Chapter 18

ROTARY INVERTER, TYPE D2-A2, FORM B5

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LEADING PARTICULARS

Rotary inverter, Type D2-A2, Form B5	*Ref. No. 5UB/7800*
Input	
Voltage	25-28*V d.c.*
Current	170*A approx.*
Output	
Voltage	200*V a.c., 3-phase*
Frequency	400 *c/s*
Power	2250 *VA*
Power factor	0·8

LEADING PARTICULARS—*contd.*

Speed	8000 *rev/min*
Rotation (viewed from slipring-end)	*Counter-clockwise*
Commutator brushes	
Grade	*EG*.12
New length (on longest side)	19 mm
Minimum length	15 *mm*
Spring pressure	37-45 *oz.*
Slipring brushes	
Grade	*KBEG*.14
New length	14·5 *mm.*
Minimum length	8 *mm.*
Spring pressure	130-154*g.*
Commutator (minimum diameter)	44·91 *mm.*
Sliprings (minimum diameter)	21 *mm.*

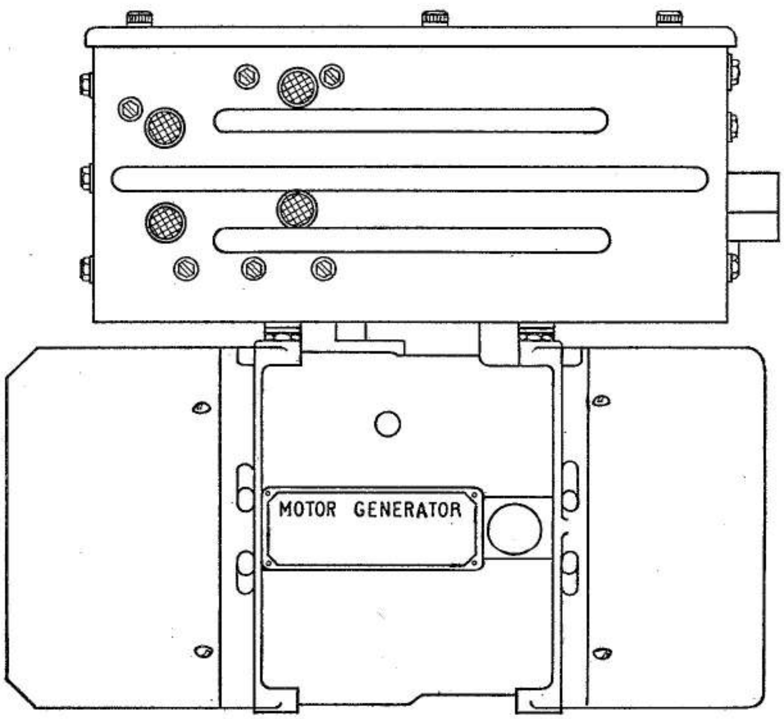


Fig. 1. General view

Introduction

1. The rotary inverter, Type D2-A2, Form B5 is designed to provide a.c. power at 200V, 2250VA, 0·8 p.f., 3-phase, 400c/s when supplied from the nominal 28V d.c. aircraft supply. The output voltage is controlled within the limits of 200V $\pm$ 2 per cent by means of a voltage regulator, and the output frequency is controlled within the limits of 400c/s $\pm$ 2 per cent by the frequency regulator. The voltage and frequency regulators are of the magnetic amplifier type.

DESCRIPTION

General

2. The rotary inverter comprises a 4-pole shunt-wound d.c. motor, fitted with interpoles, driving a 3-phase, 6-pole rotating-field type a.c. generator. The machine is combined to form a single unit having a common shaft supported on sealed ball journal bearings at each end and carrying the motor armature and the generator rotating-field system. The motor yoke and field-coiled unit and the generator stator are housed in a robust aluminium-alloy casting with spigot locations for positioning the end castings and provision for mounting the control box. Four holes are provided in the base of the frame casting for mounting purposes. The unit is self-cooled by means of a fan which is keyed to the rotor shaft at the commutator end.

3. The 3-phase output windings of the generator are star-connected, all three phases and the neutral are brought out to 4-pole socket mounted on the end of the control box. At the same end of the control box as the output socket is fitted, there are two $\frac{5}{16}$ in. U.N.F. terminals for the 28V d.c. input.

4. The control box, which is mounted on top of the frame casting and retained by four $\frac{1}{4}$ B.S.F. screws secured by nuts and lock-washers, contains the motor-starting contactor and resistor, radio interference suppressors and the voltage and frequency regulator units. The machine is designed to start with full load connected, provided that the voltage at the machine terminals is not less than 25V when full load is being delivered.

Voltage regulator unit

5. The voltage regulator unit comprises, a static exciter having three windings, a line current compounding winding, a 200V, 3-phase primary winding and an output winding, a magnetic amplifier incorporating a 3-phase transductor Type LTE-V5 and 3-phase bridge rectifier assembly, and a voltage sensing bridge made up of three resistive arms and in the fourth arm a voltage reference of series connected Zener diodes. A 3-phase, 200/30V transformer Type LTA-Y5 and a 3-phase bridge rectifier assembly is provided to supply the voltage sensing bridge.

Circuit description

6. The 3-phase a.c. generator output is fed into the voltage regulator unit, it passes through the line current compounding windings of the static exciter and is then fed to the primary windings of the static exciter and transformer LTA-Y5 within the voltage regulator unit, and externally to the frequency regulator unit and a.c. output socket.

