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Chapter 20

CONTROL UNIT, ROTAX, TYPE U3702

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LEADING PARTICULARS

Control unit, Type U3702/1C	*Ref. No.* 5*UC*/7035
Output voltage (controlled)	200*V a.c.* ± 2 *per cent (r.m.s.)*
Phases	3
Frequency	400 *c/s* ± 5 *per cent*
Load range	0-17 *kW*
Power factor	0·7 *to* 0·95 *lagging*
Temperature range	−40 *deg. C to* +60 *deg. C*
Maximum altitude	60 000 *ft.*
Rating	*Continuous*
Cooling	*Natural and aircraft fitted blower*
Overall dimensions —	
Length (over handle)	11·750 *in. (max.)*
Width	9·250 *in. (max.)*
Height	8·500 *in. (max.)*
Weight	21½ *lb. (approx.)*

Introduction

1. The Type U3702 control unit (*fig.* 1) is designed to control the 17kW emergency supply derived from a ram-air turbine alternator. As an interim measure the Merz-Price and overvoltage protection has been rendered inoperative on the U3702/1C to maintain electrical interchangeability between the U3702/1 and the U3702/2 units; subsequent introduction of the U3702/2, as described in Appendix 1 to this chapter, will have the Merz-Price and overvoltage circuitry removed.

DESCRIPTION

2. The components are housed within a metal casing and cover having perforated panels which provide ventilation.

3. Two chassis, one fixed and the other hinged, are used for mounting the components; by turning the hinged chassis about a hinge pin, access is gained to all component parts. The components are identified by code symbols which are directly related to the circuit diagram (*fig.* 6).

4. Fig. 2, 3 and 4 show the physical layout of the components in the unit.

Operation

5. Control of the bus-bar voltage is obtained by a system of operations which is based on the use of magnetic amplifiers for closed loop voltage control. The average of the three line voltages is controlled at 200 volts ± 2 per cent from no load to 17kW, power factor 0·7 to 0·95 lagging, with the speed held to 400 c/s ± 5 per cent.

Voltage control system

6. Accurate regulation of the bus-bar voltage is obtained by closed loop control of the alternator excitation, dependent on the load current delivered by the alternator, and the error between the desired line voltage and the actual line voltage.

7. Field excitation current directly proportional to the load current is provided by the current compounding transformer 1TR1 and silicon rectifier stack 1MR1, the balance to meet the machine total excitation requirement being provided at silicon rectifier stack 1MR2 by the voltage regulator. Similarly with decrease in load power factor, the compounded excitation effort remains directly proportional to the load current, and the increased balance is again provided by the regulator.

8. The principle of operation of the voltage control system is given in block schematic form in fig. 5. The voltage error is sensed in block A (error sensing circuit) and amplified in block B (error magnetic amplifier). The amplified error signal is then fed into block C (power magnetic amplifier), the output of which combines with that of block D (current compounding) to form the total alternator excitation requirement.

Voltage sensing circuit

9. The voltage sensing circuit depends on the comparison of two resistive circuits, one having a linear voltage/current relationship, viz. 1R5, 1R6, 1RV2 and 1RV3, and the other non-linear, giving substantially constant current, using barretter 1L1. The resistive arm current is adjusted by means of 1RV2 and 1RV3, so that at the desired bus-bar voltage, the two arm currents are nominally equal. These two signals are then fed in opposite senses over two control windings on the error transductor 1TD2. In practice a slight unbalance of currents at the desired voltage level obviates the use of a bias winding on the transductor 1TD2. The requirement is for voltage control to the average of the three line voltages and this is effected by supplying the voltage sensing circuit via a three-phase bridge rectifier 1MR11, with suitable voltage step down accommodated in the three-phase transformer 1TR3.

Error magnetic amplifier

10. The function of this amplifier is to relieve the duty of the output stage of amplification, and thereby improve the stability with temperature variation together with a reduced overall amplifier time constant. This pre-amplifier comprises a single-phase transductor 1TD2 and rectifier 1MR7 connected to give a magnetic amplifier of the auto-self-excited configuration.

Power magnetic amplifier

11. The error amplifier output is fed as negative control to the power magnetic amplifier, thereby determining the output delivered by the regulator source. A positive bias signal is applied to the power transductor to compensate for the standing output of the error amplifier. Adjustment of amplifier gain is achieved by modifying the

