

## Chapter 7

**RAM AIR TURBINE, ROTAX, TYPE BAT 0102**  
**(INCORPORATING GENERATOR, ROTAX, TYPE BA 1603 or BA 1604)**

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## LEADING PARTICULARS

**Ram air turbine, Type BAT0102***(incorporating generator, Type BA1603 or BA1604)***Ref. No. 5UA/7874**

<i>Controlled output</i> ... ..	15 kVA, 3-phase, 370 c/s a.c.
<i>Output current</i> ... ..	42 amp. (line)
<i>Power factor</i> ... ..	0.5-0.8 lagging
<i>Rating</i> ... ..	Continuous
<i>Overload</i> ... ..	30 kVA, 0.8 p.f. for 0.5 sec.
<i>Controlled voltage (output)</i> ... ..	185V (line)
<i>Governed speed</i> ... ..	7,400 r.p.m.
<i>Voltage regulation</i> ... ..	Control unit, Type U3703/1
<i>Excitation current (on O/C)</i> ... ..	7.5 amp.
<i>Excitation current (on S/C)</i> ... ..	19.5 amp.
<i>Excitation current (at F.L.)</i> ... ..	0.8 p.f., 26.2 amp.
<i>3-phase tickler exciter</i>	
<i>maximum line voltage on O/C at 8,000 r.p.m.</i> ... ..	8.0 volts

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## LEADING PARTICULARS (continued)

Altitude ... ..	25,000-60,000 ft.
Ambient temperature ... ..	-60 deg. C. to +30 deg. C.
Brush length (new) ... ..	0.750 in.
Brush grade ... ..	K.C.E.G. 11, P.E.G. 11—post Mod. Elect. A437
Cooling ... ..	self-cooled via turbine ram air
Speed control (mechanical governor) ... ..	via ram air turbine
Direction of rotation (viewed from drive end) ... ..	Anti-clockwise
Overall dimensions—	
Length ... ..	25.000 in.
Height (over lug) ... ..	18.242 in.
Weight (complete unit) ... ..	88 lb.

Minimum air requirements for 15kVA, 0.8 p.f.—

ALTITUDE (1,000 ft.)	MASS-FLOW (lb/sec.)	PRESSURE DROP ACROSS UNIT (lb/in <sup>2</sup> )
25	7.5	0.50
35	5.3	0.48
50	3.1	0.46
60	2.3	0.46
65	2.1	0.46

*At higher mass flow, pressure drops are reduced*

### Introduction

1. This is a 15 kVA, 0.5 to 0.8 power factor, 208V, 400 c/s, 3-phase 6-pole, self-excited ram air turbine a.c. generator designed to supply essential services with electrical power for emergency purposes in the event of main generator failure.

2. A permanent magnet a.c. generator, integral with the main generator, provides supply for control purposes and also ensures positive generation build-up. Speed control is effected by a mechanical governor which is directly coupled to the generator. The ram air turbine drives the generator via an integral mechanical governor designed to provide constant speed; the associated U3703/1 control unit ensures voltage control of the 15 kVA emergency supply to the flying control motors which form the major part of the emergency loading.

3. The original ram air turbine, Type BAT0101 (Ref. No. 5UA/6853, incorporating generator Type BA1601 or BA1602), became Type BAT0102 on the embodiment of Mod. Elec. A/410 (Rotax R.6191). This modification consists essentially of the following points:—

(1) The incorporation of a pre-loaded, double bearing ballrace in place of the original single bearing ballrace in the spider balancing assembly of the turbine, associated with the turbine hub balancing and blade assembly. This ensures positive ball loading of the bearing, and prevents "ball stick" on light loads.

(2) The incorporation of an anti-rotational locking device to prevent inadvertent rotation of the turbine in a clockwise direction due either to reverse air flow or manual handling. This could cause damage to the internal clutch mechanism due to excessive loading.

(3) Turbine component parts have been strengthened and modified to accommodate the new double-bearing ballrace and anti-rotational device; this has caused an increase of 8 lb. in the overall weight of the unit.

(4) The end shell has been modified by the incorporation of three equally-spaced cut-outs for access to the brushgear screws.

(5) Pinned locking studs have been incorporated in the BA1603 and BA1604 generators for securing the end shell and brushgear respectively, as shown in fig. 5.

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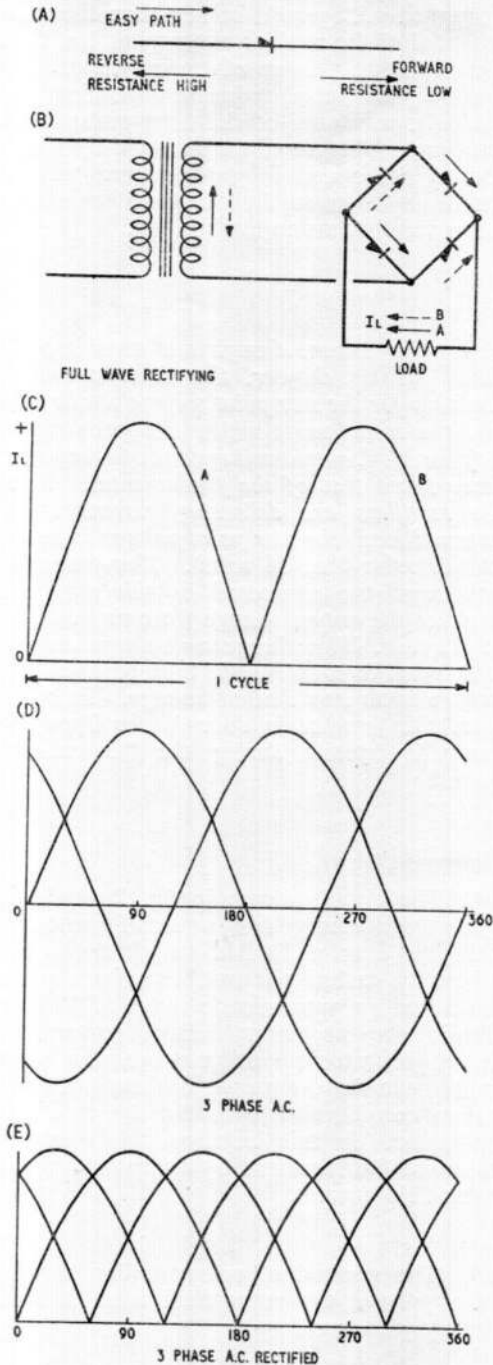


Fig. 1. Rectifier and rectified a.c.

6. Four rectifiers connected as shown in (B) form a single phase bridge rectifier circuit and have the effect of making the load

current  $I_L$  unidirectional. This load current appears as a series of pulses, as shown in (C) and is usually referred to as direct current. In the single phase system outlined, there would be two such pulses per cycle since both the negative and positive half cycles are rectified, but in the type 154 generator system three phase rectification is used so that a smoother d.c. output is obtained. This gives six pulses per cycle as shown in (D) and (E) fig. 1.

**Basic d.c. voltage regulation**

7. A simple method of voltage control is shown in fig. 2; the generator supplying alternating current, the rectifiers changing the alternating current to direct current and the regulator controlling both.

8. From this diagram it will be seen that a reference voltage is taken from the 112 volts d.c. busbar and applied via a suitable ballast resistor to the control coil of the regulator. The generator rotor field current is supplied from a 28 volt d.c. source, via the carbon pile of the regulator and is controlled by variations in pressure on the carbon pile, producing changes in pile resistance which correspond to variations in the busbar voltage. The sequence of events which takes place when the busbar voltage drops is, therefore, as follows:—

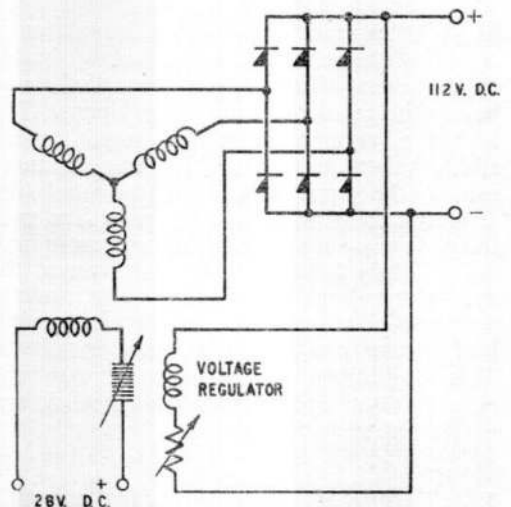


Fig. 2 Typical voltage regulator circuit

(1) The busbar and stator voltage drops, causing a drop in voltage at the control coil of the regulator.

(2) The regulator carbon pile will compress due to this drop in voltage.

(3) Rotor field current  $I_f$  will increase.

(4) Generator voltage will rise, due to increase in  $I_f$  and the busbar voltage will be restored to its nominal value of 112 volts d.c.

9. It can be similarly explained that for an increase in busbar voltage, pressure on the carbon pile will decrease. The consequent reduction of  $I_f$  will cause the busbar voltage to return to its nominal value.

#### M.V. (112 volts d.c.) Section

10. This output is derived by rectification (*para. 5*) of the 100 volt output of the generator and is controlled by a carbon pile regulator. The control circuit differs slightly from the basic circuit (*fig. 2*) but is discussed fully below.

#### Voltage control

11. Unlike a d.c. system, an a.c. rectified system is switched on to a live busbar before the set is generating. Therefore, when considering the regulator coil conventionally connected across the M.V. output and negative, the coil of the regulator is pre-energized direct from the live busbar.