7. The output from the transformer LTA-Y5 is rectified and fed to the voltage sensing bridge. The bridge is balanced with an a.c. generator line voltage of approx. 200V, and no current flows in the control winding C-CC of the transductor LTE-V5 at this line voltage. Variations in the a.c. line voltage and hence the d.c. signal to the bridge will cause the p.d. across the resistive arms to vary but the p.d. across the Zener diodes will remain substantially constant, thus the bridge becomes unbalanced and a d.c. current flows in the transductor control winding, the direction of which depending on whether the a.c. voltage error is +ve or −ve, and the magnitude depending on the magnitude of the voltage error.

8. The static exciter output windings supply the excitation windings of transductor LTE-V5, the rectified output of the transductor, which is controlled by the error signal from the voltage sensing circuit, is applied to the generator field.

9. Initial excitation of the generator field system from rest is provided from the 28V d.c. aircraft supply to a 430-ohm resistor and a blocking rectifier. This supply is essential for excitation from rest and is permanently connected. The blocking rectifier is needed, since on load the field voltage is greater than 28V d.c.

Frequency regulator unit

10. The frequency regulator unit comprises a first stage magnetic amplifier incorporating a 3-phase transductor Type LTE-V2 and a 3-phase bridge rectifier assembly, a frequency sensing circuit using a choke Type LTD-V3, and a second stage magnetic amplifier incorporating a 3-phase transductor Type LTE-V6 and a 3-phase bridge rectifier assembly. A 3-phase 200/30V transformer Type LTA-Y5 supplies the frequency sensing circuit and first stage amplifier.

Circuit description

11. *Frequency sensing circuit and first stage amplifier*. The a.c. generator output is fed into the frequency regulator and supplies the primary winding of the transformer LTA-Y5. The 3-phase, 30V transformer output is fed into the frequency sensing circuit; one side is rectified and applied to control winding C2-C2 of the transductor LTE-V2 while the other side is rectified, after passing through the LTD-V3 choke, and applied to control winding C1-C1 in the opposite direction. At the frequency of 400c/s the impedance of the circuit containing the choke is such that the control winding currents are equal and in opposition, and thus cancel each other out. Variation in the supply frequency produces variation in the current in the inductive circuit which creates an unbalanced condition between the two control windings.

12. The 3-phase, 30V output from transformer LTA-Y5 also supplies the excitation winding of the transductor LTE-V2, the rectified output of the transductor, which is the amplified error signal from the frequency sensing circuit, is fed into two 100 ohm resistors forming a push-pull output and applied to control winding C1-C1 of the second stage amplifier transductor LTE-V6.

Second stage amplifier

13. The excitation winding of the transductor LTE-V6 is fed from the a.c. generator supply, the transductor output is rectified and applied to the regulating field of the motor to assist the motor main field. The control signal for this stage is the output from the first stage passing through the control winding C1-C1.

14. A stabilizing feedback circuit is provided between the first and second stage amplifiers to minimize hunting in the frequency control circuit. A signal is obtained from the second stage output and applied through a resistor/capacitor network to the control winding TD-TD of the first stage transductor. Under steady state conditions no d.c. current is flowing in the stabilizing circuit.

OPERATION

15. Reference should be made to fig. 5 when following the operation of the starting, voltage regulator and frequency regulator circuits described in the following paragraphs.

Starting

16. When the 28V d.c. supply is made to the +ve and −ve input terminals the positive supply is connected through the starting resistor to the motor armature, through the 18-ohm trimmer resistor to the motor main field, and through the 430-ohm resistor and blocking rectifier to the generator field. The machine starts, and when it reaches a pre-determined speed, the back e.m.f. developed across the armature produces sufficient current through the operating coil of the contactor to close the contactor thus short-circuiting the starting resistor and allowing the motor to reach full speed. Radio interference from the inverter is prevented from passing into the d.c. line by an inductance-capacity filter network.

