Chapter 2

ENGINE SYNCHRONIZING EQUIPMENT, ROTOL, TYPE (c)SN4/10

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Introduction

1. This chapter contains a description, and outlines the operating principles of the engine speed synchronizing equipment, Type (c) SN4/10. Component descriptions together with Leading Particulars are given in the Appendices to this chapter.

2. The system comprises four similar a.c. generators, Type (c) SNA/18, four similar corrector units, Type (c) SNC/13, and one control panel, Type (c) SNP/8.

DESCRIPTION

A.c. generators

3. The generators (*fig.* 1), are engine mounted, and driven, and each generates a nominal 22V a.c. 3-phase supply (at 4500 generator rev/min) to operate the corrector unit.

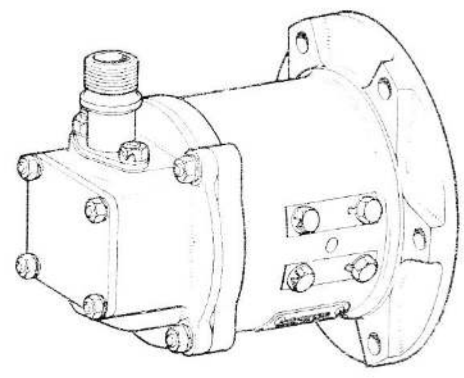

Fig. 1. External view of a.c. generator

Corrector motor

4. Each corrector unit (*fig.* 2) is capable of correcting the speed of the engine it is mounted on by means of an output rack shaft which is connected to a differential linkage, interposed in the controls between the pilot's throttle and the engine throttle control. Movement of the corrector unit output shaft, results in a change in engine speed, independent of the pilot's throttle setting to achieve synchronization.

Control panel

5. The control panel (*fig.* 3), provides ON-OFF control of the synchronizing equipment and enables either of two specified engines to be selected to serve as the master, and enables all or only the two outer engines to be synchronized.

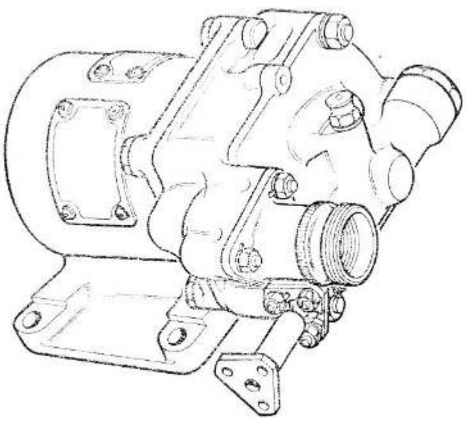

Fig. 2. External view of corrector motor

PRINCIPLES OF OPERATION

6. The function of the equipment is to bring the engine speeds into synchronization and maintain them in that condition. When the equipment is operating, one of the engines (dependent on the control panel switch position selected) acts as a master to the speed of which the other slave engines are synchronized.

7. The equipment only exercises synchronizing control over the speed of the slave engines, the master engine remaining at the speed determined by its throttle setting. The equipment corrects relatively small speed discrepancies between the master and slave engines due to the throttle setting up errors.

8. Synchronization is achieved by automatic movement of each slave engine throttle control, until its speed equals that of the master engine. Each slave engine corrector unit output rack shaft, is connected through a differential linkage, into the throttle control linkage between the pilot's control and the engine control.

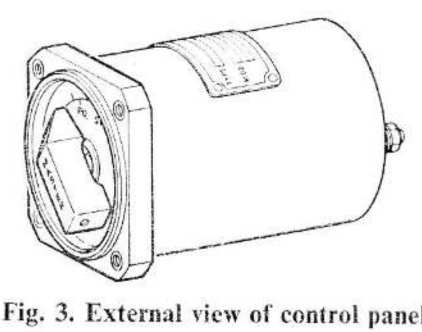

Fig. 3. External view of control panel

9. The differential linkage is so arranged that at the various engines speed, throttle settings, the maximum amount of correction which can be applied by the corrector unit will always produce a constant maximum change of engine speed.

10. The engine cruising speed is approximately 7300 rev/min and the total change which the corrector unit can apply is limited to approximately 500 rev/min. This represents the maximum control fange of the corrector unit and represents the full travel of the output rack shaft, from its mininum to maximum travel position.