12. The time constant of the regulator is such that the generator output voltage builds up in excess of its normal controlled value before the regulator carbon pile opens. The excessive voltage gives the regulator an additional "kick," which in some instances causes the springs to collapse and the armature to stick against the pole face with the pile open-circuited; this is most prominent on a lightly loaded system. It causes the generator voltage to collapse to zero, and the regulator pile to remain open-circuited as it is held in that position by the busbar voltage. This condition is aggravated when the generator sets are operating in parallel, and is referred to as "cutting out."

13. To overcome the tendency to "cut-out" a reference voltage for the regulator is taken between the negative of the 112 volt rectifiers

and the star point of the a.c. input to the rectifiers. At the instant of switching on, the star point voltage will be less than the mid-potential of the rectifier output, i.e., less than the operating voltage of the regulator. In practice, the actual value is determined by the back resistance of the three-phase M.V. rectifiers. Therefore, the amount by which the regulator coil is pre-energized will be insufficient to create the "cut-out" condition when switched on to the busbars.

#### Note . . .

*It can be shown, though not considered in detail in this chapter, that it is a natural tendency for the star point voltage to alternate about a mean value which is approximately half the M.V. output voltage and of a frequency three times that of the fundamental. When the rectifiers are delivering current to an external load, the star point voltage is locked at this value (i.e., 56 volts). Therefore a 56 volt regulator connected in this way will regulate the output voltage from the rectifiers at 112 volts. When the system is not generating, it is possible to move the star point voltage artificially to any desired voltage. In actual fact, this is what is done in the Type 154 generator system during the "switch-on" period.*

#### Compounding

14. The circuit shown in *fig. 2* would be quite satisfactory for a small generator working over a limited speed range and where the carbon pile would not be required to exceed an approximate range of 10:1 to obtain the necessary voltage control. A larger generator operating over a wide speed range necessitates a greater field current which varies considerably with the speed of the generator. In this instance it is necessary to assist the regulator by compounding the rotor field current.

15. The method of compounding consists of supplying the rotor field from two independent sources:—

(1) From a 28 volts d.c. supply via the regulator.

(2) From a rectified alternating current source which is proportional to the line output current of the generator, i.e. via the compounding transformer and rectifier.

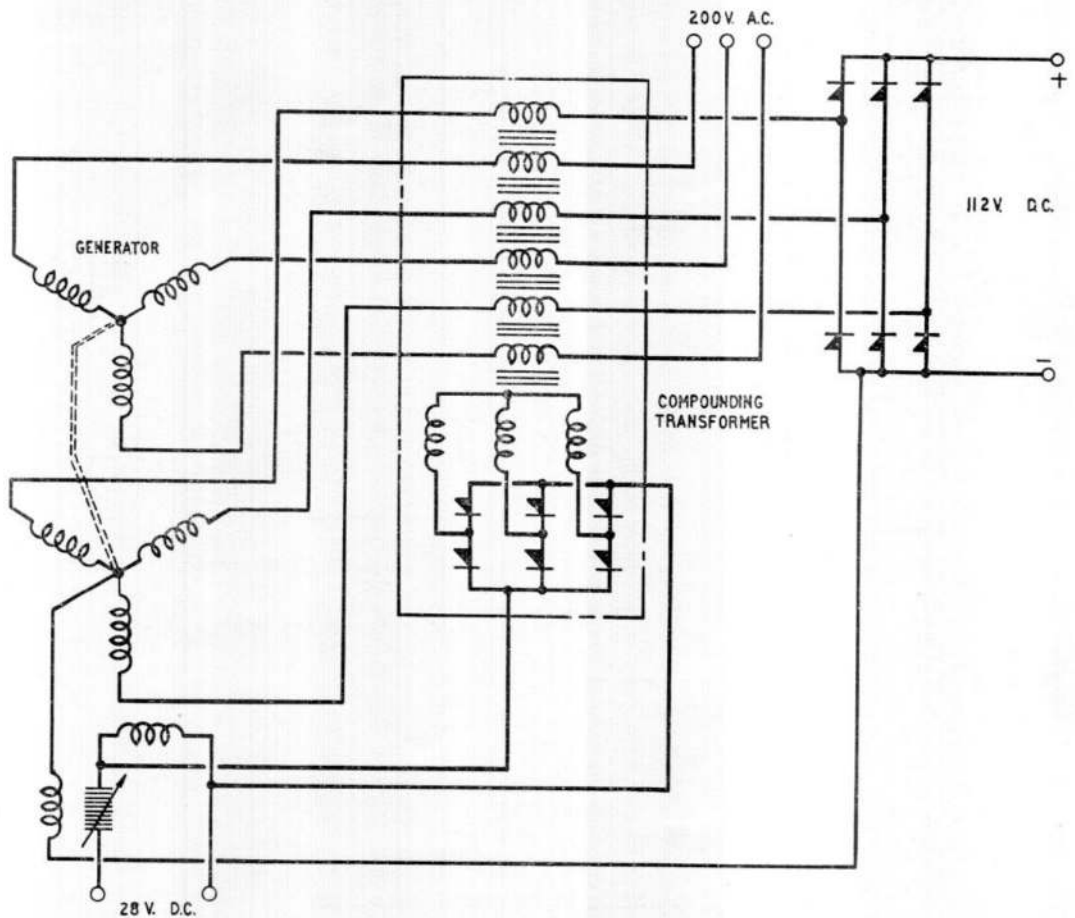


Fig. 3. Typical compounding circuit

16. Reference to fig. 3 will show the circuit arrangement required to obtain this division of rotor field current. It will be noticed that the 200 volt winding has now been incorporated in the circuit and the purpose of this winding is discussed in para. 18.

17. The primary windings of the compounding transformer are connected in series with the line output of the generator. The transformer output is rectified and fed to the rotor field in parallel with the output of the regulator carbon pile. When the generator is supplying current to an external load, only part of the total field current passes through the regulator carbon pile; therefore it is possible to keep the size and weight of the regulator to a minimum.

#### A.C. (200 volts a.c.) Section

18. The 200 volt windings mentioned in para. 16, and the 100 volt winding, are accommodated in the same stator slots and are therefore fed by a common rotor field. The 100 volt output depends on the field current which is controlled by the M.V. regulator. Therefore load variations on the M.V. circuit will be reflected in the a.c. output.

19. In practice, it is found that the latter output varies between 170-220 volts, depending on the M.V. and a.c. load. However, in the particular aircraft for which the type 154 generator system was designed, the a.c. output is used to supply de-icing equipment and for this type of load a regulated voltage is not entirely necessary.

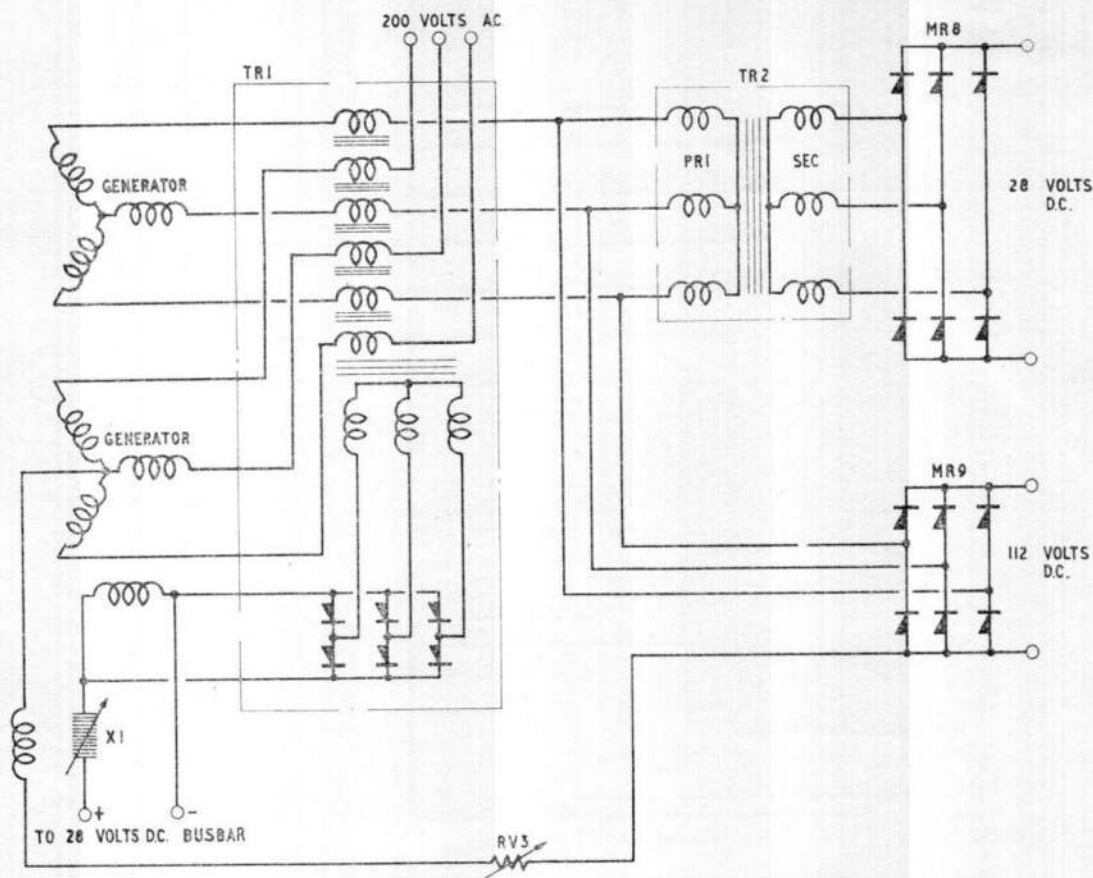


Fig. 4. Main transformer connections

#### L.V. (28 volt d.c.) Section

20. It will be seen in fig. 4 that, in addition to the compounding transformer, a main transformer has been included to "step-down" the output voltage from the secondary generator winding to that required by the L.V. rectifiers. The two d.c. outputs are therefore derived from the same source.