Voltage regulation

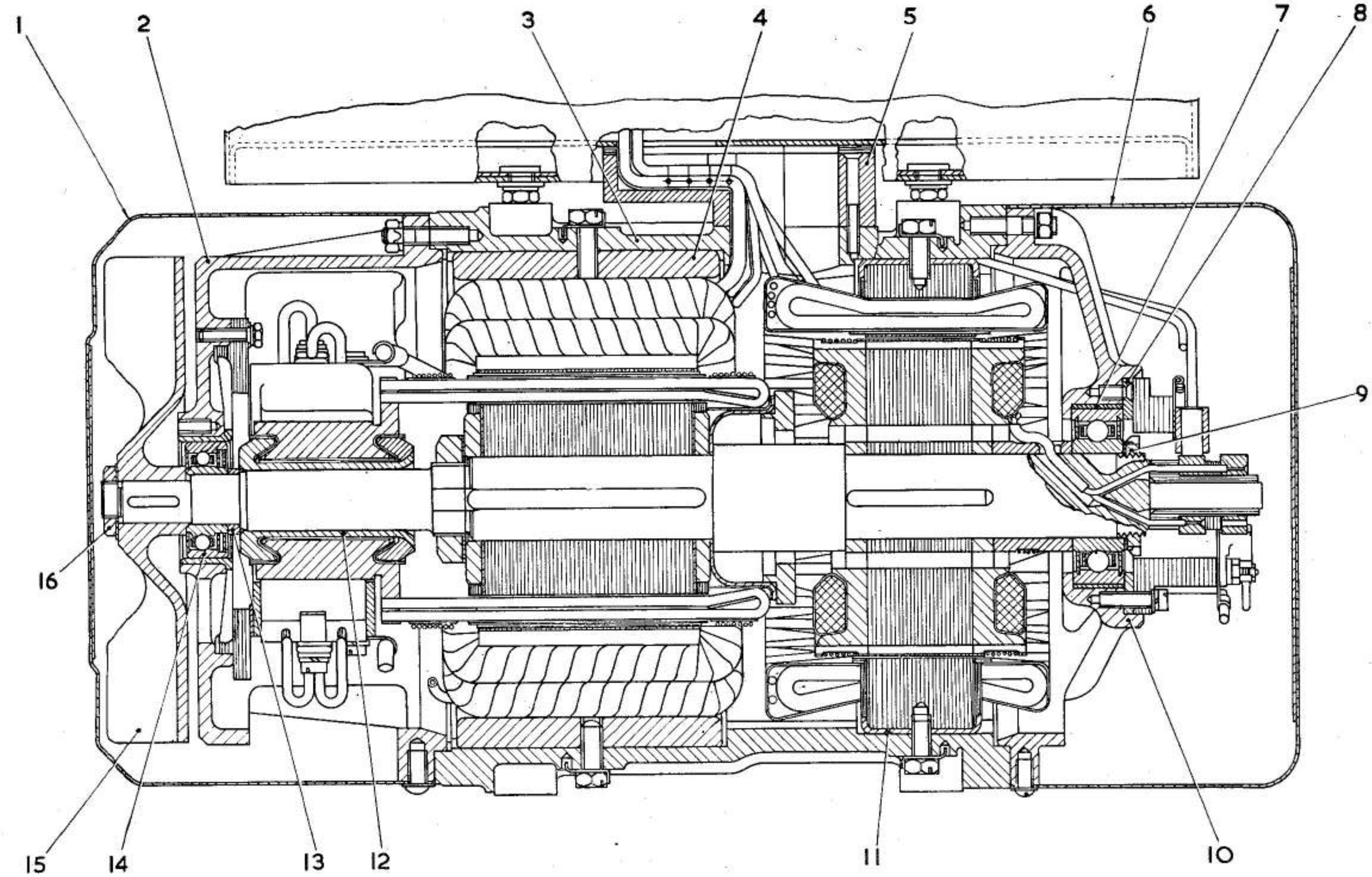
17. The initial excitation current for the generator field system is provided from the 28V d.c. supply as described in para. 9. When the machine is running the field is supplied from the static exciter output, which by virtue of the relationship between the primary, secondary and line current compounding windings, produces an output matched to the generator field requirement.

18. The output current from the static exciter is rectified by a 3-phase, fullwave, bridge rectifier incorporated in the transductor type LTE-V5, and is adjusted to the required level by the application of current to the control winding C-CC of the transductor.

19. The transductor control current is supplied from the voltage sensing bridge described in para. 7, the control winding being so connected that a rise in generator line voltage causes the transductor impedance to increase and so correct the voltage error.

Frequency regulation

20. Frequency normal. Under these conditions the output from the frequency sensing circuit is such that equal currents flow through the first stage transductor control windings which are connected in



1 COMMUTATOR-END COVER
2 COMMUTATOR-END CASTING
3 FRAME CASTING
4 YOKE AND FIELD COIL UNIT
5 AIR DUCT
6 COVER AND VENTILATING PLATE
7 BALL BEARING (SLIPRING END)
8 BEARING PLATE
9 BEARING CLAMPING NUT
10 SLIPRING-END CASTING
11 WOUND STATOR
12 ARMATURE
13 SPACER
14 BALL BEARING (COMMUTATOR-END)
15 FAN
16 FAN CLAMPING NUT

Fig. 2. Sectional view

opposite polarity; thus there is no effect on the transductor output, which is the control signal for the second stage amplifier. The output from the second stage transductor to the motor regulating field remains constant and the output frequency is maintained at the normal level.

21. Frequency above normal. When the frequency rises above normal the current in the transductor control winding connected to the inductance is reduced and the resultant effect is to decrease the impedance of the excitation winding, thus increasing the transductor output and the control signal to the second stage amplifier. The effect of a rise in current in the control winding of the second stage transductor is to increase the excitation of the motor regulating field by permitting a larger output from the transductor excitation windings, thus increasing the total flux of the motor field system, hence a reduction in motor speed.

22. Frequency below normal. When the frequency drops below normal the current through the transductor control winding connected to the inductance is increased and the resultant effect of the two control windings is to increase the impedance of the transductor excitation winding, thus giving a reduced transductor output. The effect on the second stage transductor is to decrease its output thus weakening the total flux of the motor field system, hence an increase in motor speed.

SERVICING

Brushes

23. Access to the brushes is obtained by removing the inverter end covers. The brushes should be examined for sufficient length and freedom of movement in the brush boxes. 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. The procedure for brush bedding is given in para. 43.

Commutator and sliprings

24. Examine the commutator and sliprings for signs of burning, pitting and contamination. If the commutator or sliprings are badly worn or pitted the inverter should be removed for repair.