11. In the event of the master engine failing with the equipment in operation, each slave engine cannot therefore follow the master beyond the rev/min control range limit.

12. When the equipment is not in operation, the output rack shafts of all corrector units are held at the minimum (or decrease) speed end of their travel. Therefore, when bringing the equipment into operation, a slave engine must not be operating at a speed higher than that of the master engine for synchronization to take place.

13. For the equipment to maintain synchronization over a maximum differential range of engine speed variations, the difference between master and slave engine speed should be approximately half the control range, i.e. (the output rack shafts are moved to an approximate mid-travel position).

14. This is the ideal operating condition and can be achieved either by aligning the engines at a selected rev/min, switching on and then advancing the master engine rev/min approximately half the control range, or by setting the master engine in advance of the slave engines by approximately half the control range before switching on.

Synchronizing equipment ON

15. When the equipment is switched on the engines to be synchronized (slave) and the engine to be selected as master are controlled by the position of the control panel switch. A circuit diagram of the complete system is shown in fig. 4.

16. The bottom stator windings of the corrector motors are fed continuously from their respective engine generators, irrespective of the control panel switching.

17. The circuits which are in operation during synchronization are as follows:

(1) Both stators of the corrector unit on the engine acting as the master (i.e. the P.O. or S.I. dependent on the switch position,) are fed with an anti-clockwise phase direction by the generator on the acting master engine.

(2) The top stators only of the corrector units on the engines serving as slaves (i.e. dependent on the switch position) are fed with a clockwise phase direction by the generator on the acting master engine.

(3) The bottom stators only of the corrector units on the engine serving as slaves are fed with an anti-clockwise phase direction by their associate slave engine generators.

(4) When the outer engines only are being synchronized, both stators of each inner engine corrector unit (i.e. the engine not being synchronized) are fed with an anti-clock-wise phase direction; the top stator by the master engine generator and each bottom stator by their associate engine generator.

Note . . .
The inner engine corrector unit output rack shafts are thus held at the minimum (or decrease) speed end of their travel and engine speeds are dependent on their respective throttle settings, i.e. that is as in the off condition.

18. The two stators of the master engine corrector unit are now fed continuously in an anti-clockwise phase direction, and this results in its output rack shaft being held in the minimum speed position at all times. This leaves the master engine operating at the speed determined by its throttle setting.

19. The control of the engine speed by the corrector units at this stage is basically similar to the synchronizing system, Rotor, Type SN4/5 described in A.P.4343, Vol. 1, Sect. 13. Briefly the rotor of the corrector unit is rotated by the stator receiving the greater input frequency and drives the output rack shaft in the appropriate direction to correct the sleve engine speed.

20. After initial synchronization the output rack shaft of each slave engine corrector unit will be in a position between the mininum and maximum travel limits (the ideal position being at mid travel) this will permit further correction to be made for any subsequent wandering of master and/or slave engine rev/min.

21. Synchronization will not be maintained where the rev/min of any engine (master or slave) increases or decreases in excess of the corrector unit control range, or half the control range from the output rack shaft mid-travel position.

22. If the master engine rev/min increases excessively, each slave engine corrector unit output rack shaft will move to the maximum increase speed position in an attempt to maintain synchronization, and to the minimum decrease speed position if the master engine rev/min decreases excessively.

23. If a slave engine rev/min increases excessively, its corrector unit output rack shaft will move to the minimum decrease speed position in an attempt to maintain synchronization, and to the maximum increase speed position if the slave engine rev/min decreases excessively.

Synchronizing equipment OFF

24. When the equipment is switched OFF, the output rack shaft of each slave engine corrector unit is initially returned to, and then maintained at the minimum speed position. The master engine corrector unit output shaft (and when applicable, the inner engine corrector unit output shaft) is in this position at all times.

25. The circuits which are operative with the switch in the OFF position are as follows:

(1) Both stators in the master engine corrector unit continue to be fed with an anti-clockwise phase direction by the master engine generator.

(2) Both stators in each slave engine corrector unit are fed with an anti-clockwise phase direction by their associate engine generator.

(3) When only the outer engines are being synchronized, both stators of each inner engine corrector units are fed with an anti-clockwise phase direction by their associated engine generators.