#### Note . . .

The output from the main transformer is in practice less than that required to give 28 volts from the L.V. rectifiers; the reason for this is explained in para. 22.

#### Voltage control

21. As mentioned in para. 18, the 200 volts output depends on the rotor field which is controlled by the M.V. regulator. Consequently, any change in M.V. load would

cause a corresponding change in the L.V. output voltage, such that if the M.V. circuit is on full load and the L.V. circuit is on no load, the L.V. output would be in the order of 35 volts. However, if the M.V. circuit is on no load and the L.V. circuit is on full load the L.V. output could be as low as 21 volts.

22. To obtain control of the L.V. output, independent of the M.V. load, use is made of a booster transformer and a transductor connected as shown in fig. 5. The M.V. section and compounding transformer have been omitted from this figure for the sake of clarity. The output from the main transformer is less than that required to give 28 volts d.c. from the L.V. rectifiers but is boosted to the required value by the additional transformer, the input to which is controlled by the transductor.

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23. The transducer is a three-phase saturable reactor controlled by its level of magnetic saturation. By varying the current in the control coil, the saturation level, and therefore the impedance of the reactor, is varied. It will be noted that the primary winding of the booster transformer is delta connected. Due to this delta connection and the reactance of the transducer the booster voltage is displaced by  $\theta$  degrees from main transformer secondary voltage; the additive resultant of these two vectors being the L.V. rectifier input, as shown in fig. 6.

24. As the L.V. section is loaded, the reactance of the transducer decreases and thus it tends to become more resistive and less inductive; the phase angle  $\theta$  decreases, the booster voltage M.R. increases and thus the resultant rectifier voltage increases by a considerable amount for a very small increase in the transducer control current.

25. The circuit arrangement of fig. 5 is such that with the carbon pile exhibiting a pre-determined maximum resistance, the current

through the transducer d.c. coil is at a minimum. This is achieved by including a bias resistor RV.1 (fig. 5), connected between the M.V. positive busbar and transducer coil. With the carbon pile open to its maximum safe limit the potential across the bias resistor is adjusted to approximately 26 volts so that only a minimum current flows through the transducer control coil. In this way the transducer coil can be operated over a wide range of current changes while the regular operates over a comparatively narrow range, hence the size and weight of the regulator required is greatly reduced.

26. The sequence of events when a load is applied to the L.V. rectifiers, or when the output from the 100 volts generator winding falls, is as follows:—

- (1) The d.c. output from the rectifiers falls below the 28 volt nominal.
- (2) Pressure on the carbon pile of the L.V. regulator increases slightly, and the pile closes, thereby reducing its resistance.

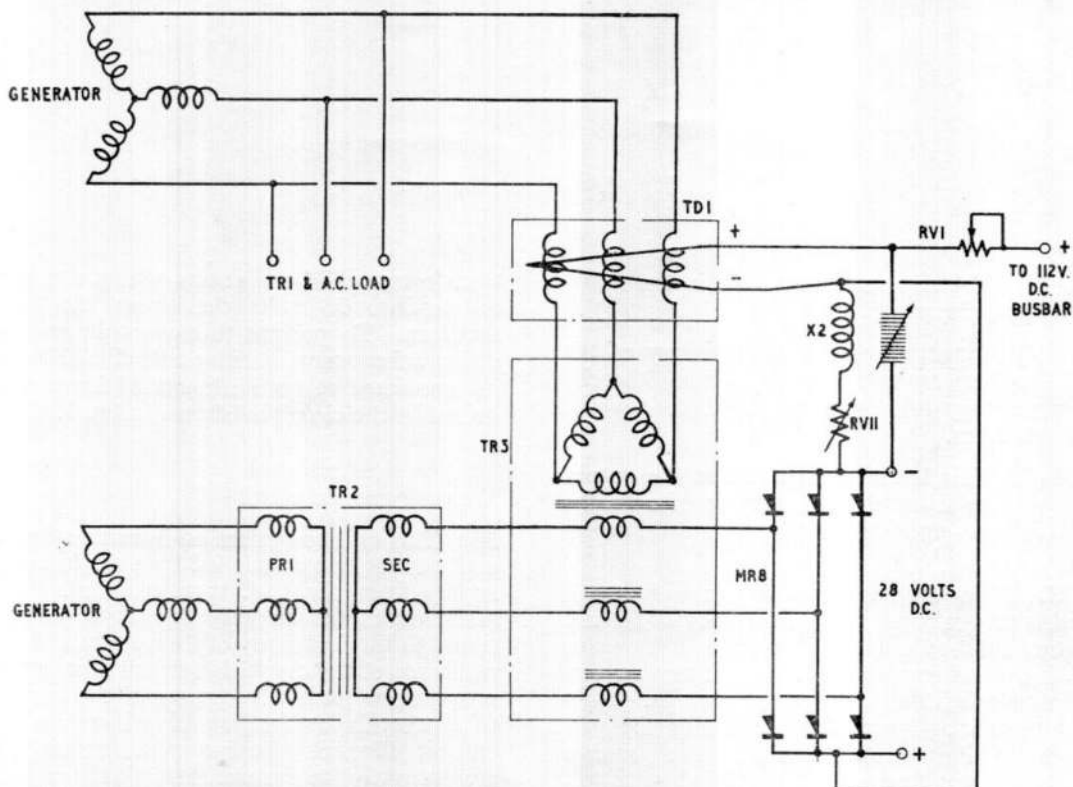


Fig. 5. Low voltage control circuit

OM = SECONDARY VOLTAGE, MAIN TRANSFORMER  
 MR = BOOSTER VOLTAGE  
 OR = RESULTANT VOLTAGE, LV RECTIFIER INPUT

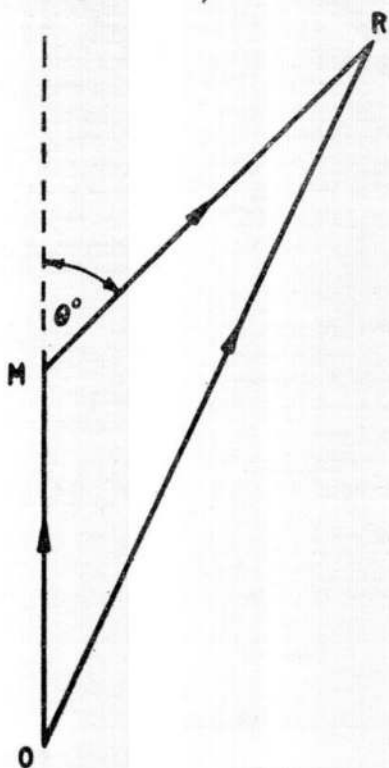


Fig. 6. Vector diagram

(3) The d.c. control current in the transductor increases.

(4) Input voltage to the primary of the booster transformer increases, thereby boosting the voltage applied to the rectifiers.

(5) This boost voltage causes the output voltage from the rectifiers to rise to the 28 volts nominal.

27. Since the reactance of a transductor is also proportional to the frequency of the a.c. input, the output obtained for a given value of control current will be greater at low frequencies than at high frequencies. Consequently at low generator speeds the preset minimum output from the booster transformer (*para.* 25) combined with the maximum secondary output from the main

transformer will be in excess of that required to produce 28 volts d.c. from the L.V. rectifiers. To prevent this overvoltage condition a frequency sensitive unit (F.5301) and its associated relays RL1 and RL2 are connected in the circuit as shown in fig. 7.

#### *Frequency sensitive unit*

28. This unit comprises an inductive circuit and a capacitive circuit fed by a single phase supply from the L.V. rectifier input. The reactance of the inductive circuit is proportional to the frequency of the supply and the reactance of the capacitive circuit is inversely proportional to the frequency of the supply. Consequently, as the frequency increases the current through the inductive circuit decreases while the current through the capacitive circuit increases.

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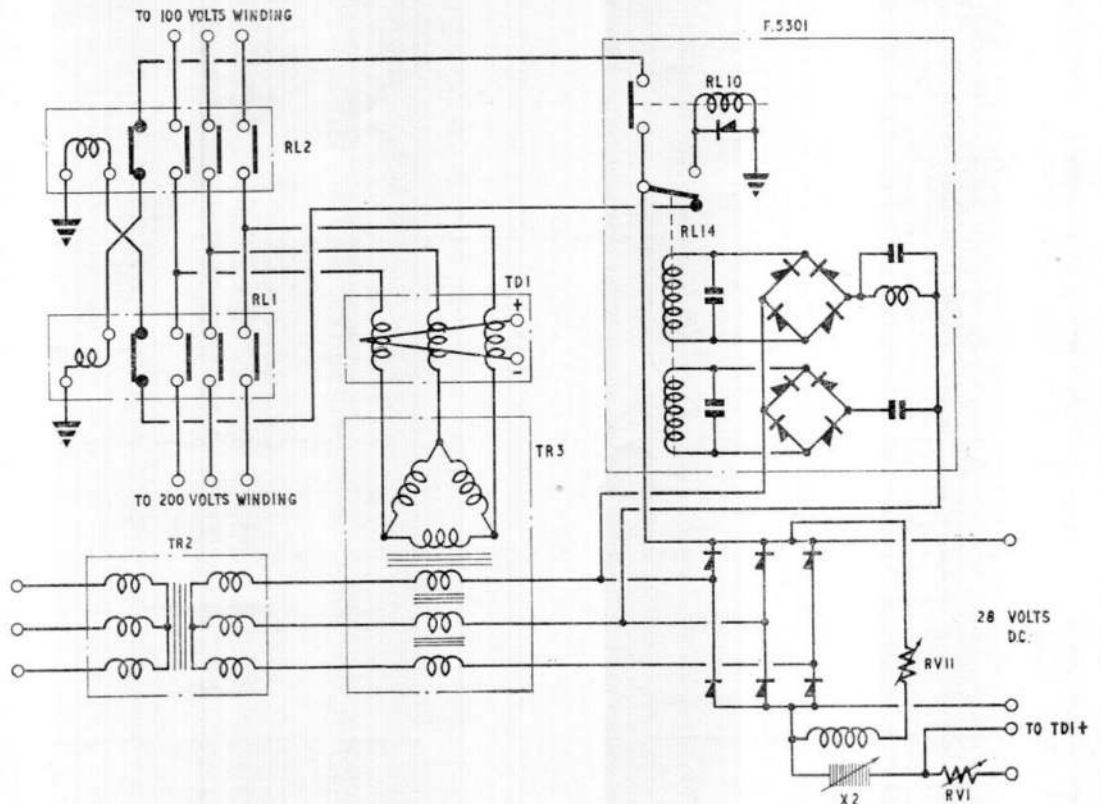