Bearings

25. The bearings of the inverter are partially packed with grease during initial manufacture, and since the bearings are sealed, they must not be washed in any solvent that would remove the grease. These bearings should be changed at the intervals specified in the relevant Servicing Schedule.

Starting contactor

26. Examine the contactor for any signs of overheating of the operating coil or the contacts. Examine the contacts for cleanliness or signs of burning or pitting. If the main contacts are worn to the extent that only $\frac{1}{32}$ in. thickness of silver remains they should be renewed. Reference should be made to A.P.4343, Vol. 1, Sect. 11, Chap. 2 for information on the servicing of electrical contacts.

27. Check that the movement of the armature is free and that with the relay energized there is at least 0·015 in. over-travel of the armature after the contacts have closed, and that the auxiliary contact gap does not exceed 0·22 in. If adjustment is required or the relay is suspected of being defective, it should be tested and adjusted as detailed in para. 45.

Dismantling

28. The following tools or their equivalents are required for dismantling.

Description	*Ref. No.*
Spanner for bearing clamping nut	5UB/6551
Extractor for bearings	5UA/3253

Control box

29. Remove the 4BA screws, washers and lockwashers securing the bracket and adjustable resistor assembly which is mounted above the contactor; lift out the resistor as far as the connecting leads will allow. Disconnect the leads from terminals No. 1 and No. 3 of the contactor. Disconnect the leads from the 24- terminal on the capacitor block. Disconnect the inverter leads from the terminal block connections A, B, C, N, X1, X2, X, XX, Z and ZZ. Remove four $\frac{1}{4}$ in. B.S.F. nuts and lockwashers securing the control box to the inverter and lift off the control box.

30. Disconnect the remaining leads from the contactor and mark them to facilitate reconnection. Remove the three 4BA screws securing the contactor and the four 4BA nuts securing the starting resistor. Lift out the contactor and starting resistor from the control box together with the insulating strip and spacer.

Armature and end castings

31. Remove the commutator-end cover and slipring-end cover and ventilating plate. Disconnect and remove the lead connections to the a.c. and d.c. brushgear after marking to facilitate correct reconnection; mark the brushes with respect to their boxes and remove the brushes.

32. Mark the position of the a.c. brushgear relative to the slipring-end casting. Remove the four 4BA securing screws and lockwashers and remove the brushgear from the end casting.

33. Unscrew the fan clamping nut and remove the lockwasher, the fan and woodruff key. Remove the slipring-end bearing clamping nut and lockwasher.

34. Mark the position of both the commutator and slipring-end castings relative to the frame casting so that they can be correctly refitted. Lift and secure the d.c. brush springs clear of the commutator. Unscrew the four 2BA nuts securing the slipring-end casting and remove the casting, together with the armature, by gently tapping the commutator-end of the shaft.

35. Remove the four 4BA screws securing the bearing plate to the slipring-end casting and remove the bearing plate. Using a suitable extractor, separate the slipring-end casting from the armature. Press the bearing from its housing in the casting.

36. Remove the four 2BA nuts and lockwashers attaching the commutator-end casting to the frame casting and separate the commutator-end casting from its spigot.

37. Extract the bearing from the commutator end of the shaft and remove the spacer, if the bearing has remained in its housing in the commutator-end casting, press it out.

Assembling

38. All lockwashers should be renewed when assembling the machine.

Armature to slipring-end casting

39. Assemble the spacer on the armature shaft and locate it against the commutator; press the commutator-end bearing into position so that the inner race butts against the spacer. Press the bearing into the housing in the slipring-end casting, refit the bearing plate and secure with four 4BA csk.hd. screws. Press the slipring-end casting onto the armature shaft until the bearing inner race butts against the shoulder on the shaft. Screw on, tighten and lock the bearing clamping nut.

End casting and armature to frame casting

40. Refit the commutator-end casting to the frame, tighten and lock the four 2BA retaining nuts and lockwashers. Assemble the armature and slipring-end casting to the frame taking care to avoid damaging the commutator, if necessary, gently tap the slipring-end casting so that it locates in its previously marked position against the frame. Refit, tighten and lock the four 4BA retaining nuts and lockwashers. Refit the woodruff key, fan, lockwasher and clamping nut onto the armature shaft and tighten and lock the clamping nut.

A.C. brushgear to slipring-end casting

41. Assemble the a.c. brushgear so that it locates in its previously marked position against the slipring-end casting and refit, tighten and lock the four 4BA securing nuts and lockwashers.

Brushes

42. Refit the a.c. and d.c. brushes ensuring that they move freely in their respective brush boxes. Reconnect the lead connections to the a.c. and d.c. brushgear.

Brush bedding

43. If new brushes have been fitted the preliminary bedding operation should be carried out in accordance with the procedure detailed in A.P.4343, Vol. 1, Sect. 1, Chap. 2.

Control box

44. Refit the contactor and starting resistor ensuring that the insulating strip is in position. Pass the inverter leads through the base of the control box, assemble the control box to the inverter and tighten the four ¼ B.S.F. securing nuts and lockwashers. Reconnect cables A, B, C, N, X1, X2, X, XX, Z and ZZ and the lead connections to the contactor and capacitor block. Refit the adjustable resistor and bracket assembly which is mounted above the contactor and secure it with the 4BA screws, washers and lockwashers.

