connected in circuit by soldered joints. Attached to the upper half of the boards are terminal blocks which connect the boards to associated components. The lower half of the

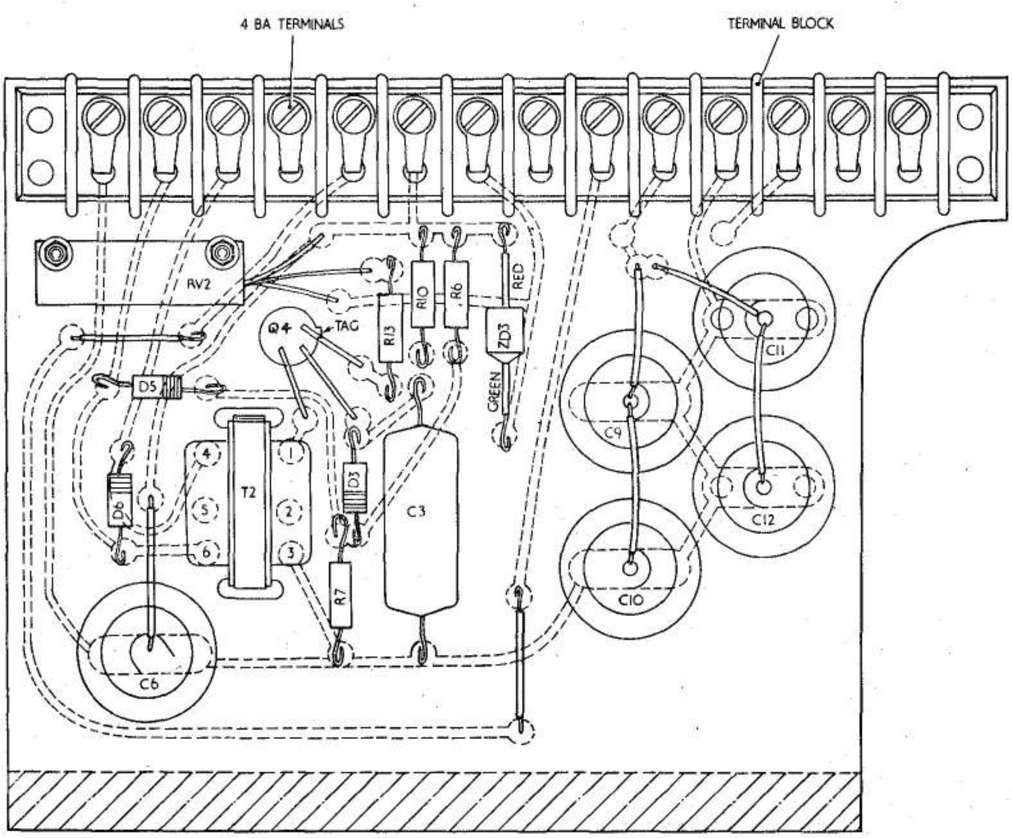

Fig. 5. Board assembly—printed circuit No. 2

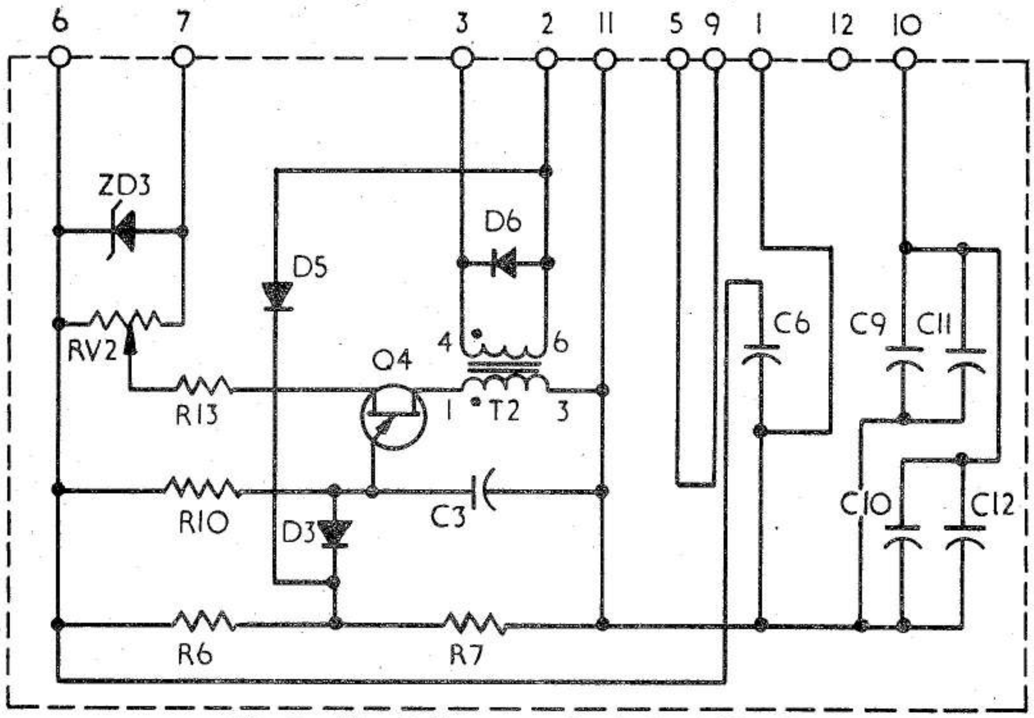

Fig. 6. Circuit diagram—printed circuit No. 2

boards have an area free from components which enable the boards to locate in bonding strips (attached to the case) on final assembly.

