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Chapter 1

CONTROL PANEL, TYPE 16

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LIST OF ILLUSTRATIONS

LEADING PARTICULARS

Control panel, Type 16	Ref. No. 5UC/5502
Inverter input	100 to 115 volts d.c.
Outputs	(1) 2 kVA, 115 volts, 1-phase a.c. ±1 per cent, 1,600 c/s (2) 1 kVA, 115 volts, 3-phase a.c. ±2 per cent, 400 c/s
Overall dimensions	12 in. × 7 in. × 15·5 in.
Weight	28·25 lb.
Used with—	
Inverter, Type 350	Ref. No. 5UB/5501
Rectifier unit, Type CP16	Ref. No. 5UC/5841

Introduction

1. The control panel, Type 16, in conjunction with the rectifier unit, Type CP16, controls the output voltage and frequency of the inverter, Type 350, described in A.P.4343B, Vol. 1, Book 3, Sect. 17, Chap. 1. With an input of 110 to 115 volts d.c., the inverter delivers an output of 2 kVA, 115 volts, single-phase a.c. at 1,600 c/s, and a second output of 1 kVA, 115 volts, 3-phase a.c. at 400 c/s.

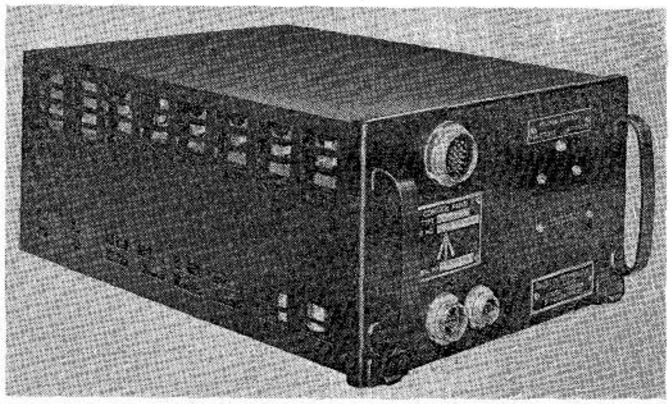

Fig. 1. Control panel, Type 16

2. The R.M.S. voltage of the 1,600 c/s output and the frequency are each controlled to within ± 1 per cent, and the average of the three voltage phases of the 400 c/s output to within ± 2 per cent. Voltage and frequency controls are provided on the front of the panel.

DESCRIPTION

3. The components of the control panel are housed within a rectangular light alloy case (*fig.* 1), intended for mounting on a standard tray. The larger components are mounted on the main chassis (*fig.* 2 and 3), which has a fixed front plate and detachable cover; smaller components are mounted on insulating panels at each side of the main chassis (*fig.* 4 *and* 5), and on a panel over the chassis deck at the rear of the control panel.

4. A list of all the components in the control panel, with their values and Reference numbers, is given in Table 1. A diagram showing the connections between the various items of equipment is given in fig. 17, and a theoretical circuit diagram of the complete installation appears on fig. 12.

Electrical circuits

5. The theoretical circuit diagram may be considered under the following main sections:—

(1) The frequency control circuit connected to the motor control field.

(2) The 1,600 c/s voltage control circuit connected to the 1,600 c/s generator control field.

(3) The 400 c/s voltage control circuit connected to the 400 c/s generator field.

(4) The overvoltage and overfrequency protective circuits.

6. The principal circuits of the inverter are shown in the circuit diagram in fig. 12. The motor and the 1,600 c/s generator both have

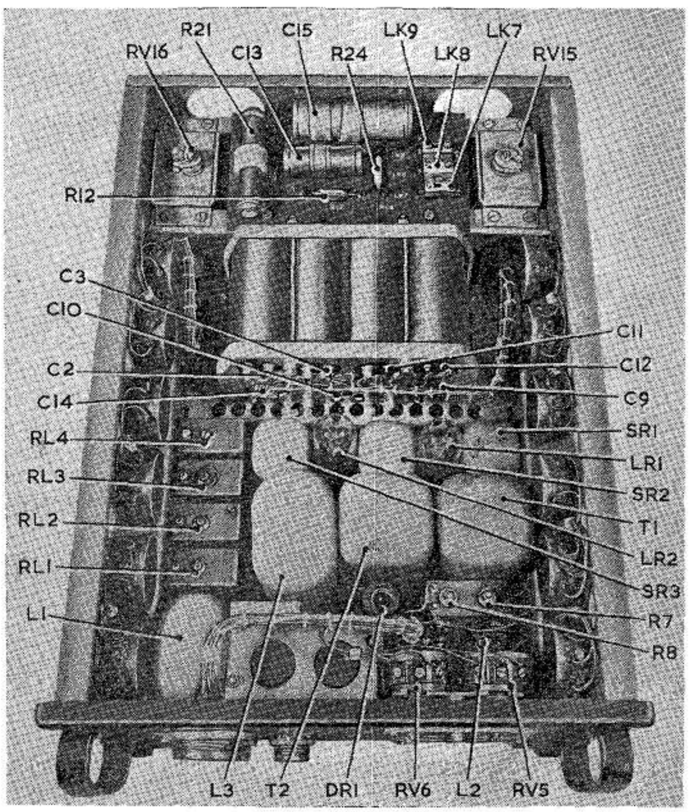

Fig. 2. Control panel chassis from above

TABLE 1
List of components

Item	No. off	Ref. No. or Joint Service Ref.	Rating	Type
Transformers				
T1	1			MD380A
T2	1			MD381A
Saturable reactors				
SR1, SR2, SR3	3			MR413A
SR4, SR5, SR6	3			MR414A
Reactors				
L1	1			MR415A
L3	1	5UC/5945		MR412A
Variable reactor				
L2A & B	1			MR416B
Relays				
RL1, RL2	2	10F/9530355		SM5–N21
RL3, RL4	2	5CW/5131		
Lamp resistors				
LR1, LR2	2	5UC/5978		T24
Thermal delay switch				
DR1	1	10F/9520333		CV342
Fuse links				
F1	1	Z590113	7 amp.	
F2	1	Z590107	250 mA	
Rectifiers				
MR1, MR2, MR3, MR4	4	5UC/5973		FAW AP.7171A
MR5, MR6, MR7	3	5UC/5974		FAX 7126A
Variable resistors				
RV1, RV2, RV3 RV4, RV16	5	10W/9272141	10K, 1W	RAC
RV5, RV6	2	10W/9271305	100 ohm, 1W	RAC
RV7, RV8, RV9	3	10W/9271051	5 ohm, 1W	RAC
RV10, RV11, RV12	3	10W/19211	1 ohm, 1W	RAC
RV13, RV14	2	10W/9271755	2·5K, 1W	RAC
RV15	1	10W/9271605	1K, 1W	RAC
Capacitors				
C1, C8, C21	3	10C/9115252	2μF, 150V	CP MIN
C2, C3, C11, C12	4	10C/19460	20μF, 150V	
C4	1	10C/9124743	0·01 μF, 350V	CMM3Y
C5	1	10C/9124731	0·0047 μF, 350V	CMM3Y
C6	1	10C/19463	0·035 μF, 150V	
C7	1	10C/19464	0·05 μF, 150V	
C9, C10, C14	3	10C/19461	40 μF, 150V	
C13	1	10C/9115288	0·25 μF, 350V	CP30M
C15	1	10C/19462	8 μF, 150V	
C16	1	10C/9112880	2 μF, 400V	CP10G
C17	1	5UC/5976	1·6 μF, 80V	
C18	1	5UC/5975	0·9 μF, 115V	
C19	1	Z115322	1 μF, 150V	CP MIK
C20	1	Z115317	0·05 μF, 350V	CP30H

Item	No. off	Ref. No. or Joint Service Ref.	Rating	Type
Resistors				
R1	1	10W/9215352	8200 ohm, 0·5W	RC2–D
R2	1	10W/9244236	6200 ohm, 3W	RWV4–J
R3	1	10W/9243317	22 ohm, 3W	RWV4–J
R4	1	10W/9243361	180 ohm, 3W	RWV4–J
R5, R6	2	10W/9243146	330 ohm, 6W	RWV4–L
R7, R8	2	5UC/6018	1500 ohm	
R9	1	10W/9244020	1500 ohm, 15W	RWV5–K
R10, R11, R12	3	10W/9243341	68 ohm, 3W	RWV4–J
R13, R15	2	10W/9243003	10 ohm, 10W	RWV5–J
R14, R21, R25	3	10W/9243180	680 ohm, 15W	RWV5–K
R16, R22	2	10W/9243020	15 ohm, 15W	RWV5–K
R17	1	10W/9243124	180 ohm, 15W	RWV5–K
R18, R19	2	10W/9243136	250 ohm, 15W	RWV5–K
R20	1	10W/9244050	3300 ohm, 6W	RWV4–L
R23, R24	2	10W/9216022	15K, 0·5W	RC2–D
R26	1	10W/9244233	4700 ohm, 3W	RWV4–J
R27	1	10W/9244221	2700 ohm, 3W	RWV4–J
Metrosils				
RX1, RX2, RX3	3	5UC/5673	2·5 mA at 50V	
Plugs				
6-pole	1	Z560080		
12-pole	1	Z560160		
25-pole	1	Z560200		

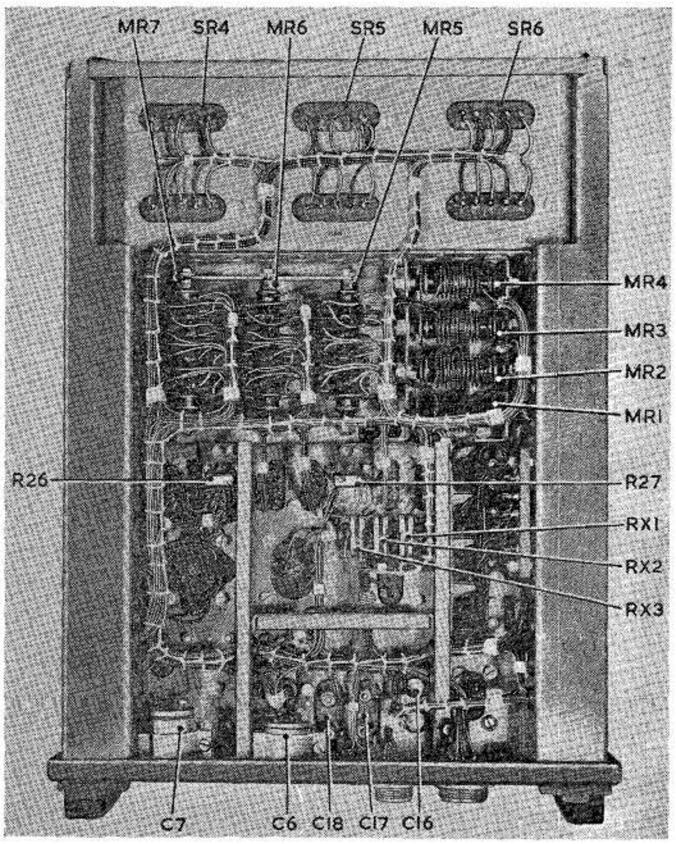

Fig. 3. Control panel chassis from beneath

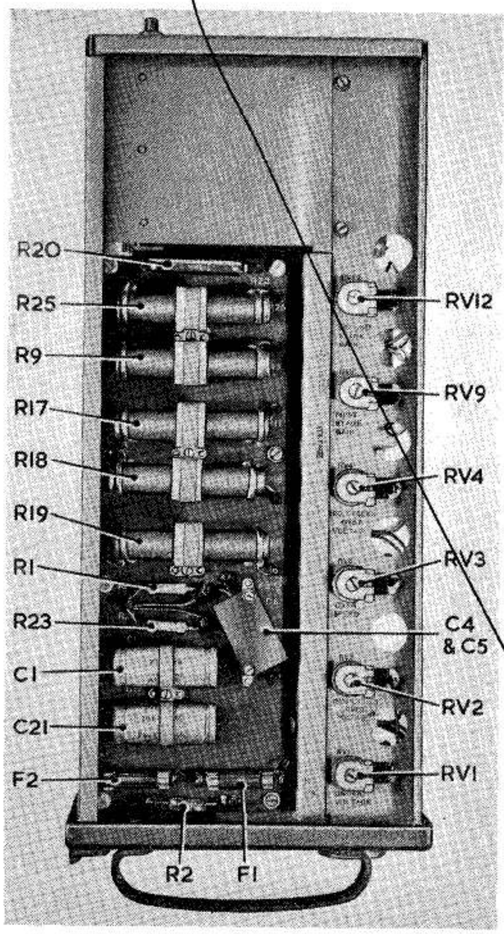

Fig. 4. Control panel chassis, left side

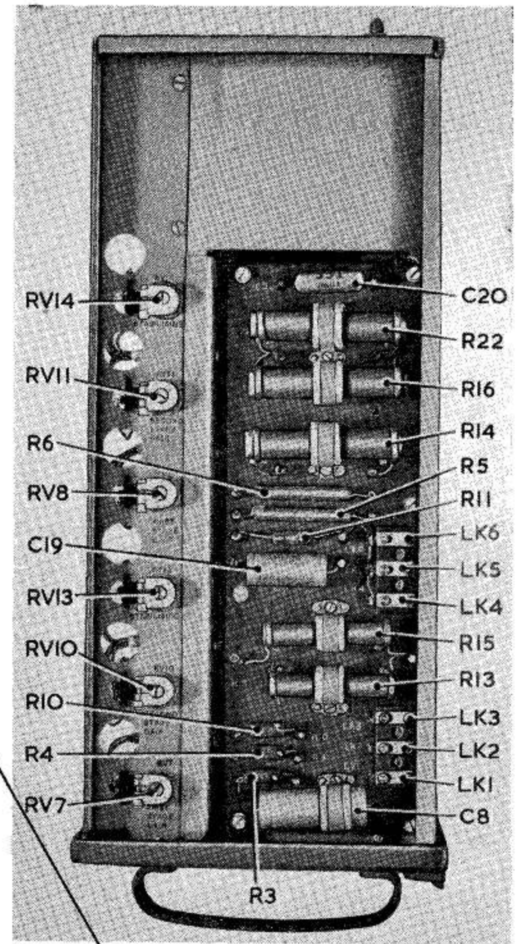

Fig. 5. Control panel chassis, right side

main and control field windings. The main field windings are connected to the d.c. supply through trimmer resistors; the control field windings, and also the 400 c/s generator field winding, are connected to the control panel.