Fig. 7. Connections to frequency sensitive circuit

29. RL14 (fig. 7) is a polarized relay with two oppositely wound operating coils; one of which is connected to the rectified output from the capacitive circuit, while the other is connected to the rectified output from the inductive circuit. The moving contact of the relay is connected to the 28 volt busbar and mates normally with a fixed contact to complete the circuit to the operating coil of RL2 (fig. 7). At frequencies up to approximately 250 c.p.s., corresponding to a generator speed of  $5000 \pm 50$  r.p.m., the current through the inductive circuit is sufficiently in excess of that through the capacitive circuit to ensure that the contacts remain held in this position. At higher frequencies however, the current through the capacitive circuit will have the greater value and the relay will operate, thus breaking the circuit to RL2 and completing the circuit to RL10 via the other fixed contact. The operation of RL10 completes the circuit to the operating coil of RL1.

30. When RL1 is closed, the a.c. supply to the transducer is taken from the 200 volt generator winding but when RL2 is closed this supply is taken from the 100 volt winding. The two relays are electrically interlocked via auxiliary contacts so that they cannot be operated simultaneously. The purpose of the metal rectifier, connected in parallel with the operating coil of RL10 (fig. 7) is to prevent arcing at the contacts of RL14.

#### Load sharing L.V. section

31. When the d.c. outputs from one or more generator sets are paralleled to meet the power requirements of a particular aircraft it becomes necessary to ensure that each set is supplying an equal load. The load sharing circuits for two 28 volts d.c. sections are shown in fig. 8, where it will be seen that a further coil has been added to each regulator assembly. To describe the operation of these circuits it must be assumed that one generator

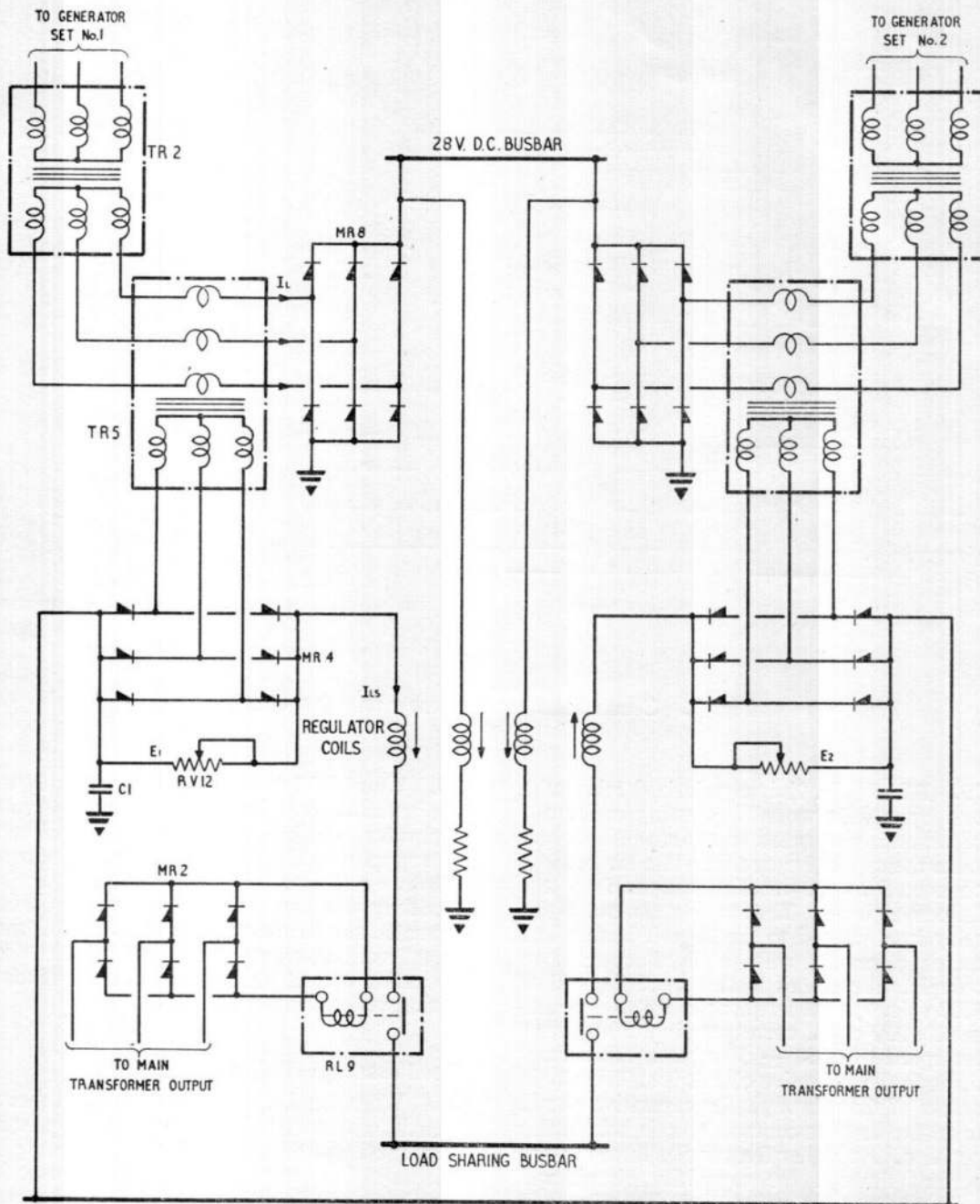


Fig. 8. Low voltage load sharing circuit

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is supplying more load than the other and the effect of the additional coils on the regulators in their attempt to restore balance must be considered. If it is assumed that E1 is greater than E2 then a current  $I_{ls}$  will flow from No. 1 generator to No. 2 generator via the load sharing coils. Now the two regulator coils of No. 1 regulator will magnetically assist one another, whereas the coils on No. 2 generator will oppose one another, thus decreasing the voltage setting on No. 1 regulator and increasing the voltage setting on the other. As the regulator voltage setting decreases, the generator supplies less load so that this action tends to reach equilibrium when the two generators are supplying equal loads. Thus, No. 1 generator will supply less load and No. 2 generator will supply more load until equilibrium is again restored.

32. The load sharing circuit is isolated by RL9 (fig. 8), operated from the L.V. rectifier a.c. supply via a rectifier. This is necessary since, if one unit is switched out and the load sharing circuits are maintained, the remaining sets would still tend to "load share" with the set that has been switched out at zero volts. By isolating the load sharing circuits, the remaining sets would function normally.

**Load sharing M.V. section**

33. Although the M.V. load sharing circuit is identical to that of the L.V. section and operates in exactly the same manner, it is shown in fig. 9 so that the components can be easily identified when reference is made to the main circuit diagram fig. 14. For convenience, TR7 has also been included in fig. 9 and its purpose is described below.

