Chapter 17

CONTROL PANEL, TYPE 40

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LEADING PARTICULARS

Control panel *Type 40*	Ref.No.5UC/6146
Voltage output	115V, a.c. ± 1 per cent
Overall dimensions	9 in. X 7 in. X 11 in.
Weight	15.75 lb.
Used with:-	
Frequency changer, Type 270	Ref.No.5UB/6430
Rectifier unit, *Type CP16*	Ref.No.5UC/6147

Fig.1 Control panel, Type 40

Introduction

1. The control panel, *Type 40,* in conjunction with the rectifier unit, *Type CP40,* controls the output voltage of the frequency changer, *Type 270.* The frequency changer, Type 270 is described in Sect. 17 of this publication, and consists of a 3-phase, 200V, 400 c/s synchronous-induction motor, and a single phase, 115V, 1600 c/s inductor type a.c. generator.

2. The control panel is designed to maintain the r.m.s. voltage of the 1600 c/s output to within ±1 per cent. Accurate adjustments of the voltage can be made by means of a trimmer accessible externally from the front of the panel. The

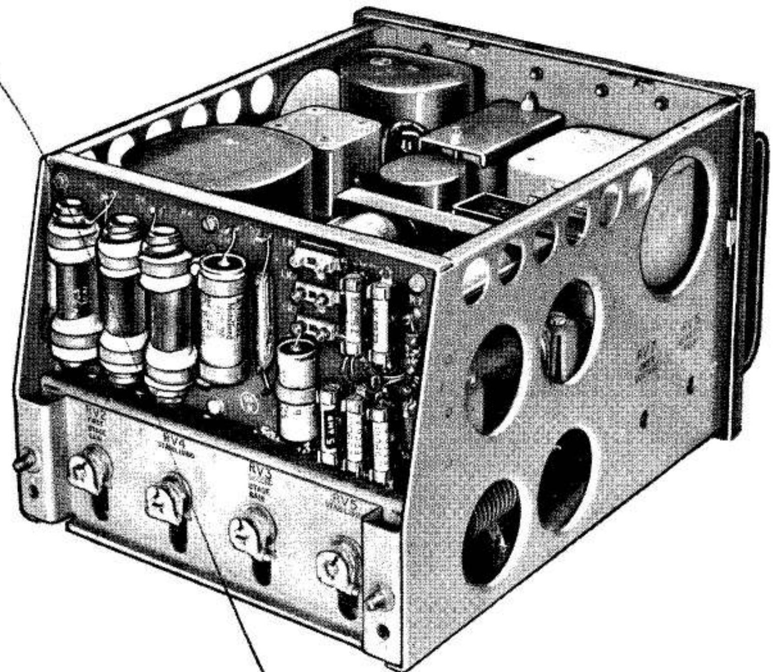

Fig.2 Back view of chassis with cover removed

rectifier unit, Type CP40, is described in Sect.19 of this publication.

DESCRIPTION

General

3. The components of the control panel are housed within a rectangular alloy case, which is of open type construction to provide for natural cooling. It is intended for mounting on a standard tray. The larger components, such as transformers, saturable reactors and rectifiers, are mounted on a chassis which has a fixed front plate and a detachable cover. The chassis deck is stiffened and stepped to obtain rigidity. The smaller components are fixed to insulating panels at the back of the chassis.

4. A list of all components in the control panel with their values and Stores Reference numbers is given in Table 1. A diagram showing the connections between the various component items of equipment is shown in fig.10, and a theoretical circuit diagram of the complete installation appears on fig.9.

Voltage sensing circuit

5. The voltage sensing circuit (fig.4), consists of a linear arm, resistors RV1 and R2, and a non-linear arm, lamp LR1. These arms are connected to the

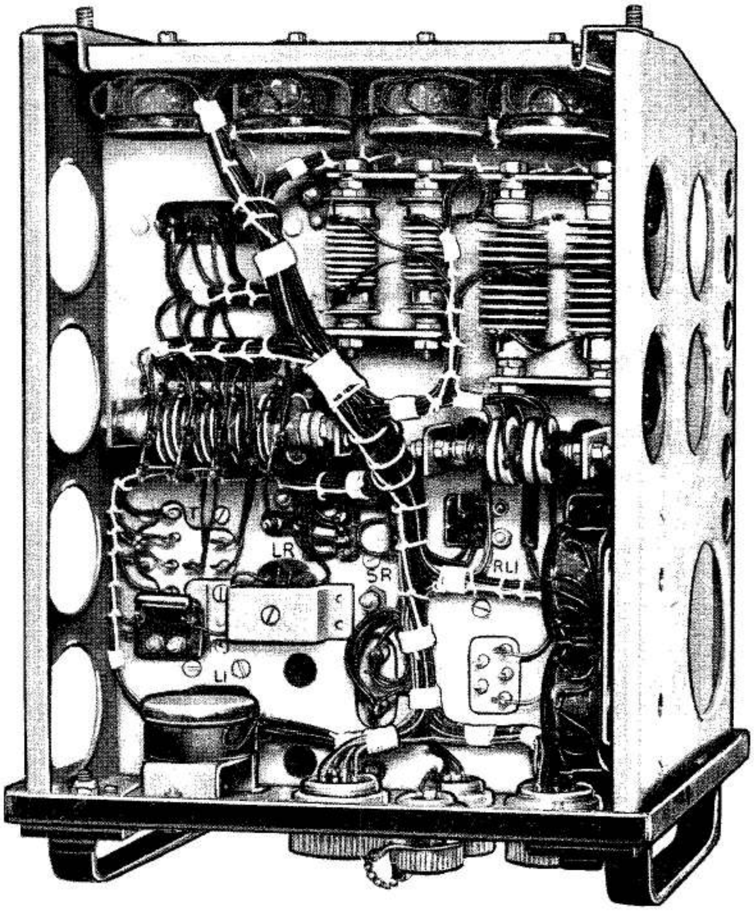

Fig.3 Underside view of chassis with cover removed

1600 c/s voltage reference circuit through separate windings on the transformer T1. The current in each arm is rectified by MR1, and passed through the control windings A1-A2 and A3-A2 of the saturable reactor SR1; the net output from the voltage bridge is the difference between the rectified currents I.1 and I.2 (fig.4). The balance is obtained when I.1 and I.2 are equal, and this occurs at one particular voltage, when the resistance of each arm is equal; the balance voltage is adjustable by variation of resistor RV1 in the linear arms. The voltage bridge responds to the r.m.s. value of the 1600 c/s voltage since the non-linear impedance consists of a filament lamp, the resistance of which is a function of filament temperature.

