Chapter 11

TRANSFORMER-RECTIFIER UNIT, ROTAX, TYPE U3306

LIST OF CONTENTS

LIST OF ILLUSTRATIONS

LIST OF TABLES

LEADING PARTICULARS

Transformer-rectifier unit, Type U3306 ... ... **Ref. No. 5UC/7131**

Outputs	(1) 200 *volts a.c.*, 112 *amp.* 400 *c/s* ± 2 *per cent* 0·96 *to* 0·86 *power factor, lagging* (2) 28 *volts d.c.* 10 *amp.*
Phase	3
Rating	*Continuous*
Temperature range	−50 *deg. C to* +50 *deg. C*
Maximum altitude	30,000 *ft.*
Cooling	*Blower (Type CA1301) at ground level to* 10,000 *ft. Blast cooled at* 4·0 *lb./min. above* 10,000 *ft.*
Overall dimensions—	
Length	20·515 *in.*
Width	9·656 *in.*
Height (including terminal mouldings)	9·218 *in.*
Weight	41·5 *lb.*

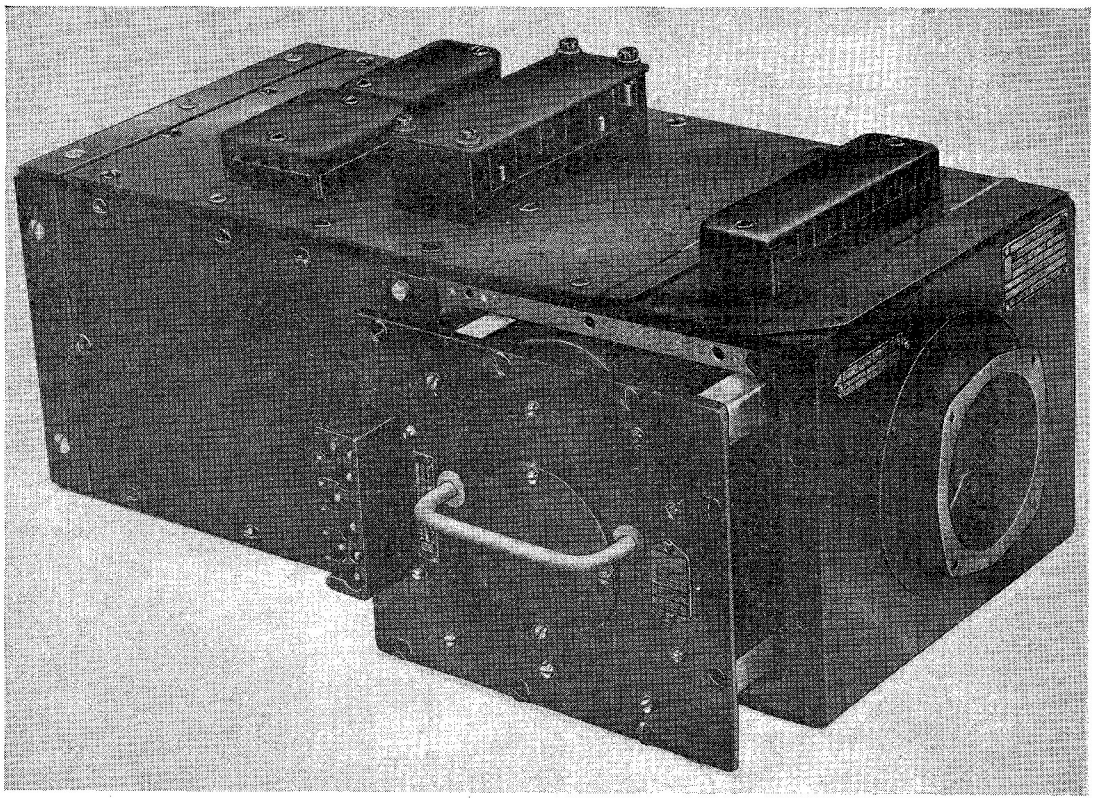


Fig. 1. Transformer-rectifier unit, Type U3306

Introduction

1. The U3306 unit is used in conjunction with the Type 155 a.c. generator (Rotax N0306) to provide a transistorized current control for the rotor field, and to regulate the generator output at 200 volts ± 2 per cent. This extends over a load range of 0–30 kVA at a power factor of 0·96 to 0·86 lagging, when the machine is run at 8,000 r.p.m. (400 c/s) within the ambient temperature limits of −50 deg. C and +50 deg C to meet the power requirements of an aircraft in an emergency.

