Chapter 5

ENGINE SPEED SYNCHRONIZING EQUIPMENT, ROTOL, TYPE SN4/5

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Introduction

1. This equipment eliminates the necessity of constant manual adjustment of engine controls to maintain synchronization.

2. In brief the equipment comprises four similar a.c. generators, Type SNA/4, four similar corrector units, Type SNC/5 and one control panel, Type SNP/3. The generator is described in A.P.4343A, Vol. 1, Sect. 1, Chap. 2, the corrector unit in A.P.4343D, Vol. 1, Sect. 16, Chap. 50, and the control panel in A.P.4343C, Vol. 1, Sect. 10, Chap. 2

DESCRIPTION

3. For the operation of the synchronizing equipment, one engine is selected as a Master to which all other engines (Slave engines,) are synchronized. When the equipment is in operation the Master engine continuously and automatically corrects the r.p.m. of the slave engines, thereby eliminating the necessity of constant manual adjustment of the engine controls to maintain synchronization.

4. One a.c. generator and one corrector unit are fitted to each engine, and the control panel is fitted to the main aircraft control panel.

A.C. generator

5. The generators are three phase delivering current at 29.5 to 34 V.a.c. at a nominal frequency of 100 c/s and at engine speeds of between 6,430 and 7,500 r.p.m. Each generator supplies only the current to operate its paired corrector unit.

Corrector unit

6. The corrector unit applies the correction to the engine speed by supplying extra fuel to its associated engine when an increase in r.p.m. is required. Each unit is incorporated in a by-pass fuel line independent of the main fuel throttle. The slave engine unit, when operated, allows an additional quantity of fuel, over and above that controlled and delivered by the main fuel throttle to be delivered to the engine concerned until its speed coincides with that of the master engine.

Control panel

7. The control panel, fitted in the cockpit, gives ON-OFF control of the synchronizing equipment, it enables either of two specified engines to be selected as the master, and enables all, or only the two outer engines to be synchronized.

PRINCIPLES OF OPERATION

8. The synchronization of the slave engines to the master is achieved by the introduction of an automatically controlled high pressure by-pass fuel supply to the slave engines working independently from, and in addition to the main fuel throttle.

9. The amount of additional fuel allowed to by-pass to the slave engines to bring about synchronization is controlled by the corrector unit fitted in each engine fuel by-pass line.

10. The r.p.m. of the engine selected as a master are uncorrected while the engine is in use as such, the plunger throttle valve of its corrector unit being maintained in the fully closed position. The r.p.m. of the master engine are therefore determined only by its main fuel throttle setting.

11. The equipment has a r.p.m. control range within which it is able to synchronize the engines and maintain them in synchronization. The control range is affected by r.p.m. and other operating conditions and is not constant; in value it is the difference in engine r.p.m. logged between when the plunger throttle valve is fully open and fully closed, i.e. the difference of r.p.m. resulting from the additional fuel supplied to the engine between these two positions under any set condition. With the engines operating at a speed of about 7500 r.p.m. the equipment has a minimum control range of 300 r.p.m.

12. When bringing the synchronizing equipment into operation the speed of any slave engine must be lower than and not differ from that of the master to an amount in excess of the equipment r.p.m. control range. For the equipment to maintain synchronization over a maximum range of engine speed variation the difference between the master and slave engine speed should be approximately half the equipment r.p.m. control range i.e. the plunger throttle valves will be in the mid-travel position when the equipment is brought into operation.

13. As the generators are engine driven, the current generated is proportional to the engine speed, consequently, any differential between master engine speed and a slave engine speed will result in one stator of the particular corrector unit receiving a current of higher frequency than the other stator. This differential causes the corrector unit rotor to rotate in the phase direction of the stator receiving the higher frequency. The movement of the rotor is transmitted to the plunger throttle valve moving it in the required direction, until sufficient extra fuel is by-passed to synchronize the slave engine r.p.m. with that of the master.

14. When the equipment is not in use the corrector unit plunger throttle valves are in the off-position. It will therefore be seen that if the equipment is switched on with the slave engine r.p.m. higher than that of the master, the valves would not open and no correction would take place.

15. To achieve synchronization, all engines should be aligned at a selected r.p.m. setting prior to switching the equipment on. After switching on, the r.p.m. of the master engine should be increased by approximately half the r.p.m. control range. Under these conditions the slave engine plunger throttle valve is in an approximately mid-way position between fully open and fully closed. This is the ideal operating condition, the equipment being capable of maintaining synchronization over a maximum increase or decrease in r.p.m.