7. The three control circuits, (1), (2), and (3) (*para.* 5), can each be simplified to the circuit shown diagrammatically in block form in fig. 6. Each such simplified circuit comprises:—

(1) A bridge used to detect deviation in the controlled output; the bridge output is approximately proportional to the deviation.

(2) A two-stage magnetic amplifier connected between the bridge output and a field winding in the inverter. This connection is such that the amplified bridge output produces a correction to the inverter output for any detected deviation.

(3) Stabilizing circuits to avoid hunting of the inverter output.

Frequency control circuit

8. The basic circuit of the frequency bridge is shown in fig. 7. It consists of two series resonant circuits, each connected to the 1,600 c/s voltage by a separate winding on transformer T1. The current in each circuit is rectified by MR5, and passed through windings A1–A2 and A3–A2 of saturable reactor SR1. The net output of the bridge, which is the effective control current for this saturable reactor, is the difference between the rectified currents shown as I1 and I2; the bridge may be considered as balanced when these two currents are equal.

9. The circuit comprising reactor L2A and capacitor C6 has a resonant frequency greater than 1,600 c/s, and that comprising reactor L2B and capacitor C7 has a resonant frequency less than 1,600 c/s. The reactors are variable, and balance of the bridge at 1,600 c/s is obtained by manual adjustment. Unbalance in the bridge, due to subsequent deviation in frequency, will alter the effective control current in saturable reactor SR1; the magnitude and polarity of the effective current is dependent upon the magnitude and direction of the deviation in frequency.

10. The first stage of the two-stage magnetic amplifier following the frequency bridge is shown in fig. 8. The amplifier comprises a single-phase bridge arrangement of rectifiers MR5, with main windings T1–T2 and T3–T4 of saturable reactor SR1 connected in series with the two left-hand side rectifiers. The rectifier bridge output is connected to the load, i.e., the control winding A1–A2 on the second stage saturable reactor SR4 in series with resistor R10. Pre-polarization of the magnetic cores of the saturable reactor by a control current shown as I3, i.e., the difference between the output currents of the frequency bridge, determines the a.c. voltage to be supported by the main windings of the reactor in each half cycle of the a.c. supply prior to core saturation. The voltage not supported by the reactor in each half cycle appears across the load. Maximum output is obtained when the cores are pre-polarized into saturation in the same direction as that engendered by load current; minimum output is obtained when the pre-polarization is in the opposite direction.

11. Typical control characteristics of this type of magnetic amplifier are indicated in fig. 8. Curves A, B and C relate to different settings of the gain control trimmer RV7. This adjustment of gain is made possible because a portion of the rectified load current, dependent upon the setting of RV7, passes through control winding A4–A5, thus introducing positive (or negative, if winding A4–A5 is reversed) current feedback to the amplifier. With reference to fig. 8, curve A is obtained with no current in winding A4–A5, curve B with a certain amount of positive current feedback, and curve C with the winding reversed, i.e., negative current feedback.

12. The second stage amplifier, comprising saturable reactor SR4 and rectifier MR8, is shown in fig. 9. Although the rectifier arrangement is different, the principle of operation is similar to that of the first stage. Rectifier MR8 consists of sections in series with the saturable reactor and a separate bridge section connected to the load. Gain control is effected by adjustment of trimmer RV10. The control signal for this stage is the output of the first stage passing through

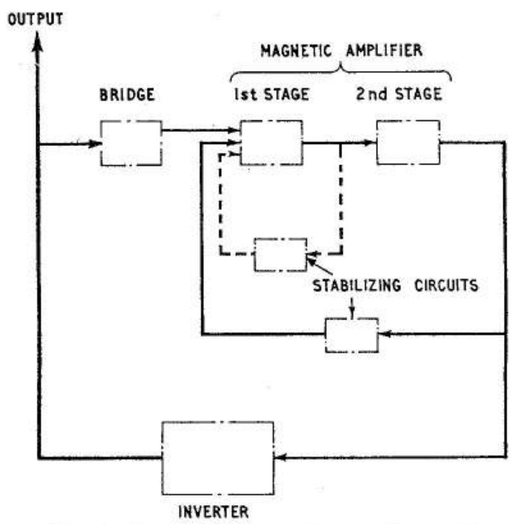

Fig. 6. Block diagram of control circuit

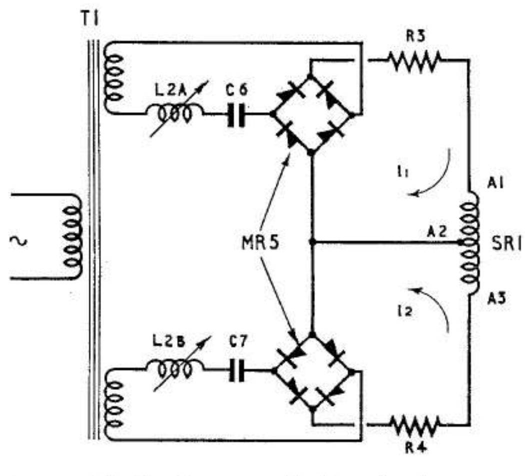

Fig. 7. Frequency bridge circuit

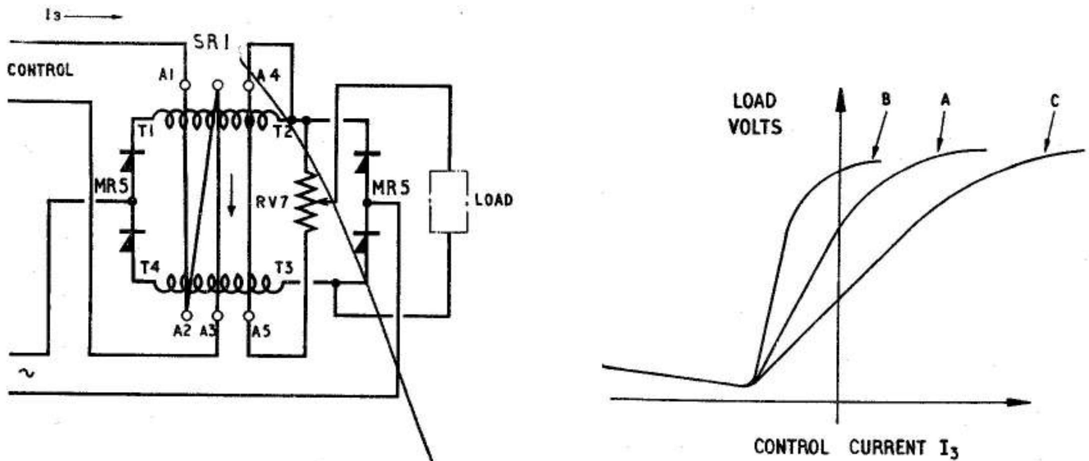

Fig. 8. First stage of magnetic amplifier

winding A1–A2. A fixed bias signal, obtained from the d.c. supply is applied to the winding A3–A4; this bias is necessary since a reversible signal is required to control this type of amplifier over its full output range.

13. The amplifiers are connected so that an increase in frequency above normal, increases the output of both stages; the resulting increase in motor field excitation tends to reduce the motor speed, and thus restore frequency to normal. The amplifiers are designed to produce full swing in motor field current for only a small change in frequency, and the control panel is thus capable of maintaining frequency within close limits under normal operating conditions.

14. The frequency control is stabilized to avoid hunting by the use of transient negative feedback from the motor control field current into the first stage amplifier control winding. This circuit comprises resistors R13 and R15, across which is produced a voltage proportional to the field current, capacitors C9 and C10, and variable resistor RV13. Optimum stability of control is obtained by adjustment of resistor RV13.

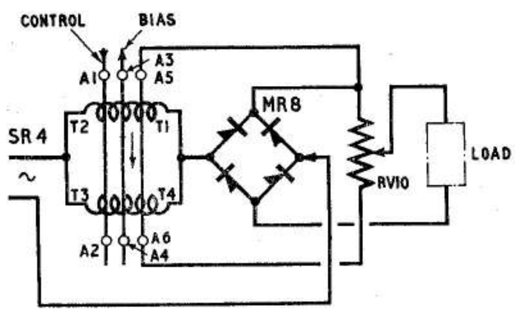

Fig. 9. Second stage of magnetic amplifier

1,600 c/s voltage control circuit

15. The voltage bridge (*fig.* 10) consists of a linear arm, resistors R5 and RV5, and a non-linear arm, lamp LR1. These arms are connected to the 1,600 c/s supply through separate windings on transformer T1. The current in each arm is rectified by MR6, and passed through windings A1–A2 and A3–A2 of saturable reactor SR2; the net output from the voltage bridge is the difference between the rectified currents shown as I4 and I5. The balance is obtained when I4 and I5 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 RV5 in the linear arm. The voltage bridge responds to the RMS value of the 1,600 c/s voltage since the non-linear arm consists of a filament lamp, the resistance of which depends upon the heating effect, or RMS value, of the voltage.

16. The two-stage magnetic amplifier, comprising saturable reactors SR2 and SR5 and rectifiers MR6 and MR9, is similar to that used in the frequency control circuit except for the matching of the two stages. The amplifiers are connected so that an increase in the output of the first stage produces a decrease in the output of the second stage; this differs from the frequency control circuit. Adjustment of amplifier gain can be effected by trimmers RV8 and RV11.

17. The control circuit is arranged so that a fall in 1,600 c/s voltage produces a reduction in the output of the first stage, and hence an increase in the output of the second stage connected to the 1,600 c/s generator control winding. The increase in generator excitation tends to correct any fall in voltage detected by the bridge, and the amplifiers have sufficient gain to maintain the 1,600 c/s voltage within close limits under normal operating conditions.

18. The 1,600 c/s voltage control circuit is stabilized to avoid hunting by the use of transient negative feedback derived from generator field current and also from first stage output current. Voltages proportional to these two currents are obtained across resistors R16 and R22 and resistor R11 respectively. Adjustment of stability is obtained by means of variable resistors RV14 and RV15.

19. Resistors R7 and R26 in parallel with lamp LR1 provide compensation for changes that would otherwise occur in the balance setting for the control circuit with changes in ambient temperature. Resistor R7 is wound with nickel wire having a relatively high temperature coefficient, so that when the ambient temperature rises, the current in this circuit decreases. This current is added to that of the non-linear arm of the voltage bridge, and the change with temperature is such as to provide the desired temperature compensation, the 1,600 c/s voltage being maintained with the necessary tolerance over a wide temperature range.

400 c/s voltage control circuit

20. The voltage bridge of the 400 c/s control is similar to that used in the 1,600 c/s voltage control circuit. The supply to the bridge is obtained from the 400 c/s, three-phase voltage through a positive phase sequence circuit which effectively averages the three line voltages. The circuit is shown in fig. 11. The output voltage Em from this circuit is obtained between points 112 and 114, and is greater than the line voltage for the indicated positive sequence of phases A, B and C.

