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# Chapter 6

◀*Revised up to modification RB/23*▶

# OPERATION AND PRESENTATION OF BANK AND ELEVATION ATTITUDES AND OF FLIGHT DIRECTOR DISPLAY

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## LIST OF ILLUSTRATIONS



### Introduction

**1.** The attitude of the aircraft in terms of bank and elevation is derived from the master reference gyro and is presented on the attitude indicator, Type F4C (Ref. No. 6A/7287). This indicator (*fig.* 1) is a roller blind servo-operated instrument which displays bank and elevation angles on a linear scale. The positions of the servo-mechanisms are controlled by stator voltages representing bank and elevation angles from a.c. synchro-transmitters in the M.R.G. Bank and elevation angles are indicated throughout 360 degrees of roll and pitch to an accuracy of ±1 degree. The rate of response is better than 360 deg/sec in bank and 180 deg/sec in elevation. False verticals due to 'g' effects are overcome by a combination of erection cut and a pitch-bank system in the M.R.G. Thus the pilot is given an instantaneous display of aircraft attitude relative to the horizon.

**2.** The attitude indicator in this aircraft also includes a flight director presentation the function of which is to display information which assists the pilot to maintain a pre-determined flight plan. The attitude and flight director presentations are completely independent of each other except for the zero datum which is common to both displays. A ball-in-tube slip indicator is mounted on the face of the instrument.◀A reference mark at the top centre of the dial provides an illuminated datum for the slip indicator.

**Note . . .**

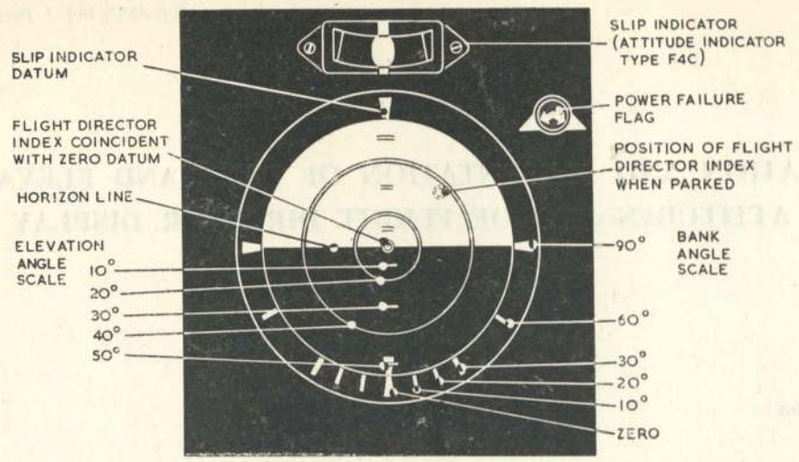
*Prior to the inclusion of modification RB/23, an illuminated datum mark for the slip indicator is not included.*▶

## BANK AND ELEVATION

### Description

**3.** The attitude presentation consists of a roller blind similar in operation and mounting to that of the navigation display (*fig.* 4, *Chap.* 1 of this section). The bezel glass is marked with a central circular index and two concentric circles. Each circle has double black lines filled white to contrast with either blind section. The inner circle indicates 20 degrees of elevation and the outer circle 40 degrees of elevation; 10, 30 and 50 degrees of elevation are indicated by arcs appropriately spaced (*fig.* 3).

◀**Fig. 1. Attitude indicator, Type F4C**▶




**◀Fig. 2. Attitude presentation—straight and level flight indicated▶**

**4.** The roller blind is divided into two sections, one pale grey and the other black, representing the sky and earth respectively. The blind is driven up or down, relative to the instrument bezel glass, with changes in aircraft elevation. The roller blind carriage is driven to maintain a bank pointer vertical, movement of the case thus representing bank angle. Straight and level flight is indicated when the division between the two blind sections lies coincident with the central zero datum on the bezel glass (*fig.* 3) which represents the nose of the aircraft and when simultaneously, the bank pointer is coincident with the zero bank reference at the bottom of the dial. 10, 20, 30, 60 and 90 degrees of bank are indicated in both senses.

**5.** Reference signals from the stators of the bank and elevation synchros in the M.R.G. are fed directly to the corresponding synchros in the attitude indicator. The S2 lines of the synchrostators are internally connected in the M.R.G. For illustrations of typical attitude displays, reference should be made to fig. 3 and 4.

