# Chapter 7

# COMPASSES, GYRO-MAGNETIC, Mk. 4B

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* *Also issued in the A.D.6284/Min. series*

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### Introduction

**1.** The construction and the method of operation of the Mk. 4B gyro-magnetic compass are described in this chapter. Test procedure and routine servicing instructions are also included.

**2.** The compass is an aircraft flight instrument which combines the functions of the directional gyro and the magnetic compass and, in so doing, combines the particular advantages of each. The indications shown by the compass are stabilized by means of a gyro, and synchronized with the earth's magnetic field by a remote detector unit and a monitoring system so that a steady and accurate directional reference is always obtained. As a result of gyro stabilization, northerly turning error and other errors common to magnetic compasses are greatly reduced and the effect of the monitoring system is to eliminate the slow inherent drift of the gyro.

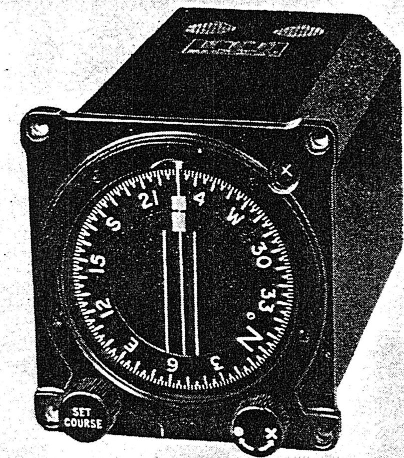
**3.** Separate indicators are provided for the pilot and for the navigator, but, if required, an additional indicator may be fitted for the use of the second pilot. The compass also includes a power repeater system for operating compass repeaters and for controlling in azimuth such equipments as automatic pilot, the ground position indicator, radio compass and radar equipment, up to an equivalent of six pilot's repeaters. A synchronous transmission system is also available and a separate signal system is incorporated for monitoring the automatic pilot, Mk. 9.

**4.** By means of a control on the navigator's indicator, magnetic variation can be set into the compass so that all indicators and monitored equipment are automatically connected to the true heading of the aircraft.

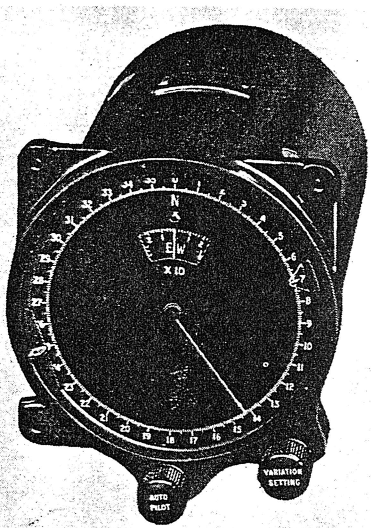
## GENERAL DESCRIPTION

### General

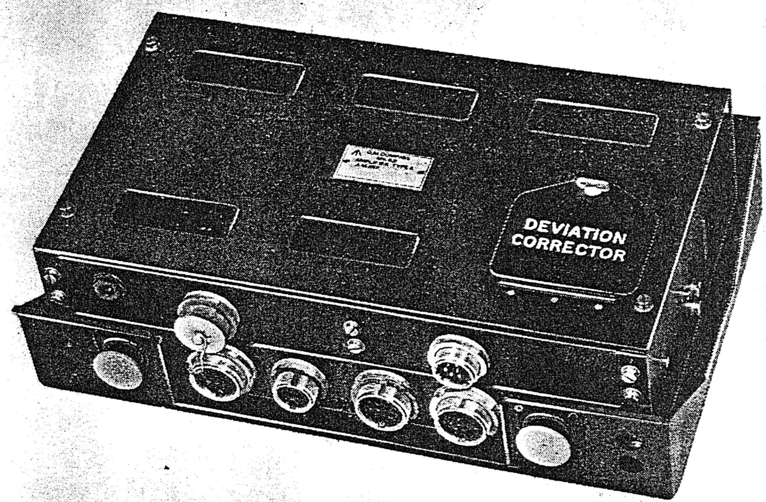
**5.** The Mk. 4B compass consists of the five separate units shown in fig. 1. An additional gyro unit for the second pilot can be installed if required. Each of the five units comprising the compass is separately described in this chapter and to facilitate a clear understanding of the relative functions of each unit and of the system as a whole, a simplified schematic diagram of the compass is given in fig. 2.



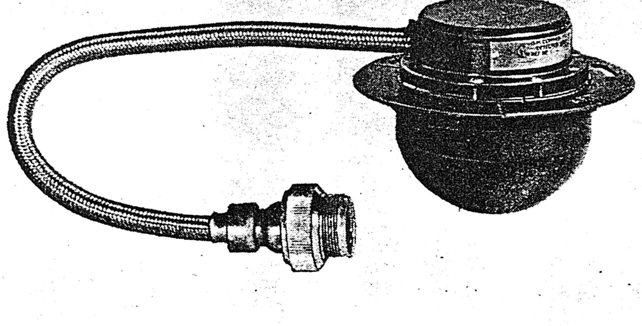

GYRO UNIT



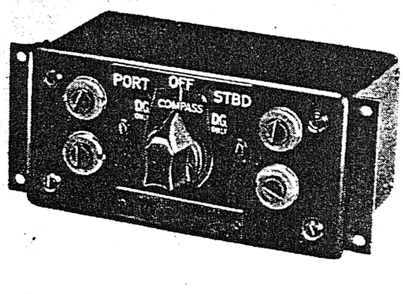

MASTER INDICATOR




AMPLIFIER AND MOUNTING TRAY



DETECTOR UNIT




CONTROL PANEL

**Fig. 1. Compass, gyro-magnetic, Mk. 4B (Type A)**

#### Detector unit

**6.** The detector unit, Type A, (*Ref. No.* 6*B*/1993), a sectional view of which is given in fig. 3, senses the direction of the earth's magnetic field and provides signals for monitoring the compass. It comprises a pendulous sensitive element and an electro-magnetic deviation compensator.

**Note . . .**

*Specific information on Types is given in Chapter 5 of this section.*

**7.** The sensitive element of the detector unit, known as the flux valve, is free to swing up to 25° in pitch and roll, but is fixed to the aircraft in azimuth. In construction the flux valve resembles a wheel with three spokes spaced 120° apart. The rim is divided between the spokes so that each section of the rim forms a flux collector horn for its respective spoke. By referring to the schematic diagram, fig. 4, which shows the general arrangement, it will be seen that a pick-off coil is wound around each spoke and an exciter coil is wound around the hub which forms a central core. The axis of the exciter coil is at right-angles to the axes of the pick-off coils.

**8.** Referring to fig. 3, the detector unit and compensator assembly is provided with a mounting flange which is marked FORE and AFT. When the unit is installed, it must be aligned with the fore-and-aft axis of the aircraft, so that the axes of the pick-off coils are horizontal and that of the exciter coil is vertical.

**9.** The exciter coil is supplied with 400 c/s, single-phase a.c. to produce a flux sufficient to saturate each spoke. The horizontal component of the earth's magnetic field however, also affects the flux density in the spokes, and as a result the amplitude of the alternating signals, induced in the coils, is proportional to the component of the earth's magnetic field in line with each particular spoke. Fig. 5 shows schematically the relation between the heading of the aircraft and the flux in the spokes caused by the earth's field.

**Note . . .**

*A detailed explanation of the operation of the flux valve and a description of the Selsyn transmission system (used extensively in the Mk. 4B compass) are given in Chapter 5 of this section.*

#### Deviation compensator

**10.** The deviation compensator, shown in fig. 3, is mounted in a housing secured to the top of the detector unit from which it must not be removed. It consists of four mu-metal cores around each of which is wound a coil supported on a Bakelite former. Two of the cores are mounted in, or parallel to, the fore-and-aft of the aircraft, and two athwartships. The coils are supplied from a stabilized d.c. source, and the current through them is adjusted by two calibrated potentiometers so that the resultant magnetic field neutralizes the local magnetic interference.

#### Master indicator

**11.** The master indicator, Type A (*Ref. No.* 6*B*/1996), is shown in fig. 6 and 7. The main shaft, which carries the pointer and the rotors of the signal and data Selsyns, is driven through gears by a small two-phase motor. One phase of this motor is continuously energized, the control phase being supplied with power from the follow-up amplifier.

**12.** The master indicator is maintained in synchronism with the gyro unit by a signal transmission system, and to enable the navigator to verify that the gyro unit is correctly synchronized, an indicating device, in the form of a small flag marked with a dot and a cross, is provided. The flag is visible through a small aperture immediately below the N calibration mark on the indicator dial and is operated by a small electro-magnetic indicator connected in series with the annunciator coil in the gyro unit.

**13.** The lubber line, which registers against the variation scale, is not fixed to the indicator case but can be moved, within limits, to the left or to the right by means of a compass corrector key. The key fits over the end of the shaft accessible through a hole on the left of the indicator case. This adjustment is used to make small final corrections for coefficient A, since it is not practicable to make adjustment of the detector unit of less than 2° in azimuth.

**14.** A course setting device, consisting of a rotatable ring and a Perspex cursor, is included to enable the navigator to note any divergence from the selected course. The ring should be turned until the cursor indicates the selected course. If the master indicator pointer is not then in alignment with the cursor, this indicates to the navigator that the aircraft is being flown "off course".

**15.** Provision is also made for setting in magnetic variation by means of the variation setting control, located at the bottom right-hand corner of the bezel. By means of this control the master indicator, gyro unit and any monitored equipment which may be in use can be made to indicate the heading of the aircraft relative to true north instead of Magnetic north. A locking ring may be fitted to the master indicator variation setting knob to prevent inadvertent operation, in aircraft where the variation setting control is not required.

**16.** An auto-pilot control, located directly beneath the bezel, is provided specifically for use with the automatic pilot, Mk. 9, and permits the navigator to make fine adjustments to the course within limits of $\pm$ 4° in ½° steps.

#### Gyro unit, Type A

**17.** The gyro unit, Type A (*Ref. No.* 6*B*/1992), a sectional view of which is given in fig. 8, is essentially an electrically-driven directional gyro and can be used as such if required. It incorporates a gyroscopic movement, a data Selsyn assembly compass card, annunciator, course setting, and synchronizing controls.

**18.** The gyro movement consists of an electrically-driven rotor which spins about a horizontal axis. The rotor is carried in a housing which is pivoted in a vertical gimbal ring about a horizontal axis at right-angles to the rotor axis. The vertical gimbal ring is free to move about its vertical axis.

**19.** The compass card in the gyro unit is mounted at one end of the data Selsyn rotor shaft. The other end of the shaft carries a bevel gear in mesh with a second bevel gear which is secured to the base of the vertical gimbal ring. Thus, any movement of the gyro assembly in azimuth will cause the rotor of the data Selsyn and the compass card to rotate.

**Gyro drift**

**20.** Gyroscopic inertia maintains the spin axis of the gyro rotor in a fixed position irrespective of the movements of the aircraft, but all gyros have an inherent tendency to drift due to such causes as the rotation of the earth and low-level friction.

**21.** Any drift in azimuth, however, causes the rotor of the data transmitter Selsyn in the gyro unit to move in relation to its stator and a signal is transmitted via the data Selsyn in the master indicator, to the follow-up amplifier. The follow-up motor is thus energized and the rotor of the signal Selsyn moves away from zero signal position, i.e., "off null". This null position occurs when the electro-magnetic axis of the rotor is at 90° to that of the effective field.

**22.** A signal is passed from the signal Selsyn to the precession amplifier thus energizing the precession coil which exerts a torque about the horizontal axis causing the gyro to precess about the vertical axis back to its original position. As a result, the shaft carrying the compass card will rotate until

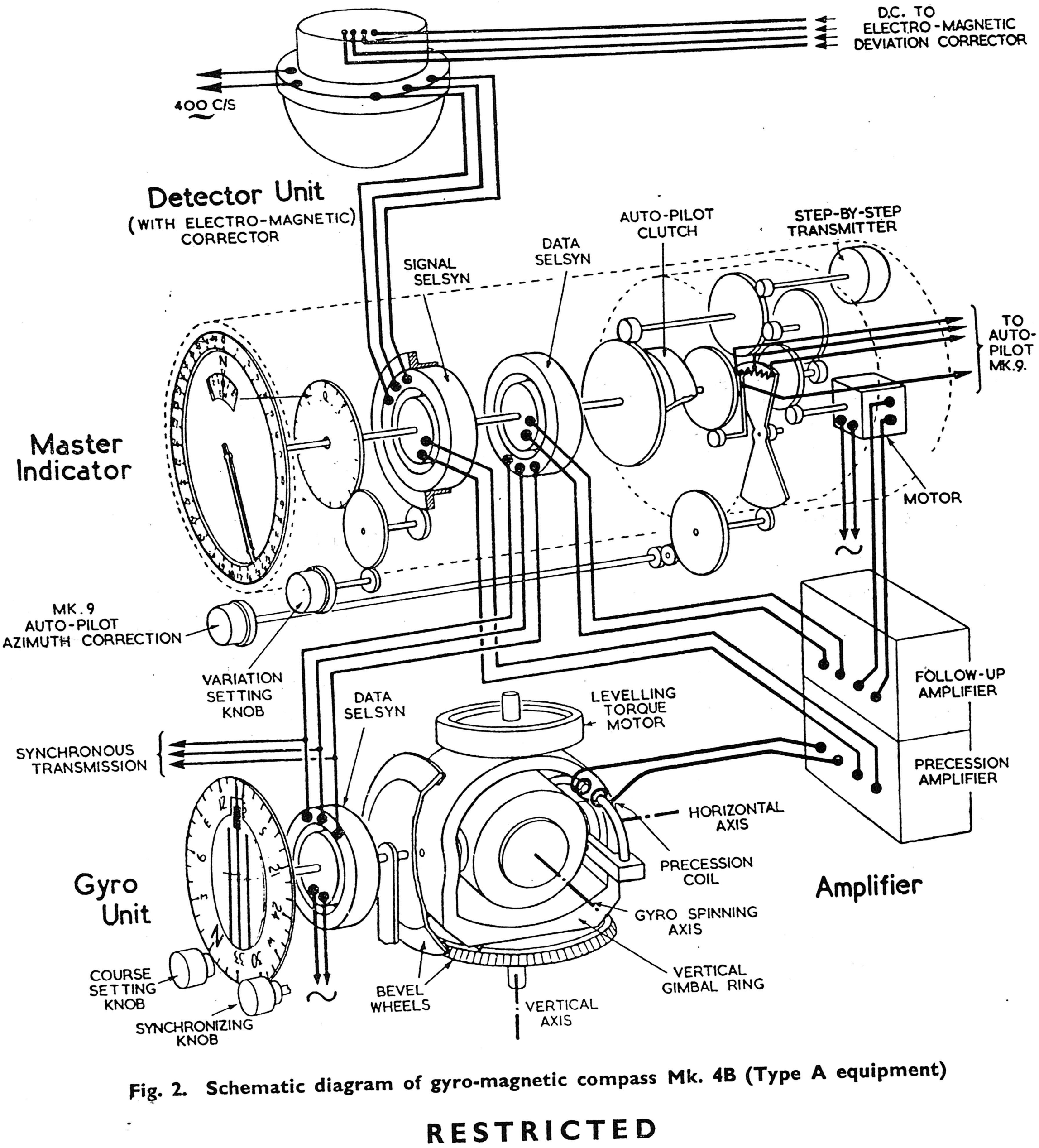



**Fig. 2. Schematic diagram of gyro-magnetic compass Mk. 4B (Type A equipment)**

the rotor and the stator of the signal Selsyn in the master indicator are re-aligned, the precession signal is cancelled, and the compass card again indicates the magnetic heading of the aircraft.

**Corrective torque**

**23.** The arrangement of the Mk. 4B compass provides for a corrective torque to be applied immediately the gyro commences to drift, and the sensitivity is such that the compass card is continuously synchronized with the direction of the earth's magnetic field. The monitoring rate is approximately $2\frac{1}{2}°$ to $4°$/min at maximum signal. This maximum rate is obtained at any position over 3° from the null position.

**Behaviour in turns**

**24.** When the aircraft turns, the compass card, data Selsyn rotor and the vertically mounted bevel gear on the rotor shaft move around the gyro-stabilized vertical gimbal ring, causing the shaft to rotate about its own axis and altering the position of the data Selsyn rotor relative to its stator. The resulting misalignment signal from the data Selsyn in the master indicator starts the follow-up motor, and the course pointer thus follows the movement of the compass card.

**25.** The signal Selsyn rotor in the master indicator is mounted on the same shaft as the course pointer and will have rotated with it, but since the signals from the detector unit, which has turned with the aircraft, have progressively altered to correspond with the new heading, the electrical alignment between the rotor and stator of the signal Selsyn is maintained. During turns, therefore, the compass card and the course pointer remain in synchronizm and continuously indicate the aircraft heading.

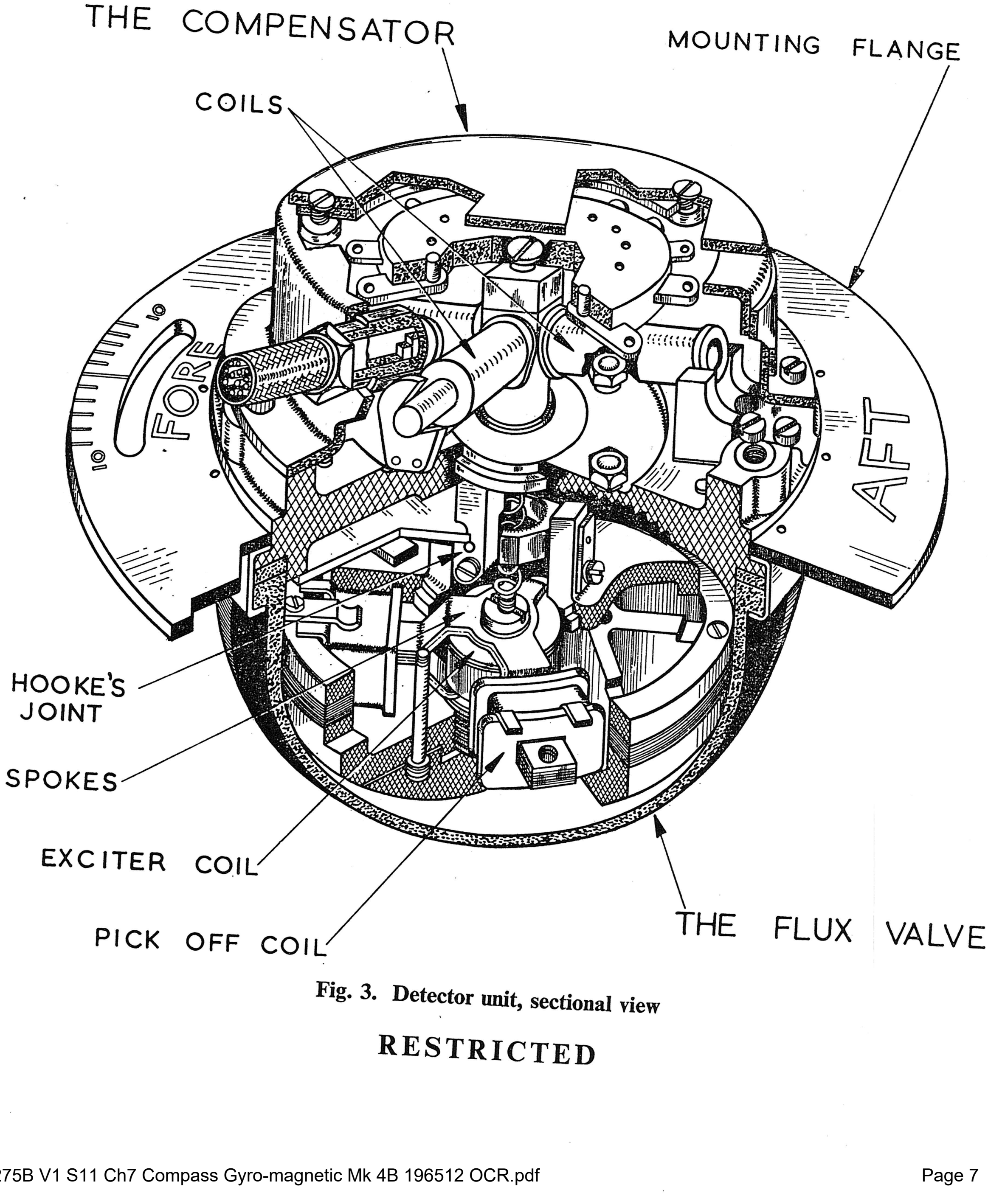



**Fig. 3. Detector unit, sectional view**

**RESTRICTED**

**Annunciator**

26. The annunciator facilitates the initial synchronization of the gyro unit and provides a constant visual indication enabling the pilot to verify whether or not synchronism is maintained. Synchronism is indicated by half the cross and half the dot being displayed. The mechanism consists of a small flag mounted on a pivoted staff operated by an electro-magnet and marked with the dot and cross, visible through the annunciator window at the front top right-hand corner of the gyro unit. The annunciator in the master indicator is connected in series with the annunciator in the gyro unit. A display of a cross indicates that the gyro is being processed to give higher readings on the card.

**Use as a directional gyro**

27. For certain flight operations it may be desirable to use the compass as a directional gyro. Provision is therefore made for removing the monitoring of the detector unit by means of the selector switch located on the control panel which should be turned to COMPASS OFF.

**Note . . .**

*When the gyro unit is functioning as a directional gyro, an indicating flag marked* D.G. *is moved in front of the annunciator flag, and on the master indicator. Master indicators before serial No.* 464 *were manufactured without the* D.G. *flag, but most instruments will now have been modified.*

**Amplifier unit**

28. The amplifier unit, Type A (*Ref. No.* 6*B*/1994), shown in fig. 9, comprises two separate amplifiers, the precession amplifier and the follow-up amplifier, fitted in one rectangular case (*see also fig.* 31). Two fuses are provided to protect the amplifiers. The unit also incorporates two calibrated potentiometers and a d.c. voltage stabilizing circuit (referred to in *para.* 10), for the deviation compensator in the detector unit. A jack socket is provided so that an external centre-zero voltmeter can be plugged in when testing or compensating the compass. This component also serves as a junction box.

29. The precession amplifier consists of a two-stage valve amplifier and a phase-discrimination rectifier circuit. The follow-up amplifier consists of a two-stage a.c. valve discrimination circuit with a transductor output circuit. A detailed circuit description of the precession and follow-up amplifiers is given in para. 141 to 146 and 149 to 165 respectively.

**Control panel**

30. The control panel (*Ref. No.* 6*B*/408), shown in fig. 10, is used to control the monitoring signals to the gyro unit. It consists of a rectangular metal box which carries a selector switch, four fuses, one 12-pole plug and two 12-pole sockets. On the particular unit illustrated in fig. 1, three switch positions can be seen: PORT COMPASS, STBD. COMPASS and COMPASS OFF. The selector switch indicating plate, however, can be reversed so that on installations where only one gyro unit is installed two switch positions only, GYRO COMPASS and COMPASS OFF are available (*fig.* 10). The control panel can be used for rail or bulkhead mounting by altering the position of the receptacles.

31. On single gyro unit installations the master indicator is always synchronized with the gyro unit, whether it is functioning as a compass or as a directional gyro. On installations where two gyro units are installed the master indicator is synchronized with whichever gyro unit is functioning as a compass, or with the port gyro unit if both units are functioning as directional gyros.

**Note . . .**

*The control panel is usually installed in a position where it is accessible to the pilot, but on single gyro installations provision is made for installing the panel wherever convenient and effecting the control of the monitoring signals by a separate two-way switch.*

**Power requirements and weights**

32. The power supplies required for the Mk. 4B compass are as follows:—

(1) 115 volts, 400 cycles, 3-phase a.c.

(2) 28 volts d.c.

33. The a.c. power consumption, when one gyro unit only is used, is approximately 75 watts. An additional gyro unit for the second pilot necessitates an increase of 20 watts.

34. The d.c. power consumption is less than 3·5 watts, but if repeaters are fitted this consumption is increased by 10 watts for each additional repeater, the maximum permissible load being 2·5A (equivalent to six pilot's repeaters). Where more than three repeaters are in use, it is advisable to supply a 28V, d.c. + ve feed to pin A of the salmon pink connector of the master indicator, this feed then being in parallel with the 28V, d.c. + ve feed to the D pin of the amplifier WHITE connector (*fig.* 11).

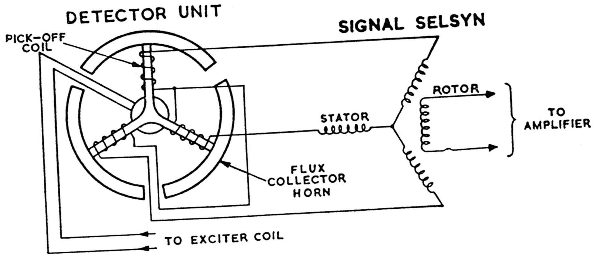



**Fig. 4. Flux valve and Selsyn system**

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**35.** The Ref. No. and the approximate weights, excluding cabling, of each unit included in the Mk. 4B compass are as follows:—

| Ref. No. | Item | Weight |
|---|---|---|
| ◄ 6B/1993 | Detector unit, Type A | 1 lb. 10 oz. |
| 6B/2906 | or Type B | 1 lb. 11 oz. |
| 6B/2994 | or Type C | 1 lb. 12 oz. |
| 6B/3229 | or Type D | — |
| 6B/1992 | Gyro unit, Type A | 6 lb. 0 oz. |
| 6B/561 | or Type B | 6 lb. 5 oz. |
| 6B/557* | or Type C | 7 lb. 7 oz. |
| 6B/2850 | or Type D | 6 lb. 5 oz. |
| 6B/1996 | Master indicator, Type A | 6 lb. 9 oz. |
| 6B/634 | or Type B | 6 lb. 8 oz. |
| 6B/2644 | or Type C | 6 lb. 10 oz. |
| 6B/2758 | or Type D | 7 lb. 8 oz. |
| 6B/2863 | or Type E | |
| 6B/1994 | Amplifier, Type A | 9 lb. 11 oz. |
| 6B/562 | or Type B | 11 lb. 0 oz. |
| 6B/3126 | or Type C | 11 lb. 6 oz. |
| 6B/437 | Amplifier mounting tray c/w screws | 11 oz. |
| 6B/408 | Control panel, Type A | 1 lb. 5 oz. |
| 6B/2890 | or Type B | |

* For use with autopilot Mk. 11 ►

## BASIC OPERATION PRINCIPLES

### General

**36.** The basis of the Mk. 4B compass is the gyroscope. The gyro rotor is mounted in the gyro unit so that it possesses freedom about three axes; a horizontal spin axis, a second horizontal axis at right-angles to the spin axis, and a vertical axis. The rotor spins at approximately 23,000 rev/min.

**37.** All practical applications of the gyroscope are based upon two fundamental characteristics, gyroscopic inertia and precession. Gyroscopic inertia tends to maintain the spin axis of the gyro in a fixed attitude irrespective of the movements of the aircraft. Precession is the angular change in direction of the axis of rotation. In the Mk. 4B compass the property of inertia is used to stabilize the indications of the compass and the tendency to drift is overcome by a monitoring system which utilizes the signals from a remote detector unit to synchronize the card with the earth's magnetic field. Fig. 5 shows in schematic form, the relationship between the magnetic heading of the aircraft and the signals from the detector unit.

### Monitoring and follow-up systems

**38.** Referring to the schematic diagram of the Mk. 4B compass (*fig.* 2) and the functional diagram (*fig.* 12) it will be seen that two amplifiers are incorporated. These amplifiers are quite independent of each other and differ widely in their electrical characteristics but, for convenience, are mounted in the same chassis.

**39.** The signal Selsyn in the master indicator, the precession amplifier and the precession circuit in the gyro unit constitute the monitoring system by means of which the card is synchronized with the earth's magnetic field. The data Selsyn in the master indicator, the follow-up amplifier and the data Selsyn in the gyro unit, comprise the follow-up system which maintains synchronism between the master indicator and the gyro unit.

### Operation

**40.** The detector unit originates alternating electrical signals at 800 c/s which vary in amplitude and sign according to the magnetic heading of the aircraft. These signals are fed to the stator of the signal Selsyn in the master indicator, thus establishing a magnetic field in the stator. It will be seen from the illustration that the rotor of the signal Selsyn is mounted on the same shaft as the course pointer and rotates with it. During manufacture, the pointer indication is correlated with the angular position of the rotor relative to its stator so that, provided the electro-magnetic axis of the rotor is at right-angles to the vector of the stator field, a correct indication of the heading of the aircraft is always given. Under these conditions of zero signal input a current of approximately 6·5 mA, d.c., flows through the D and F halves of the precession circuit in the gyro unit.

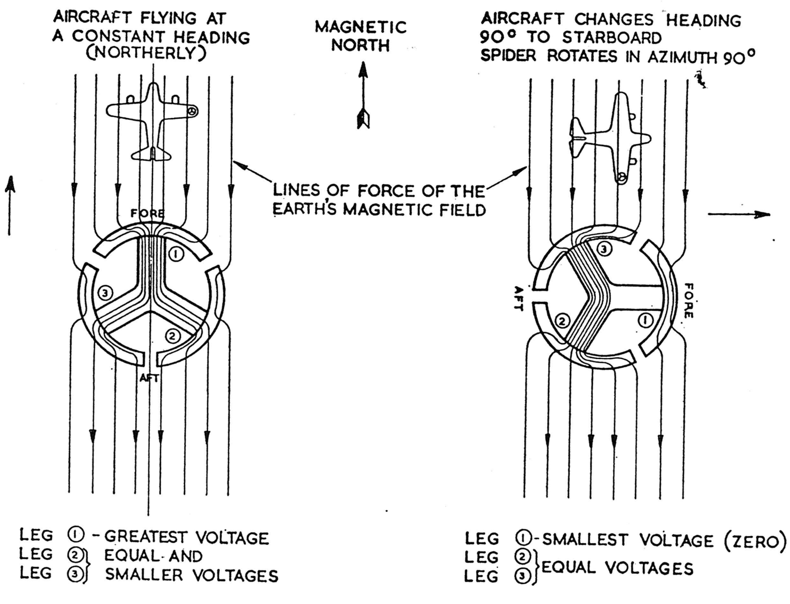


**Fig. 5. Operation of flux valve, schematic diagram**

**41.** If, during flight, the pointer does not indicate the heading of the aircraft, the rotor is out of alignment with the magnetic field set up in its stator by the signals from the detector unit, i.e., it will be off null. An error signal, proportional to the sine of the degree of misalignment, is therefore induced in the rotor. Maximum signal error is obtained 90° off null. At 180° a false unstable null is produced.