21. If the sequence of the phases is reversed, for instance by the interchanging of phases B and C, a negative phase sequence results and the output voltage Em becomes zero, providing the system is balanced. Now, any unbalanced three-phase voltage will give co-existent positive and negative phase sequence components, which in themselves are balanced three-phase voltages; the proportion of negative to positive sequence components will increase with the voltage unbalance. In the circuit shown in fig. 11 the output voltage Em is proportional to the positive phase sequence component of the unbalanced voltage, the negative sequence component being ignored. The positive sequence voltage is approximately proportional to the average of the three line voltages in the event of phase unbalance. The voltage Em is applied to the voltage

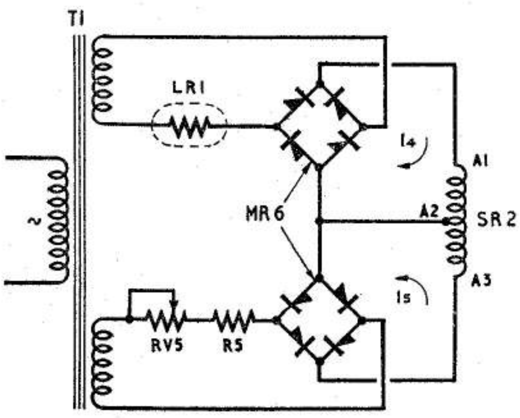

Fig. 10. Voltage bridge circuit

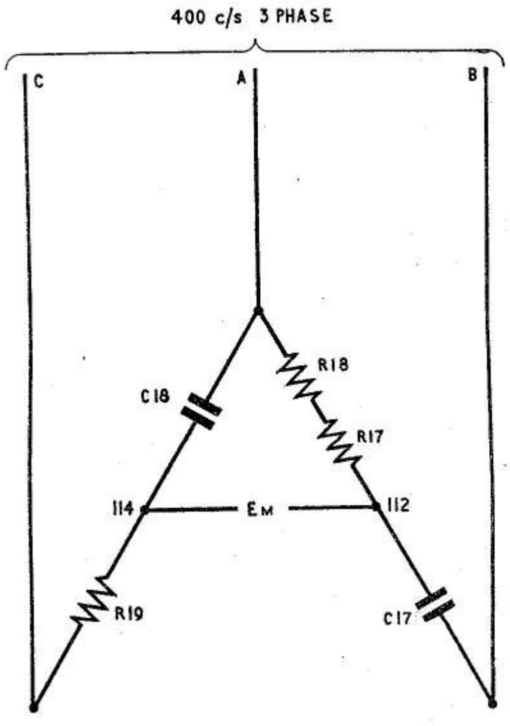

Fig. 11. Positive phase sequence circuit

bridge through transformer T2, and the control circuit will function to maintain constant the average of the three-phase voltages.

22. The two stage amplifier is similar to that used in the frequency control circuit. Any increase in the output from the first stage produces an increase in output from the second stage, otherwise the control functions in a similar manner to that for the 1,600 c/s generator. Adjustment of amplifier gain may be effected by trimmers RV9 and RV12.

23. Adjustment of the 400 c/s voltage is obtained on variable resistor RV6. Temperature compensation is provided by the connection of resistors R8 and R27 in parallel with the lamp LR2; resistor R8 is wound with nickel wire.

24. Stabilization of the control circuit is effected by the use of transient negative feedback derived from the output voltage of the second amplifier stage. Stabilization adjustment is obtained by means of variable resistor RV16. Capacitor C13 filters objectionable ripple, so avoiding the feedback of this ripple into the first stage.

Protective circuits

25. The following relay circuits are provided in the control panel for protective purposes:—

(1) Relay RL3 operates in the event of an overvoltage of the 1,600 c/s voltage or in the event of overfrequency.

(2) Relay RL4 operates in the event of an overvoltage of the 400 c/s voltage.

(3) Relay RL1 operates at a low 1,600 c/s voltage, and is connected to provide no-volt protection.

26. Contacts on these relays are wired to the 6-pole plug connected to the inverter. A normally-closed circuit is provided between pins D and E and a normally-open circuit between pins F and E. The 6-pole plug is connected to the inverter and, to obtain protection, connections should be made from pins A and B of the 3-pole socket on the inverter to the supply circuit breaker (*fig.* 17). The breaker coil circuit shown in that figure requires a normally-open (make) protective circuit. The normally-closed (break) protection circuit can be connected, if required, to pins A and B of the 3-pole socket by adjustment of a link inside the box on the inverter.

27. In the control panel, the coil of relay RL3 is connected to two circuits, one voltage sensitive and the other frequency sensitive. The voltage sensitive circuit consists of a variable resistor RV2, rectifier MR2, Metrosil resistor RX2, and the coil of the relay RL3 connected in series across the 1,600 c/s supply. The non-linear resistance of the Metrosil RX2 enhances the voltage sensitivity of this circuit. Overvoltage setting is obtained by adjustment of variable resistor RV2. The relay is operated by d.c. produced by the rectifier MR2 and smoothed by capacitor C2. This capacitor also slugs the operation of the relay, so avoiding operation during switching surges.

28. The frequency sensitive circuit comprises capacitor C4, reactor L1, resistor RV3, rectifier MR3 and the coil of relay RL3. Capacitor C4 and reactor L1 are connected to a portion of the 1,600 c/s voltage obtained from a tapping on transformer T1. The resonant frequency of this series capacitor-reactor circuit is greater than 1,600 c/s, and, at 1,600 c/s, the voltage across capacitor C4 is approximately equal to the supply voltage. Hence, the voltage between points 29 and 11 is small at normal frequency. As the frequency rises above normal, the voltage applied to the relay circuit, points 29 and 11, rapidly increases, and at 25 per cent overfrequency, sufficient current flows through this circuit to operate the relay. Adjustment of the overfrequency setting is obtained by variable resistor RV3. Additional trimmers R1 and R23 are provided, either or both of which may be short-circuited to obtain the desired overfrequency setting. Variable resistors RV2 and RV3 are adjusted to obtain operation of relay RL2 at 125 per cent normal voltage (143 volts) when the frequency is 1,600 c/s, and at 125 per cent frequency (2,000 c/s) when the voltage is normal (115 volts).

29. Protection against loss of voltage from the 1,600 c/s generator is desirable, since without this voltage the motor control field would be unexcited, and the motor, having only a small main field, would run at excessive speed. Protection against this condition is provided by the circuit comprising variable resistor RV1, rectifier

MR1, Metrosil resistor RX1 and the coil of relay RL1. This circuit de-energizes relay RL1 in the event of loss of 1,600 c/s voltage. A normally-open contact of relay RL1 is provided in the normally-closed protective circuit, pins D to E, and a normally-closed contact in the normally-open protective circuit, pins F to E. In order that the inverter may be started, it is arranged that these contacts are not effective in the protective circuit until a short time after starting. This delay is provided by thermal delay switch DR1 in the coil circuit of relay RL2.

30. The heater of switch DR1 is connected initially to a secondary winding on transformer T1. A bi-metallic strip in the switch, carrying a contact, slowly distorts when the heater is energized; after about a minute the movement is sufficient to close the contact and relay RL2 operates. The coil of relay RL2 is excited from the d.c. supply, and locks itself in through contact RL2a, which also disconnects the heater supply from switch DR1.

31. Protection against 400 c/s overvoltage is obtained from the circuit comprising relay RL4, Metrosil resistor RX3, rectifier MR4 and variable resistor RV4, which are connected to phases A and B of the 400 c/s output. The non-linear resistance of the Metrosil RX3 enhances the voltage sensitivity of this circuit. The relay is operated by d.c.; the overvoltage setting is adjusted by the variable resistor RV4, the relay being set to operate when the 400 c/s voltage rises to 125 per cent of the normal value, i.e., 143 volts.

Auxiliary circuits

32. A simple filter consisting of capacitor C16 and reactor L3 resonating at about 1,600 c/s is connected in parallel across the 1,600 c/s supply. This filter assists in smoothing waveform distortion produced by the magnetic amplifiers in the panel. 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 amplifiers has a high harmonic content. Bad distortion of the 1,600 c/s voltage waveform results if this current passes through the relatively high reactance of the 1,600 c/s a.c. generator. The function of the capacitor C16 is mainly to absorb these harmonic currents, and reactor L3 may be regarded as a means of correcting the power factor of the current taken from the a.c. generator at fundamental frequency.

INSTALLATION

33. The control panel and rectifier unit are intended for mounting in standard trays. The tray holding the control panel must have resilient mountings to protect the two lamps in the panel from damage due to vibration. Although the control panel and rectifier unit will normally be fitted into standard trays in a horizontal plane, they may be mounted at any convenient angle provided they are adequately secured.

34. The units should be installed in positions allowing free circulation of cooling air. When mounted one above the other, they should be separated by a reasonable vertical distance of approximately 4 in.

35. The interconnections between the various components are shown in fig. 17. A 25-core cable connects the control panel and rectifier unit, and one 12-core and one 6-core cable connects the control panel to the inverter. The length of the 12 and 6-core cables should not exceed 15 feet, otherwise poor regulation of a.c. generator voltages will occur.

36. The hold-in circuit of the circuit breaker connecting the d.c. supply to the inverter is connected to pins A and B of the socket on the inverter. This connection provides protection against overvoltage or over-frequency, since it places the normally-open protective circuit of the control panel in series with the grip coil. The circuit shown in fig. 17 requires a normally-open protective circuit, but other circuit breaker control systems may require a normally-closed circuit to initiate the tripping of the circuit breaker. Provision for this alternative is made by incorporation of a link box on the inverter, whereby the required circuit, either break or make, can be selected. The position of the link should be examined upon installation of the inverter.

OPERATION

Starting

37. With the control panel, rectifier unit and inverter connected as shown in fig. 17, the inverter may be started by a switch which initiates the closing of the circuit breaker. The inverter has a single-stage starting relay, and it will run rapidly up to speed under control of the panel.