2. In addition, a 28-volt d.c. supply up to 10 amp. (max.) is made available for the operation of essential low voltage equipment. Devices for the protection of the system in which the unit is used are incorporated so that the control unit is switched off should any fault condition (such as excessive field current or an a.c. line to earth leakage of 25 amp.) occur.

3. The U3306 unit supersedes the earlier U3301/1 (Ref. No. 5UC/6682), from which it differs in having a modified carbon pile regulator unit, controlled by a transistor amplifier unit to give closer regulation and improved temperature compensation. The single coil of the regulator has been replaced by a main coil and an auxiliary coil, and the bi-metal temperature compensating disc has been removed, as shown in the basic circuit diagrams in fig. 5A and B.

DESCRIPTION

4. A general view of the transformer-rectifier unit is given in fig. 1. The components of the unit, together with their references on the circuit diagram (*fig.* 6) are listed in Table 2.

5. Fig. 2 to 4 show the positions of the major components in their housing, which is a framework of light alloy angle panelled on four sides and open at one end to provide an entrance for cooling air. The remaining end panel has a circular orifice, around which is a mounting flange having four 0·191 in. dia. fixing holes on a 4·093 in. P.C.D. This

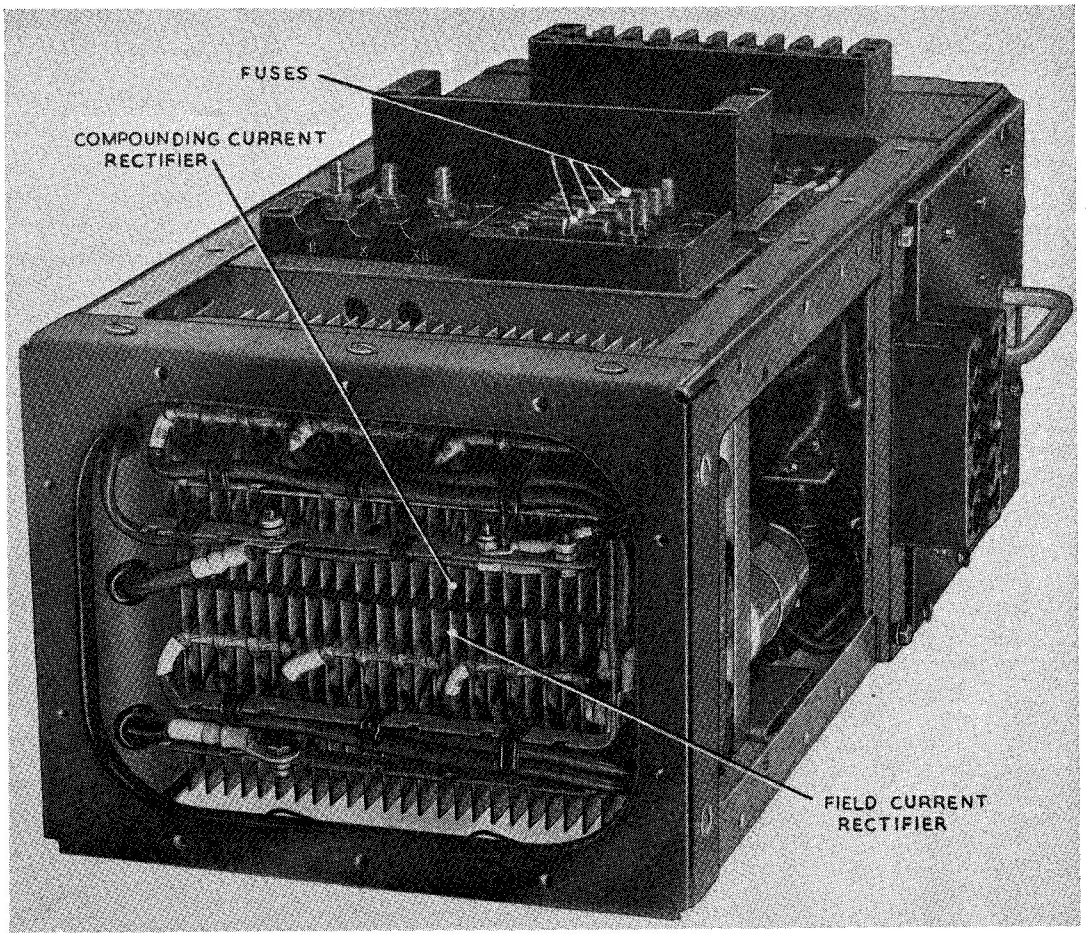


Fig. 2. End view of U3306 unit

enables the unit to be coupled directly to the cooling fan when it is installed. The power requirements of the fan are met by the regulated 200-volt a.c. output from the unit, connections being made via terminals 1A, 1B, and 1C.