Terminal block assembly

10. The eight way terminal block is of moulded construction which is secured to the terminal block mounting bracket and case assembly by screwed pillars and c'sk. hd. screws. The transparent terminal block cover is secured to the terminal block assembly by screws locating in the screwed pillars.

OPERATION

Paragraphs 11 to 17 should be read in conjunction with fig. 7.

General

11. The regulator controls the output of a d.c. generator by the control of uni-directional current injection into the shunt field of the machine. The current pulses have a square wave form which have a frequency and width which vary in accordance with the excitation requirements of the generator. To enable initial build up of shunt field excitation, it is necessary to 'tickle' the field system of the generator from a battery supply. The injection of the battery voltage (24 volts) is necessary since the regulator represents a high impedance in series with the machine shunt field, thus preventing the build up of generator terminal voltage from armature residual voltage. Oscillation of the regulator commences when the battery voltage is applied to terminals 1 and 2 via terminals 7 and 4, D10, and the external circuit. Short circuiting by the armature is prevented by D11.

Sensing amplifier

12. The generator output voltage, fed to the regulator between terminals 1 and 8, is set to 29·2V by the potentiometers RV1 (coarse) and RV3 (fine). Capacitor C1 ensures that the sensing amplifier is insensitive to machine ripple voltage and the amplifier is fed from the 16·8V zener stabilized supply ZD6, ZD7, ZD8 and R19. Voltage variations between the set position of R4 and the generator feed line are compared with the voltage appearing across ZD1 (i.e. at the base of Q5) of the temperature stable reference circuit ZD1, R21, R26. Since the voltage appearing at the base of Q5 is fixed, sensed voltage between the base of Q1 and the generator feed line varies the current flow through Q1, depending on the polarity of the sensed voltage change. Consider a rise in the sensed voltage at the base of Q1. An increased current will flow through Q1, and the voltage applied to the base of Q7 will be increased. With an increase in voltage at the base of Q7 and a consequent decrease in the difference of voltages between the generator line and the base of Q7, the output from Q7 will increase. When the output from Q7 increases, the voltage difference between generator line and emitter of Q7 decreases, resulting in Q6 being back biased via ZD9. With the back biasing of Q6 the output from Q6 is reduced and consequently the charging time of C2 is increased.

Pulse generator No. 1

13. The generator is fed from a 16 volt stabilizing circuit consisting of ZD4 and R15. Negative feed back from the d.c. chopper circuit is prevented by D7. Q3 acting as a relaxation oscillator will set the voltage at which C2 will discharge. When C2 becomes fully charged Q3 starts conducting, C2 will then discharge through Q3 and trigger SCR3 of the pulse amplifier circuit C4, D1, SCR3, R14, R22 via D4; incorrect firing of SCR3 by leakage current is prevented by the resistor R22. When SCR3 fires, C4 discharges and amplifies the pulse given to the primary winding of the isolating pulse transformer T1 the secondary winding of which applies the pulse to the gate of SCR1. A clamp in the form of ZD2 limits the gate voltage to 6·8 volts, thus safeguarding against gate overdrive; ZD2 also suppresses negative pulses.

D.C. chopper circuit

14. The main shunt field circuit within the unit is via terminal 1 (+ve) L1, SCR1, the primary side of T3, L2 and terminal 3. When a positive pulse is applied to the gate of SCR1, it will conduct, discharging current into the field circuit of the generator. Conduction will take place until a pulse from SCR2 applied to the gate of SCR1, switches SCR1 off. When SCR1 starts conducting, a charge is applied to C8 from the secondary of T3, via D8. This charge which is blocked on C8 by D8, is held until a pulse, from pulse generator No. 2, fires SCR2, which will conduct until C8 becomes fully discharged. The relative timing of SCR1 and SCR2 determines the length of current pulse delivered to the shunt field of the generator. When the length of pulse is short, minimum current for reliable SCR switching is ensured by R17, which provides a resistive path across the inductive field windings. Diode D9 allows the circulation of inductive currents stored in the field windings when SCR1 is switched off. Radio frequency suppression is affected by L1, L2, C13, C14 and C15 and d.c. smoothing by C9 to C12 (inclusive).

Pulse generator No. 2

15. The capacitor C3 is fed from the zener stabilized circuit ZD5, ZD3, and R16, via R10. When the capacitor becomes fully charged (i.e. when D3 becomes blocked via D5 by SCR1 conducting), Q4 will fire and SCR1 will be switched off by SCR2 which is triggered by T2 (for clamp on C3 refer to para. 16). Negative feedback to T2 is suppressed by D6. The operating frequency of Q4 is set by RV2 which compensates for the purchase tolerance on the intrinsic stand off ratio of Q4. The capacitor C6 ensures that a constant voltage is maintained across the network during transient conditions.

Note . . .

The intrinsic stand off ratio is the ratio of the unclamped voltage across C3 and that tapped off between RV2 wiper arm and the line connected to terminal 2 (fig. 7). This ratio fluctuates between limits fixed by the transistor manufacturers (i.e. purchase tolerance).