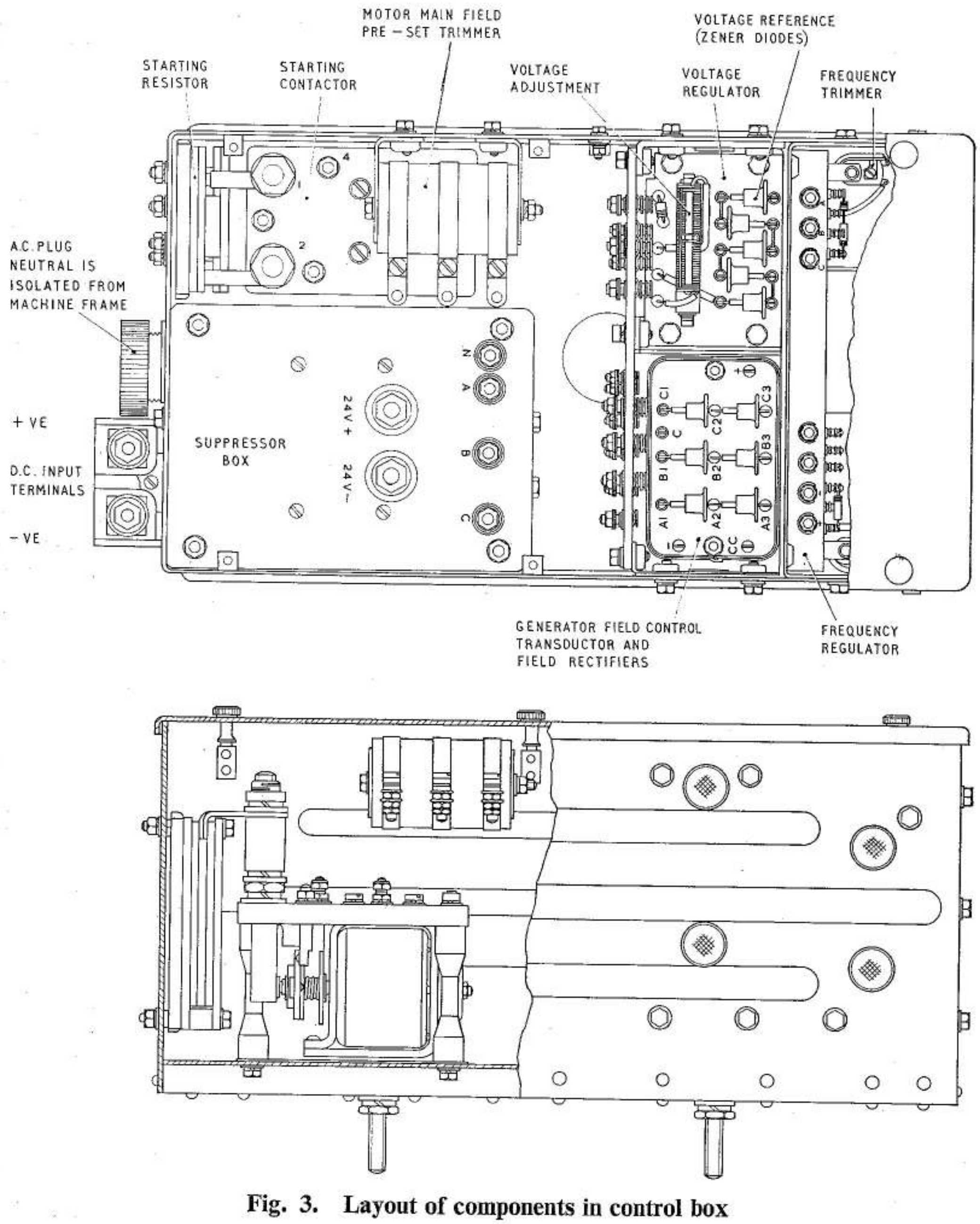


Fig. 3. Layout of components in control box

Adjustment of starting contactor

45. The contactor should be tested and adjusted as follows:—

(1) Set the over-travel of the armature to within the limits of 0·018 in. and 0·026 in. by slackening off the four 4BA screws securing the yoke to the moulding and adjusting the position of the yoke assembly in the slots in the moulding. With the armature fully closed, set the auxiliary contact gap to within the limits of 0·020 and 0·030 in. Lock the contact screw with its locknut after adjustment, and seal the thread with air-drying varnish.

(2) Measure the closing coil resistance between terminals 3 and 4; this must be within the limits of 6·4 ohms $\pm$ 10 per cent at 20 deg.C. Connect a variable d.c. supply to these terminals, and measure the minimum voltage for the contactor to close, this value being the product of the resistance measured and the current at pull-in. Adjust the pull-in current by variation of the stop screw until the pull-in voltage is within the limits of 13·4 $\pm$ 0·2V. Check that the contacts close fully in one motion and that the armature is fully home at the minimum applied voltage. Lock the stop screw with its locknut and seal the thread with air-drying varnish.

(3) Determine the total resistance of the coil by holding open the auxiliary contacts and measuring between terminals 3 and 4; this must be within the limits of 207 ohms $\pm$ 10 per cent.

(4) Pass a current of 150A between terminals 1 and 2 with the contactor closed, and measure the voltage drop directly across the terminals. This must not exceed 100mV.