6. The side panels are attached to the main framework by quick-release fasteners, and are easily removed when it is required to gain access to the components for servicing. To further facilitate servicing, the regulator unit is assembled on its own chassis (shown partly withdrawn in fig. 1). Complete withdrawal from the unit is described in para. 33.

Transistor amplifier

7. The regulator transistor amplifier is secured to the main chassis framework by locking nuts and associated locking washers, adjacent to the carbon pile regulator unit, Type ZA6410. Access to the amplifier is obtained on withdrawal of the regulator unit and release of the connecting links to the 6 and 8-way terminal connection blocks on the outside panels of the unit.

8. The output of the transistor amplifier acts on a main and an auxiliary coil incorporated in the regulator unit. The amplifier uses three 2SO17X silicon transistors and a B.T.H. silicon zener diode (1MR10) as a reference source. The diodes 1MR7, 1MR8, and 1MR9 are used to lock the reverse base/emitter voltage of the transistors 1T1, 1T2, and 1T3 to the forward volt drop of the

diodes (0·75 volt). This is in order to protect the transistors from damage when the base/emitter junction is subjected to inverse voltage transients during the following conditions:—

(1) When the amplifier is switched off and a portion of the discharge voltage of 1C1 is impressed across the base/emitter junction of 1T3 (−6 volts).

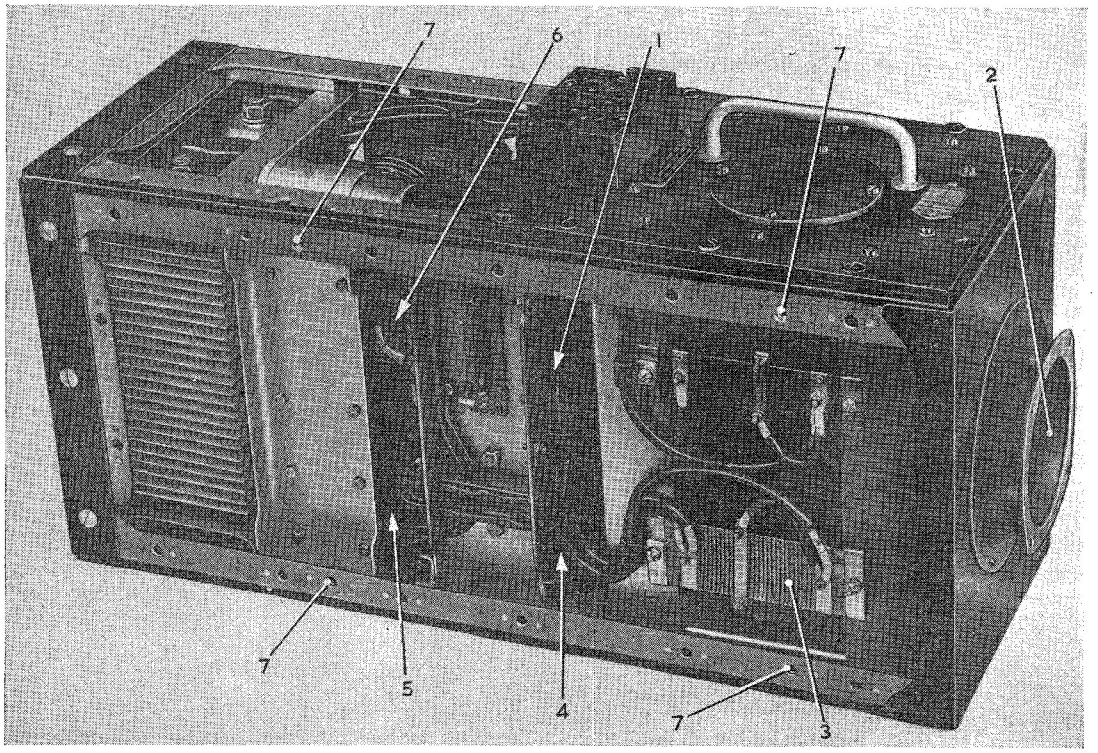
(2) During large load switches when spurious voltages are induced in the auxiliary coil from the main coil of the carbon pile, causing reverse voltages to appear across the base/emitter junctions of 1T1 and 1T2 of (−5 volts).