6. Temperature compensation is provided for by the addition of resistors R1 and R9, in parallel with the non-linear resistor LR1. Resistor R1 is wound with pure nickel wire and has a high temperature co-efficient. With an increase in temperature, the current through the resistors for a given 1600 c/s voltage decreases thus effectively opposing any variation in circuit resistances. As a result of this temperature compensation,

the 1600 c/s voltage is maintained within the required tolerance, over a wide variation in ambient temperature.

Amplifier circuits

First stage amplifier

7. The first stage amplifier shown in fig.6, consists of a single phase bridge arrangement of rectifier MR1, with saturable reactor windings T1-T2 and T3-T4 in series with the two arms of MR1. The output of the bridge is applied to the control windings A1-A2 of the second stage magnetic amplifier saturable reactor SR2.

8. The net polarising m.m.f. supplied from the sensing circuit determines the a.c. voltage to be supported by the windings T1-T2 and T3-T4, and hence the point in each half cycle at which the reactor saturates. The voltage in each half cycle not supported by the windings appears across the load. The output falls to a minimum determined by core magnetisation current, when sufficiently high polarising m.m.f. is in the opposite direction to that produced by the load current in the windings T1-T2 and T3-T4, and rises to a maximum when the polarising m.m.f. of requisite magnitude acts in the same direction as that due to load current. The relationship between polarising m.m.f. and load current is approximately linear within the working range of the amplifier.

9. Typical control characteristics of this type of magnetic amplifier are indicated in fig.6, where curves A, B and C refer to three different settings of the gain control potentiometer RV2. Adjustment of the gain control potentiometer varies the portion of rectified load current passing through the control winding A4-A5, thus providing an additional polarising m.m.f. proportional to the load current. The amplifier sensitivity varies with the setting of the gain control potentiometer. The additional polarising m.m.f. may aid or oppose the control m.m.f. depending upon the polarity of the control winding A4-A5. With reference to fig.6, the control curve A is obtained with no additional m.m.f. in the winding A4-A5, and curves B and C with a certain amount of polarising m.m.f., the winding being reversed for curve C.

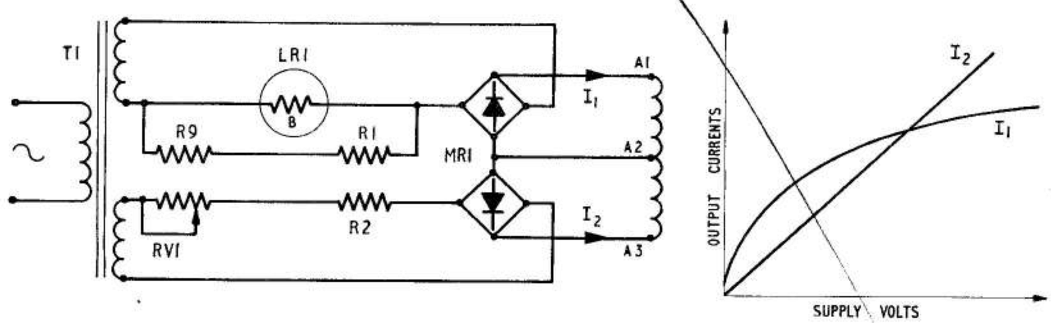

Fig.4 Voltage sensing circuit

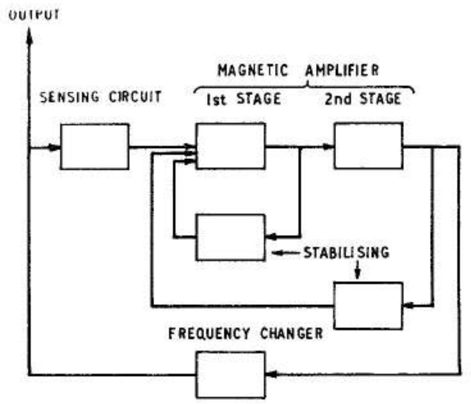

Fig.5 Block diagram of control circuit

Second stage amplifier

10. The second stage amplifier, comprising saturable reactor SR2 and rectifier MR2 are shown in fig.7. Although the rectifier arrangement is different, the principle of operation is similar to that of the first stage amplifier. The rectifier MR2 consists of two rectifiers in series with windings T1-T2 and T3-T4, followed by a bridge section connected to the load. As with the first stage, an adjustable portion of the load current is passed through the winding A5-A6. Gain control is effected by the adjustment of potentiometer RV3. The control signal for this voltage is the output from the first stage passing through the winding A1-A2. A fixed d.c. bias signal obtained from the bridge rectifier MR4, is passed through the winding A3-A4, after smoothing by the resistors R7 and R8, and capacitor C3.

11. The amplifiers are connected so that an increase in 1600 c/s voltage above normal, produces an increase in the output of the first stage and a decrease in the output of the second stage. The decrease in a.c. generator field excitation tends to correct any rise in voltage detected by the voltage sensing circuit. The combined gain of the two amplifiers is sufficiently high to produce a full swing in field current for a small deviation of 1600 c/s voltage, thus maintaining the 1600 c/s voltage within close limits under normal operating conditions.