16. The same operating condition may be arrived at by setting the speed of the master engine in advance of that of the slave engines by approximately half the equipment r.p.m. control range, before switching on.

Synchronizing equipment OFF

17. With the equipment OFF all plunger throttle valves are in the closed position, consequently no additional fuel is by-passed to any engine. The electrical circuits involved bring about the following conditions:—

Both stators of each corrector unit are fed in a clockwise phase direction by their associated generators i.e. the port outer engine generator feeds the port outer engine corrector unit etc.

18. When the equipment is switched off at the control panel all slave engine corrector

unit rotors rotate in a clockwise direction thus closing the plunger throttle valves.

Note . . .
The plunger throttle valve of the master engine corrector unit or of any engine not being synchronized, will already be in the fully closed position.

Synchronizing equipment ON

19. With the equipment ON the slave engines are synchronized to the r.p.m. of the master engine. The actual engines to be synchronized and the engine to be selected as a master are controlled by the position of the control panel switch. The electrical circuits involved bring about the following conditions:—

(1) Both stators of the master engine corrector unit are fed in a clockwise phase direction by the master engine generator.

(2) The top stator of each slave engine corrector unit is fed in an anti-clockwise phase direction by the master engine generator.

(3) When the outer engines only are being synchronized, both stators of each inner engine corrector unit are fed in a clockwise phase direction. The top stators are fed by the master engine alternator and the bottom stators by the associate engine generators.

Note . . .
The bottom stator of each corrector unit is fed continuously in a clockwise phase direction by its associate engine generator, irrespective of whether its engine is functioning as a master or slave engine and also when the equipment is off. The control panel switch does not affect these electrical circuits.

20. When the equipment is switched ON with the master engine r.p.m. higher than the slave engine r.p.m., the top stator in each slave engine corrector unit receives the higher frequency current in an anti-clockwise phase direction. The corrector unit rotor turns anti-clockwise and commences to open the plunger throttle valves, thereby allowing additional fuel to by-pass to the slave engines. The r.p.m. of the slave engines are therefore increased and approach those of the master engine. At the same time the current frequencies of the bottom stators approach that of the top stators progressively decreasing the revolutions of the corrector unit rotors.

21. Each slave engine corrector unit plunger throttle valve will continue to open independently until it reaches a position within its metering bore where sufficient additional fuel is by-passed to synchronize the slave engine r.p.m. with the master engine r.p.m. At this point the corrector unit rotor will cease to revolve, the frequencies of both stators being equal. Synchronization will have been achieved by an automatically controlled additional fuel supply to the slave engines.

Maintaining synchronization

22. Initial synchronization achieved, the slave engine corrector unit plunger throttle valves are in a position between fully open and fully closed, thus permitting synchronization correction to be made for increases or decreases in r.p.m. of master or slave engines.

23. In the event of a fall in r.p.m. of the master engine, the bottom stators of all slave engine corrector units receive the higher frequency and the plunger throttle valves move towards the fully closed position. The quantity of fuel by-passed is thus reduced and the slave engine r.p.m. decreased until synchronization is again achieved.

24. Should the master engine r.p.m. rise, the top stators of all slave engine corrector units receive the higher frequency and the plunger throttle valves move towards the fully open position. The quantity of fuel by-passed is thus increased until synchronization is again achieved.

25. Should the r.p.m. of a slave engine fall, its corrector unit top stator will be receiving the higher frequency, and the plunger throttle valve moves towards the fully open position until the engine is again synchronized with the master. Conversely, should the r.p.m. of the slave engines rise, its corrector unit bottom stator will receive the higher frequency and the plunger throttle valve will move towards the fully closed position until the engine is again synchronized with the master.

26. Synchronization will not be maintained should the r.p.m. of any engine, master or slave, rise or fall excessively. The limit of r.p.m. change is determined by the relationship of each slave engine unit plunger throttle valve to its fully open and fully closed positions.

27. Should a slave engine r.p.m. rise excessively, its plunger throttle valve will move towards the fully closed position to maintain synchronization. When the valve reaches the fully closed position no more correction to the slave engine r.p.m. can be applied. Conversely an excessive fall in a slave engine r.p.m. moves its plunger throttle valve to the fully open position, when no further correction to the r.p.m. can be applied.