9. The transistors 1T1 and 1T2 form an emitter coupled output stage, with the auxiliary coil of the pile connected between the collectors of the transistors. The transistor 1T3 is used to increase the sensitivity of the amplifier and act as a driver for the output stage.

10. The potentiometers 1RV1, 1RV2, 1RV3, and 1RV4 are used to set the amplifier to its working point over the full range of the tolerance variation of the transistors.

11. A feedback path is formed by the resistor 1R11 and capacitor 1C3 from the rotor field to the amplifier. This enables feedback to be supplied to the amplifier to stabilize the system.

12. A filter, to smooth the sensing control unit output via 1TR2 and 1MR1–6, is provided by resistor 1R9 and capacitor 1C2. This is essential to the operation of the amplifier, to reduce the ripple voltage of the U3306 control unit and assist the d.c. gain. The connection between the collector and base of the input transistor of a 2 μF capacitor (1C1), reduces the a.c. gain of the stage and lowers the amplifier response to any remaining ripple voltage.



1 FIELD THERMAL UNIT
2 AIR INLET
3 FIELD INITIATION RESISTOR
4 FIELD RELAY
5 VOLTAGE REFERENCE TRANSFORMER
6 VOLTAGE REFERENCE RECTIFIER
7 FIXING HOLES (4 off)

Fig. 3. View on base of unit

13. As it is only necessary to smooth the input voltage to the base of each transistor, the supplies to the collectors of the output transistors and the reference diode are taken from the control unit direct. This allows a large value of smoothing resistor to be used without any substantial volt drop across it, resulting in improved smoothing.

Operation

14. When the system incorporating the U3306 unit is switched on, the generator is initially excited by a "tickler" circuit, supply being derived from the batteries via 1VR1. Thereafter the field current is supplied from the transformer-rectifier arrangement 1TR3 and 1MR12 via the contacts of 1RL2 which is operated by the battery supply when the system is switched on. The "tickler" circuit is then switched off by an external contactor.

15. The rectified output from 1TR2, the primary winding of which is also connected to the output terminals L, L2 and L3, is used as a reference voltage for the amplifier (*para.* 17 to 21).

16. In addition to supplying the field current, the 28-volt d.c. output from the rectifier 1MR12 is also used to operate essential low voltage equipment, e.g., fire protection, connected to the unit via terminal F. Electrically interlocked relays within the system ensure that a battery supply immediately becomes available for the operation of this equipment, when the system is switched off the busbar, or if the generator is switched out of the system owing to a fault condition (*para.* 25 to 27).

Transistor amplifier

17. When the regulated line voltage is 202 volts, the output from the amplifier is zero, and only the main coil of the carbon pile is energized. Under these conditions the operation of the amplifier is as follows.

18. The voltage developed across the sensing arm of the amplifier between the slider of 1RV2 and earth is in excess of the reference diode (1MR10) voltage. This causes a flow of current in the base and collector of transistor 1T3. The collector current of 1T3 is of such a value that the voltage drop across the resistor 1R6 holds the base voltage of the transistor 1T2 at the same potential as the base of transistor 1T1. This results in an equal flow of base and collector currents in each of the transistors. Since the collector