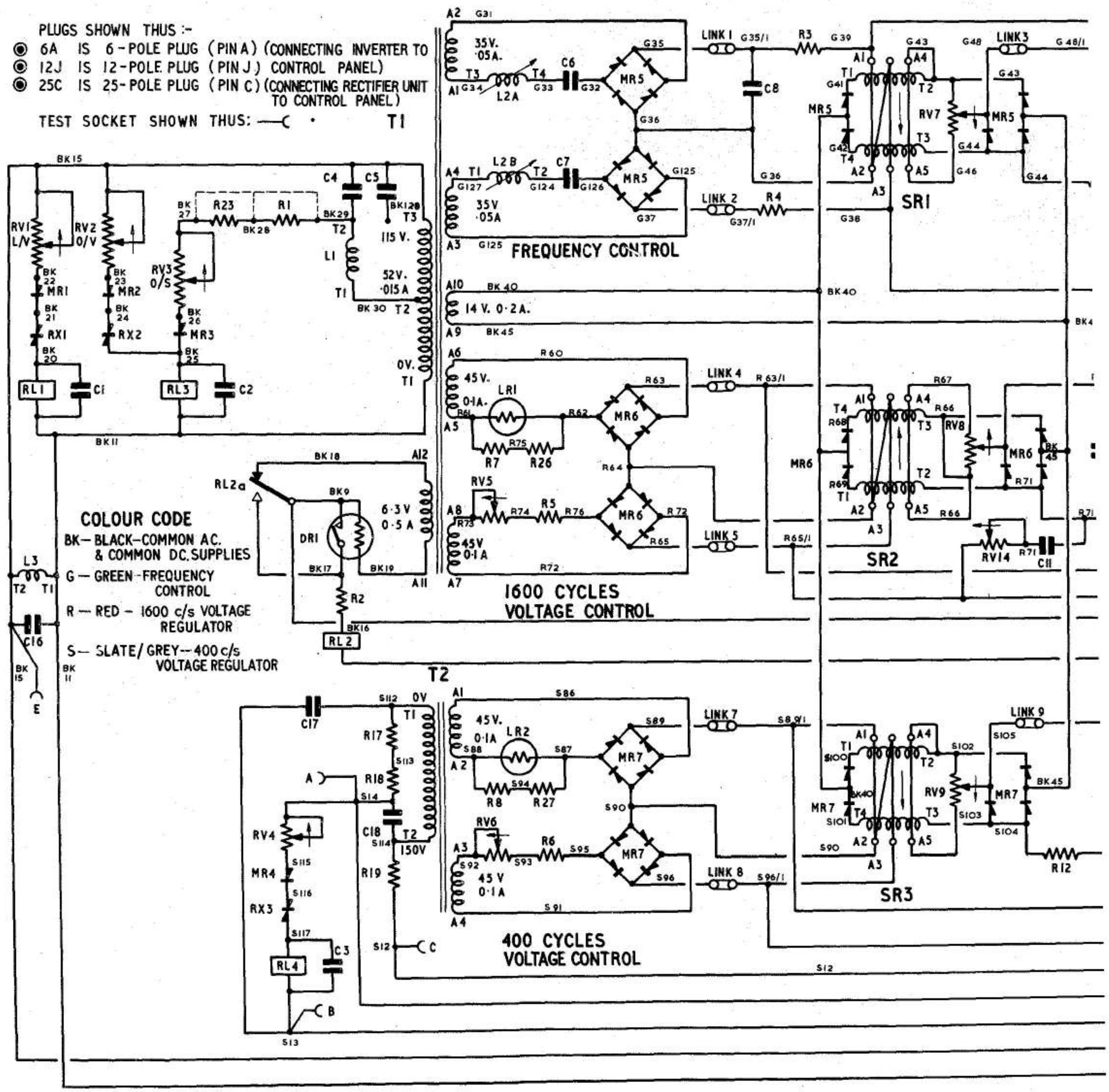

Fig. 12

Theoretical c

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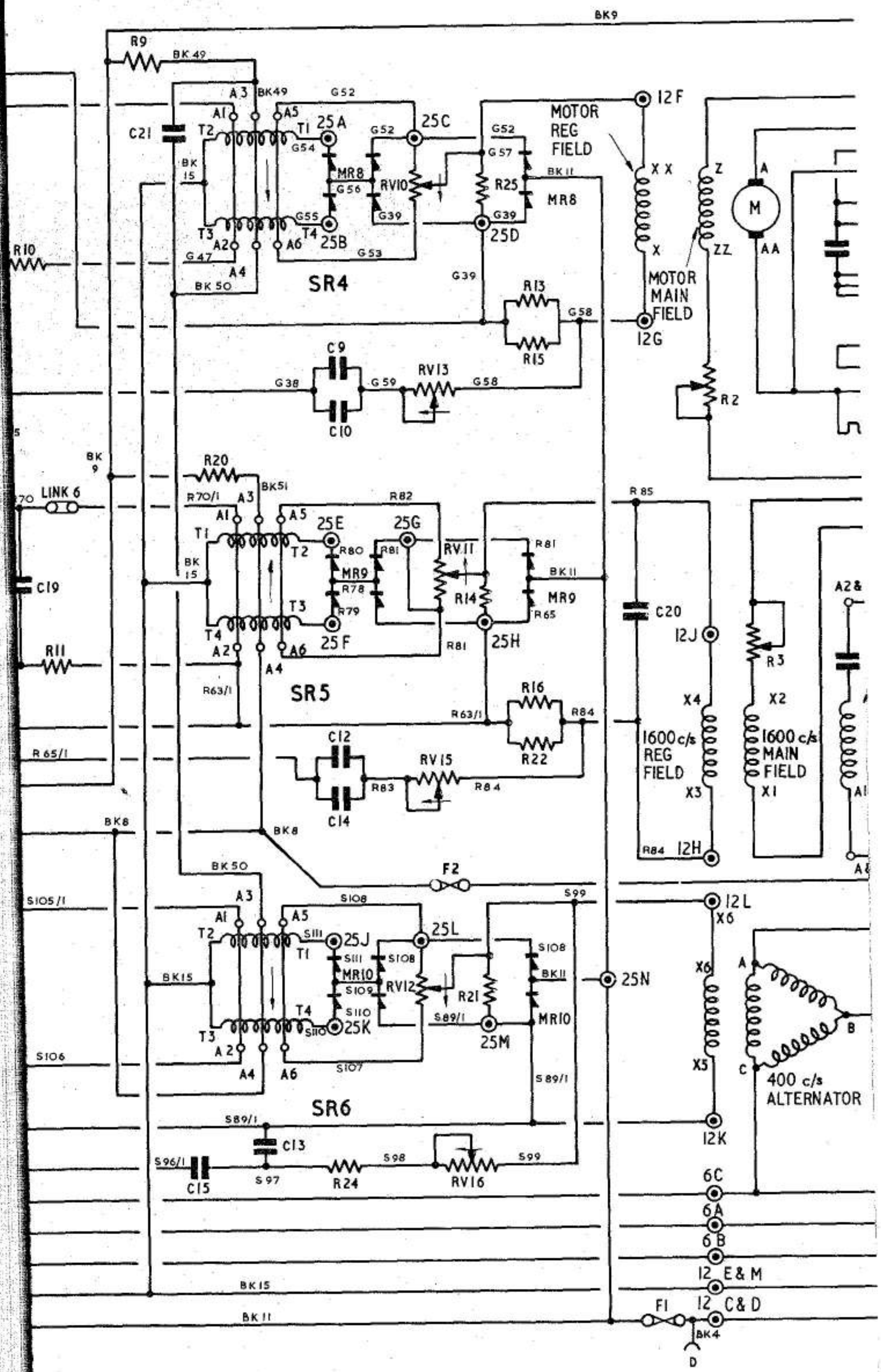

ircuit diagram

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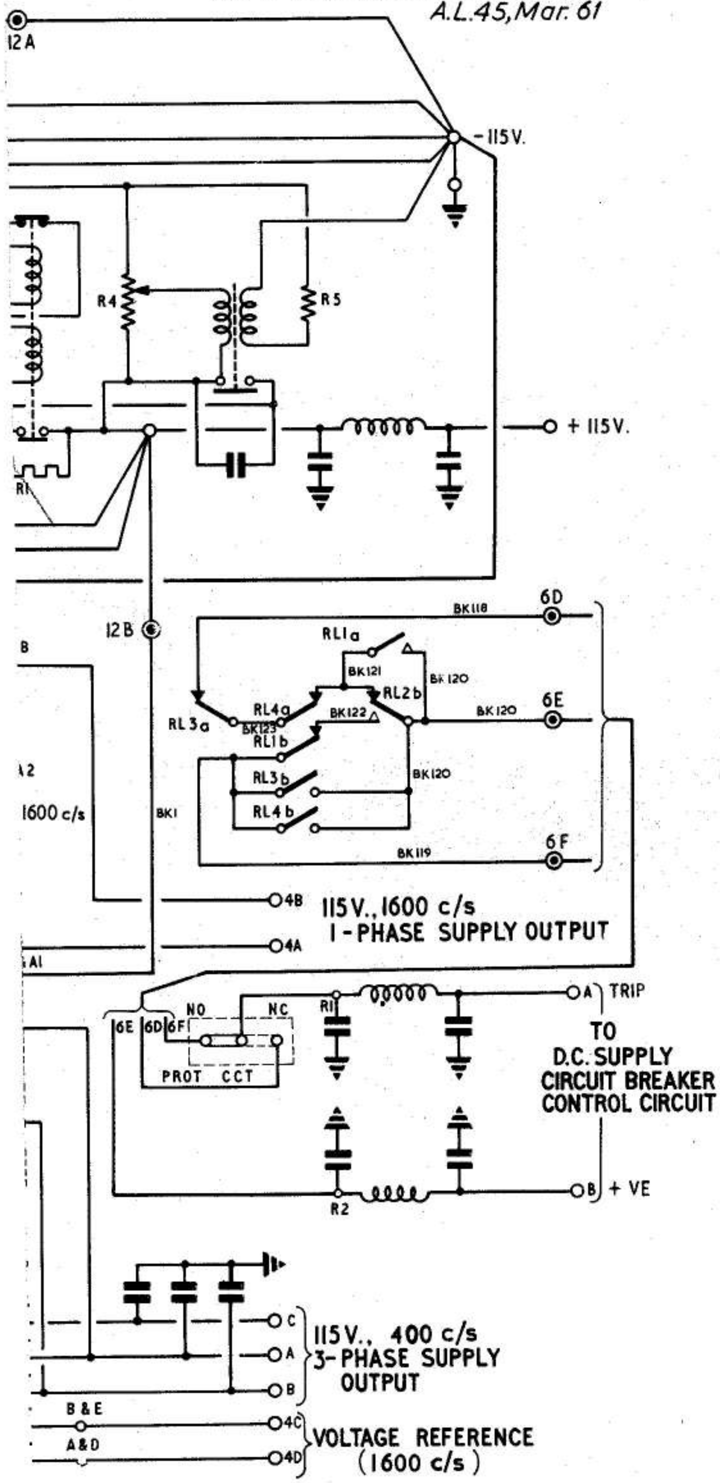

12A
-115V.
R4
R5
R1
+ 115V.
12B
B
A2
1600 c/s
BK1
BK118
6D
RL1a
BK121
BK120
RL2b
RL4a
RL3a
BK123
BK122
RL1b
BK120
6E
BK120
RL3b
RL4b
BK119
6F
4B
115V., 1600 c/s
1-PHASE SUPPLY OUTPUT
4A
A1
6E
6D
6F
NO
NC
PROT CCT
R1
A
TRIP
TO
D.C. SUPPLY
CIRCUIT BREAKER
CONTROL CIRCUIT
B
+ VE
R2
C
A
B
115V., 400 c/s
3-PHASE SUPPLY
OUTPUT
B & E
A & D
4C
4D
VOLTAGE REFERENCE
(1600 c/s)

Fig. 12

38. The 1,600 c/s output must be unloaded during starting, but it may be loaded as soon as voltage and frequency control has been established. The 400 c/s output may be connected to its load during starting.

39. The d.c. supply voltage must not be outside the specified range of 100 to 115 volts at the inverter terminals. Unsatisfactory performance will result when the d.c. supply voltage is outside this range.

40. It is recommended that the setting of the a.c. generator voltages at 115 volts (R.M.S.) and the frequency at 1,600 c/s be checked when the control panel is used for the first time after installation. Instructions for the trimming of voltage and speed settings will be found in para. 41 to 45.

SERVICING

41. After installation, and at regular intervals during service, the voltage and frequency settings must be checked. The a.c. generator voltage should be 115 volts (R.M.S.), and the frequency 1,600 c/s. If the voltage or speed is incorrect, correction must be made by adjustment of the control trimmers which are accessible from the front of the control panel. Adjustment should be made first to the 1,600 c/s voltage trimmer, then to the frequency trimmer and the 400 c/s voltage trimmer.

42. The 1,600 c/s voltage should be measured on a thermal type meter, such as Ref. No. 5Q/462, since the regulator controls the R.M.S. value of a.c. generator voltage. This voltage should be measured at the junction of the voltage reference leads to the 1,600 c/s supply. It should be noted that the reference leads from pins C and D on the 1,600 c/s output plug on the inverter are connected to the supply leads, pins A and B, at the load end of the cable.

Note . . .

In some early inverters, links are provided in the box on the inverter for monitoring the voltage either as described above, or at the machine terminals. If the links are connected for control of terminal voltage, the 1,600 c/s voltage should be measured at the output terminals and not at the junction of the reference leads.

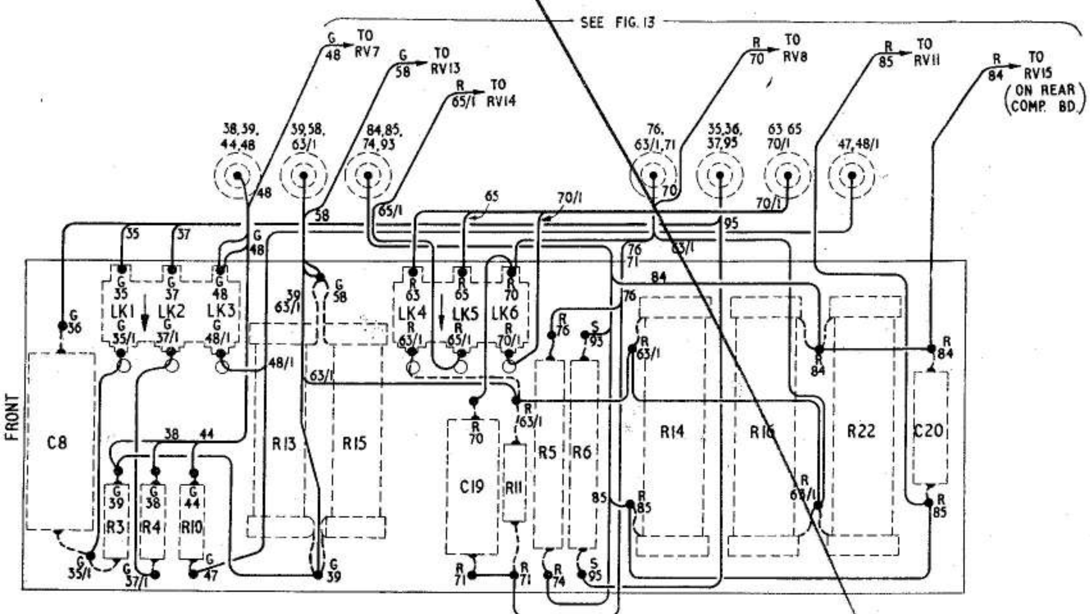


Fig. 14. Wiring diagram — Back of R.H. component board

43. The frequency should be measured on a suitable frequency meter, such as Ref. No. 5Q/181. As an alternative, the motor speed may be measured with a tachometer; this method is not recommended, however, since it necessitates the removal of the end cover of the inverter.

44. When adjusting the frequency, only the left-hand side adjusting spindle on the variable reactor L2 should be moved. The locking screws, marked L, should be unscrewed sufficiently to release the locking bar. Adjustment should then be made slowly by turning the screwdriver slotted adjustment spindle, marked A. The locking screws must be screwed down, and themselves locked with the nuts provided after adjustment has been completed.

45. Adjustment of the 400 c/s a.c. generator voltage is more readily made with the 400 c/s a.c. generator on no load, since the three line voltages will normally be balanced on no load. If the 400 c/s a.c. generator is loaded, it is necessary to measure all three line voltages and adjust the trimmer until the mean value of the three line voltages is correct. The 400 c/s voltage should be measured at the output terminals on the inverter.

46. The setting of the protective circuits should be checked regularly, and if necessary adjusted as described in para. 67 to 70.

47. The control panel and rectifier unit should be regularly blown out with a jet of dry compressed air, since the accumulation of dust and other foreign matter will be a cause of trouble if it reaches excessive proportions. Further information on servicing the rectifier unit is given in Sect. 19, Chap. 1 of this publication.

Location of faults

48. In the event of failure of the inverter output, first establish whether the fault is in the control panel, the rectifier unit, the inverter or the connecting cabling. 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.