28. Should the master engine r.p.m. rise excessively, all slave engine plunger throttle valves move towards the fully open position to maintain synchronization. When the valves reach the fully open position, no further increase in slave engine r.p.m. can be applied. Conversely an excessive fall in master engine r.p.m. results in all slave engine plunger throttle valves moving to the fully closed positions where no further decrease in slave engine r.p.m. can be applied.

INSTALLATION

29. The full circuit diagram of the complete system is shown in fig. 1. Installation details of the individual items can be obtained from the chapters mentioned in para. 1.

SERVICING

30. Periodic checks should be made to see that all wiring, between units is in good condition, and that all electrical connections are tight and free from corrosion.

31. Many of the possible causes of trouble on this system are, of course, purely to do with the engines and are therefore beyond the scope of this chapter. However, Table I gives a guide to some possible defects.

TABLE I

POSSIBLE DEFECTS

Defect	Probable cause	Remedy
One slave engine r.p.m. unstable.	Slave engine generator output voltage low.	Check generator output voltage. Renew generator if defective.
One slave engine fails to synchronize.	Mal functioning of corrector unit.	Renew corrector unit.
One slave engine fails to return to pre-selection r.p.m. on switching OFF.	Associate wiring circuit defective.	Electrical checks of associated wiring circuit and rectification of fault.
One slave engine does not synchronize over full control range All slave engines unstable. Failure of all slave engines to synchronize.	Master engine generator output voltage low	Check generator output voltage. Renew generator if defective

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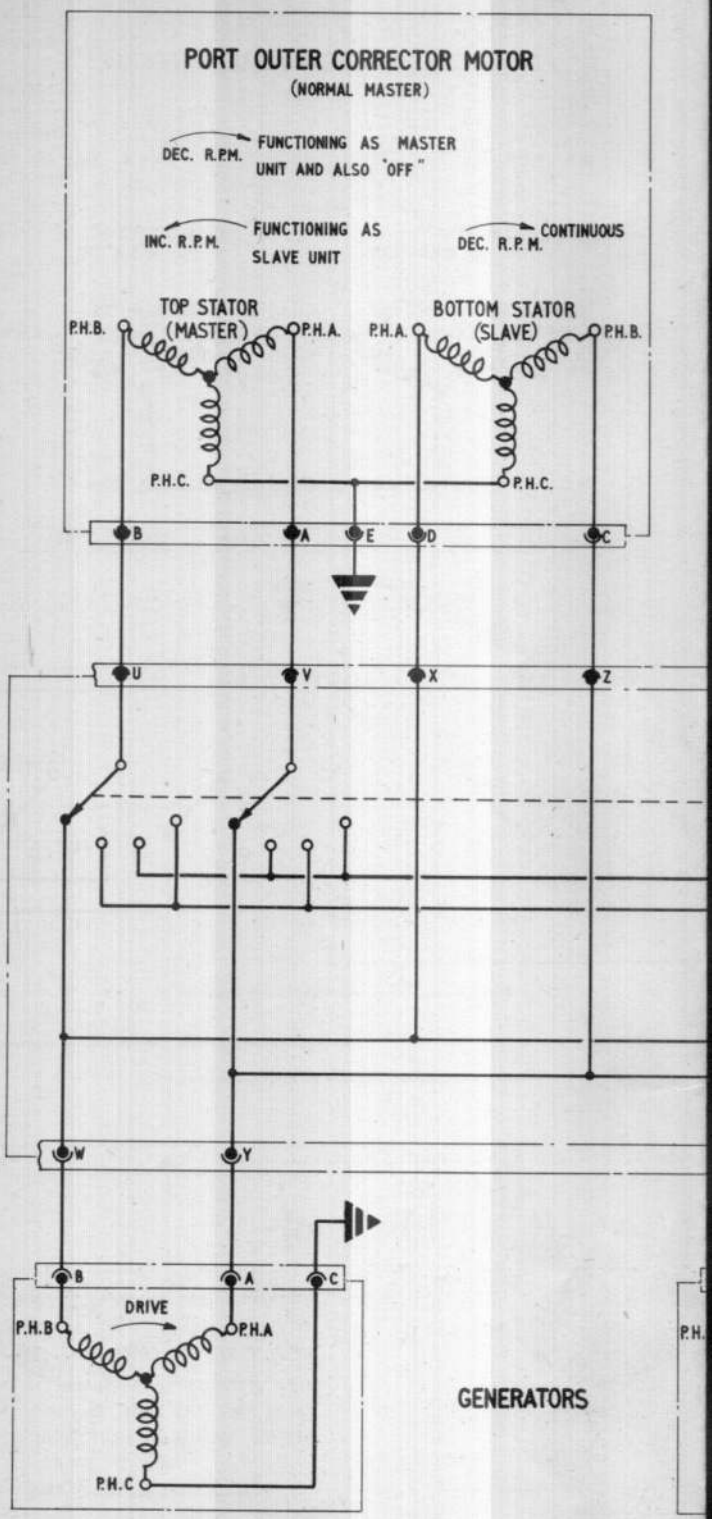

