# Chapter 5

# FREQUENCY CHANGER, TYPE 270

## LIST OF CONTENTS



## LIST OF ILLUSTRATIONS



## LEADING PARTICULARS

| | |
|---|---|
| *Frequency changer Type* 270 | *Ref. No.* 5*UB*/6430 |
| *Input voltage* | 200*V*, 3-*phase*, 400 *c/s* |
| *Controlled output* | 0·25–2·22 *kVA, single-phase* |
| *Power factor* | 0·9 *to* 1·0 |
| *Voltage* | 115*V*±1 *per cent* |
| *Frequency* | 1600 *c/s*±400 *c/s supply tolerance* |
| *Rating* | *Continuous* |
| *Driving motor field brushes* | |
| *Grade* | *KCEG*.12 |
| *New length* | 0·790 *in.* |
| *Minimum length* | 0·560 *in.* |
| *Spring pressure* | 9·5 *oz.* |
| *Rotation (viewed from fan end)* | *Counter-clockwise* |
| *Overall dimensions* | |
| *Length* | 17·6375 *in.* |
| *Width* | 8·875 *in.* |
| *Height* | 16·03125 *in.* |

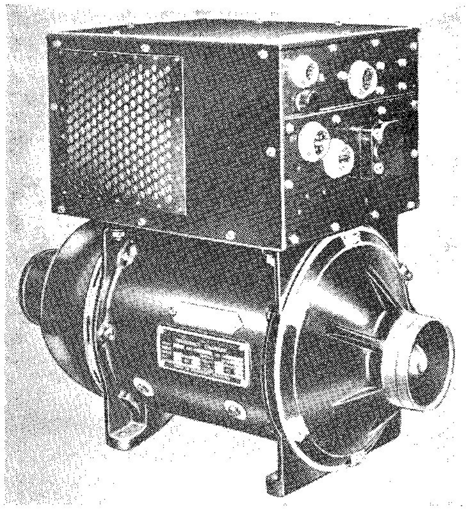

**Fig. 1. Frequency changer, Type 270**

## Introduction

1. The frequency changer, Type 270, is used to change the frequency of the main power supply in a 200V, 3-phase, 400 c/s a.c. constant frequency system. It is a two-unit machine consisting of a 200V, 3-phase, 400 c/s synchronous motor running at 8000 r.p.m. and a 2 k.W, 115V, single-phase 1600 c/s inductor type a.c. generator, within the same frame.

2. The output frequency is dependent upon the controlled input frequency, and no output frequency control is provided. The 1600 c/s output voltage is controlled as 115V $\pm$ 1 per cent by the control panel Type 40 in conjunction with the rectifier unit, Type CP40. These units are described in Sections 8 and 19 of this publication respectively.

## DESCRIPTION

### General

3. The frequency changer (*fig.* 1), consists of a cylindrical main frame with an integrally cast end frame, and end casting and two end covers. The wound rotor of the driving motor, and rotor of the inductor type a.c. generator are located within the bore of the main frame casting. The end casting houses the driving motor brush gear assembly, and encloses the slip-rings. There are 2 B.A. studs fitted at each end of the main frame casting, eight studs at the slip-ring end and six studs at the generator end. The slip-ring end casting is mounted on the studs and secured by nuts and locking tabwashers. The fan cover is mounted and secured in a similar manner to the studs at the generator end. A rectangular control box, housing the various contractors and control relays is mounted on top of the frame. The machine is mounted on four feet which form part of the main frame casting.

### Rotor

4. The rotor comprises two slip-rings, the six-pole wound rotor of the driving motor and the rotor of the inductor type generator, mounted on a common shaft. The rotor shaft is supported in enclosed type ball bearings, one located in the slip-ring end casting, and the other in the main frame end casting. The shaft at the generator end protrudes through the bearing and provides a mounting for the fan. The fan end bearing is a push fit within a lined recess in the main frame housing. After fitting the bearing, a shim washer is interposed between the bearing and the fan. The fan is keyed to the shaft and secured by a spinner nut and lockwasher.

### Control box

5. The control box contains the various relays, resistors, capacitors, current transformers and rectifiers used in the motor starting and control circuits, the trimmer resistors for the motor and generator main fields, and the interference suppressor. It is mounted on top of the main frame and retained by four $\frac{1}{4}$ B.S.F. studs which are secured by locknuts and washers. The studs are fixed to the control box and locate in four flanges cast integral with the main frame. The cover and side plates are removable to allow access to the various components. The connecting leads, eight from the driving motor and six from the generator are passed through grommets in the top of the main frame and the base of the control box, and connected to a terminal block located on the side of the control box. A wiring diagram of the internal connections in the control box is shown in fig. 4. The various contactors and relays are described in A.P. 4343C, Vol. 1, Sect. 3 and Sect. 4.