26. As both stators of all corrector units now have an unopposed anti-clockwise phase direction, the output rack shaft of each corrector unit will be driven to its minimum speed position. The rev/min of each engine will now be determined by their respective throttle settings. The output rack shafts of all engine corrector units are thus maintained at the minimum position while the equipment is not in use.

INSTALLATION

27. For installation details of individual items in this system reference should be made to the appropriate appendix to this chapter.

SERVICING

28. In accordance with the relevant aircraft Servicing Schedule the condition of all leads between units should be checked, and all electrical connections examined to ensure that they are free from corrosion. After examination the connections should be securely tightened and wire locked.

29. Possible defects and their causes are given in Table 1. Other defects attributed to engine faults are beyond the scope of this chapter.

30. Details of Servicing to individual items in this system are given in the appropriate appendix to this chapter.

Table 1

Possible defects

Defects	Probable cause	Remedy
1. A slave engine is unstable when ON	(a) Slave generator output voltage is low.	(a) Check the appropriate generator and renew if defective.
	(b) Mal-functioning slave corrector unit.	(b) Renew the unit.
	(c) Defect in associated wiring circuit.	(c) Check the associate circuit and rectify as necessary.
2. All slave engines are unstable when ON.	(a) Master generator output voltage low.	(a) Check the master generator output voltage and renew if defective.
	(b) As for 1c.	(b) As for 1c.
3. A slave engine stabilizes but fails to synchronize, or fails to de-synchronize.	(a) Incorrect adjustment of throttle differential linkage.	(a) Check the control settings and rectify as necessary.
	(b) As for 1b.	(b) As for 1b.
	(c) As for 1c.	(c) As for 1c.
4. An engine fails to maintain selected rev/min when OFF.	(a) Associate generator output voltage low.	(a) As for 1a.
	(b) Mal-functioning corrector unit.	(b) As for 1b.

Appendix 1

A.C. GENERATOR, ROTOL, TYPE (c) SNA18

LEADING PARTICULARS

Line voltage at 4500 rev./min	*22V a.c. ± 1V*
Frequency at 4500 rev./min	*75 c/s*
Line to line resistance	*1·71-1·99 ohms at 15 deg. C*
Stator windings	*3-phase, star connected*
Electrical connection	*4-pole, R.R. feed plug*
Phase rotation	*A-B-C when generator is run counter-clockwise looking from terminal end*
Connections	*Pin A phase A*
	Pin B phase B
	Pin C phase C
	Pin D not connected

LIST OF ILLUSTRATIONS

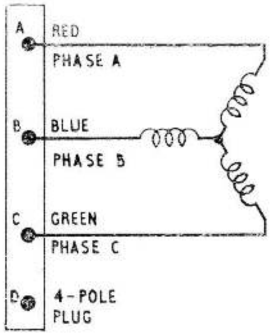

Fig. 1. Circuit diagram

1. The generator, Rotol, Type (c) SNA/18 is basically similar to the Rotol, Type SNA/23 which is described and illustrated in Chapter 1 of this section.

2. Differences are in the type of electrical plug fitted, and the line output voltage, details of which are given in the Leading Particulars.