**Elevation**

**6.** The elevation signals from the synchro in the M.R.G. are passed, via slip rings, to the stator of the elevation control transformer in the attitude indicator (*fig.* 5). When misalignment occurs, an error signal is developed across the rotor winding and after phase advance and amplification is fed, via sliprings, to the elevation motor. This motor which is mechanically coupled to the roller blind mechanism and to the rotor of the elevation control transformer, drives the system to a null on the elevation control transformer.

**Loop manoeuvre**

**7.** Consider the loop manoeuvre which is illustrated in fig. 3. In position 1 the nose of the aircraft, as represented by the central circular index, is coincident with the horizon line. In position 2, the aircraft has climbed through 45 degrees and the horizontal has moved down 45 degrees as indicated by the bezel glass elevation angle markings. In this position it will be observed that the centre of a black four-pointed star also indicates 45 degrees as read from the upper scale divisions. Positive angles greater than 50 degrees are read by means of this, the zenith star, which moves progressively towards the central zero datum. When coincident with the outer circle the angle of elevation of the aircraft is 50 degrees and when coincident with the inner circle, the angle of elevation is 70 degrees.

**8.** In position 3, the aircraft reaches the extreme attitude of vertical climb and the maximum elevation angle of 90 degrees is achieved. In this position, the zenith star is coincident with the central datum. The long tail of this star normally points in the direction in which the horizon lies but the horizon has no single direction from the vertical climb position. As the aircraft begins inverted flight (i.e. 180 degrees of bank), the bank presentation is changed. This occurs 2 degrees after passing through the zenith (vertical) when the bank output signals from the M.R.G. are reversed and the roller blind carriage is motored to indicate 180 degrees of bank. Simultaneously the rotational sense of the elevation output signals from the M.R.G. is reversed so that continuation of the loop drives the blind in the opposite direction, that is, back towards zero indication; this obviates the need for two horizon lines on the roller blind.

**9.** In position 4, the aircraft has moved through a further 45 degrees of the loop. This can be deduced from the dial by observing either that the zenith star has moved through 45 degrees or that the horizon line is now 45 degrees from the central datum.

**10.** In position 5, the aircraft has reached the inverted flight attitude. In position 6 it has moved through a further 45 degrees with a corresponding relative angular movement of the horizon line with respect to the bezel glass.