**42.** This signal is fed to the precession amplifier where it is amplified, phase-detected and rectified. The balance of current in each half of the precession circuit is then disturbed and the precession coil exerts a torque causing the gyro unit to precess in azimuth. The differential current builds up to approximately 15 mA at about 3° off null and this value is maintained for any increase in misalignment.

**43.** The precession of the gyro is transmitted through bevel gears to the shaft which carries the compass card and the rotor of the data Selsyn assembly. The rotor is energized by single-phase a.c. and its stator is connected to the stator of a similar data Selsyn in the master indicator. The movement of the rotor caused by the precession of the gyro, therefore, alters the magnetic field induced in the data Selsyn stator and, as a result, the rotor of the master indicator data Selsyn passes a signal to the follow-up amplifier.

**44.** After phase discrimination and power amplification by the follow-up amplifier, the signal is fed to the follow-up motor on the master indicator causing it to turn the Selsyn rotor shaft and re-align the rotors of the signal and the data Selsyns to the null position.

**45.** The misalignment signals throughout the monitoring and the follow-up systems cease when the rotors and stators are at null, and at this point the gyro unit and the master indicator are synchronized with each other and with the directional references supplied by the detector unit. Both units therefore indicate the magnetic heading of the aircraft.

**Note . . .**

*In the explanation given in para.* 38 *to* 43 *inclusive, it has been assumed that the magnetic variation control referred to in para.* 15 *is set to zero. If, however, the correct variation has been set in, the true heading of the aircraft will be shown by the gyro unit and the master indicator and transmitted to the compass repeaters and monitored equipment.*

## INSTRUCTIONS FOR USE

### General

**46.** In the subsequent paragraphs the adjustments necessary to synchronize the gyro unit and to set and alter course when in flight have been allocated specifically to the pilot and the navigator. Fig. 15 and fig. 16 show the presentation of the gyro unit and the master indicator respectively.

### Procedure before flight

*Variation setting*

**47.** NAVIGATOR. Set in local variation on the scale by pushing in and turning the variation setting control knob until the correct variation is read against the lubber line.

**Note . . .**

*It is most important that the navigator should verify that both the lamps in the compensator circuit are alight, since the failure of either lamp will cause the value of the current flowing through the compensator coil to alter, thus introducing compass errors. The lamps are visible through small holes on the front of the amplifier case.*

*Synchronizing the gyro unit*

**48.** (1) PILOT. Note the indication shown in annunciator window of the gyro unit. If D.G. shows, turn the selector switch on the control panel to COMPASS.

**Note . . .**

*This instruction is applicable only to installations with one gyro unit. In some installations, however, the control panel is mounted remotely and control is effected by a separate selector switch. Where two gyro units are fitted, the selector switch should be turned to* PORT *or* STARBOARD *according to which unit is to be synchronized.*

(2) Press in the synchronizing knob and turn it in the direction marked on the knob as indicated by dot (·) or cross (+), shown in the annunciator window (i.e., dot: clockwise, cross: counter-clockwise), until the indication changes to the opposite sign; then turn the knob slowly back until the annunciator window is cleared, or a dot and a cross appear alternately.

(3) NAVIGATOR. Navigators should check that the annunciator flag in the master indicator shows the same sign as that shown on the gyro unit.

*Setting course*

**49.** (1) PILOT. Press in and turn the SET COURSE knob until the course pointer is aligned with the desired heading.

(2) NAVIGATOR. Set the index line on the cursor to the desired heading.

### Procedure during flight

**50.** (1) PILOT. Press in and turn SET COURSE knob until the course pointer is aligned with the designed heading.

(2) NAVIGATOR. Set the index line on the master indicator cursor to the same heading as the course pointer on the gyro unit.

(3) PILOT. Fly the aircraft so that the course pointer is aligned with the lubber line and maintains course by keeping the course-pointer rectangle aligned with the aircraft heading rectangle.

*Setting variation*

**51.** (1) NAVIGATOR. Re-set the variation setting as required to compensate for changes which occur during flight.

**52.** The information given in the following sub-para. should be memorized by pilots and navigators.

(1) The gyro unit, the master indicator and any other apparatus which is coupled to the Mk. 4B compass will be monitored to the true heading of the aircraft when the correct variation is set in.

(2) If, for any reason, a large change in variation must be set in, such as would occur when changing to a grid navigation system during flight, the monitoring system will re-synchronize the gyro unit automatically at an approximate rate of $2\frac{1}{2}$ to 4° per min. This time lag can, however, be reduced by re-synchronizing the gyro unit manually (*para.* 48). The master indicator is at all times in synchronism with the gyro unit.

(3) The operating limits which, if exceeded, necessitate re-synchronization of the gyro unit, are ± 84° in pitch or roll. There is complete freedom in azimuth.

*Re-synchronizing the gyro unit*

**53.** (1) PILOT. Proceed as described in para. 48. It will not be necessary to re-synchronize the gyro unit unless the operating limits have been exceeded, the control panel selector switch has been operated, or a large change in variation has been set in by the navigator.

*Automatic flight*

**54.** NAVIGATOR. When the aircraft is under the control of the Mk. 9 automatic pilot which is being monitored by the Mk. 4B compass, the navigator can make corrections to the course being flown up to a maximum of 4° to port or starboard in $\frac{1}{2}$° steps provided a Type A master indicator is fitted.

*Using the gyro unit as a directional gyro*

**55.** When the selector switch on the control panel is turned to OFF, the monitoring signals from the detector unit cease to affect the gyro unit which then functions as a directional gyro. The indication D.G. is displayed in the annunciation windows on the gyro unit and on the master indicator (see note following *para.* 27).

**56.** On installations where there are two gyro units fitted, i.e., on the pilot's and the second pilot's instrument panels, one gyro unit is normally used as a compass and the other as a directional gyro. Either or both gyros can, however, be used as directional gyros by operating the selector switch on the control panel as follows:—

(1) Switch to STARBOARD: port gyro unit functions as a directional gyro only.

(2) Switch to PORT: starboard gyro unit functions as a directional gyro only.

(3) Switch to OFF: both gyro units function as directional gyros.

**Note . . .**

*If either or both gyro units have been used as directional gyros, it is essential to re-synchronize the unit that is switched to* COMPASS.

**57.** The master indicator is always synchronized with the gyro unit whether it is functioning as a compass or as a directional gyro. When two gyro units are installed, however, the master indicator is synchronized with whichever gyro unit is functioning as a compass; or with the port gyro unit if both units are functioning as directional gyros.

**Flight characteristics**

*Annunciators*

**58.** Under normal flight conditions in piston-engined aircraft, the dot and cross will be displayed alternately in the annunciator windows on the gyro unit and the master indicator. This is caused by the flux valve in the detector unit moving about its neutral position due to vibration and air turbulence and is quite consistent with satisfactory operation.

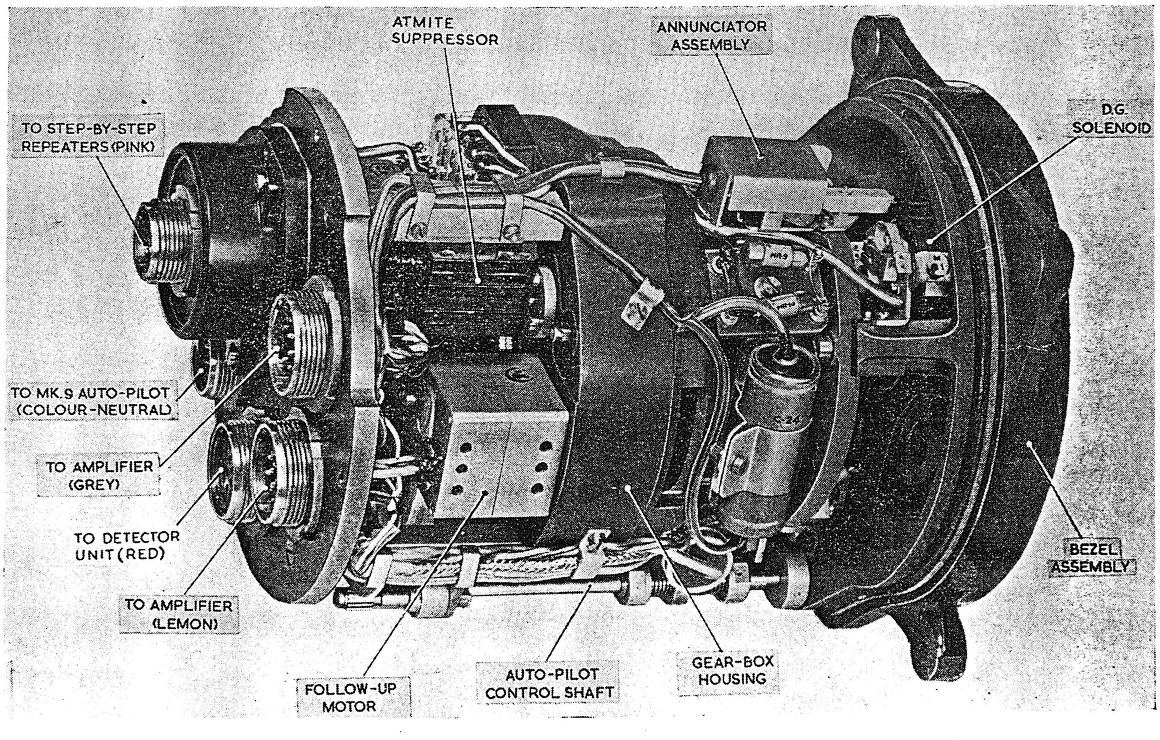


**Fig. 6. Master indicator, Type A, view showing back plate and connections**

**59.** On jet-propelled aircraft, however, the dot and cross will alternate at a slower rate and may be only partially visible as the annunciator flag reaches the extremities due to the absence of vibration and the stable straight flight path of high speed aircraft.

**60.** Unless aerobatics have been carried out or the operating limits of the gyro specified in para. 50 have been exceeded, the gyro will not normally require re-synchronization during flight.

*Gyro topple*

**61.** The mechanical limits of the gyro in pitch and roll are $\pm$ 84° If these limits are exceeded during flight, the gyro must be re-synchronized as described in para. 48.

*Turn error*

**62.** A small indicated error may be introduced after a prolonged turn but will be monitored out after two or three minutes flight on a straight and level course. This would be indicated by the annunciator. If desired, the error may be removed immediately by means of the synchronizing knob. For certain manoeuvres it may be desirable to switch to D.G. returning to COMPASS when on a straight and level course, and re-synchronizing.

*Stopping*

**63.** The Mk. 4B compass should not be switched off in flight or when taxying but should be left running until the aircraft is stationary at its base. Switch off the main compass switch and not at the control panel. Switching to COMPASS OFF on the control panel switches off the monitoring signals only and leaves the gyro unit functioning as a directional gyro (*para.* 55).

*Compass calibration*

**64.** Calibration should be carried out on the standard occasions and additionally, when any component, other than the control panel is renewed. After replacement of a deviation network lamp with a new one, calibration is only necessary if the B or C correction exceeds 2°.

**65.** During compass calibration all equipment should be in the stowage position as in flight. Owing to the change in conditions causing deviation which may occur only in flight, it may be found desirable to carry out compass calibration when airborne in place of or as a check on the ground calibration.

## GENERAL OPERATION AND DETAILED DESCRIPTION

**Detector unit**

**66.** A detailed description and a mathematical analysis of the theory of operation of the detector unit is given in Chapter 5 of this section which should be referred to if further information is required. ◀ Chapter 5 also contains specific information on Types. ▶

▶ ◀

**67.** In the description given hereafter the physical construction of the unit is described and a general explanation of its operation is given. It should be noted that, since the detector unit is hermetically sealed, should any fault develop, the complete unit must be renewed.

**68.** A sectional view of the detector unit and the deviation compensator is shown in fig. 3 and a

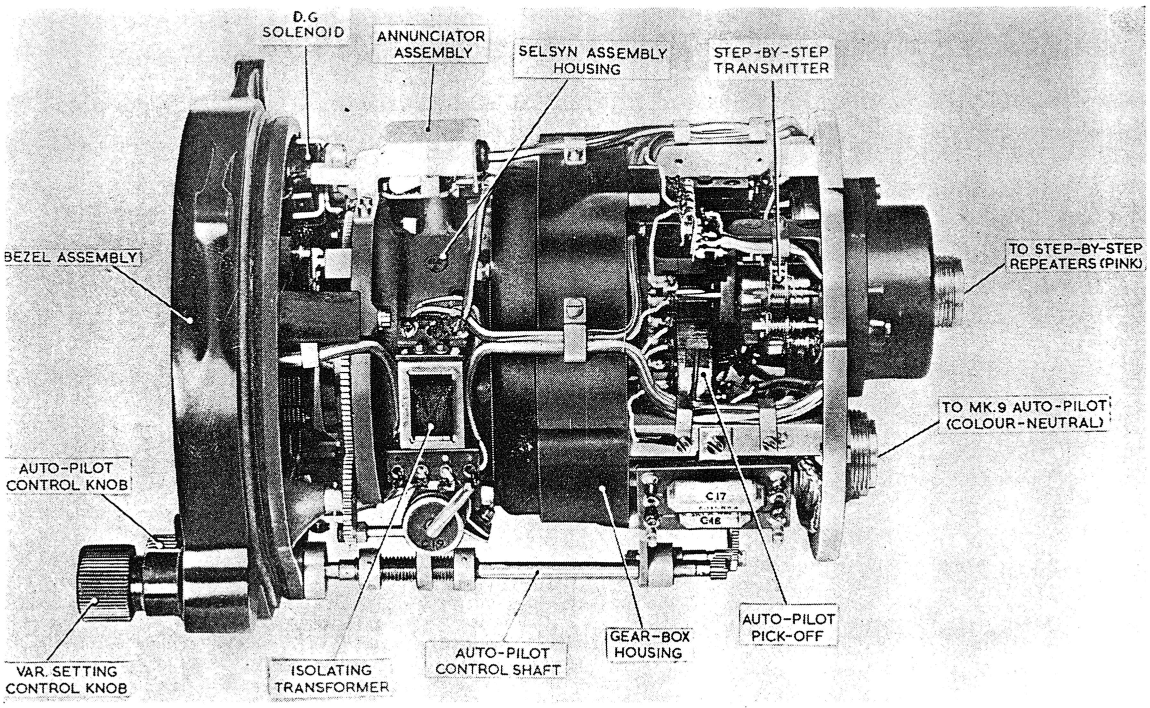


Fig. 7. Master indicator, Type A, view showing variation setting mechanism

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ircuit diagram is given in fig. 17. The mounting flange is engraved FORE and AFT and the unit, when installed, must be in alignment with the fore and aft axis of the aircraft. One of the three screw slots in the flange is engraved up to 10 deg. on each side of the zero index mark to serve as a reference when installing the unit in an aircraft or when correcting coefficient A (*para.* 8). The electrical connections to the detector unit and to the compensator coils are made via a 12-pole coupler plug attached to the detector unit by twelve inches of free lead.

**Flux valve**

**69.** The sensitive element of the detector unit, known as a flux valve, is pendulously mounted and is free to move up to a maximum of 25 deg. in pitch and roll but is fixed to the aircraft in azimuth. It is composed of a series of laminations of a special nickel alloy having a high magnetic permeability and low hysteresis; it takes the form of a wheel with three spokes spaced 120 deg. apart. The wheel is divided around its periphery into three parts, each of which forms a flux collector horn for the spoke attached to it.

**70.** Each spoke consists of two members, separated by insulating material, which extend outwards from the central hub to the rim. A pick-off coil is wound around both members of each spoke, and the central hub forms a core around which an exciter coil is wound. The detector unit is installed so that the axes of the pick-off coils are horizontal and axis of the exciter coil vertical.

**71.** The exciter coil is energized from a 400 c/s single-phase a.c. supply of approximately 23 volts, sufficient to produce a flux to saturate the spokes. The polarity at each end of the core is thus alternately north and south, and therefore at any instant the flux in the top members of each spoke is in the opposite direction to that in the lower members so that the flux cutting the pick-off coils is zero.

**72.** The earth's magnetic field, however, also affects each of the spokes to an extent depending upon the degree of its alignment with the direction of the earth's field, and, as a result of the periodic magnetic saturation caused by the excitation current, alternating signals at twice the excitation frequency i.e., 800 c/s are induced in the pick-off coils. The amplitude and phase of the signal in each pick-off coil is proportional to the component of the earth's magnetic field in line with the spoke which forms its core.

**73.** Referring to fig. 4, it will be seen that the pick-off coils are star-connected to the stator of the signal selsyn in the master indicator and, therefore, the magnetic field produced in the stator by the flux valve signals has a vector directly related to the direction of the earth's magnetic field. The detector unit is fixed to the aircraft in azimuth and the signals originated by the flux valve will vary according to the magnetic heading of the aircraft as shown in schematic form in fig. 5.

**74.** As only the horizontal component of the earth's field is of value for obtaining a directional reference, it is desirable that the sensitive element of the detector unit should, as far as possible, maintain a horizontal position irrespective of the movement of the aircraft. Accordingly, the flux valve is suspended pendulously from a Hooke's joint which permits freedom of movement about the roll and pitch axes. In order to damp down oscillation the assembly is enclosed in a plastic bowl partially filled with oil.

**75.** In turbulent air conditions, the element tends to oscillate slightly about its neutral position and issue fluctuating signals. The gyro unit integrates and stabilizes these signals, and as a result the compass card continuously provides accurate and dead beat indications irrespective of the oscillatory motion of the sensitive element.

**Deviation compensator**

**76.** The general arrangement of the compensator is shown in fig. 3. It comprises four mu-metal cores around each of which is wound a coil supported on a Bakelite former. Two of the cores are mounted in the fore-and-aft axis of the aircraft and two athwartships. The compensating coils are connected via two centre-tapped potentiometers in the amplifier to a source of approximately 7 volts obtained from a voltage stabilizing network connected across the aircraft d.c. supply as shown in fig. 15.

**77.** When no current is flowing in the coils, the compensator is magnetically inert. By adjusting each potentiometer appropriately, however, the polarity and field strength of each pair of coils can be regulated so that the resultant field produced by the coils neutralizes the local magnetic interference. The potentiometers are provided with calibrated scales. By means of a toggle switch, either of two ranges can be selected. The scales are calibrated 15 deg. —0—15 deg., 3 deg. —0—3 deg. The selected range applies to both B and C correction and thus the switch must be in the same position throughout the calibration. The electrical connections to the compensator are made via the 12-pin plug through which the connections to the detector unit are taken.

**Master indicator, Type A** (*fig. 6, 19 and 20*)

*General construction*

**78.** The master indicator which is shown in fig. 1, is intended for panel mounting and is provided with three integral lugs as fixing points. It consists of three principal assemblies; the bezel assembly, the selsyn assembly, and the gear box assembly, which are bolted together and form a rigid unit. The complete indicator is enclosed by a protecting cover which fits into a sealing gasket behind the bezel and is secured to the back plate by four screws. The cover is provided with two breathers which are covered by tropicalized felt held in position by circlips. Fig . 17 and 19 show, in schematic form, the various assemblies comprising the master indicator. Mod. Inst. B87 introduces a selenium rectifier stack which replaces the atmite spark suppressor to increase the serviceable life of the step-by-step transmitter.

*Bezel assembly*

**79.** This assembly comprises the course setter, glass, dial, lubber line adjustment, variation setting scale, variation setting and auto-pilot control knobs and actuating mechanism. The assembly also includes the front bearing for the selsyn rotor shaft.

**80.** The course setter comprises a rotatable snap ring which carries a small Perspex cursor. The bezel is recessed in front of the glass and the ring is retained in the groove by its own snap action and can be turned so that the cursor is aligned with any required course. The glass is retained in position by a corrugated spring ring.

**81.** The dial is secured to the bezel by three screws and its scale is engraved from 0 deg. to 360 deg. in one degree markings. The centre part of the dial is recessed so that the tip of the course pointer lies flush with the scale, thus eliminating parallax error. Two windows are provided in the upper half of the dial, a circular one for the annunciator flag or D.G. indicator, and a curved rectangular aperture for the variation scale.

**82.** The lubber line which is visible in the same aperture as the variation scale is mounted at one end of a thin metal strip which is bushed to the centre of the rear face of the dial. The other end of the strip is slotted to receive the actuating pin projecting from a small tapped steel block which travels on a threaded shaft. The shaft is supported in plain bearings in the lower part of the bezel casting and its outer end is of square section. A hole in the side of the bezel gives access to the outer end of the shaft which can be adjusted by means of a compass corrector key.

**83.** When the key is turned the tapped block travels along the shaft and the strip carrying the lubber line pivots about its centre, causing the lubber line to move to the left or to the right over the variation scale, depending on which way the key is turned. This adjustment is provided so that coefficient A can be compensated for during compass calibration without altering the position of the detector unit, but it should only be used if the error is less than 2 deg.

**84.** Variation can be set in by means of the variation setting control knob. When this knob is pushed in and turned, a gear on the shaft extending from the knob engages with a train of gears which rotates the stator of the signal selsyn and also the variation scale.

**85.** The signals from the detector unit are fed to the stator of the signal selsyn via brush contacts on the back of the bezel assembly which establish contact with slip rings on the stator. Thus, if the stator is rotated, the vector of the stator field will move, and a signal will be transmitted by its rotor to the precession amplifier. By appropriately

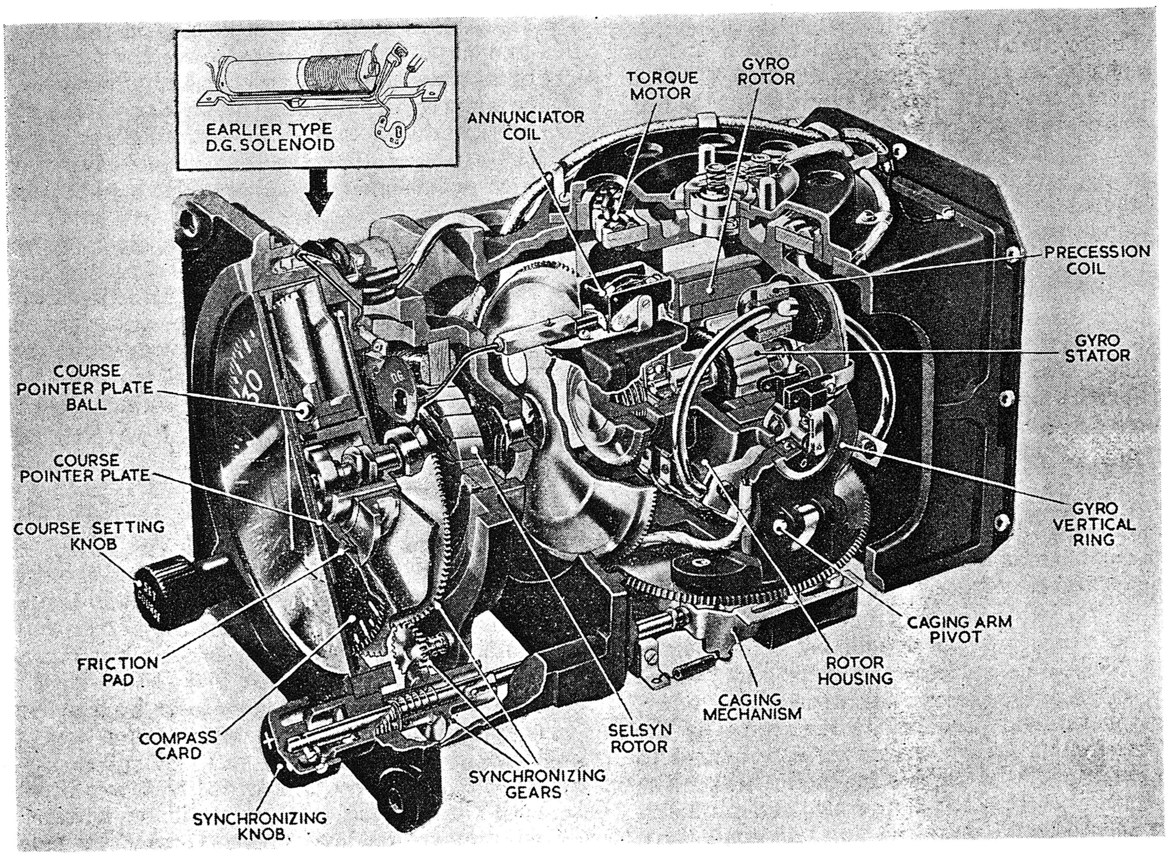


**Fig. 8. Gyro unit, Type A, sectional view**

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adjusting the angular position of the stator relative to its rotor, the local magnetic variation can be set into the compass so that true indications are shown by the master indicator, gyro unit and any repeaters which may be included in the installation.

*Selsyn assembly*

**86.** This assembly is bolted to three mounting bosses which project from the back of the bezel casting. It incorporates the rear bearing for the rotor shaft, two Selsyns, three slip ring assemblies, an interference shield and the course pointer.

**87.** The data Selsyn stator is fixed to the Selsyn assembly casting but the signal Selsyn stator is mounted in a plain bearing and can be rotated through 360° by means of the variation setting control as shown in fig. 19 (para. 84 and 85).

**88.** A gear and slip ring assembly is bolted to the signal Selsyn stator, the gear engaging with the variation correction gear train operated by the control knob.

**89.** Brushes attached to the bezel casting contact a slip ring assembly on the signal stator and transmit the signals from the detector unit to the stator windings.

**90.** The rear end of the rotor shaft projects into the gearbox and carries a spring-loaded circular plate which forms part of an electro-magnetic clutch. The clutch is energized when the auto-pilot switch is operated and the movement of the rotor shaft is then transmitted via the clutch to a gear train which operates the brush contact arm on the auto-pilot pick-off potentiometer. Stops are provided so that this contact arm is prevented from travelling beyond prescribed limits. The clutch plate is frictionally mounted to the Selsyn rotor shaft so that slip will occur when the contact arm reaches the stops. A schematic circuit diagram of the pick-off connections is shown in fig. 22.

**91.** The follow-up motor is a two-phase squirrel-cage induction motor and is mounted on the outside of the gearbox assembly. One phase is continuously energized from the 115 volt a.c. supply, and the control phase is energized from the output of the follow-up amplifier. The rotor turns at a maximum speed of 11,880 rev/min.; the transmission ratio at the rotor shaft is 1980 : 1 (max. speed 6 rev/min.) and at the transmitter it is 33 : 1 (max. speed 360 rev/min.). The rotor shaft is fitted with a friction damping device to minimize any tendency to hunt. Fig. 20 shows the follow-up motor and gear train and fig. 23 shows the circuit connections to the follow-up motor and step-by-step transmitter.

**92.** Later production master indicators, Type A (carrying Mod. B74), and all master indicators, Type B, are fitted with a tacho-generator instead of the follow-up motor. The motor assembly is a similar two-phase induction motor. On the same shaft is mounted a mild steel rotor which is copper plated on its outer periphery to a depth of 0·005 in., the complete assembly of the two rotors on the shaft being dull nickel plated. The stator in which this rotor rotates carries an excitation winding and the tacho-generator output winding. The excitation winding is supplied from A phase in parallel with the fixed winding of the motor assembly, and a series resistor reduces the excitation voltage to between 15V and 25V approximately. Earlier type tacho-generators carry a single 1000 ohms series resistor on a tagboard but those of later production have two 2200 ohm resistors mounted in parallel to improve heat dissipation.

**93.** With any change of heading, rotation of the motor shaft causes the 0·005 in. thick copper drum to be rotated, and a small voltage, proportional to the motor speed, is induced in the tacho-generator output winding. At 5000 rev./min. this is not less than 0·85V, a.c. It will be observed (fig. 24) that this output winding is wired in series with the data Selsyn rotor and it is so connected that the tacho-generator output voltage is in opposition, being at any instant approximately 5 per cent of the displacement signal. This negative feedback provides damping which reduces the overswings of the heading pointer to about three under extreme conditions. The mechanical friction brake, with its need for frequent re-setting is thus eliminated.

**94.** The 0·25 μF capacitor C20 remains disconnected if the follow-up motor is fitted, but it is re-connected if a tacho-generator is fitted.

*Annunciator*

**95.** The annunciator is mounted on the Selsyn

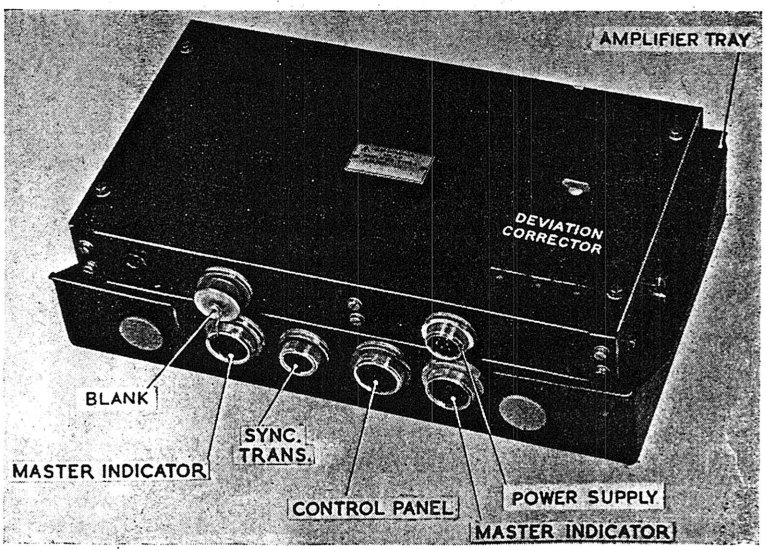


**Fig. 9. Amplifier, Type A, and mounting tray**

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casting, and it consists of a flag displaying a dot or a cross below the N point of the dial. The flag is carried on the end of a pivoted staff the other end of which carries a small permanent magnet, and swings between two coils wound on soft iron pole pieces. The cross is luminized and the dot is filled in white as with the gyro unit annunciator.

