Chapter I

ROTARY INVERTER, TYPE 350 (B.T.H.)

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LEADING PARTICULARS

Rotary inverter, Type 350	Stores Ref. 5UB/5501
Input voltage	100–115 volts d.c.
Controlled output (1)	0·25–2·0 kW, 1-phase
Power factor	−0·9 to 1·0
Voltage	115 volts ± 1 per cent
Frequency	1,600 c/s, ± 1 per cent
Controlled output (2)	0·125 — 1·0 kW, 3-phase
Power factor	−0·8 to 1·0
Line voltage	115 volts ± 2 per cent
Frequency	400 c/s, ± 1 per cent
Rating	Continuous
Driving motor brushes	
Grade	KCN.10
Spring pressure	18 oz. ± 3 oz.
Slip ring brushes	
Grade	KCEG.11
Spring pressure	2·75 oz. (approx.)
Rotation (viewed from commutator end)	Clockwise
Weight	90 lb.
Overall dimensions	
Length	18 in.
Width	$8\frac{3}{16}$ in.
Height	$15\frac{1}{2}$ in.

Introduction

1. The inverter, Type 350, is used to convert the general purpose 112-volt d.c. supply in aircraft to alternating current for use in radar and navigation instruments. The inverter is a three-unit machine, consisting of a 112-volt, 8,000 r.p.m. d.c. motor; a 2-kW, 115-volt, 1-phase, 1,600 c/s, inductor type alternator; and a 1-kW, 115-volt, 3-phase, 400 c/s, salient pole alternator.

2. The output voltages and frequencies of the inverter are controlled by the Type 16 control panel, which is described in Book 2, Sect. 8, Chap. 1 of this publication.

DESCRIPTION

General

3. The inverter (*fig.* 1) is a cylindrical unit mounted on four feet cast integral with the frame. A rectangular control box is mounted on top of the frame.

4. The cylindrical unit (*fig.* 2), housing the armature assembly, consists of a main centre casting forming the frame, two end castings, and two end covers. The commutator end casting houses the driving motor brush gear and encloses the commutator. The armatures of the driving motor and the inductor type alternator are located within the bore of the frame casting, whilst the rotor and slip-ring assembly of the salient pole alternator lies within the other end casting.

5. Each end of the frame casting is fitted with eight 2 B.A. studs, arranged in pairs. The end castings are mounted on these studs and secured by nuts and locking tab-washers. Both end castings are spigoted to ensure correct alignment of the armature.

Cooling

6. The inverter is provided with an extractor fan, keyed to the armature shaft outside the commutator end casting and enclosed by the end cover. The fan, which is secured by a nut and locking washer, draws air through the machine from the inlet in the alternator end cover and expels it through vent holes in the commutator end cover. With blast cooling, slipstream air is ducted to the inlet, while an outlet may be fitted in place of the end cover shown in fig. 1. The arrangement differs in various aircraft, and the relevant Aircraft Handbook should be consulted for a particular installation.

Armature

7. The armature (*fig.* 2) is supported in ball bearings, one located in the commutator end casting, and the other at the alternator end of the frame casting. The ends of the shaft protrude through the bearings to mount the fan at the commutator end, and the rotor and slip-ring assembly of the salient pole alternator at the other end.

8. The motor armature and the rotor of the inductor type alternator are mounted on the shaft, and are dynamically balanced as one unit. The 6-pole rotor of the salient pole alternator is mounted on a sleeve which is extended at one end to accommodate two slip-rings. The slip-rings are mounted on an insulating bush and are separated by an insulating barrier ring. This assembly is dynamically balanced as a separate unit.

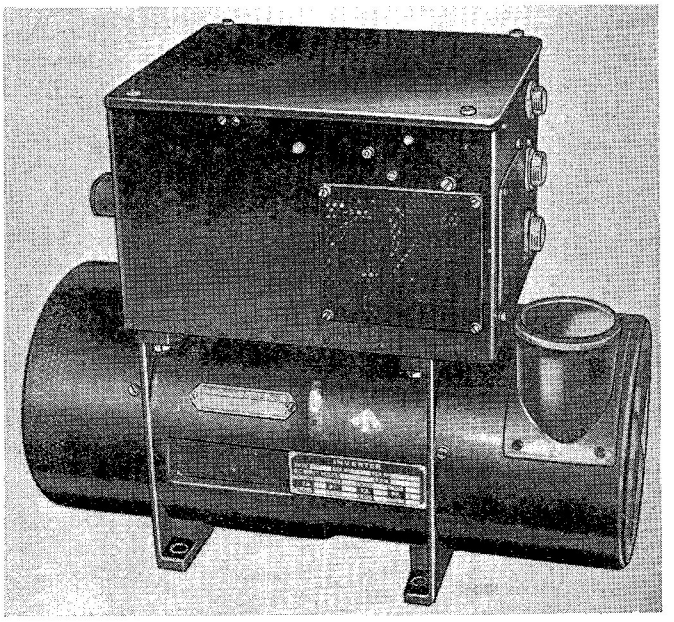


Fig. 1. Rotary inverter, Type 350

9. The alternator end ball bearing is a push fit within a lined recess in a bearing housing (*fig.* 2) and is mounted on the shaft between the two alternator rotors. After fitting the bearing, the salient pole alternator rotor and slip-ring assembly is keyed to the shaft and secured by a nut and locking washer.