Stabilizing

12. The control circuit is stabilized to avoid hunting, by the use of two separate transient feedback signals, derived from the generator field current and the first stage output. Voltages proportional to these two currents are obtained from the voltage drop across resistors R5 and R6, and resistor R3 respectively. Both signals are applied to the first stage control winding in such a direction as to oppose the system disturbances producing the signals. Under steady state conditions, no current is flowing in the stabilizing circuits because of the series capacitors C5, C6, C7 and C4. Adjustment of stability is obtained by variable resistors RV4 and RV5.

Auxiliary circuits

Overvoltage circuit

13. Overvoltage protection is obtained from the circuit consisting of variable resistor RV7, rectifier MR6, Metrosil resistor RX2 and the coil of relay RL2 connected in series across the 1600 c/s input voltage to the control panel. The non-linear resistor Metrosil RX2 ensures that under normal operating conditions the current in the circuit is small, but increases rapidly under overvoltage conditions. Overvoltage setting is adjusted by means of variable resistors RV7 for the

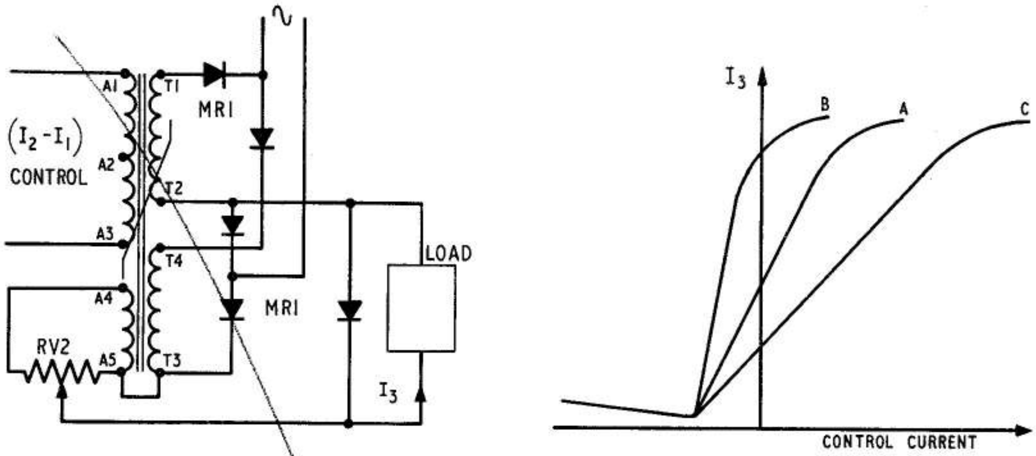

Fig.6 First stage amplifier

relay to operate when the voltage reaches 125 per cent of the rated value (i.e.) 144V. The relay is operated by d.c. produced by rectifier MR6, and smoothed by capacitor C8. This capacitor also slugs the operation of the relay, so avoiding operation during switching surges. When the relay is energized the normally closed contacts open. These contacts are connected in series with the coil of the main supply contactor in the frequency changer Type 270.

Filter circuit

14. A filter circuit consisting of capacitor C9 and reactor L3 is connected in parallel across the 1600 c/s supply. This filter assists in smoothing the waveform distortion produced by the magnetic amplifiers. Each magnetic amplifier allows current to be conducted from the supply for only a part of each half cycle of the supply and therefore the current taken by the amplifier has a high harmonic content. Bad distortion of the voltage waveform results if this current passes through the relatively high reactance of the 1600 c/s generator. The capacitor acts as an acceptor of the higher harmonics of current produced by the magnetic amplifier, while the reactor corrects the power factor of the current taken from the a.c. generator at the fundamental frequency of 1600 c/s.

A.C. generator excitation circuit

15. The self-excitation circuit comprises the transformer-rectifier system, T2 and MR3 supplying the main field X1-X2 of the 1600 c/s generator. The transformer primary voltage is taken from a capacitor in series with the generator output. Since the generator frequency is constant the reactance presented by the capacitor is constant, and the voltage drop across it

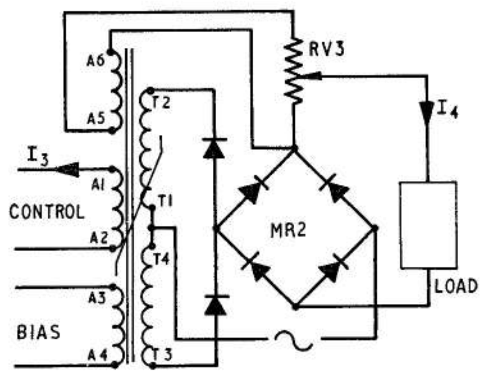

Fig.7 Second stage amplifier

is proportional to load current. For an increase in generator load, the self-excitation strengthens the generator field and the opposite occurs when the load is decreased.

16. A circuit consisting of variable resistor RV6, rectifier MR5, Metrosil resistor RX1 and the coil of relay RL1, is connected in series across the 1600 c/s supply voltage. This circuit is similar to the overvoltage circuit described in para. 13, but operates to energize relay RL1 when the a.c. generator voltage builds up to 85V.

17. The remanent flux in the generator magnetic circuit would not normally produce a build up of voltage on starting, therefore the field has to be temporarily excited from the 28V d.c. supply. This supply is connected to the field through the normally made contacts of relay RL1 When the generator voltage builds up to approx. 85V, the relay operates to remove the 28V d.c. supply, and excitation current is then provided by the self-excitation circuit (para.15).

18. The control panel is designed for mounting on a standard tray which must be resiliently mounted in order to protect the lamp LR1 in the panel from damage due to vibration. Although the panel will normally be fitted into a standard tray on a horizontal plane, there is no restriction on the mounting angle provided it is adequately secured.

19. The unit should be installed in a position allowing free circulation of cooling air. When the rectifier unit and the control panel are mounted one above the other, they should be separated by a reasonable vertical distance of approx. 4 in.

20. Interconnections between the control panel, rectifier unit, and frequency changer are shown in fig.8. A 12-core cable connects the rectifier unit to the control panel, and one 12-core and one 4-core cable connect the control panel to the frequency changer. The 12-core cable connecting the control panel to the frequency changer should not exceed 15 ft. in length otherwise the accuracy of the voltage regulation will be impaired.