(5) Check the insulation resistance between the yoke and the winding, this should be not less than 5 megohms, when measured with a 250V insulation resistance tester.

Testing

46. Details of the tests which may be applied to verify the serviceability of this machine will be found in Appendix A to this Chapter.

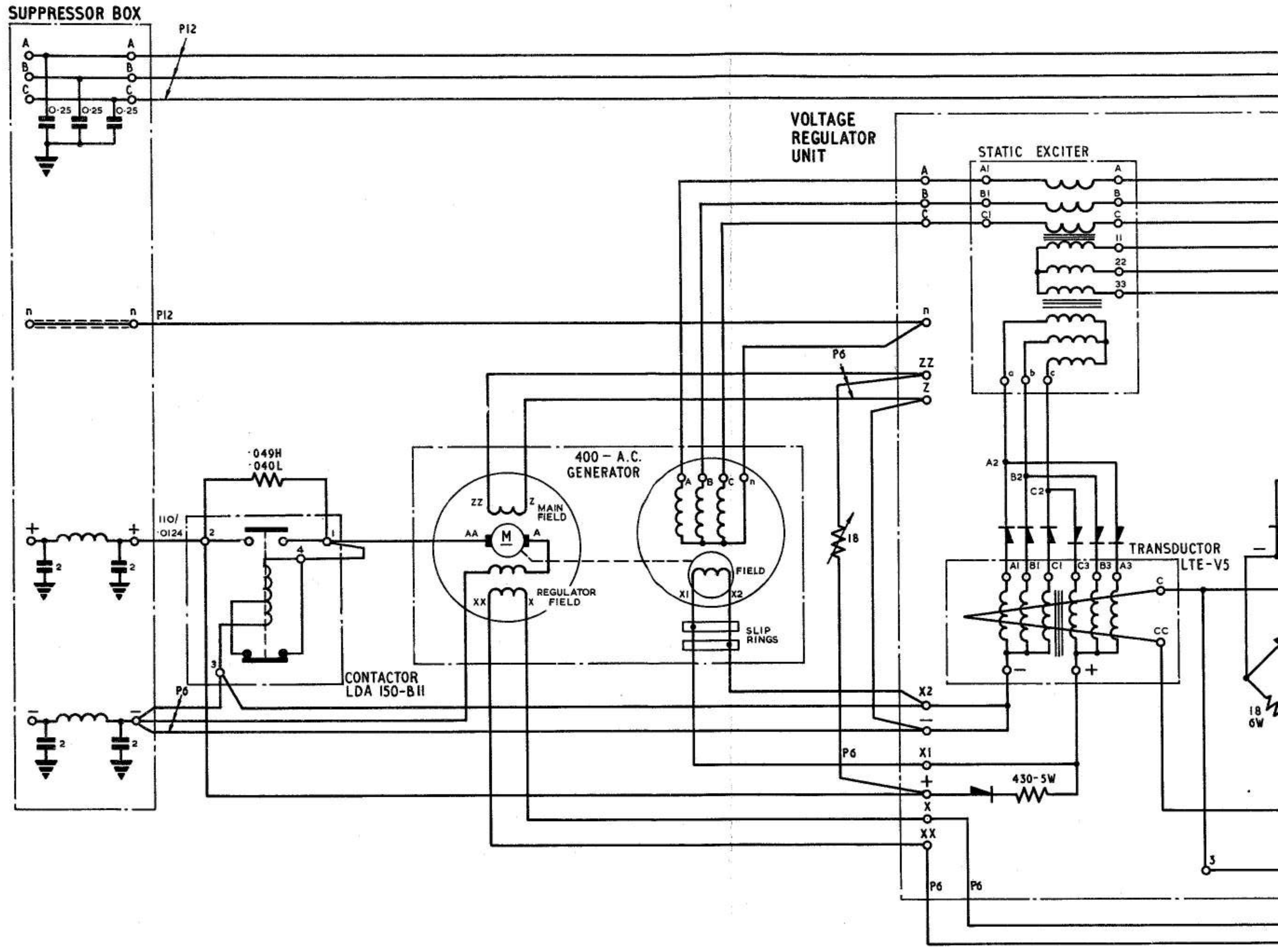
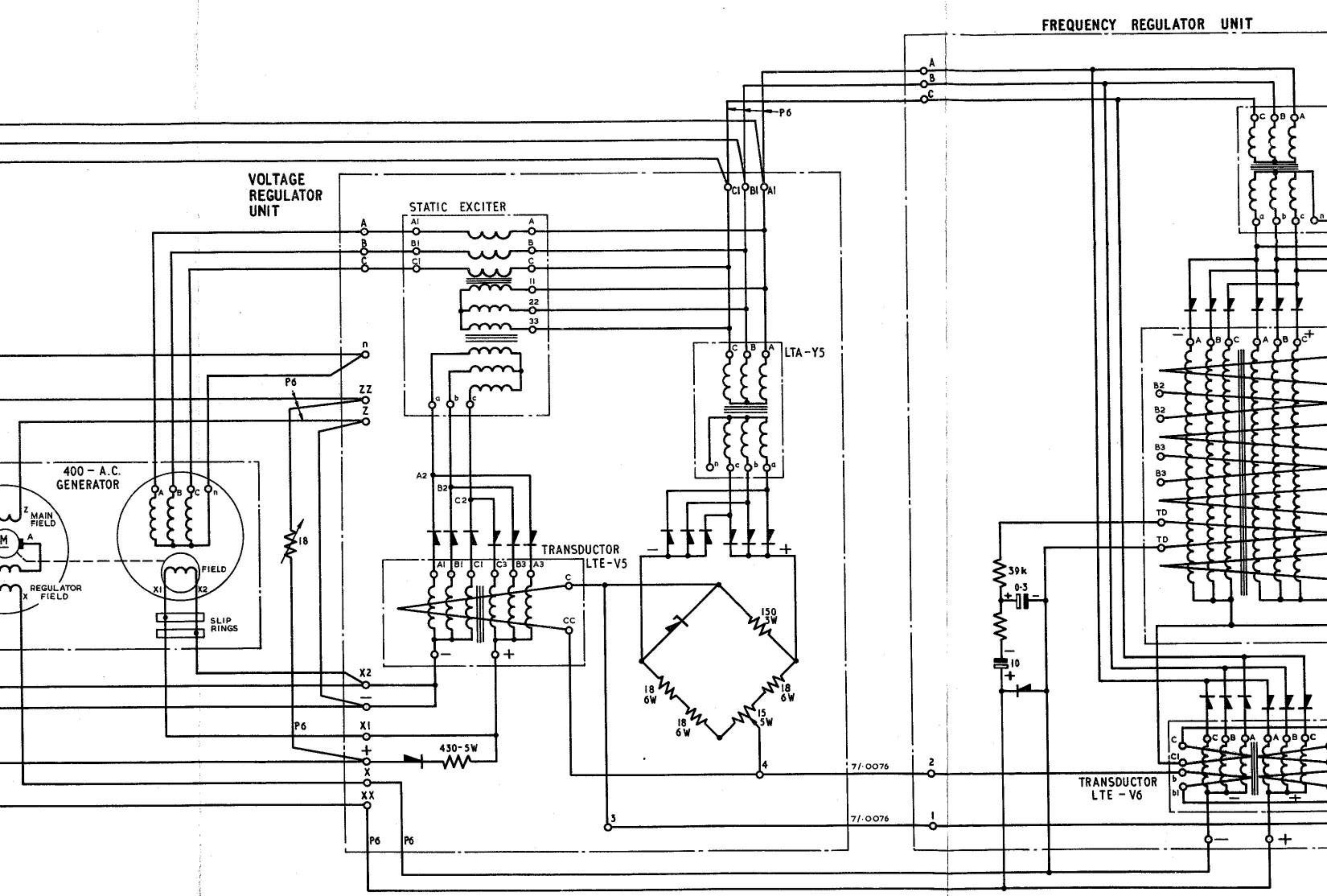