49. If it is established that the fault is in the control panel, remove the cover and examine fuses F1 and F2, also the filaments of lamps LR1 and LR2. Check that all of the links, LK1 to LK9, are firmly secured. Visually inspect the wiring and other components for any obvious cause of failure. Failure could be caused by a breakdown in reverse resistance of any one of the discs of rectifiers MR5, MR6, or MR7; such a fault can be detected by the use of an ohmmeter, but such testing is not recommended as routine procedure, unless it is almost certain that the fault lies in a rectifier, since it necessitates the unsoldering of cables from the rectifier units.

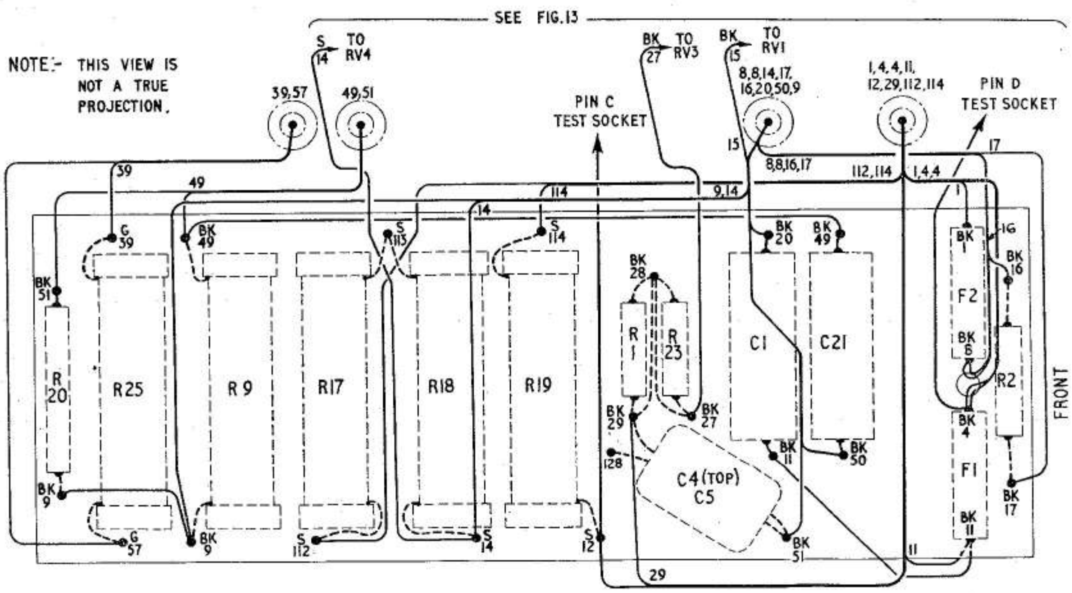


Fig. 15. Wiring diagram — Back of L.H. component board

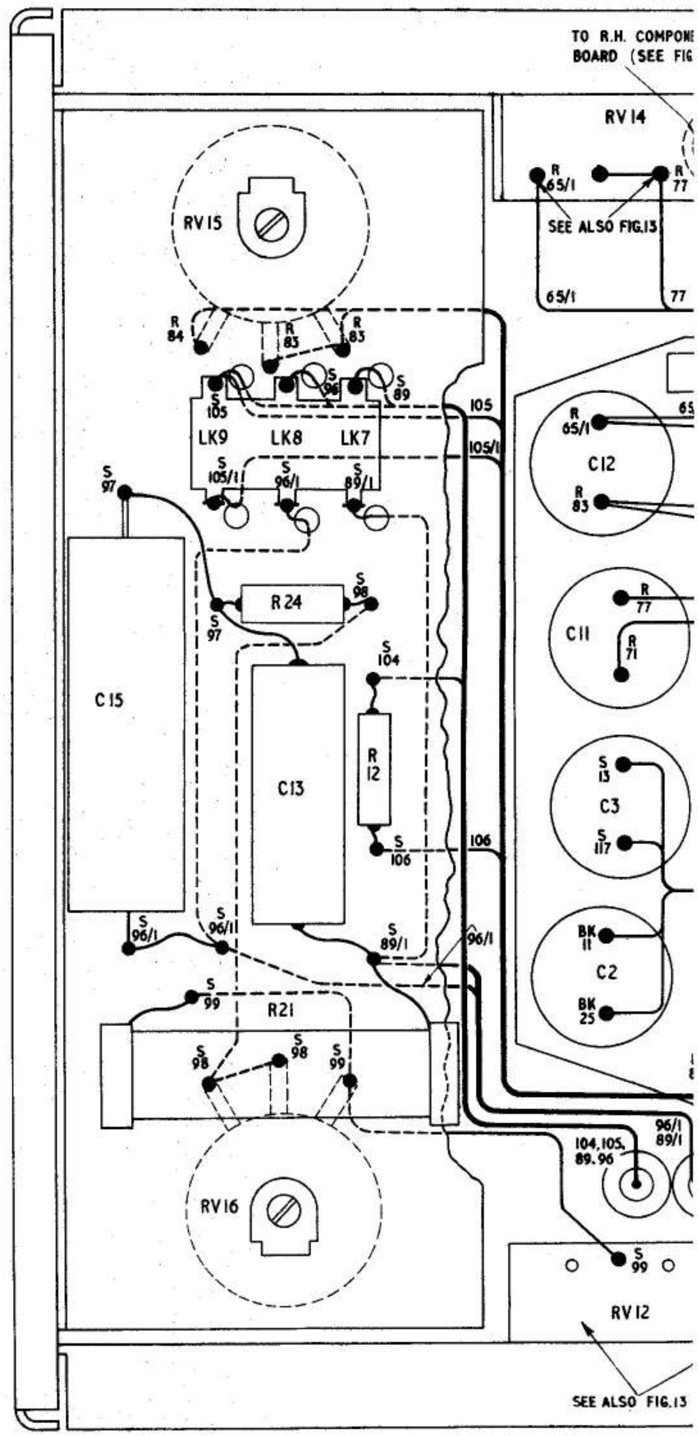
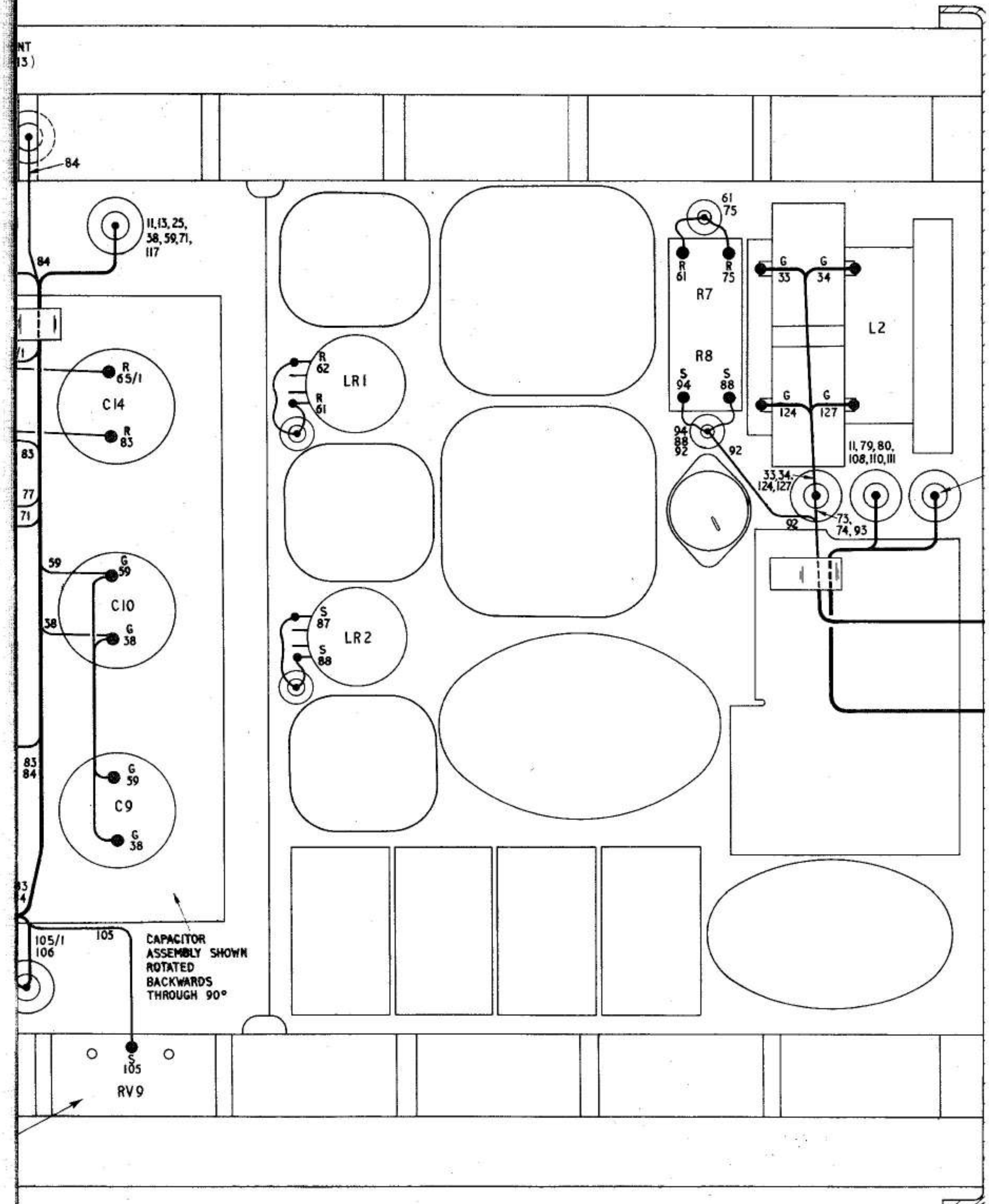


Fig. 16

PP8868 573443 8836 4 61 2131 C & P Gp. 9



Wiring diagram - top of control panel

RESTRICTED

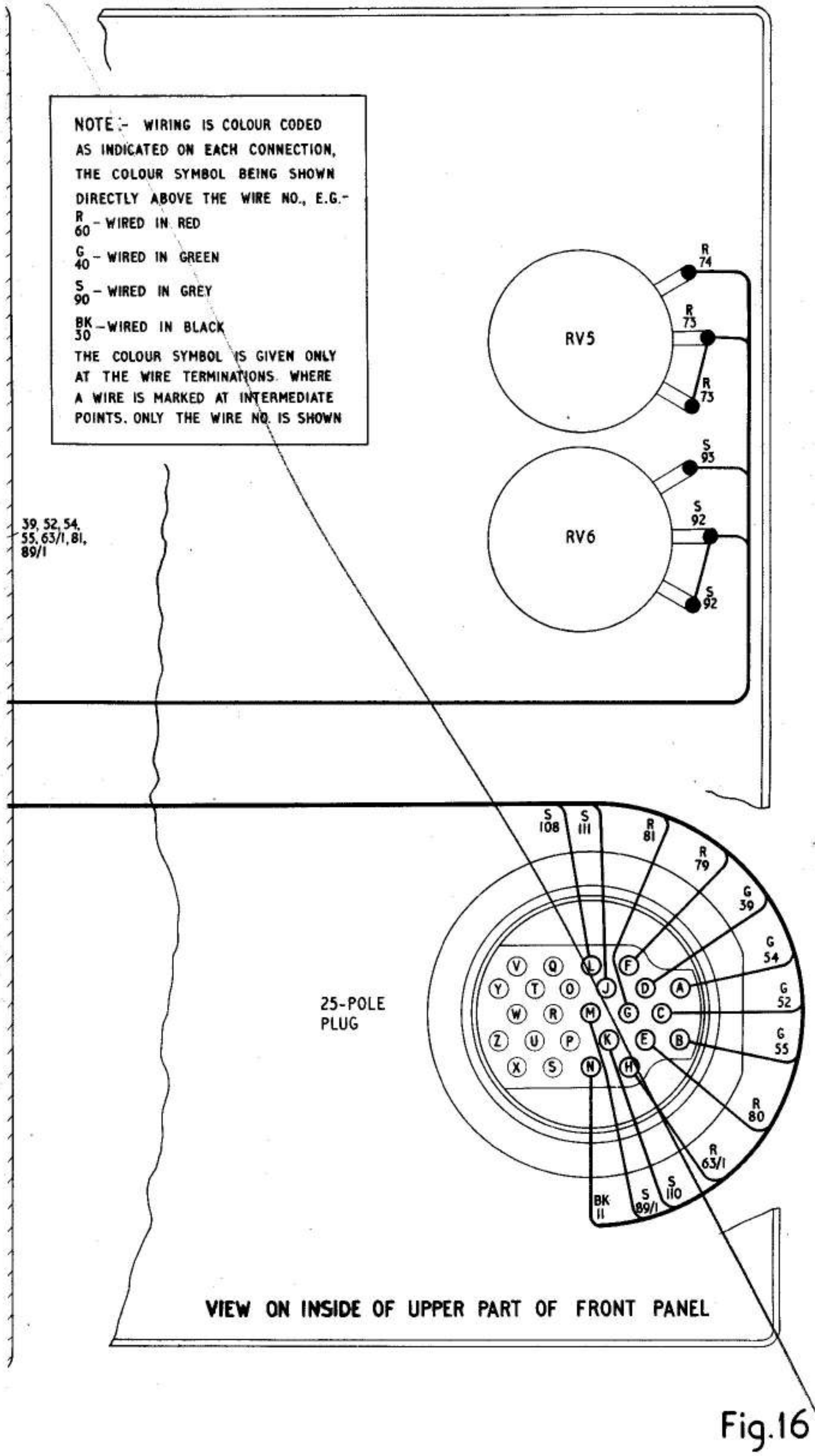

NOTE :- WIRING IS COLOUR CODED AS INDICATED ON EACH CONNECTION, THE COLOUR SYMBOL BEING SHOWN DIRECTLY ABOVE THE WIRE NO., E.G.-
R 60 - WIRED IN RED
G 40 - WIRED IN GREEN
S 90 - WIRED IN GREY
BK 30 - WIRED IN BLACK
THE COLOUR SYMBOL IS GIVEN ONLY AT THE WIRE TERMINATIONS. WHERE A WIRE IS MARKED AT INTERMEDIATE POINTS, ONLY THE WIRE NO. IS SHOWN
RV5
RV6
R 74
R 73
R 73
S 93
S 92
S 92
39, 52, 54, 55, 63/1, 81, 89/1
25-POLE PLUG
S 108
S 111
R 81
R 79
G 39
G 54
G 52
G 55
R 80
R 63/1
S 110
S 89/1
BK 11
VIEW ON INSIDE OF UPPER PART OF FRONT PANEL