21. It is recommended that the voltage setting be adjusted to 115V r.m.s., when the control panel is used for the first time after installation. Instructions for adjustment of the voltage are given in para.25.

TABLE 1

LIST OF COMPONENTS

Component No.	Qty. Per Unit	Title	Joint Service or Stores Ref.No.	Description
T1	1	Transformer		Parmeko
T2	1	Transformer		Parmeko
SR1	1	Saturable Reactor	5UC/5941	MR 413C
SR2	1	Saturable Reactor	5UC/5942	MR 4140
L1	1	Reactor	5UC/5945	MR 412B
RL1	2	Relay	Z.530530	SM5 N51
LR1	1	Resistor Non Linear Voltage sensitive, in glass envelope	5UC/5978	Lamp Type T24
F1, 2	2	Fuse	Z.590111	3A
F3	1	Fuse	Z.590112	5A
F4, 5	2	Fuse	Z.590108	500 mA
		Fuse Unit	Z.590102	
MR1	1	Rectifier	5UC/5974	FAX 7126A
MR4A & B	2	Rectifier	Z.751556	MDA 25-6-1GZ
M5, 6	2	Rectifier	5UC/5973	FAX 7171A
RV1	1	Resistor Variable	Z.271305	100 ohm, 1W RAC
RV2	1	Resistor Variable	Z.271051	5 ohm, 1W RAC
RV3	1	Resistor Variable	10W/19211	1 ohm, 1W RAC
RV4	1	Resistor Variable	Z.271755	2.5 kohm, 1W RAC
RV5	1	Resistor Variable	Z.271605	1 kohm, 1W RAC
RV6, 7	2	Resistor Variable	Z.272141	10 kohm, 1W RAC
RX1, 2	2	Resistor Non Linear	5UC/5673	Metrosil 2.5mA at 50V.
R1	1	Resistor Assy	5UC/6018	1500 ohm Nickel
R2	1	Resistor	Z.243146	330 ohm, 6W RWV4-L
R3	1	Resistor	Z.243341	68 ohm, 3W RWV4-J
R4	1	Resistor	Z.243180	680 ohm, 15W RWV5-K
R5, 6	2	Resistor	Z.243020	15 ohm, 15W RWV5-K
R7	1	Resistor	Z.243381	470 ohm, 3W RWV4-J
R9	1	Resistor	Z.244233	4.7 kohm, 3W RWV4.J
R8	1	Resistor	Z.244209	1.5 kohm, 3W RWV4-J
C1	1	Capacitor	Z.115322	1 µfd, 150V CPMIK
C2	1	Capacitor	Z.115554	0.05 µfd, 350V CP31H
C3	1	Capacitor	10C/19462	8 µfd, 150V
C4,5,6,7,8	5	Capacitors	10C/19460	20 µfd, 150V

TABLE 1 (continued)

Component No.	Qtu. Per Unit	Title	Joint Service or Stores Ref.No.	Description
C9	1	Capacitor	Z112880	2 μfd, 400V CP10G
C10	1	Capacitor	Z.115252	2 μfd, 150V CPMIN
	1	Plug 12 (12 pin)	Z.560150	
	1	Plug 12-1 (12 pin)	Z.560151	(Orientation No.1)
	1	Plug 4 (4 pin)	Z.560070	
	1	Socket 3.s (3 pin)	Z.560240	

OPERATION

Starting

22. With the control panel, rectifier unit and frequency changer connected as shown in fig.8, the frequency changer may be started by the operation of a push-button switch which energizes the main supply contactor. The main supply contactor, when energised, supplies the star/delta contactor which closes, and the frequency changer starts up as a star connected induction motor. At about half speed the a.c. generator self-excitation circuit operates and the generator produces a regulated output of 115V a.c. This output voltage is applied to a relay in the control box of the frequency changer causing the star/delta contactor to change the motor input to delta connection. The star/delta contactor, when connected in delta, energises the motor main field contactor which closes to supply 28V d.c. to the motor field circuit. The motor then runs as a synchronous machine.

23. The 1600 c/s generator load should not exceed 250W during starting, but as soon as the motor is synchronised, the full generator load may be applied.

24. The d.c. supply voltage should not exceed the limits of 26-29V, otherwise unduly high transient voltages may result during starting.

SERVICING

25. After installation, and at regular intervals during service, the voltage setting should be checked. The a.c. generator voltage should be 115V r.m.s., and may be adjusted by the voltage control trimmer which is accessible from the front of the control panel. The voltage should be measured by means of a thermal type meter, such as the Voltmeter Ref.No. 5Q/462, since the control panel regulates the r.m.s. value of the generator voltage. This voltage should be measured at pins A and B on the 3-pole test socket mounted on the front of the control panel.

26. The setting of the overvoltage circuit should be checked regularly, and should be re-adjusted if necessary according to the method given in para.41.

27. The control panel should be inspected for signs of corrosion and damage to the case, components and electrical connections. Collection of dust and other foreign

matter should be blown out by means of a jet of dry and clean compressed air.

Location of faults

28. In the event of failure of the 1600 c/s generator output, or of otherwise unsatisfactory performance, an attempt should first be made to determine which unit in the system is responsible. A simple method is to substitute for each unit in turn, a unit which is known to be in good working order, starting with the control panel and then the rectifier unit. If the fault is in the control panel, remove the cover and examine fuses, F1, F2 and F3, and also the filament of lamp LR1. Check that the links LK1, LK2 and LK3 are firmly secured. Visually inspect the wiring and other components for any obvious cause of failure. If the fault in the panel is not obvious, the panel should be subjected to the tests as given in para.36 to 45.

DISMANTLING AND ASSEMBLY

General

29. Access to the inside of the control panel is obtained by removal of the cover which is secured by two captive nuts at the back. These captive nuts should be unscrewed as far as possible and the cover pulled away from the front plate. The cover will move over the chassis once it has pulled clear of the spring clip on the front plate. The captive nuts should be firmly tightened when the cover is replaced.