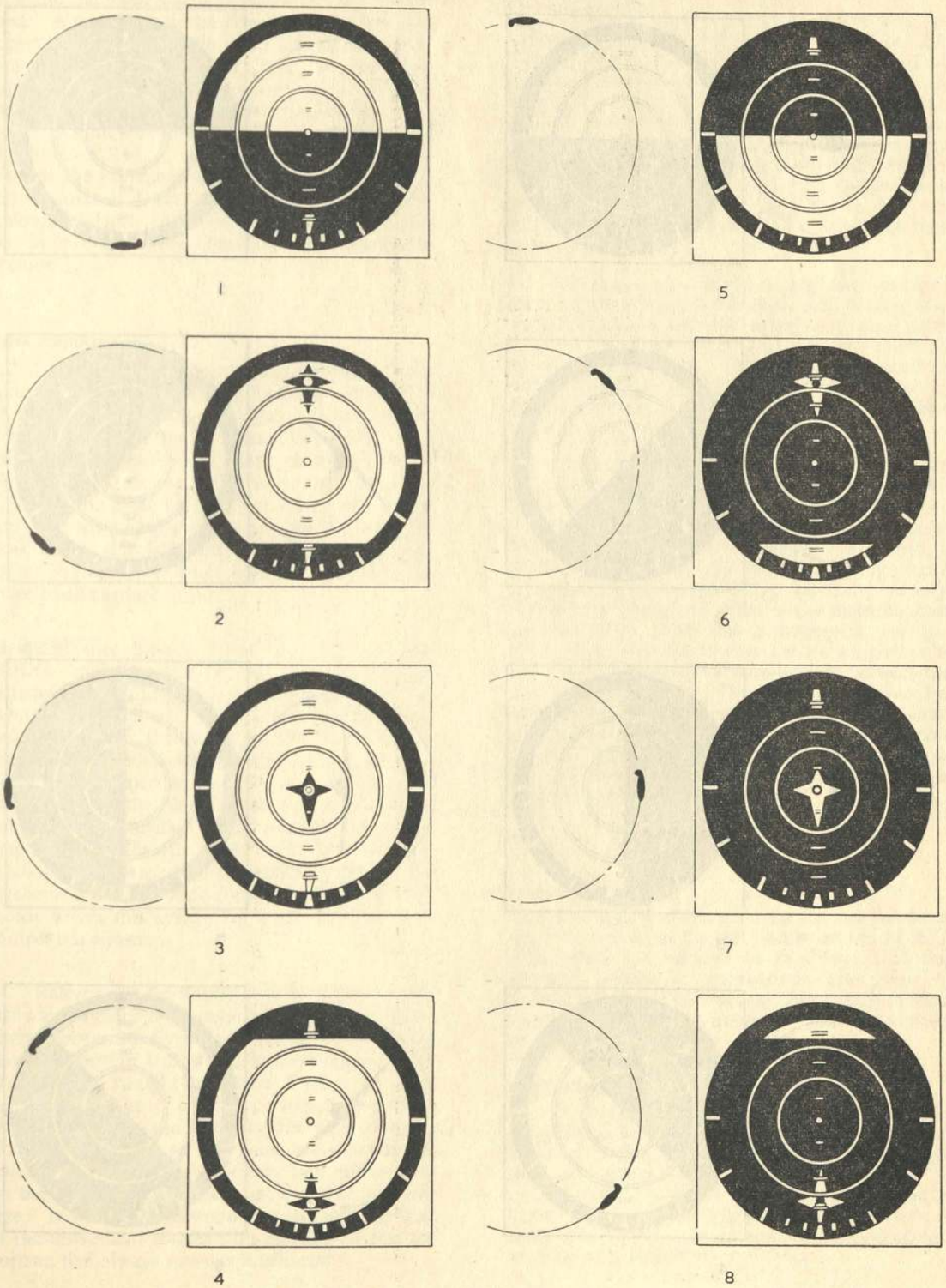



**Fig. 3. Presentation during a loop**

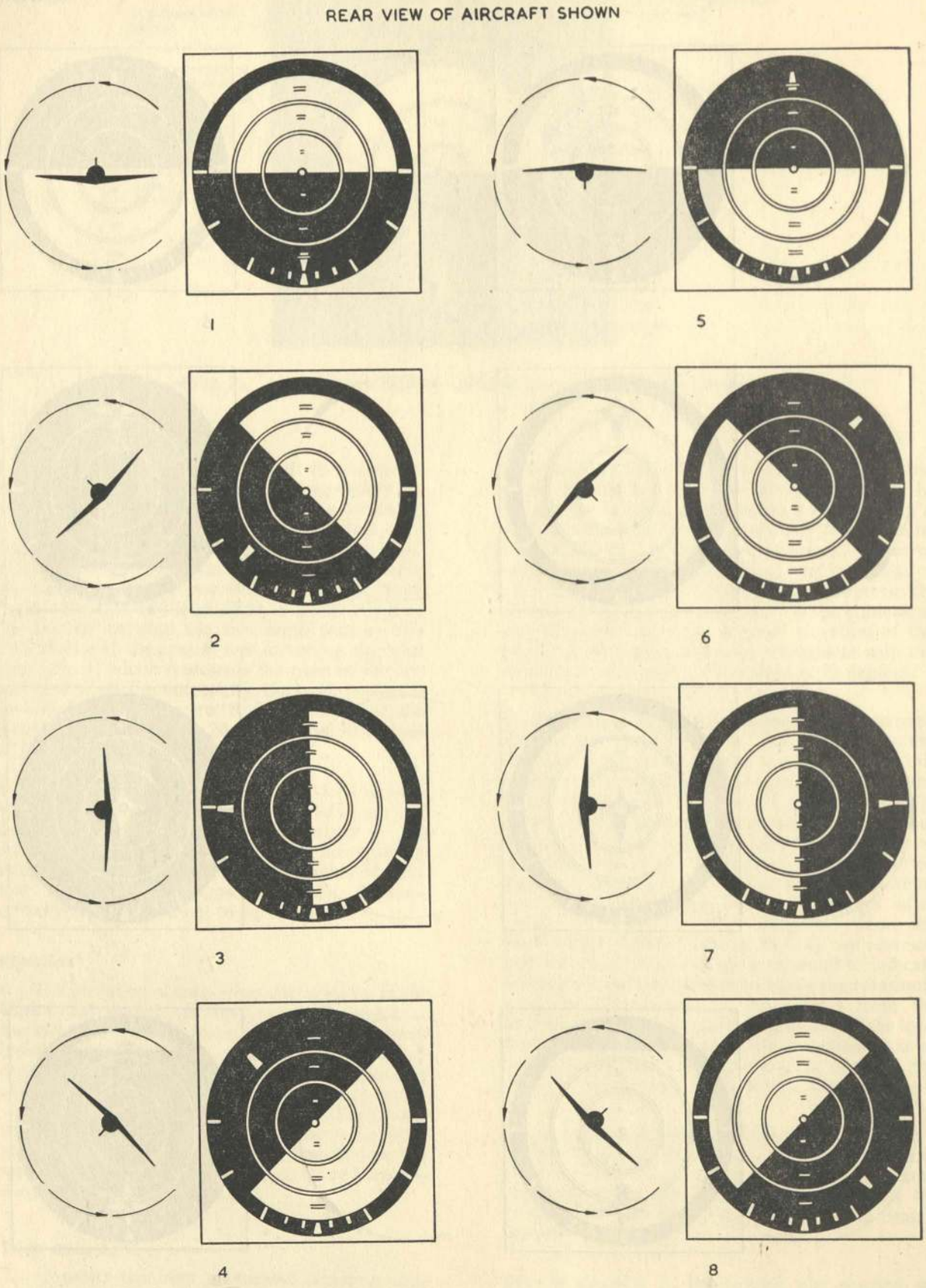



**Fig. 4. Presentation during a roll to the left**

**11.** In position 7, the aircraft is descending vertically and the nadir star is in the centre of the bezel glass. Again, as it passes beyond the vertical and begins normal flight, the roller blind carriage is rotated through 180 degrees (i.e. to zero bank angle) and the rotational sense of the M.R.G. elevation output signals is restored to normal. The long tail of the star indicates the direction in which the horizon lies. As the aircraft progresses towards the horizontal (position 8), the grey (sky) sector moves in from the top of the dial. The remaining 45 degrees of travel from position 8 brings the aircraft and dial back to that shown in position 1.

**Bank manoeuvre**

**12.** Fixed behind the bezel glass of the attitude indicator is a wide black ring the outer diameter of which coincides with the glass circumference. Referring to fig. 2, it may be seen that, on the lower half of the ring radial white lines indicate 0, 10, 20, 30, 60, and 90 degrees of bank in each direction. Those to the right represent positive bank angles (i.e. right wing low) and those to the left, negative bank angles (i.e. left wing low). The bank indication is given by a white pointer attached to the roller blind carriage.

**13.** ◀Reference signals from the stator of the M.R.G. bank synchro are fed, via the M.R.G. distribution box, to pins 8, 9 and 10 on plug A1 of the attitude indicator. From these pins the signals pass directly to the stator of the bank control transformer.▶When misalignment occurs, an error signal is developed across the rotor winding and this is fed, via the phase advance network, to the bank servo amplifier. The output from this amplifier is fed directly to the bank motor which is mechanically coupled to the roller blind carriage mechanism and the bank control transformer. The motor drives this system for a null on the bank control transformer.

**14.