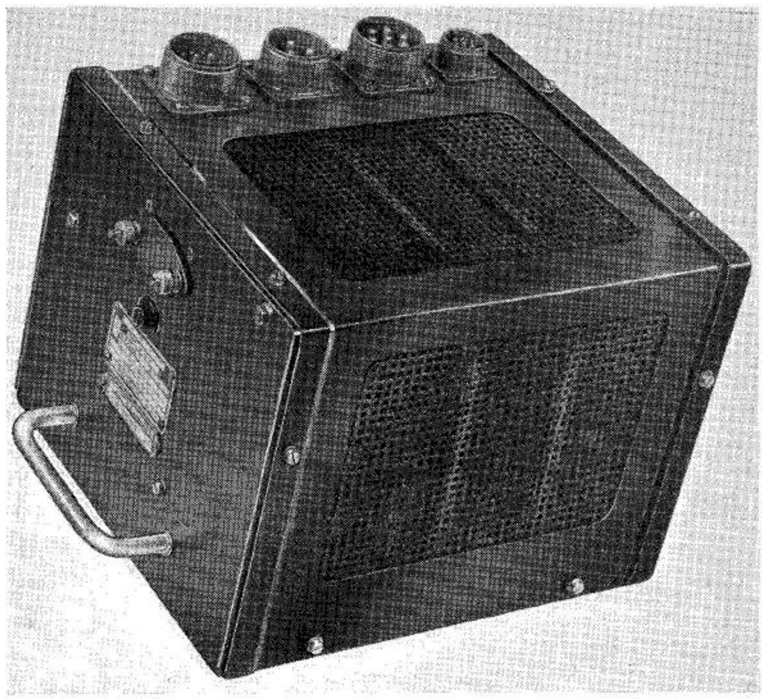

Fig. 1. General view

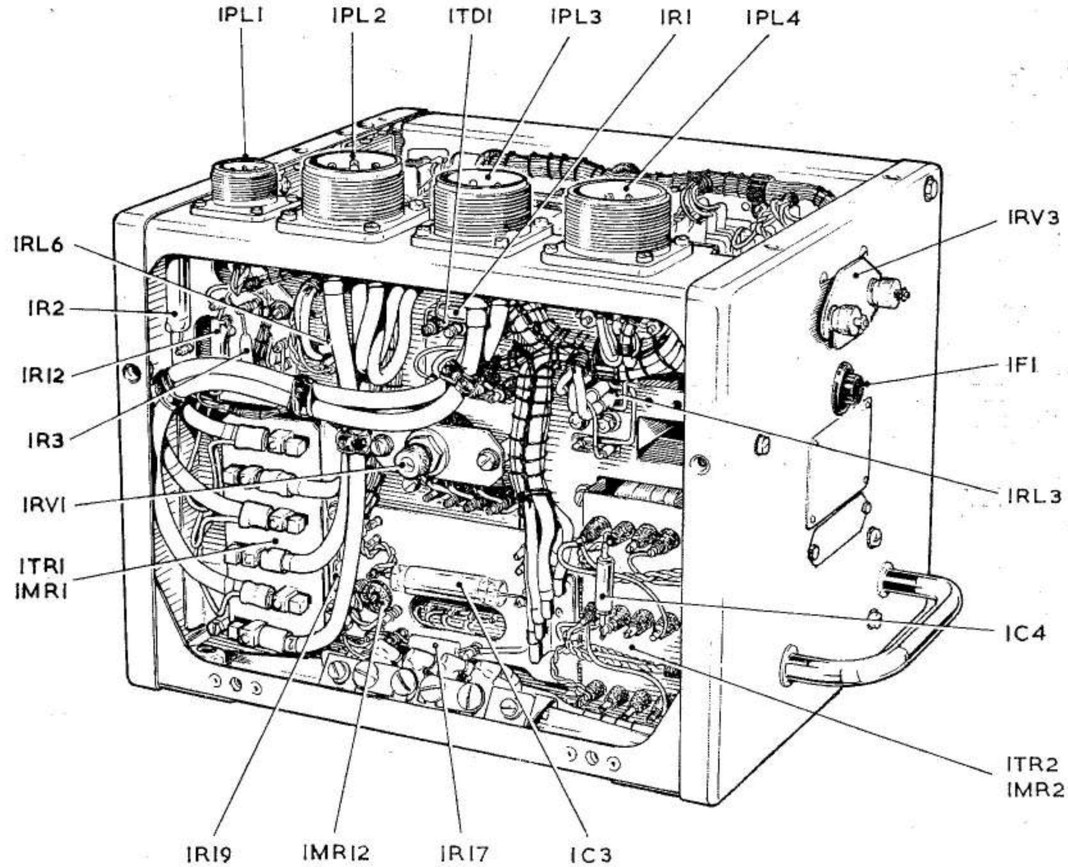

Fig. 2. Layout of components (1)

coupling resistance 1RV7. The power amplifier comprises a six element, three-phase transductor 1TD1 and rectifier 1MR4, arranged to give a magnetic amplifier of the auto self-excited configuration.
The three-phase transformer 1TR2 matches the transductor output to the excitation circuit, with silicon rectifier stack 1MR2 providing three-phase bridge rectification.

12. Stabilization of the closed loop voltage regulating system is provided by transient negative feed-back networks passed over each amplifier stage. A signal proportional to the output current of the error amplifier is derived across coupling resistor 1RV7 and is fed over transductor 1TD2 via network 1C3 and 1R17. At the output stage a three-phase voltage proportional to the field voltage is rectified by 1MR3, and fed over transductor 1TD1 via capacitor 1C1.

13. The combination of transductor 1TD4 and rectifier 1MR9 develops sensibly infinite gain to provide a triggering action for relay control. The relay 1RL6 is used to energize the line contactor when the generated voltage level reaches approximately 180 volts. This ensures rapid acceleration of the turbine to controlled speed in the unloaded condition.

14. A resistance of 3 ohms has been introduced which is capable of continuous rating; this is to prevent overheating and is fitted externally for when the ram air turbine is extended in still air, e.g., ground testing and/or servicing.

15. The dimensions of the cooling fins associated with 1MR1 have been increased; this, together with a forced cooling of 0·7 lb. of air per minute, assists in maintaining an even temperature when maximum loading is applied at 60 000 ft. Forced cooling is provided by a small blower mounted in the aircraft with the air directed at the perforated base of the control unit.

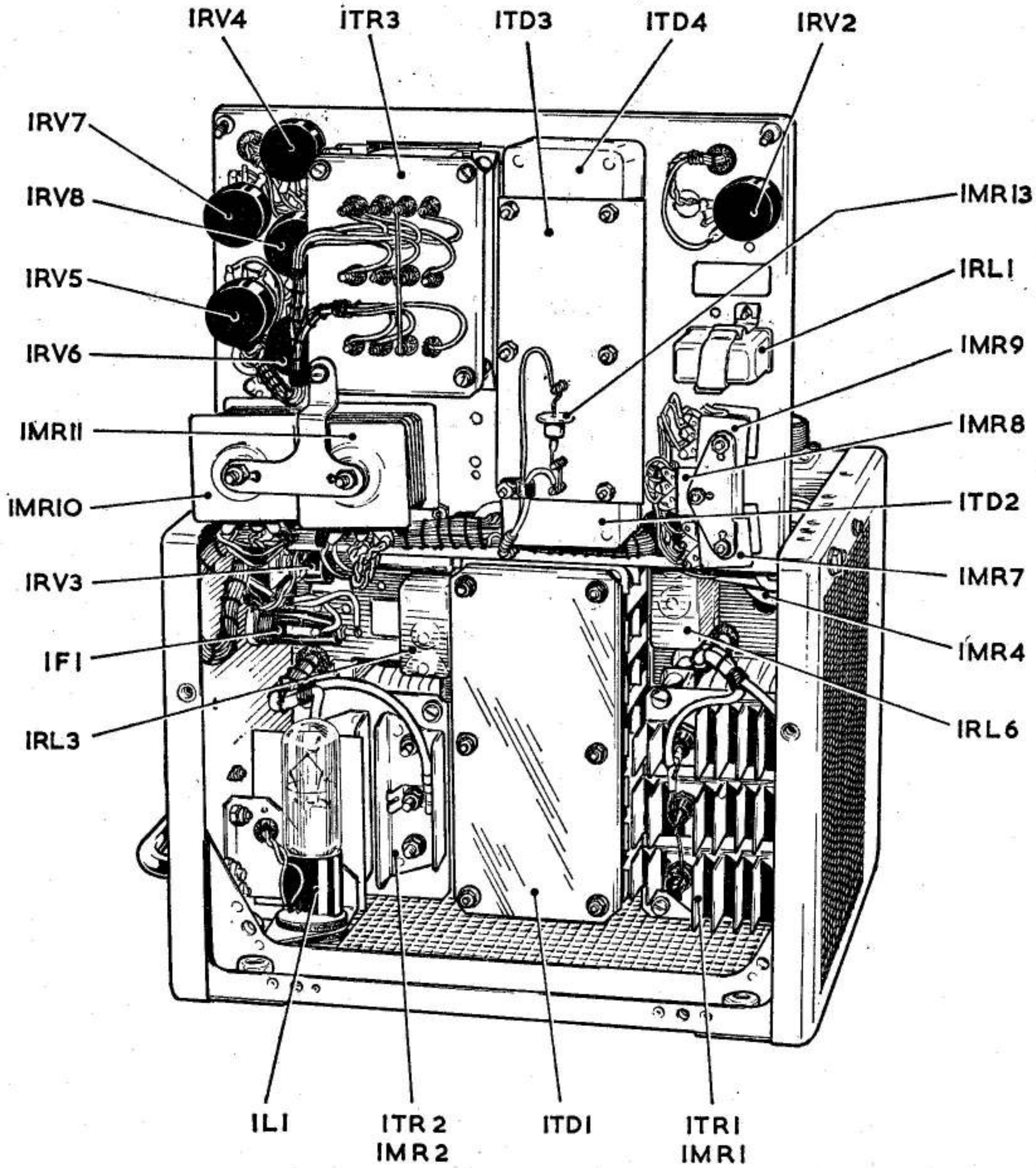

Fig. 3. Layout of components (2)

INSTALLATION

16. The unit must be mounted base downwards and secured by four 0·250 in. B.S.F. stiff anchor nuts, located in the base of the unit.

17. Electrical connections are made via four 'Amphenol' light-weight plugs and sockets together with fuse and fuse holder as follows:—

(1) A.C. protection lines plug, 7-pole, 22A (AN3102E-16S-1P).
(2) A.C. feed in plug, 7-pole, 73A (AN3102E-24-10P).
(3) A.C. feed out plug, 3-pole, 73A (AN3102E-22-2P).
(4) D.C. control lines plug (2×41A, 14×22A) (AN3102E-24-7P).
(5) Fuse (Belling-Lee L693).
(6) Fuse holder (Belling-Lee L356).