Commutator end casting

10. This end casting houses the ball bearing within a lined recess in its end face. The armature shaft is a push fit within the bearing, and is positioned by a circular spacer interposed between the bearing and a step in the shaft.

11. The driving motor brush gear (*fig.* 3) is mounted within the end casting. Each brush box is attached by a pair of screws to an insulating carrier ring. Four bolts secure the carrier ring to bosses projecting from the inner surface of the end face of the casting. The coiled brush springs are mounted on retaining pins projecting from the boxes, and are not adjustable. There is one connecting lead from the motor field winding to each brush box. The lead and the brush pigtail are secured by the same screw.

Alternator end casting

12. This end casting forms the stator frame for the salient pole alternator, and encloses the slip-ring brush gear. An aperture at the top provides an ingress for the connecting leads.

Frame casting

13. The frame casting houses the stators of the driving motor and inductor type

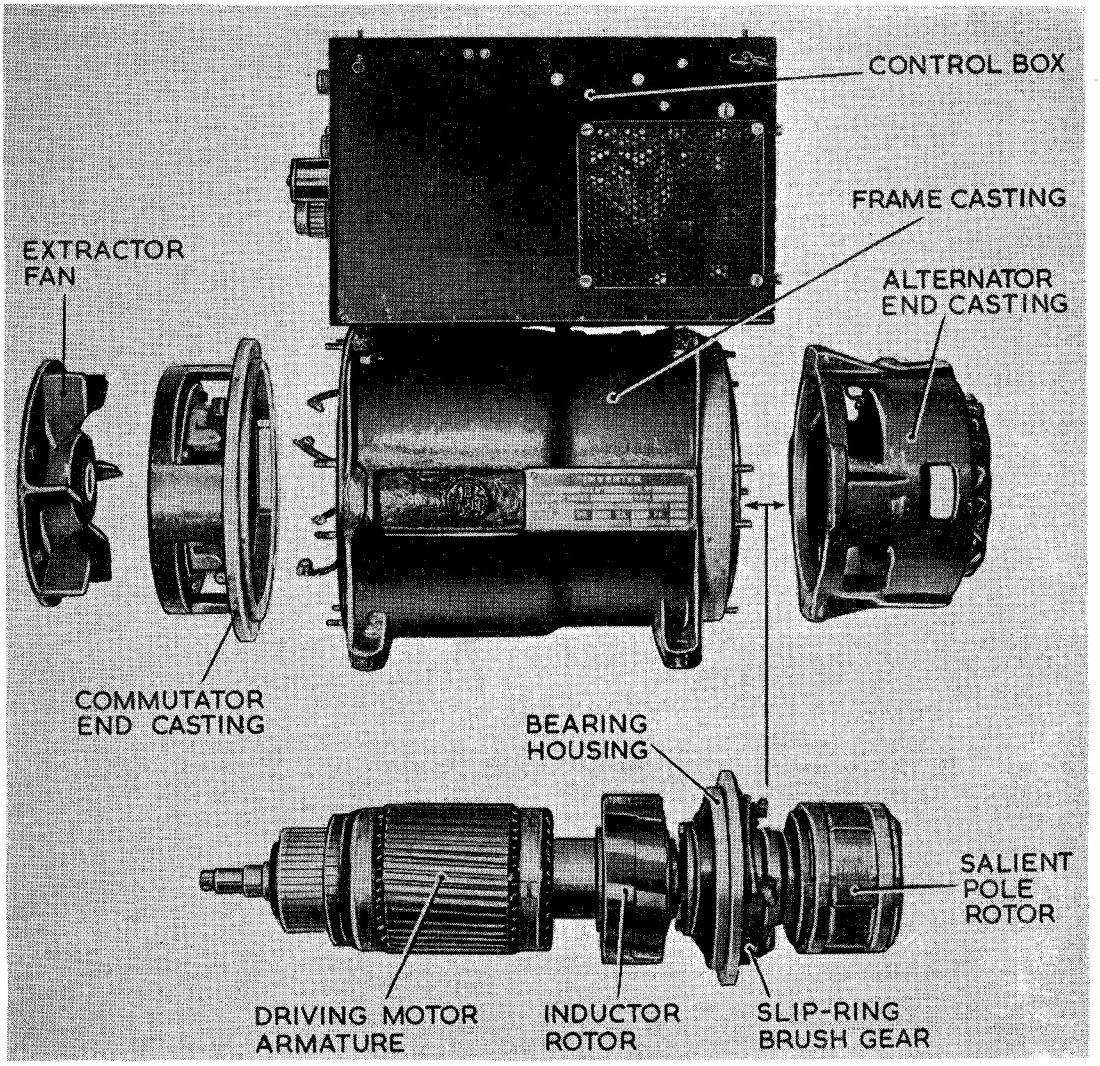


Fig. 2. Assembly of inverter

alternator within its bore. The connecting leads emerge through a grommet inserted in a hole at the top of the casting.

14. At the alternator end, the frame casting is provided with an internal flange in which are four studs. These studs secure the bearing housing (*fig.* 2).

15. The slip-ring brush gear consists of four brush boxes each holding a single brush, mounted on an insulating carrier which is attached by screws to the bearing housing. The brush boxes are fitted with non-adjustable coiled brush springs. There are two adjacent boxes per ring and these are connected by a short length of lead. There is one connection to each pair of brush boxes.