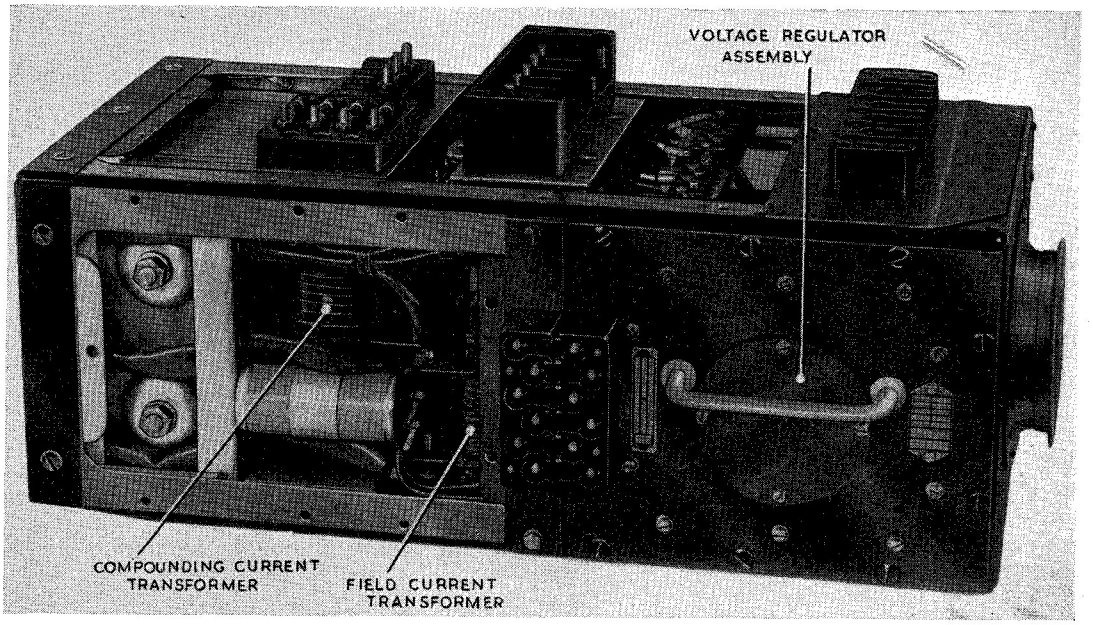


Fig. 4. View on side of unit

resistors have the same value of resistance, the potential difference between the collectors (and across the auxiliary coil) is zero and, therefore, no current flows in the auxiliary coil.

19. If the regulated line voltage rises, the voltage between the slider of 1RV2 and earth will rise. This will increase the base and collector currents of 1T3 and increase the voltage drop across resistor 1R6. As a result there will be a fall in the base voltage of 1T2, reducing the base and collector currents of the transistor. With the drop in the current in the common emitter resistor 1R5, due to the change in 1T2, the potential across the base and emitter of transistor 1T1 will increase. This will increase the base and collector currents of 1T1.

20. With the rise in collector voltage of 1T2, and the fall in collector voltage of 1T1 (due to the decrease and increase of the collector currents of the respective transistors), a current will flow in the auxiliary coil.

21. This will increase the pull on the armature of the pile solenoid and thus reduce the pressure exerted on the carbon discs by the reference spring, increasing the pile resistance. As a result of this change in resistance the rotor field current and regulated line voltage will fall, thus making regulation of the line voltage automatic. If the line voltage falls, the reverse action will take place.

Compounding

22. The rotor field current of a generator operating over a wide output and power factor range is supplied from two sources:—

(1) From a 28-volt d.c. rectified output via the transistor amplifier controlled carbon pile, as described in para. 8 to 13 inclusive.

(2) From the compounding transformer and rectifier, thereby providing a supply proportional to the line current. Therefore, when the generator is supplying current to an external load, only part of the total field current passes through the carbon pile. This division of field current has the advantage that it enables the rating and size and weight of the carbon pile to be maintained at a minimum.

System stabilizing

23. Stabilization of the system is achieved by the use of derivative negative feedback applied to the transistor 1T3 from the rotor field.

Rotor protection

24. The bi-metal element of the field thermal unit 1RL3 is connected in series with the field current so that if the field current becomes excessive, the resulting thermal action on the bi-metal element will cause the auxiliary contactor to close. The closing of these contacts completes the 28-volt circuit to the operating coil which, when energized, opens the main contacts to break the circuit to the operating coil of the field contactor 1RL2. The generator will therefore be switched out of the system.

Earth leakage protection

25. In the event of an a.c. line to earth fault occurring, current will flow through the stud connecting the star point of the generator to earth, thus inducing a voltage in the secondary turns wound around the stud.