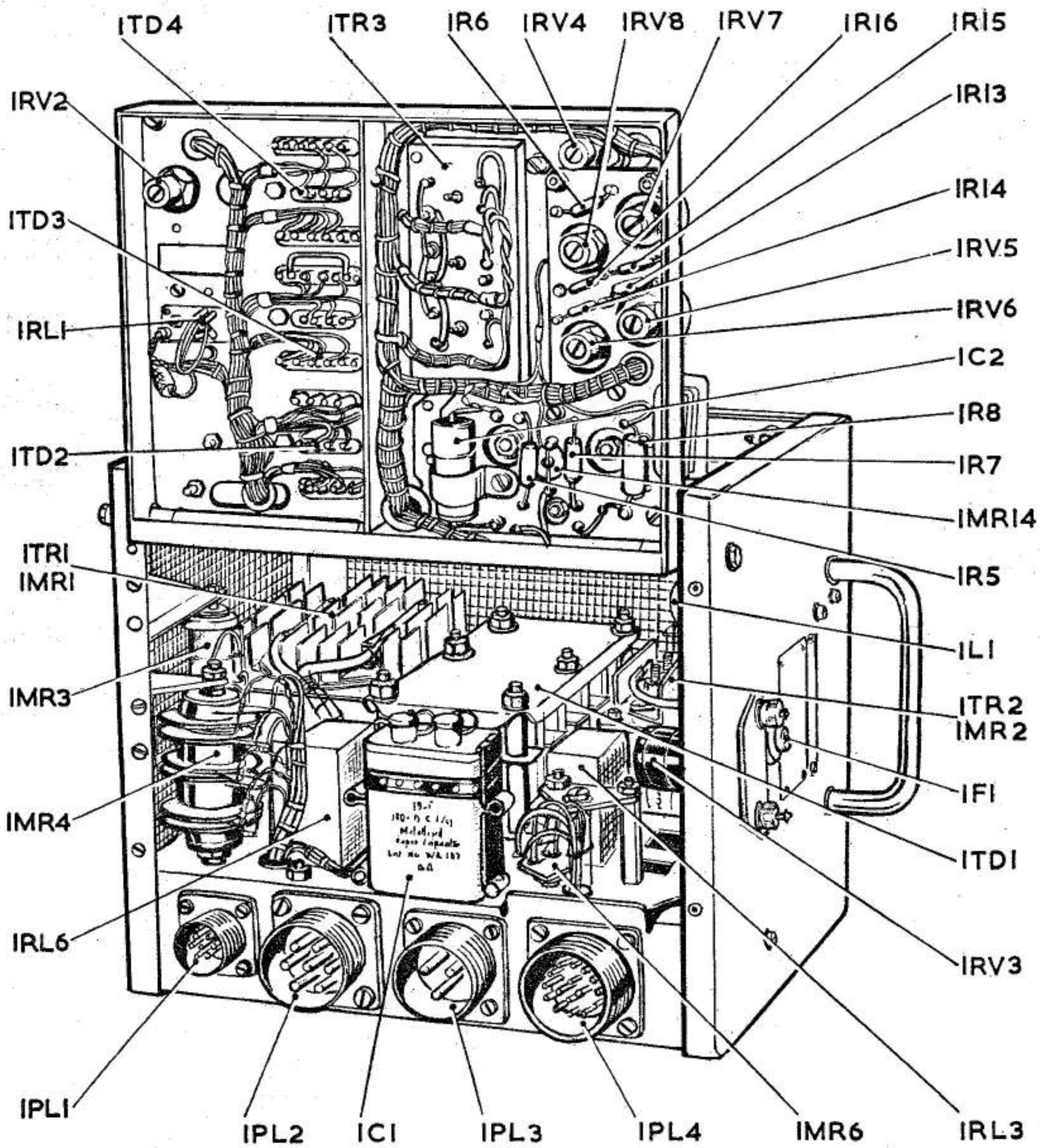

Fig. 4. Layout of components (3)

18. The perforated area on the top and bottom and on both sides of the unit must be kept free and clear to allow free passage of convected air.

SERVICING

19. Servicing of these units will normally be restricted to checking security of connections and that no damage is apparent. Where it is obvious that such components as transformers, rectifiers, etc. are unserviceable, these components will need renewal. A list of components and their identification is given in Table 1.

Insulation resistance tests

20. (*a*) Common together pins A, B, C, D, E and F of the 7-pole socket (AN3106A-16S-1S) for PL1, also pins D and E on the 7-pole socket (AN3106A-24-10S) for PL2, and pins A and P on the 16-pole socket (AN3106A-24-7S) for PL4; and by means of flying leads and crocodile clips, connect terminals A7, B7, C7, B9 and B10 on transformer TR3 together and bring out the connections as a common lead.

(*b*) On the above socket for PL2 common together pins A, B and C, and on the above socket for PL1 pin G, and bring out this connection as a common lead.

(*c*) Common together by means of flying leads and crocodile clips A3, B3, C3, C9 and C10 on transformer TR3, and bring out the connection as a common lead.

(*d*) On the above socket for PL4 bring out *separate* leads from pins B, D, and E.

(*e*) Common together terminals A9 and A10 on transformer TR3 and bring out as a common lead.

(*f*) Connect all but the first commoning lead to a suitable point on the chassis, e.g., the shell of the connecting plug, and measure the insulation resistance between the first commoning lead and the chassis; the reading should not be less than 5 megohms using a 500-volt insulation resistance tester.

(*g*) Repeat the insulation resistance test between the chassis and each of the remaining commoning leads in turn with the other six commoning leads connected to the chassis. In each case the insulation resistance must not be less than 5 megohms.