30. No special instructions are required for dismantling the components from the chassis, such dismantling should only be necessary when the components require to be renewed. Some guide as to the fitting of components is given in the following paragraphs.

Resistors and capacitors

31. Where these are held by clips, sufficient layers of glass tape should be wound around the replacement components, so that they are firmly held by the clips.

Variable resistors

32. The spindle locking device must be fitted on replacement.

Transformers, reactors and rectifiers

33. Lockwashers must be placed under the head of each securing nut or screw.

Lamp LR1

34. To remove the lamp, unsolder the leads at the terminals on the small insulating panel underneath the chassis. Remove the screw holding the lamp to the chassis and withdraw the lamp with the attached leads. Unsolder the leads from the lamp base. Re-assembly should be carried out in the reverse order.

Capacitors C3, C4, C5, C6, C7 and C10

35. These capacitors are secured together in a removable sub-unit which can be lifted upwards when the fixing screws attaching it to the chassis have been removed. To remove a capacitor from the sub-unit, unsolder the connecting leads at the terminals and unclamp the capacitors by removing the nuts from the four tie bars. When re-assembling it should be noted that Neoprene gasket must be placed between the end plate and the capacitors at the opposite end to the terminals.

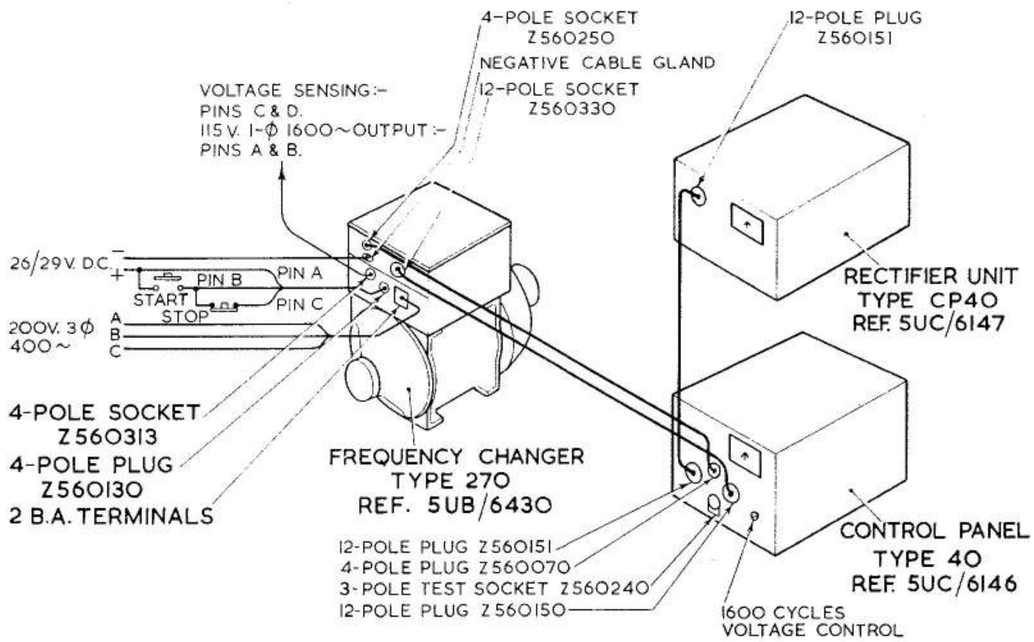

Fig.8 Interconnection diagram

TESTING

General

36. The correct functioning of the control panel when installed can be checked by measuring the change of 1600 c/s voltage when the load is switched on and off. The voltage should be within the limits quoted in para.2, when measured with a thermal type meter as specified in para.25.

37. The following tests relate to the checking and re-adjustment of the control panel, and the relevant tests must be performed when any of the following components are replaced: Rectifiers MR1, 2, 3, 4, 5 and 6, saturable reactors SR1 and 2, non-linear resistors RX1, RX2 and LR1, and variable resistors RV2, 3, 6 and 7.

38. All tests should be made with the control panel disconnected from the control of the frequency changer. The supplies required for the tests are 115V, 1600 c/s, a.c. single phase variable voltage, and a 26-29V d.c. supply. The rectifier unit, Type CP40 should be connected for the tests given in para.43 to 45.

39. Links 1 and 2 must not be opened without a shunting meter when the 1600 c/s voltage is applied to the panel. Damage will be caused to the rectifier if either of these links are open with the voltage applied.

NOTE . . .

Connect 115V, 1600 c/s supply to the panel means that 115V r.m.s., 1600 c/s *single phase supply is to be connected to pins AC and BF of the 12-pole plug.*

Starting relay circuit

40. Connect variable 1600 c/s voltage to the panel and a continuity meter to pins J and L on the 12-pole plug and test as follows:-

(1) Adjust variable resistor RV6 until the relay RL1 operates when the voltage is raised to 85V ±2 per cent. Continuity meter will indicate the opening of the circuit when RL1 operates.

(2) Check the voltage across pins A and B of the 3-pole test sockets, this should be 115V when the 1600 c/s supply voltage is raised to 115V.

Overvoltage relay circuit

41. Connect continuity meter between pins A and B on the 4-pole plug and test as follows:-

(1) Adjust variable resistors RV7 until RL2 operates when the supply voltage is slowly raised to 144V r.m.s. The voltage must not be maintained above 115V for longer than is necessary to perform this test.