26. This voltage is connected across the single-phase bridge rectifier of the earth leakage relay. The output from the rectifier will operate the relay, and the contacts will close to connect a 28-volt supply to the operating coil of 1RL3. The operation of this relay will cause the generator to be switched out of the circuit as described in para. 24.

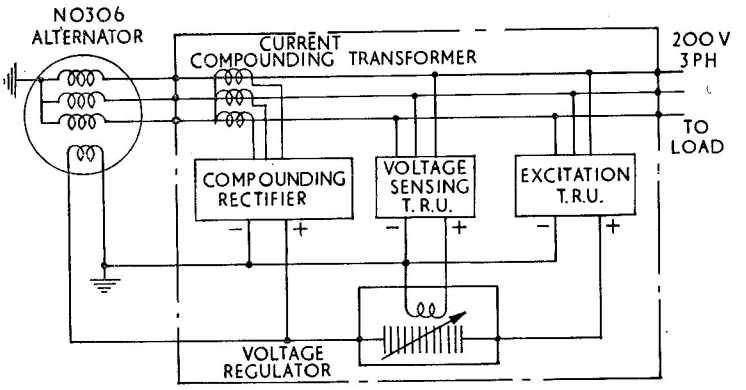
27. If either of the above fault conditions occur, and the field relay 1RL2 is operated, the generator will remain switched out of the system until the external relays are re-set and the field re-energized. This is achieved by moving the external master switch to the OFF position and back to ON to re-commence the cycle of operations.

INSTALLATION

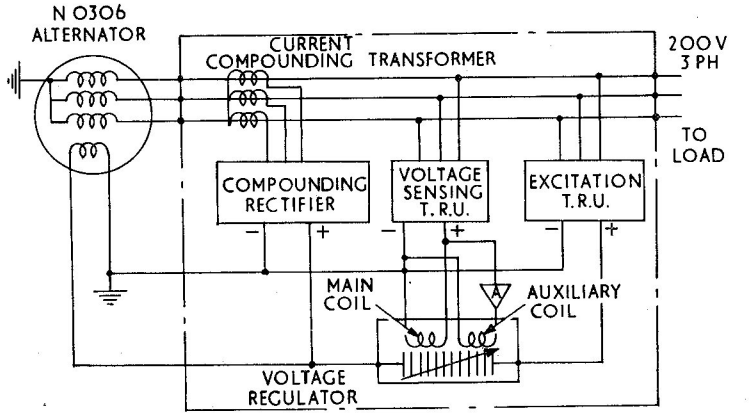
28. The unit is constructed to stand with the terminal boxes uppermost, in a mounting rack incorporated in the aircraft for which it was designed. So that it may be bolted in position, four anchor nuts, tapped $\frac{1}{4}$ in. B.S.F. are secured to the bottom angles of the main frame as shown in fig. 3. The centres of these anchor nuts from a rectangle 10·00 × 7·812 in., one short side of which is 3·25 in. from the far end of the unit. Clearance holes for the bolts are drilled in the bottom panel at similar centres.

Air flow requirements

29. At ground level and 20 deg. C the blower CA1301 will deliver 8·45 lb. of air



A TYPE U3301



B TYPE U3306

Figs. 5A and 5B. Simplified circuit diagrams

per minute. The pressure drop across the unit at 8·45 lb./min. is 0·40 in W.G. The minimum air requirement for maximum temperature rise is as follows:—

Ambient temperature (deg. C.)	Mass flow (lb./min.)
+50	7·54
+20	5·65
0	4·85
−10	4·52
−20	4·25
−30	4·00

Electrical connections

30. Electrical connections to the unit are made as listed in Table 1 and described in para. 31.

31. Connections from the components in the main chassis to the carbon pile control unit are made via a six-way terminal block located on the left-hand side of the unit. This terminal block is constructed in two halves, one secured to the control unit, and the other to the main frame; electrical connections

TABLE 1

Terminal connections

Terminal	Marking	Type	Cable lug Ref. No.
Input	A, B, C	0·250 in. B.S.F. studs	5X/9400126
Output	L1, L2, L3	0·250 in. B.S.F. studs	5X/9400126
Rotor	X, X1	0·250 in. B.S.F.	5X/9400120
Blower	1A, 1B, 1C	2 B.A. studs	5X/9450393
Field initiation	F	2 B.A. studs	5X/9450380
Field initiation resistor	9, 10	2 B.A. studs	5X/7010
Earth leakage	1, 2, 3, 6	2 B.A. studs	5X/9450393
Spare	4, 5, 7, 8	2 B.A. studs	—
Spare	11	0·250 in. B.S.F. stud	—

between the two are made by six connecting links.