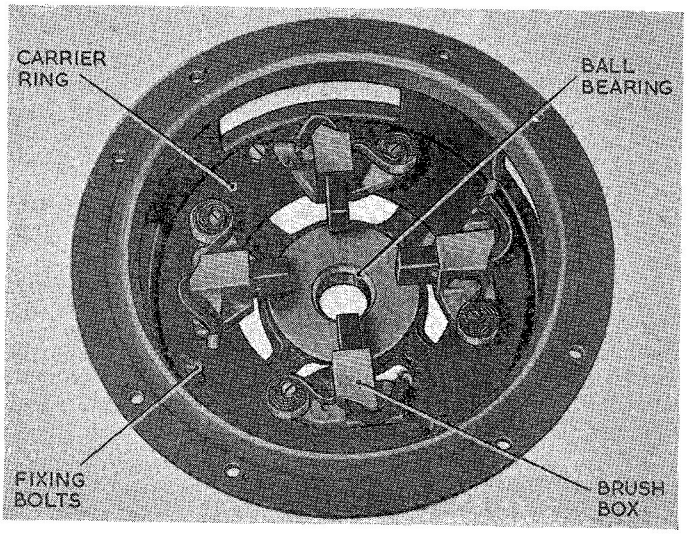


Fig. 3. Driving motor brush gear

Driving motor

16. The pole pieces of the motor field assembly are attached to a cylindrical yoke by pairs of csk/hd. screws. The yoke itself is secured within the bore of the frame casting by bolts. There are four main poles and two interpoles.

17. The field is compound wound, the shunt winding being connected in series with a trimmer resistance across the d.c. input. The main poles are also provided with a regulating field winding fed from the associated control circuit (*see para.* 29). The purpose of this regulating field is to maintain the motor speed, and hence alternator output frequency, within pre-determined limits. Should the frequency exceed the upper limit, the regulating field is increased and so tends to reduce the motor speed and hence restore the frequency to normal.

Inductor type alternator

18. The yoke of the stator is secured within the bore of the frame casting by bolts. The stator itself is built up from ring laminations, stamped to form the pole system. There are six poles wound with main and regulating field coils. The a.c. output winding is embedded in slots within the pole faces. The main field winding, in series with a trimmer resistance, is connected in shunt across the d.c. input to the driving motor. The regulating winding is fed from the associated control circuit which varies the magnitude of the regulating field so as to maintain the 1,600 c/s, output voltage within pre-determined limits.

Salient pole alternator

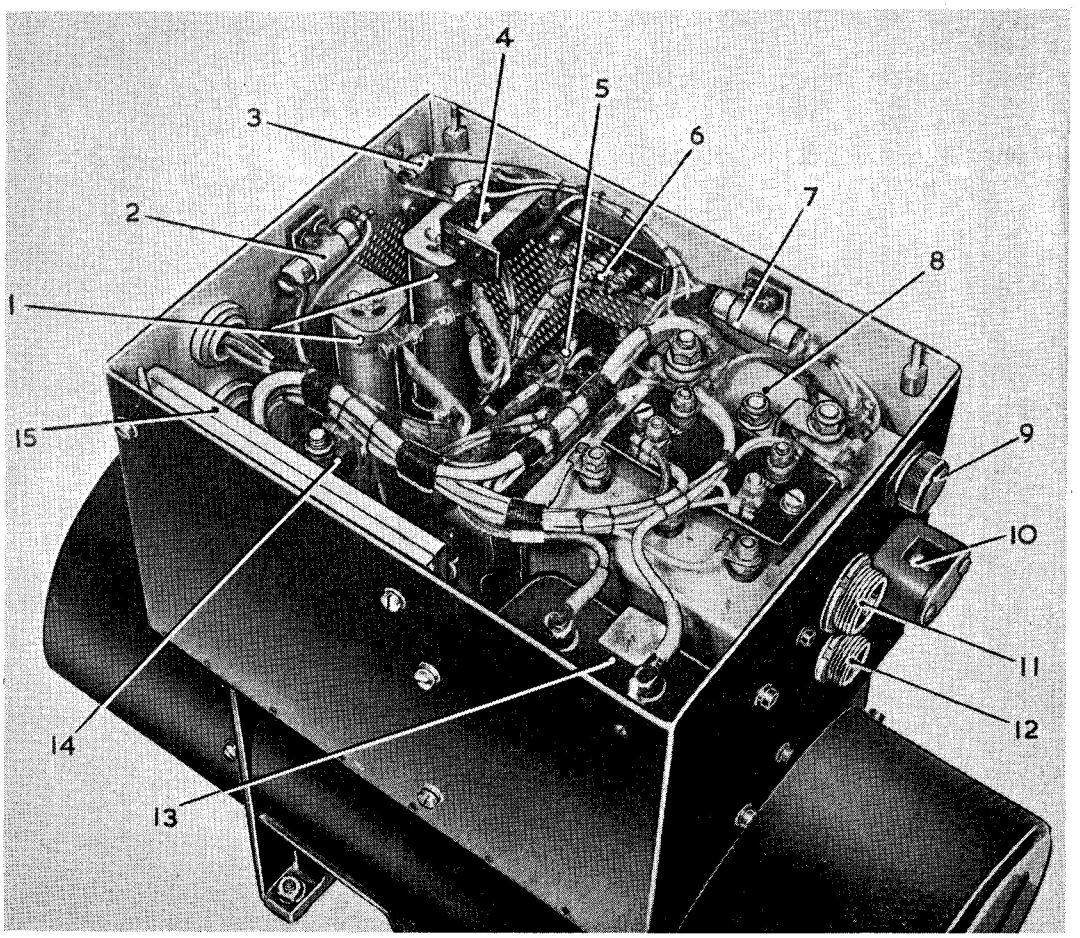
19. The yoke and stator ring stamping assembly is bolted within the bore of the alternator end casting. The stator houses a 3-phase winding.