Voltage sensing circuit

42. The warning in para.39 must be observed when the links are opened during this test.

(1) Open links 1 and 2 and connect a d.c. milliammeter in each circuit. Connect 115V, 1600 c/s supply to the panel. Adjust RV1 so that the current in link 1 is equal to the current in link 2,

Second stage amplifier circuit

43. Connect an inductive load of 25 ohms, 0.25 henry, with an ammeter in series to pins E and D on the 12-pole plug. Open link 3. Connect a variable d.c. supply of ± 1.2V, ± 10 mA with a d.c. milliammeter in series, to points 33/1 and 32, point 33/1 being more positive with respect to 32. The d.c. voltage source impedance must be less than 10 ohms. Connect 115V, 1600 c/s supply to the panel, and test as follows:-

(1) Adjust variable resistor RV3 to obtain an increase in load current from 0.3 to 1.3A, when the control current is changed negatively by 7 mA ± 5 per cent. Reverse connections to windings A5-A6 on saturable reactor SR2 if necessary.

First stage amplifier circuit

44. The warning in para.39 must be observed when the links are opened during this test.

(1) Short together points 22, 23, and 28 and open links 1 and 2. Open link 3 and connect a d.c. milliammeter in circuit.

(2) Connect a variable d.c. supply of ± 0.125V, ± 5 mA with a d.c. milliammeter in series, to points 22/1 and 28/1. Connect 115V, 1600 c/s supply to the panel.

(3) Adjust variable resistor RV2 to obtain an increase in current in link

3 from 20 mA to 30 mA, when the control current is changed by 0.11 mA ± 5 per cent. Reverse connections to winding A4-A5 on saturable reactor SR1, if necessary.

Voltage regulator circuit

45. Disconnect variable d.c. supply, and remove short circuit from points 22, 23 and 28. Close links 1, 2 and 3. Connect an inductive load of 25 ohms, 0.25 henry, with an ammeter in series to pins E and D of the 12-pole plug. Connect 115V, 1600 c/s to the panel, and test as follows:-

(1) Adjust variable resistor RV1 to obtain a sudden change in load current from less than 0.25A to greater than 1.7A.