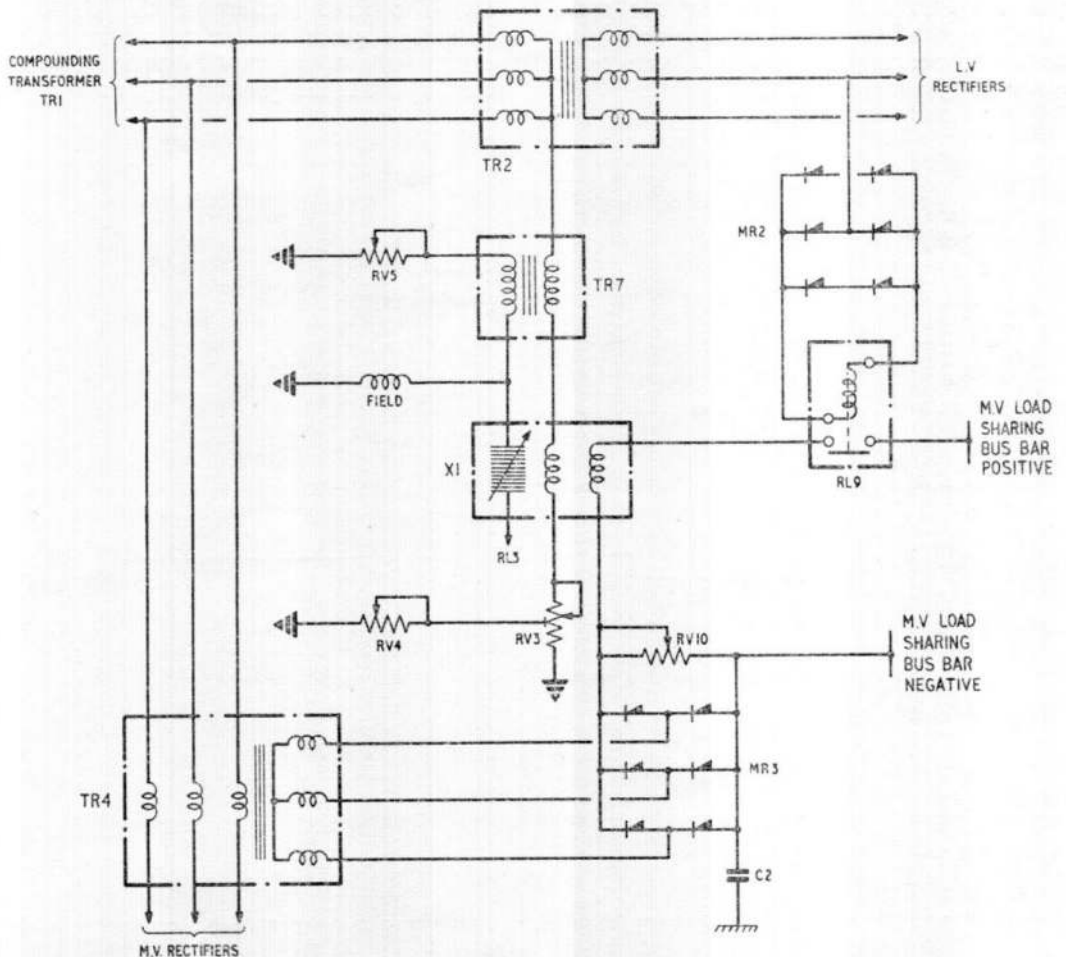


Fig. 9. Medium voltage load sharing circuit

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### M.V. stabilizing transformer

34. An electrical disturbance in the circuit, which may be due to a sudden switching of the load, is damped by the use of a stabilizing transformer (TR7). Such a disturbance would otherwise appear in the control coil of the M.V. regulator and its amplified effect would be repeated in the circuit, consequently building up into a series of oscillations.

35. Circuit connections to the stabilizing transformer are made so that the initial electrical disturbance occurs in the transformer primary. This disturbance, opposite in phase when reflected in the secondary of the transformer, opposes current variations occurring in the control coil.

### Note . . .

It can be seen from fig. 9 that the star point connection for the M.V. regulator has been transferred to the star point of the main transformer primary. This is done simply to avoid the necessity of taking a star point connection from the generator.

### Protection

36. A protection unit (F.5401), a thermal overload relay and a field contactor are incorporated within the transformer/rectifier unit U3101/2 to protect the system in the event of rectifier failures, a.c. line to line faults or excessive rotor current.

37. The F.5401 unit comprises three independently operated sections, each section being connected in either the L.V. or M.V. main rectifier circuits. In the event of a rectifier failure or an a.c. line to line fault the respective section will operate and break the supply to the operating coil of the field contactor and thereby switch off the generator. For the purpose of explanation, each of the three sections will be considered individually.

### L.V. rectifier protection circuit

38. The L.V. section of the F.5401 is basically a potentiometer and a relay. These components together with their respective connections in the system are shown in fig. 10.

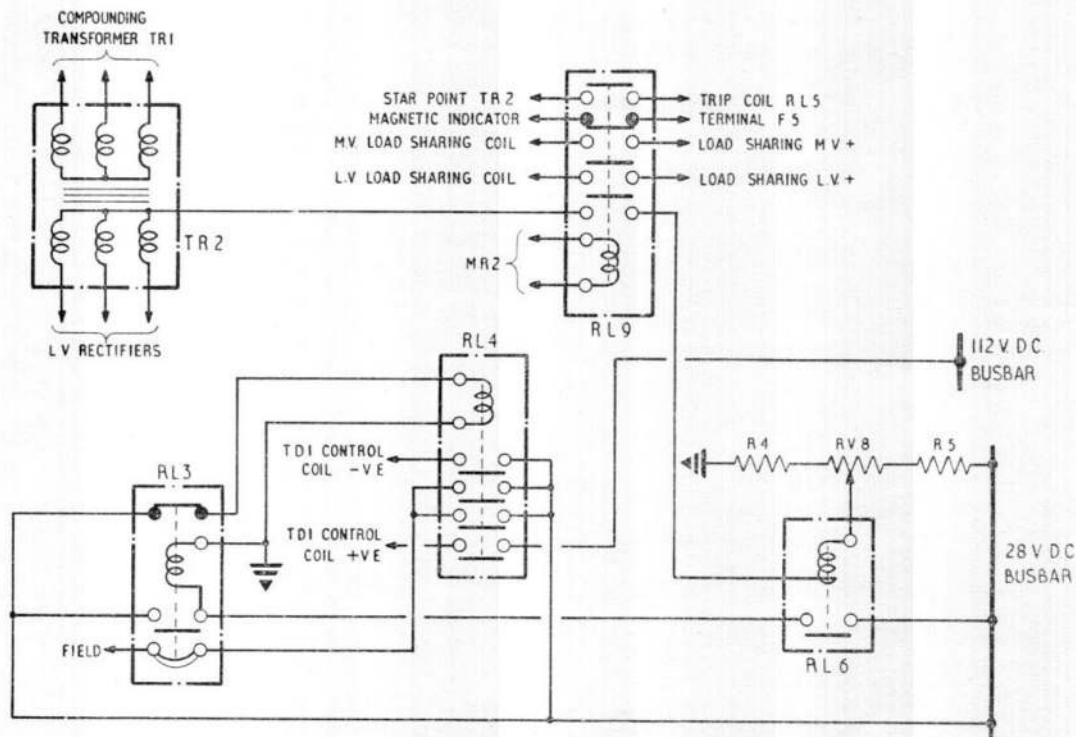


Fig. 10. Low voltage rectifier protection circuit

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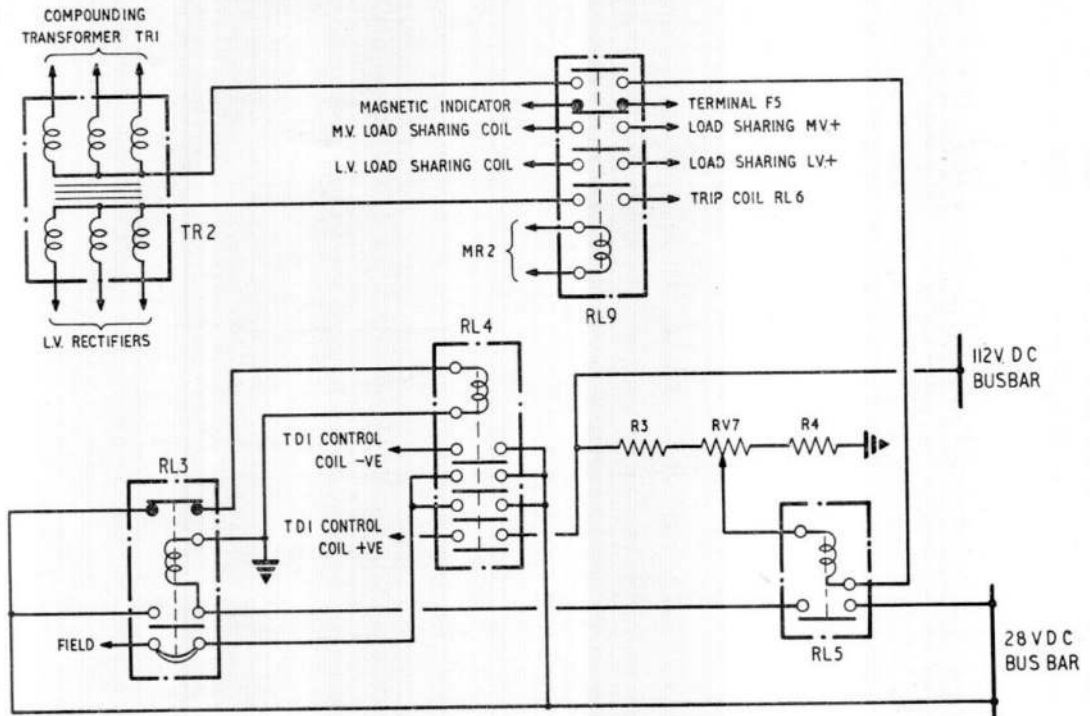


Fig. 11. Medium voltage rectifier protection circuit

39. The potentiometer is connected across the 28 volts d.c. busbars and the relay is connected between the electrical mid-point of the potentiometer and the star point of the main transformer secondary, which will normally be at 14 volts with respect to earth.

40. The relay is connected between these points of equal potential so that under normal conditions no current flows through its operating coil. In the event of a fault, such as a main rectifier failure, the a.c. line connected to the main rectifier bank will be connected either to the positive busbar or the negative busbar (earth) with a consequent change in the star point voltage. The change depends on the extent of the fault, e.g., the voltage may change from 14 volts to as much as 20 volts d.c. When the star point voltage increases to a value three or four volts in excess of the normal 14 volts the relay will operate and complete a 28 volt d.c. circuit to the operating coil of RL3. RL3 will in turn operate and break the circuit to the operating coil of the field contactor RL4, thus switching the generator out of the system. In the event

of an a.c. line to earth fault, associated with the L.V. circuit, a similar action to the above would result and cause the relevant generator to be switched out of the system.