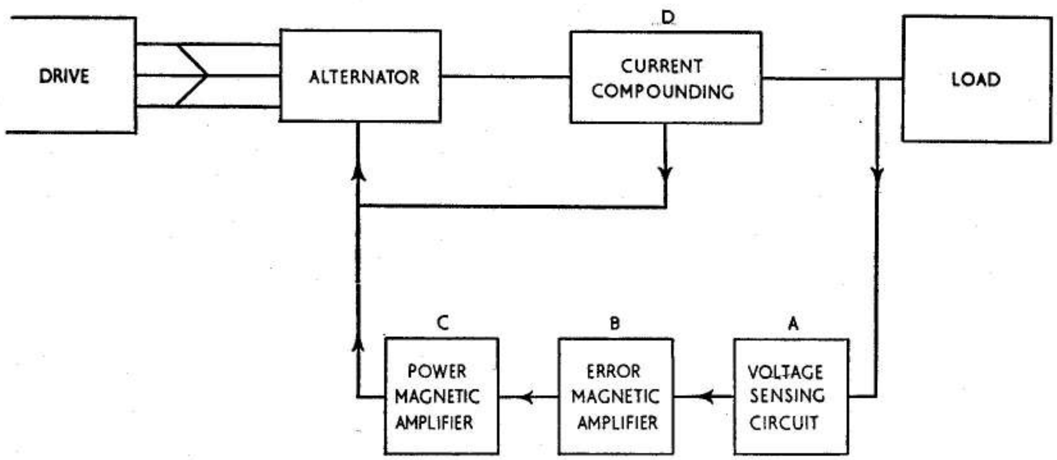

Fig. 5. Voltage control block schematic diagram

Table 1

Circuit Component Details

Circuit Ref.	Description	Value	Rotax No.
1TR1	Compounding transformer (1TR1 + 1MR1)		P7303
1TR2	Excitation transformer (1TR2 + 1MR2)		P7401
1TR3	Supply and reference transformer		P7501
2ALT1	Alternator		N0409
2TR1	Merz-Price transformer		P6601
3TR1	Merz-Price transformer		P6601
1TD1	Excitation transductor		P7102
1TD2	Pre-amp. transductor		P7201
1TD3	Overvoltage protection transductor		P7002
1TD4	Undervoltage indication transductor		P7003
1RL1	Protection relay		
1RL3	Field shorting relay		
1RL6	D.C. isolation and undervoltage indication relay		
1L1	Barretter	Siemens T25	N124897
1C1	Feedback capacitor	15 μF, 150V	
1C2	Isolating capacitor	1 μF, 150V	
1C3	Current feedback capacitor	40 μF, 12V	
1C4	Output transductor control winding capacitor	10 μF, 6V	
1R1	Bias resistor	620 ohm, 3W	
1R2	Feedback load resistor	10K ohm, 4½W	
1R3	Gain limiting resistor	390 ohm, 1½W	
1R5	Signal resistor	120 ohm, 3W	
1R6	Signal trim resistor	33 ohm, 1½W	
1R7	Undervoltage resistor	120 ohm, 3W	
1R8	Overvoltage resistor	150 ohm, 3W	
1R12	Field short ballast resistor	1·2K ohm, 3W	
1R13	Overvoltage trim resistor	10 ohm, 1½W	
1R14	Overvoltage trim resistor	10 ohm, 1½W	
1R15	Undervoltage trim resistor	22 ohm, 1½W	
1R16	Undervoltage trim resistor	22 ohm, 1½W	
1R17	Feedback current resistor	1·5K ohm, 3W	
1R19	Relay hold resistor	330 ohm, 3W	
1RV1	Output bias control (variable resistor)	350 ohm, ½W	
1RV2	Signal control, coarse (variable resistor)	25 ohm, ½W	
1RV3	Signal control, fine (variable resistor)	25 ohm, ½W	
1RV4	Merz-Price trim	100 ohm, ½W	
1RV5	Undervoltage trim	25 ohm, ½W	
1RV6	Overvoltage trim	25 ohm, ½W	
1RV7	Coupling control (208V)	450 ohm, ½W	
1RV8	Reference diode control	25 ohm, ½W	

(*continued*)

Table 1

Circuit component details (*continued*)

Circuit Ref.	Description	Value	Rotax No.
1MR1	Compounding rectifier		see 1TR1
1MR2	Excitation rectifier		see 1TR2
1MR3	Feedback rectifier		
1MR4	Main auto rectifier		
1MR6	Merz-Price rectifier		
1MR7	Pre-amp. rectifier		
1MR8	Protection rectifier		
1MR9	Indication rectifier		
1MR10	Contactor supply rectifier		
1MR11	Signal rectifier		
1MR12	Blocking diode		
1MR13	Reference diode		
1MR14	Merz-Price shaping diode		
1PL1	A.C. protection lines plug	7×22A	
1PL2	A.C. feed in plug	7×73A	
1PL3	A.C. feed out plug	3×73A	
1PL4	D.C. control lines plug	2×41A 14×22A	
1F1	Fuse (Belling Lee L.693)		N128823/2
	Fuse holder (Belling Lee L.356)		N67334