SERVICING

32. Make a visual examination of the unit to ensure that it has not sustained any physical damage and that it is secure on its mounting. Remove the terminal covers and examine the mouldings for signs of cracks or distortion; renew any terminal block if its condition is unsatisfactory. Check that the electrical connections are clean and secure and that there are no signs of corrosion.

33. Unscrew the twenty quick-release fasteners securing the top panel to the main frame and remove the panel. Similarly remove the left and right-hand panels which are secured to the main frame by 15 and 9 fasteners respectively. Unscrew the nuts securing the connecting links to terminals 1 to 6 on the six-way terminal block on the left hand of the unit and unscrew the eight quick-release fasteners which hold the regulator unit in position. This assembly which is mounted on its own chassis may then be withdrawn from the unit as shown in fig. 1.

34. When the side panels, top panel and regulator unit have been removed, make a visual examination of the internal components to ensure that there is no sign of damage or chafed leads and that electrical connections are secure. Make a similar examination of the regulator unit, paying particular attention to the suspension springs. Any faulty spring should be renewed.

35. Replace the side panels, top panel and regulator unit on completion of the examination, but apply the following test before replacing the terminal covers.

Insulation resistance test

36. Measure the insulation resistance between the points enumerated below using a 500-volt insulation resistance tester; the reading should not be less than 0·5 megohm (for R.N.) or 5 megohms (for R.A.F.).

(1) Terminal A, 1, X1, and the frame.

(2) Terminal A, and terminals 1 and X1.

(3) Terminal 1, and terminal X1.

TABLE 2

Components of unit

Rotax Code	Component	Value	Circuit Ref.
P4701	Compounding transformer	—	1TR1
P4103	Voltage reference transformer	—	1TR2
P4601	Excitation transformer	—	1TR3

TABLE 2 (contd.)

Components of unit

Rotax Code	Component	Value	Circuit Ref.
F6102	Earth leakage relay	—	1RL4
D6239	Field thermal relay	—	1RL3
F1504/1	Field relay	—	1RL2
N147249–61	Silicon rectifier diodes (pos.)	—	1MR1–3
N147249–81	Silicon rectifier diodes (neg.)	—	1MR4–6
N131415	Metal rectifier	—	1MR11
N143994	Metal rectifier	—	1MR12
N113593/38	Resistor	360 ohms	1R12
N108415–1	Variable resistors (2 in parallel)	each 15 ohms	1RV9
N69671/3	Variable resistor	33 ohms	1RV10
ZA6410	Regulator unit	—	1RV1
Incorporating—			
—	Carbon pile regulator (Type 50/66293)		
N108415–4	Variable resistance	42 ohms	1RV6
N108415	Variable resistance	4·4 ohms	1RV7
N108415	Variable resistance	4·4 ohms	1RV8
N158174	Transistor amplifier	—	1TA1
Incorporating—			
N151918–22	Tantalum capacitor	1 μF	1C1
N140828	Capacitor	50 μF (70V wkg.)	1C2
N151917–11	Tantalum capacitor	4 μF	1C3
N151049	Silicon diode (3 off)	—	1MR7–8–9
N151054–1	Reference diode (Zener)	—	1MR10
N113590/34	Resistor	240 ohms, 1·5W	1R1
N113590/30	Resistor	160 ohms, 1·5W	1R2
N113590/35	Resistor	270 ohms 1·5W	1R3
N113590/35	Resistor	270 ohms, 1·5W	1R4
N113591/30	Resistor	160 ohms, 3W	1R5
N113590/53	Resistor	1500 ohms, 1·5W	1R6
N113590/57	Resistor	2200 ohms	1R7
N113590/45	Resistor	680 ohms	1R8
N113590/21	Resistor	68 ohms	1R9
N113590/49	Resistor	1000 ohms, 1·5W	1R10
N113590/61	Resistor	3300 ohms	1R11
N158518–8	Potentiometer	500 ohms	1RV1
N154378–7	Potentiometer	250 ohms	1RV2
N154378–5	Potentiometer	5K ohms	1RV3
N67351–31	Potentiometer	350 ohms	1RV4
N151051–6	Transistor	—	1T1
N151051–6	Transistor	—	1T2
N151051–6	Transistor	—	1T3