Test

3. Run the generator at 4500 rev/min in

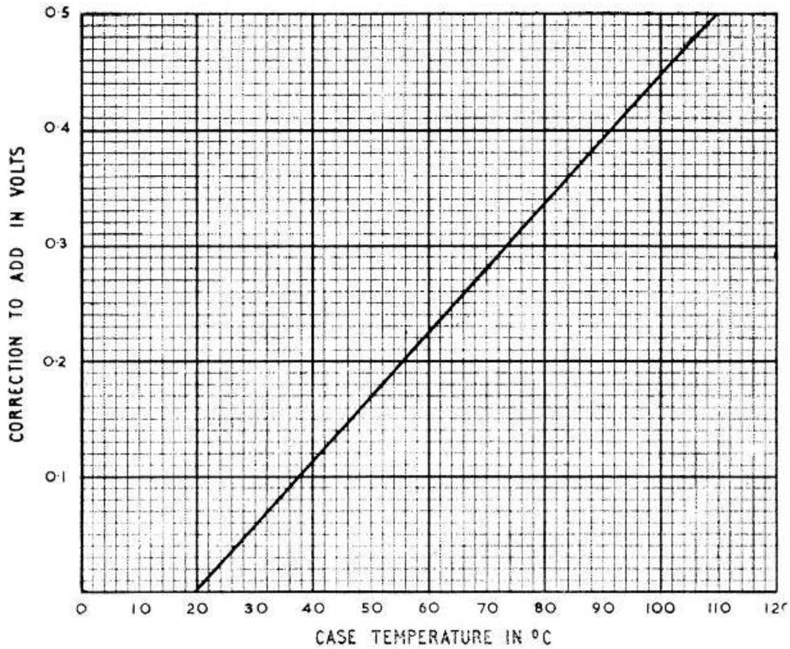

Fig. 2. Voltage correction graph

the off-load condition. With the generator case temperature not exceeding 40°C check that the open circuit line voltage is within the limits of 22V ± 1V. Fig. 2 gives a voltage correction graph for varying case temperatures.

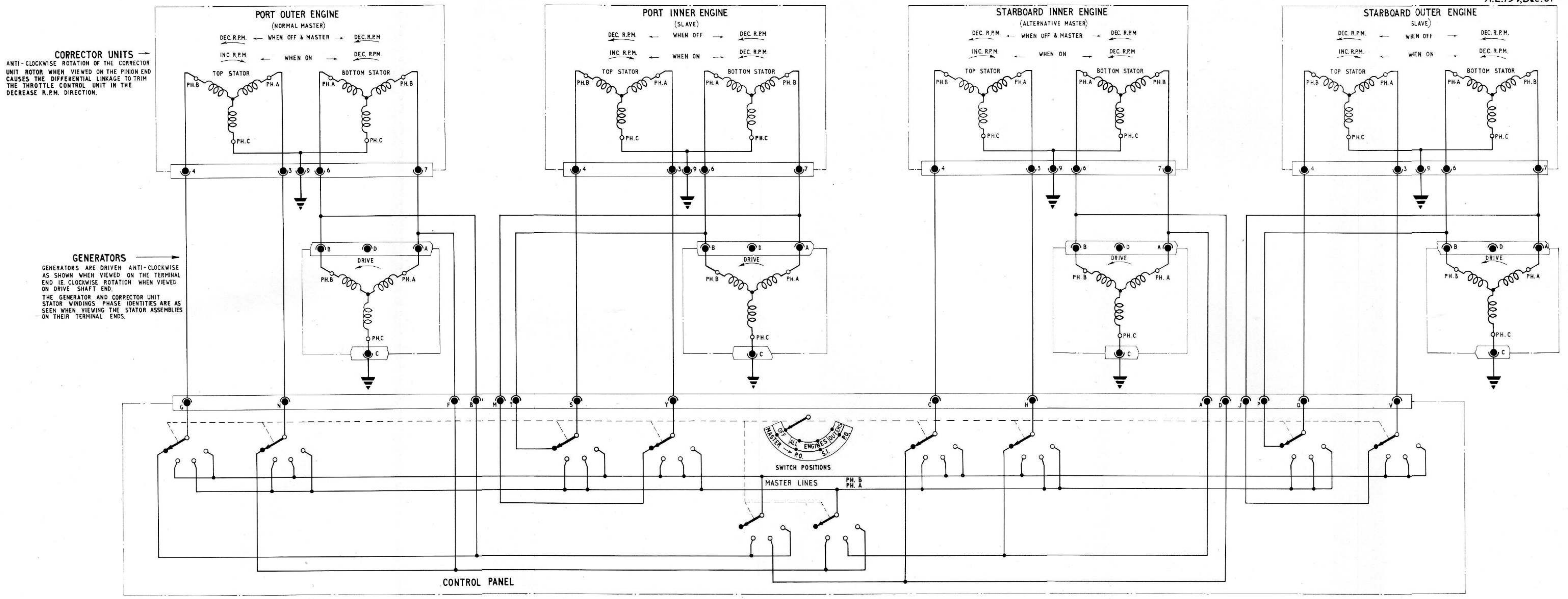

Fig. 4 Circuit diagram of complete system

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Appendix 2

CORRECTOR UNIT, ROTOL, TYPE (c) SNC/13

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LEADING PARTICULARS

Corrector unit, Rotol, Type (c) SNC/13	*Ref. No.*
Voltage	*22V a.c. nominal*
Stator winding	*3-phase star connected*
Rotor	*Squirrel cage type*
Electrical connections	*9-pole R.R. keyed plug*

Introduction

1. The corrector unit, rotor, Type, (c) SNC/13 provides a means of correcting the speed of the engine it is mounted on, by means of the output rack shaft which is connected to a differential linkage interposed in the controls between the pilot's throttle and the engine throttle control.