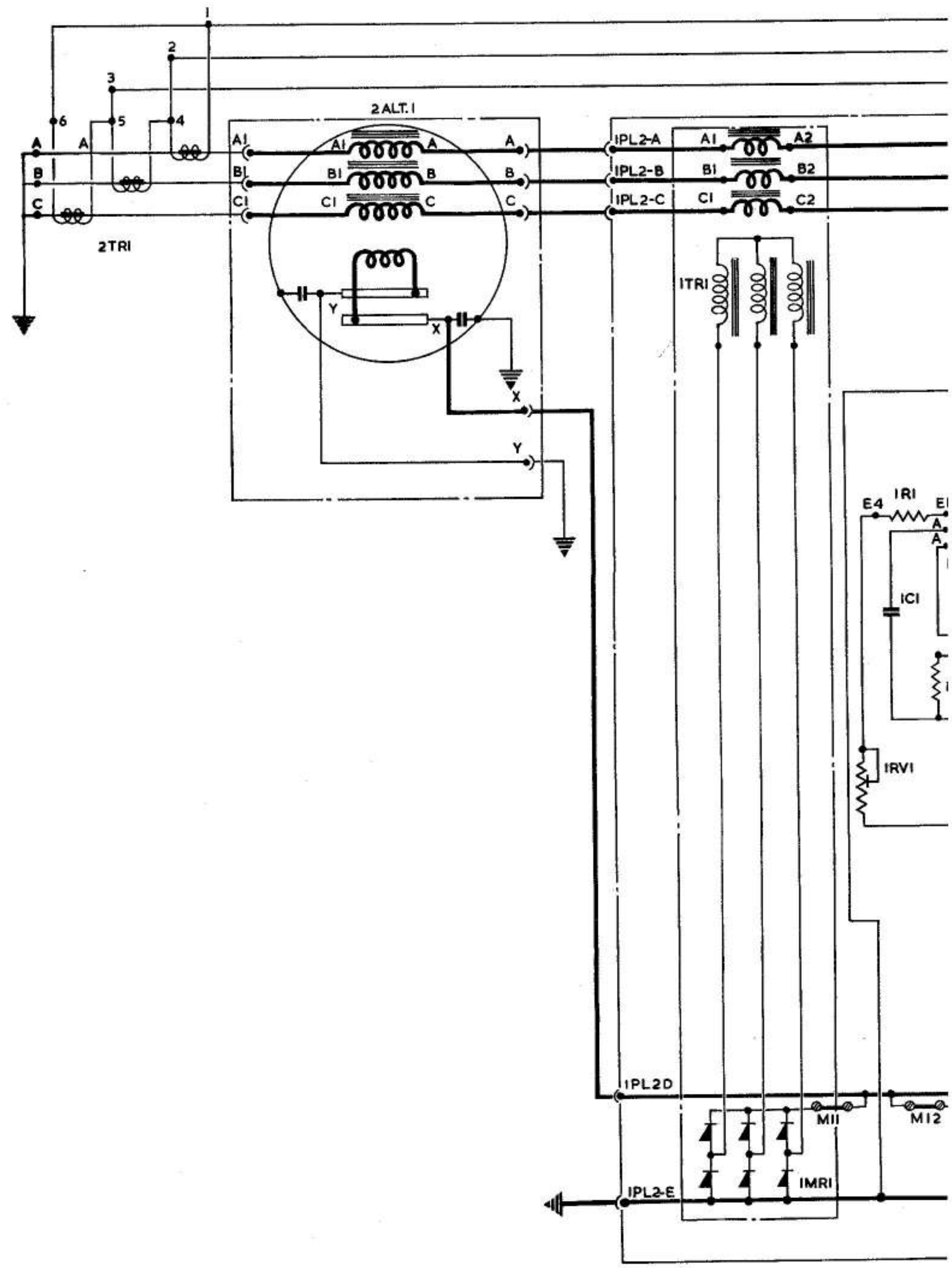

Fig. 6

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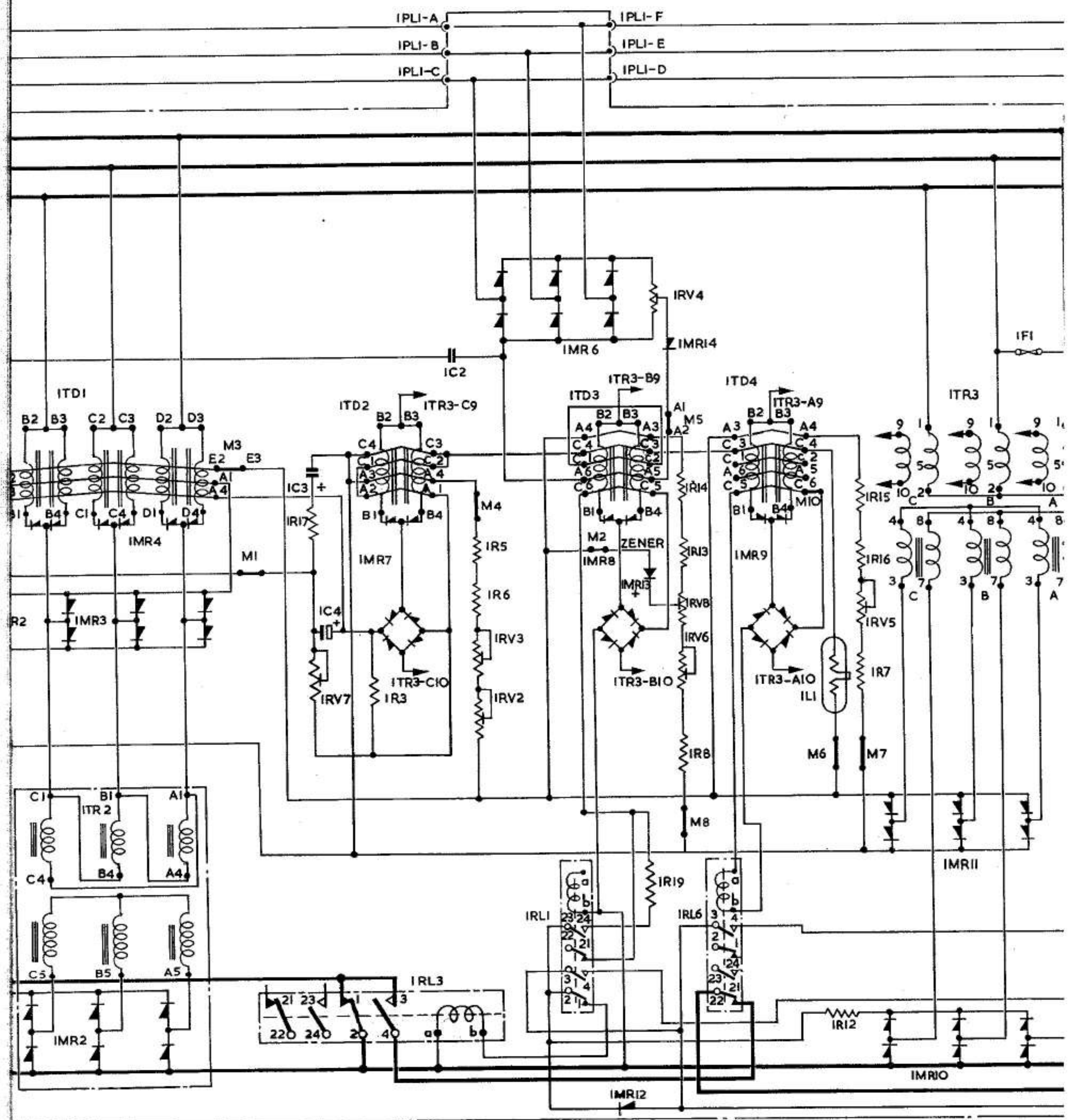

Circuit diagram

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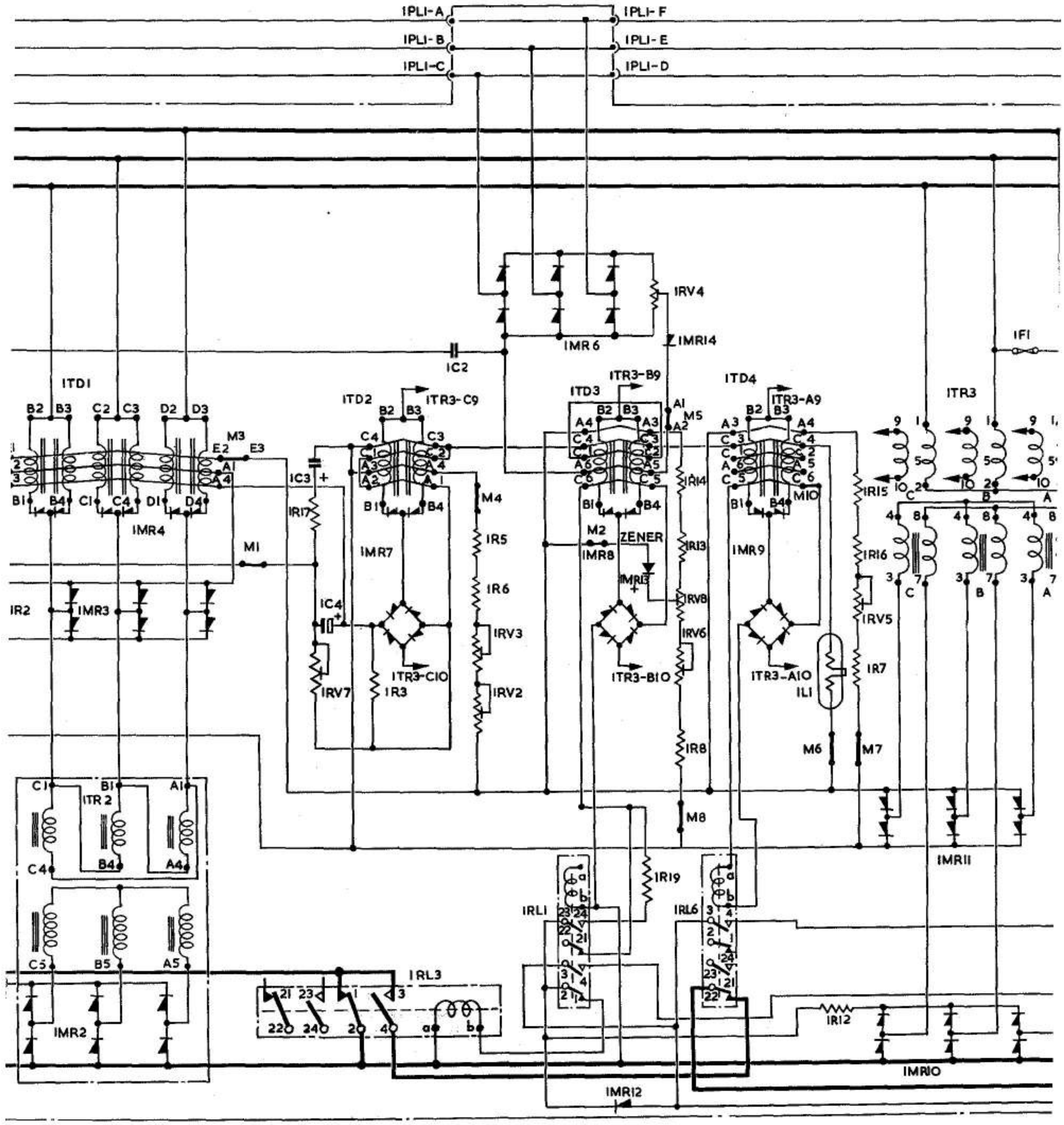