Pulse interlocks

16. To prevent loss of SCR switching and a consequent lock-on condition, synchronism must be maintained between the two pulse generators. This is achieved by interlocking the action of the pulse generators to the switching of SCR1. When SCR1 is conducting, the supply to ZD4 (pulse generator No. 1) from across SCR1 is removed, thus rendering Q3 inoperative, therefore gate pulses to SCR1 can only take place when SCR1 is in a non-conducting condition. Pulse generator No. 2 has a clamped timing circuit which ensures that a charge on C3 is clamped below the firing level of Q4. The clamp network comprises, R6, R7 and D3. The capacitor C3 is in the clamped condition whilst SCR1 is not conducting, when SCR1 conducts, a positive voltage unclamps the timing circuit by blocking D3 thus enabling C3 to fire Q4. Gate pulses from Q4 can only be generated when SCR1 is conducting. The timing circuit also ensures a minimum field current pulse width for efficient SCR switching.

Pulse width and frequency

17. The width and frequency of the pulse delivered to the field of the generator is governed by the charging time of the capacitors C2 and C3. The charging time of C2 varies in accordance with the generator field excitation requirement, whilst the charging time of C3 is constant. When the generator field current is low the d.c. chopper is operated below its nominal frequency, and the pulse width delivered to the excitation field of the generator is at a minimum, since length of pulse is governed by the charge time of C3 from the clamped condition only. Under this condition the charging time of C2 is long. With a high generator field current requirement, the d.c. chopper frequency is at a nominal value and the charging time of C2 is short; consequently, a long pulse is delivered to the generator field since C3 has not yet reached the state of charge to fire Q4 when Q3 fires.

INSTALLATION

18. When mounting the unit in position ensure that the terminal block of the unit is always positioned on the underside of the unit (i.e. so that the fins of the heat sink are always vertical).

SERVICING

19. Remove the cover from the unit and check the security of all fixing screws, nuts and locking devices. Check also for signs of mechanical damage, corrosion and general serviceability of components.

Torque tightening

20. If during servicing procedure component removal has been necessary, ensure that nuts securing the items detailed in this para. are tightened to the torque values indicated.

(1) SCR1 to 150 lb. in.

(2) SCR2 to 20 lb. in.

(3) D8, D9, D10 and D11 to 15 lb. in.

(4) ZD4 and ZD5 to 8 lb. in.

(5) RV1 and RV3 to 35 lb. in.

When tightening the control lock device in position on RV1 or RV3 tighten to a torque of 15 lb. in.

Testing

21. The details of tests which should be applied to the voltage control panel to determine its serviceability will be found in Appendix A to this chapter.

22. If the control panel fails the S.S.T. the unit should be tested in accordance with para. 23 to 32. Tests should be performed in the order shown and switches should be returned to the normal position on completion of tests or any sequence of tests.

Test equipment

23. The following test equipment should be available, in addition to that given in Appendix A to this chapter, when testing the voltage control panel.

Item	Apparatus	Description	Qty.	Ref. No.
1	A3	Milli-ammeter 0-100 mA d.c.	1	
2	F1	Electronic frequency meter 0 to 9·9 kc/s	1	
3	—	Brush crystal type ZL15	1	
4	—	Resistor 100 ohms	1	
5	—	Resistor 150 ohms 4·5 W	1	
6	S4	Changeover switch	1	
7	—	Resistor 100 ohm 4·5 W	1	
8	—	Silicon control rectifier 3A 150 P.I.V.	1	
9	—	Capacitor 2 μF	1	
10	—	Resistor 33 ohms	1	
11	—	Inductance 80 μH	1	
12	—	Multimeter	1	

Tests on printed circuit board No. 1

24. Connect the printed circuit board to the test equipment as shown in fig. 8. Adjust the voltage indicated by V1 to 29·2 V d.c. and close switch S3. Close switches S1 and S2 and perform the tests detailed in sub-para. (1) to (4).

(1) With switch S4 in position a check that the frequency indicated by F1 is greater than 4·0 kc/s.

(2) Switch S4 to position b and check that the frequency indicated by F1 is zero.

(3) Open switch S3 and check that the current indicated by A3 is less than 1 mA.

(4) Switch S4 from position b to a and then back to b and check that the reading of A3 is 160 ± 40 mA d.c.

Tests on printed circuit board No. 2

25. Connect the printed circuit board to the test equipment as shown in fig. 9. Adjust the voltage indicated by V1 to 29·2V d.c. and close switch S2 then perform the test detailed in sub-para. (1) and (2).

(1) Check that the frequency (generated across terminals 2 and 3) indicated by F1 is approximately 600 c/s.

(2) Open switch S1 and check that the frequency indicated by F1 is zero c/s.

Note . . .

(1) *If the reading of F1 is not satisfactory adjust the setting of the potentiometer RV2 to obtain a reading of 19·0 ± 0·5V d.c. on V2 and trim the frequency indicated by F1 until a figure of approximately 600 c/s is obtained.*

(2) *The maximum torque applied to the adjustment screw of the potentiometer should not exceed 9 oz. in.*

Wiring check (cover not fitted to unit)

26. Test the regulator for correct internal connections using a multimeter set to the 10000 ohm range. (If the regulator fails any of the tests do not proceed further). During each test ensure that the left hand column of regulator terminals (tabulated in this paragraph) is connected to the d.c. negative terminals of the multimeter.