DESCRIPTION

General

2. The rotor corrector unit, a sectional view of which is shown in fig. 1, consists basically of a squirrel cage type rotor rotating within two, 3-phase, coil-wound stators positioned one above the other, two gears, an output rack shaft and a 9-pole plug to which the stator leads are connected.

3. The rotor, which runs in two bearings, and the stators, are housed within a cylindrical casing having one end open and incorporating an integral mounting base. The gears and output rack shaft are housed in a gear box on which the plug is mounted. The gear box is secured to the open end of the casing.

Main frame

4. The mounting base for the corrector unit is formed integral with the casing and four attachments holes are provided in the mounting flange. The flanged head of the casing, to which the gear box is secured, is also provided with four attachment holes.

5. Fitted in the centre board end of the casing is a bearing liner which is pressed into position and locked by peening. The rotor shaft lower bearing locates in this liner. A small, triangular, access panel which is secured with spring washers and lock nuts to studs in the bottom of the casing, provides access to the lower end of the rotor shaft.

6. The upper bore of the casing is threaded

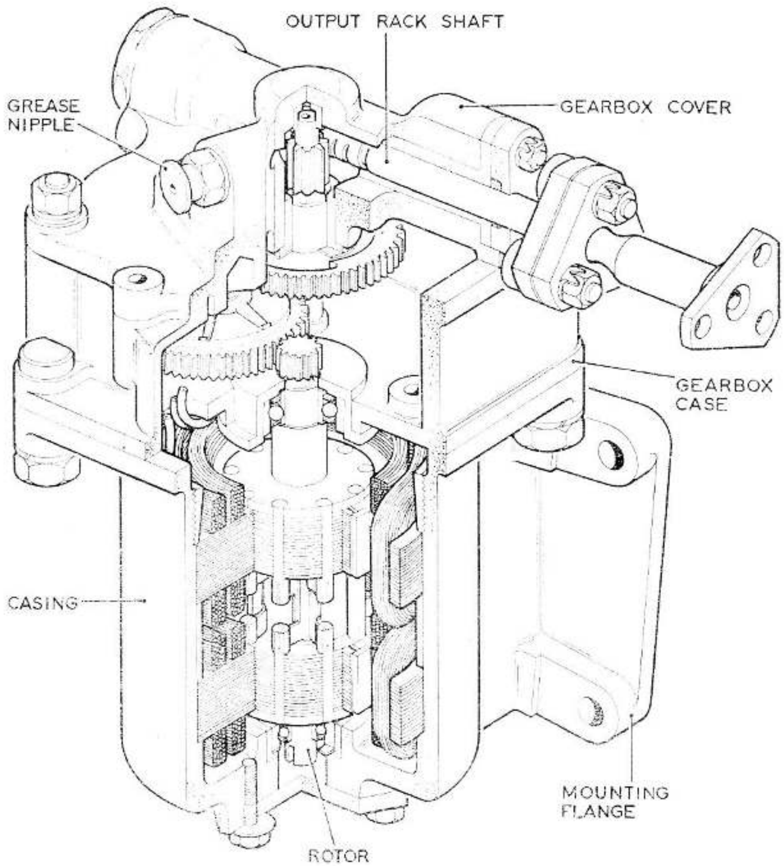

Fig. 1. Sectional view of corrector unit

to receive a retaining ring which secures the stators in the casing. Locking of the retaining ring is effected by a set-screw, the head of which locates in one of four equally spaced slots in the end of the ring. This set screw is fitted in the base of the gear box.

7. Fitted in the wall of the casing, one above the other on the same axial centre line, are two rivets the heads of which serve to locate the stators in the casing.

Stators

8. The top and bottom stators are of similar construction, each consisting of coils wound around a slotted stack made up of magnetic steel stampings. The coil windings pass through six equally spaced, insulated lined slots in the stack, where they are retained by slot wedges. The three ends of each coil winding terminate in connector tags, to which the leads from the plug pins are soldered.