Circuit diagram

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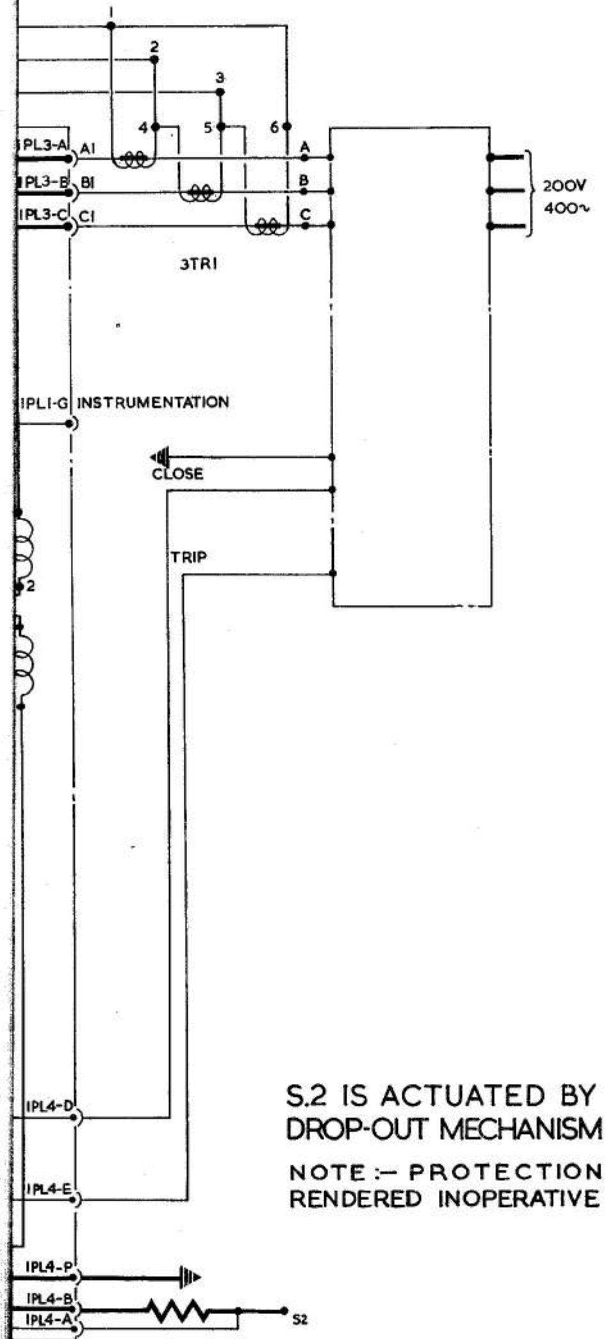

S.2 IS ACTUATED BY DROP-OUT MECHANISM

NOTE :— PROTECTION RENDERED INOPERATIVE

Fig.6

Appendix 1

CONTROL UNIT, ROTAX, TYPE U 3702/2

LEADING PARTICULARS

Control unit, Type U3702/2	*Ref. No.* 5UC/7035
Output voltage (controlled) ...	200*V a.c.* ± 2 *per cent (r.m.s.)*
Phases	3
Frequency	400 *c/s* ± 5 *per cent*
Load range	0-15 *kW*
Power factor	0·7 *to* 0·95 *lagging*
Temperature range	−40 *deg. C. to* +60 *deg. C*
Maximum altitude	60 000 *ft.*
Rating	*Continuous*
Cooling	*Natural*
Overall dimensions —	
Length (over handle)	11·750 *in. (max.)*
Width	9·250 *in. (max.)*
Height	8·500 *in. (max.)*
Weight	21½ *lb. (approx.)*

1. The U3702/2 control unit is identical to the U3702/1C described and illustrated in the main chapter, except that the U3702/2 is without overvoltage and Merz-Price protection, this being no longer required; the internal connections are as shown in the theoretical circuit diagram (*fig.* 1).

2. The circuit component details are as for Table 1 in the main chapter, except for the deletion of the following:—

Ref.	Description	Value	Part No.
2TR1	Merz-Price transformer	—	P6601
3TR1	Merz-Price transformer	—	P6601
1TD3	Overvoltage protection transductor	—	P7002
1RL1	Protection relay	—	—
1C2	Isolating capacitor	1μF, 150V	—
1R8	Overvoltage resistor	150 ohms, 3W	—
1R13	Overvoltage trim resistor	10 ohm, 1½ W	—
1R14	Overvoltage trim resistor	10 ohm, 1½W	—
1R19	Relay hold resistor	330 ohm, 3W	—
1RV4	Merz-Price trim	100 ohm, ½W	—
1RV6	Overvoltage trim	25 ohm, ½W	—
1MR6	Merz-Price rectifier	—	—
1MR8	Protection rectifier	—	—
1MR13	Reference diode	—	—
1MR14	Merz-Price shaping diode	—	—

SERVICING

3. All soldered connections should be carefully inspected for dry and high resistance joints.

Reference should be made to the theoretical circuit diagram (*fig.* 1) when applying tests detailed in para. 4 and 5 respectively.

Continuity test

4. (1) Using a low voltage bridge (e.g. Wheatstone) connect leads to the shells of PL1 and PL2. The resistance measured between PL1 and PL2 must not exceed 0·05 ohms.

(2) Transfer the lead from the shell of PL2 to that of PL3. The resistance measured between PL1 and PL3 must not exceed 0·05 ohms.

(3) Transfer the lead from the shell of PL3 to that of PL4. The resistance measured between PL1 and PL4 must not exceed 0·05 ohms.

Insulation resistance test

5. (1) Common together pins D and E on a 7-pole socket (AN.3106A-24-10S) for PL2, pins A and P on a 16-pole socket (AN. 3106A-24-7S) for PL4, and by means of flying leads and crocodile clips, the terminals A7, B7 and C7 on transformer TR3, and bring out the connection as a common lead.

On the above socket for PL2 common together pins A, B and C, and on the above socket for PL1 pin G, and bring out this connection as a common lead.

Common together by means of flying leads and crocodile clips A3, B3, C3, C9 and C10 on transformer TR3, and bring out the connection as a common lead.

On the above socket for PL4, bring out *separate* leads from pins B and D.
Common together terminals A9 and A10 on transformer TR3 and bring out as a common lead.

(2) Connect all but the first commoning lead to a suitable point on the chassis, e.g., the shell of the connecting plug, and measure the insulation resistance using a 500-volt insulation resistance tester; the reading must not be less than 5 megohms.

(3) Repeat the insulation resistance test between the chassis and each of the remaining commoning leads, in turn with the other commoning leads connected to the chassis. In each case the insulation resistance must not be less than 5 megohms.