6. External connections are made by a terminal block and miniature plugs and sockets which are mounted on the side plate of the control box at the generator end. Connection to the control panel and the 115V, 1600 c/s output are made by two miniature sockets, and to the 28V d.c. input

and control circuit by a miniature plug. Connection to the 200V, 3-phase, 400 c/s supply is made by three 2 B.A. terminal studs mounted on an insulating moulding and fitted with an insulated cover. A gland is fitted to provide entry for the d.c. negative cable.

**Cooling**

**7.** Cooling air is provided by a fan keyed to the rotor shaft at the generator end secured by a spinner nut and lockwasher. The fan, which is enclosed by a fan cover, draws air through the inlet in the fan cover and forces it through vent holes in the end frame casting, over the rotor to the slip-ring end, where it is expelled through vent holes in the slip-ring end casting into the air outlet cover. With blast cooling, slipstream air is ducted to the inlet in the fan cover and leaves the machine through an outlet which is fitted in place of the temporary cover. The arrangement differs in various aircraft, and the relevant Aircraft Handbook should be consulted for details of a particular installation.

## OPERATION

**Starting**

**8.** The power supplies required for starting and the satisfactory performance of the machine are the 200V, 400 c/s, 3-phase main power supply, and the 28V d.c. field and control circuits supply. The 1600 c/s load should not exceed 250W during starting, full load may be switched on when the machine has attained synchronous speed.

**9.** Operation of the start push button switch energizes the coil of the main supply contactor which closes contacts 1, 2, 3 and 4. A 200V, 3-phase, 400 c/s supply is now connected through contacts 1, 2 and 3 to the field terminals A, B and C of the motor. A 28V d.c. supply is connected through contacts 4 to the coil of the star contactor through the normally closed contacts of the star/delta relay, contacts 5–6 of the main field contactor, and the normally closed interlock contacts of the delta contactor. The star contactor closes and the machine starts up as a star connected induction motor. The main supply contactor remains energized after the start button is released, the hold-in circuit is supplied from contact 4, through contacts 3 and 1 of the delta contactor, and the normally closed contacts of the single phasing relay and overvoltage relay.

**10.** The a.c. generator main field excitation current is initially provided from the 28V d.c. supply through contact 4 of the main supply contactor. This supply is connected through the normally made contacts of relay RL1 in the control panel Type 40, and returns through the pre-set resistor R3 in the frequency changer, to the a.c. generator main field. When the generator voltage builds up to 85V, relay RL1 opens and isolates the 28V d.c. supply, the field excitation current is then supplied from the a.c. generator output through a transformer–rectifier system in the control panel, Type 40.

**11.** The 115V a.c. generator output is applied to the coil system of the star/delta relay, this supply is controlled by the star contactor contacts 5–6, which are now closed as a result of the star contactor being energized. The star/delta relay operates after approx. two seconds time delay, and the normally open contacts close to supply 28V d.c. from contacts 4 of the main supply contactor to the pick-up coil of the field failure relay and to the coil of the delta contactor; the normally closed contacts open to isolate the supply to the star contactor coil.

**12.** The field failure contacts are closed before the delta contactor is energized, this ensures that the hold-in circuit for the main supply contactor is maintained when contacts 3–1 of the delta contactor open as a result of the contactor being energized. When the star contactor is de-energized by the opening of the normally closed contacts of the star/delta relay, the delta contactor coil is then energized from a 28V d.c. supply through the closed contacts of the star/delta relay, the blocking rectifier D1 and the now closed interlock contacts of the star contactor. The machine is now running as a delta connected induction motor.

**13.** The 28V d.c. supply from contacts 4 of the main supply contactor is applied through contacts 3–2 of the delta contactor to the coil of the main field contactor. The main field contactor normally open contacts 1–2 and 7–8 are closed and the normally closed contacts 5–6 are opened. The motor field circuit is then connected to the 28V d.c. supply through contacts 1–2 of the main field contactor variable resistor R5 and the retaining coil of the field failure relay. The machine synchronizes and is now running as a synchronous motor. The main field contactor contacts 7–8 supply 28V d.c. to maintain itself energized and the same contacts supply 28V d.c. through the blocking rectifier D1 and the closed interlock contacts of the star contactor to the coil of the delta contactor. The star contactor coil, already isolated by the operation of the normally closed contacts of the star/delta relay is further isolated by the operation of contacts 5–6 of the main field contactor.

