PART 2: SECTION 3

CHAPTER 3

THE DISTANT READING COMPASS MK. 1 AND HEADING INDICATOR MK. 1

Introduction

1. The D.R. Compass Mk. 1 is in limited use in the Royal Air Force, and is therefore only described in broad outline in this manual. Pilots requiring detailed information are referred to A.P. 1275B, Instrument Manual.

Purpose

2. This instrument gives stabilized, remote indication of heading, and is capable of relaying directional information to the mechanisms of other instruments requiring heading information, *e.g.* repeaters at specified positions in the aircraft, computing bombsights, and similar apparatus.

3. The ordinary magnetic compass designed for use in aircraft, though developed to a high degree of efficiency within its limits, is, by its nature, inadequate for many of the tasks which an aircraft is called upon to perform.

Implementation

4. The D.R. Compass Mk. 1 has a compass unit which detects the aircraft heading and transmits it to repeaters, after correcting for variation. The compass unit is sited in a part of the aircraft least subject to magnetic interference.

5. Since the compass unit detects the heading of the aircraft and transmits it to repeaters, it follows that the repeaters all give the same indication of heading. Furthermore, since the repeaters are simply electric motors and not subject to local magnetic interference they can be placed at any positions in the aircraft most convenient to crew requirements.

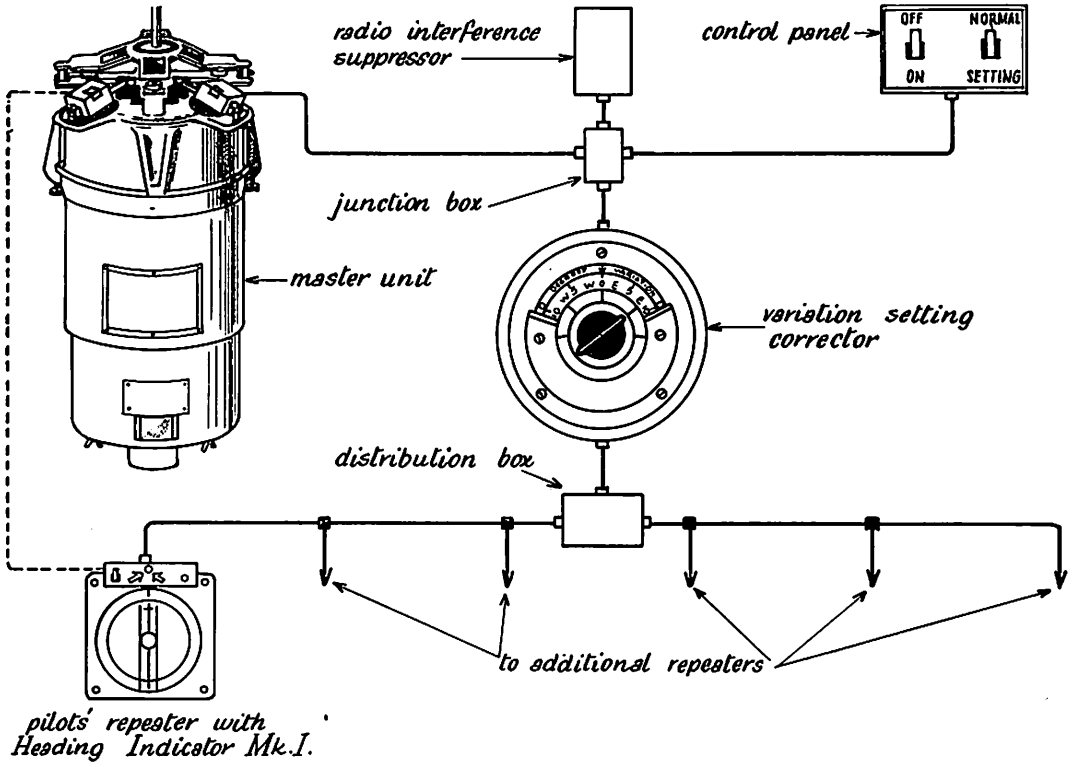

Fig. 1. A Typical D.R. Compass Installation Layout.