**96.** The annunciator coils are connected in series with those of the gyro unit and the currents in the D and F lines are balanced at about 6·5 mA when the gyro unit is synchronized, in azimuth, with the detector unit. Under these conditions the centralized flag shows portions of both dot and cross.

**97.** Should the gyro unit card be out of synchronizm, the currents in the D and F lines change in value, but not in sense. For example, if the current in D line exceeds that in F line, the gyro unit card is precessed to a higher reading and, at the same time, the magnet on the staff is attracted by the appropriate coil so that the flag indicates a cross.

**98.** Under normal flight conditions in piston-engined aircraft, the dot and the cross will appear alternately in the annunciator window due to the flux valve in the detector unit moving about its neutral position. The movement is caused through vibration effect and air turbulences affecting the aircraft. In jet-propelled aircraft, however, the flag will alternately show a dot and a cross at a slower rate. Such a condition is quite normal and is due to the absence of vibration and to the stable straight flight path of this type of aircraft.

**99.** When the gyro is precessing, either a dot or a cross will be displayed continuously, the particular indication shown depending on the direction of precession. If the dot or the cross is continuously displayed under normal straight flight conditions, the gyro should be re-synchronized (para. 46)

**100.** When the compass is switched to D.G. and is functioning as a directional gyro, an electro-magnetic indicator is energized in the gyro unit causing a small flag marked D.G. to move in front of the annunciator flag and mask its indications. A similar indication fitted in the later series of master indicators is also energized by the operation of the selector switch and operates in the same manner, so that a D.G. indication is displayed in the annunciator windows of both indicators. This device is fitted to all master indicators with serial numbers from 464 upwards.

*Automatic pilot control*

**101.** The automatic pilot control shaft, operated by the automatic pilot control knob is fitted with a clicker mechanism which operates once during each complete revolution of the shaft. Limit stops are fitted which prevent the shaft from being turned more than eight revolutions in each direction. Each revolution of the shaft is equivalent to an alteration in aircraft heading of ½°, and thus a maximum correction of 4° to port or to starboard can be made.

**102.** A spur gear on the end of the control shaft engages with an intermediate gear train which is in mesh with a quadrant gear. The quadrant gear is bolted to the pick-off potentiometer and thus, when the control knob is turned, the potentiometer rotates and the position of the brush contact relative to the centre tap on the potentiometer is altered as shown in fig. 19. A signal is therefore transmitted to the auto-pilot and a change of course results.

**Note . . .**

*The pick-off incorporated in the Type A master indicator of the Mk. 4B compass is designed specifically for use with the automatic pilot Mk.9.*

**Master indicator, Type B** (fig. 25)

**103.** The master indicator, Type B, differs from the Type A indicator in the variation dial presentation and the auto-pilot pick-off. The aperture through which the variation dial is visible has been modified and it is located in the 9 o'clock position. This has enabled all the figures to be included in the scale numbering and the caption "X10" used on the Type A scale to be eliminated. The scale has also been sub-divided into 1° intervals, a finer lubber mark has been provided and the scale markings are now in black on a white dial. The facility for trimming the course held by the auto-pilot has been deleted from the Type B unit, this has resulted in the elimination of the knob and associated mechanism at the bottom of the instrument. The range of the pick-off potentiometer has also been increased from ±4° to ±10°; although the total monitoring signal for the full misalignment remains unaltered at 300 mV. The Type B unit is suitable for operation with the auto-pilots Mk. 9 or Mk. 10. All Type B master indicators are fitted with a tacho-generator.

**Master indicator, Type C**

**104.** This instrument is basically a Type B indicator with a screened step-by-step transmitter containing a filter for the d.c. supply. The internal link connecting A (salmon) to C (lemon) connectors is deleted and the 28V, d.c. supply for repeaters is fed in at A and B of the (salmon) connector. 28V, d.c. must still be provided at D (white) on the amplifiers for the operation of the deviation network. The aircraft installation does not require screened cable for interconnection of items except between the step-by-step transmitter and the suppressor to which the d.c. supply is connected.

**Master indicators, Type D and D8**

**105.** In the Type D and D8 master indicators, the front bezel and housing accommodating the synchronizing mechanism are basically similar

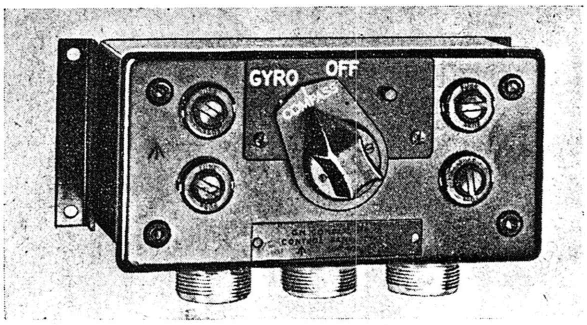
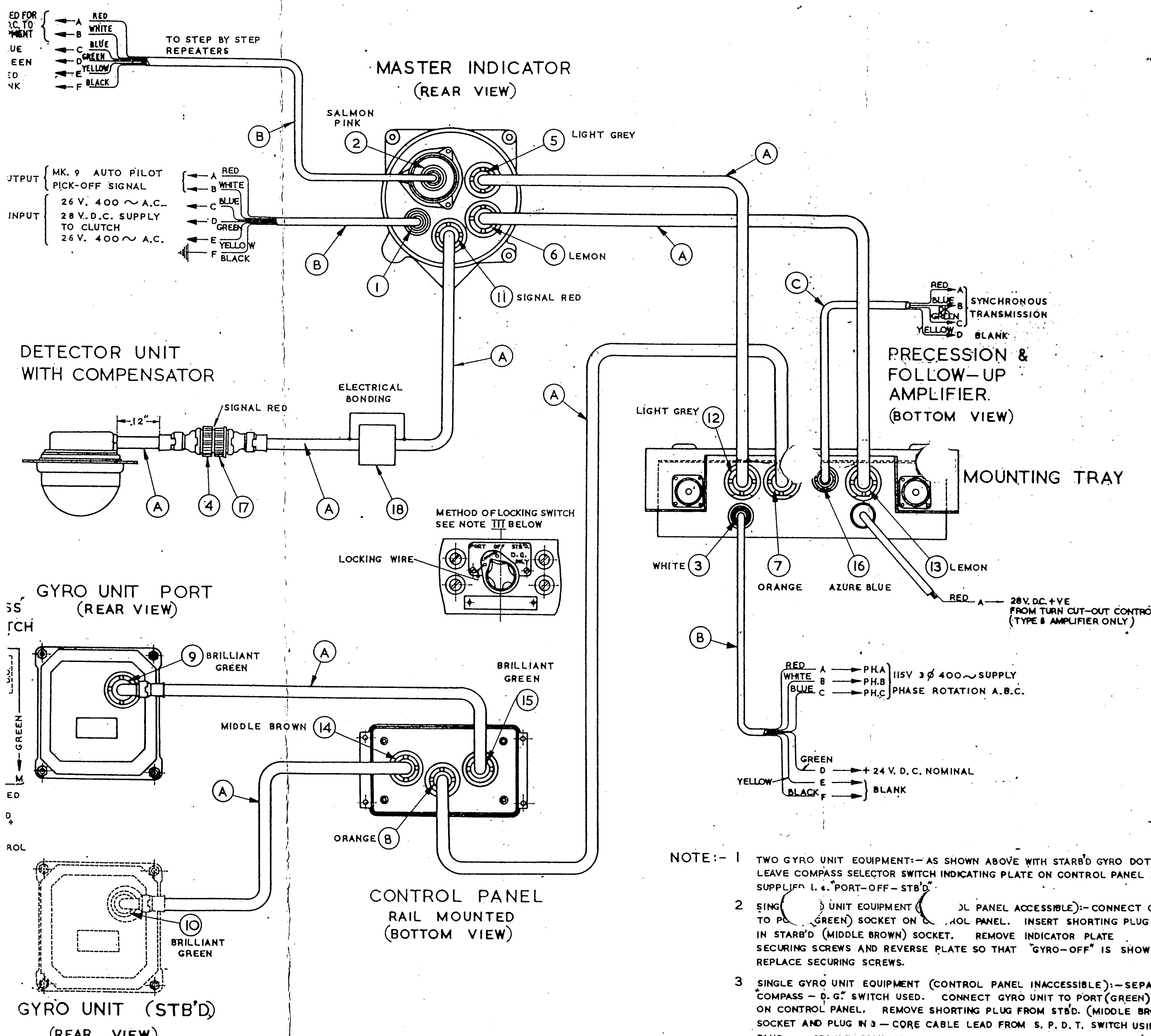



**Fig. 10. Control panel, bulkhead mounting, Type A**




NOTE:- 1 TWO GYRO UNIT EQUIPMENT:– AS SHOWN ABOVE WITH STARB'D GYRO DOTTED. LEAVE COMPASS SELECTOR SWITCH INDICATING PLATE ON CONTROL PANEL AS SUPPLIED I.e. "PORT–OFF–STB'D".

2 SING[illegible] UNIT EQUIPMENT ([illegible]OL PANEL ACCESSIBLE):– CONNECT GYRO UNIT TO PO[illegible](GREEN) SOCKET ON C[illegible]ROL PANEL. INSERT SHORTING PLUG IN STARB'D (MIDDLE BROWN) SOCKET. REMOVE INDICATOR PLATE SECURING SCREWS AND REVERSE PLATE SO THAT "GYRO–OFF" IS SHOWN. REPLACE SECURING SCREWS.

3 SINGLE GYRO UNIT EQUIPMENT (CONTROL PANEL INACCESSIBLE):– SEPARATE "COMPASS – D.G." SWITCH USED. CONNECT GYRO UNIT TO PORT (GREEN) SOCKET ON CONTROL PANEL. REMOVE SHORTING PLUG FROM STB'D. (MIDDLE BROWN) SOCKET AND PLUG IN 3 – CORE CABLE LEAD FROM S.P.D.T. SWITCH USING REDUCER PLUG. SECURE COMPASS SELECTOR SWITCH IN PORT POSITION WITH LOCKING WIRE.

## DETAILS OF PLUGS, SOCKETS & COUPLER PLUG ATTACHED TO CABLE ENDS

| No. OF WAYS | DESIGNATION | COUPLER PLUG BODY ASS'D. | SOCKET BODY ASS'D. | PLUG BODY ASS'D. | OUTLET GASKET | OUTLET & NUT ASS'D | SEALING RING | INNER FERRULE | OUTER FERRULE |
|---|---|---|---|---|---|---|---|---|---|
| 6 | 1 | | Z.560542 | | Z.970058 | Z.970062 | Z.970088 | Z.970078 | Z.970077 |
| 6 | 2 | | | Z.560360 | Z.970058 | Z.970062 | Z.970088 | Z.970078 | Z.970077 |
| 6 | 3 | | Z.560120 | | Z.970058 | Z.970062 | Z.970088 | Z.970078 | Z.970077 |
| 12 | 4 | Z.560470 | | | Z.970059 | Z.970065 | Z.970091 | Z.970084 | Z.970083 |
| 12 | 5 | | Z.560184 | | Z.970059 | Z.970065 | Z.970091 | Z.970084 | Z.970083 |
| 12 | 6 | | Z.560182 | | Z.970059 | Z.970065 | Z.970091 | Z.970084 | Z.970083 |
| 12 | 7 | | | Z.560363 | Z.970059 | Z.970065 | Z.970091 | Z.970084 | Z.970083 |
| 12 | 8 | | Z.560181 | | Z.970059 | Z.970065 | Z.970091 | Z.970084 | Z.970083 |
| 12 | 9 | | Z.560185 | | Z.970059 | Z.970072 | Z.970091 | Z.970084 | Z.970083 |
| 12 | 10 | | Z.560185 | | Z.970059 | Z.970072 | Z.970091 | Z.970084 | Z.970083 |
| 12 | 11 | | | Z.560360 | Z.970059 | Z.970065 | Z.970091 | Z.970084 | Z.970083 |
| 12 | 12 | | | Z.560360 | Z.970059 | Z.970065 | Z.970091 | Z.970084 | Z.970083 |
| 12 | 13 | | | Z.560362 | Z.970059 | Z.970065 | Z.970091 | Z.970084 | Z.970083 |
| 12 | 14 | | | Z.560361 | Z.970059 | Z.970065 | Z.970091 | Z.970084 | Z.970083 |
| 12 | 15 | | | Z.560365 | Z.970059 | Z.970065 | Z.970091 | Z.970084 | Z.970083 |
| 4 | 16 | | | Z.560290 | Z.970058 | Z.970062 | Z.970088 | Z.970078 | Z.970077 |
| 12 | 17 | | Z.560180 | | Z.970059 | Z.970065 | Z.970091 | Z.970084 | Z.970083 |
| — | 18 | WING ROOT, TRANSPORT OR PRESSURE BULKHEAD JUNCTION BOX | | | | | | | |
| — | A | 12 CORE VINMETSMALL CABLE | | | | | | | |
| — | B | 6 CORE VINMETSMALL CABLE | | | | | | | |
| — | C | 4 CORE VINMETSMALL CABLE | | | | | | | |
| — | D | 3 CORE VINMETSMALL CABLE | | | | | | | |

INTER-UNIT CONNECTOR DIAGRAM AND DETAILS OF PLUGS, SOCKETS AND COUPLER PLUG FIG. 11

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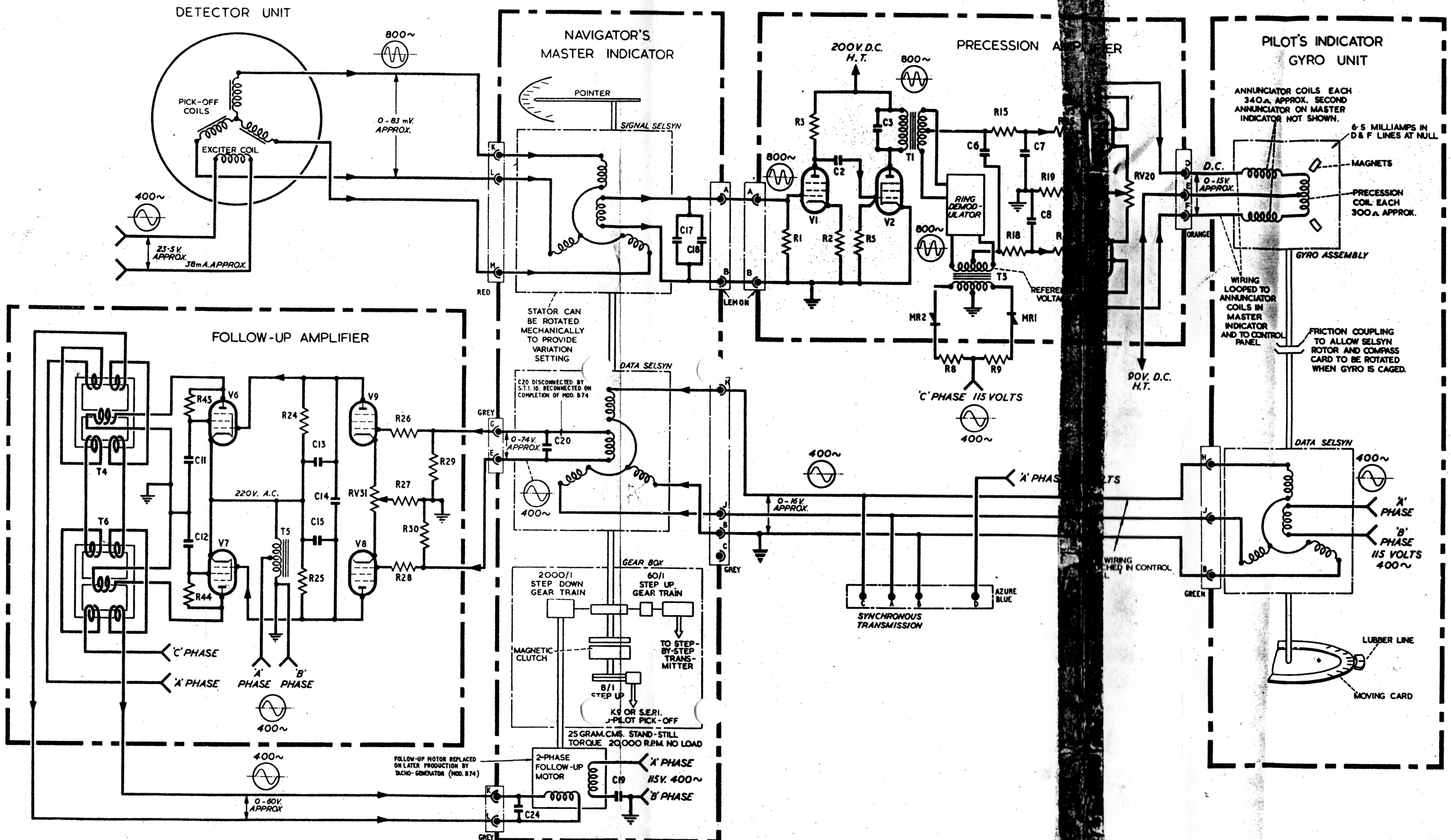


Fig. 12

**Functional diagram, G-M Compass, Mk. 4B, Type A equipment**

Fig. 12

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PP8343 263129/8636 4/58 C & P Gp. 959 (4)

(A.L.11, Feb.58)

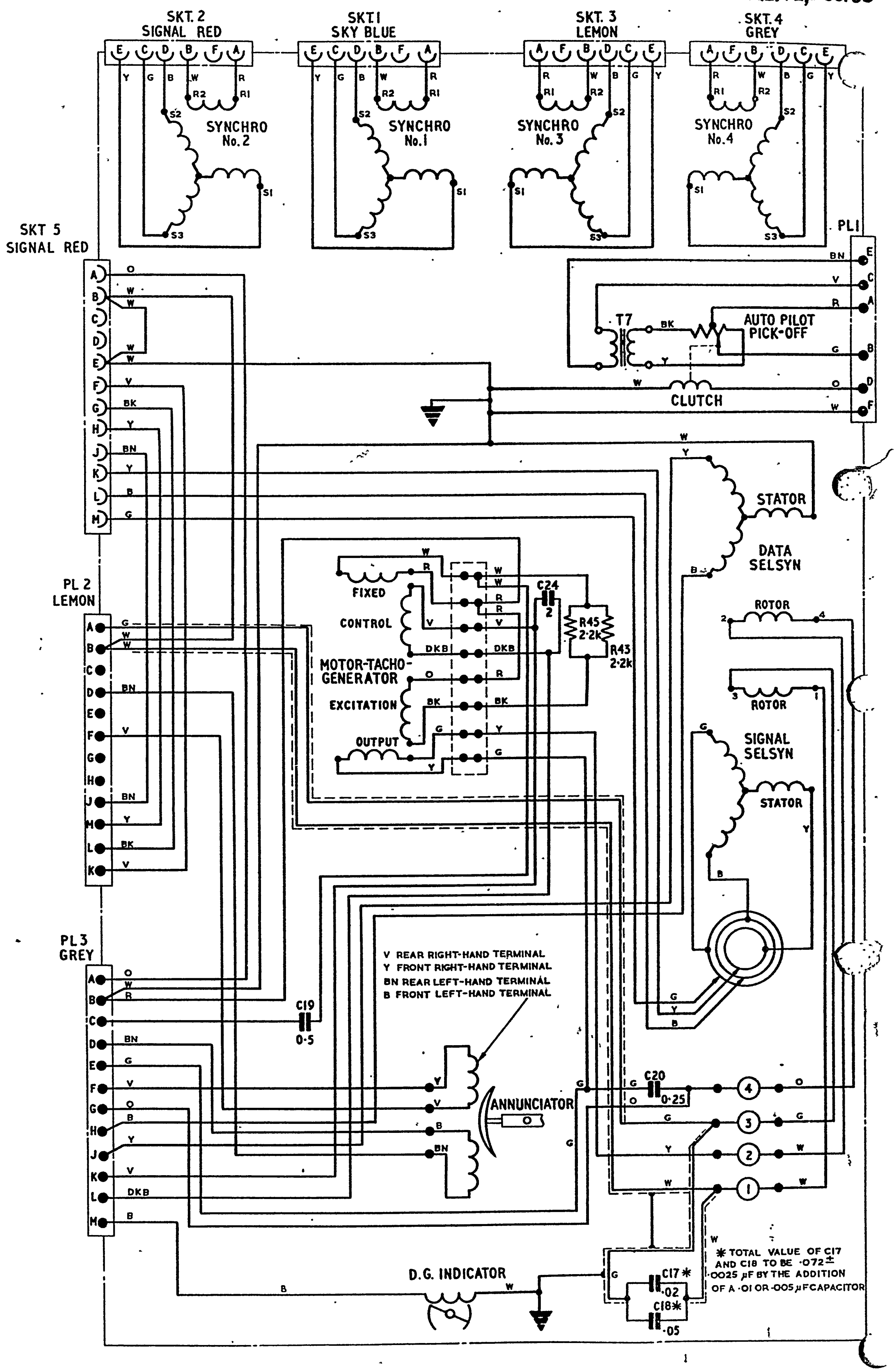


Fig.12A Master indicator, Type D8 - circuit diagram to the Types B and C master indicators. The gear train and back plate assembly has been re-designed to accommodate up to a maximum of four transmitting synchronizing units, (one being fitted in the Type D instrument and four being fitted in the Type D8 instrument. The circuit diagram of the Type D8 master indicator is given in fig. 12A). ▶ This has been necessary owing to the increasing number of radio and electronic equipment installed in aircraft, which require accurate heading information from the synchronous system. No provision is made for M-transmission in these indicators.

**Master indicators, Type E and E4**

**105A.** The master indicators Type E and E4 are dealt with in Appendix 3 to this chapter.

**Gyro unit, Type A**

*General*

**106.** This unit, Type A, a sectional view of which is given in fig. 8, can conveniently be considered to consist of three main assemblies: the gyro assembly, the Selsyn bezel assembly and the chassis. The gyro assembly is fitted in the chassis which is bolted to the Selsyn bezel assembly. The complete unit is enclosed by a metal cover, which fits into a neoprene sealing gasket, behind the bezel casting and is secured, together with the back plate, by four screws. Two breathers covered with tropicalized felt are provided on the top surface at the rear of the cover.

*Gyro assembly*

**107.** The gyro is a 3-phase squirrel-cage induction motor, the rotor of which spins at approximately 23,000 rev/min. The rotor is of mild steel and is of cup cross-section with a central shaft. Its interior is sleeved with a cylindrical insert of aluminium alloy centrifugally cast about a laminated iron core, and forms the squirrel-cage armature of the motor.

**108.** The rotor housing is a light-alloy casting, one end of which is spanned across its diameter by a bridge-piece which carries one bearing for the rotor shaft. This is a ball type bearing, the balls being housed in a plastic cage. The other end of the rotor housing carries the stator windings of the motor which are supported by the stator tube surrounding the rotor shaft. The rotor shaft projects through the rotor housing and is carried in a ball race which is fitted in a brass cup in the rotor housing end plate. The brass cup is spring-loaded inwards by a coil spring between the cup and the bearing cover plate in order to provide automatic compensation for temperature variations.

**109.** The inner gimbal ring has two bearing pivots on its outside at right-angles to the rotor axis which fit into ball races on the vertical gimbal ring. The bearing pivots are insulated, and extend through the vertical gimbal ring to serve as commutators for light spring contacts through which the electrical connections to the gyro stator are made. The circuit diagram of the gyro unit is given in fig. 27.

*Erection mechanism*

**110.** A torque motor is used to maintain the gyro spin axis horizontal. The stator of this motor is mounted on the top of the vertical gimbal ring whilst the squirrel-cage rotor is secured to the gyro assembly.

**111.** If the gyro spin axis tends to depart from its position at right-angles to the vertical ring axis, an electrical contact is made via the levelling switch. This switch is in the form of a two-segment commutator and two diametrically opposed brushes. The two segments of the commutator are continuously energized at approximately 2 volts a.c. from phases A and B via a small auto-transformer mounted on the vertical ring.

**112.** Two brushes are mounted on the vertical ring and are connected to the control winding of the torque motor stator so that when the gyro rotor axis tilts from the horizontal, the commutator rotates, establishing contact with the brushes on the vertical ring, and causing the torque motor to be energized. The rotating field induced in the stator reacts with the rotor which is mounted on the gyro unit chassis to produce a torque which causes the gyro to precess about its horizontal axis until its spin axis is again at right-angles to the vertical axis. The gyro should precess through 30° of tilt in 4 to 8 minutes.

*Precession*

**113.** The compass indication is monitored to the magnetic meridian by precessing the gyro in azimuth by a d.c. signal applied to the precession coil on the vertical gimbal ring.

**114.** By referring to fig. 8, it will be seen that the rotor housing has attached to it two curved permanent magnets, which pass through the precession coil. At null, 13mA d.c. flow from E pin of the amplifier orange connector to the centre of the coil, about 6·5 mA flowing back to the amplifier in the D and F lines. The magnetic effect of the two halves of the precession coil upon the horn magnets is therefore balanced. As soon as any misalignment signal is produced the balance in the D and F lines is disturbed, building up to a maximum of 15mA differential current about 3° off null (further misalignment of the signal rotor does not increase the amplifier output). One half of the coil having more current passing than the other, a pull is exerted on the unit north pole created by the horn magnets. This will cause the gyro vertical ring to precess in the direction necessary to restore the alignment of the compass card with the magnetic heading of the aircraft. With 15·5mA d.c. in one half of the coil and 1mA in the other gyro should precess 20° in azimuth in between 5 and 8 minutes. When the current in the D line exceeds that in the F line the annunciator displays a cross and the gyro is precessed to a higher reading.

**115.** Electrical connection to the precession coil is made via three brushes which contact three slip rings on the bottom pivot of the vertical gimbal ring. A large bevel gear is mounted horizontally on the base of the vertical gimbal ring and engages with a second vertically-mounted bevel gear on the

Selsyn rotor shaft which also carries the compass card. Any movement of the gyro in azimuth is, therefore, transmitted to the compass card by the bevel gears.

**116.** The caging mechanism of the gyro consists of two alloy rings situated below the horizontal bevel gear at the base of the gyro vertical ring. The upper ring carries three tapered cam projections which engage with three corresponding slots in the lower ring.

**117.** When the synchronizing control knob is pushed in, the lower ring is rotated slightly, and the cams, moving up the slots, cause the upper ring to lift, locking the bevel gear so that it cannot rotate. At the same time, a caging arm is raised by the upward movement of the ring so as to level and cage the rotor housing, thus preventing the gyro from precessing and toppling while the compass is being synchronized.

*Selsyn and bezel assembly*

**118.** This assembly consists of two castings one forming the gyro unit and face and carrying the bezel glass, dial, synchronizing control knob and annunciator window. The assembly also incorporates the operating mechanism for the synchronizing and set course controls, an annunciator, an auto-transformer, and the shaft which carries the course pointer, compass card, data Selsyn rotor and the vertical bevel gear.

**119.** The lubber line is marked at the top of the bezel and is also etched and fluorized on the bezel glass. The aircraft heading rectangle and two parallel grid lines are provided on the glass to assist the pilot in maintaining an accurate course. The course pointer and a matching reference in the form of a rectangle, are marked on a circular metal plate which is friction loaded to the compass card by an annular friction pad. The compass card is engraved from 0° to 360°. Fluorescent material is used throughout for all markings, except the annunciator.

*Set course control*

**120.** This control is operated by a knob located at the bottom left-hand corner of the instrument face. When the set course is pressed in, the course pointer plate is lifted slightly off the friction pad. A gear on the shaft extending from the set course knob is constantly in mesh with a second gear carried on a sleeve fitted to the Selsyn assembly casting. As the knob is turned, this sleeve rotates three ball bearings which project through apertures in the compass card mounting and bear on the course pointer plate causing it to rotate. When the set course knob is released, contact between the course pointer plate and the friction pad is restored and the course pointer is again friction loaded to the compass card.

*Synchronizing control*

**121.** This control is operated by a knob, marked with a DOT and CROSS and direction arrows. It is situated at the bottom right-hand corner of the bezel. When the knob is pushed in and turned, a train of gears is operated which rotates the Selsyn rotor and the compass card. Since the horizontal bevel gear on the vertical ring of the gyro is now locked (para. 117), a slipping clutch assembly is interposed between the vertical bevel gear and the shaft carrying the compass card, so that when the knob is turned the card and the Selsyn rotor can be rotated relative to the Selsyn stator. By means of this control and the follow-up mechanism the signal Selsyn rotor in the master indicator can be quickly brought to null, thus synchronizing the compass card indication with the magnetic heading of the aircraft. It is possible to obtain a false (unstable) null 180° out. The annunciator will then show a dot for reading below null. If the direction arrows on the knob are followed, the correct null will be found.

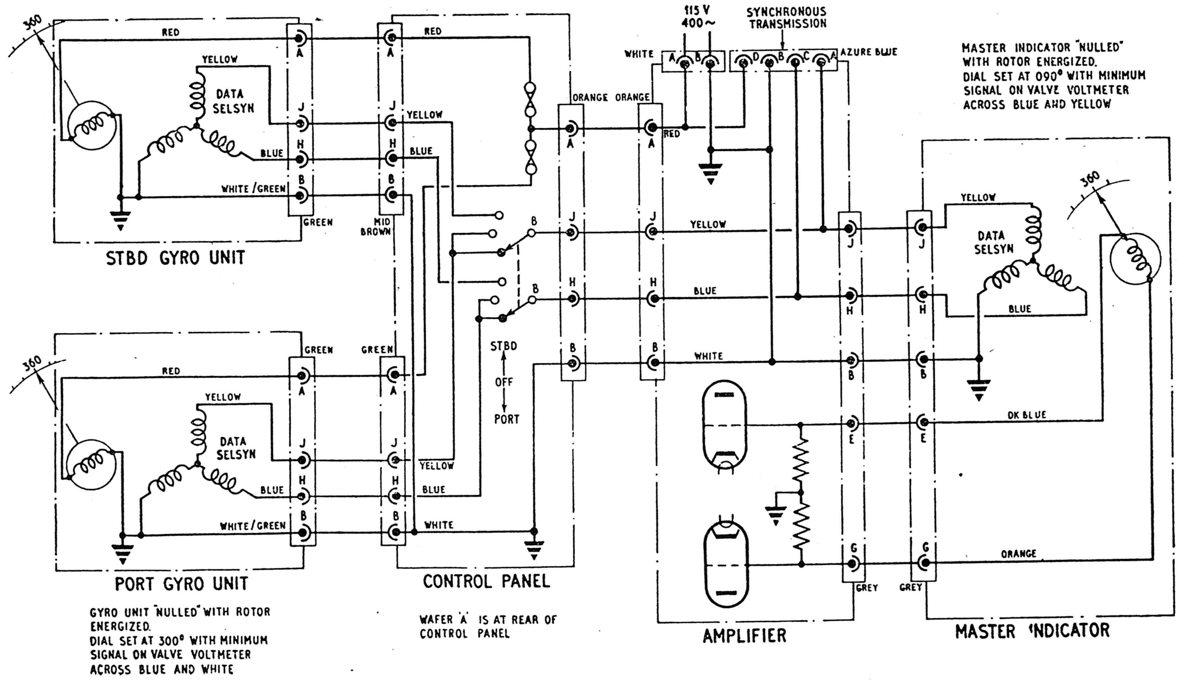


**Fig. 13. Data Selsyn circuit**

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*Chassis*

**122.** The chassis is bolted to the selsyn assembly casting and carries the bearings for the vertical gimbal ring, the slip ring brushes for the a.c. supply, the annunciator and the back cover plate.