20. The 6-pole rotor field winding is energized via the slip-rings by a regulated d.c. supply fed from the control circuit.

Control box

21. The control box is fitted with a cover secured by four knurled captive screws. Located centrally in the base of the box is a grommet through which pass the 12 leads connecting to the driving motor and inductor type alternator. The five leads connecting to the salient pole alternator pass through a smaller grommet located towards the alternator end. Three miniature sockets are mounted on the alternator end of the box (*fig.* 1). At the commutator end, an aperture is cut in the wall of the box to reveal the end of the suppressor box unit. Mounted on this end are two miniature sockets and the 112-volt positive d.c. supply terminal. This terminal is mounted on an insulating moulding fitted with an insulating cover plate secured by two screws. Mounted on the wall of the control box, above the d.c. positive terminal, is a gland to provide an entry for the d.c. negative cable.

22. The contents of the control box (*fig.* 4) consist of the various relays, resistors, and



1 TRIMMER RESISTORS, R2 and R3
2 CAPACITOR
3 RESISTOR, R5
4 RELAY, P
5 TERMINAL BOARD
6 PROTECTIVE CIRCUIT CHANGE-OVER LINK
7 CAPACITOR
8 SUPPRESSOR BOX UNIT
9 NEGATIVE CABLE GLAND
10 POSITIVE SUPPLY TERMINAL
11 SOCKET, 400 C/S OUTPUT
12 SOCKET, CIRCUIT BREAKER CONTROL
13 CAPACITOR
14 STARTING RELAY, Q
15 STARTING RESISTOR, R1

Fig. 4. View of control box

capacitors which comprise the motor starting and interference suppression circuits. The trimmer resistors, which are connected in series with the motor and inductor type alternator main fields, are also mounted within the control box.

Connections

23. The internal connections are shown in the circuit diagram (*fig.* 5), whilst the arrangement of the connections to the components of the control system are shown in the interconnection diagram (*fig.* 6).

INSTALLATION

24. The inverter is secured to its mounting by four bolts located in the mounting feet. The air inlet (and outlet if fitted) are connected to the cooling air pipes according to the layout of the installation.

25. When making the electrical connections to the associated units (*fig.* 6) it should be noted that the 12-core and 6-core cables connecting the inverter control box to the Type 16 control panel are not to exceed 15 ft.

(A.L.3, Dec. 57)

If this length is exceeded, poor regulation of alternator voltages will result.

26. With the circuit breaker control system shown in fig. 6, a normally open protective circuit is necessary, but in other systems a normally closed circuit may be required. Provision is made for this alternative by means of a link within the control box (*fig.* 4). This link has a normally open (N.O.) position and a normally closed (N.C.) position. The position of the link should be set, according to the system used, when installing the inverter.

OPERATION

Starting

27. The inverter may be started with the 400 c/s, 3-phase load connected, but the 1,600 c/s, 1-phase output must be on open-circuit until normal running speed is attained. The d.c. supply voltage must be within the range 100–115 volts at the inverter terminals. Unsatisfactory performance will result if the supply voltage is outside this range.

28. Operation of a starting switch initiates closure of the circuit breaker and so energizes the motor armature and field windings. Initially, the armature current is limited by the series starting resistor R1 (*fig.* 5). The relay P has two coils, a series-connected current coil and a voltage coil connected in series with resistor R5 across the armature. The current coil acts so as to hold the relay open, while the voltage coil tends to close it. The relay will operate under the action of the voltage coil when the proportion of the starting current flowing through the current coil falls below a certain value. This proportion is determined by the pre-set shunting resistor R4. As the motor speeds up, the starting current falls to the pre-determined value and relay P operates. Relay Q is then energized and operates so as to short out the starting resistor R1.

Running

29. The output voltages and frequencies of the inverter are controlled by the regulating field windings of the motor and alternators, which are fed from the associated control circuit. The methods by which this control is achieved are described in Book 2, Sect. 8, Chap. 1 of this publication.

30. During operation, radio interference is suppressed by the filter networks connected in the 400 c/s, 3-phase output, the d.c. supply, and the circuit breaker control circuits. The 1,600 c/s, 1-phase output is not suppressed. The capacitor connected in series with the output winding of the 1,600 c/s, inductor type alternator is inserted in order to reduce the inherently large synchronous impedance of this type of alternator, and so increase the output.

SERVICING

General

31. Information on servicing, common to all airborne rotary inverters, is to be found in A.P.4343, Vol. 1, Sect. 8, Chap. 2. The following paragraphs should be read in conjunction with that chapter and with the relevant Servicing Schedule.

Note . . .

Particular reference should be made to A.P. 4343, Vol. 1, Sect. 1, Chap. 1 in relation to the servicing of the brushes and commutator.

32. To examine the machine, disconnect the connecting leads and air pipes and remove the machine from its installation. Remove the end covers and the control box cover.