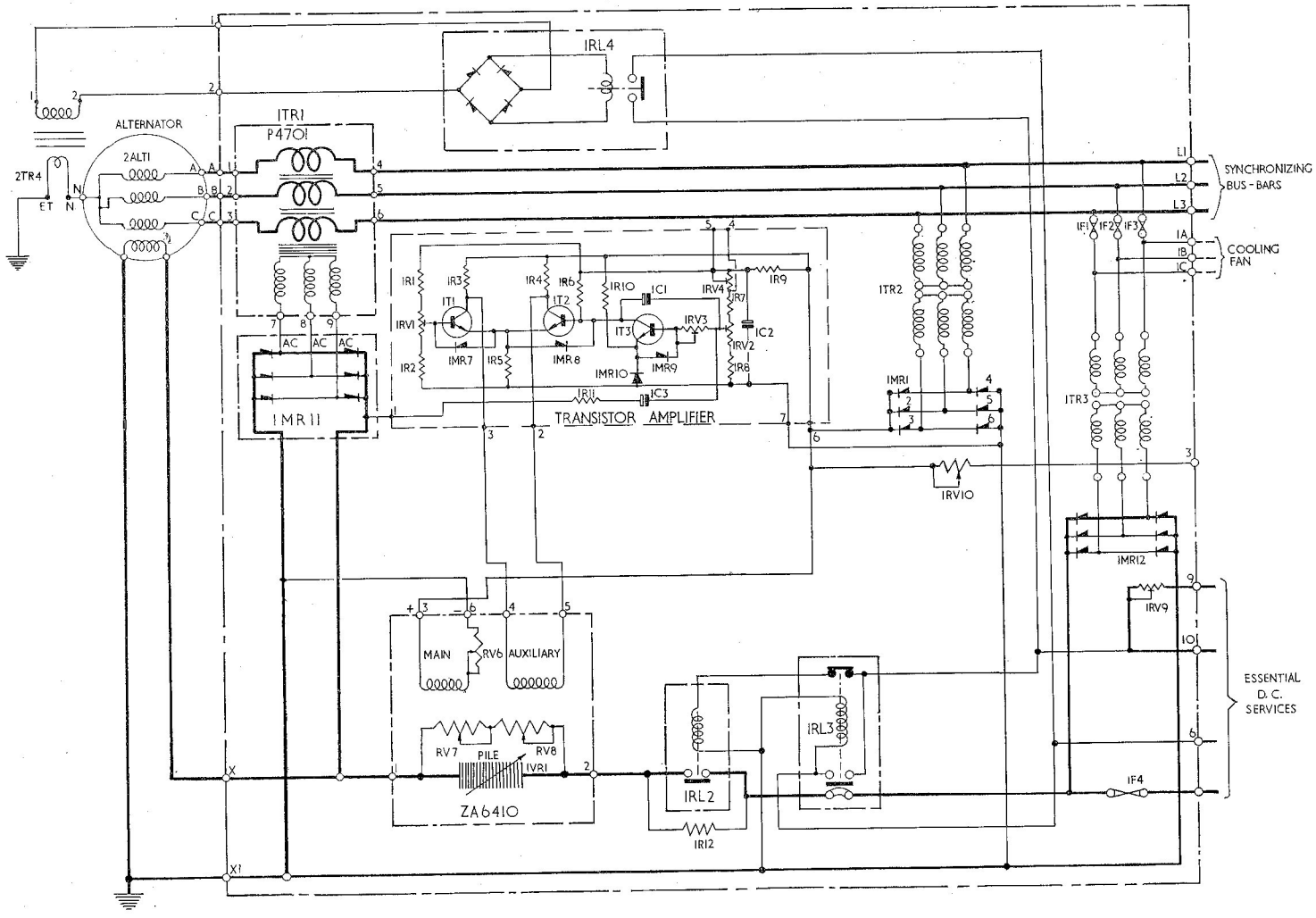


Fig. 6. Theoretical circuit diagram