Fig.16

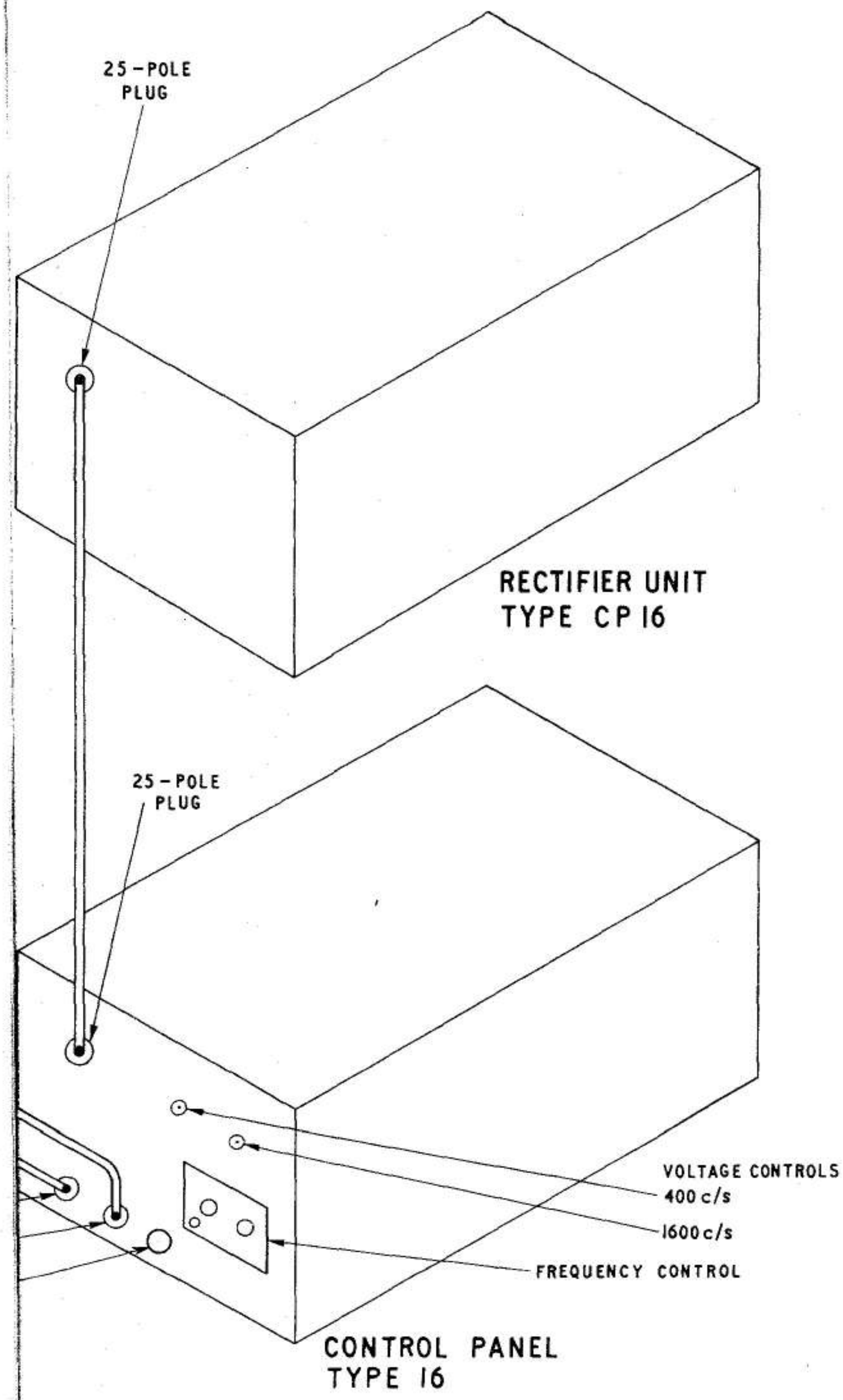

25 - POLE
PLUG
RECTIFIER UNIT
TYPE CP 16
25 - POLE
PLUG
VOLTAGE CONTROLS
400 c/s
1600 c/s
FREQUENCY CONTROL
CONTROL PANEL
TYPE 16

Fig. 17

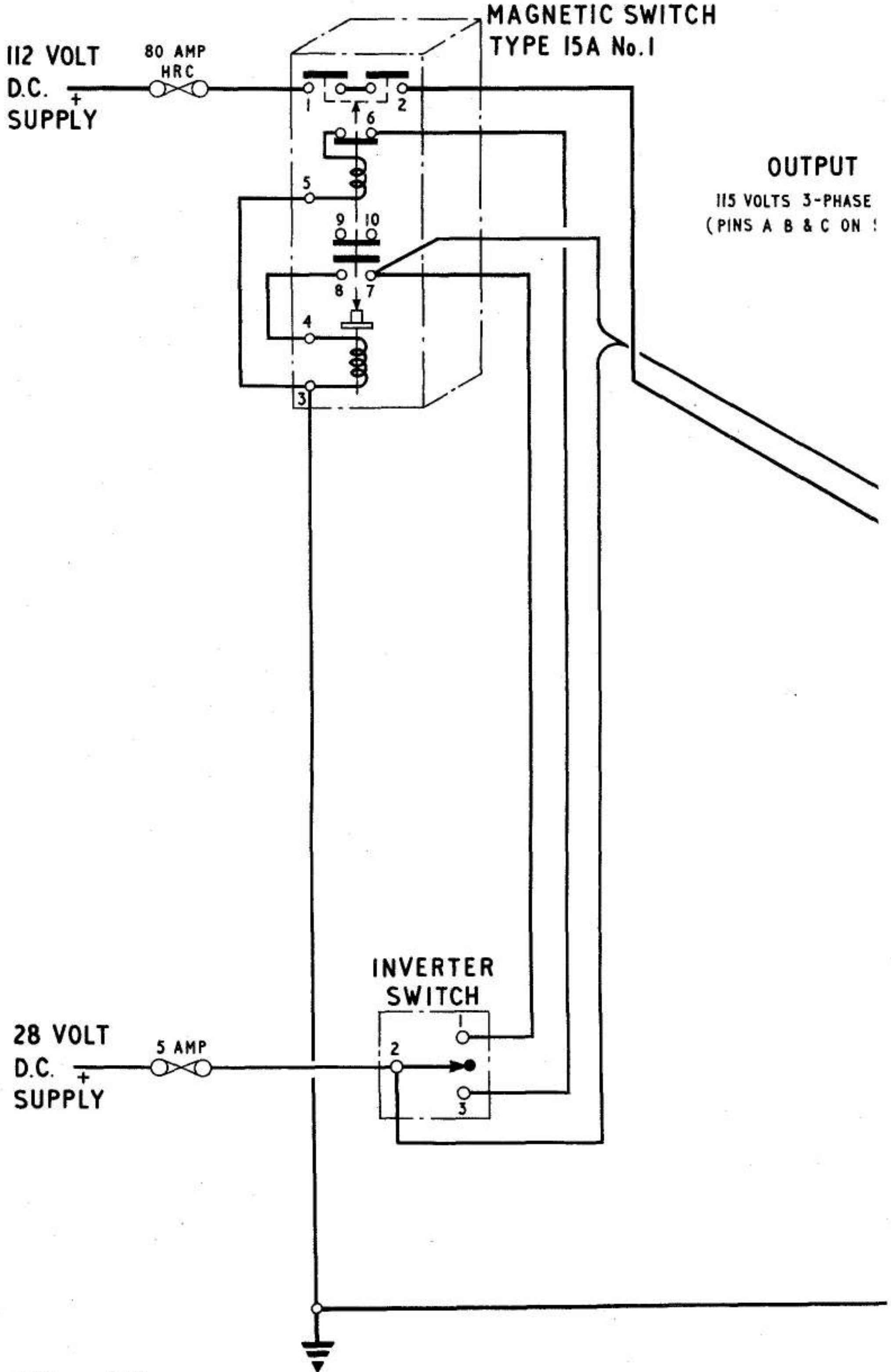

MAGNETIC SWITCH
TYPE 15A No.1
112 VOLT
D.C. +
SUPPLY
80 AMP
HRC
OUTPUT
115 VOLTS 3-PHASE
(PINS A B & C ON
INVERTER
SWITCH
28 VOLT
D.C. +
SUPPLY
5 AMP