9. Machined in the periphery of each stator stack is a slot which enables the stators to be correctly located on the rivet heads in the bore of the casing on assembly. To ensure correct spacing of the stators in the casing, a split separator ring is interposed between the components.

Rotor

10. The squirrel cage type rotor consists of two magnetic steel stacks mounted on a shaft and separated by a tube, with shorting rings on the outer ends of the stack, inter-connected by conductor rods and connector strips.

11. The rotor shaft runs in two, single row, caged ball type bearings. The upper bearing locates against a shoulder formed by a reduction in the shaft diameter and the lower bearing locates against a distance piece fitted on the shaft in abutment with the bottom of the rotor. The upper end of the

rotor shaft is machined to form a pinion which meshes with the clutch gear wheel in the gear box.

Gear box

12. The gear box, comprising a case and a cover, is secured to the corrector unit casing by spring washer and lock nuts fitting on studs and special headed bolts. The cover itself is secured to studs in the case of the gear box by spring washer and lock nuts. Two dowels in the gear box case ensure correct location of the cover, on which the 9-pole plug assembly is mounted.

13. The rotor shaft pinion meshes with and drives the clutch gear wheel, on the shaft of which is a pinion meshing with the integral intermediate gear wheel. A pinion on the shaft of this intermediate wheel meshes with teeth machined on the output rack shaft. Revolutions of the rotor are hus converted into linear movement of the rack shaft.

14. The three plate clutch fits in the recessed face of the clutch gear wheel. The bores of the two outer clutch plates and the periphery of the centre plate are serrated to engage the serrated gear wheel and shaft respectively. The clutch is set to slip at a specific torque by means of a pronged, disc spring and an adjusting washer.

15. The gear wheel and clutch assembly are secured on the shaft by a retaining clip fitted in a groove in the shaft. The clutch shaft runs in two bushes, one in the gear box base and the other in the gear box cover; both bushes are locked in position by pegs.

16. The end of the integral intermediate gear wheel shaft is machined to form the pinion which meshes with the output rack shaft teeth. To limit the travel of the rack shaft, the inner rim of the gear wheel is cut away over an arc of approximately 213 degrees to form two shoulders, which in turn abut a stop pin secured in the gear box by a taper pin.

17. The intermediate gear shaft runs in two bushes fitted in the gear box cover, and bottoms on a locating pad in the gear box base. Each bush is locked in position by a peg.

18. The throttle control output rack shaft is fitted in a rack sleeve housed in a transverse bore of the gear box cover. Felt washers, one at each end of the rack sleeve, are secured in position by a seal retaining plug screw at one end and a seal retaining plate at the other. These washers retain the grease with which the rack sleeve is packed. A grease nipple is provided in the cover for greasing purposes.

19. The output rack shaft terminates in a universal ball end link which is interconnected into the throttle control linkage. The ball end link is attached to the flanged ball joint end of the rack shaft by a retaining plate secured by special headed bolts and tab washer locked nuts. Shims are employed in the joint to maintain a minimum of end float.

INSTALLATION AND REMOVAL

20. For details of removal and installation reference should be made to the appropriate Aircraft Handbook.

SERVICING

21. In accordance with the appropriate aircraft Servicing Schedule, examine the unit for security of mounting, and ensure that the throttle linkage system is secure.

22. Check the condition of the cables and examine the plug and socket for signs of corrosion. Ensure the connection is tight and wire locked after inspection.

23. Some of the defects attributable to the corrector unit are given in Table 1 of the main chapter. A suspect unit should be removed from the aircraft and a new one fitted. The unit removed from the aircraft should be returned to store and dealt with in accordance with current authorised procedure.

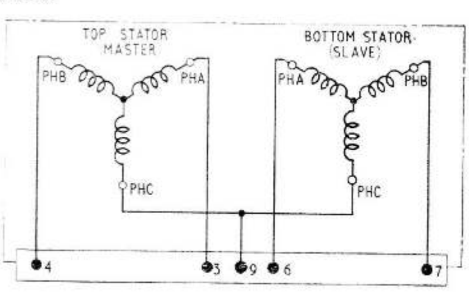

Fig. 2. Circuit diagram