Fig. 4

PP9193 1840A/370848 12/63 C&P

Circuit diag

RESTRICT



Circuit diagram

RESTRICTED

Appendix A

STANDARD SERVICEABILITY TEST FOR ROTARY INVERTER, TYPE D2-A2, FORM B5

Introduction

1. The tests detailed in this Appendix should be applied to the machine before it is put into Service, or at any time when its serviceability is suspect.

TEST EQUIPMENT

2. The following test equipment together with a 24–28·5V d.c. variable voltage supply is required.

R.A.F.

Description	Ref. No.
Inverter tester	5G/564
Test meter, 200V, 400 c/s, 3-phase a.c.	5QP/3198
Test meter, Type D (or equivalent)	5QP/10610
Insulation resistance tester, Type A	5G/1621
Insulation resistance tester, Type C	5G/152
Spring balance 0–4 lb.... ...	1H/97
Tension gauge, No. 3	1H/59

R.N.

Description	Ref. No.
Variable air-cored reactive load	5G/3723
Variable rheostat	5G/4019
A.C. test set	5G/3626
Multimeter	0557/ A.P.48A
Insulation resistance tester, 250V	0557/ A.P.5047
Insulation resistance tester, 500V	0557/ A.P.12924
Spring balance 0–4 lb.... ...	1H/97
Tension gauge, No. 3	1H/59

Brushgear

3. Check the brush spring tension and brush length. The spring tension should be within the limits of 37–45 oz. and 130–154 g., and the minimum length, measured on the longest side, should be not less than 15 mm. and 8 mm. for the d.c. and a.c. ends respectively.

FUNCTIONAL TEST

Note . . .

(1) *The d.c. supply voltage for the following test should not be from a rectified a.c. source.*

(2) *The adjusting screws of the frequency and voltage trimmer resistors are live, and a screwdriver having an insulated blade should be used for adjustment.*

(3) *Para.* 4 *is for R.N. use only.*

4. Connect the test equipment as shown in fig. 1. Set the reactive load (5G/3723) to 57 mH, and the rheostat (5G/4019) to 33·9 ohms, each limb. This will give the equivalent of a load of 1·8kW or 2·25kVA at 0·8p.f. lagging.

5. Remove the voltage trimmer resistor outer securing screw and slacken the inner securing screw. Lift the resistors clear as far as the connecting leads will allow so that the adjusting screw is accessible. If Mod. CS–1158 is incorporated, access to the voltage trimmer can be obtained by removing one voltage regulator fixing screw which also retains a large gland washer used to cover the access holes.