Fig. 17

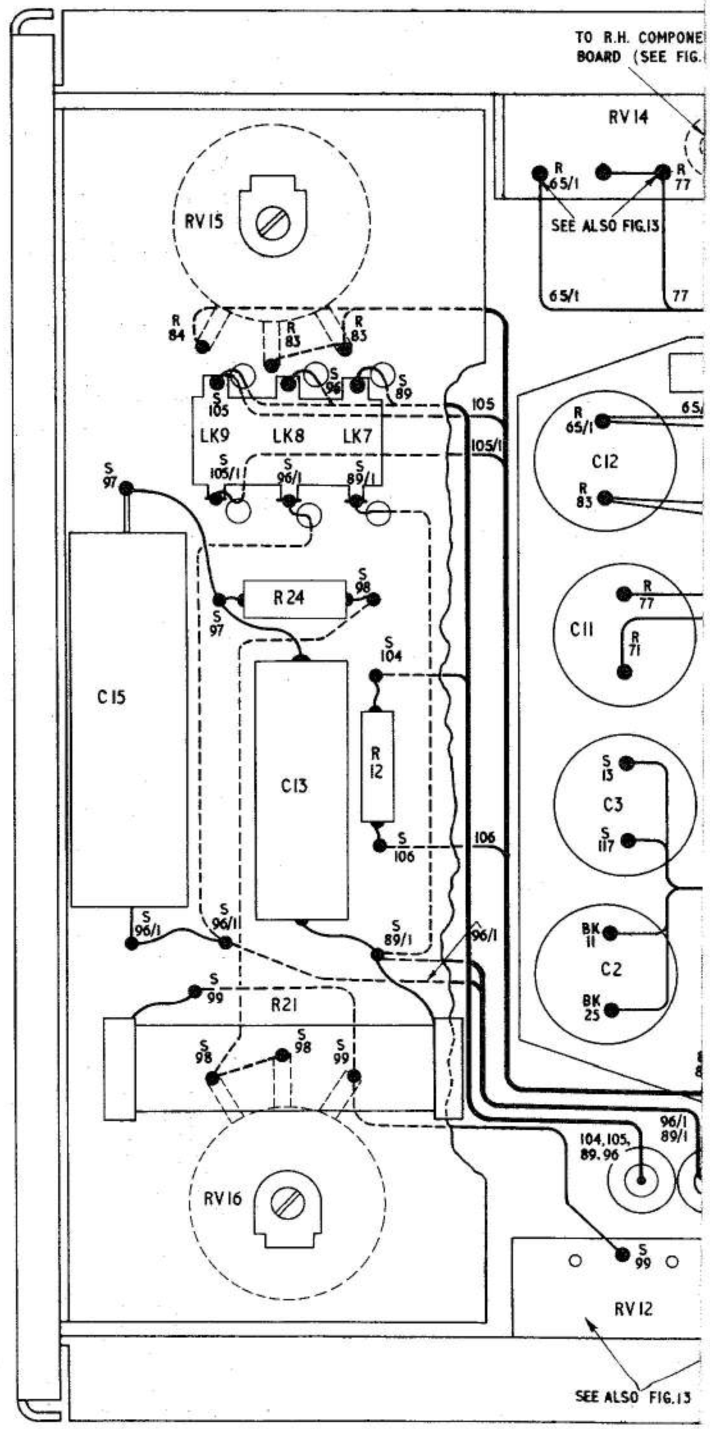
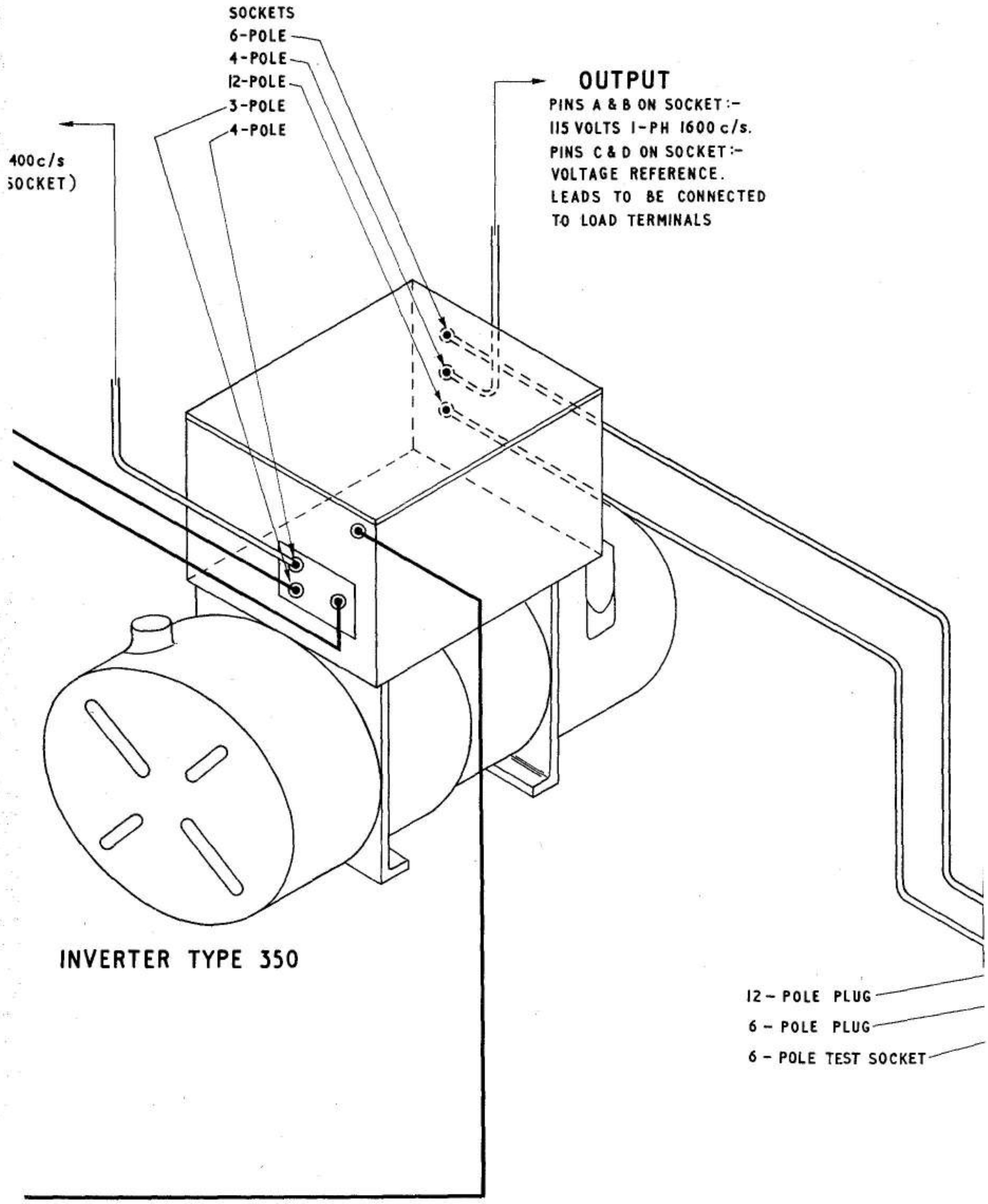


Fig. 16

PP8868 573443 8836 4 61 2131 C&P Gp. 92



Interconnection diagram

RESTRICTED

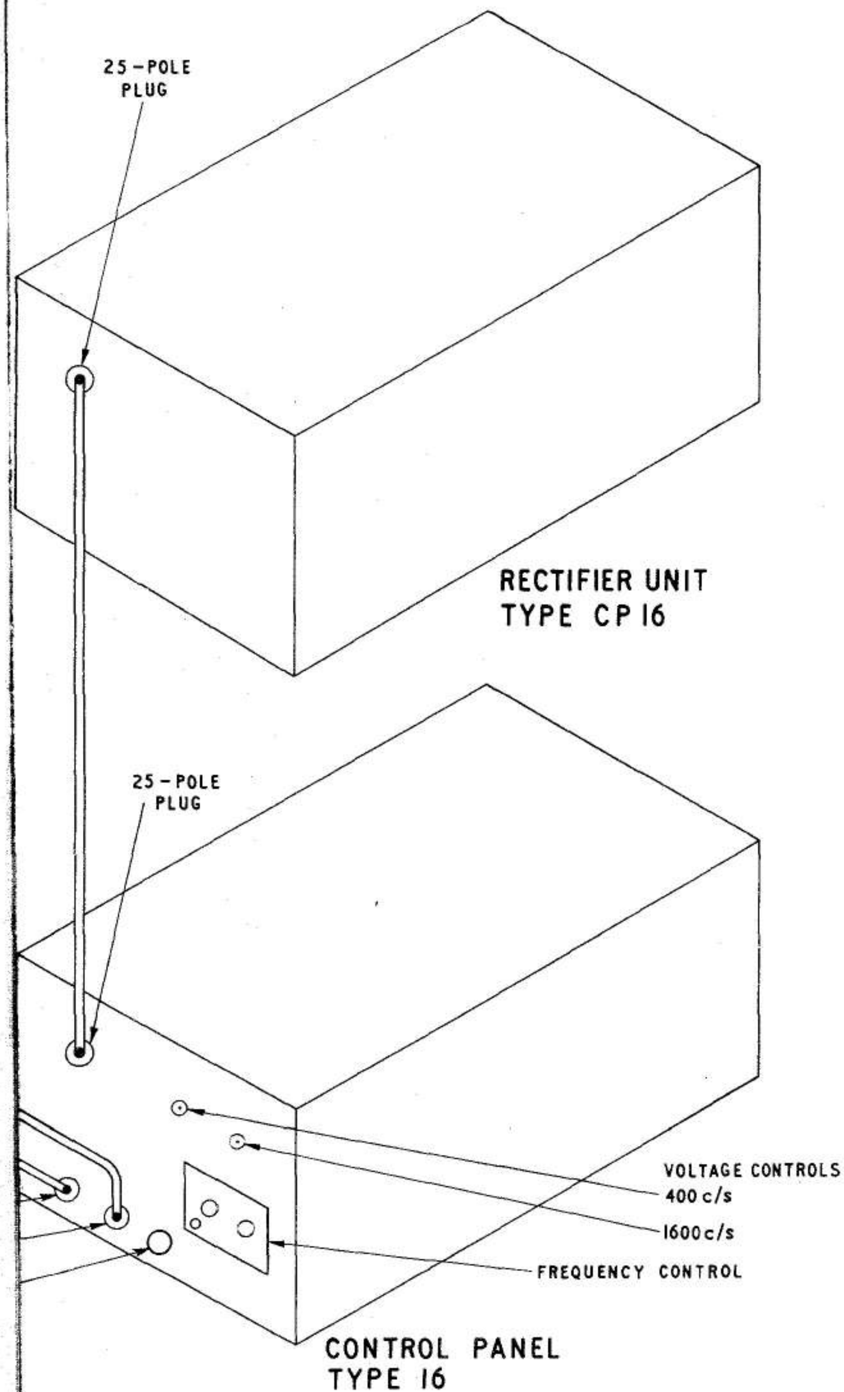

25-POLE
PLUG
RECTIFIER UNIT
TYPE CP 16
25-POLE
PLUG
VOLTAGE CONTROLS
400 c/s
1600 c/s
FREQUENCY CONTROL
CONTROL PANEL
TYPE 16

Fig. 17

If the fault in the panel is not obvious, the panel should be subjected to the tests as given in para, 71 to 80.

DISMANTLING AND ASSEMBLY

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

51. No special instructions are required for dismantling most of the components from the panel; such dismantling should be necessary only when the components require to be renewed. The following paragraphs give notes on the refitting of certain components.

Resistors and capacitors

52. Where these are held by clips, sufficient layers of woven glass tape should be wound round the new components so that they are firmly held by the clips.

Variable resistors

53. The spindle locking device must be fitted inclusive of its locking screw and nut, except with RV5 and RV6, where the spindle locking device merely steadies the spindle.

Transformers, reactors and rectifiers

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

Lamps LR1 and LR2

55. To remove these lamps, unsolder the leads from the lamp at the terminals on the small insulating block under the chassis. Remove the screw holding the lamp on to the chassis and withdraw the lamp with attached leads. Unsolder the leads from the lamp base. Assembly should be carried out in the reverse order, viz., solder the leads to the lamp base, secure the lamp to the chassis, and finally solder the other ends of the leads to the terminal block.

Relays RL1 to RL4

56. To remove these relays. unsolder the leads from the relay at the terminals on the insulating panel under the chassis. Unscrew the two nuts holding the relay to the chassis and withdraw the relay. Fit the new relay on the chassis and secure with the two nuts. Cut the leads form the relay to the required length, place PVC insulating sleeving over these leads and solder the free ends to the appropriate terminals on the block.

Variable reactors L2A and L2B

57. To remove these reactors, unscrew the three screws on the front plate which secure the bracket for the variable resistors RV5 and RV6, and move this bracket to one side. Unsolder the leads to the coils on the variable reactors L2A and L2B. Remove from the underside of the chassis the three fixing screws for the reactor and withdraw the reactor. Assemble the new reactor in the reverse order.

Compensating resistors R7 and R8

58. The two compensating resistors are detachable from the chassis as a sub-unit. Unsolder the leads connected to the sub-unit, and, from the underside of the chassis remove the two securing nuts and withdraw the complete sub-unit. Renew either or both resistors as required, and assemble the sub-unit in the reverse order.

Capacitors C2, C3 C9, C10, C11, C12 and C14

59. These capacitors are secured together in a removable sub-unit on the upper side of the chassis. This sub-unit may be lifted upwards when the four screws securing 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 assembling, it should be noted that the synthetic rubber gasket must be placed between the end plate and the capacitors at the opposite end to the terminals.

Saturable reactors SR4, SR5, and SR6

60. These reactors can be removed only after removal of the rear component board. The removal of four screws, two on each side of the chassis and accessible from the sides, will release the component board, and the reactors can be withdrawn upwards when released from the chassis.

Variable resistors RV15 and RV16

61. These variable resistors are situated on the rear component board, which must be removed before the resistors can be replaced. The removal of four screws, two on each side of the chassis and accessible from the sides, will release the component board.

TESTING

62. The correct functioning of the control panel, when installed in the aircraft, can be checked by the measurement of change in a.c. generator voltages and frequency when the inverter load is switched on and off. Voltages and frequency should be maintained constant within the limits quoted in para. 1 and 2. When making this test, it is essential that the d.c. supply voltage should be between 100 and 115 volts, with the meters connected as described in para. 42.

63. The tests in para. 67 to 70 relate to the checking and re-adjustment of the protective circuits. The remaining tests are intended to assist in fault location, and in setting up the amplifier circuits after renewal of a saturable reactor. All tests must be be made when the control panel is disconnected from control of the inverter. They necessitate provision of a 100/115-volt d.c. supply, a 115-volt, 1,600 c/s single-phase supply, and a 115-volt, 400 c/s 3-phase supply from regulated sources, together with such other apparatus as will be described for individual tests.

64. The rectifier unit requires to be connected to the control panel for tests given in para. 74 to 80 only.

65. All d.c. measurements must be made with moving coil instruments.

66. Links 1, 2, 4, 5, 7 and 8 must not be opened without a shunting meter when voltage is applied to the panel. Damage will be caused to the rectifiers if any of these links are opened with voltage applied.

Notes . . .

(1) *"Connect 115-volt, 1,600 c/s supply to panel" means that a 115-volt R.M.S., 1,600 c/s single-phase supply is to be connected to pins CD and EM of the 12-pole plug.*

(2) *"Connect 115-volt, 400 c/s supply to panel" means that a 115-volt R.M.S., 400 c/s 3-phase supply is to be connected to pins A, B and C of the 6-pole plug, the phase rotation being in sequence A, B, C.*

(3) *"Connect 100-volt d.c. supply to panel" means that a 100-volt d.c. supply is to be connected to pins A and B of the 12-pole plug, pin B being of positive polarity with respect to pin A.*

Time delay relay circuit

67. Connect 115-volt, 1600 c/s supply to panel, and test as follows:—

(1) Measure the heater voltage, points 9 to 19 (valve holder pins 1 and 7), of thermal delay switch DR1. The voltage should be 6·3 volts ± 5 per cent.

(2) Connect 100-volt d.c. supply to panel. Check that relay RL2 operates when DR1 contact closes. Check also that DR1 heater voltage disappears when RL2 operates.

(3) With RL2 operated, disconnect 115-volt, 1,600 c/s supply. Check for discontinuity between pins D and E of the 6-pole plug and for continuity between pins F and E.