33. Clean and examine the frame, commutator, slip-rings, and both sets of brush gear. Ensure that all nuts, bolts, screws, and locking devices are secure. Check the insulation of all connecting leads for damage or deterioration, and ensure that the connections are tight.

Brushes

34. When removing the brushes from their boxes, mark each brush so that it may be replaced in its own box the correct way round. This is to ensure that the brush will be bedding correctly.

35. New brushes should be fitted if the existing ones are worn down to their minimum length or it appears likely that they will be before the machine is again serviced.

36. The minimum length of the commutator brushes is 14 mm. (0·55 in.) and of the slip-ring brushes 12·5 mm. (0·492 in.) unless the machine has been modified (recognisable by a slot in the top of the brush box) when the minimum length is 10·5 mm. (0·413 ins.).

Bedding

37. When new brushes are fitted, they must be bedded by running the inverter, in the normal direction of rotation, for a minimum period of 12 hours, even though the brushes may have become correctly shaped in less than this time. The purpose of the 12-hour bedding run is to ensure that an adequate film has been built up on the commutator or slip-ring surface.

38. For the bedding run, the machine should be run light on the bench at 8,000 r.p.m., with approximately 80 volts d.c. applied across the d.c. terminals of the control box.

Spring pressure

39. The pressure of each brush spring should be checked to ensure that it lies between the limits quoted under Leading Particulars. The measurement may conveniently be carried out if a small length of wire, hooked to engage in the loop on the spring where it bears on the brush, is attached to a suitable pull-type spring balance.

Bearings

40. The ball bearings supporting the armature are of the enclosed type and are greased during manufacture. They require no further lubrication within the period of their working life.

41. The armature should be revolved by hand to check that rotation is smooth and even. The end play in the bearings should not be excessive, but slight radial play between the shaft and bearings which can just be felt by hand is permissible. The machine should also be observed for undue vibration during the running tests.

TESTS

General

42. The tests detailed in the following paragraphs prove the operation of the inverter and control box under various conditions of loading and with various supply voltages. The following points should be observed during all tests:—

(1) Ensure that the direction of rotation is always clockwise when viewed from the commutator end.

(2) Check that the quality of commutation is good. There should be no more than pin-point sparking under all load conditions.

(3) Check that the machine runs evenly at all speeds without undue vibration.

Test equipment

43. Tests are carried out with the inverter connected to an inverter tester (Specification No. E.L.1777 *Ref. No. 5G/564*). This tester incorporates variable unity power factor 1-phase and 3-phase loads, and mounts the meters necessary for checking the inverter outputs.

44. The regulating fields of the motor and alternators are to be controlled by a Type 16 control panel which has been previously tested for correct functioning.

45. The connections to the control panel are as shown in fig. 6. The d.c. supply terminals on the control box of the inverter are to be connected to the terminals marked INVERTER INPUT on the tester. The inverter output sockets are to be connected to the corresponding terminals on the tester. A suitable d.c. supply, variable between 100 volts and 115 volts is to be connected to the tester terminals marked SUPPLY.

Note . . .

Before switching on for any test, it is important to ensure that the connections are such that the positive terminal on the inverter control box is at positive potential. If the polarity of the d.c. supply is reversed, unstable operation will result.

Starting test

46. Adjust the d.c. supply to the inverter to 100 volts, and select the following loads on the tester:—

(1) 400 c/s, 3-phase — 1 kW

(2) 1,600 c/s, 1-phase — No load

47. Start the inverter and allow it to run up to speed. Observe the points listed in para. 42. When running at normal speed, switch in a test load of 2 kW on to the 1,600 c/s, 1-phase output, and ensure that the inverter still runs satisfactorily.

Note . . .

Under no circumstances may the inverter be started with the 1,600 c/s, 1-phase output loaded.

Running tests

48. Meter readings of voltage and frequency should be taken when the inverter is running under each of the following load conditions:—

(1) 1 kW on the 400 c/s, 3-phase output, and 2 kW on the 1,600 c/s, 1-phase output.

(2) 0·125 kW on the 400 c/s, 3-phase output, and 0·25 kW on the 1,600 c/s, 1-phase output.

49. With each of these loadings, the inverter should be run with a d.c. supply voltage of firstly, 100 volts, and secondly, 115 volts.

50. For each of these four tests, ensure that the meter readings of the output voltages and frequencies are within the limits given in Table 1. In the case of the 3-phase output, each line voltage should be measured in turn and the average of the three readings compared with the values given in the table.

Table 1

Output test limits

Output	Voltage (volts)	Frequency (c/s)
1,600 c/s, 1-phase	113·9–116·1	1,584–1,616
400 c/s, 3-phase	112·7–117·3	396– 404

Setting of starting circuit

51. Start the machine and apply full load to the three-phase alternator. Adjust the d.c. supply voltage to 100 V. and shut down the machine leaving the three-phase load connected.

52. Re-start the machine on the same supply voltage and whilst reading the input current during the starting period, determine the current immediately prior to the operation of the starting relay. Adjust the resistor R6 so ◄ that this current is within the limits of 40 to 65 amperes. ►

53. Check that the machine starts satisfactorily when switched directly on to 100 and 115 V. supplies and with full load applied to the three-phase alternator. Check that the direction of rotation is correct.