** Referring to fig. 4, positions 1–8 represent the attitude indicator dial presentation changing as the aircraft progressively rolls to the left in 45 degree stages. Position 1 shows the aircraft (viewed from the rear) in straight and level flight; the bank pointer is at the 6 o'clock position. It will be observed that as the aircraft rolls in a counter-clockwise direction so the bank pointer and the horizon line which move together, turn relatively to the bezel glass in a clockwise sense and at the same rate. It will be understood that in flight the case of the instrument rotates with the aircraft and the horizon line always remains horizontal.

## FLIGHT DIRECTORS

**15.** Deviation from a computed flight path is indicated by a flight director index bead on the attitude indicator. This bead, which is controlled by a flight control computer (F.C.C.) gives direct indication of the control action required to correct such deviation. In order that the director is followed, the aircraft controls must be corrected to bring the director index bead coincident with the central fixed datum. Demands by the index bead are in the correct sense, that is, if the bead moves at 2 o'clock, the aircraft is required to fly up and to the right.

**16.** The bead is operated by a rectilinear arrangement of two moving cross-wires, one moving in a vertical direction and the other in a horizontal direction, the bead being located at the point at which the wires cross. The wires are attached to sliders, worked on a rack principle, which move in response to signals derived from identical linear potentiometer control systems (*fig.* 5).

**17.** The flight director outputs from the F.C.C. are d.c. signals approximately proportional to the required aircraft control movements. These are fed to horizontal and vertical magnetic modulators each having two control windings. The first, a signal winding fed with the flight director signal and the second, a feedback winding connected between the datum tapping and slider of the flight director potentiometer. With this arrangement, an a.c. output is only produced when there is a signal voltage causing an ampere turn un-balance between the two control windings. The current so produced is amplified and used to motor the index bead until the feedback voltage from the flight director potentiometer backs off the flight director signal, that is, when the displacement of the bead is proportional to the demand signal.