*Annunciator*

**123.** This device is included in the gyro unit to provide a constant indication which enables the pilot to verify whether or not the compass is synchronized with the earth's magnetic field. It consists of a small flag marked with a dot and cross which is visible through a window in the top right-hand corner of the bezel. The flag is carried at one end of a pivoted staff, on the other end of which is mounted a small permanent magnet which swings between two coils wound around soft iron pole-pieces. The coils are connected in series with

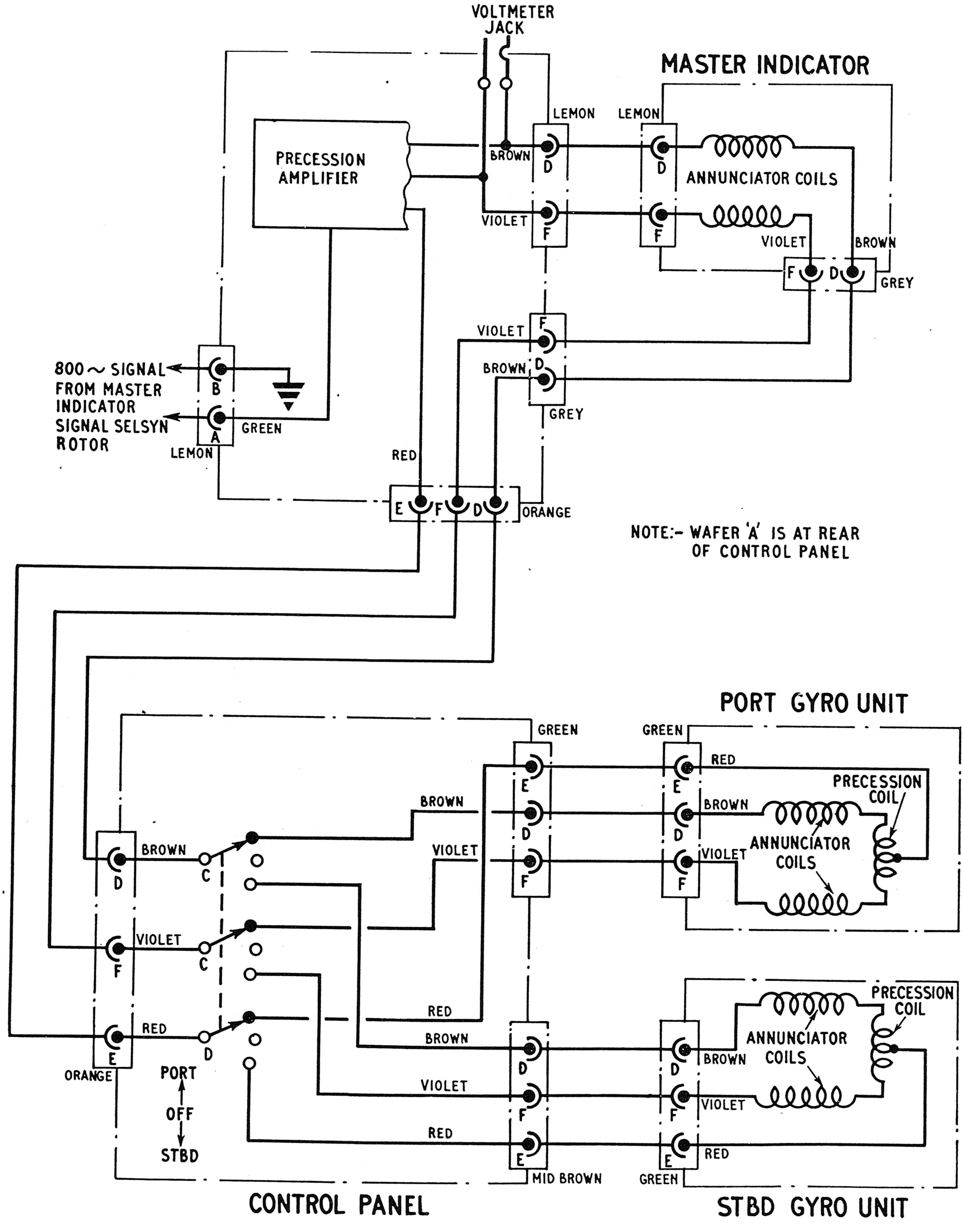


**Fig. 14. Precession circuits (Type A)**

the annunciator coils in the master indicator and, together with the precession coil, are energized by the amplified signals from the detector unit. Mod. B89 provides an improved mechanism with large pole pieces to give a better defined null. This modification also removes the corner, on Type B only.

**124.** In piston-engined aircraft the flag will move from side to side and the dot and the cross will alternately be visible. In jet-propelled aircraft, however, the alternations will be slower and the dot or cross may be only partially visible. When the gyro is precessing, either the dot or the cross will be continuously displayed, the particular indication shown depending on the direction of precession. These indications are characteristic and have already been explained in the description given of the annunciator in the master indicator (*para.* 95 *to* 100).

**125.** When the selector switch is in the OFF position, a coil, mounted on the back of the bezel assembly, is energized and causes a small flag marked D.G. to be moved in front of the annunciator flag. An electro-magnetic indicator is also energized and a similar indication is shown in the annunciator window of that instrument.

*Cover*

**126.** The gyro unit is enclosed in an alloy cover which fits into a neoprene sealing gasket at the back of the bezel. Circular breather apertures covered with tropicalized felt are provided on the front top surface of the cover, and two drains on the bottom surface. The cover is secured to the chassis by eight screws which also pass through the back plate.

*Back plate*

**127.** The alloy plate which closes the back of the chassis is secured in place by four screws and carries a 12-pin plug for connection to the control panel.

**Gyro unit, Type B** (*fig. 28 and 29*)

**128.** The main changes are in the bevel gear linking the card to the vertical gimbal ring, and in the introduction of an a.c. precession system.

**129.** In the Mk. 4B compass, synchronous transmission of heading information is obtained from a transmitter mounted behind the card of the gyro unit. This is coupled to the vertical gimbal ring by the large bevel gear. In order to maintain a sufficiently low level of friction in this system, it is necessary to give a tolerance of $\frac{1}{4}$ deg. backlash in the bevel gear. In certain associated equipments it is desired to make use of the azimuth stabilization provided by the compass gyro unit. For this application the presence of $\frac{1}{4}$ deg. backlash in the transmission is very undesirable. In the Type B gyro unit, the simple bevel wheels are replaced by wheels the main drive of which is taken by friction surfaces, a portion of tooth being retained to eliminate the possibility of cumulative slip.

**130.** As with the Mk. 4F compass, trouble is sometimes occasioned by interference caused at the emergency compass by the permanent magnets used for the d.c. precession system of the Type A gyro unit. This has been largely eliminated in the Type B unit by the introduction of an a.c. precession system not requiring permanent magnets. The safe distance of a Type B gyro unit is considerably better that that for a Type A, the values being quoted in A.P.970, Vol. 2, Leaflet 717.

**131.** Referring to the wiring diagram (*fig.* 30) it will be seen that the precession coil is replaced by a precession motor with two separately wound coils. One coil is connected to a 30V, a.c. supply derived from the transformer mounted on the front bezel casting, and is permanently energized.

**132.** Mounted on the inside of the backplate are two transductors the output coils of which are connected in antiphase via the second, or control, coil of the precession motor. If, therefore, the output of each coil is equal (at approximately 20V), then no current passes through the control coil of the precession motor.

**133.** The primary windings of the two transductors are wired in series and are connected to "A" phase 115V.

**134.** If the signal selsyn rotor is at null and there is no 800 c/s signal input to the precession amplifier, about 13 mA flows from E pin of the amplifier through the d.c. windings of each transductor, the D and F lines each carrying approximately 6·5 mA. The outputs of the transductors being matched no current passes through the control coil.

**135.** As soon as the signal selsyn rotor is moved from null the consequent 800 c/s signal input causes a change in the D and F line currents returning to the amplifier, one increasing and the other decreasing. Should, for example, the D line current increase, then the output of the D transductor will diminish and that of the F transductor increase so as to cause a current to flow in the control coil of the precession motor.

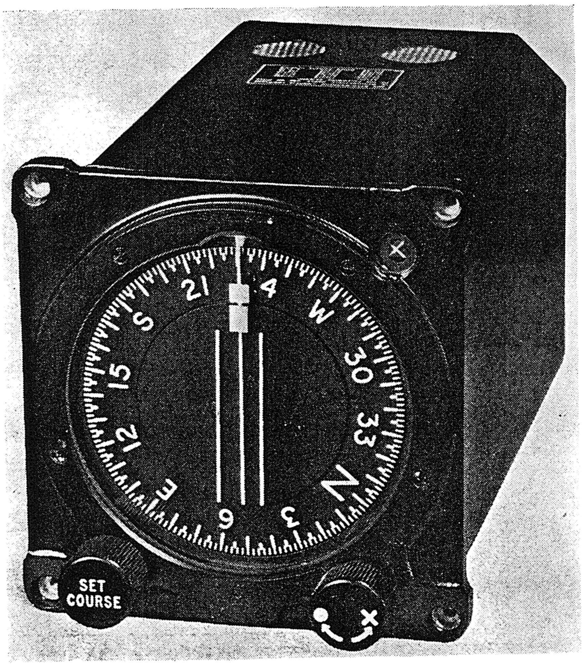


**Fig. 15. Presentation of gyro unit, Type A**

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**136.** The two coils of the motor now being energized, a pull is exerted on the copper-plated mu-metal armature ring (electro-tin finish) which is fitted to the inner ring in place of the Type A horn magnets. This torque on the inner ring causes the gyro to precess in azimuth and, through the bevel gearing and data selsyn follow-up mechanism, to return the signal selsyn rotor to null.

**137.** At 1 degree of null the difference between the D and F line currents will be approximately 8 mA and under these conditions the voltage across the control coil is about 12V.

**138.** Mod. B.101 introduced the capacitors in the transductor circuit, as previously an interference signal caused a Type B gyro unit to synchronize to a slightly different heading from a Type A. No Type B gyro unit should be fitted without this modification.

**139.** A proportion of Type A gyro units tend to change their drift rate at extremes of ambient temperature. To obviate this effect all Type B units, except those of early manufacture, have been modified to Modification Inst./B98. This provides a bi-metal support for a small azimuth balance weight, which is located on the opposite side of the gyro to the drift nut.

**140.** On the gyro cover the breather vents which were originally on the top surface have been moved to the sides to avoid the possibility of water percolating through the felt and dripping down onto the actual gyro assembly. The cover has been lightly formed in the region of the top and bottom slip-rings to provide increased clearance.

◄ **Gyro units, Type C and D** ►

**141.** The gyro unit, Type C (*Ref. No.* 6*B*/557), is used for the automatic pilot Mk. 11. It is essentially a Type B unit fitted with a pick-off to provide azimuth reference signals for the automatic pilot. ◄ The Type D gyro unit is dealt with in Appendix 2 to this chapter. ►

**Amplifier, Type A** (*fig.* 9, 31 *and* 32)

**142.** The precession amplifier is employed to amplify and rectify the monitoring signals, relayed from the detector unit by the signal Selsyn in the master indicator before they are applied to the precession coil on the gyro.

**143.** Although this amplifier is contained in the same case as the follow-up amplifier, it is electrically a completely separate unit. It comprises four amplifying valves, a half-wave rectifying valve for H.T. supplies and a phase-discriminating rectifier circuit.

**144.** A d.c. voltage stabilizing circuit and two calibrated centre-tapped potentiometers for adjusting the current to the electro-magnet deviation compensator (*para.* 10) are also incorporated and a jack socket is provided for an external centre zero voltmeter used when calibrating the compass. This meter is connected across D and F precession lines and will read zero when the gyro unit is synchronized.

**145.** The case in which both amplifiers are contained is secured to a mounting bracket by four bolts which pass through anti-vibration mountings on the bracket, and screw into four tapped bosses. These bolts are part of the tray and not the amplifier. The plug and socket connections are as shown in Table 1.

*Circuit description*

**146.** Referring to the precession amplifier test circuit diagram included in fig. 24, it will be seen that the signal input is applied, via a screen lead, directly to the control grid of V1 which functions as an amplifier. Cathode bias for this valve is obtained from the voltage drop across R2; R3 is the load resistor connecting the anode of V1 to the H.T. line. After amplification, the signals are fed via the capacitor C2 to the control grid of V2 which also functions as an amplifier in the same manner as V1.

**147.** The anode circuit of V2 includes the primary winding of the transformer T1. The capacitor C3 (C25 was deleted by Mod. B.111), across the inter-stage primary, serves as a final correction to the phase of the incoming signal. This ensures that the

**Table 1**

**Plug and socket connectors**

| Type | Colour code | Connection |
|---|---|---|
| 12-pole socket | Light grey | To master indicator |
| 12-pole socket | Orange | To control panel |
| 4-pole socket | Azure blue | To equipment requiring synchronous transmission |
| 12-pole socket | Lemon | To master indicator |
| 6-pole plug | White | To power supplies |

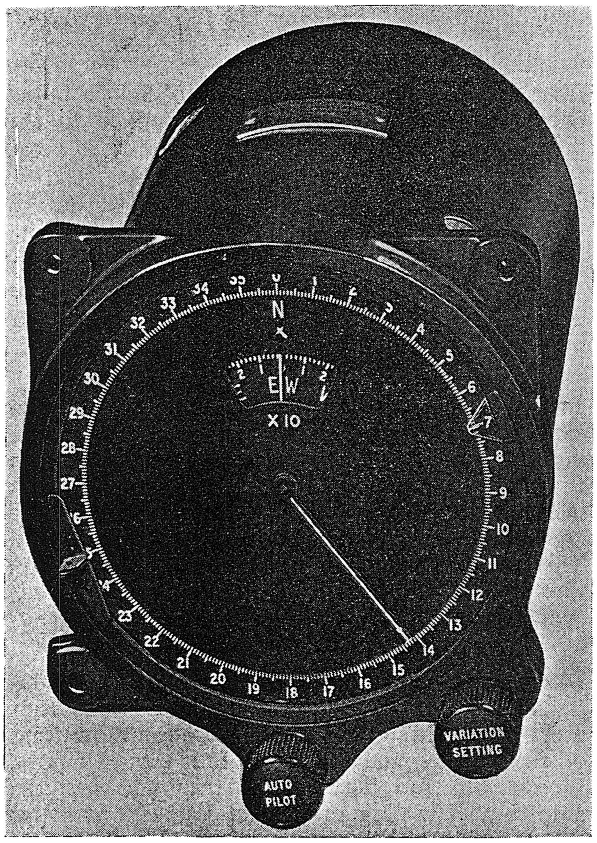


**Fig. 16. Presentation of master indicator, Type A**

amplified 800 c/s signal applied to the ring bridge demodulator is either in phase or 180° out of phase with the reference voltage. In effect the initial phase adjustment is provided by the capacitance across the signal Selsyn rotor, which is determined on test.

**148.** The amplified signals are then applied via the secondary winding of T1, to a ring demodulator circuit consisting of the four metal rectifiers MR3-MR6 and the resistors R11-R14.

**149.** A reference a.c. voltage is also applied to the demodulator circuit from the secondary winding of T3. The frequency of the reference voltage is the same as that of the signal input, i.e., 800 c/s, and is obtained by the circuit arrangement of the primary winding of T3 and the action of the two rectifiers MR1 and MR2.

**150.** The amplitude of the reference voltage is arranged to be large in comparison with the signal voltage, but is prevented from over-loading the rectifiers, when they are conducting, by the resistors R11 to R14 which are included for this purpose.

**151.** The ring demodulator functions as a phase sensitive rectifier circuit by means of which a d.c. voltage is obtained from the centre-taps on the secondaries of T1 and T3, the magnitude and direction of this voltage varying in accordance with the amplitude and sign (relative to the reference voltage) of the signal input.

**152.** After demodulation, the rectified half-cycles are smoothed by C6 and are then fed, via the resistors R15 and R18, to the control grids of V3 and V4 where they are power amplified and applied in d.c. form either to the precession coil on the Type A gyro unit or to the d.c. windings of the transductors on the Type B gyro unit.

**153.** With the signal input earthed, the outputs of V3 and V4 should be equal at approximately 6·5 mA. Cathode bias to these valves is controlled by the adjustment of the pre-set resistor R38 and their outputs are balanced by suitably adjusting

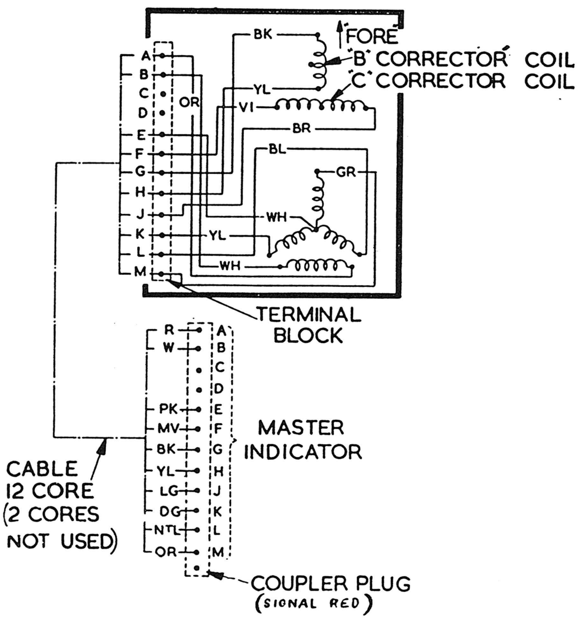


**Fig. 17. Circuit diagram, detector unit**

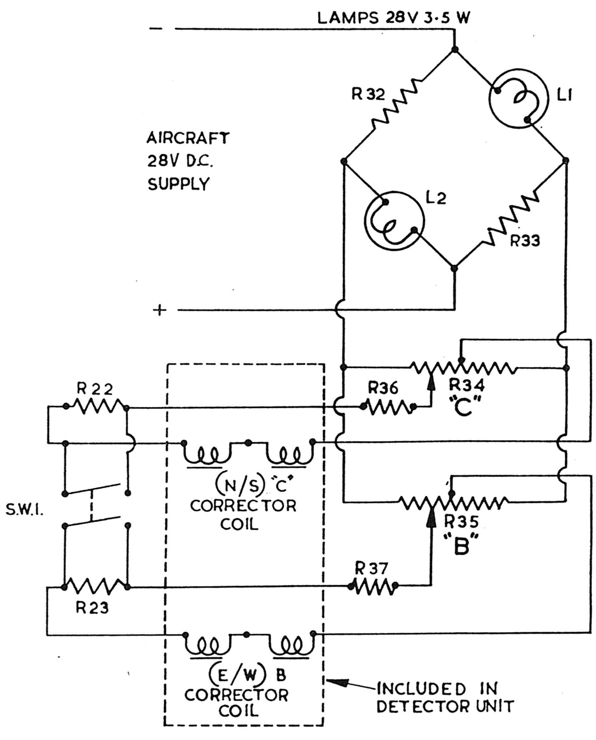


**Fig. 18. Electrical compensator circuit**

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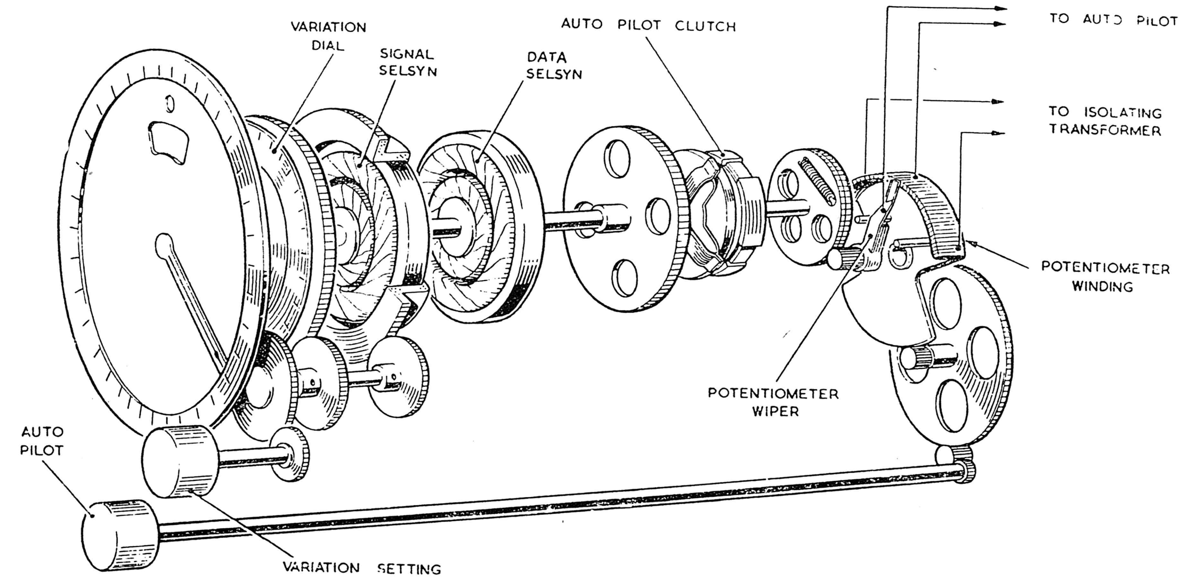


**Fig. 19. Selsyn and automatic pilot pick-off assembly (Type A)**

R20. All amplifier valve heaters are connected in parallel to the heater winding on the power transformer T2, and the requisite H.T. supplies are obtained from the cathode of the rectifier valve V5, which is also connected to pin E of the gyro unit.

*Ring demodulator circuit*

**154.** This part of the amplifier circuit can be considered to function as a double-pole change-over switch whereby the amplified alternating signals originated by the flux valve are converted into rectified half-cycles of a.c.

**Follow-up amplifier** (*fig. 31*)

*General*

**155.** The follow-up amplifier is employed to provide a suitable a.c. power output related in amplitude and sign to the signal input, which is used to energize the control winding of the follow-up motor and so maintain synchronism between the master indicator and the gyro unit.

**156.** The amplifier incorporates four valves forming a two-stage a.c. phase discrimination amplifier followed by a transductor output. Transductors, sometimes referred to as magnetic amplifiers, are essentially saturable reactors of special design and are used in pairs. They are reliable in operation, and in the follow-up amplifier they have been preferred to the large output valves which would otherwise have been required. A description of their mode of operation is given in para. 165 to 171.

*Circuit description*

**157.** By referring to the follow-up amplifier circuit diagram included in fig. 32, it can be seen that the amplifier comprises a two stage phase discriminator of push-pull amplification, both of which are supplied with an alternative H.T. voltage of the same frequency and phase as the a.c. supply to the data selsyn in the master indicator.

**158.** The rotor winding of the data selsyn is connected to the input of the amplifier, and under no signal conditions the valves V8 and V9, which comprise the first stage of amplification, carry equal pulse of anode current during the positive half-cycles of the H.T. supply; thus their anode potentials are always equal.

**159.** The anodes of V8 and V9 are connected directly to the control grids of V6 and V7 repectively, which comprise the second stage of amplification. The anodes of V6 and V7 are also supplied with an alternative H.T. voltage obtained from the common H.T. transformer T5, but the phase opposite to that supplied to V8 and V9. Hence, equal pulses of anode currents are carried by V6 and V7 but, due to the difference in the polarity of the H.T. supply, only when V8 and V9 are non-conducting.

**160.** The capacitors C13, C14 and C15 form the coupling between the first and second stages of amplification, and during the periods when V8 and V9 are conducting, C15 and C13 store a proportion of the anode voltage of these valves. This voltage is applied to the control grids of V6 and V7 during the next half-cycle thus bringing V6 and V7 to near cut-off point.

**161.** When an a.c. signal of one polarity is applied to the control grids of V8 and V9 from the data

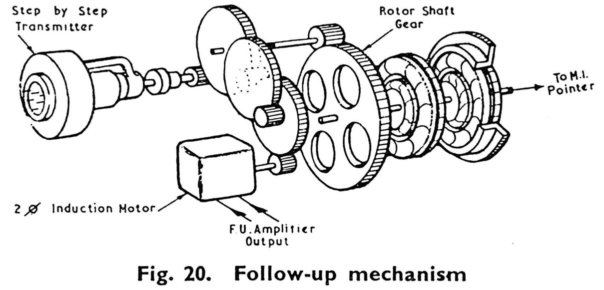


**Fig. 20. Follow-up mechanism**

(A.L.11, Feb. 58)

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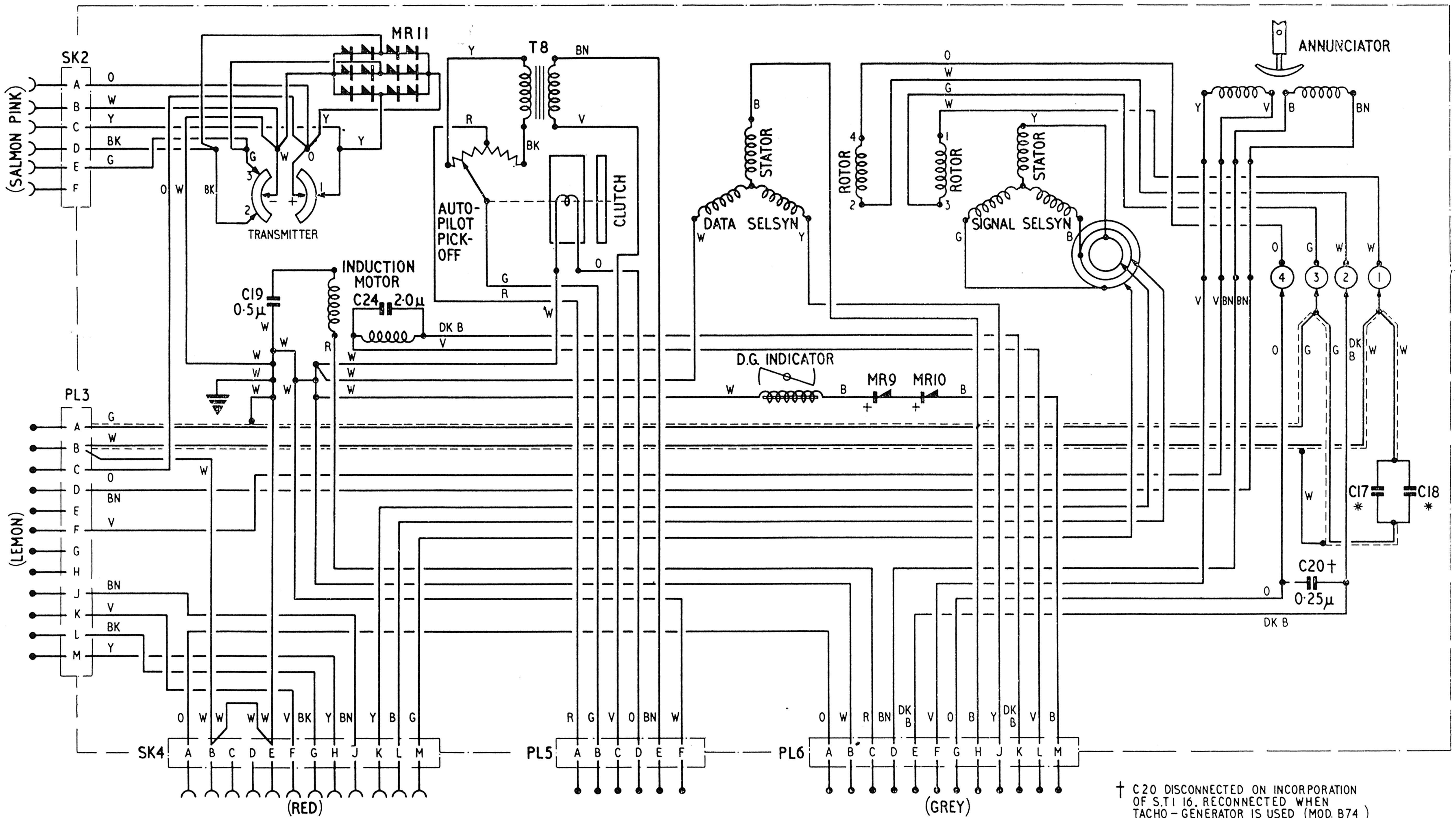



† C20 DISCONNECTED ON INCORPORATION OF S.T.I 16. RECONNECTED WHEN TACHO – GENERATOR IS USED (MOD. B74)

ABBREVIATIONS OF COLOURS

| | | | | | |
|---|---|---|---|---|---|
| R | RED | G | GREEN | O | ORANGE |
| W | WHITE | Y | YELLOW | V | VIOLET |
| B | BLUE | BK | BLACK | DK B | DARK BLUE |
| | | BN | BROWN | | |

* C17 AND C18 SELECTED ON TEST FROM 0·005μ, 0·01μ, 0·02μ, 0·05μ

**Fig. 21. Circuit diagram, master indicator (Type A)**

selsyn, the pulses of anode current through V9 increase, since the control grid and the anode are positive at the same time.

**162.** Similarly, the pulses of anode current through V8 decrease since when its anode is positive and the valve is conducting, its control grid is driven negative. A differential voltage therefore exists between the anodes of V8 and V9 which is stored in C14 and then applied to the control grids of V6 and V7.