54. It may be necessary to adjust the voltage and frequency trimmers on the Type 16 control panel in order to bring the outputs within the limits given in Table 1. Once the trimmers have been set, however, the limits must be met for all four test conditions without further adjustment. If the limits cannot be met for one or more test conditions, and the control panel has been proved to be functioning correctly, the inverter should be sent for repair.

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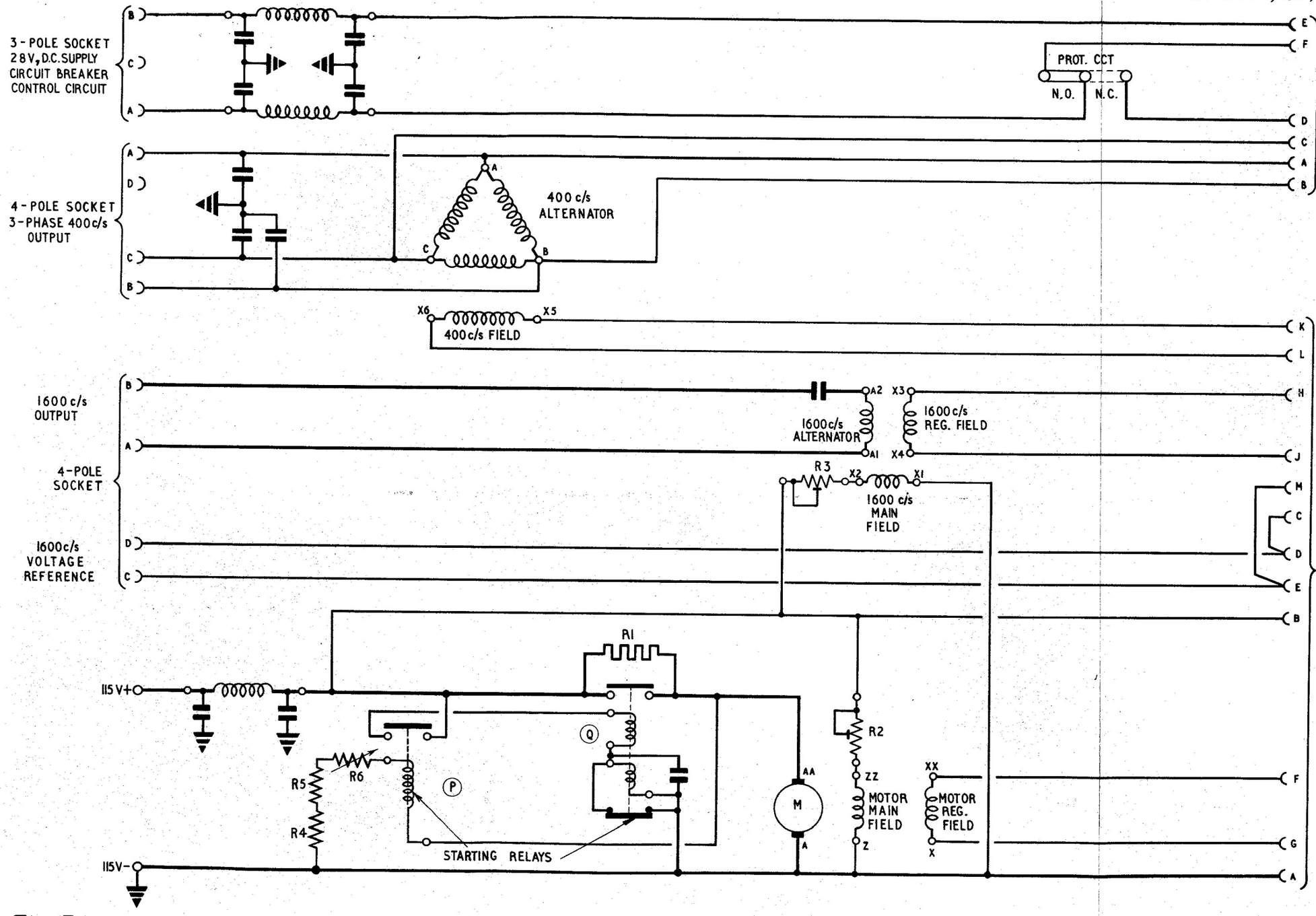