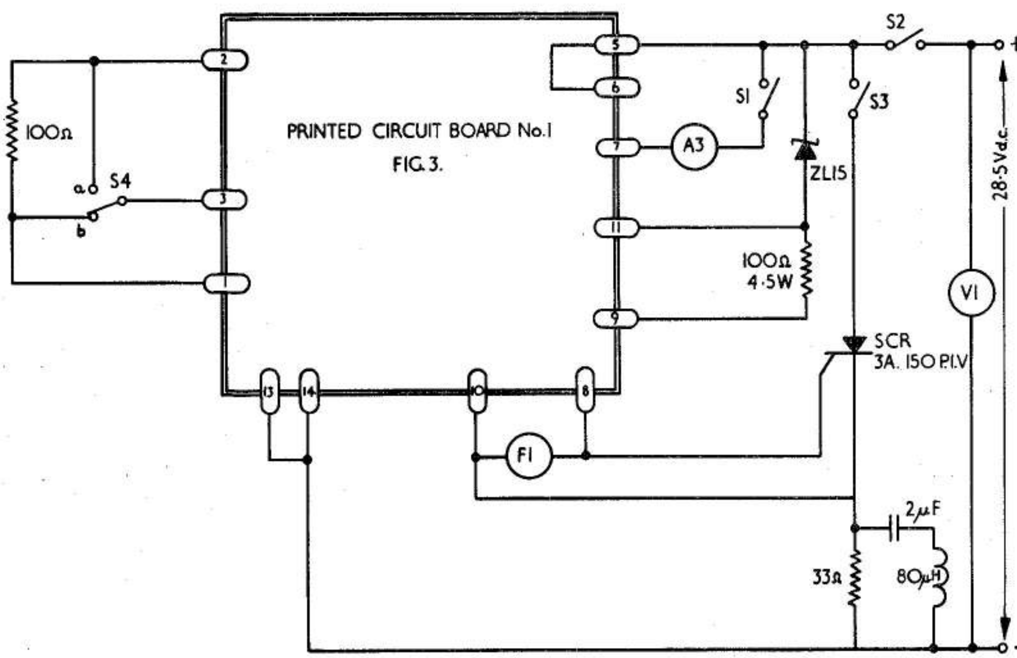

Fig. 7. Test circuit—printed circuit board No. 1

Regulator Terminals multi-meter (−ve)	multi-meter (+ve)	Resistance
1	2	3·7 kilohm ± 1·0 kilohm
1	3	3·7 kilohms ± 1·0 kilohm
1	5	Greater than 0·01 megohm
1	6	Greater than 10·0 megohms
1	8	700 ohms ± 100·0 ohms
2	3	Less than 105·0 ohms
3	1	2·5 kilohms ± 1·5 kilohms
3	2	90 ohms ± 15·0 ohms
4	7	Greater than 10·0 megohms
5	1	Less than 2·0 kilohms
7	4	Less than 2·0 kilohms
6	Frame	Zero ohms

Static characteristic (cover not fitted to unit)

27. Connect the regulator as shown in fig. 1, Appendix A and set the potentiometer (RV3) in the mid-travel position. Set the voltage V1 to 29·2V d.c., close switch S2 and vary potentiometer RV1 through the full range of movement. Check that the current indicated by A1 during the movement of RV1 is within the following limits.

(1) Maximum value between 17 and 23A d.c.

(2) Minimum value is less than 1A d.c.

Note . . .

It may be necessary to vary the voltage V1 to obtain the maximum and minimum readings of current A1. This voltage should not be varied outside the range 28·5 to 30V d.c.

Setting up procedure (cover not fitted to unit)

28. Connect the regulator as shown in fig. 2, Appendix A and allow the unit to warm up for a period of at least five minutes. Open switch S2, close switch S1 and set the generator speed at 3000 rev/min. Momentarily close switch S4 and check that the voltage V3 builds up to approximately 29·0V d.c. Close switch S3 and check that the voltage indicated by V2 is approximately 28·5V d.c. Using RV1 adjust the voltage of V3 to read 29·2 ± 0·05V d.c., if necessary use RV3 to trim the voltage to the figure stated.

29. Perform the tests detailed in sub-para. (1) to (6) and check that the steady state voltage of V3 (except in sub-para. (1)) is within the range 29·2 ± 0·10V d.c., at each speed and load value stated.

(1) Reduce the generator speed from 3000 rev/min to 2100 rev/min and apply a load of 1·5 kW.