6. The requirement that the compass shall be capable of supplying azimuth control to directional mechanisms implies that it must be capable of feeding *true* directions to such equipment. As the D.R. compass uses the local magnetic meridian as a datum, provision is made for manually offsetting the repeater readings by the amount of local variation so that true heading is read. This is effected by a unit known as the Variation Setting Corrector (V.S.C.), situated between the master unit and the repeaters.

Description

7. The complete installation comprises a master unit, V.S.C., a variable number of repeaters, a small control panel carrying the switches for the circuit, and a radio interference supressor. The precise composition of the installation varies according to the requirements of particular aircraft types ; but a typical layout is shown in Fig. 1.

8. The supply voltage is 24 volts D.C., but the compass should operate satisfactorily if the voltage rises to 27 volts or falls to 22 volts. The temperature range within which the compass functions correctly is from −20°C. to + 50°C. The flight operating limits are 75° in bank, climb, and dive.

9. While one of the main advantages of a remote indicating compass system is that the master unit can be placed in the optimum position to minimize magnetic interference, this very fact sometimes proves inconvenient when it is necessary to read the heading direct from the master unit for the purpose of synchronizing repeaters. In aircraft whose D.R.C. master unit is inaccessible, an ancillary unit known as the Heading Indicator, Mk. 1 may be installed as an attachment to the pilot's repeater to obviate the necessity of reading the master unit directly during the process of synchronization. This attachment is fully described in the Instrument Manual, and briefly at the end of this chapter.

10. The three principal characteristics of the D.R.C.—stabilization, remote indication, and the provision of torque for power repeaters—each entail the adoption of principles quite unlike those of the direct reading magnetic compass.

11. Stabilized heading indication cannot be achieved by the use of a pendulous magnet system alone, since turns and accelerations inevitably allow the vertical component of terrestrial magnetism to affect the compass reading. A directional gyroscope, on the other hand, is relatively stable over short periods and correctly shows the heading during turns and accelerations. By the use of such a gyroscope, therefore, these errors can be eliminated ; but for various reasons, *e.g.* imperfect balance of the gyroscope, pivot friction, etc., a gyro does not in fact remain directionally stable over a period of time. Moreover, even an ideal gyroscope would, although stable *in space*, exhibit movement relative to the earth owing to the latter's rotation.

12. In order to use a directional gyroscope for stabilized heading indication, therefore, it is necessary to control the gyro so that its axis is maintained relative to some fixed datum on the earth. This control is secured in the D.R.C. by the use of a monitoring compass magnet which, by energizing small electro-magnets, keeps the gyro continuously in a fixed relation to the local magnetic meridian. Despite the fact that the magnet is subject to turning and acceleration errors, its rate of control over the gyro is made too slow to deflect the latter appreciably during the relatively short periods when the magnet is in error. A detailed description of this method of control is given in the Instrument Manual.

13. It is immaterial to the functioning of the compass whether the axis of the gyro is parallel to the meridian or at right angles to it, so long as a constant relationship is maintained. In point of fact, however, the gyro axis is at right angles to the meridian ; *i.e.* it lies in an east-west direction, as shown in Fig. 2.

14. By combining the properties of the magnetic needle and the directional gyro in this way, a stabilized indication of heading is achieved for all practical purposes, though sustained slow turns may affect the D.R.C. reading by an amount not exceeding 1°, as may dives of 20° or more.

15. The gyroscope, *tied to the magnetic meridian* and corrected for wander by the magnet, thus serves as the datum relative to which the heading is measured. To read the aircraft's heading, a scale fixed relative to the gyro is required, against which a lubber line, fixed in relation to the aircraft, indicates aircraft heading, as shown in Fig. 2. In the distant reading compass the scale is not fixed directly to the gyro, as in the normal types of gyroscopic direction indicator,

but to the *inner frame*, the latter being a stirrup-shaped component which carries the controlling magnet and also the gyro in its gimbals, as shown in Fig. 3.

16. The gyroscope is so mounted in the inner frame as to have $\pm 30°$ freedom in azimuth, and it follows that some means is required to keep the inner frame, and subsequently the scale, in alignment with the gyro. For this purpose a reversing motor is employed to drive the inner frame in either direction, as required, to bring it into line with the gyroscope.