6. Run the machine on full load, at 25V, d.c. input, for 30 to 60 min. to allow the equipment to reach normal working temperature and the system to become electrically stable.

7. With the machine on full load, check that the d.c. input current does not exceed 140A (meter A1, fig. 1), at an input voltage of 25V.

8. (1) At an input voltage of 26·5V d.c., apply a full load of 1·8kW or 2·25kVA at 0·8p.f. Check that the phase rotation at the output plug is A, B, C. Run the machine for 5 min. under these conditions, and then trim the output voltage to 200$\pm$0·5V and the output frequency to 400$\pm$2 c/s.

(2) Check that the neutral connection to the output plug is satisfactory, by measuring any one line to neutral voltage at the output plug. The value of voltage

should be between 112V and 118V inclusive.

(3) Connect a suitable meter in the motor regulating field circuit and adjust the frequency trimmer, if necessary, to obtain the following conditions.

(a) Run the machine on full load and reduce the supply voltage to obtain a motor regulating field current of 50mA d.c. Check that the frequency is not less than 392 c/s.

(b) Run the machine on no load and increase the supply voltage to obtain a motor regulating field current of 350mA d.c. Check that the frequency does not exceed 408 c/s.

9. With the machine running on full load at 28V d.c. input, measure the mV drop between the external +ve and the internal +ve terminals and between the external −ve and internal −ve terminals. The maximum permissible mV drop should not exceed 1·0mV/A input current for each test.

Regulation test

10. Record the output voltage and frequency for no load and full load at input voltages of 25V d.c. and 28V d.c. In all instances the output voltage must be maintained within the limits of 196V and 204V, and the output frequency within the limits of 392 c/s and 408 c/s.

Starting test

11. Run the machine at 24V d.c. input with full load applied. Shut down, and without removal of the load or adjustment of the supply voltage, check that the machine will start satisfactorily. Repeat this test twice, as quickly as possible, i.e. restarting as soon as the machine has come to rest and switching off as soon as full speed has been reached.

Insulation resistance test

12. With the machine at normal working temperature and using a 250V insulation resistance tester, measure the insulation resistance between the supply terminals and the frame. Using a 500V insulation resistance tester, measure the insulation resistance between the output plug pins, A, B, C and the frame. The reading in each case should not be less than 0·05 megohms.

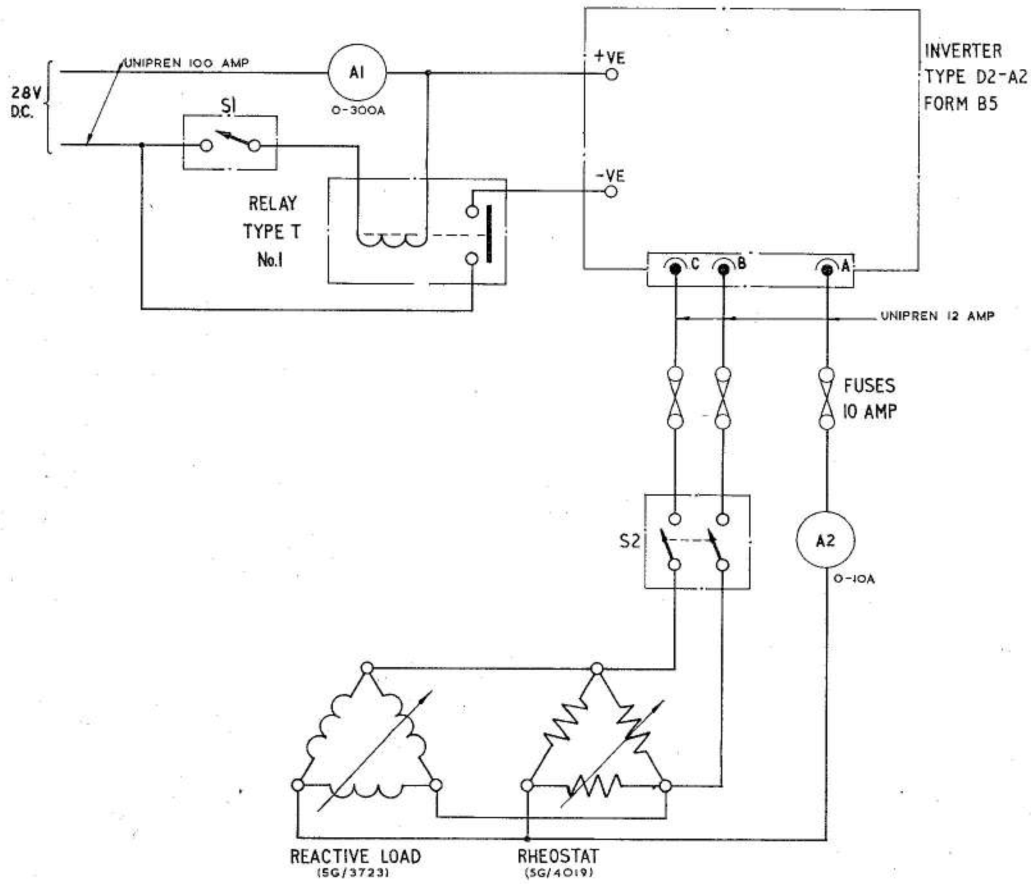


Fig. 1. Test circuit diagram


MIG PILOT
MIKOYAN