(2) With the generator on no load

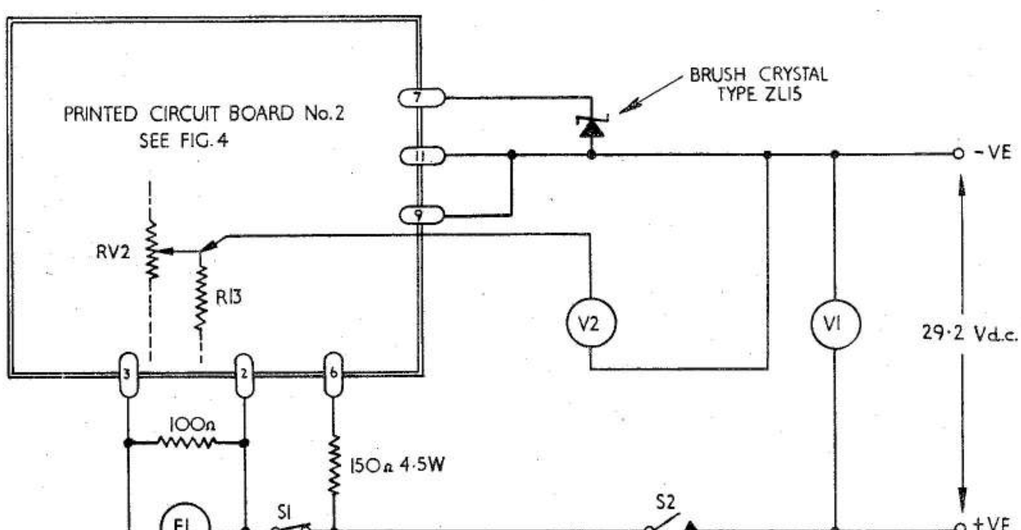

Fig. 8. Test circuit—printed circuit board No. 2

increase the speed of the machine to 2850 rev/min.

(3) Maintain the generator speed at 2850 rev/min and apply a load of 400A.

(4) Increase the generator speed to 6900 rev/min maintaining a load of 400A.

(5) Increase the generator speed to 8550 rev/min maintaining a load of 400A.

(6) Maintain a speed of 8550 rev/min and remove the load from the machine.

Voltage regulation tests (cover fitted to the unit)

30. Check that the regulator has stood in an ambient temperature of 20°C for at least 5 hours then connect the unit as shown in fig. 2, Appendix A and start the unit oscillating as detailed in para. 28.

31. Perform the tests detailed in sub-para. (1), (2), (3) and check that the voltage indicated by V3, in each case, is within 29·2 ± 0·10V d.c. except where stated.

(1) Run the generator at a speed of 3000 rev/min and check the steady state values of voltage at loads 0, 200 and 400A. On no load the voltage should be 29·2 ± 0·05V d.c. If the voltage on no load is outside these limits but within the limits of 29·2 ± 0·18V d.c., repeat para. 36, resetting RV3 and RV1, if necessary, to give a nominal value of voltage of 29·2V d.c.

(2) Increase the speed of the generator to 7900 rev/min and check the steady state values of voltage at loads of 0, 200 and 400A.

(3) Reduce the speed of the generator to 2100 rev/min and check the steady state values of voltage at a load of 1·5 kW.

Note . . .

*At this stage of test procedure check that the control lock device on the potentiometers RV*3 *and RV*1 *is tightened in accordance with para.* 20 *of this chapter.*

Insulation resistance test (cover fitted to unit)

32. With the cover fitted to the regulator, measure the leakage current using a 0-50 micro-ampere Industrial grade d.c. ammeter which has a 0·5 megohm 0·25 watt resistor in series with the positive probe (fig. 3, Appendix A). Using a variable 28V d.c. (20mA) supply applied between terminal Nos. 1, 2, 3, 4, 5, 7 and 8 all strapped together and terminal 6, check that the leakage current does not exceed 1 micro-ampere. Voltage should be applied and removed gradually.