Fig. 5

Circuit diagram

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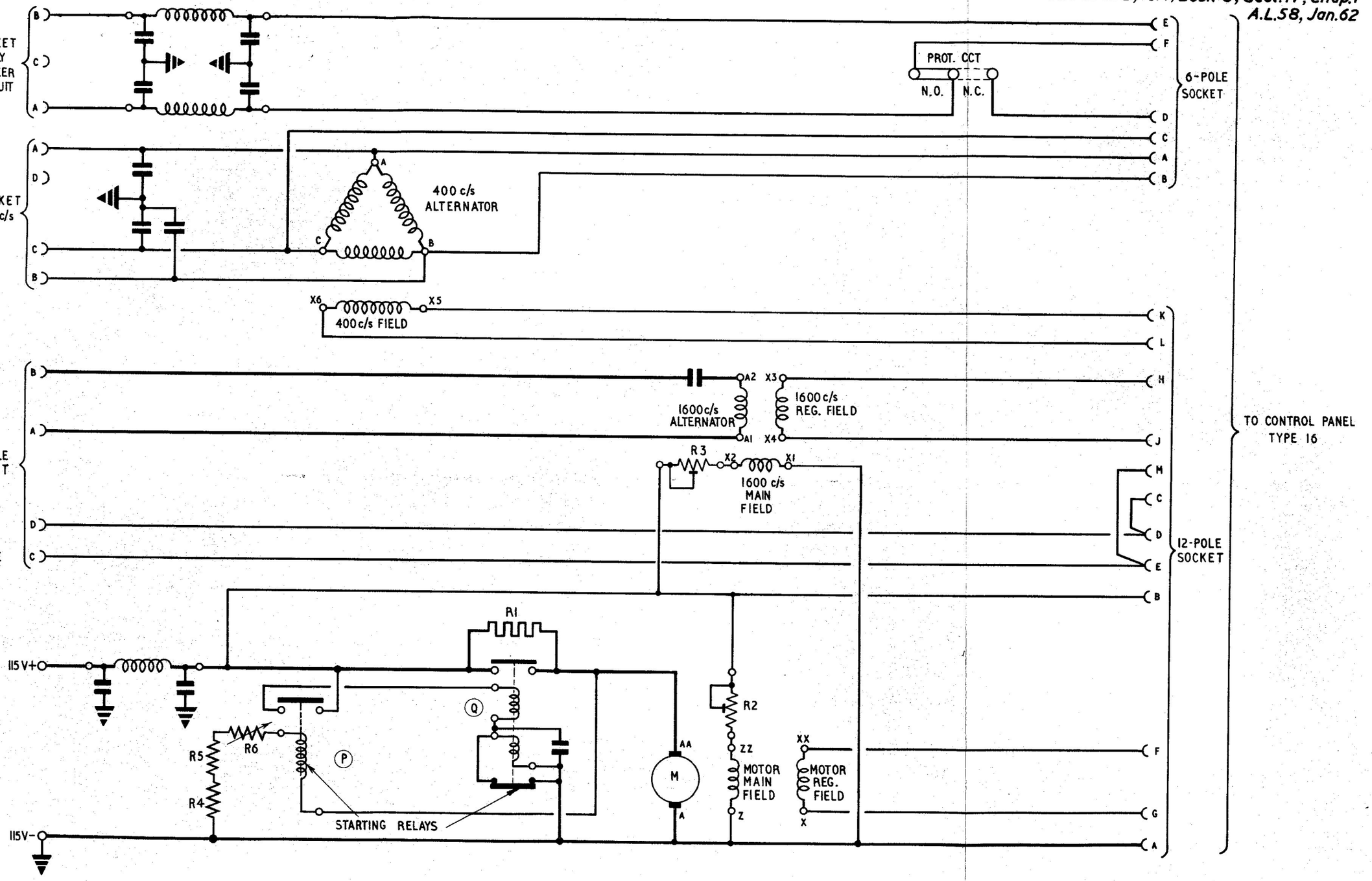

Circuit diagram

Fig.5

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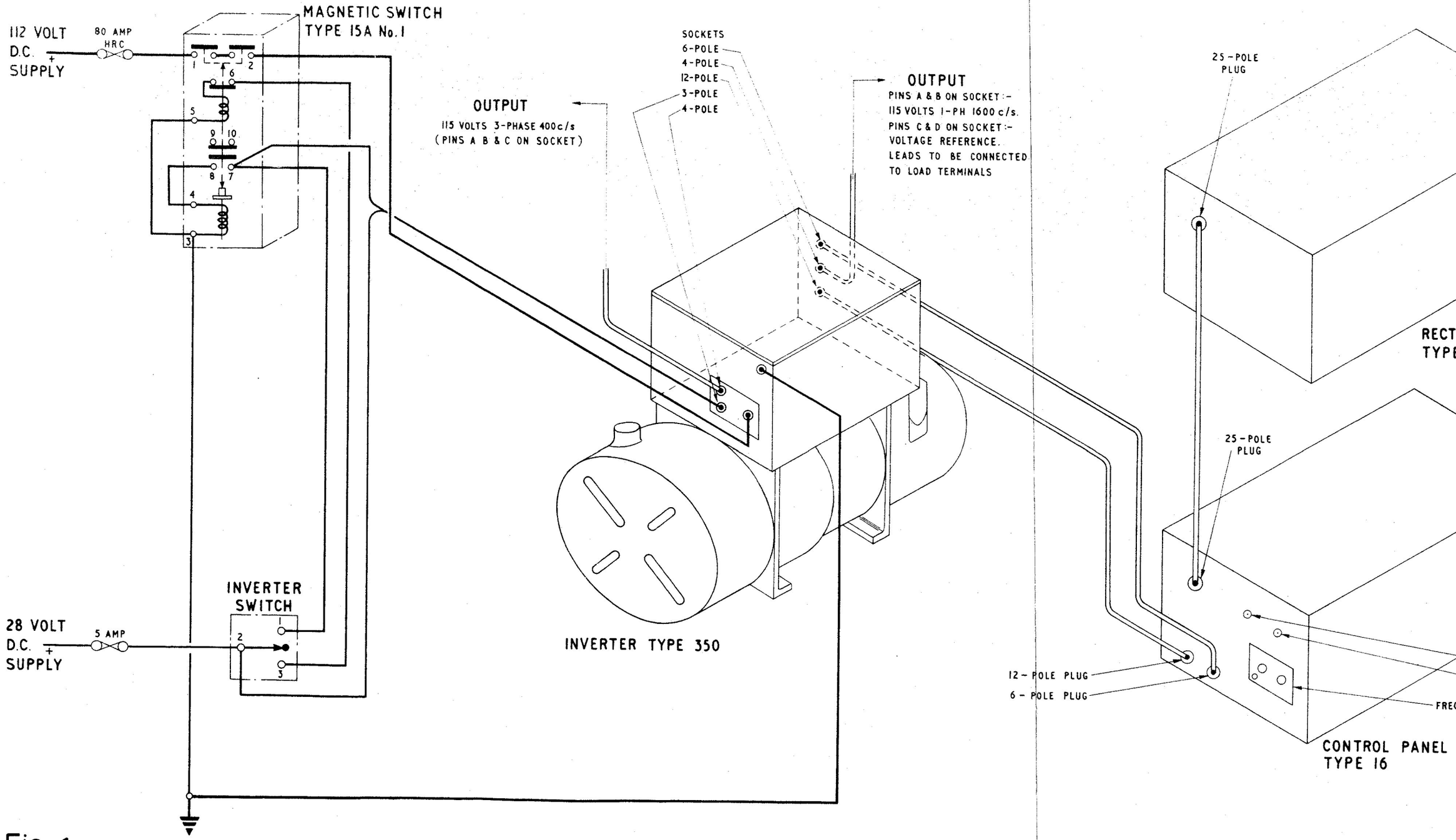