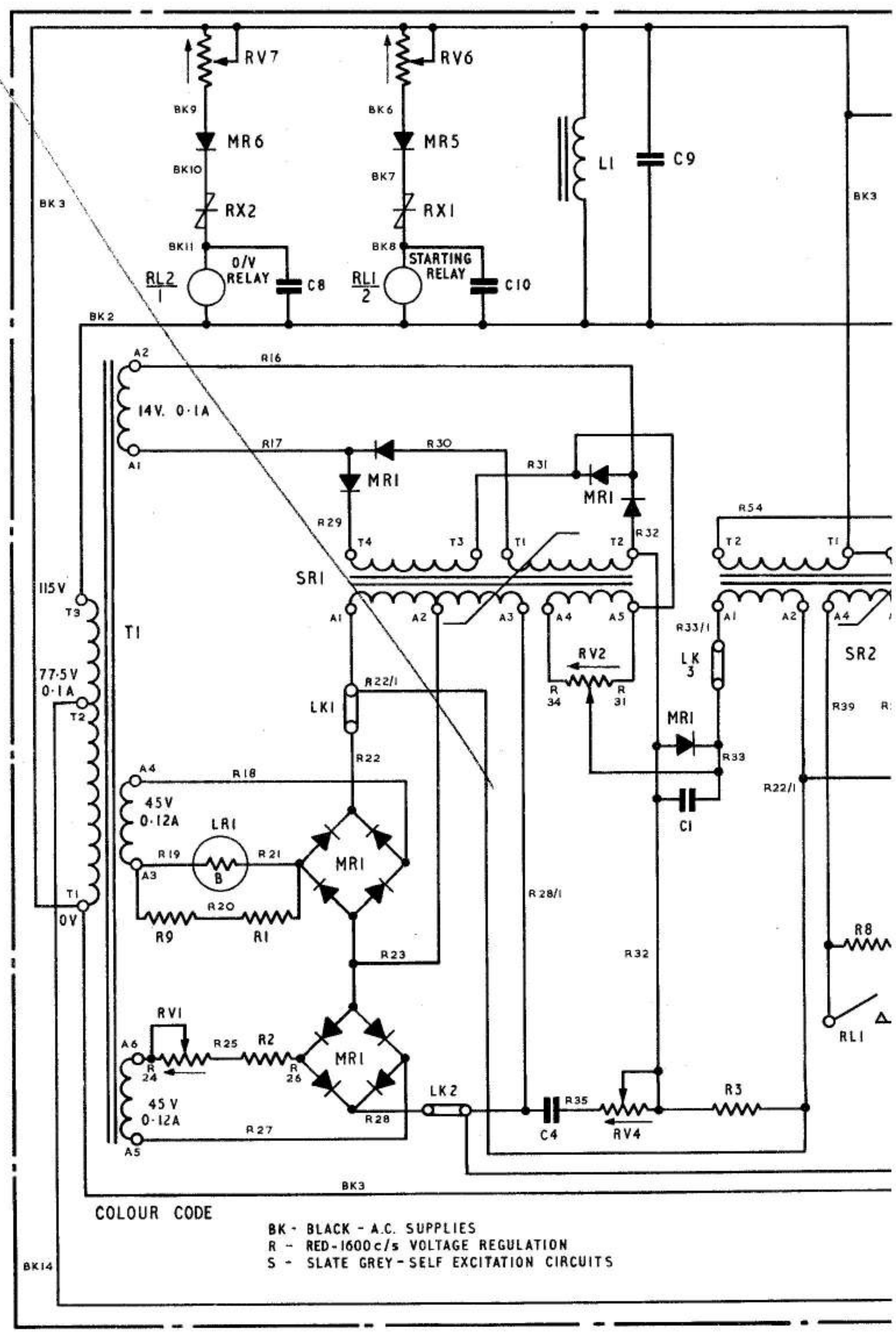

Fig. 9 Theoretical circui
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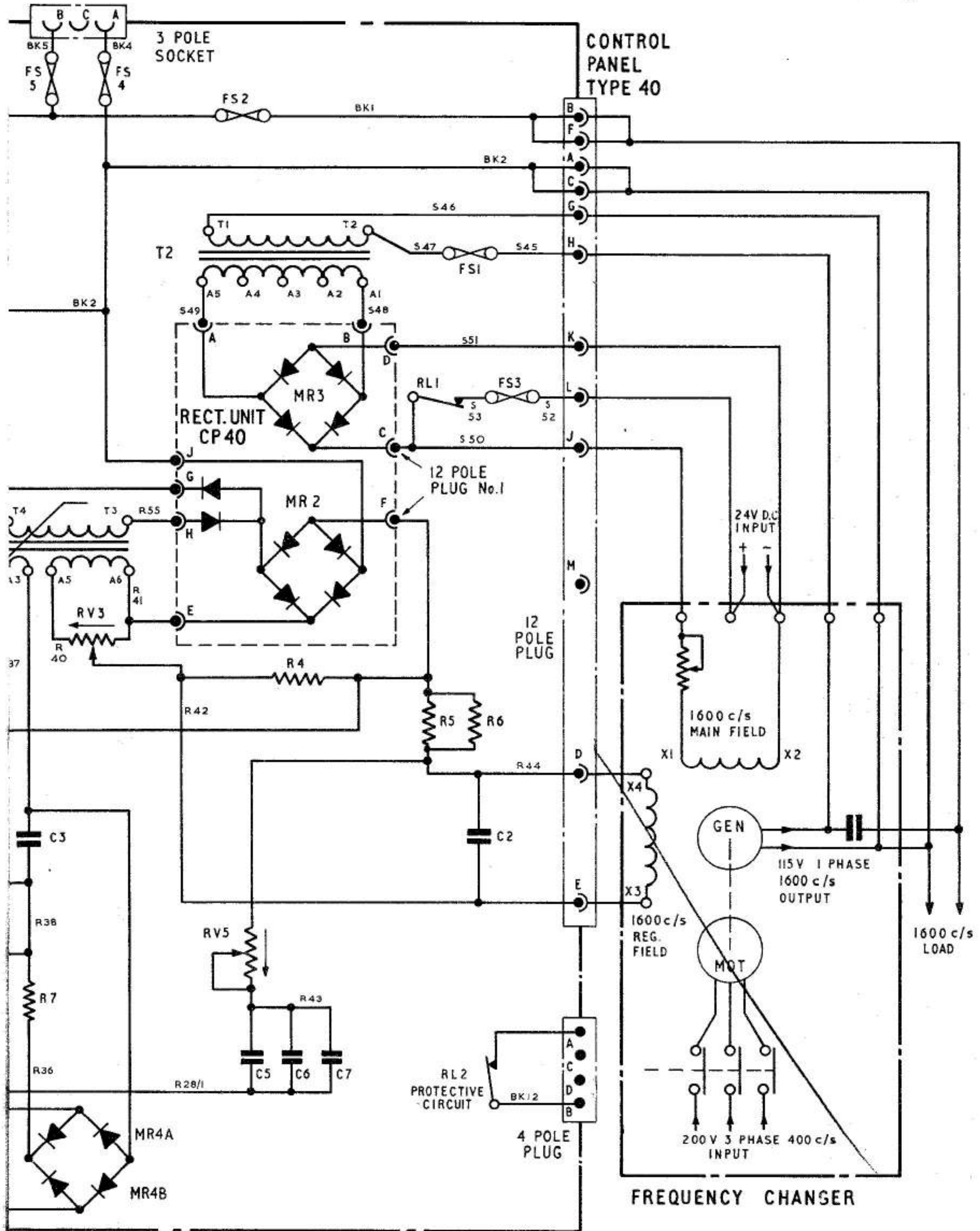

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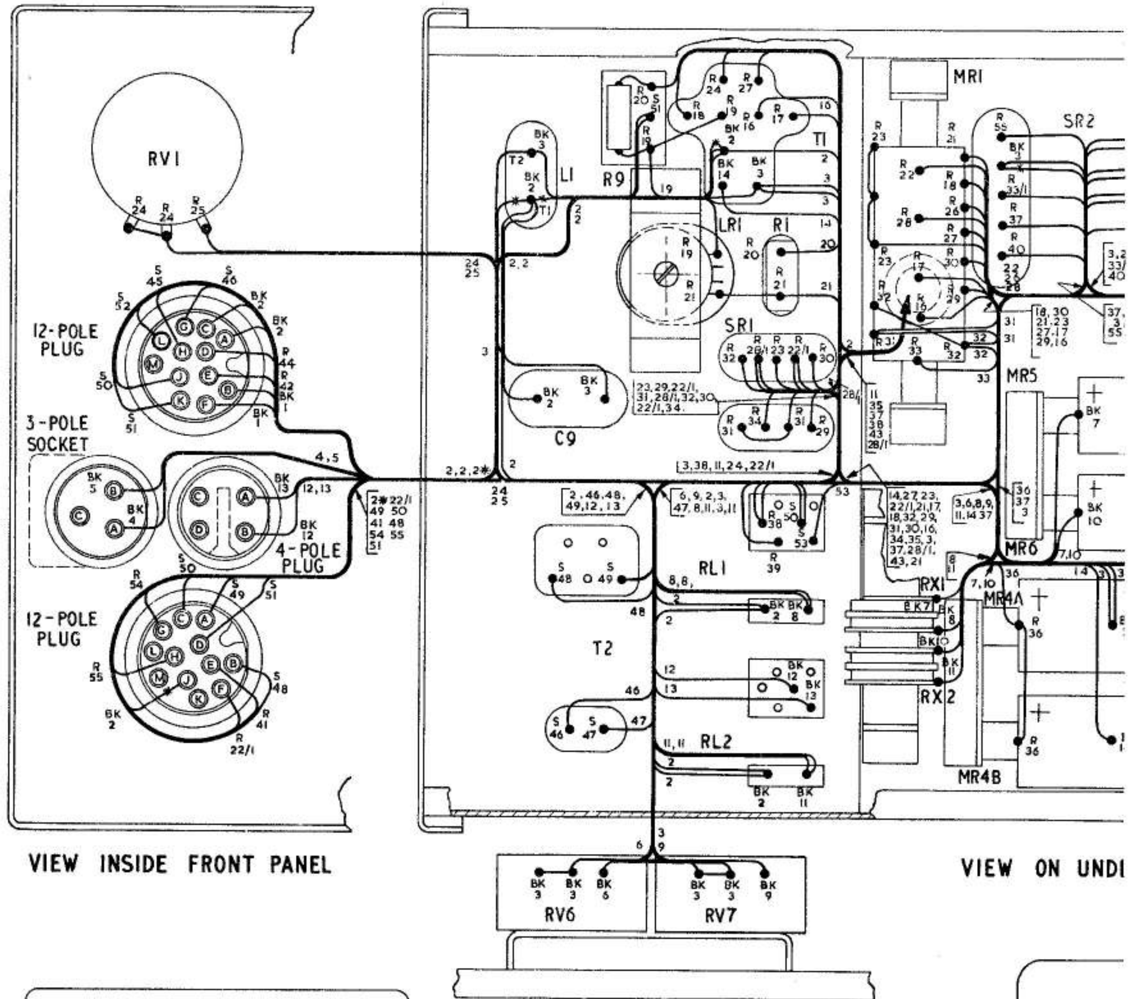
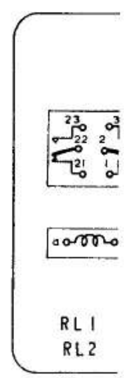
Fig. 9