1,600 c/s no-voltage protection circuit

68. Connect 1,600 c/s supply and 100-volt d.c. supply to panel. Operate relay RL2 by momentarily shorting points 9 and 17 (to avoid 1 minute delay). Test as follows:—

(1) Connect continuity meter between pins D and E of the 6-pole plug. Adjust variable resistor RV1 until relay RL1 just operates when 1,600 c/s voltage is slowly raised to 90 volts ± 2 per cent. The continuity meter will indicate closing of circuit when RL1 operates.

(2) Transfer the continuity to meter pins F and E of the 6-pole plug, and check that continuity is broken when RL1 operates.

1,600 c/s overvoltage and overfrequency circuit

69. Connect 1,600 c/s supply to panel. Connect continuity meter between pins D and E of the 6-pole plug; operation of relay

RL3 is indicated by disappearance of continunty. Test as follows:—

(1) ◀Measure 1600 c/s voltage between wiring point 15 on capacitor C4, and terminal T2, on transformer T1. It is important that this voltage is measured between the stated terminals on C4 and T1.▶

(2) With supply frequency at 1,600 c/s ± 1 per cent, adjust variable resistor RV2 until relay RL3 just operates when the 1,600 c/s voltage is slowly raised to 144 volts R.M.S. The voltage must not be maintained above 115 volts for longer than is necessary to make the test.

(3) With the voltage supply at 115 volts ±1 per cent, adjust the variable resistor RV3 until the relay RL3 just operates when the supply frequency is slowly raised to 2,000 c/s. Short circuit resistors R1 and/or R23 as required.

(4) Repeat the tests in (1) and (2) until the accuracy of setting is within ±1 per cent.

(5). Transfer the continuity meter to pins F and E of the 6-pole plug, and check that continuity is made when relay RL3 operates.

400 c/s overvoltage circuit

70. (1) Connect 400 c/s supply to panel and continuity meter between pins D and E of the 6-pole plug. Adjust the variable resistor RV4 until the relay RL4 just operates when the 400 c/s voltage is slowly raised to 144 volts RMS ±1 per cent. Operation of relay RL4 is indicated by disappearance of continuity.

(2) Re-connect the continuity meter to pins F and E of the 6-pole plug. Check that continuity is made when relay RL4 operates.

Frequency bridge circuit

71. The warning in para. 66 must be observed when links are opened during this test.

(1) Connect a d.c. milliammeter in circuit and open link 1. Connect 115 volt 1,600 c/s supply to the panel; it is important that the frequency should be 1,600 c/s ±1 per cent. Adjust the reactor L2A to obtain 35 mA d.c. in the meter. Measure the current at 1,650 c/s; this current must be greater than 38·5 mA.

(2) Close link 1 and transfer the milliammeter to link 2. Connect 115-volt, 1,600 c/s supply to panel. Adjust the reactor L2B to obtain 35mA in meter. Measure the current at 1,550 c/s; this current must be greater than 38·5 mA.

1,600 c/s voltage bridge circuit

72. The warning in para 66 must be observed when links are opened during this test.

(1) Connect a d.c. milliammeter in circuit and open link 4. Connect 115-volt, 1,600 c/s supply to panel. The current must be between 87 mA and 102 mA.

(2) Close link 4 and transfer the milliammeter to link 5. Connect 115-volt, 1,600 c/s supply to panel. By adjustment of the variable resistor RV5, set the current in the meter to the same value as that obtained in (1).

400 c/s voltage bridge circuit

73. The warning in para. 66 must be observed when links are opened during this test.

(1) Connect a d.c. milliammeter in circuit and open link 7. Connect 115-volt, 400 c/s supply to panel. The meter current must be between 84 mA and 105 mA.

(2) Close link 7 and transfer the milli ammeter to link 8. Connect 115-volt, 400 c/s supply to panel. By adjustment of variable resistor RV5, set the meter current to the same value as that obtained in (1).

Frequency control circuit

74. Connect an inductive load of 35 ohms, 0·25 henry, with an ammeter in series, to pins F and G of the 12-pole plug. Open link 3 and connect a 100 mA d.c. meter in circuit. Connect 100-volt d.c. supply and 115-volt, 1,600 c/s supply to panel. Check that the current in the load is less than 0·1 amp. when the frequency is decreased to 1,550 c/s, and greater than 1·6 amp. when increased to 1,650 c/s.

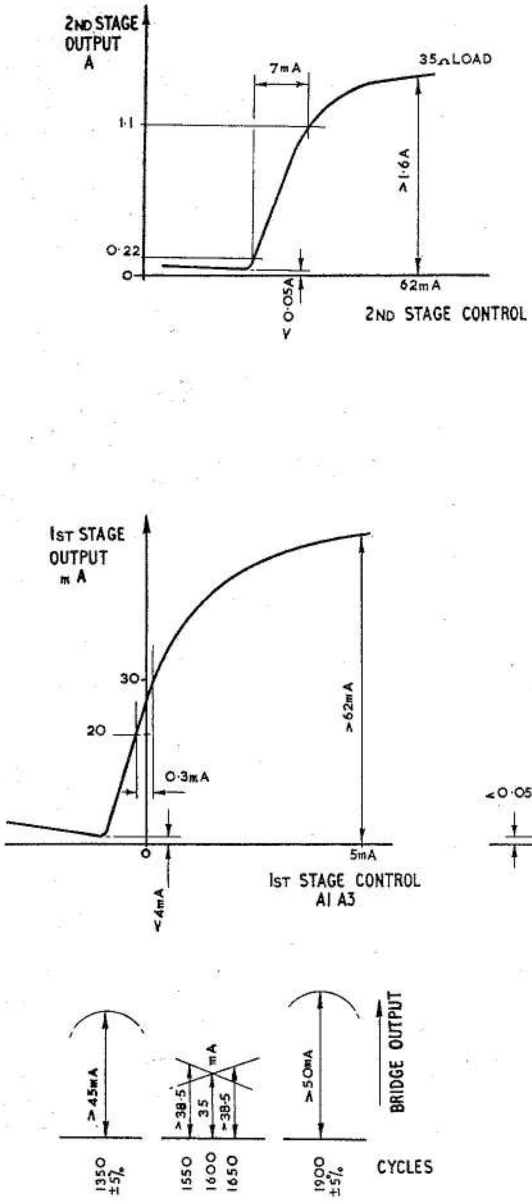


Fig. 18 Amplifier characteristics—frequency control

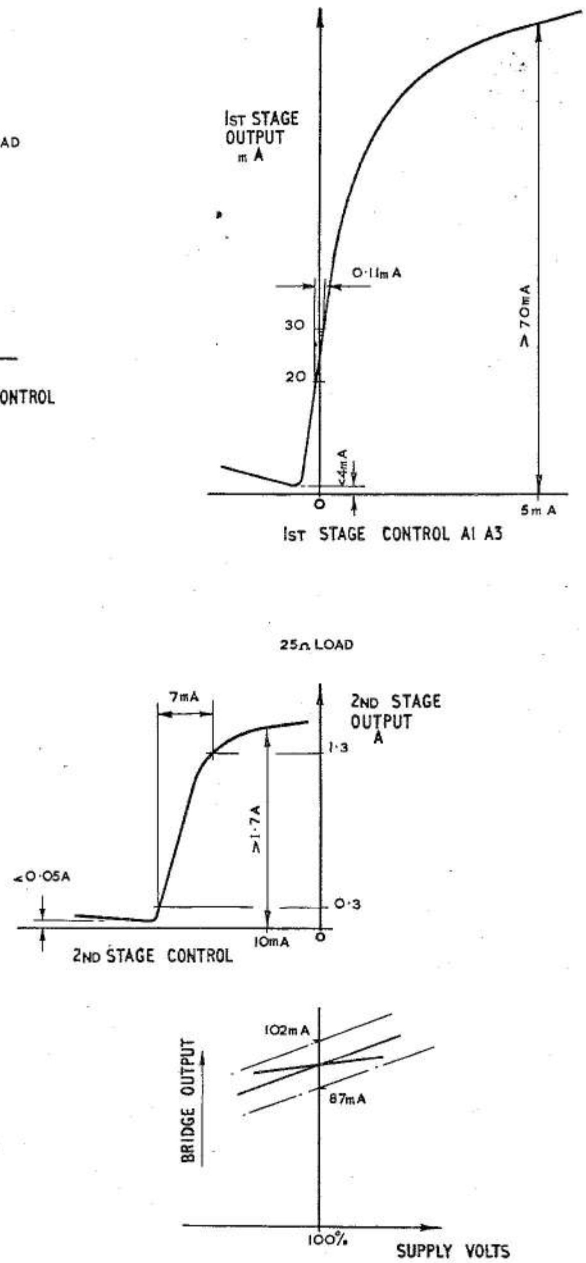


Fig. 19. Amplifier characteristics—1,600 c/s voltage control

75. The characteristic of each amplifier stage is indicated in fig. 18, and, when necessary, each stage may be tested separately by connecting its control winding to a suitable d.c. supply. It is important in testing the first stage, which necessitates the opening of links 1 and 2, to short together points 35, 36 and 37 on rectifier MR5.

1,600 c/s voltage control circuit

76. Connect an inductive load of 25 ohms, 0·25 henry, with an ammeter in series, to pins J and H of the 12-pole plug. Open link 6 and connect a 100 mA d.c. meter in circuit. Connect a 100-volt d.c. supply and 115-volt, 1,600 c/s supply to panel. Check that the current in the load is greater than 1·7 amp. when the 1,600 c/s voltage is decreased to 110 volts, and less than 0·1 amp. when the voltage is raised to 120 volts.

77. The characteristic of each amplifier stage is indicated in fig. 19, and, when necessary, each stage may be tested separately by connecting its control circuit to a suitable d.c. supply. It is important in testing the first stage, which necessitates the opening of links 4 and 5, first to short together points 63, 64 and 65 on rectifier MR6.

400 c/s voltage control circuit

78. Connect an inductive load of 30 ohms, 0·25 henry, with an ammeter in series, to pins L and K of the 12-pole plug. Open link 9 and connect a 100 mA d.c. meter in circuit. Connect 100-volt d.c. supply, 115-volt, 1,600 c/s supply and 115-volt, 400 c/s supply to the panel. Check that the current in the load is greater than 1·7 amp. when the 400 c/s voltage is decreased to 110 volts, and less than 0·1 amp. when the voltage is increased to 120 volts.

79. The characteristic of each amplifier stage is indicated in fig. 20, and, when necessary, each stage may be tested separately by connecting its control circuit to a suitable d.c. supply. It is important in testing the first stage, which necessitates the opening of links 7 and 8, first to short together points 89, 90 and 96 on rectifier MR7.

80. If a saturable reactor has to be renewed, it is very important to test the amplifier circuit in which the new saturable reactor is fitted, and to adjust the gain control setting of this amplifier to obtain the required sensitivity. This sensitivity is indicated on the relevant characteristic to be found on either fig. 18, 19 or 20.

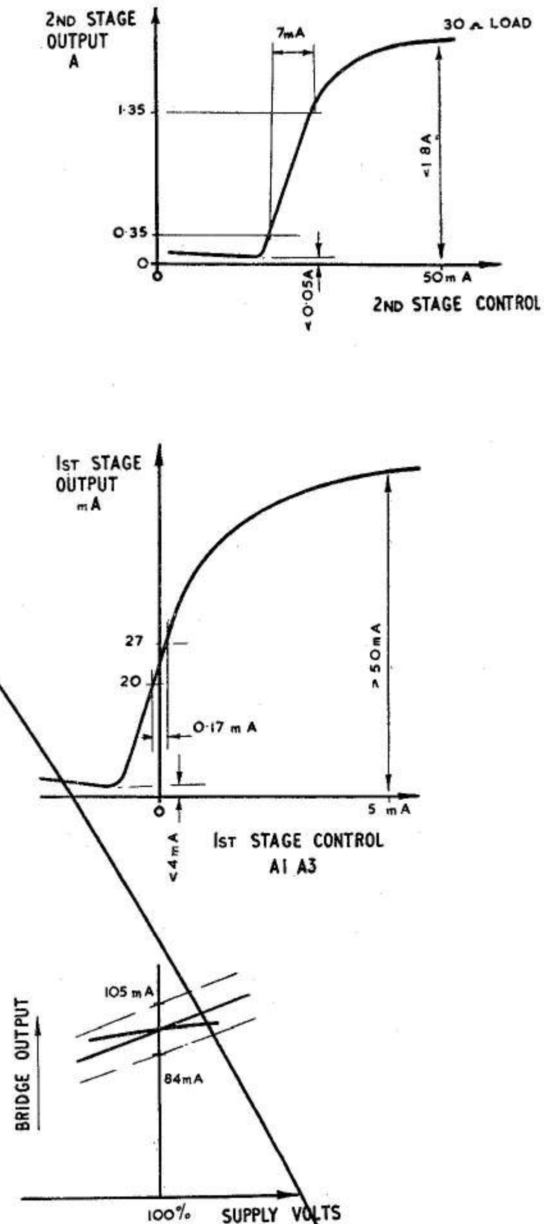


Fig. 20. Amplifier characteristics—400 c/s voltage control