**163.** During the next half-cycle, when V6 and V7 are conducting, the voltage applied from C14 causes V6 to be driven further towards cut-off, whilst V7 carries current pulses of increased magnitude. Similarly, a signal input to V8 and V9 of the opposite polarity results by exactly the same process in current pulses of increased magnitude in V6, whilst V7 is driven towards cut-off point.

**164.** The signal windings of the transductors T4 and T6 are connected in the anode circuits of V6 and V7, and in this manner the pulses of anode current through these valves are made to control the transductor output. The capacitors C11 and C12 are included in the circuits to provide smoothing so that the anode current flow is sensibly constant.

*Transductors*

**165.** Transductors are saturable reactors and they are employed in the follow-up amplifier to provide a suitable power output which is related in magnitude and sign to the direct current input, and is used to energize the control winding of the follow-up motor.

**168.** When a signal reaches the amplifier input causing a current of increased magnitude in the anode circuit of V6, the increase in current through the signal coil of T4 will cause the core to become saturated. The impedence of T4 will therefore be reduced and the voltage across its inner a.c. coils will be decreased. The voltage across the inner a.c. coil of T6 will, however, be increased since V7 is driven towards cut-off.

**169.** Since the inner and the outer a.c. coils each have the same number of turns, the voltages induced in the outer a.c. coils of T4 and T6 are equal at any instant to the voltages across the inner a.c. coils. The outer a.c. coils, however, are connected so that their voltages are in opposition and therefore the output voltage is equal to the difference between the voltage appearing across the inner a.c. windings of T4 and T6.

**170.** The sign of the ouput voltage will, therefore, depend upon which of the transductors is saturated and the magnitude of the voltage will depend upon the amplitude of the signal input to the amplifier.

**171.** The output from the transductors is fed directly to the control winding of the two-phase follow-up motor in the master indicator, the capacitor being connected across the winding to improve the power factor. The reference of this phase motor is continuously energized from a single-phase a.c. supply, and the follow-up amplifier output supplies the controlling phase. Thus, the direction of rotation of its rotor is directly related to the phase of the signal input. The values of components used in the precession and follow-up amplifiers are given in Table 2.

**166.** The transductor consists essentially of a three-legged laminated iron core of high permeability, around which three separate coils are wound. The centre leg carries the input, or signal, coil and each of the outer legs carries an inner a.c. coil on top of which an outer a.c. coil is wound. The windings of the inner and the outer a.c. coils are divided and their ends are connected as shown in fig. 33.

*Operation*

**167.** Referring to the simplified circuit diagram of the transductor output (*fig.* 33) it will be seen that the anode current of V6 and V7 flows through the signal coils of the transductors T4 and T6 respectively. The inner a.c. coils on each transductor are connected in series and supplied with 115 volt, 400 c/s, a.c. and therefore, since the transductors are identical in design, the voltage across each coil are equal and opposite.

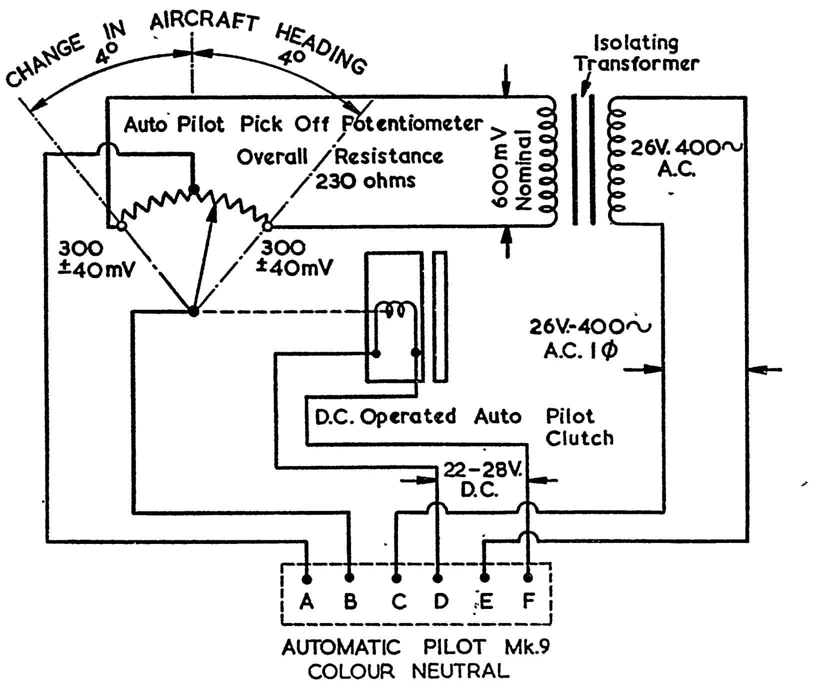



**Fig. 22. Automatic pilot pick-off circuit (Type A)**

*(A.L.21, Feb. 59)*

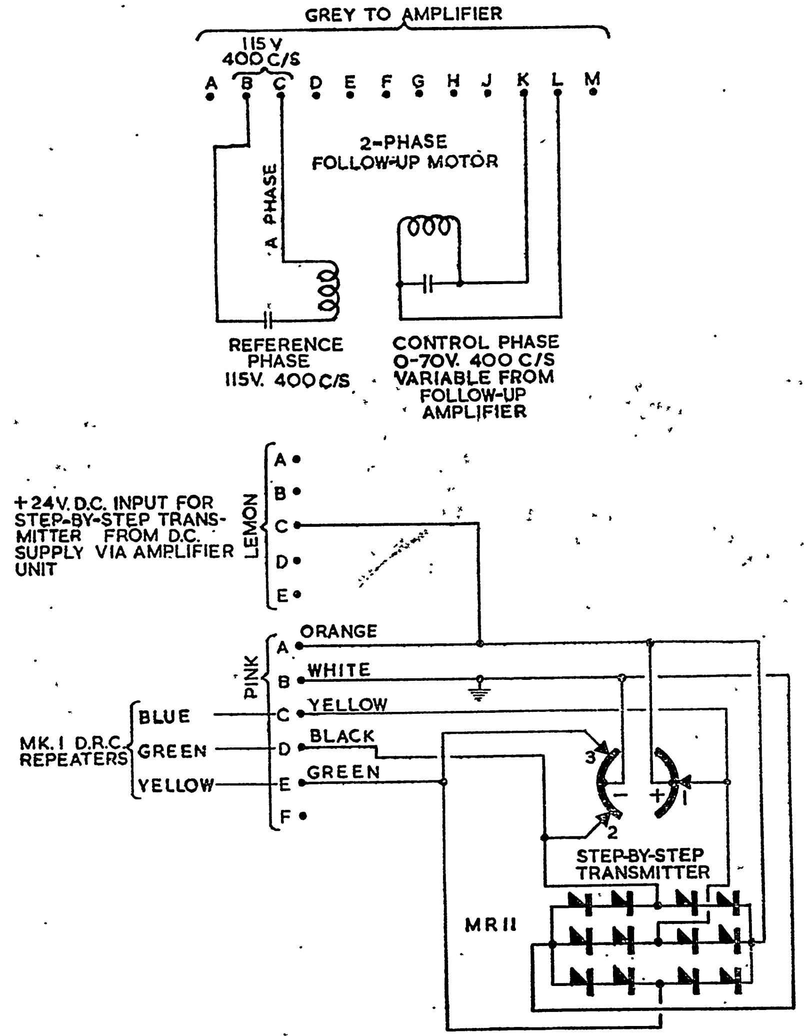
**Voltage stabilizing circuit**

**172.** The current which energizes the coils of the deviation compensator described in para. 10, is obtained from the aircraft d.c. supply. It is, therefore, necessary to provide an adequate degree of stabilization to ensure that the current in the compensator coils remains reasonably constant irrespective of voltage fluctuations.

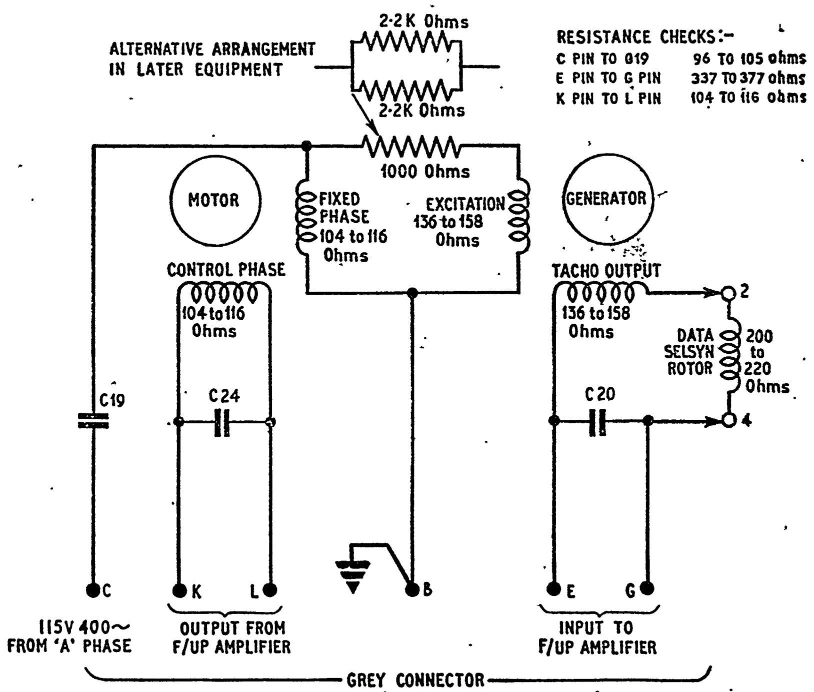
**173.** In the Mk. 4B compass, the stabilizing circuit and the potentiometers for adjusting the current in the compensator coils are included in the amplifier unit. A small hinged flap at the bottom right-hand corner of the amplifier case gives access to the two potentiometer spindles which can be adjusted by means of a compass adjusting key (Stores Ref. 6E/337).

**174.** A toggle switch, immediately beneath the potentiometer spindles, enables either of two calibration ranges (3 deg. —0 deg. —3 deg. or 15deg. —0 deg. —15 deg.) to be selected, and a jack socket at the bottom left-hand end of the amplifier case is provided so that a 15–0–15 voltmeter can be plugged in when calibrating the compass.

**175.** The stabilizing circuit is included in fig. 18 from which it will be seen that the lamps L1 and L2 and the resistors R32 and R33 form a bridge network connected across the aircraft d.c. supply. The lamp filaments have a high temperature resistance coefficient and thus the effective resistance of each lamp increases or decreases considerably for a small rise or fall in voltage. By utilizing this characteristic and selecting suitable circuit constants for a bridge circuit, a reasonably steady output voltage can be obtained with input voltages varying between 20 and 30 volts. This output voltage will vary between 6 and 8 volts, according to the lamps, which should be selected so that the consumption is between 108 and 122 mA. Mod. B100 changes the values of R 22, R 23, R 32, R 33, R 36, and R 37.




◄ **Fig. 23. Follow-up and step-by-step transmission system, master indicator, Type A** ►




◄ **Fig. 24. Tacho-generator circuit, master indicators, Type B and C (after mod. Inst. B155) and D** ►

**RESTRICTED**

**176.** The calibrated centre-tapped potentiometers R34 and R35, which control the current in the compensator coils, are connected across this source and thus the current is maintained at a steady value. The two-way change-over switch SW1 and the resistors R22 and R23 provide a means of altering the range of correction in relation to the degree of adjustment of the potentiometers to suit the requirements on any particular installation. With the switch open, the range is 3° —0° —3° and with it closed it is 15° —0° —15°. The selected range applies to both B and C corrections; thus the switch must be in the same position throughout the calibration.

**177.** The correction potentiometers are set during manufacture to give accurate zero. At 10° and above, however, there may be scale inaccuracies up to 20 per cent when the system is operating in an earth's field of horizontal strength of 0·18 oersted. This inaccuracy may be even greater in those parts of the world where the earth's magnetic field has a different strength. The potentiometer scales should, therefore, only be regarded as a rough guide.

**178.** It is most important that the same type of lamp is always used in the stabilizing circuit otherwise the voltage stabilization will not be effective. Should either lamp fail, it should be replaced by 24V lamp (Ref. No. 6B/3240) ◀(see para. 190).▶

**Amplifier Type B**

**179.** The rectifier valve, Type CV.135, has been replaced by the Type CV.493 (see para. 179B).

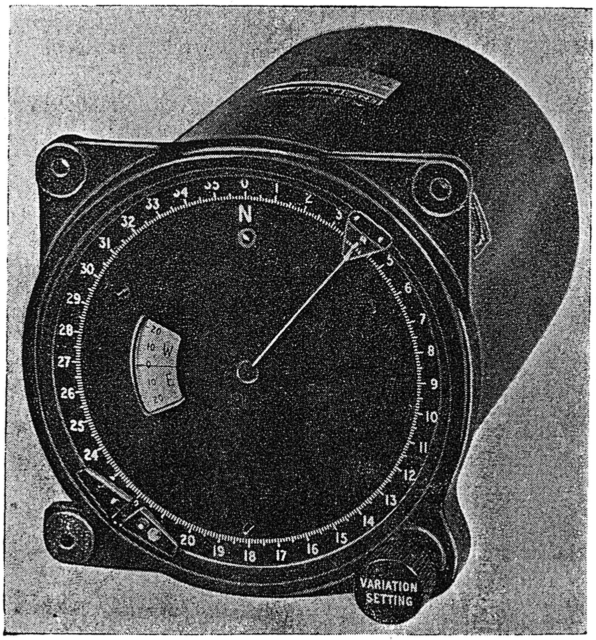



**Fig. 25. Presentation of master indicator, Type B**

Since the latter is physically larger than the CV.135 it cannot be used in the Type A amplifier. The Type B unit has been designed to accommodate the CV.493. By suitable cross-connection of the valve-holder, it has been possible to arrange that the CV.135 can still be

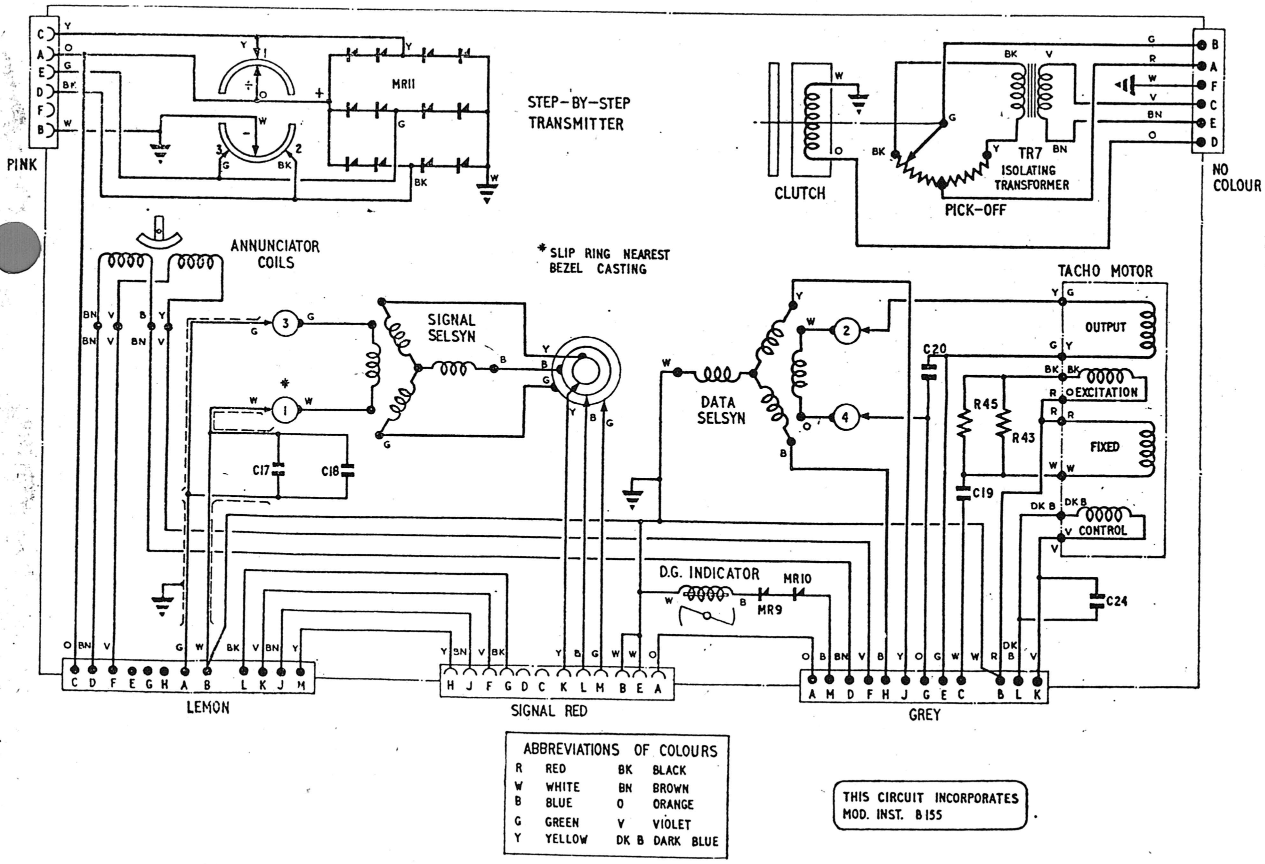



**Fig. 26. Circuit diagram, master indicator, Type B (after mod. Inst. B155)**

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**Table 2**

**Components used in Compass G-M, Mk. 4B equipment**

| Symbol | Description | Value | Rating |
|---|---|---|---|
| | Amplifier, Type A (*Ref. No. 6B*/1994) (incorporating Mods. B.57, B.79, B.80, B.100, B.109, B.111, B.115, B.120) | | |
| R1 | Resistor, carbon | 470K Ω | ½ W |
| R2 | Resistor, carbon | 1K Ω | ½ W |
| R3 | Resistor, carbon | 47K Ω | ½ W |
| R4 | Resistor, carbon | 1M Ω | ½ W |
| R5 | Resistor, carbon | 470K Ω | ½ W |
| R6 | Resistor, carbon | 470K Ω | ½ W |
| R7 | Resistor, carbon | 10K Ω | ½ W |
| R8 | Resistor, W.W.vit. enam. | 2·2K Ω | 4½ W |
| R9 | Resistor, W.W.vit. enam. | 2·2K Ω | 4½ W |
| R10 | Resistor, carbon | 15K Ω | ½ W |
| R11 | Resistor, carbon, high stab. | 110K Ω | ½ W |
| R12 | Resistor, carbon, high stab. | 110K Ω | ½ W |
| R13 | Resistor, carbon, high stab. | 110K Ω | ½ W |
| R14 | Resistor, carbon, high stab. | 110K Ω | ½ W |
| R15 | Resistor, carbon | 220K Ω | ½ W |
| R16 | Resistor, carbon | 470K Ω | ½ W |
| R17 | Resistor, carbon | 470K Ω | ½ W |
| R18 | Resistor, carbon | 220K Ω | ½ W |
| R19 | Resistor, carbon | 47K Ω | ½ W |
| R21 | Resistor, carbon | 15K Ω | ½ W |
| R22 | Resistor, carbon | 3·9K Ω | ¼ W |
| R23 | Resistor, carbon | 3·9K Ω | ¼ W |
| R24 | Resistor, carbon | 180K Ω | ¾ W |
| R25 | Resistor, carbon | 180K Ω | ¾ W |
| R26 | Resistor, carbon | 100K Ω | ½ W |
| R27 | Resistor, carbon | 1·5K Ω | ½ W |
| R28 | Resistor, carbon | 100K Ω | ½ W |
| R29 | Resistor, carbon | 4·7K Ω | ¾ W |
| R30 | Resistor, carbon | 4·7K Ω | ¾ W |
| R32 | Resistor, W.W.vit. enam. | 250 Ω | 4½ W |
| R33 | Resistor, W.W.vit. enam. | 250 Ω | 4½ W |
| R36 | Resistor, carbon | 390 Ω | ¼ W |
| R37 | Resistor, carbon | 390 Ω | ¼ W |
| R40 | Resistor, W.W.vit. enam. | 12K Ω | 4½ W |
| R43 | Resistor, carbon | 100 Ω | ½ W |
| R44 | Resistor, carbon | 100 Ω | ½ W |
| RV20 | Resistor, var. W.W. | 500 Ω | 1 W |
| RV31 | Resistor, var. W.W. | 500 Ω | 1 W |
| RV34 | Resistor, var. W.W. | 1K Ω | 1 W |
| RV35 | Resistor, var. W.W. | 1K Ω | 1 W |
| RV38 | Resistor, var. W.W. | 500 Ω | 1 W |
| C1 | Capacitor, paper, tubular | 0·05μF | 350 W.V. |
| C2 | Capacitor, paper, tubular | 0·05μF | 350 W.V. |
| C3 | Capacitor, paper, tubular | 0·01μF | 350 W.V. |
| C4 | Capacitor, paper, tubular | 0·05μF | 350 W.V. |
| C5 | Capacitor, paper, tubular | 0·01μF | 350 W.V. |
| C6 | Capacitor, paper, tubular | 0·01μF | 350 W.V. |
| C7 | Capacitor, paper, tubular | 0·05μF | 350 W.V. |
| C8 | Capacitor, paper, tubular | 0·05μF | 350 W.V. |
| C9 | Capacitor, paper, tubular | 2·0μF | 250 W.V. |
| C10 | Capacitor, paper, tubular | 2·0μF | 250 W.V. |
| C11 | Capacitor, paper, tubular | 0·05μF | 350 W.V. |
| C12 | Capacitor, paper, tubular | 0·05μF | 350 W.V. |
| C13 | Capacitor, paper, tubular | 0·002μF | 500 W.V. |
| C14 | Capacitor, paper, tubular | 0·005μF | 500 W.V. |
| C15 | Capacitor, paper, tubular | 0·002μF | 500 W.V. |

Table 2 (*continued*)

| Symbol | Description | Value | Rating |
|---|---|---|---|
| MR1, MR2 | Rectifier, metal | | |
| MR3, MR4, MR5, MR6 | Rectifier, MQ8-2 | | |
| T1 | Transformer inter-stage | | |
| T2 | Transformer power | | |
| T3 | Transformer ref. voltage | | |
| T4 | Transductor | | |
| T5 | Transformer power | | |
| T6 | Transductor | | |
| V1 | Miniature, R.F. pentode, CV138 | See para. 179B | |
| V2 | Miniature, L.F. pentode, CV136 | See para. 179B | |
| V3 | Miniature, L.F. pentode, CV136 | See para. 179B | |
| V4 | Miniature, L.F. pentode, CV136 | See para. 179B | |
| V5 | Miniature high vac. half-wave rectifier | See para. 179B | |
| V6 | Miniature L.F. pentode, CV136 | See para. 179B | |
| V7 | Miniature L.F. pentode, CV136 | See para. 179B | |
| V8 | Miniature R.F. pentode, CV138 | See para. 179B | |
| V9 | Miniature R.F. pentode, CV138 | See para. 179B | |
| TJ | Test jack | | |
| F5 | Fuse cartridge 1A | | |
| F6 | Fuse cartridge 1A | | |
| LPR1 | Lamp resistor ◄ 24V, 2·8W ► | | |
| LPR2 | Lamp resistor ◄ 24V, 2·8W ► | | |
| SW1 | Switch D.P.S.T. | | |

Amplifier, Type B (*Ref. No. 6B/562*)
(incorporating Modifications B.100, B.109, B.119, B.120)

| Symbol | Description | Value | Rating |
|---|---|---|---|
| R1 | Resistor, carbon | 470K Ω | ½ W |
| R2 | Resistor, carbon | 470 Ω | ½ W |
| R3 | Resistor, carbon | 100K Ω | ½ W |
| R4 | Resistor, carbon | 330K Ω | ½ W |
| R5 to R37 | As Type A | | |
| R41 | Resistor, carbon | 3·3K Ω | ½ W |
| R42 | Resistor, carbon. Selected on test from | 22K Ω / 33K Ω | ½ W / ½ W |
| R44 | Resistor, W.W.vit. enam. | 12K Ω | 4½ W |
| RV20 | Resistor, var. W.W. | 500 Ω | 1 W |
| RV31, RV34, RV35 | Resistor, var. W.W. | 1K Ω | 1 W |
| RV38 | Resistor, var. W.W. | 500 Ω | 1 W |
| RV40 | Resistor, var. W.W. | 5K Ω | 1 W |
| C1 to C13 as Type A | | | |
| C14 | Capacitor, paper, tubular | 0·05μF | 500 W.V. |
| C15 | Capacitor, paper, tubular | 0·002μF | 500 W.V. |
| C21 | Capacitor, paper, tubular | 0·05μF | 350 W.V. |
| RL1 | Relay, 4-pole | | 24 V |
| V5 | Miniature high vac. rectifier CV493 (CV135 may be used as substitute if CV493 not available) | See para. 179B | |
| Remainder of components as Type A | | | |

RESTRICTED

**TABLE 2**—*cont.*

| Symbol | Description | Value | Rating |
|---|---|---|---|
| | Gyro Unit Type A, Ref. No. 6B/1992 | | |
| R39 | Resistor, W.W.vit.enam. selected on test from | 62 Ω | $1\frac{1}{2}$ W |
| | | 82 Ω | $1\frac{1}{2}$ W |
| | | 110 Ω | $1\frac{1}{2}$ W |
| | | 150 Ω | $1\frac{1}{2}$ W |
| T7 | Transformer, erection control | | |
| MR7 | Rectifier, germanium, CV425 | | |
| MR8 | Rectifier, germanium, CV425 | | |
| | Gyro Unit Type B, Ref. No. 6B/561 | | |
| | Resistors and rectifiers as Type A | | |
| T8 | Transformer, erection control | | |
| T9 | Transformer, precession | | |
| T10 | Transductor, precession | | |
| T11 | Transductor, precession | | |
| C26 | | 0·25μF | 250 W.V. |
| C27 | | 0·25μF | 250 W.V. |
| C28 | | 0·05μF | 350 W.V. |
| C29 | | 0·05μF | 350 W.V. |
| | Master Indicator Type A, Ref. No. 6B/1996 or Type No. B, Ref. 6B/634 | | |
| R43, R45 | Resistor, W.W.vit.enam. | 2·2K Ω | 3 W. |
| C17, C18 | Capacitor, paper, tubular selected on test from | 0·005μF | 350 W.V. |
| | | 0·01μF | 350 W.V. |
| | | 0·02μF | 350 W.V. |
| | | 0·05μF | 350 W.V. |
| C19 | Capacitor, paper, tubular | 0·5μF | 350 W.V. |
| C20 | Capacitor, paper, tubular | 0·25μF | 250 W.V. |
| C24 | Capacitor, paper, tubular | 2·0μF | 150 W.V. |
| C26 | Atmite suppressor | | |
| C27 | Atmite suppressor early type A only | | |
| C28 | Atmite suppressor | | |
| MR9 | Rectifier, germanium Type CV.425 | | |
| MR10 | Rectifier, germanium Type CV.425 | | |
| MR11 | Rectifier, FSW 7160A (Alternative to atmite suppressors) (Mod. B.87) | | |
| T8 | Transformer, isolating (Type A) | | |
| T7 | Transformer, isolating (Type B) | | |
| | Control Panel, Ref. No. 6B/408 | | |
| F1 | Fuse, cartridge, 2 A | | |
| F2 | Fuse, cartridge, 2 A | | |
| F3 | Fuse, cartridge, 2 A | | |
| F4 | Fuse, cartridge, 2 A | | |
| SW2 | Switch, 4-wafer, 3-pole, 3-position | | |

used in the Type B amplifier. A relay has also been included to enable the compass monitoring to be interrupted by the application of a 28V, d.c. signal. This facility is sometimes required when it is necessary to reduce compass errors during turns. Finally, to assist the task of the designers of autopilots in obtaining heading stabilization from the compass, the monitoring characteristics have been brought under closer control by the introduction of negative feed-back. This has the further useful result that the amplifier is rendered more independent of valve characteristics and voltage variation. By means of this the amplifier is adjusted to give 7 to 9 mA differential current at 1° off null and 13 to 17½ mA at full signal.

**Amplifier, Type C**

**179A.** The Type C amplifier (*Ref. No.* 6B/3126) is similar to the Type B except that it includes an integrating circuit with additional capacitors and resistance and with a relay built on for operation by a remote switch with associated cable. It has been introduced to increase stability of heading indication on Northerly headings (340°–020°) with the Mark 4B compass in certain aircraft.

**◄ Amplifier valves**

**179B.** The valves CV136, CV138 and CV493, specified for the precession amplifiers, Type A, B and C and the follow-up amplifiers, are now in very short supply having been declared obsolescent, and are to be replaced by their equivalent ruggedized valves CV4063, CV4014 and CV4005, respectively. Such replacement can be made without detriment to the performance of the system. There is no ruggedized equivalent to the CV135. When the Type A precession amplifier was produced, the appropriate preferred rectifier valve was the CV135. This has since been declared obsolescent and its replacement is the CV493. This is a larger valve and cannot be used in the Type A unit. The same also applies to the CV4005 which is the ruggedized replacement for the CV493. In the Type B unit the valve-holder sub-chassis has been altered to accommodate the CV493 and also its equivalent ruggedized valve CV4005. It has also been possible to interconnect the CV493 holder sockets so that the CV135 can still be used, if necessary.