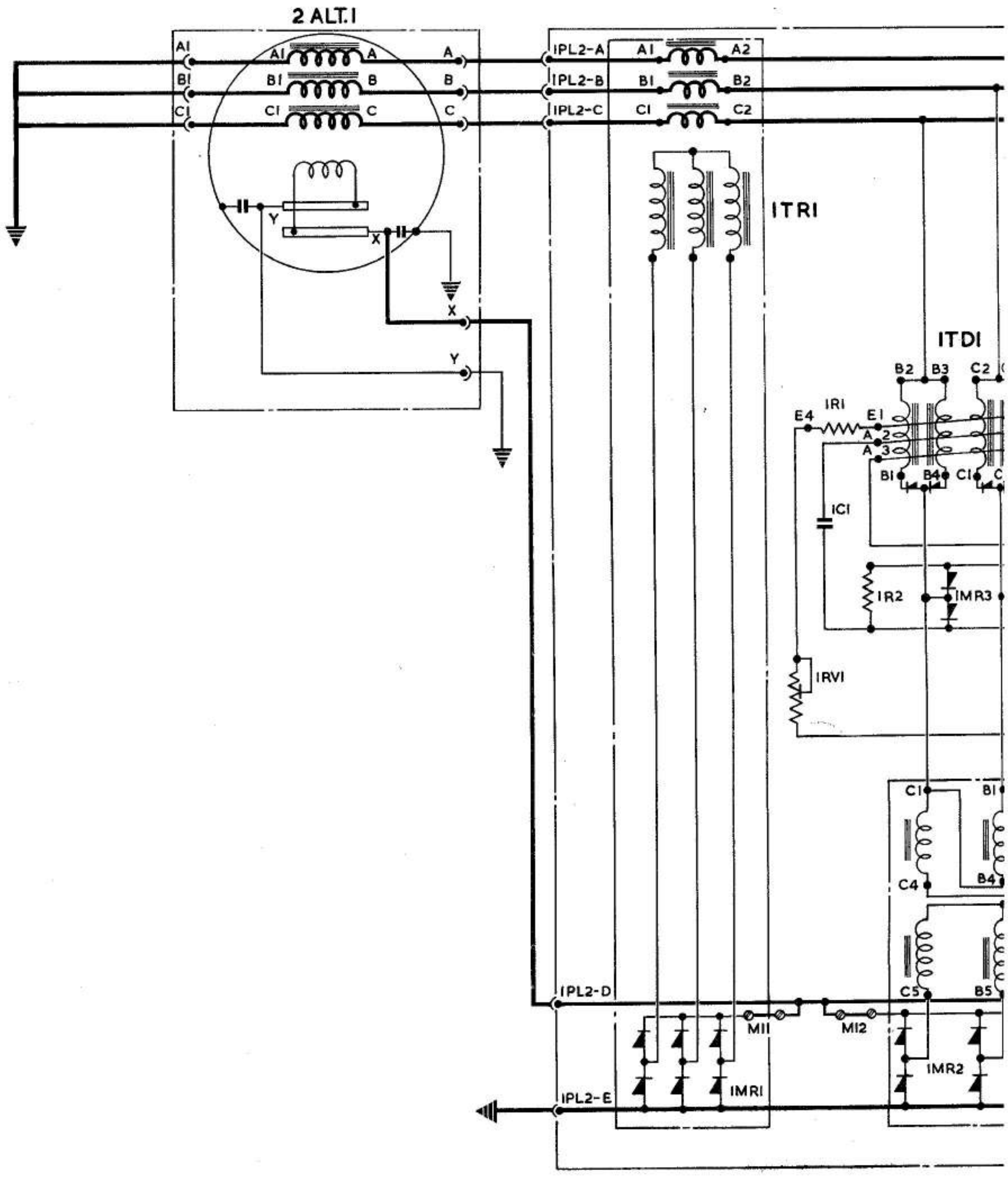

Fig. I

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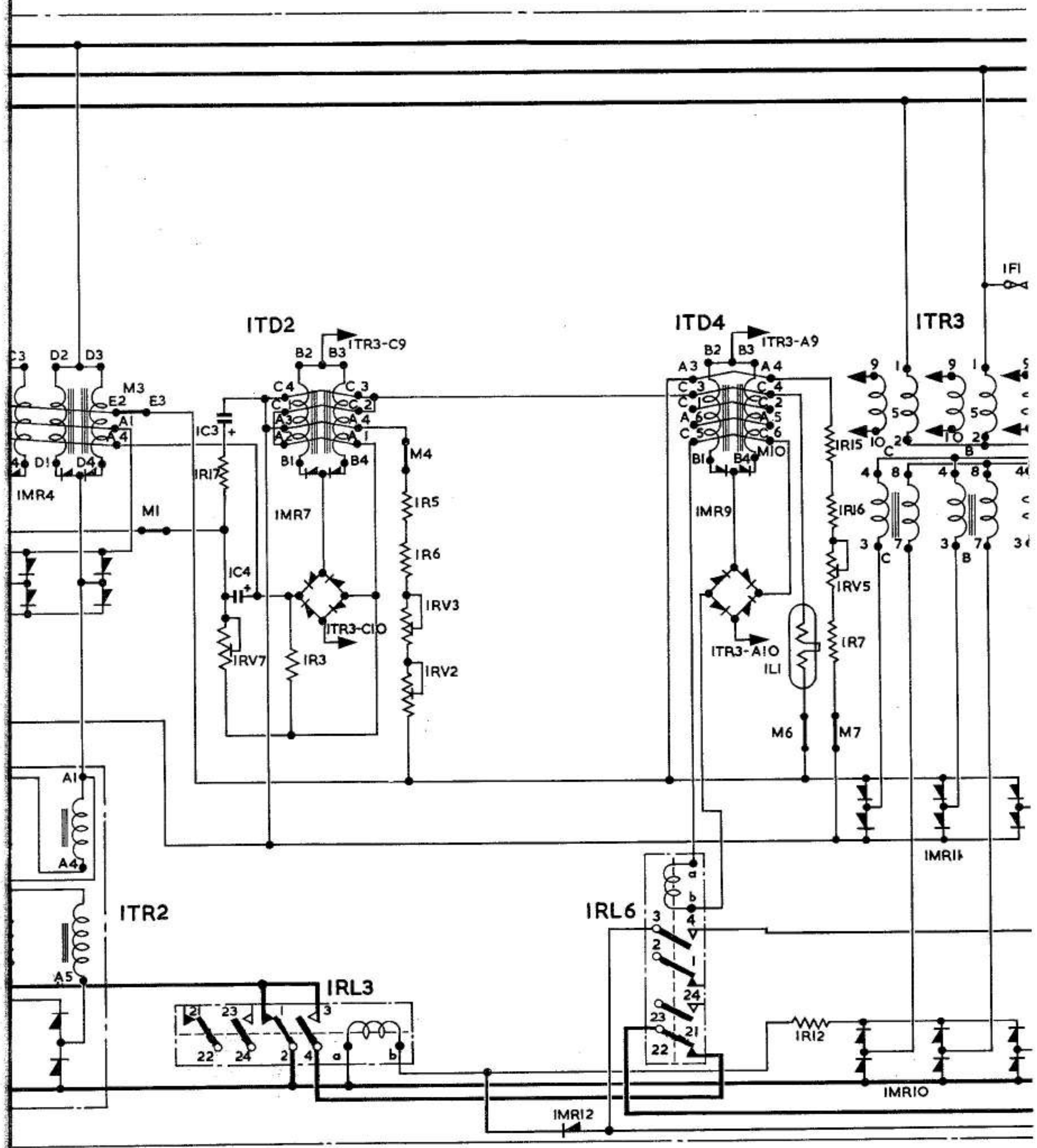