**14.** The 115V supply to the coil system of the star/delta relay was interrupted by the opening of the star contactor contacts 5–6 when the contactor was de-energized. The star/delta relay is de-energized after approx. two seconds time delay, and its normally open contacts break, isolating the supply to the pick-up coil of the field failure relay. The field failure relay is now dependent upon the motor field current through its retaining coil to maintain it in the closed position.

### Stopping

**15.** The machine is stopped by the operation of the main supply contactor. The series circuit consisting of the normally made push-button switch, overvoltage relay, field failure relay and single-phasing relay, complete the hold-in circuit for the main supply contactor. Operation of either of these components will cause the main supply contactor to become de-energized and the machine will be shut down.

### Overvoltage relay

**16.** The overvoltage protection circuit is incorporated in the control panel, Type 40 and reference should be made to that chapter which contains a full description of the operation of the circuit.

### Field failure relay

**17.** Protection against the loss of motor field current is provided by the field failure relay. If the field current is less than 4A the relay retaining coil will become de-energized, and the relay contacts will open breaking the hold-in circuit of the main supply contactor.

### Single-phasing relay

**18.** The single-phasing relay is operated by a coil system supplied from three current transformers which are interposed between the main supply contactor and the star/delta

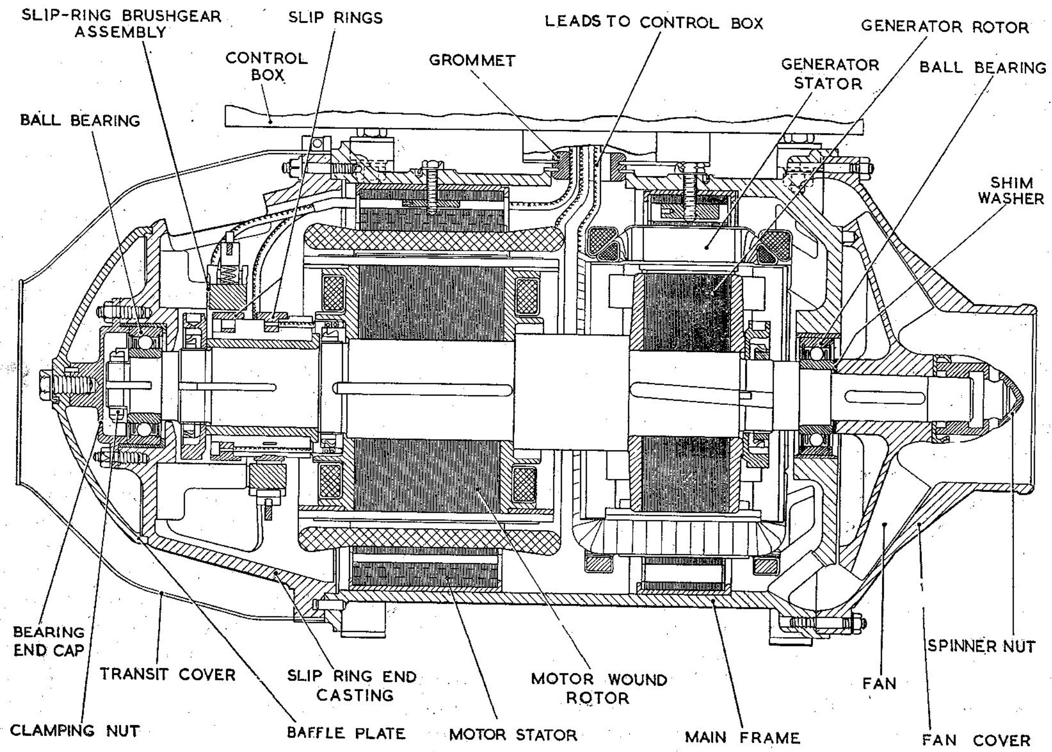


**Fig. 2. Sectional view**

contactor, one in each line. The rectified output of each current transformer is connected through a 10-ohm resistor in each positive line to a common negative line. Two oppositely wound relay coils are connected across the positive lines. With a balanced 3-phase load, no current is flowing in the relay coils. If one power line becomes open circuited the voltage across one resistor collapses and current flows in the relay coils causing the relay to be energized. The relay contacts operate to break the hold-in circuit of the main supply contactor.