**179C.** The gain of the Type A amplifier has proved to be unnecessarily high. In the Type B and C units, negative feed-back has been introduced to control the gain and at the same time to render the amplifier less sensitive to valve changes and voltage variations. ►

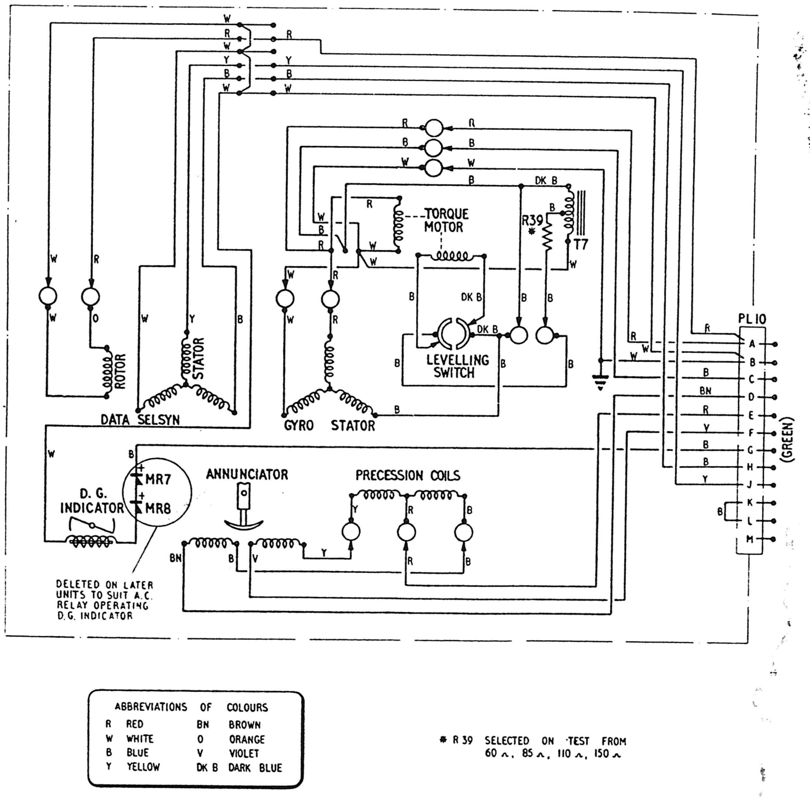



**Fig. 27. Circuit diagram, gyro unit, Type A**

**Control panels, Type A and B**

**180.** The control panel, Type A, shown in fig. 10 is used to control the monitoring signals to the gyro unit. It consists of a rectangular box which

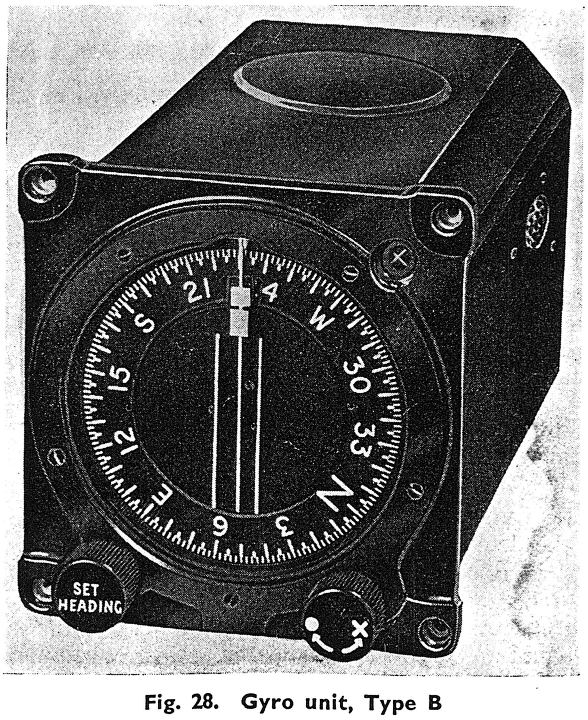
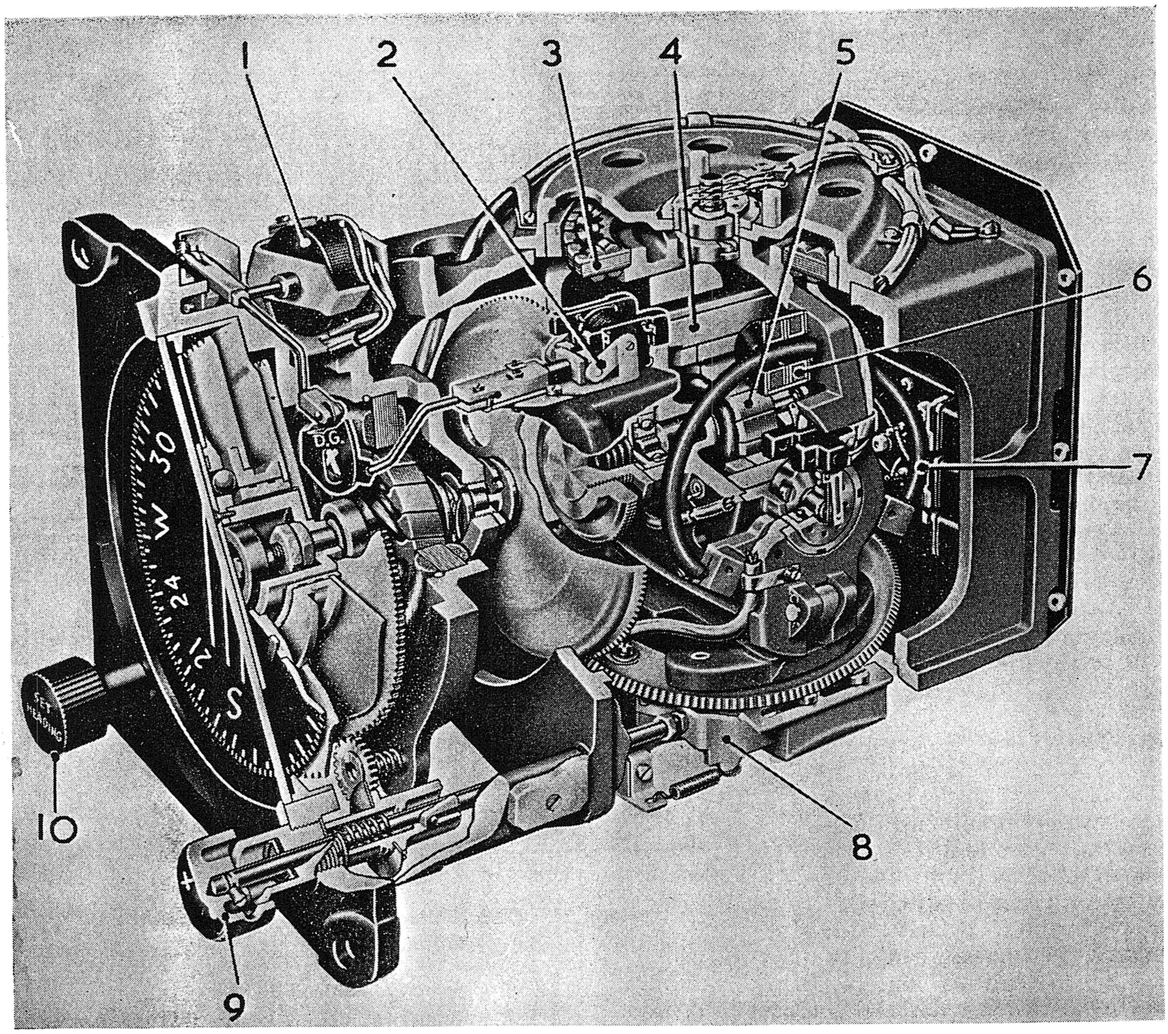



**Fig. 28. Gyro unit, Type B**




1 D.G. SOLENOID
2 ANNUNCIATOR COIL ASSEMBLY
3 TORQUE MOTOR
4 GYRO ROTOR
5 GYRO STATOR
6 PRECESSION COIL
7 PRECESSION MAGNETS
8 CAGING MECHANISM
9 SYNCHRONIZING KNOB
10 HEADING KNOB

**Fig. 29. Gyro unit, Type B, sectional view**

carries a 3-pole selector switch, four fuses, one 12-pole plug and two 12-pole sockets. The control panel, Type B, is dealt with in Appendix 4 to this chapter.

**181.** The selector switch indicating plate (*fig.* 10) is reversible, one side being engraved to suit single gyro unit installations and the other to suit installations where an additional gyro unit is fitted for use by the second pilot. The indicating plate is provided with a stop so that on single gyro unit installations only two switch positions can be used:—

(1) GYRO COMPASS. The gyro unit is monitored by the detector unit and functions as a compass.

(2) COMPASS OFF. The gyro unit is unmonitored and functions as a directional gyro. A D.G. indication is shown in the annunciator windows of the gyro unit and the master indicator. The precession amplifier is switched off, only the follow-up amplifier being operative.

**Note . . .**
*The master indicator is synchronized with the gyro unit in either switch position.*

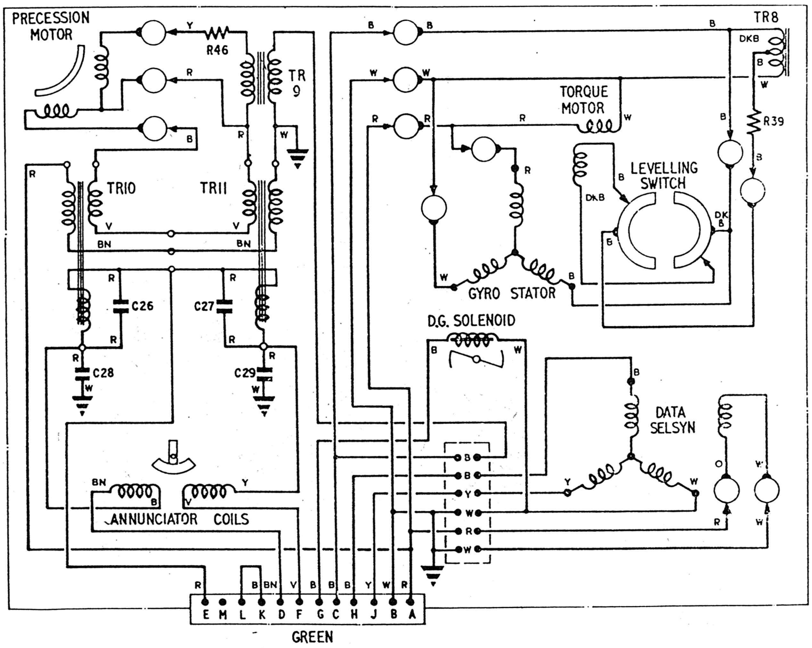
**182.** On installations where two gyro units are fitted, three switch positions are available:

(1) PORT COMPASS. The port gyro unit functions as a compass, the starboard as a directional gyro.

(2) STARBOARD COMPASS. The starboard gyro functions as a compass, the port as a directional gyro.

(3) COMPASS OFF. Both gyro units function as directional gyros. Precession amplifier switched off.

**Note . . .**
*The master indicator is synchronized with whichever gyro unit is acting as a compass, or with the port gyro unit when both units are functioning as directional gyros.*




| ABBREVIATIONS OF COLOURS | | | |
|---|---|---|---|
| R | RED | BK | BLACK |
| W | WHITE | BN | BROWN |
| B | BLUE | O | ORANGE |
| G | GREEN | V | VIOLET |
| Y | YELLOW | DK B | DARK BLUE |

**Fig. 30. Circuit diagram, gyro unit, Type B**

**183.** The control panel is usually mounted in the cockpit in a position accessible to the pilot, but if this is impracticable owing to limitation of cockpit space in small aircraft, it can be mounted on a bulkhead or at any other convenient point. In such instances the selector switch is turned to COMPASS or PORT COMPASS and wire-locked in this position. Remote control is effected by means of a 2-way switch in the pilot's cockpit which is connected to the control panel by a special connector. A circuit diagram of the control panel is given in fig. 36.

## SERVICING

### General

**184.** The storage requirements, pre-flight serviceability checks, inspection periods and routine servicing are described in the subsequent paragraphs.

### Storage

**185.** All the equipment comprising the Mk. 4B compass is generally supplied in airtight tropicalized, preservation packs and does not require any attention for periods not exceeding twelve months. If the equipment is not contained in preservative packs, the gyro unit must be exercised for 15 minutes every three months on a roll, pitch and yaw table. ▶ ◀

### Pre-flight serviceability check

**186.** In aircraft having this compass installed, each unit of the equipment must be inspected and a serviceability check made before the aircraft takes off. The inspection and check must be made only by authorized personnel. A diagram showing the inter-unit connectors is given in fig. 11.

### Mounting and connectors

**187.** (1) Check the security of the gyro unit and the master indicator mountings. Ensure that all other units comprising the compass are securely fixed.

(2) Check the security of all plugs and socket connections on the inter-unit connector harness.

### Bezel glasses

**188.** The glass on the gyro unit and on the master indicator must be cleaned and examined for cracks. Should it become necessary to remove an instrument glass, extreme care must be taken to avoid touching the inner surface as this is coated with an anti-condensation compound which is adversely affected by the slightest trace of grease. If required, the inner surface of the glass can be lightly dusted with a perfectly clean rag which is free from fluff. The bezel assembly is retained by 5 screws of which the longest must be fitted at the 6 o'clock position.

### Fluorescent and luminous markings

**189.** Inspect all markings for discolouration or chipping.

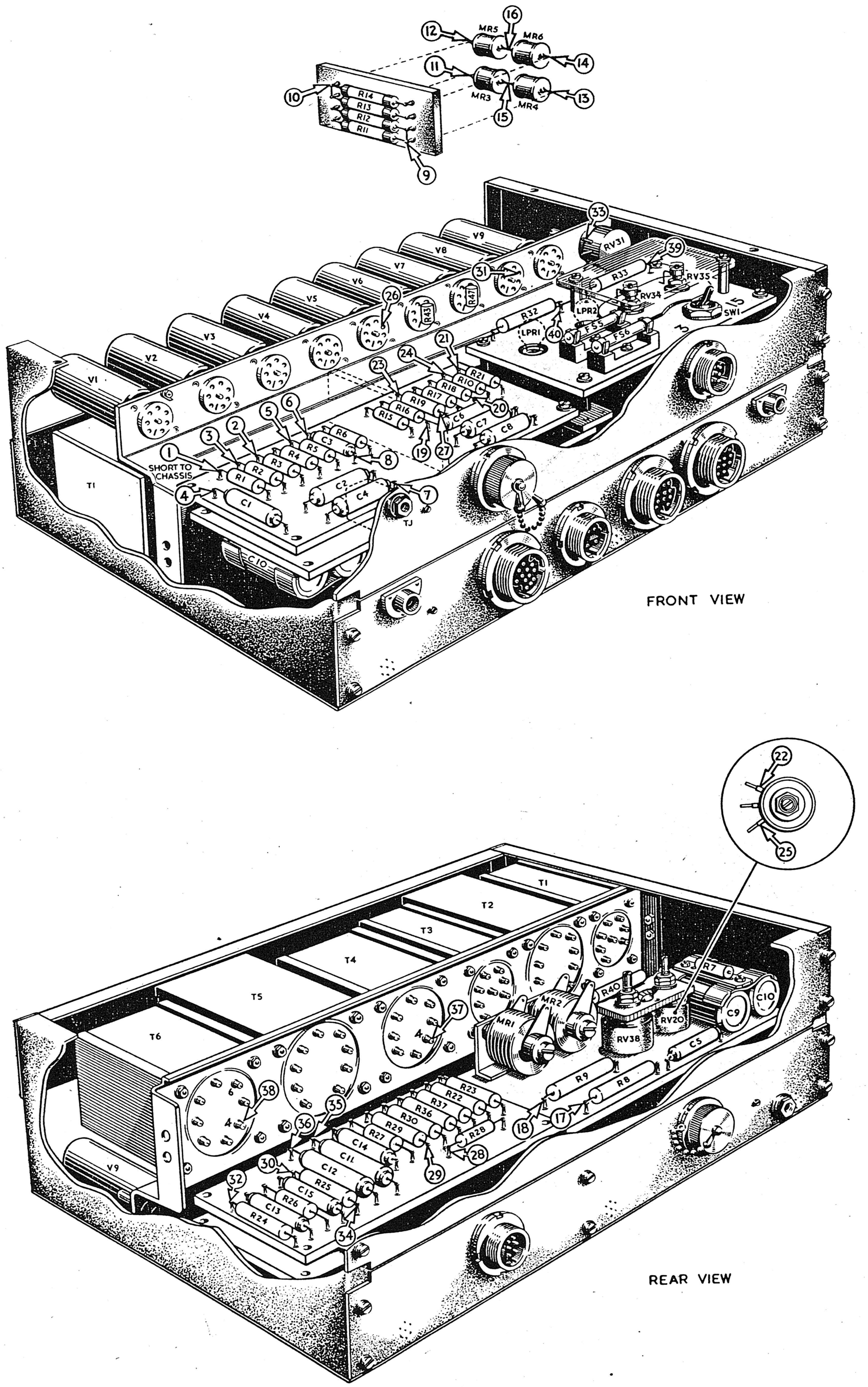



**Fig. 31. Amplifier, component layout diagram**

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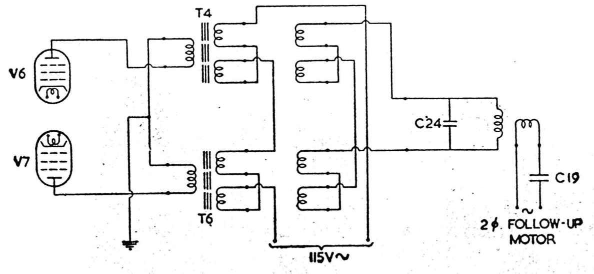



**Fig. 33. Simplified diagram, Transductor output**

### Compass calibration

**190.** The calibration of the Mk. 4B compass installation must be checked at periodic intervals in conformity with regulations governing the use of this equipment. Instructions concerning the method of carrying out the calibration check are given in Chapter 5 of this Section. Change of any unit within the installation except the control panel, necessitate re-calibration due to the small individual manufacturing tolerances. Should more than 2 deg. of deviation be set on the correction network, any change of lamp also makes a re-calibration necessary.

### Routine checks

**191.** The security of all connector terminals, mountings, and in particular the four mounting screws on the amplifier tray must be checked in accordance with the current Servicing Schedule.

### Lubrication

**192.** All bearings and moving parts are lubricated during assembly and require no further lubrication until next reconditioning.

### Repair and reconditioning

**193.** There is no set period before reconditioning; units of a compass system remain in use until they fail to pass the tests. When Units are returning equipment for repair it is important that it is packed in the carton and transit case in which the serviceable replacement was supplied, and the gyro unit must be caged with the wooden bar supplied with the new units.

**194.** Repairs to the equipment may be made by qualified instrument (Nav.) tradesmen providing that correct facilities exist for a functional check after repair. Details of certain tests that may be carried out are given in Appendix 1 to this chapter. Complete information regarding reconditioning and tests is given in the repair and reconditioning volume of this publication, but the special test equipment required will only be available to authorized repair depots.

**195.** As a general aid to the location of faults throughout the compass installation, a list of symptoms typical of certain faults, their probable cause and the remedy is given in Table 3.

### Fault finding

**196.** For information regarding the location of faults throughout the compass installation, probable causes and remedies, reference should be made to Table 3.

**Note . . .**

*As no convention exists for the connection of a centre reading voltmeter to its jack, it is advisable to establish on a serviceable compass system which direction it swings for a cross (plus) or a dot (minus).*

### ◄ Check points

**197.** Circuit diagrams of amplifiers, Type A and B, are given in fig. 32 and 35, respectively. In these diagrams, various check points are indicated, arranged so that the voltages in different parts of the circuit can be measured.

**198.** The correct voltages (*para.* 199) between appropriate check points for amplifiers, Type A and B, are given in Table 4. The testmeters used were Valve voltmeter, Type CT54, Admiralty Pattern 67921, Ref. No. 10S/16373 and Avometer, Multimeter, Type 1, 20000 ohms/volt, Admiralty Pattern 12945, Ref. No. 10S/16411.

**199.** It should be stressed that the figures given should be used only as a guide in systematic fault diagnosis. As tolerances are not given, it cannot be assumed that any deviation from these figures will indicate an amplifier as unserviceable, and variations may occur from amplifier to amplifier ►

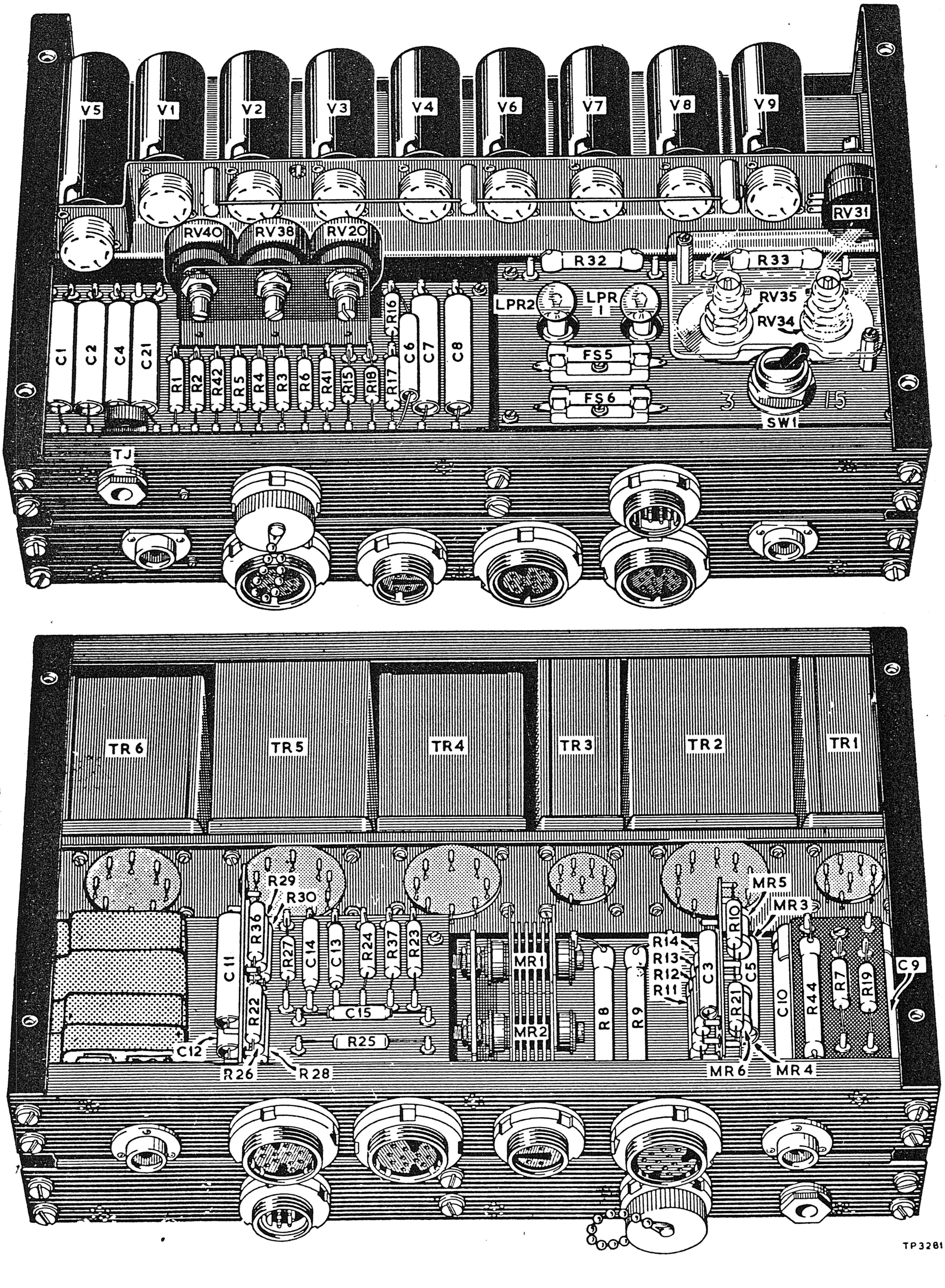
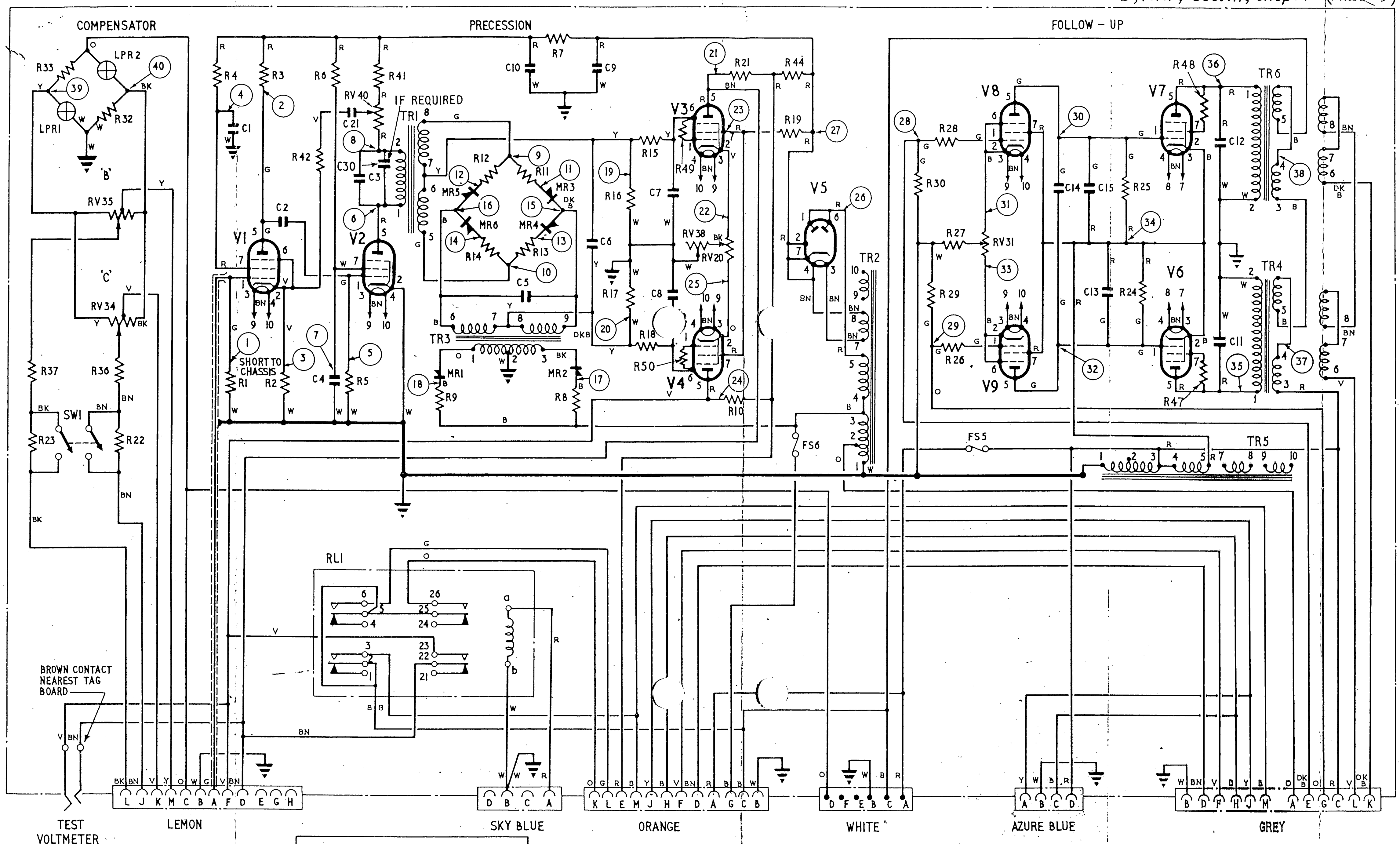



**Fig. 34. Amplifier Type B, layout of components**




| ABBREVIATIONS OF COLOURS | | | |
|---|---|---|---|
| R | RED | BK | BLACK |
| W | WHITE | BN | BROWN |
| B | BLUE | O | ORANGE |
| G | GREEN | V | VIOLET |
| Y | YELLOW | DK B | DARK BLUE |

TEST POINTS SHOWN THUS :— ⟵(13)

Fig. 35 G-M compass, Mk.4B — Circuit test diagram, amplifier, Type B Fig.35

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(A.L.20, Dec.58)

AIR DIAGRAM 6284B/MIN.