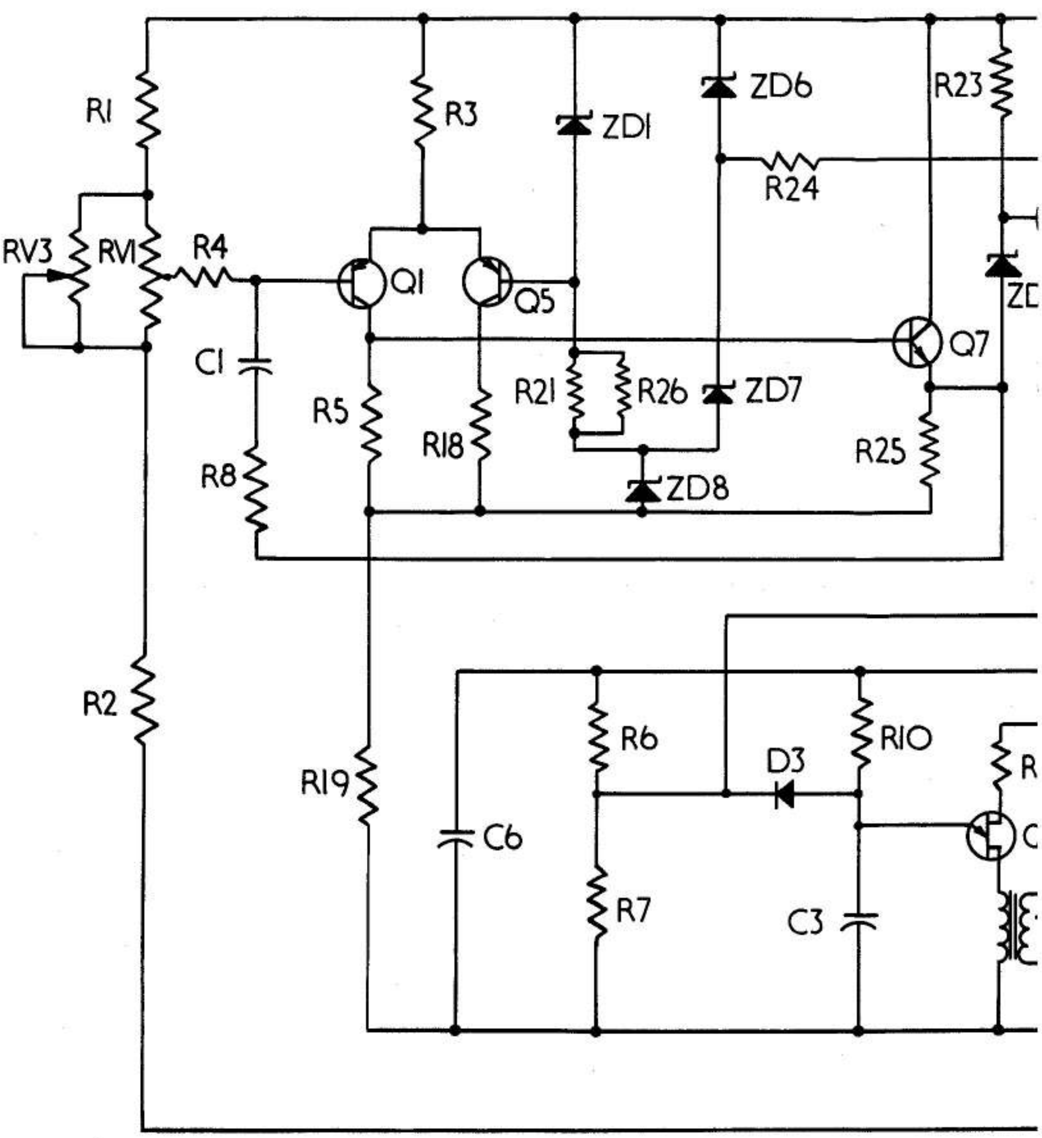

Fig. 9

Voltage con

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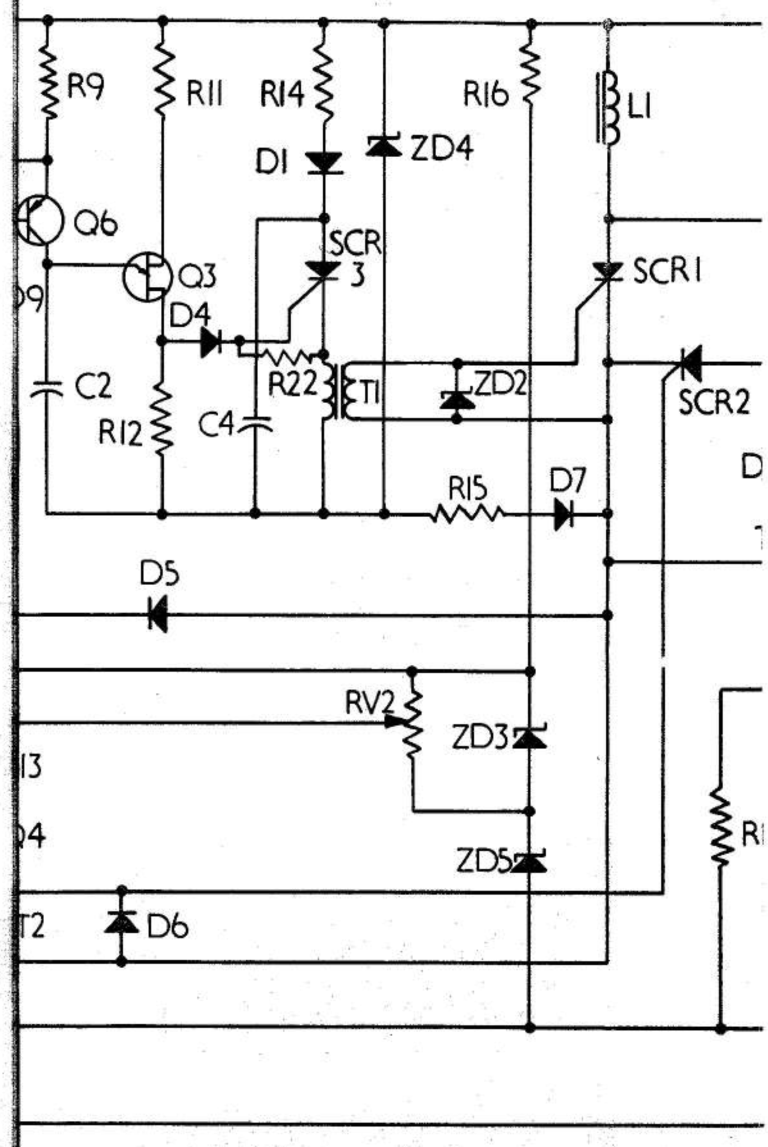