41. It should be noted that the change in star point voltage during the "switch-on" period is likely to bring about the operation of the L.V. rectifier protection circuit. To prevent this, the star point connection to the trip coil of RL6 is made via a normally open pair of contacts in RL9. During the "switch-on" period the main transformer output is not sufficient to operate RL9; consequently during this period the protection circuit is switched out of the system.

#### M.V. rectifier protection circuit

42. This circuit (fig. 11) is similar in every respect to that shown in fig. 10, except that the potentiometer is connected across the 112 volt busbar and earth, the relay being connected between the electrical mid point of this potentiometer and the star point of the main transformer primary. Both these points are at 56 volts, or half the busbar voltage.

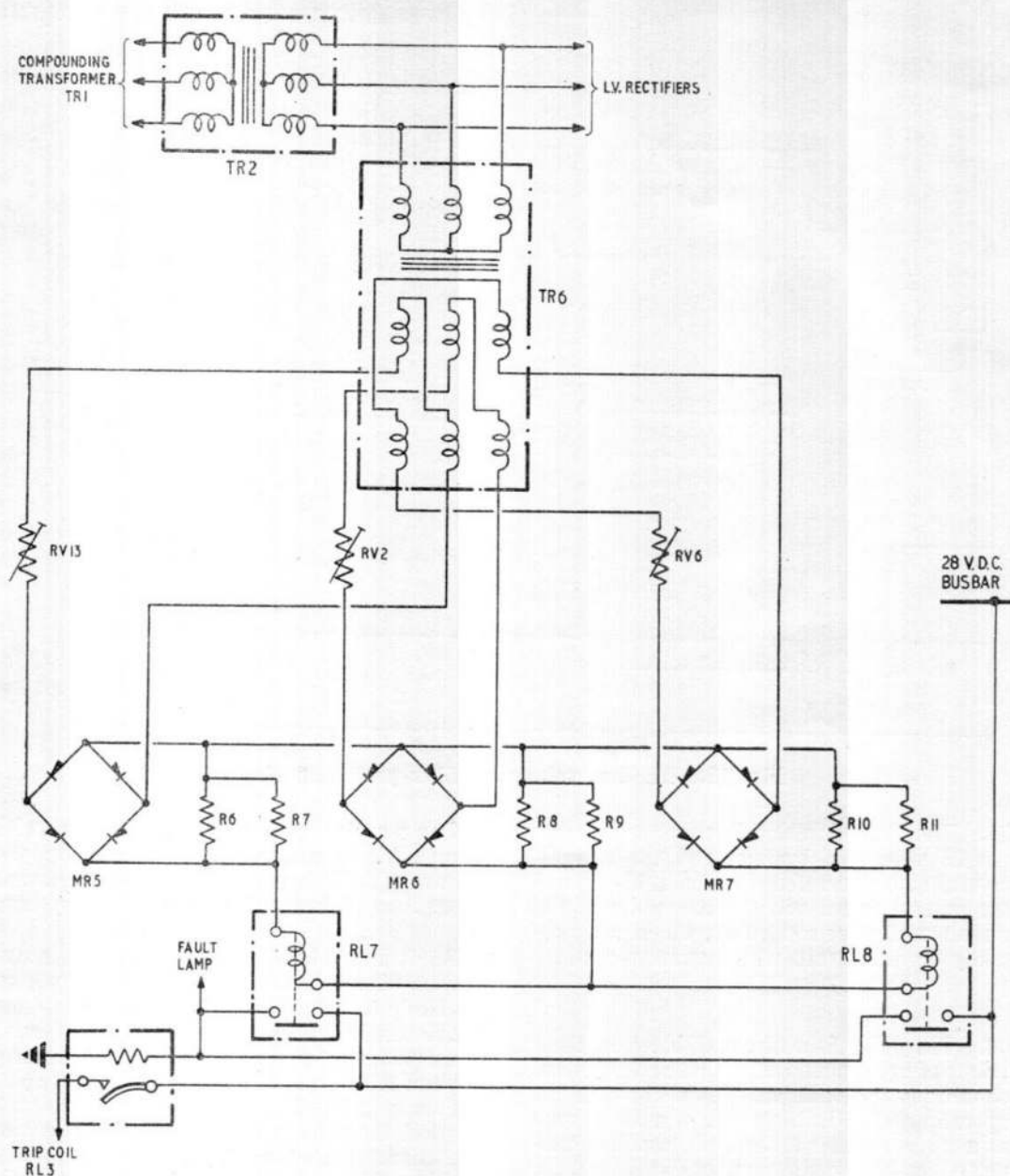


Fig. 12. Asymmetric protection circuit

43. The system operates in a similar manner to that outlined in paras. 38 to 41. Any rectifier failure, whether it be on the positive or negative side, or any earth fault on the a.c. lines associated with the M.V. circuit will cause a change in star point voltage, thereby operating RL5 and completing the 28 volt circuit to RL3. Use is again made of RL9 to switch the circuit out of the system during the switch-on period.

#### Asymmetric Protection

44. The third section of F.5401, fig. 12, is used to switch the generator out of the system should an a.c. line become out of balance.

45. The primary winding of TR6 is connected to the L.V. rectifier input which is used as a reference voltage for the circuit. The secondary winding is "Zig-Zag" connected and provides three separate outputs

each of which is supplied to a bridge rectifier. Two of the rectifier inputs are connected across the linked operating coils of RL7 and RL8, the remaining rectifier output is connected to the link so that while the three outputs are in equilibrium no current flows through either operating coil.

46. If a fault occurs and the current is in one or more of the a.c. lines increases or decreases, the change is reflected in the secondary winding of TR6 and consequently in the outputs from the rectifiers. The resulting unbalance in the rectifier outputs will cause a current flow in the resistor and depending on the

direction of this current flow either RL7 or RL8 will close. Thus if the output from MR5 is greater, current will flow from MR5 through the operating coil of RL7 and back to negative via the ballast resistors R8 and R9. Similarly RL8 is operated if the output from MR7 becomes the greater under fault conditions.

47. When either RL7 or RL8 is energized, a 28 volt circuit to the thermal time delay switch (*fig. 12*), is completed; in turn this switch operates to complete the circuit to RL3, thus switching the generator out of the system as described in para. 40.

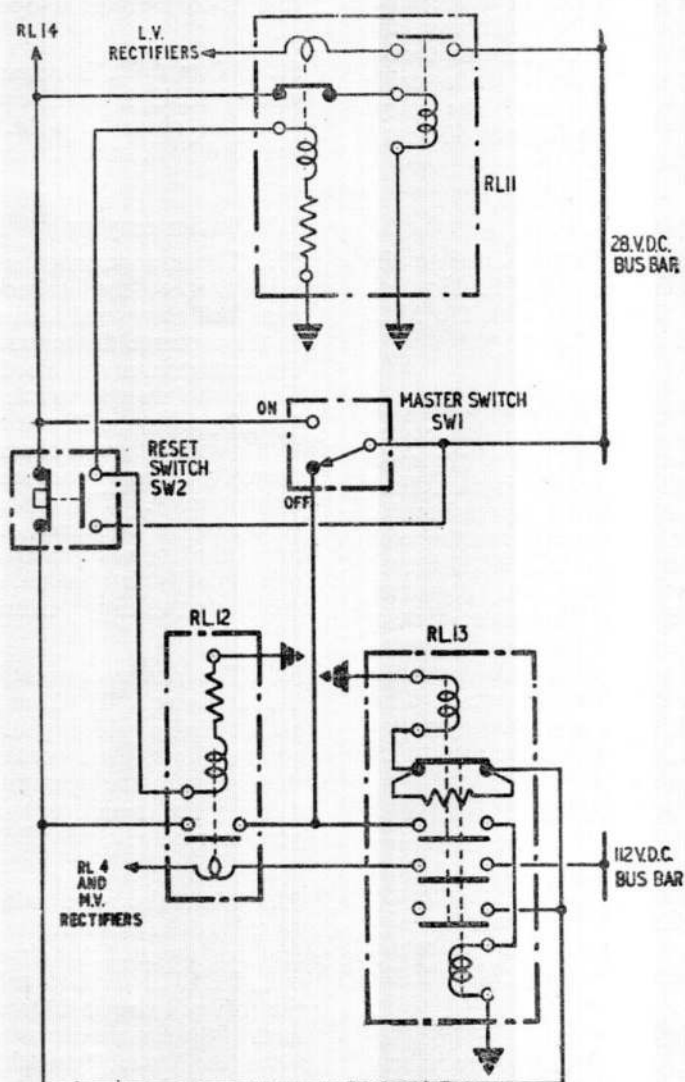


Fig. 13. Medium voltage and low voltage busbar coupling

48. The purpose of the time delay switch is to allow the local protection fuses in the a.c. de-icing lines to blow under fault conditions without causing the T.R.U. to be switched off the busbar.

#### *Rotor protection*

49. The rotor circuit of the generator is completed via the bi-metal element of RL3 (figs. 10 and 11). Should the rotor current become excessive the thermal action of the bi-metal element will cause the relay to operate, thus breaking the supply to the "hold-in" coil of the field contactor RL4.

#### *Reverse current protection*

50. Both the d.c. sections of the system incorporate a device for switching the generator off the busbar in the event of a reverse current flowing owing to a cable fault or main rectifier failure. The relays which provide this protection are discussed further in paras. 54 and 57.

#### **M.V. Busbar coupling**

51. The M.V. section is connected to the busbars by the main contacts of RL13 which is shown in fig. 13 together with the M.V. reverse current relay RL12.