Fig. 6

Interconnection diagram

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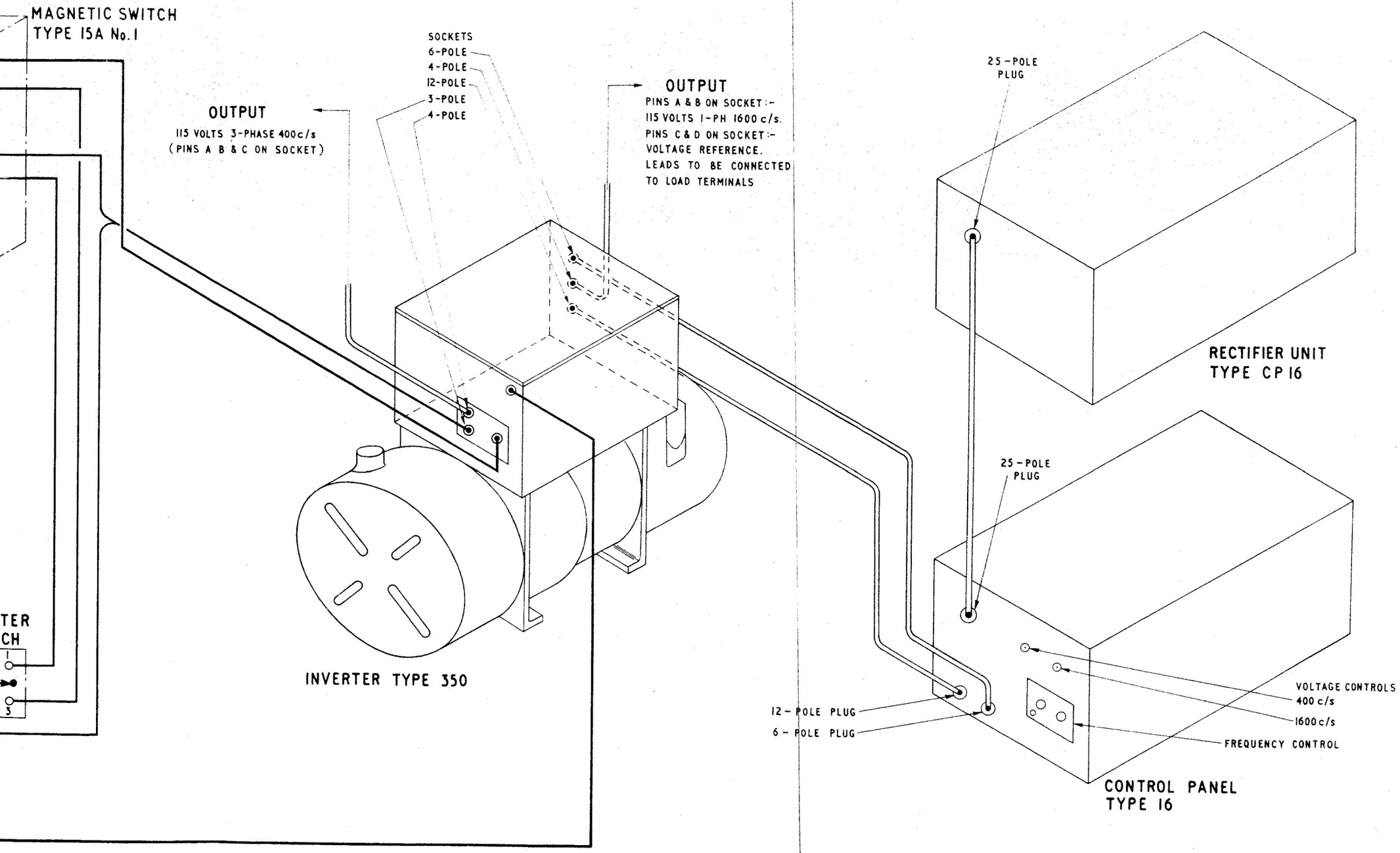

Interconnection diagram

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Fig.6