## TEST POINT

**Bank and elevation**

**18.** The bank and elevation signals and functions may be checked at the test socket on the M.R.G. distribution box referred to in Chap. 2 of this section. Details of connections are given in Table 3 Chap. 7 of this section. For details of tests, reference should be made to the appropriate chapter in A.P.4685T.

**Flight director**

**19.** By connecting a test set, Type 8 (Ref. No. 6C/2198) to FS14 on the test panel on the aft port bulkhead in the main equipment bay, various flight director continuity and simulation tests may be carried out. Details of connections are given in Table 5, Chap. 7 of this section. For details of tests, reference should be made to the appropriate chapter of A.P.4685T.

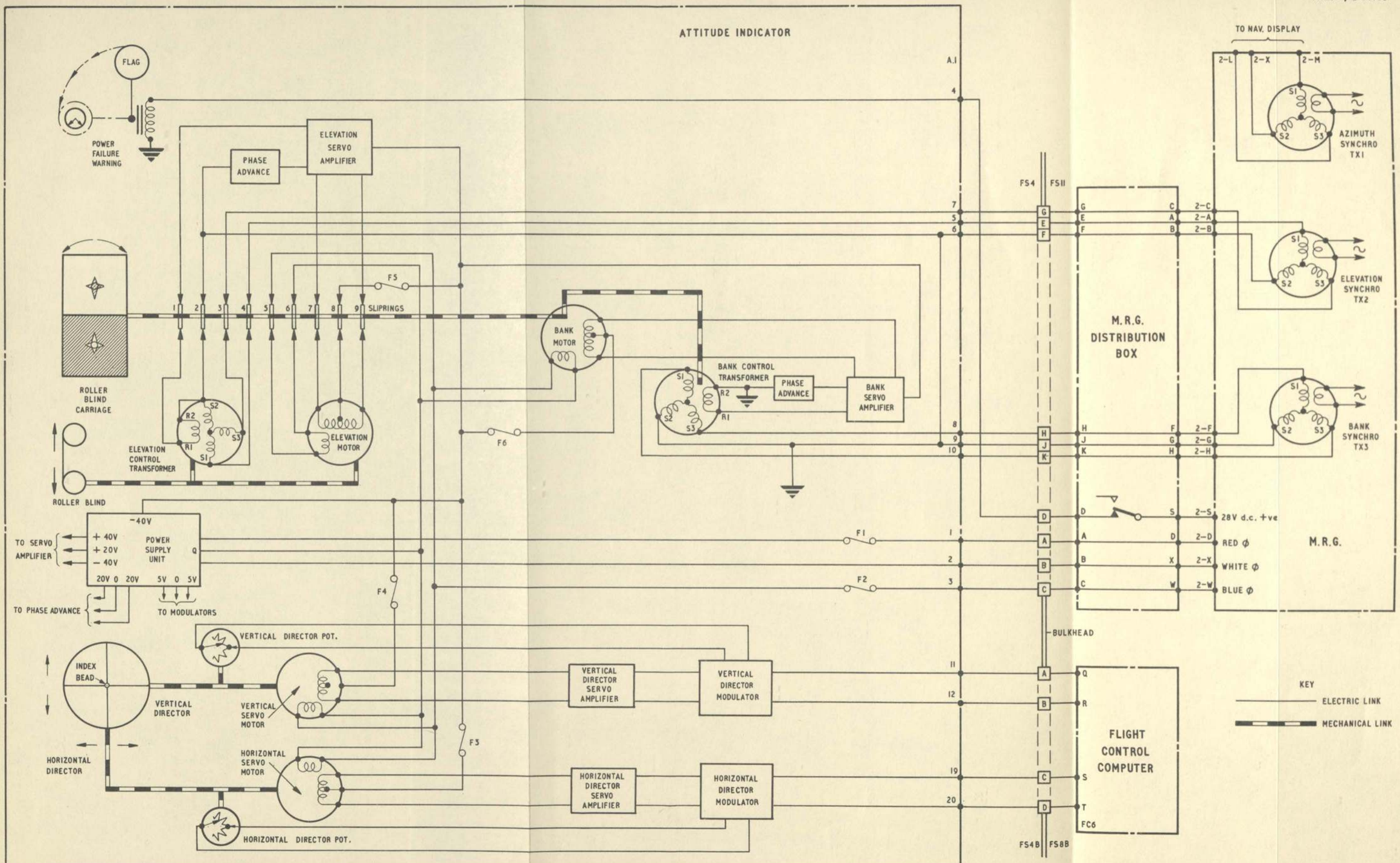



Fig.5

(M.F.P.)

Attitude indicator — schematic diagram

SECRET

Fig.5