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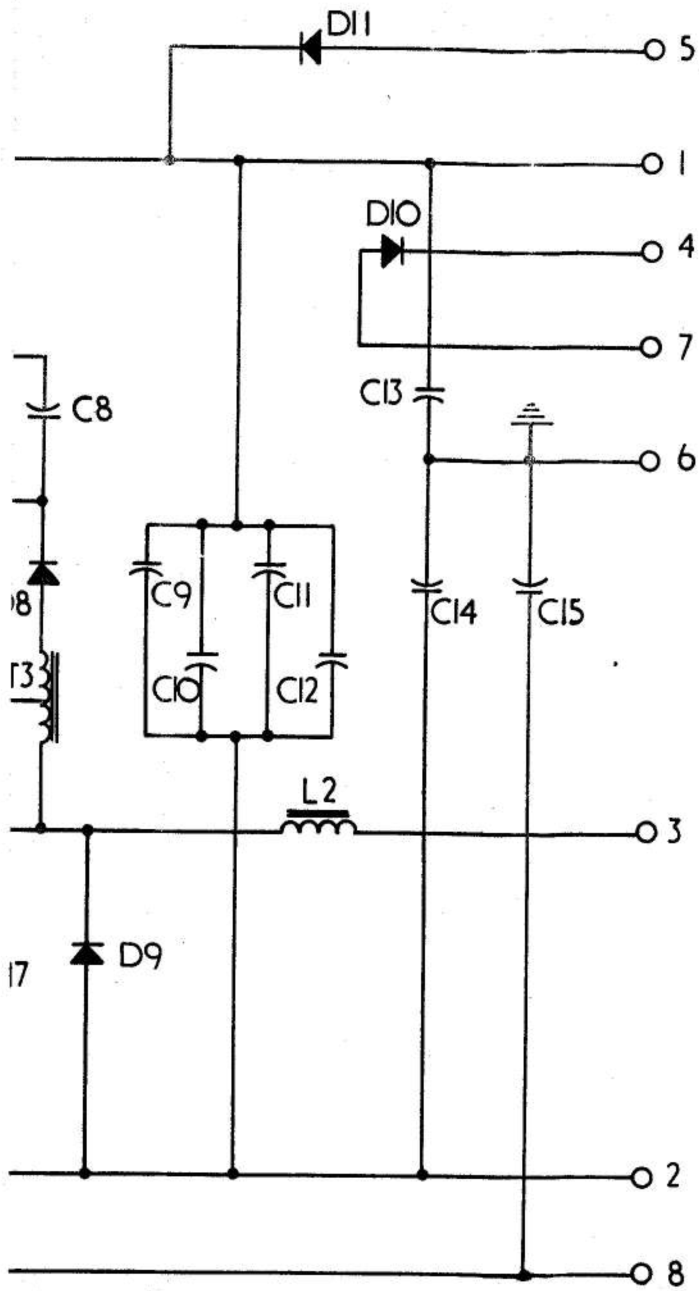

t diagram Fig.9

Appendix A

STANDARD SERVICEABILITY TEST for VOLTAGE CONTROL PANEL TYPE 50A

(E.E. TYPE A.E.7307 STYLE 2)

LIST OF CONTENTS

LIST OF ILLUSTRATIONS

Introduction

1. The following tests should be applied to the voltage control panel whenever the serviceability of the unit is suspect or before it is put into Service.

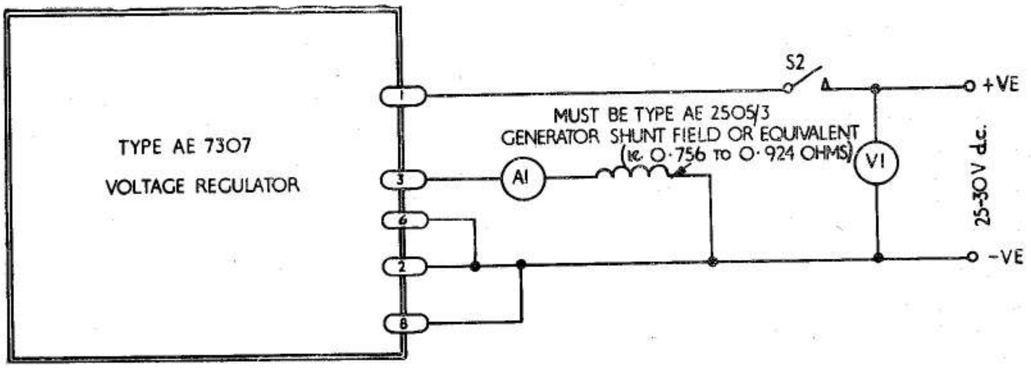

Fig. 1. Test circuit, static characteristic

Test equipment

2. The following test equipment should be available when testing the voltage control panel.

Item	Apparatus	Description	Qty.	Ref. No.
1	V1 V2	Voltmeter 0-30V d.c. precision grade	2	
2	V3	Voltmeter 0-30V d.c. accurate to 0·02V d.c.	1	
3	A1	Ammeter 0-30A d.c. precision grade	1	
4	A2	Ammeter 0-500A d.c. precision grade	1	
5	—	28 or 24V battery Varley Type 2419/25C	1	
6	—	25 to 33V d.c. supply (30A load rating)	1	
7	—	0 to 28V variable d.c. supply	1	
8	—	0-50 μA Industrial grade ammeter	1	
9	—	Slave d.c. generator, E.E. Type AE2505/3	1	
10	S1 S2 S3	Single pole switch	3	
11	S4	Double pole switch	1	
12	—	Overvoltage relay (comprising 2 change-over contacts 500 ohm coil)	1	
13	—	Overvoltage unit (Rotax U3617)	1	
14	—	Contactor (400A)	1	
15	—	Rheostat (0-12kW)	1	
16	—	Resistor (0·756 to 0·924 ohms)	1	
17	—	Resistor (0·5 megohms)	1	
18	—	Test prods.	2	
19	—	Silicon rectifier 12F20 (1 RC)	1	
20	—	Field relay (30A contacts)	1	
21	—	Silicon rectifier 70U40 (1 RC)	4	
22	—	Fuse 20A rating	2	
23	—	Fuse 50A rating	1	
24	—	Resistor 2·2 kilohms	1	
25	—	Capacitor 1000μF 100V d.c.	1	

TEST PROCEDURE

General

3. (1) All tests should be performed in the order shown.