Circuit diagram

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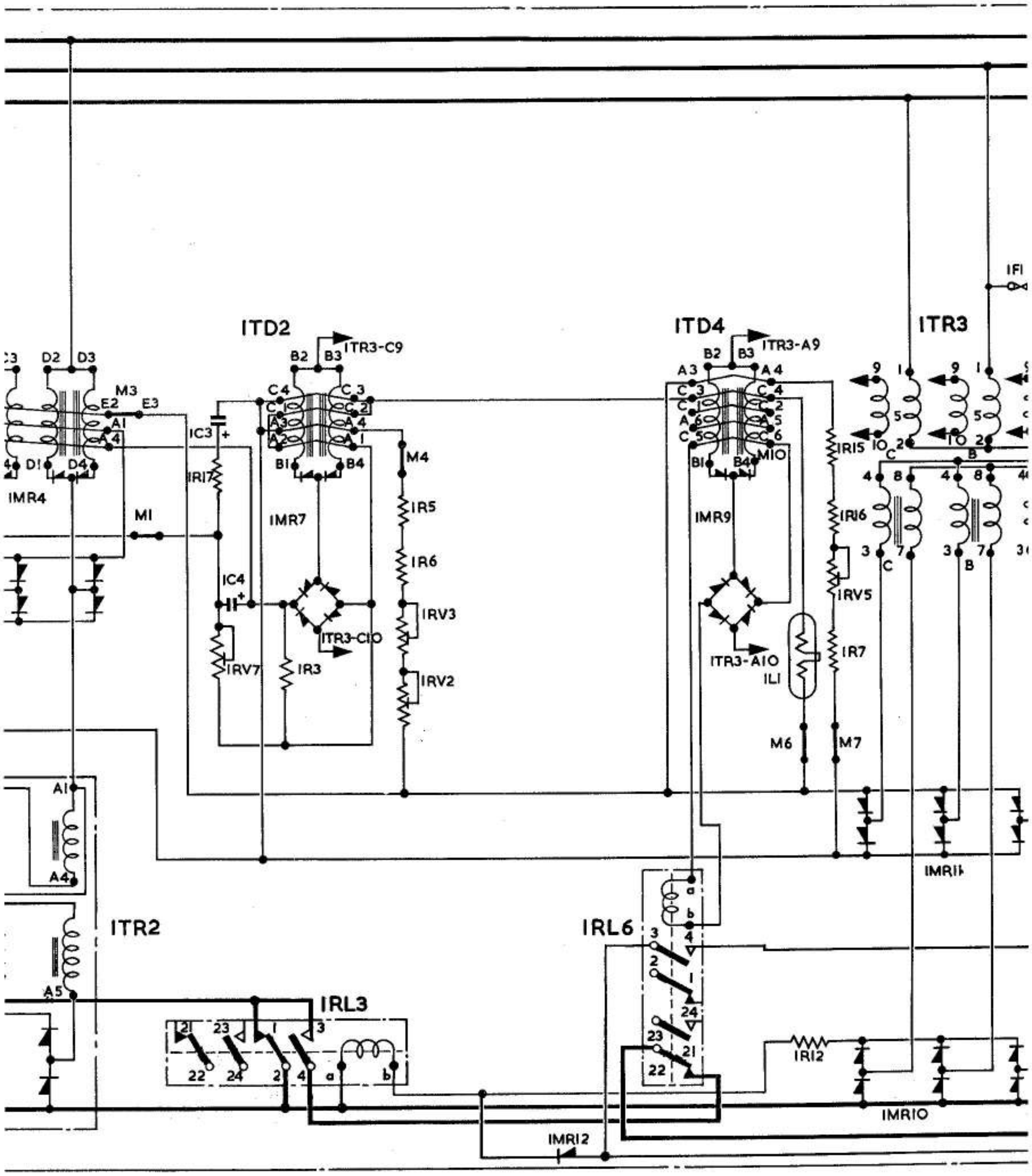

Circuit diagram
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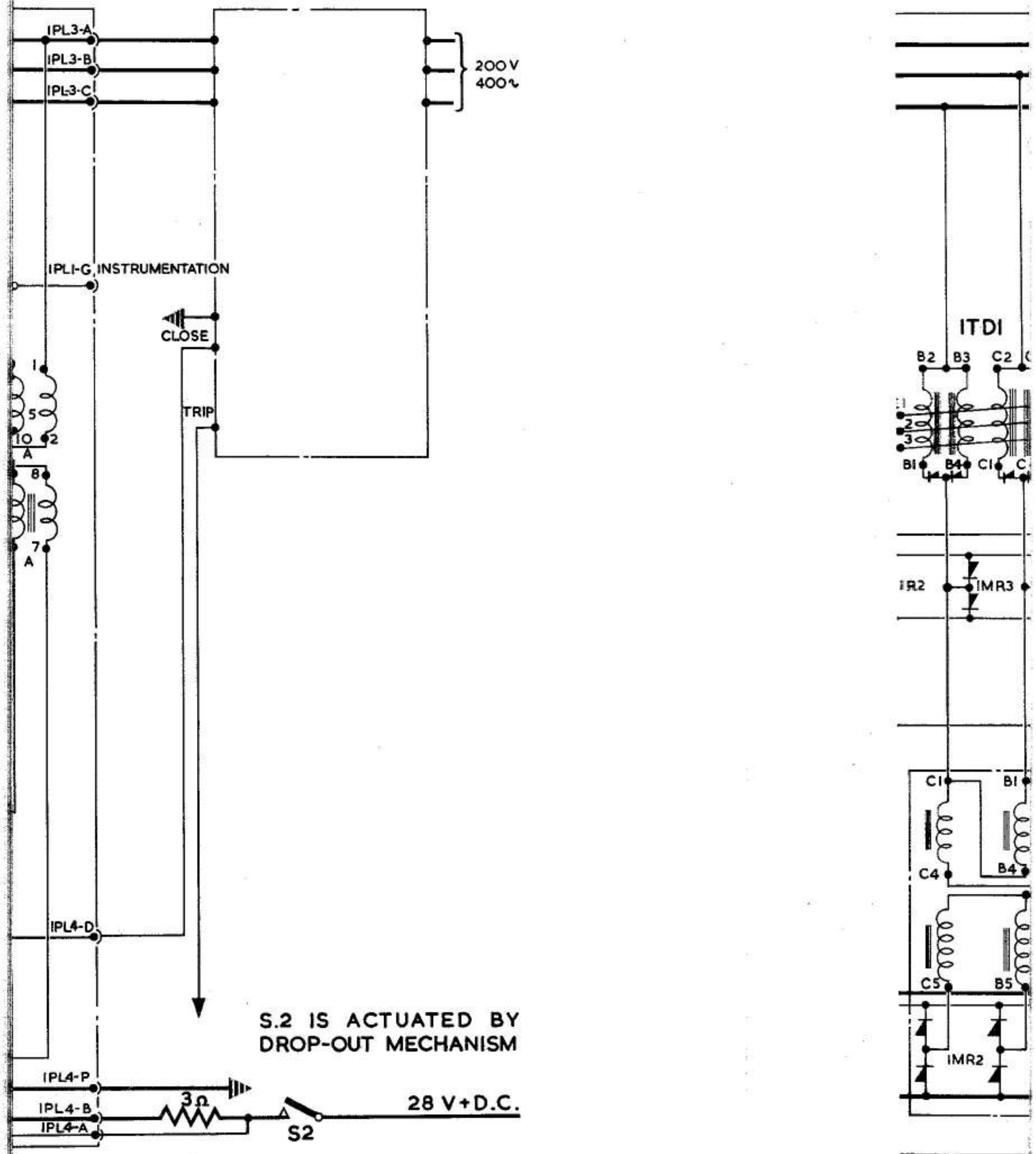
IPL3-A
IPL3-B
IPL3-C
200 V
400~
IPL1-G
INSTRUMENTATION
CLOSE
TRIP
ITD1
B2
B3
C2
B1
B4
C1
IMR3
C1
B1
C4
B4
C5
B5
IMR2
IPL4-D
S.2 IS ACTUATED BY
DROP-OUT MECHANISM
IPL4-P
IPL4-B
IPL4-A
3Ω
S2
28 V+D.C.

Fig.1


847
ENTRANCE OTHER SIDE