## SERVICING

### General

**19.** Reference should be made to A.P.4343, Vol. 1, Sect. 1, Chap. 1, and Sect. 8, Chap. 2, where information on servicing common to all airborne rotary machines is to be found. The following paragraphs should be read in conjunction with the relevant Bay Servicing Schedule.

**20.** To examine the machine, disconnect the connecting leads and air pipes and remove the machine from its installation. Remove the air outlet end cover and the control box cover. Clean and examine the frame, slip-rings and 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

**21.** New brushes should be fitted if the rate of wear indicates that the minimum length may be reached before the next servicing period or examination. When new brushes are fitted they should be bedded in over 50 per cent of their contact surface area, by running the machine at 8000 r.p.m. on no load. The pressure of each brush spring should be checked to ensure that it lies within the limits quoted under Leading Particulars.

### Bearings

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

## TESTING

### General

**23.** The full test procedure is described in the relevant Bay Servicing Schedule. The tests detailed in the following paragraphs prove the operation of the frequency changer under various conditions of loading and input voltage and frequency.

**24.** The machine should be connected to the inverter and frequency changer tester (*Ref. No.* 5G/3267). The 200V, 3-phase, 400 c/s input to the tester may be obtained from a suitable airborne type a.c. generator, driven by a Mk, 5 generator test bench. The unit should be connected in circuit with the 28V d.c. supply through the stop and start push-button switches, and with a control panel Type 40 and rectifier unit, Type CP40, as shown in the Interconnection diagram to be found in Sect. 8, Chap. 17 of this publication. The control box cover, together with the right-hand side panel when viewed from the air inlet end, should be removed.

### Starting test

**25.** Ensure that the load switches are in the off position, and adjust the a.c. input to 200V, 400 c/s and the d.c. input to 28V. Operate the start push button and check that the machine runs in a counter-clockwise direction when viewed from the fan end, and that it reaches synchronous speed satisfactorily.

**26.** Repeat the previous test, but with the d.c. input voltage adjusted to 25V and the a.c. input voltage adjusted to 196V, 400 c/s, and with the d.c. input voltage adjusted to 29V and the a.c. input voltage adjusted to 240V, 400 c/s.

**27.** Set the input voltages to 28V d.c. and 200V, 400 c/s a.c. respectively. Check that the machine will start and stop under the control of the push buttons, with the output voltage adjusted to 112V, 115V and 118V a.c.

**Protection circuits**

**28.** Disconnect, at the control box, the 4-pole plug connection from the control box to the control panel Type 40, and insert a switch in series with a connection across pins A and B on the 4-pole socket on the control box.

**29.** Disconnect the lead to terminal X6 of the 14-way terminal block in the control box, and connect a switch between that terminal and the lead X6. It should be noted that this test will not apply if the field failure protection circuit has been made inoperative.

**30.** Set the input voltages to 28V d.c. and 200V a.c. respectively. Start the machine and check that it will shut down under the following conditions.

(1) If the switch across pins A and B (*para.* 28) is broken.

(2) If the switch in series with the motor field (*para.* 29) is broken.

(3) With full load applied, and any one of the 3-phase input voltage lines is open circuited.

**31.** Check that when the a.c. supply is removed with the machine running, the star/delta contactor returns the machine to the star connected condition, and that when the supply is reconnected, no current is taken from the supply until the start push button is operated. This test does not apply to early manufactured machines.

**Output voltage test**

**32.** Adjust the input voltages to 28V d.c. and 200V, 400 c/s a.c., and switch on a load of 250W. Start the machine, and check that the output voltage and frequency is 115V, 1600 c/s. Increase the load to 2kW and check that the output voltage is 115V$\pm$1 per cent. It should be noted that the 1600 c/s frequency regulation is dependent upon the 400 c/s input supply tolerance.

**Overspeed test**

**33.** Adjust the input frequency to 500 c/s. With the machine still hot from the previous tests, run on no load for a period of two minutes at this setting. There should be no signs of excessive vibration or damage.

**Insulation tests**

**34.** With the earth link on the suppressor box in position, and pins A, B and C of the 4-pole d.c. plug connected to pins D and E of the 12-pole socket, use a 500V insulation tester to measure the insulation resistance as follows:—

(1) Between the 3-phase, 400 c/s input terminals and the frame.