52. When the master switch is moved to the "On" position, a 28 volt supply is connected to the operating coil of RL13 and the main contacts close. At the same time, auxiliary contacts switch in an economy resistor to reduce the current through the operating coil. The mechanical arrangement of RL13 is such that if the trip coil is subsequently energized, the contacts open while the contact plunger remains held in owing to the current flowing through the operating coil. Consequently before the contactor can be reset it is necessary to break the supply to the operating coil to allow the plunger to return to its normal position.

53. This is achieved when the two way master switch SW1 is moved to the "Off" position to complete the circuit to the trip coil of RL13. This circuit is broken by auxiliary contacts immediately the contactor trips and the generator is switched off the busbar.

54. RL12, fig. 13 is the M.V. reverse current relay previously mentioned in para. 50. The forward current in the series coil assists a

pair of permanent magnets to retain the contacts in the open position. Reverse current through the series coil closes the contacts and this completes the circuit to the trip coil of RL13. The main contacts of RL13 open and the M.V. section is switched off the busbar. At the same time, auxiliary contacts open to break the circuit to the operating coil of the field contactor RL4.

55. If the Reset switch SW2 is operated to reconnect the M.V. section to the busbar, subsequent to being switched off owing to a fault condition, the circuit to the operating coil of RL13 will be broken thus allowing the plunger to return to its normal position. The reset coil of RL12 will also be energized so that its contacts are re-opened.

56. When SW2 is released, the operating coil of RL13 is again energized and if the fault has cleared the M.V. section will be switched back on to the busbar.

#### **L.V. Busbar coupling**

57. The arrangement for switching the L.V. section on to the busbar is similar to that described above and is also shown in fig. 13. In this instance the reverse current relay and the contactor are combined as one unit, RL11. When the master switch is moved to the "On" position, a 28 volt supply is connected to the operating coil of the contactor via the normally closed contacts of the reverse current relay. The contacts close and the generator is switched on to the busbar. Since the main contacts of RL11 are not mechanically latched in, they re-open immediately this supply is broken.

58. The reverse current relay operates in the same way as RL12 but has contacts which are normally held closed. When a reverse current flows, these contacts open to break the circuit to the operating coil of the contactors; the main contacts open and the generator is switched off the busbar.

59. When the reset switch is operated, to reconnect the generator to the busbar after a fault has occurred, the circuit to the operating coil of RL11 is broken and at the same time the trip coil circuit is completed. The contacts of the reverse current relay close so that, when the "reset" switch is released, a 28 volt supply is again connected to the operating coil.

### Complete system

60. A circuit diagram for a single generator system is shown in fig. 14, to which reference should be made when considering the operation of the complete system. Internal connections of the generator, transformer-rectifier unit, protection unit and other components of the system are shown within their respective dotted lines. The aircraft for which the system was designed incorporates two such channels, one to each engine, each with their d.c. circuits in parallel. The a.c. circuits are not paralleled because of the frequency and phase considerations between independent generators.

61. Whilst the aircraft is on the ground and the master switch is in the "Off" position, the generator is inactive. When the engines are running and the aircraft prepares for take-off the master switch is moved to the "On" position and the relevant contactors switch the system on to the busbars. At the

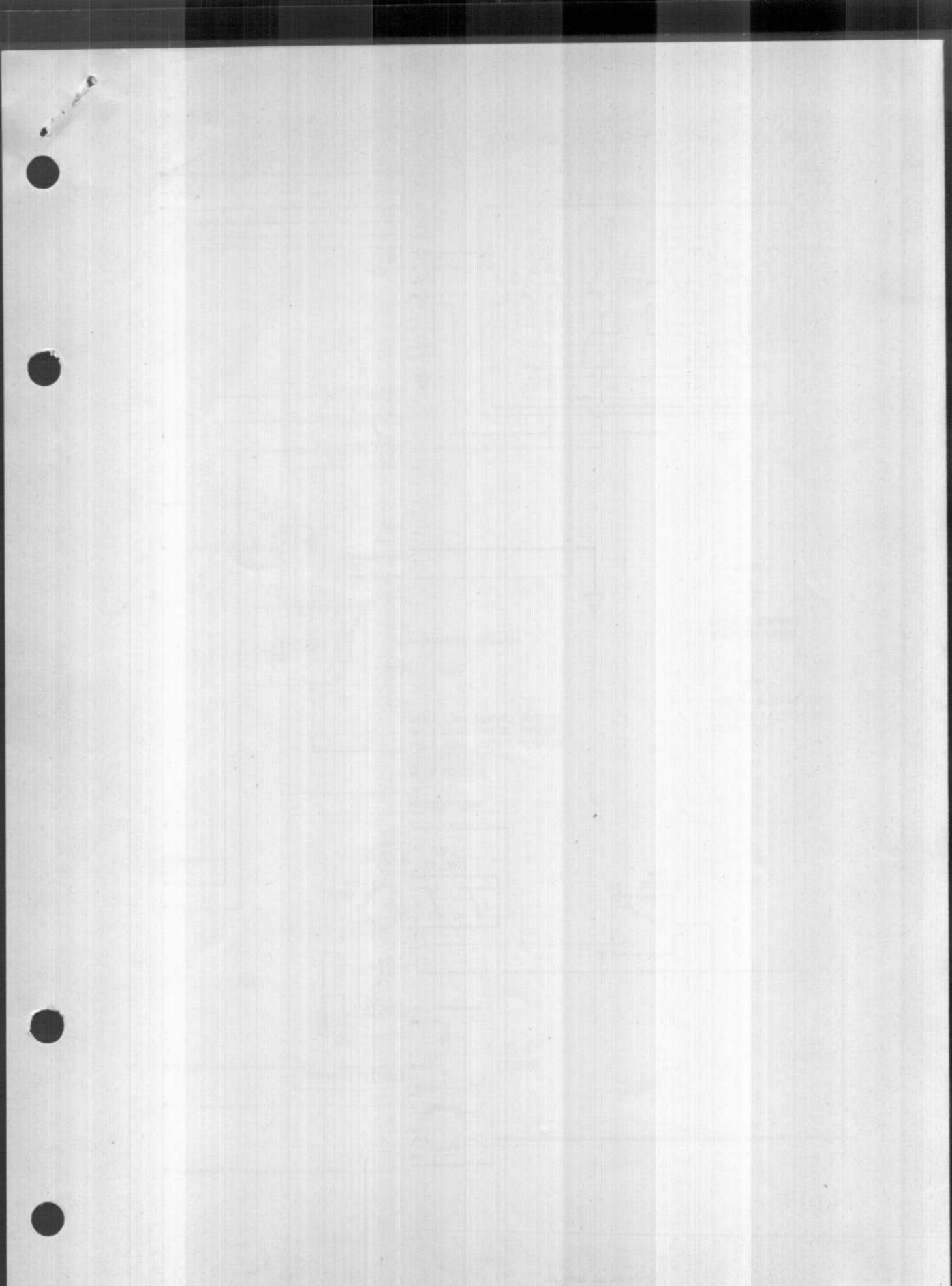
same time, auxiliary contacts of RL13 close to complete the circuit to the field contactor RL4. Immediately the field contactor closes, the generator is excited and the resulting output from the main transformer closes RL9, thus switching in the load sharing and rectifier protection circuits. At the same time RL9 breaks a battery supply to a magnetic indicator connected to the transformer-rectifier unit via terminals F5 and D3.

62. Internal faults occurring in a channel will be detected by the relevant protection circuits and in consequence the faulty channel will be switched off. If a fault condition causes a channel to trip out, then the channel may be reset by operating the appropriate reset switch. If there should be a recurrence of the fault and the channel again trips out, the master switch should be moved to the "Off" position. The load requirements of the aircraft will then be supplied by the remaining serviceable channel.