Fig.1

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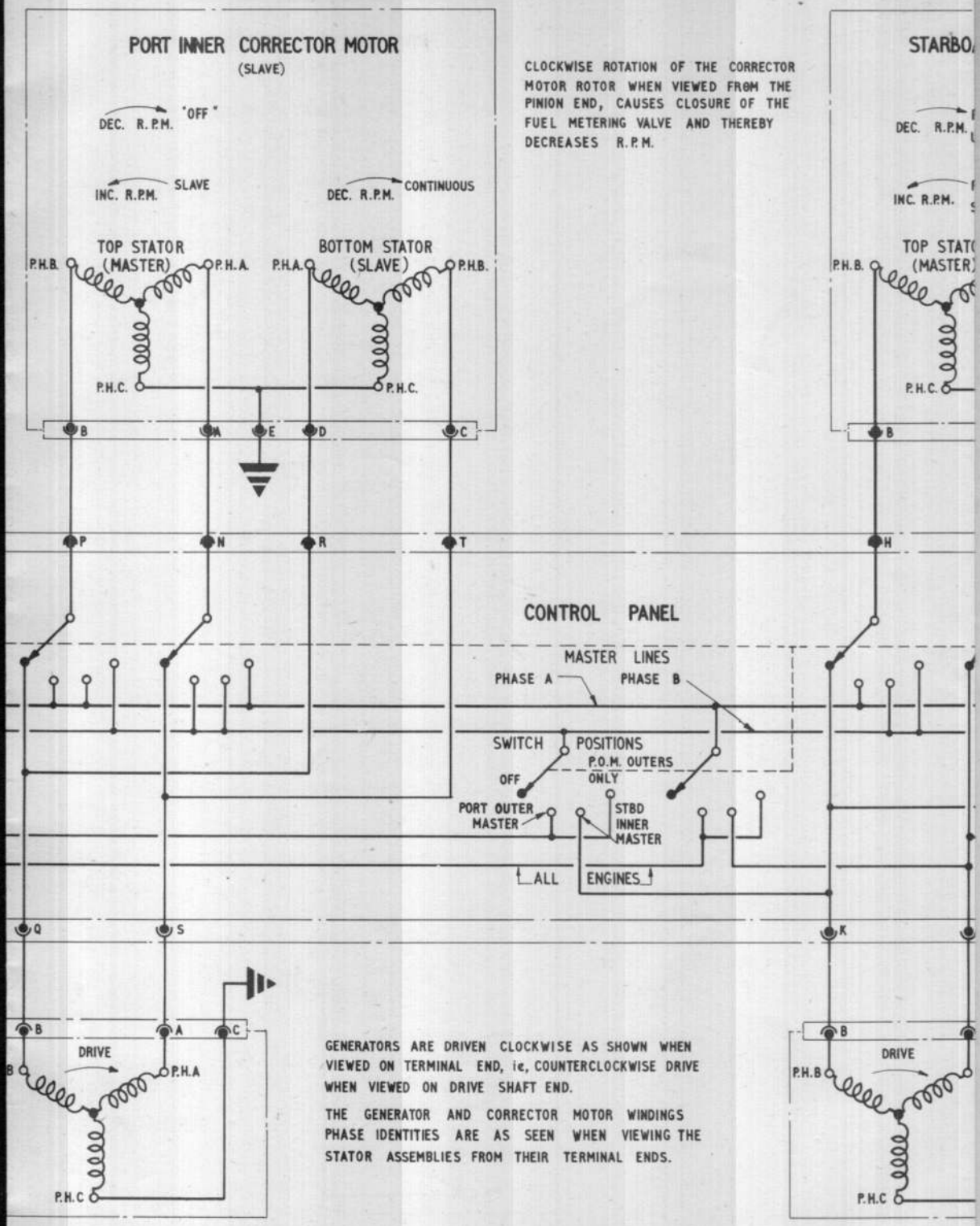