(2) Between lines on the 3-phase, 400 c/s circuits.

(3) Between the single-phase 1600 c/s output terminals and the frame, with all the 3-phase terminals connected to the frame. The reading should exceed 50 000 ohms for each test.

**35.** Remove the earth link on the suppressor box and check the insulation resistance using a 250V insulation tester, between the frame and terminals A, B and C on the 4-pole d.c. plug and pins D and E on the 12-pole socket. The values obtained should be not less than 50 000 ohms.



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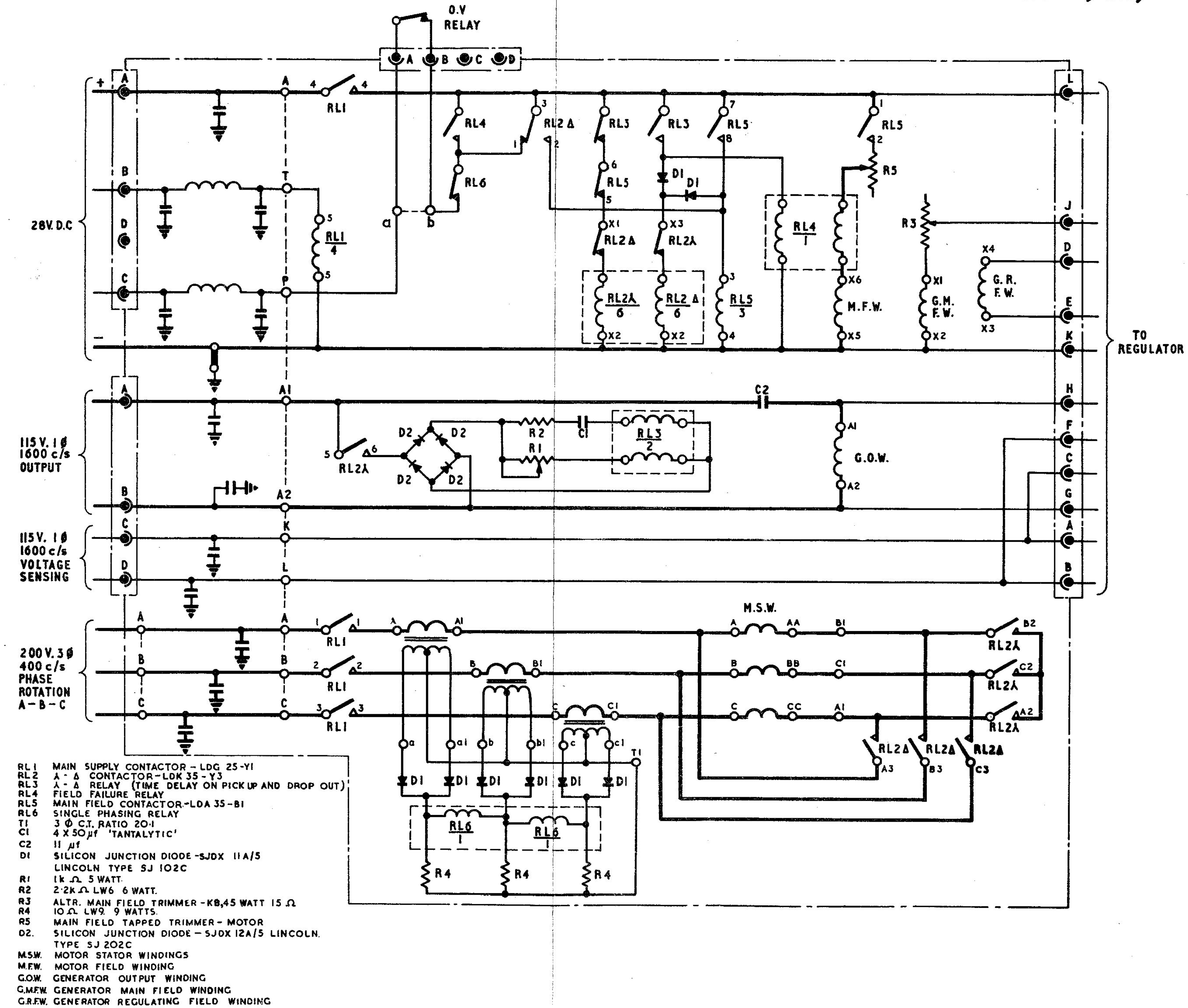


Fig. 3 Theoretical wiring diagram Fig. 3