1911

1912





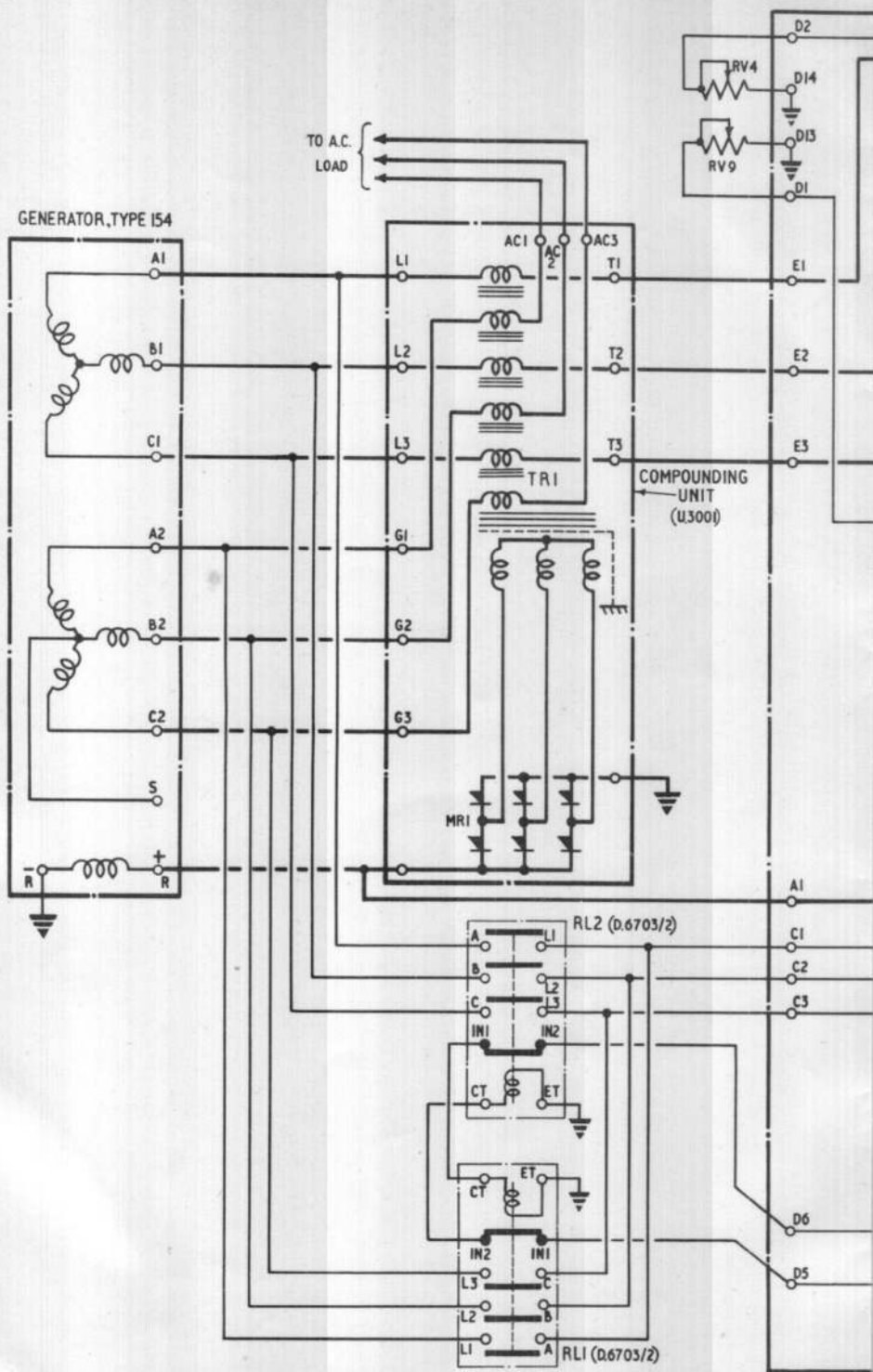
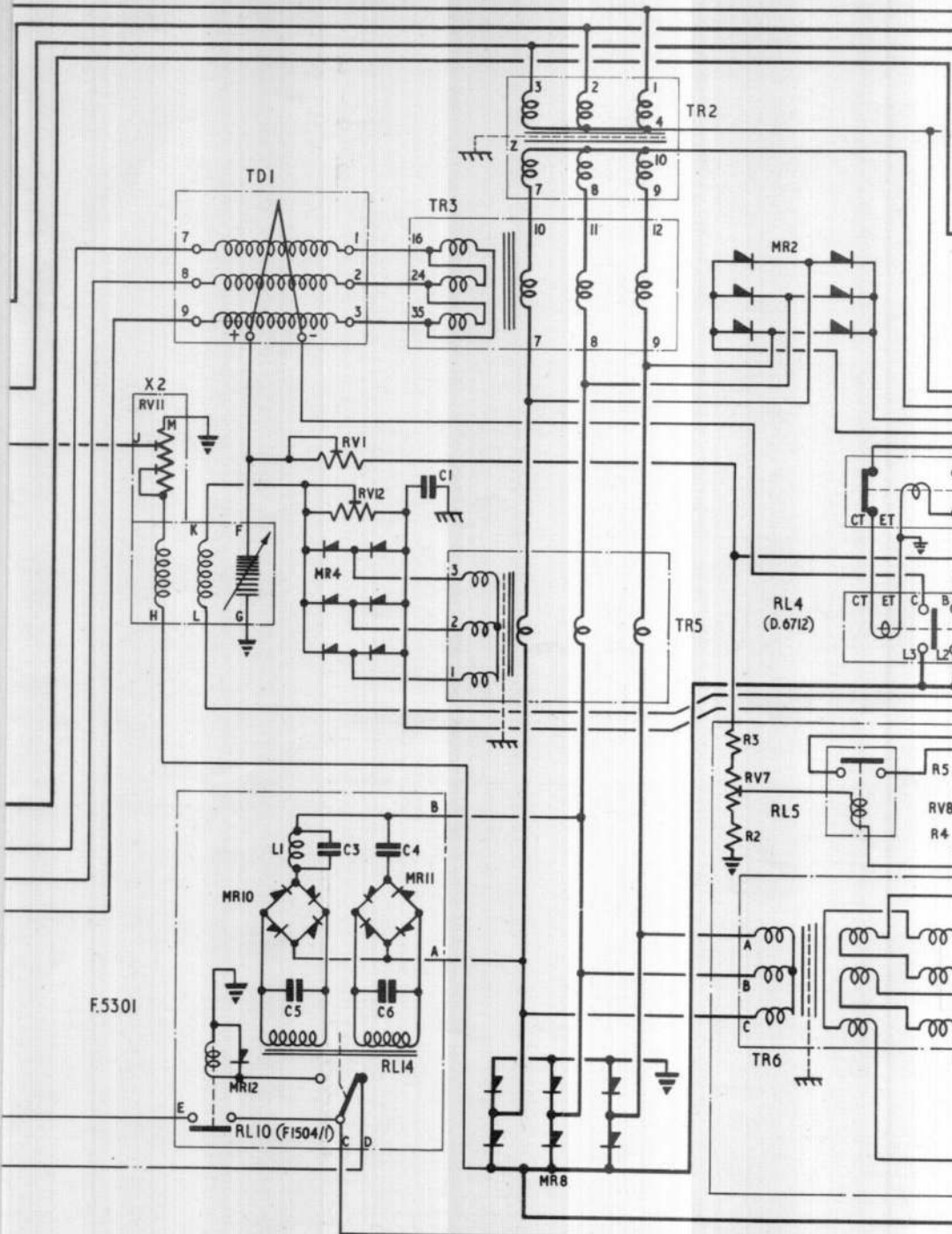


Fig.14

TRANSFORMER-RECTIFIER UNIT (U.3101/2)



F.5301

Type I54 generator system  
RESTRICTED

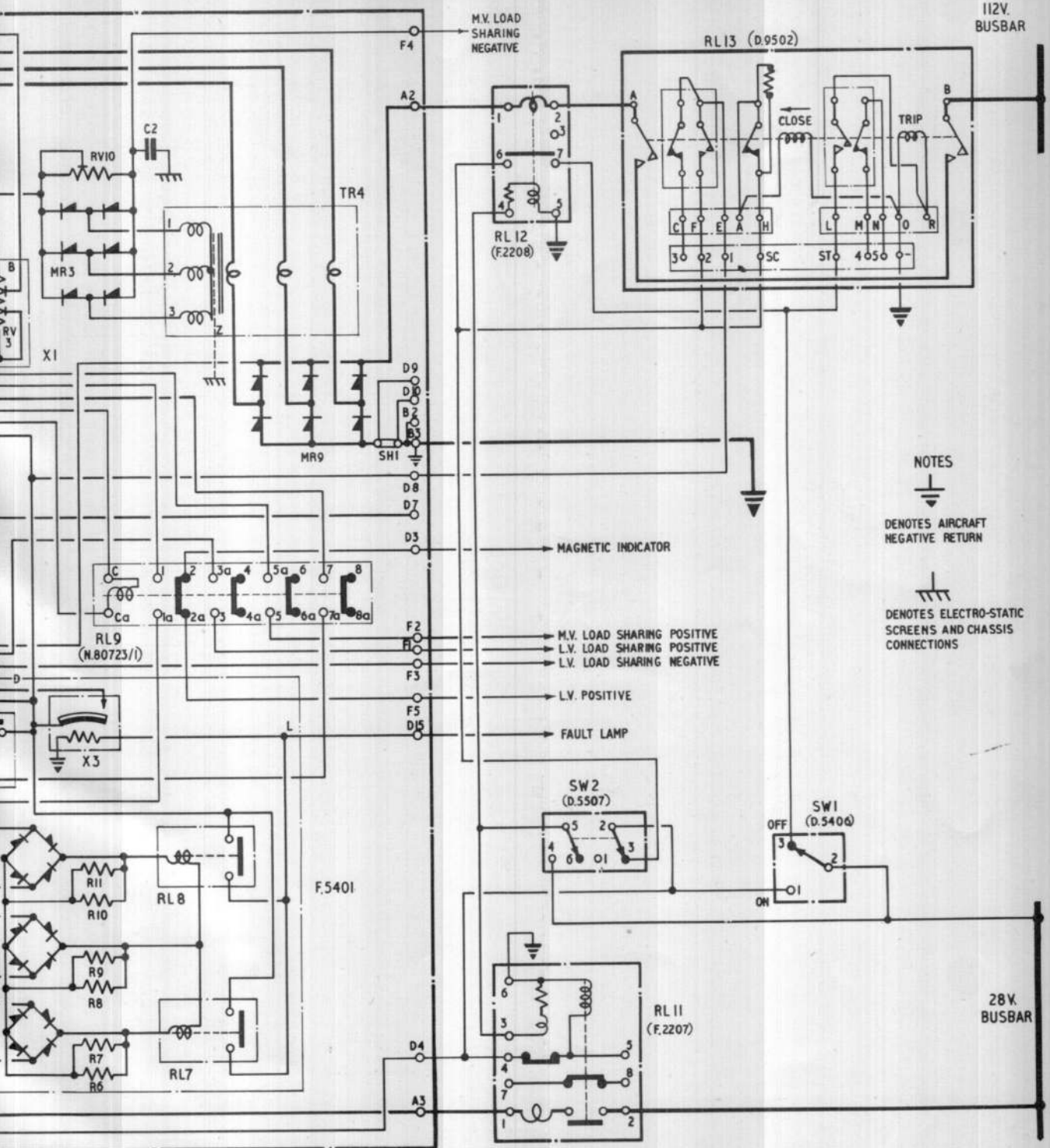


Fig.14  
(A.L.148, Oct.58)

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