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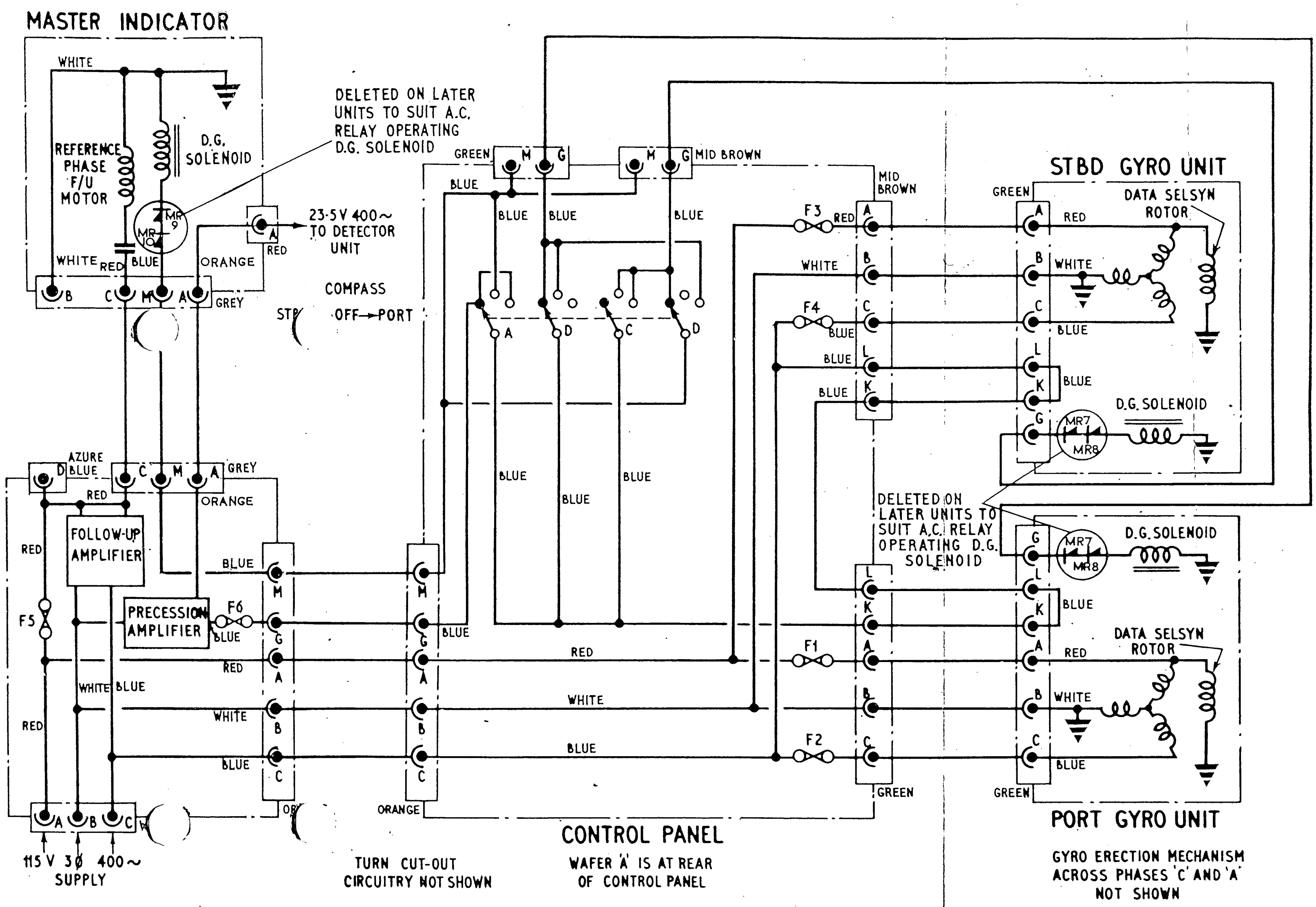


Fig. 37. G-M compass, Mk.4B — A.C. power circuits

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| AIR DIAGRAM 6284C/MIN. | |
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**Table 3** (*continued*)

| Symptom | Possible cause | Action |
|---|---|---|
| | (3) Detector unit fault. | A d.c. continuity tester must NOT be used for checking a detector unit. Unless an a.c. tester, such as the flux-valve continuity tester, is available, substitute a known serviceable detector. This may conveniently be done within the aircraft using test bench cable 6C/807. |
| Very sluggish annunciations at certain headings, no annunciation elsewhere around scale. Master indicator follows gyro unit. | Lead fault as under:— Very sluggish annunciation at 0 to 180—no annunciation at other headings. K shorted to L<br>Similar characteristics at 120 or 300. L shorted to M<br>Similar characteristics at 60 or 240. K shorted to M | Disconnect RED cable harness from detector unit and check insulation of K, L and M lines, to each other and to earth. |
| Annunciator indicates null at any position of gyro unit card. No precession. | (1) Fuse F.6 blown. | Precession amplifier will be inoperative. Clear fault and renew fuse. |
| | (2) Fault in precession amplifier. | Remove amplifier for repair. Various tests are described in Appendix 1 to this Chapter. |
| | (3) No excitation supply to detector unit. | Disconnect RED cable harness from detector unit. An a.c. voltage of approx. 23V should be obtained between pin A of the free harness connector and earth. |
| | (4) Fault in detector unit excitation coil. | Do not use d.c. continuity tester. Check with a.c. tester, preferably flux valve continuity tester. |
| | (5) Cable interconnection fault. | Check interconnections KLM RED, ABDF LEMON, DF GREY, DEF ORANGE, DEF GREEN. |
| | (6) Turn cut-out relay fault (Type B amplifier only). | See that relay is not stuck in and repeat DEF line checks itemised in (5) above. |
| Annunciator sluggish in operation. Less than 6 volts obtained on 15–0–15 centre-reading d.c. voltmeter for 1 degree of null. | (1) Derated valve in precession amplifier. | Check V1 to V5. Replace where necessary. Check settings of RV20 and RV38, also RV40 on Type B amplifier. |
| | (2) Incorrect power supply. | Check power supply. Though compass should operate satisfactorily at 104 to 126V and 380 to 420 c/s. in general, a sharp null will only be obtained at 390 to 410 c/s. The one degree misalignment check should preferably be done at 395 to 405 c/s. |
| | (3) Improper shielding of detector unit cable. | Check continuity of earth shield. |
| | (4) Detector unit insensitive. | This fault may be more evident on one heading than another. Substitute a known serviceable detector unit using cable 6C/807. |

(A.L.1, Mar. 56)

Table 3 (*continued*)

| Symptom | Possible cause | Action |
|---|---|---|
| No monitoring signal to auto-pilot. On Type A master indicator no signal when auto-pilot knob retained. | (1) Circuit not energized from auto-pilot. | Remove no colour six pin connector from rear of master indicator. 26V a.c. should be obtained across pins C and E of free socket. |
| | (2) Clutch not engaging. | See that 28V, d.c. is available at pin D of free socket. Resistance of clutch coil within the indicator pin D to earth, should be 388 to 452 ohms. If clutch is faulty, remove master indicator for repair. |
| | (3) Fault on isolating transformer or potentiometer within master indicator. | Remove master indicator for repair. |
| Incorrect monitoring signal to auto-pilot, signal one way only. | Partial open circuit in potentiometer winding of master indicator. | Remove master indicator for repair. |
| Intermittent monitoring signal to auto-pilot. | Poor contact between wiper and potentiometer within master indicator. | Remove master indicator for repair. |
| Step-by-step repeaters do not operate correctly. | (1) No supply to transmitter. | Check that 28V, d.c. is available a pin A of SALMON PINK connector. |
| | (2) Faulty transmitter (insufficient brush pressure, dirty commutator, or insulation fault). | Remove transmitter for repair. When replacing transmitter, No. 1 brush must be —ve, No. 2 brush +ve and No. 3 neutral when the master indicator pointer reads zero. |
| | (3) Faulty suppressor circuit within master indicator. | Earlier indicators have atmite supressors; later types have metal rectifier suppression. Neither should be checked with a megger, but forward and reverse resistances may be checked with an avometer. If the suppression circuit is faulty, remove indicator for repair. |



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**Table 3** (*continued*)

| Symptom | Possible cause | Action |
|---|---|---|
| Gyro precesses and annunciators indicate cross or dot continuously. Master indicator pointer does not move. | (2) Fault in master indicator. | Resistance across pins K and L of the fixed GREY plug should be 103 to 130 ohms. If zero resistance obtained, check C.24.<br>Connect fixed GREY plug of indicator as follows:—<br>Pin B to B phase of 115V 3-phase 400 c/s.<br>Pin C to A phase of 115V 3-phase 400 c/s.<br>Pins K to L to a supply not exceeding 50V, derived from A and B phases. With supply switched on, pointer should start to revolve at about 15 to 50V on control phase K and L. Reversal of K and L should reverse pointer. In general, a tacho generator will give a lower value of starting voltages. |
| | (3) Fuse F.5 blown. | Follow-up amplifier will be inoperative. Clear the fault and renew fuse. |
| | (4) Fault in follow-up section of amplifier. | If other checks above are satisfactory, then follow-up amplifier is suspect. For details of tests see Appendix 1 to this chapter. |
| Gyro precesses and annunciators indicate dot or cross. Master indicator pointer moves in one direction only: either continuously or intermittently. | (1) Anti-clockwise rotation—V6 or V8 faulty.<br>Clockwise rotation—V7 or V9 faulty. | Renew valve and check setting of RV.31. |
| | (2) Fault in transductors in follow-up amplifier. | Remove amplifier for repair. |
| | (3) H and J lines broken in grey cable harness. | Check continuity. |
| | (4) Short between tacho-output and excitation of tacho-generator. On Type B master indicators and Type A modified to B.74. | Remove indicator for repair. |
| Gyro precesses and annunciators indicate cross or dot. Master indicator settles on an approx. heading of 0, 60, 120, 180, 240 or 300°, irrespective of gyro unit heading. | Heading 0 or 180, H shorted to J<br>Heading 120 or 300, H shorted to B<br>Heading 060 or 240, J shorted to B.<br>Short in data Selsyn stator circuitry. | Check insulation of data Selsyn circuitry, starting at pins J, B, and H of the GREY cable harness.<br>Resistance between pins B, J and H of GREY fixed plug should be 10½ to 12½ ohms. |
| Gyro precesses and annunciators indicate cross or dot. Master indicator settles on an approx. heading of 30, 90, 150, 210, 270 or 330°. | Heading 150 or 330—H line broken<br>Heading 30 or 210—J line broken<br>Heading 90 or 270—B line broken<br>Break in data Selsyn stator circuitry. | Check continuity, starting with H and J lines within GREY cable harness. See fig. 11. |
| When synchronized gyro unit has 180° error, M.I. pointer travels in reverse direction to gyro. | Reversed connections between master indicator and amplifier or gyro unit. | Check continuity within cable harness of pins H, J, E and G |
| When synchronized gyro unit is correct, master indicator has a 180° error. | (1) Incorrect phase rotation of power supply. | Check phase rotation is A-B-C with B phase earthed. |
| | (2) C.19 shorted within master indicator. | Remove master indicator for repair. |

Table 3 (*continued*)

| Symptom | Possible cause | Action |
|---|---|---|
| Sluggish follow-up between master indicator and gyro unit. | (1) Derated valve in follow-up amplifier. | Check V6 to V9. Renew as necessary. Recheck setting of RV31. |
| | (2) C14 faulty in follow-up amplifier. | Remove amplifier for repair. |
| | (3) Master indicator fault. | Check setting of friction disc on indicators not fitted with tacho-generator. Check master unit resistance and follow-up as described above. |
| When synchronized gyro unit and master indicator have a small error from the correct heading this error varying from one heading to another. | (1) No deviation correction due to failure of d.c. supply. | If deviation network lamps within amplifier are not alight, check d.c. supply to compass system at pin D of WHITE connector. |
| | (2) Cable harness fault. | Disconnect RED cable harness from detector unit. Switch off d.c. supply to compass system. Measure resistance at pins G and H and at pins F and V of free red connector on RED harness. With the 3-15 switch at 15 the value should be between 390 ohms and 1500 ohms depending on the position of the corrector potentiometer and the modification state of the amplifier. |
| | (3) Faulty compensator coil on detector unit. | A d.c. continuity tester must NOT be used for checking a detector unit. Unless an a.c. tester, such as the flux-valve continuity tester, is available, substitute a known serviceable detector. This may conveniently be done within the aircraft using test bench cable 6C/807. |
| When synchronized both gyro unit and master indicator have a small error (9° max.) which is constant at all headings. | Deviation network lamp unserviceable. This will give opposite sense of deviation correction. | ◄ Replace with lamps 5L/X951273, 28V, 3·5W ► |
| Compass system will only synchronize on particular headings. master indicator follows gyro unit. | (1) Lead fault as under:—K line broken—synchronizes at 30 or 210°. L line broken—synchronizes at 150 or 330°. M line broken—synchronizes at 90 or 270°. | Disconnect RED cable harness from detector unit and check continuity of K, L and M lines (resistance between any two of these when connected to master indicator should be 10½ to 12½ ohms). |
| | (2) Signal Selsyn stator circuit fault in master indicator. | Remove red cable from rear of master indicator. Check that resistance between any two of pins K, L and M is 10½ to 12½ ohms. While measuring this resistance rotate variation dial to check cleanliness of stator slip-rings. If stator is found to be at fault remove master indicator for repair. |



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**◄ Table 4**

**Check points, amplifiers, Type A and B**
(*fig.* 32 *and* 35)

| Test Number | Avometer, Multimeter, Type 1, 20,000 ohms/volt Ref. No. 10S/16411, Ad. Patt. 12945 | | | Remarks |
|---|---|---|---|---|
| | Range (Volts) | Reading (Volts) Type 'A' | Type 'B' | |
| 1 | — | — | — | To obtain dynamic conditions for tests, short cct. V1 control grid. |
| 2 | 100 d.c. | 75 | 75 | |
| 3 | 2·5 d.c. | 0·7 | 0·7 | |
| 4 | 100 d.c. | 42 | ·75 | |
| 5 | 2·4 d.c. | 500 mV | 100 mV | Using V.V.M., Ref. No. 10S/16373. Remove the short cct. on V1 control grid and turn the synchronizing knob, to rotate the compass card more than 3° from the synchronized position. |
| 6 | 250 d.c. | 180 | 145 | |
| 7 | 100 d.c. | 28 | 28 | |
| 8 | 250 d.c. | 190 | 155 | |
| 9 } | 48 a.c. | 38 | | Using V.V.M., Ref. No. 10S/16373. Remove the short cct. on V1 control grid and synchronize the compass. |
| 10 } | 24 a.c. | | 6 | |
| 11 | 50 a.c. | 16 | 7 } | The figures indicated are obtained when there is no precession signal. Note that when short cct. on V1 control grid is removed and gyro unit displaced 90° from the synchronized position that the Multimeter Type 1 readings increase above the figures obtained for tests 11 to 14 inclusive. |
| 12 | 50 a.c. | 16 | 7 } | |
| 13 | 50 a.c. | 16 | 7 } | |
| 14 | 50 a.c. | 16 | 7 } | |
| 15, 16 } | 100 a.c. | 65 | 65 | |
| 17 | 100 a.c. | 60 | 62 | |
| 18 | 100 a.c. | 60 | 62 | |
| 19, 20 } | 25 d.c. | 10 | 15 | Remove the short cct. on V1 control grid and turn the synchronizing knob to obtain the signal. |
| 21 | 100 d.c. | 49 | 60 | |
| 22 | 10 d.c. | 4 | 6 | |
| 23 | 250 d.c. | 98 | 120 | |
| 24 | 100 d.c. | 49 | 60 | |
| 25 | 10 d.c. | 4 | 5·5 | |
| 26 | 250 a.c. | 200 | 200 | |
| 27 | 250 d.c. | 220 | 235 | |
| 28, 29 } | — | — | — | Short R26 to R28. If amplifier is out of balance, the Master Indicator pointer may rotate continuously in one direction. Adjust RV31 until pointer comes to rest. Check that RV31 is approximately central in its track. If not, V6, 7, 8 and 9 should be checked for similarity of characteristics. Remove the short cct. Repeat this test on completion of tests No. 30, 32, 37 and 38. |

**Table 4**—*continued*

| st nber | Avometer, Multimeter, Type 1, 20,000 ohms/volt Ref. No. 10S/16411, Ad. Patt. 12945 | | | Remarks |
|---|---|---|---|---|
| | Range (Volts) | Reading (Volts) Type 'A' | Type 'B' | |
| 0<br>2<br>7<br>38 | — | — | — | Connect V.V.M., Ref. No. 10S/16373, across C14, range 2·4, and Avometer, Multimeter, Type 1, range 10V a.c. to test points 37 and 38. Adjust RV31 to obtain minimum readings on both meters. Reading on Multimeter to be less than 1 volt. Select 48 range on V.V.M., 100V a.c. range on Multimeter, Type 1, and whilst turning the synchronizing knob ensure that Multimeter and V.V.M. readings increase to above 60V and 20V, respectively. |
| 31 | 25 a.c. | 1 | 2 | See under Test 30. |
| 32 | — | — | — | |
| 33 | 25 a.c. | 1 | 2 | |
| 34 | 250 a.c. | 205 | 205 | |
| 35 | 100 a.c. | 60 | 65 | |
| 36 | 100 a.c. | 60 | 65 | |
| 37<br>38 | — | — | — | See under Test 30. |
| 39 | 100 d.c. | 10 | 10 | |
| 40 | 100 d.c. | 18 | 18 | |

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adjusting the angular position of the stator relative to its rotor, the local magnetic variation can be set into the compass so that true indications are shown by the master indicator, gyro unit and any repeaters which may be included in the installation.

*Selsyn assembly*

**86.** This assembly is bolted to three mounting bosses which project from the back of the bezel casting. It incorporates the rear bearing for the rotor shaft, two Selsyns, three slip ring assemblies, an interference shield and the course pointer.

**87.** The data Selsyn stator is fixed to the Selsyn assembly casting but the signal Selsyn stator is mounted in a plain bearing and can be rotated through 360° by means of the variation setting control as shown in fig. 19 (*para.* 84 *and* 85).

**88.** A gear and slip ring assembly is bolted to the signal Selsyn stator, the gear engaging with the variation correction gear train operated by the control knob.

**89.** Brushes attached to the bezel casting contact a slip ring assembly on the signal stator and transmit the signals from the detector unit to the stator windings.

**90.** The rear end of the rotor shaft projects into the gearbox and carries a spring-loaded circular plate which forms part of an electro-magnetic clutch. The clutch is energized when the auto-pilot switch is operated and the movement of the rotor shaft is then transmitted via the clutch to a gear train which operates the brush contact arm on the auto-pilot pick-off potentiometer. Stops are provided so that this contact arm is prevented from travelling beyond prescribed limits. The clutch plate is frictionally mounted to the Selsyn rotor shaft so that slip will occur when the contact arm reaches the stops. A schematic circuit diagram of the pick-off connections is shown in fig. 22.

**91.** The follow-up motor is a two-phase squirrel-cage induction motor and is mounted on the outside of the gearbox assembly. One phase is continuously energized from the 115 volt a.c. supply, and the control phase is energized from the output of the follow-up amplifier. The rotor turns at a maximum speed of 11,880 rev/min: the transmission ratio at the rotor shaft is 1980: 1 (max. speed 6 rev/min) and at the transmitter it is 33:1 (max. speed 360 rev/min). The rotor shaft is fitted with a friction damping device to minimize any tendency to hunt. Fig. 20 shows the follow-up motor and gear train and fig. 23 shows the circuit connections to the follow-up motor and step-by-step transmitter.

**92.** Later production master indicators, Type A (*carrying Mod. B*74), and all master indicators, Type B, are fitted with a tacho-generator instead of the follow-up motor. The motor assembly is a similar two-phase induction motor. On the same shaft is mounted a mild steel rotor which is copper plated on its outer periphery to a depth of 0·005 in., the complete assembly of the two rotors on the shaft being dull nickel plated. The stator in which this rotor rotates carries an excitation winding and the tacho-generator output winding. The excitation winding is supplied from A phase in parallel with the fixed winding of the motor assembly, and a series resistor reduces the excitation voltage to between 15V and 25V approximately. Earlier type tach-generators carry a single 1000 ohms series resistor on a tagboard but those of later production have two 2 200 ohm resistors mounted in parallel to improve heat dissipation.

**93.** With any change of heading, rotation of the motor shaft causes the 0·005 in. thick copper drum to be rotated, and a small voltage, proportional to the motor speed, is induced in the tacho-generator output winding. At 5000 rev/min this is not less than 0·85V, a.c. It will be observed (*fig.* 24) that this output winding is wired in series with the data Selsyn rotor and it is so connected that the tacho-generator output voltage is in opposition, being at any instant approximately 5 per cent of the displacement signal. This negative feedback provides damping which reduces the overswings of the heading pointer to about three under extreme conditions. The mechanical friction brake, with its need for frequent re-setting is thus eliminated.

**94.** The 0·25 $\mu$F capacitor C20 remains disconnected if the follow-up motor is fitted, but it is re-connected if a tacho-generator is fitted.

*Annunciator*

**95.** The annunciator is mounted on the Selsyn

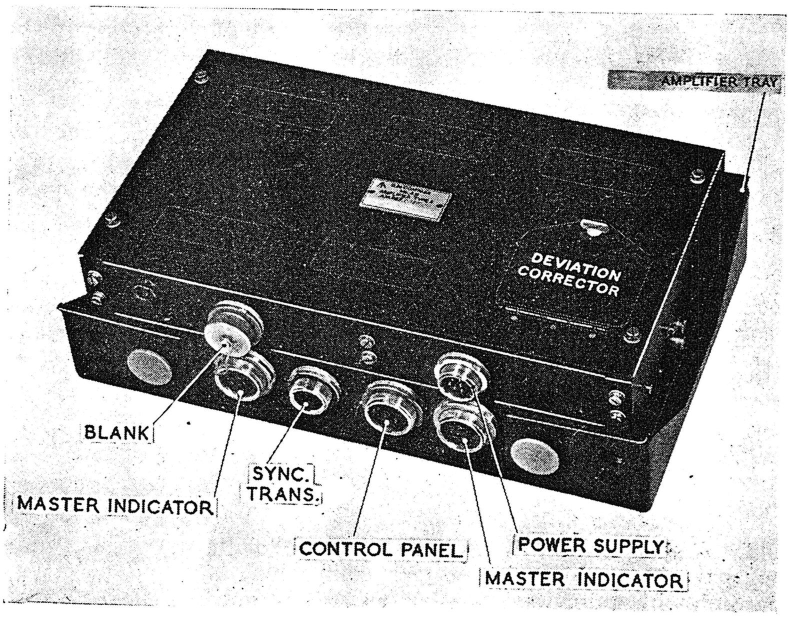


**Fig. 9. Amplifier, Type A, and mounting tray**

casting, and it consists of a flag displaying a dot or a cross below the N point of the dial. The flag is carried on the end of a pivoted staff the other end of which carries a small permanent magnet, and swings between two coils wound on soft iron pole pieces. The cross is luminized and the dot is filled in white as with the gyro unit annunciator.

**96.** The annunciator coils are connected in series with those of the gyro unit and the currents in the D and F lines are balanced at about 6·5 mA when the gyro unit is synchronized, in azimuth, with the detector unit. Under these conditions the centralized flag shows portions of both dot and cross.

**97.** Should the gyro unit card be out of synchronizm, the currents in the D and F lines change in value, but not in sense. For example, if the current in D line exceeds that in F line, the gyro unit card is precessed to a higher reading and, at the same time, the magnet on the staff is attracted by the appropriate coil so that the flag indicates a cross.

**98.** Under normal flight conditions in piston-engined aircraft, the dot and the cross will appear alternately in the annunciator window due to the flux valve in the detector unit moving about its neutral position. The movement is caused through vibration effect and air turbulences affecting the aircraft. In jet-propelled aircraft, however, the flag will alternately show a dot and a cross at a slower rate. Such a condition is quite normal and is due to the absence of vibration and to the stable straight flight path of this type of aircraft.

**99.** When the gyro is precessing, either a dot or a cross will be displayed continuously, the particular indication shown depending on the direction of precession. If the dot or the cross is continuously displayed under normal straight flight conditions, the gyro should be re-synchronized (*para.* 46).

**100.** When the compass is switched to D.G. and is functioning as a directional gyro, an electro-magnetic indicator is energized in the gyro unit causing a small flag marked D.G. to move in front of the annunciator flag and mask its indications. A similar indication fitted in the later series of master indicators is also energized by the operation of the selector switch and operates in the same manner, so that a D.G. indication is displayed in the annunciator windows of both indicators. This device is fitted to all master indicators with serial numbers from 464 upwards.

*Automatic pilot control*

**101.** The automatic pilot control shaft, operated by the automatic pilot control knob is fitted with a clicker mechanism which operates once during each complete revolution of the shaft. Limit stops are fitted which prevent the shaft from being turned more than eight revolutions in each direction. Each revolution of the shaft is equivalent to an alteration in aircraft heading of $\frac{1}{2}$°, and thus a maximum correction of 4° to port or to starboard can be made.

**102.** A spur gear on the end of the control shaft engages with an intermediate gear train which is in mesh with a quadrant gear. The quadrant gear is bolted to the pick-off potentiometer and thus, when the control knob is turned, the potentiometer rotates and the position of the brush contact relative to the centre tap on the potentiometer is altered as shown in fig. 19. A signal is therefore transmitted to the auto-pilot and a change of course results.

**Note . . .**
*The pick-off incorporated in the Type A master indicator of the Mk. 4B compass is designed specifically for use with the automatic pilot Mk. 9.*

**Master indicator, Type B** (*fig.* 25)

**103.** The master indicator, Type B, differs from the Type A indicator in the variation dial presentation and the auto-pilot pick-off. The aperture through which the variation dial is visible has been modified and it is located in the 9 o'clock position. This has enabled all the figures to be included in the scale numbering and the caption "X10" used on the Type A scale to be eliminated. The scale has also been sub-divided into 1° intervals, a finer lubber mark has been provided and the scale markings are now in black on a white dial. The facility for trimming the course held by the auto-pilot has been deleted from the Type B unit, this has resulted in the elimination of the knob and associated mechanism at the bottom of the instrument. The range of the pick-off potentiometer has also been increased from ± 4° to ± 10°; although the total monitoring signal for the full misalignment remains unaltered at 300 mV. The Type B unit is suitable for operation with the auto-pilots Mk. 9 or Mk. 10. All Type B master indicators are fitted with a tacho-generator.

**Master indicator, Type C**

**104.** This instrument is basically a Type B indicator with a screened step-by-step transmitter containing a filter for the d.c. supply. The internal link connecting A (salmon) to C (lemon) connectors is deleted and the 28V, d.c. supply for repeaters is fed in at A and B of the (salmon) connector. 28V, d.c. must still be provided at D (white) on the amplifiers for the operation of the deviation network. The aircraft installation does not require screened cable for interconnection of items except between the step-by-step transmitter and the suppressor to which the d.c. supply is connected.

**Master indicator, Type D**

**105.** The front bezel and housing accommodating the synchronizing mechanism are basically similar

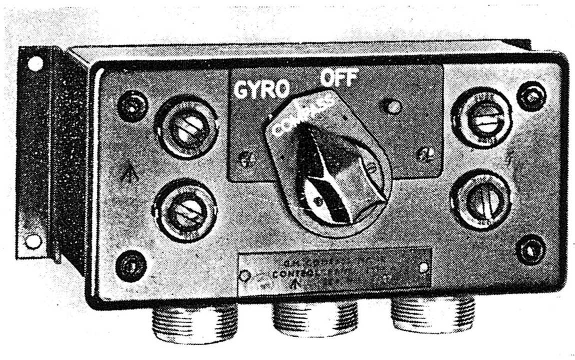


**Fig. 10. Control panel, bulkhead mounting, Type A**

to the Types B and C master indicators. The gear train and back plate assembly has been re-designed to accommodate up to a maximum of four transmitting synchronizing units (one being fitted as standard). This has been necessary owing to the increasing number of radio and electronic equipment installed in aircraft, which require accurate heading information from the synchronous system. No provision is made for M Type transmission in this indicator.

### ◄ Master indicator, Type E

**105A.** The master indicator, Type E, is dealt with in Appendix 3 to this chapter. ►

### Gyro unit, Type A

*General*

**106.** This unit, Type A, a sectional view of which is given in fig. 8, can conveniently be considered to consist of three main assemblies: the gyro assembly, the Selsyn bezel assembly and the chassis. The gyro assembly is fitted in the chassis which is bolted to the Selsyn bezel assembly. The complete unit is enclosed by a metal cover, which fits into a neoprene sealing gasket, behind the bezel casting and is secured, together with the back plate, by four screws. Two breathers covered with tropicalized felt are provided on the top surface at the rear of the cover.

*Gyro assembly*

**107.** The gyro is a 3-phase squirrel-cage induction motor, the rotor of which spins at approximately 23,000 rev/min. The rotor is of mild steel and is of cup cross-section with a central shaft. Its interior is sleeved with a cylindrical insert of aluminium alloy centrifugally cast about a laminated iron core, and forms the squirrel-cage armature of the motor.

**108.** The rotor housing is a light-alloy casting, one end of which is spanned across its diameter by a bridge-piece which carries one bearing for the rotor shaft. This is a ball type bearing, the balls being housed in a plastic cage. The other end of the rotor housing carries the stator windings of the motor which are supported by the stator tube surrounding the rotor shaft. The rotor shaft projects through the rotor housing and is carried in a ball race which is fitted in a brass cup in the rotor housing end plate. The brass cup is spring-loaded inwards by a coil spring between the cup and the bearing cover plate in order to provide automatic compensation for temperature variations.

**109.** The inner gimbal ring has two bearing pivots on its outside at right-angles to the rotor axis which fit into ball races on the vertical gimbal ring. The bearing pivots are insulated, and extend through the vertical gimbal ring to serve as commutators for light spring contacts through which the electrical connections to the gyro stator are made. The circuit diagram of the gyro unit is given in fig. 27.

*Erection mechanism*

**110.** A torque motor is used to maintain the gyro spin axis horizontal. The stator of this motor is mounted on the top of the vertical gimbal ring whilst the squirrel-cage rotor is secured to the gyro assembly.

**111.** If the gyro spin axis tends to depart from a position at right-angles to the vertical ring axis, an electrical contact is made via the levelling switch. This switch is in the form of a two-segment commutator and two diametrically opposed brushes. The two segments of the commutator are continuously energized at approximately 2 volts a.c. from phases A and B via a small auto-transformer mounted on the vertical ring.

**112.** Two brushes are mounted on the vertical ring and are connected to the control winding of the torque motor stator so that when the gyro rotor axis tilts from the horizontal, the commutator rotates, establishing contact with the brushes on the vertical ring, and causing the torque motor to be energized. The rotating field induced in the stator reacts with the rotor which is mounted on the gyro unit chassis to produce a torque which causes the gyro to precess about its horizontal axis until its spin axis is again at right-angles to the vertical axis. The gyro should precess through 30° of tilt in 4 to 8 minutes.

*Precession*

**113.** The compass indication is monitored to the magnetic meridian by precessing the gyro in azimuth by a d.c. signal applied to the precession coil on the vertical gimbal ring.

**114.** By referring to fig. 8, it will be seen that the rotor housing has attached to it two curved permanent magnets, which pass through the precession coil. At null, 13mA d.c. flow from E pin of the amplifier orange connector to the centre of the coil, about 6·5mA flowing back to the amplifier in the D and F lines. The magnetic effect of the two halves of the precession coil upon the horn magnets is therefore balanced. As soon as any misalignment signal is produced the balance in the D and F lines is disturbed, building up to a maximum of 15 mA differential current about 3° off null (further misalignment of the signal rotor does not increase the amplifier output). With one half of the coil having more current passing than the other, a pull is exerted on the unit north pole created by the horn magnets. This will cause the gyro vertical ring to precess in the direction necessary to restore the alignment of the compass card with the magnetic heading of the aircraft. With 15·5mA d.c. in one half of the coil and 1 mA in the other gyro should precess 20° in azimuth in between 5 and 8 minutes. When the current in the D line exceeds that in the F line the annunciator displays a cross and the gyo is precessed to a higher reading.

**115.** Electrical connection to the precession coil is made via three brushes which contact three slip rings on the bottom pivot of the vertical gimbal ring. A large bevel gear is mounted horizontally on the base of the vertical gimbal ring and engages with a second vertically-mounted bevel gear on the Selsyn rotor shaft which also carries the compass card. Any movement of the gyro in azimuth is, therefore, transmitted to the compass card by the bevel gears.

**116.** The caging mechanism of the gyro consists of two alloy rings situated below the horizontal bevel gear at the base of the gyro vertical ring. The upper ring carries three tapered cam projections which engage with three corresponding slots in the lower ring.

**117.** When the synchronizing control knob is pushed in, the lower ring is rotated slightly, and the cams, moving up the slots, cause the upper ring to lift, locking the bevel gear so that it cannot rotate. At the same time, a caging arm is raised by the upward movement of the ring so as to level and cage the rotor housing, thus preventing the gyro from precessing and toppling while the compass is being synchronized.