Circuit diagram of complete system

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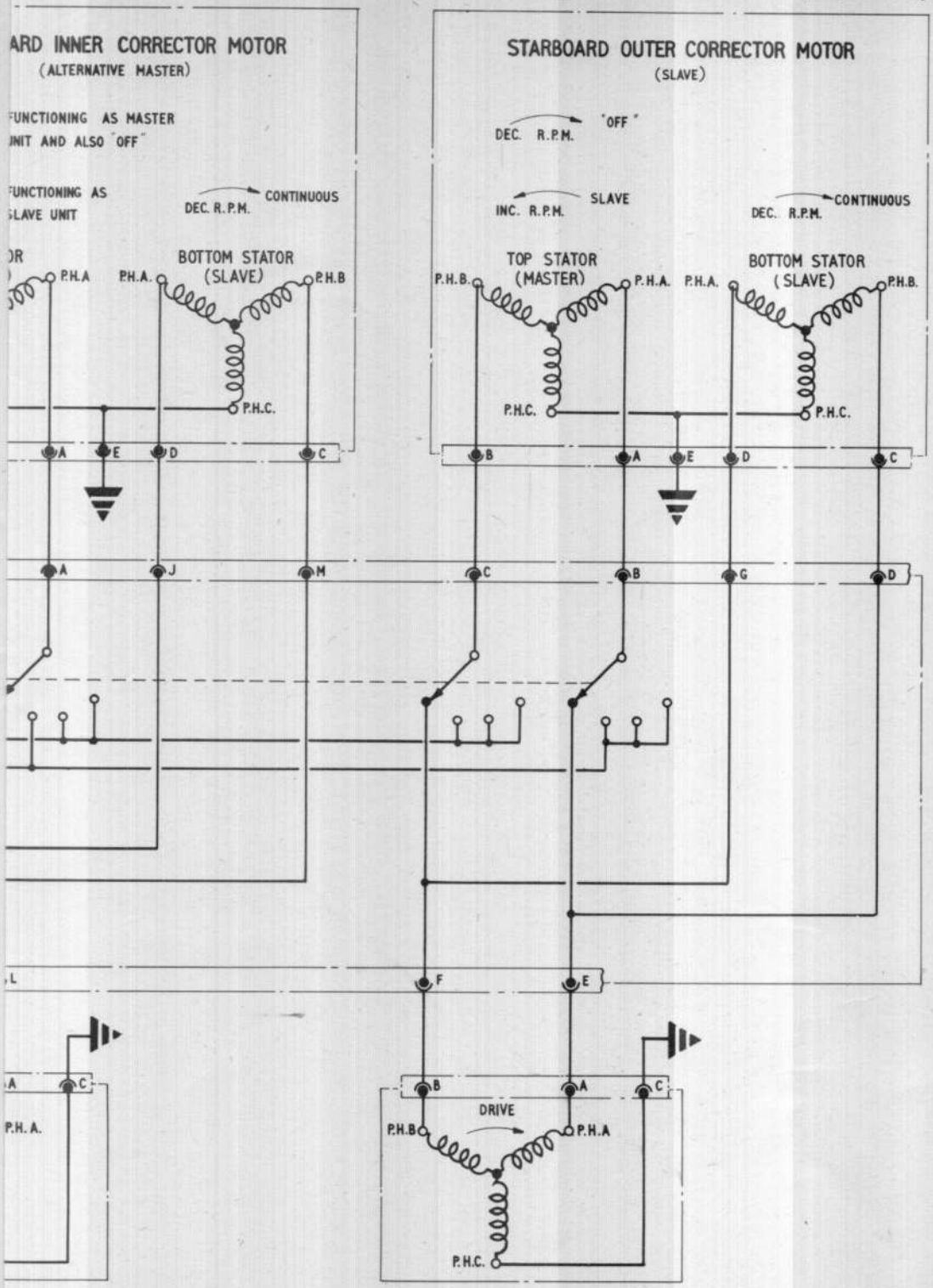

Fig. 1

(A.L.114, June 57)