(2) All switches should be returned to the normal position on completion of tests or any sequence of tests.

Static characteristic (cover fitted to unit)

4. Connect the regulator as shown in fig. 1 and set the voltage reading of V1 to 29·0V d.c. and close switch S2. Adjust the voltage of V1 to read 30V d.c. and check that the current indicated by A1 does not exceed 1·0A d.c. Reduce the voltage of V1 and check that a current of between 17 and 23A can be obtained. Ensure that during the test V1 is not varied outside the range 28·5 to 30V d.c.

Voltage regulation tests (cover fitted to unit)

5. Note . . .

(1) *The voltage indicated by V3 in tests* (4) *no-load,* (5), (6), *should be within the limits of* 29·2 ± 0·1*V*.

(2) *The voltage indicated by V*3 *in test* (4) *no-load, should be within the limits* 29·2 ± 0·05*V*. *If on the no-load test the voltage is within the range* 29·2 ± 0·2*V*, *but outside* 29·2 ± 0·05*V*, *reset the voltage using RV*1 *and RV*3 *until* V_A *reads* 29·2 ± 0·05*V*.

Before commencing the following tests check that the regulator has stood in an ambient temperature of 20 deg. C for at least 5 hours before connecting the unit as shown in fig. 2. Start the unit oscillating after allowing a warm up period of at least 5 minutes.

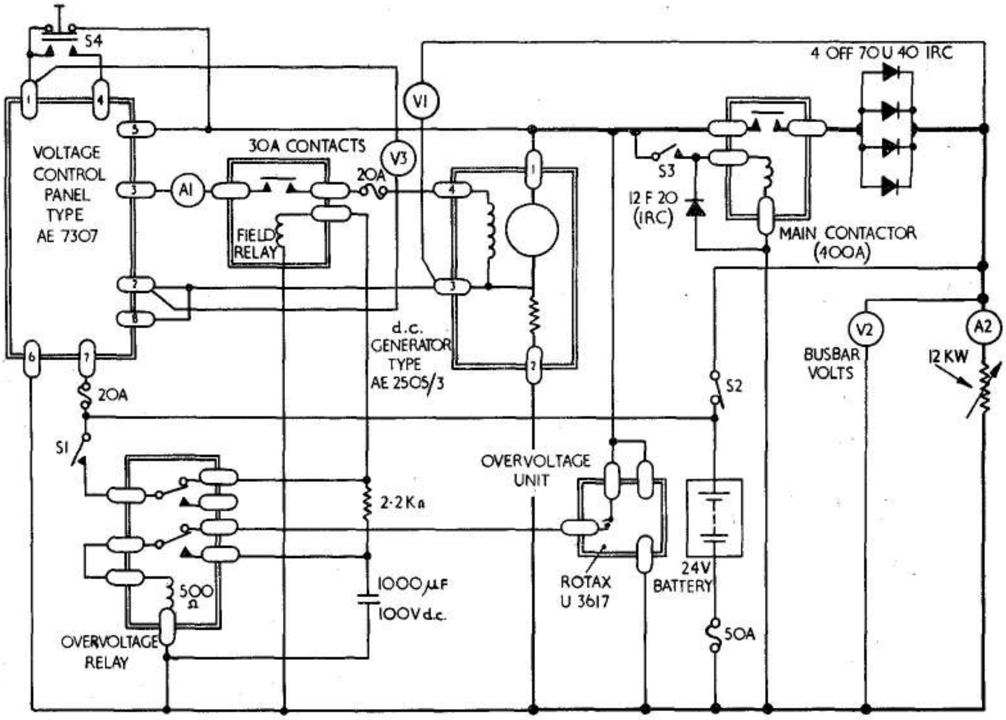

Fig. 2. Test circuit, functioning

(1) Open switch S2, close S1 and set the generator speed at 3000 rev/min.

(2) Momentarily close S4, and check that the voltage builds up to approximately 29·0V.

(3) Close S3, and check that the voltage indicated by V2 is approximately 28·5V. If necessary trim RV1 and RV3 to give a reading of 29·2 ± 0·05V. on V3.

(4) Run the generator at 3000 rev/min and check the steady state values of voltage at loads of 0, 200, 400A.

(5) Increase the speed of the generator to 7900 rev/min and check the steady state values of voltage at loads of 0, 200, 400A.

(6) Reduce the speed of the generator to 2100 rev/min and check the steady state value of voltage at a load of 1·5 kW.

Note . . .

When tightening the control locking device in position on RV1 or RV3 tighten to a torque of 15 lb. in.

Insulation resistance test (cover fitted to unit)

6. With the cover fitted to the regulator measure the leakage current using a 0-50 micro-ampere Industrial grade d.c. ammeter which has a 0·5 megohm $\frac{1}{4}$W resistor in series with the positive probe (see fig. 3). Using a variable 28V d.c. (20 mA) supply applied between terminal No. 1, 2, 3, 4, 5, 7 and 8 all strapped together and terminal 6, check that the leakage current does not exceed 1 micro-ampere. Voltage should be applied and removed gradually.

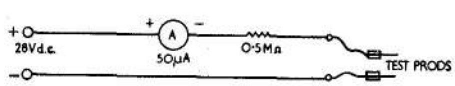

Fig. 3. Test circuit, insulation resistance

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