*Selsyn and bezel assembly*

**118.** This assembly consists of two castings one forming the gyro unit and face and carrying the bezel glass, dial, synchronizing control knob and annunciator window. The assembly also incorporates the operating mechanism for the synchronizing and set course controls, an annunciator, an auto-transformer, and the shaft which carries the course pointer, compass card, data Selsyn rotor and the vertical bevel gear.

**119.** The lubber line is marked at the top of the bezel and is also etched and fluorized on the bezel glass. The aircraft heading rectangle and two parallel grid lines are provided on the glass to assist the pilot in maintaining an accurate course. The course pointer and a matching reference in the form of a rectangle, are marked on a circular metal plate which is friction loaded to the compass card by an annular friction pad. The compass card is engraved from 0° to 360°. Fluorescent material is used throughout for all markings, except the annunciator.

*Set course control*

**120.** This control is operated by a knob located at the bottom left-hand corner of the instrument face. When the set course is pressed in, the course pointer plate is lifted slightly off the friction pad. A gear on the shaft extending from the set course knob is constantly in mesh with a second gear carried on a sleeve fitted to the Selsyn assembly casting. As the knob is turned, this sleeve rotates three ball bearings which project through apertures in the compass card mounting and bear on the course pointer plate causing it to rotate. When the set course knob is released, contact between the course pointer plate and the friction pad is restored and the course pointer is again friction loaded to the compass card.

*Synchronizing control*

**121.** This control is operated by a knob, marked with a DOT and CROSS and direction arrows. It is situated at the bottom right-hand corner of the bezel. When the knob is pushed in and turned, a train of gears is operated which rotates the Selsyn rotor and the compass card. Since the horizontal bevel gear on the vertical ring of the gyro is now locked (*para.* 117), a slipping clutch assembly is interposed between the vertical bevel gear and the shaft carrying the compass card, so that when the knob is turned the card and the Selsyn rotor can be rotated relative to the Selsyn stator. By means of this control and the follow-up mechanism the signal Selsyn rotor in the master indicator can be quickly brought to null, thus synchronizing the compass card indication with the magnetic heading of the aircraft. It is possible to obtain a false (unstable) null 180° out. The annunciator will then show a dot for reading below null. If the direction arrows on the knob are followed, the correct null will be found.

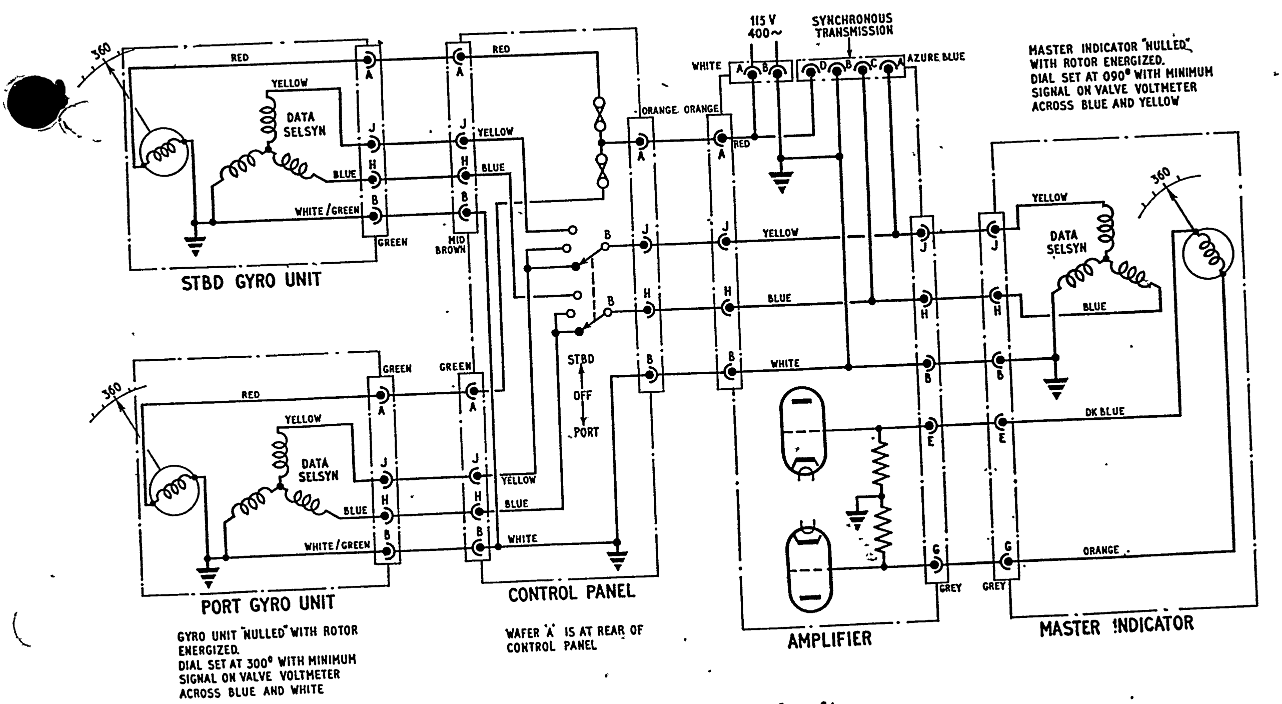


**Fig. 13. Data Selsyn circuit**

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# Appendix I

## STANDARD SERVICEABILITY TEST FOR COMPASS, GYRO MAGNETIC, Mk. 4B

### LIST OF CONTENTS



### LIST OF ILLUSTRATIONS



#### Introduction

**1.** The tests contained in this Appendix must be applied to the Mk. 4B compass system immediately before it is installed in an aircraft and at any time that the serviceability is suspect. The tests must also be applied at inspections made at Equipment Depots.

#### CONDITIONS FOR TESTS

**2.** The following conditions must be adhered to at all times during a test and the tolerances specified must not be exceeded.

**3.** All tests must be applied in a room temperature of from 10 to 25 deg. C.

**4.** When in use during any of the tests the detector unit must be placed in a position where magnetic interference is a minimum.

#### Power supplies

**5.** The power supplies used during the tests must conform to the following requirements:—

(1) The a.c. supply must be 115±2V, 3-phase, 400 ±5 c/s. Phase rotation must be A–B–C with phase B earthed.

(2) The d.c. supply must be steady at 26V.

**Note . . .**

*It is important that the phase rotation is correct; reversed phase rotation will cause excessive gyro drift. After switching on the a.c. supply to a gyro unit verify at once that the gyro rotor commences to rotate and accelerates up to full speed. If the gyro rotor does not start up at once, switch off the power supply immediately. If one phase is open-circuited, failure to switch off at once will cause serious damage to the gyro unit.*

**6.** Except where otherwise specified, full voltage must be applied during the tests but provision must be made for reducing the voltage at the a.c. supply during the gyro starting test.

#### Inter-unit connection

**7.** The standard Mk. 4B bench test harness must be used for inter-unit connections.

**WARNING**

*Under no circumstances is a d.c. continuity tester to be used for checking the detector unit circuits.*

#### TEST EQUIPMENT

**8.** The following equipment is required for the tests:—

(1) Insulation tester, Type C, 250V (Stores Ref. 5G/152).

(2) Frequency meter (Stores Ref. 5Q/154).

(A.L.11, Feb. 58)

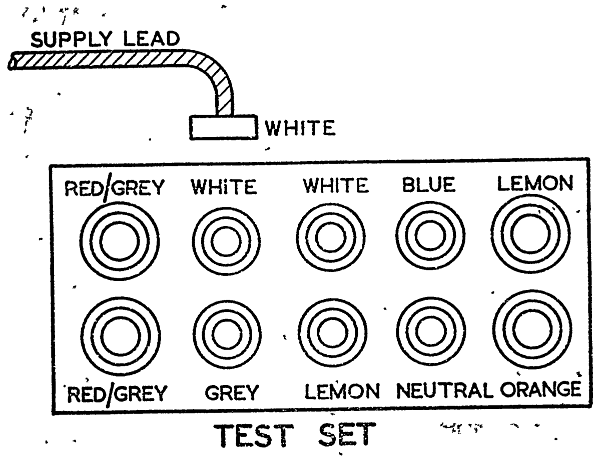



**Fig. 1. Power supply connection to test set for supply check**

(3) Stop watch, G.S., $\frac{1}{5}$ sec. (Stores Ref. 6B/539).

(4) Gyro test table, Mk. 4 (Stores Ref. 6C/790).

(5) Bench test harness (Stores Ref. 6C/803).

(6) Amplifier power supply cable (Stores Ref. 6C/808).

(7) Compass test set (Stores Ref. 6C/848).

(8) Testmeter, Type D (Stores Ref. 10S/10610) complete with leads and jack plug (Stores Ref. 10H/9072).

(9) Inverter, Type 100B (Stores Ref. 5UB/4935) or some other source of 3-phase a.c. supply capable of supplying 115 ±2 V, 400 ±5 c/s.

(10) Stand for holding detector and compass units; local manufacture.

(11) Switch, Type B (Stores Ref. 5CW/543) and 2 terminal blocks Type B (Stores Ref. 5CZ/432).

**Note . . .**

*For convenience the testmeter will be referred to as an ammeter, voltmeter or ohmmeter during a test.*

### CHECKING A.C. SUPPLY

**9.** Check that the voltage and frequency of the supply obtained from the Type 100B inverter (or alternative supply) is within the required limits as follows:—

(1) Connect the power supply plug to the white socket of the test set (*fig.* 1).
(2) Set supply switches to ON.
(3) Set selector switch to PHASE SEQ. TEST.
(4) Set test set A.C. SUPPLY to ON and check that the green lamp lights to indicate correct phase rotation.
(5) Set selector switch to VOLTS AB.
(6) Plug frequency meter into JK1.
(7) Connect 0 to 150V. a.c. voltmeter into JK2.
(8) Press FREQUENCY push button and note the frequency on the meter; this should be 400±5 c/s.
(9) Press AC–DC VOLTS push button and note the voltage; this should be 115 ±2 volts.
(10) Repeat (8) and (9) with selector switch set to VOLTS BC and VOLTS AC in turn.

**10.** On completion of the test, switch off the a.c. supply and disconnect the frequency meter and voltmeter from the test set. Switch off the main power supply.

### CHECKING D.C. SUPPLY

**11.** Check that the d.c. supply is within the required limits as follows:—

(1) Plug a 0 to 30V. d.c. voltmeter into JK2.
(2) Set selector switch to D.C. VOLTS
(3) Switch on the power supply.
(4) Set D.C. SUPPLY SWITCH to ON.
(5) Press AC–DC VOLTS push button and note the d.c. voltage; this should be 26V.

**12.** On completion of the test, set the D.C. SUPPLY SWITCH to OFF and disconnect the voltmeter. Switch off the power supply.

### TESTING SEPARATE UNITS

**Amplifiers, Type A and B**

*Precession test*

**13.** (1) Connect the amplifier to the test set as shown in fig. 2.
(2) Plug wander lead into jacks JK6 and JK7.
(3) Set selector switch to PREC. AMP. TEST.
(4) Switch on the a.c. supply and allow 30 seconds for the amplifier to become operative.
(5) Set PREC. AMP. TEST to 0°; the voltmeter should indicate zero. If necessary, set the voltage to zero by adjusting the potentiometer RV20 (*fig.* 3) which is reached by removing the amplifier cover.
(6) Turn the PREC. AMP. TEST control anti-clockwise until the voltmeter indicates 6V, then check that the indication on the PREC. AMP. TEST does not exceed 1° for Type A amplifier and 3° for Type B amplifier.
(7) Repeat (6), turning the PREC. AMP. TEST clockwise. If necessary, adjust RV38 (*fig.* 3) to obtain the required results.

**14.** On completion of test, switch off the a.c. supply. Remove the wander lead from JK6 and JK7.

*Follow-up test*

**15.** (1) Connect the test set to the amplifier as shown in fig. 4.
(2) Plug 0 to 150V a.c. voltmeter into JK2.
(3) Set selector switch to F.U. AMP. TEST.
(4) Switch on the a.c. supply and allow 30 seconds for the amplifier to become operative.
(5) Set F.U. AMP. TEST to 0°.
(6) Press A.C.–D.C. VOLTS push button and observe the voltmeter; this should indicate not more than 10V. If necessary remove the amplifier cover and adjust potentiometer RV31 to obtain not more than 10V.
(7) Turn F.U. AMP. TEST switch anti-clockwise until the voltmeter indicates 40V; the F.U. AMP. TEST switch should indicate not more than 0·5°.
(8) Repeat (7), turning the F.U. AMP. TEST switch clockwise.

**16.** On completion of the test, switch off the a.c. supply.

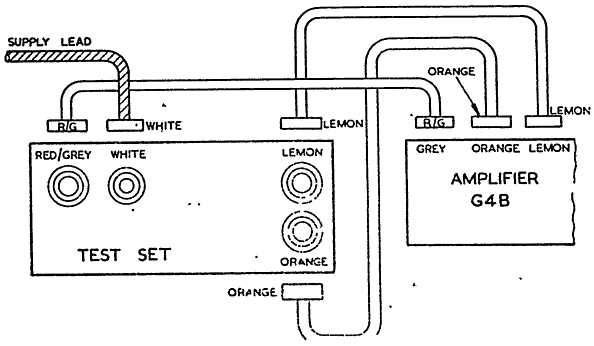



**Fig. 2. Amplifier connections to test set for precession test**

*Synchronous transmission*

**17.** (1) Connect the power supply to the compass system.

(2) Switch on the a.c. supply and allow 30 seconds for the amplifier to become operative.

**Note . . .**

*When the a.c. supply is switched on, press the gyro unit* SET COURSE (HEADING) *knob and rotate the pointer. If the compass card rotates with the pointer, switch off immediately and investigate cause of gyro failure to start.*

(3) Connect a 0 to 75V a.c. voltmeter across pins A and B of amplifier dark blue socket.

(4) By operating the gyro unit synchronizing knob, progressively change heading to each side of the null point and check that the voltmeter indicates increasing and decreasing voltages with a maximum of approx. 16V.

(5) Repeat (3) and (4) with the voltmeter across pins B and C, and C and A in turn.

**18.** On completion of the test, switch off the a.c. supply, then switch the main power supply off. Disconnect the voltmeter.

*Turn cut-out relay check (Type B amplifier only)*

**19.** (1) Connect the power supply to the compass system.

(2) Switch on the power supplies and allow 30 seconds for the amplifier to become operative.

**Note . . .**

*When the a.c. supply is switched on, press in the gyro unit* SET COURSE (HEADING) *knob and rotate the pointer. If compass card rotates with pointer, switch off immediately and investigate cause of gyro failure to start.*

(3) Set control panel selector to PORT.

(4) Connect 24V d.c. positive to pin A of amplifier blue socket and listen for the operation of the turn cut-out relay.

(5) Check that the D.G. flags are shown on the master indicator and port gyro unit when the relay is energized.

(6) By operating the synchronizing knob, displace the gyro unit 5° and check that it is not monitored.

(7) Set control panel selector to STBD. and repeat

**20.** On completion of test, disconnect the d.c. supply from the amplifier light blue socket and switch off the power supply.

**Master indicator, Type A, autopilot pick-off signal test**

**21.** (1) Connect the amplifier and master indicator to the test set as shown in fig. 5.

(2) Plug a 0 to 150V a.c. voltmeter into JK2.

(3) Set test set selector to AUTOPILOT P.O. RES. TEST.

(4) Switch on the a.c. and d.c. supplies and allow 30 seconds for amplifier to become operative.

(5) Press and hold AC–DC VOLTS push button and turn the indicator AUTOPILOT knob until the minimum voltage is obtained on the voltmeter. Release push button.

(6) Switch off the d.c. supply.

(7) Turn AUTOPILOT knob fully clockwise then 8 turns anti-clockwise.

(8) Switch on the d.c. supply.

(9) Press and hold AC–DC VOLTS push button, turn AUTOPILOT knob fully clockwise and note voltmeter reading; turn knob fully anti-clockwise and note voltmeter reading; ◄ minimum voltage in either direction must be not less than 20 volts. Also, one complete turn of the knob must change the voltage by not less than 2 volts. ► Release the push button.

**22.** On completion of the test, switch off the a.c. and d.c. supplies.

**Master indicators, Type B, C and D, autopilot pick-off signal test**

**23.** (1) Connect the power supply to the compass system then connect the amplifier, master indicator and testmeter to the test set as shown in fig. 6.

(2) Set control panel selector to PORT.

(3) Turn test set selector to AUTOPILOT P.O. RES. TEST.

(4) Connect a 10mA a.c. ammeter across pins E and G of test set top Red/Grey socket.

(5) Switch on the a.c. and d.c. supplies and allow 30 seconds for amplifier to become operative.

**Note . . .**

*When the a.c. supply is switched on, press the* SET COURSE (HEADING) *knob on the gyro unit and rotate the pointer. If the compass card rotates with the pointer, switch off immediately and investigate cause of gyro failure to start.*

(6) By operating the gyro unit synchronizing knob, obtain the minimum reading on the milliammeter.

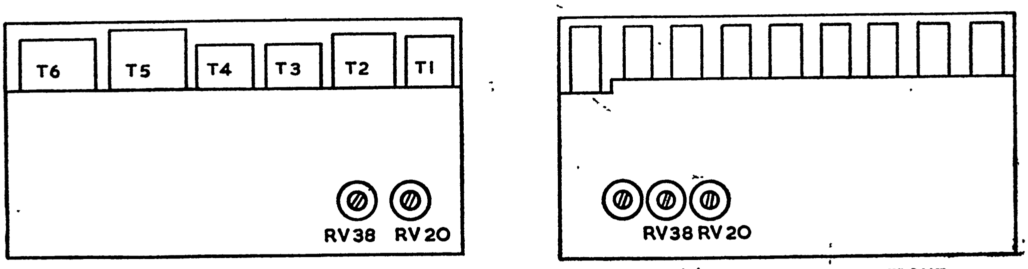
(7) Switch off the a.c. and d.c. supplies.

(8) Disconnect the neutral coloured cable at the test set neutral coloured socket.

(9) Switch on the a.c. and d.c. supplies and allow 30 seconds for amplifier to become operative.

(10) Operate the port gyro unit synchronizing knob to synchronize gyro unit and master indicator with detector unit.

(11) Switch off the a.c. and d.c. supplies.




TYPE 'A' AMPLIFIER WITH REAR COVER REMOVED.

TYPE 'B' AMPLIFIER WITH FRONT COVER REMOVED.

**Fig. 3. Positions of variable resistors in Type A and B amplifiers**

(12) Re-connect the neutral coloured cable to the test set neutral socket.

(13) Switch on the a.c. and d.c. supplies and allow 30 seconds for the amplifier to become operative.

(14) Operate the port gyro unit synchronizing knob clockwise and check that the milli-ammeter reading changes until a maximum of approx. 1mA is reached at 10° displacement.

(15) Repeat (14) operating gyro unit synchronizing knob anti-clockwise.

(16) Operate gyro unit synchronizing knob until system is synchronized.

**24.** On completion of test, switch off the a.c. and d.c. supplies.

**Master indicators, Type A, B, C and E, M-type transmitter check**

**25.** (1) Connect the power supply to the compass system.

(2) Switch on the a.c. and d.c. supplies and allow 30 seconds for the amplifier to become operative.

**Note . . .**

*When the a.c. supply is switched on, press in the gyro unit* SET COURSE (HEADING) *knob and rotate the pointer. If the compass card rotates with the pointer, switch off immediately and investigate the cause of the gyro failure to start.*

(3) By operating gyro unit synchronizing knob, set the master indicator to 0° exactly.

(4) Switch the a.c. and d.c. supplies off.

(5) Remove salmon-pink and grey plugs from master indicator.

(6) Unscrew the 3 screws and remove the transmitter from the indicator.

(7) Check that the transmitter brushes are at least $\frac{2}{3}$ the new length.

(8) Clean the transmitter commutator with clean dry air pressure, carefully lifting each brush in turn.

(9) Position the transmitter spindle so that brushes 1, 2 and 3 are connected negative, positive and neutral respectively.

(10) Refit transmitter into the master indicator, and secure with the 3 screws.

(11) Switch a.c. and d.c. supplies on. Check polarity of pins C, D and E (negative, positive and neutral respectively on salmon-pink plug on master indicator) using a 0 to 30V d.c. voltmeter.

**26.** On completion of test, switch off the a.c. and d.c. supplies.

**Gyro units**

*Resistance check*

**27.** Using the testmeter, check the resistance between the pins of the green plug on the Type A, B and D units as indicated in the following table:—

**Permissible resistance (ohms)**

| Between pins | Type A | Type B and D |
|---|---|---|
| D and E | 600 to 750 | 900 to 1,000 |
| E and F | 600 to 750 | 900 to 1,000 |
| D and F | 1,200 to 1,500 | 1,800 to 2,000 |

D and F is to be the sum of the other two resistances.

*Starting test, gyro units, Type A to D*

**28.** (1) Mount the gyro unit on the gyro test table and connect the a.c. supply, using connector, Ref. No. 6C/865.

(2) Switch on the supply, adjust voltage to 115 $\pm$2 volts and allow the gyro to attain full speed.

**Note . . .**

*When the supply is switched on, press in the* SET COURSE (HEADING) *knob and rotate the pointer. If the compass card rotates with the pointer, switch off immediately and investigate cause of gyro failure to start.*

(3) Adjust the a.c. voltage control until 90 volts is obtained.

(4) Switch off the supply and allow gyro to come to rest.

(5) Switch on the supply and check that, with the reduced voltage, the gyro rotates and attains full speed.

(6) Adjust the a.c. voltage control to obtain 115 $\pm$2 volts.



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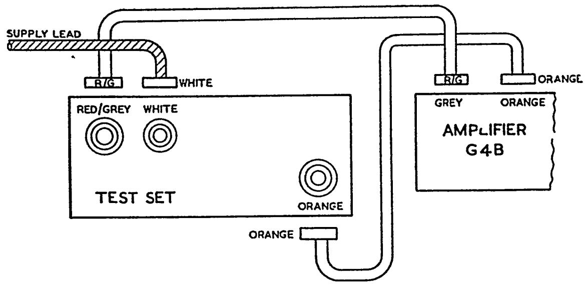


**Fig. 4. Connections between amplifier and test set for follow-up motor test**

*Drift test, gyro units, Type A to D*

**29.** Mount the gyro unit on the test table and connect the a.c. supply, using connector, Stores Ref. 6C/865, then proceed as follows:—

(1) Set the test table for 7½ degrees roll, pitch and yaw at the rate of 6 to 10 oscillations per min. Operate for not less than 20 min., reversing the direction of movement at intervals of 1 min.

(2) Stop, level and align the test table.

(3) Set the gyro unit card to 0 degrees.

(4) Set test table for 7½ degrees roll, pitch and yaw, and operate table for 10 min., reversing at intervals of 1 min.

(5) Stop, level and align gyro test table. Record the gyro unit reading.

(6) Rotate the test table through 90 degrees, re-set gyro unit card, as necessary, to 90 degrees and repeat (4) and (5).

(7) Repeat (4) to (6) for 180 and 270 degrees heading. Maximum permissible drift (ignoring the sign plus or minus) is 10 degrees after the observed drift has been corrected for latitude; maximum permissible drift on any one heading is 3 degrees. Typical examples of drift are given in Table 1.

**Note . . .**

◄ (1) *For Type A units that are being checked at other than Lat. 51 deg. N., and Type B, C and D at other than Lat. 30 deg. N., corrections are to be applied to the observed drift, using the following formula:—*

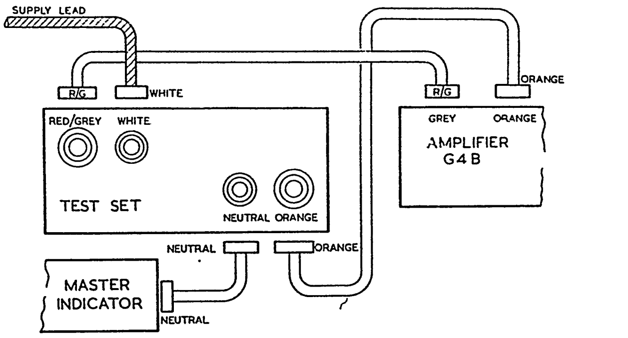


**Fig. 5. Connections for autopilot pick-off signal test, master indicator, Type A**

*Apparent drift=15 × sin. Lat. deg./hr.*

*The correction, with the correct sign, i.e. negative for N. Lat. and positive for S. Lat., is to be made before applying the drift limits. For example, gyro unit Type A has been calibrated to have zero observed drift at latitude 51 deg. N., and has been given a real drift of +15 sin 51 deg., i.e. +11½ deg. per hr. to counteract the effect of the earth's rotation of —11½ deg. per hr., so that its observed drift at 51 deg. N is +11½—15 sin. 51 deg. (which =11½) = 0. If this gyro is being tested at some other latitude X deg. N, the drift will be +11½ deg. —15 sin. X deg. per hr. If tested at latitude X deg. S, the drift will be +11½ + 15 sin X deg.*

(2) *Table 2 contains the drift which is to be added to or subtracted from the observed drift when testing a gyro unit at the indicated latitude over a period of 10 min. If the calculated drift is positive, this is allowed for by subtracting from the observed drift, and vice versa. An example of the corrections, is as follows:—*

◄ *Observed drifts of a Type B gyro, tested at 40 deg. N, are —3, —2½, +2½, +3½ deg.; correction to be applied (from Table 2) is +½ deg., making the corrected drifts —2½, —2, +3, +4 deg. If the gyro had been tested at 10 deg. N, the correction would have been —1 deg. (from Table 2) making the corrected drifts —4, —3½, +1½, +2½ deg. When testing at latitudes not given in Table 2, calculate the correction by using the formula.* ►

**TABLE 1**

**Examples of observed drift corrected for latitude error**

| Example | Heading (degrees) 0 | 90 | 180 | 270 | Total | Remarks |
|---|---|---|---|---|---|---|
| | Drift (degrees) | | | | | |
| 1 | +2½ | +2½ | 0 | 1 | 6 | Acceptable |
| 2 | +2½ | +2½ | —2½ | —3 | 10½ | Reject (excessive total) |
| 3 | +2½ | +2½ | +3 | +2 | 10 | Acceptable |

**TABLE 2**

**Apparent drift of gyro**

| Latitude | Apparent drift per hr. | Setting of | Drift in 10 minutes when tested at the given latitude | | | |
|---|---|---|---|---|---|---|
| | | | Gyro unit, Type A | | Gyro units, Type B, C and D | |
| | | | Add | Subtract | Add | Subtract |
| 0° | 0° | | | 2° | | 1¼° |
| 10°N | 2½° | | | 1½° | | 1° |
| 20°N | 5½° | | | 1° | 0 | ½° |
| 30°N | 7½° | Type B, C and D | | ½° | 0 | 0 |
| 40°N | 9½° | | | ½° | ½° | |
| 51°N | 11½° | Type A | 0 | 0 | ¾° | |
| 60°N | 13° | | 0 | 0 | 1° | |
| 70°N | 14° | | ½° | | 1° | |

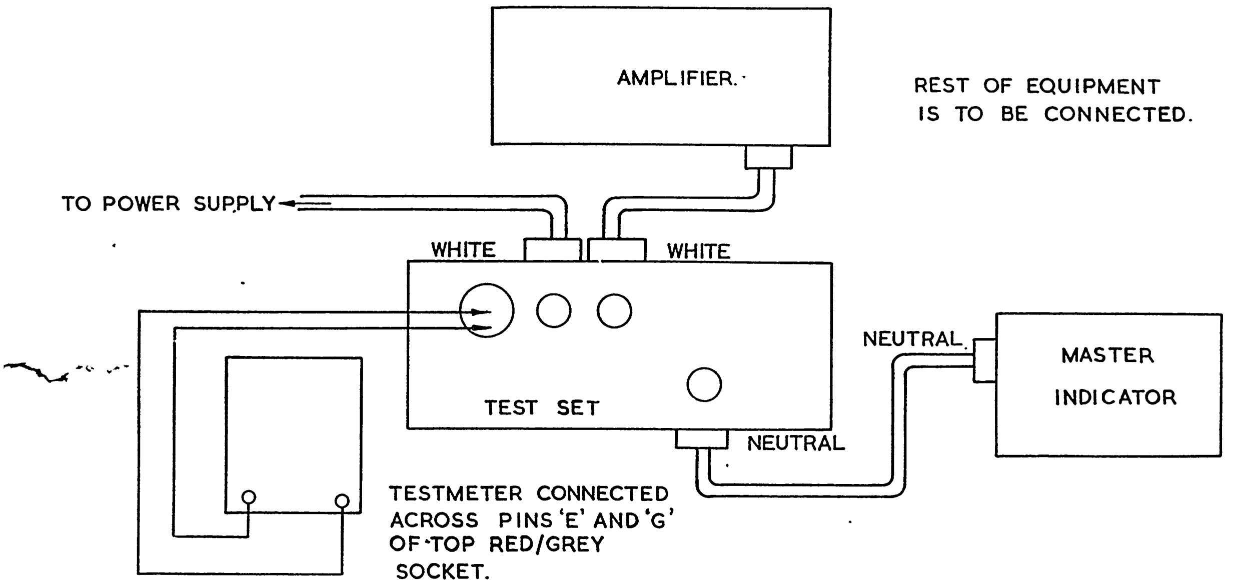


**Fig. 6. Connections for autopilot pick-off signal test, master indicators, Type B, C and D**

**30.** On completion of the test, switch off the main supply and remove the gyro unit from the test stand.

*Pick-off test for gyro unit, Type B, used with autopilot, Type A.L.3*

**31.** Check operation of the pick-off as follows:—

(1) Connect the gyro unit and d.c. supply to the terminal block (*fig.* 7).

(2) Switch the d.c. supply on and off, and listen for the pick-off engaging and disengaging the gyro unit.

(3) Disconnect the d.c. supply from the terminal block.

**32.** Check the resistances of the pick-off by checking between the terminals, using the test-meter, as follows:—

| Between terminals | Permissible resistance (Ohms) |
|---|---|
| A and B | 141 to 189 |
| A and C | 48 to 117 |
| B and C | 48 to 117 |
| A and E | 380 to 420 |
| Resistance between D and F is to be short circuit | |

**Note . . .**

*Resistance between A and C, and B and C are to be equal, denoting that the wiper is central on the potentiometer.*

**RESTRICTED**