VIEW INSIDE FRONT PANEL

VIEW ON UNDI



NOTE ÷

WIRING IS COLOUR CODED AS INDICATED ON EACH CONNECTION, THE COLOUR SYMBOL BEING SHOWN DIRECTLY ABOVE THE WIRE No.

E.G. ÷ R/27 WIRED IN RED

BK/3 WIRED IN BLACK

S/49 WIRED IN GREY

THE COLOUR SYMBOL IS GIVEN ONLY AT THE WIRE TERMINATIONS WHERE A WIRE IS MARKED AT INTERMEDIATE POINTS, ONLY THE WIRE No. IS GIVEN.

WIRE MARKED THUS ✱ IS 23/·0076

Fig.10

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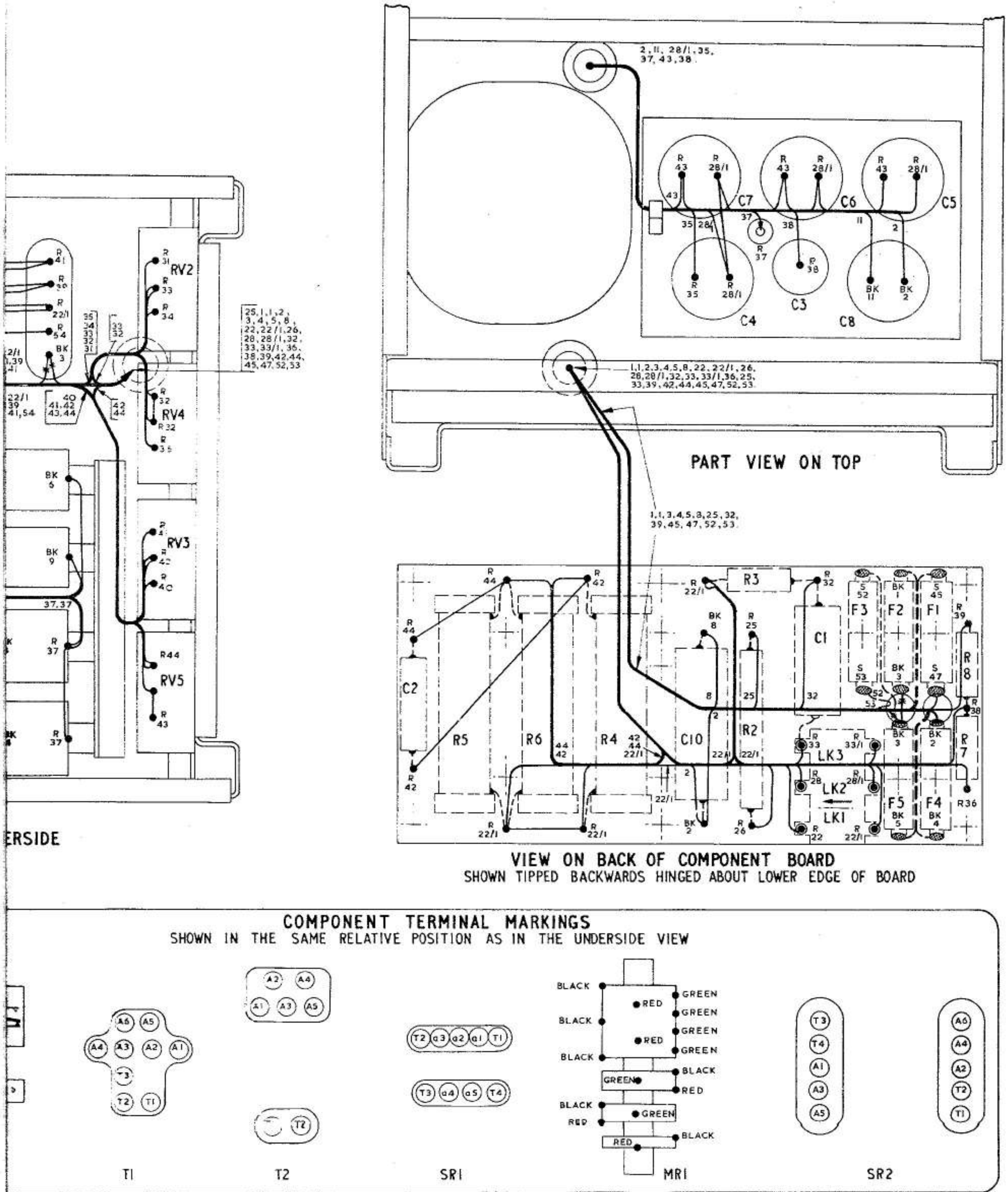

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Fig.10