17. The reversing motor, also known as the *frame motor*, is carried on the outer frame of the master unit, as shown in Fig. 3, and is consequently fixed relative to the aircraft. When the aircraft turns, carrying with it the outer frame, the inner frame tends to turn also, since it is geared to the reversing motor. The gyro, however, remains stable in direction, and under its control the reversing motor simultaneously imparts to the inner frame an equal and opposite turn to that of the aircraft in order to maintain the relationship between gyro and frame. The net result is that the inner frame and scale, like the gyro, remain stable, while the aircraft and the outer frame, carrying the lubber line, rotate about them.

18. To transmit the information from the master unit to remote indicating repeaters a system of electrically-produced magnetic fields is employed.

19. The system of transmission does not automatically ensure a repeater reading which is identical to that of the master unit. The compass card of the repeater, although faithfully repro-

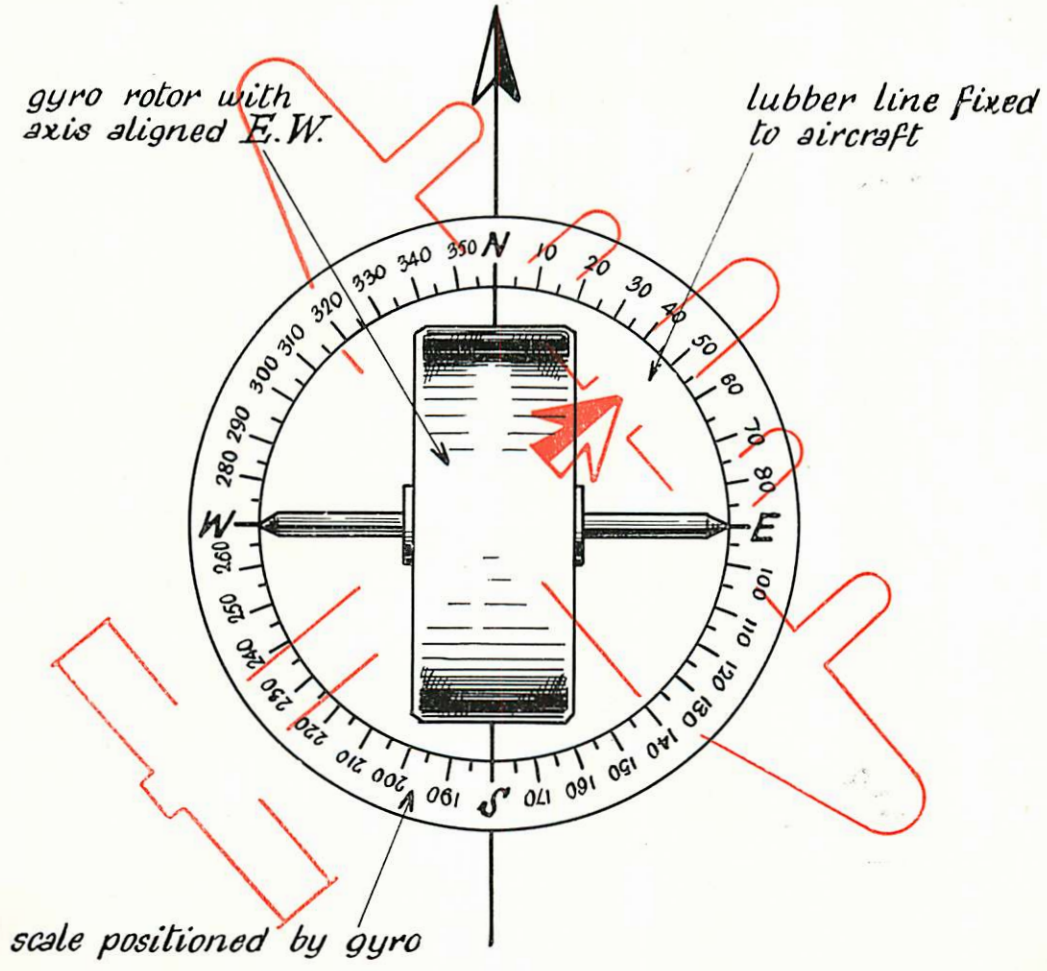

Fig. 2. Relation of Gyro Axis and Magnetic Meridian.

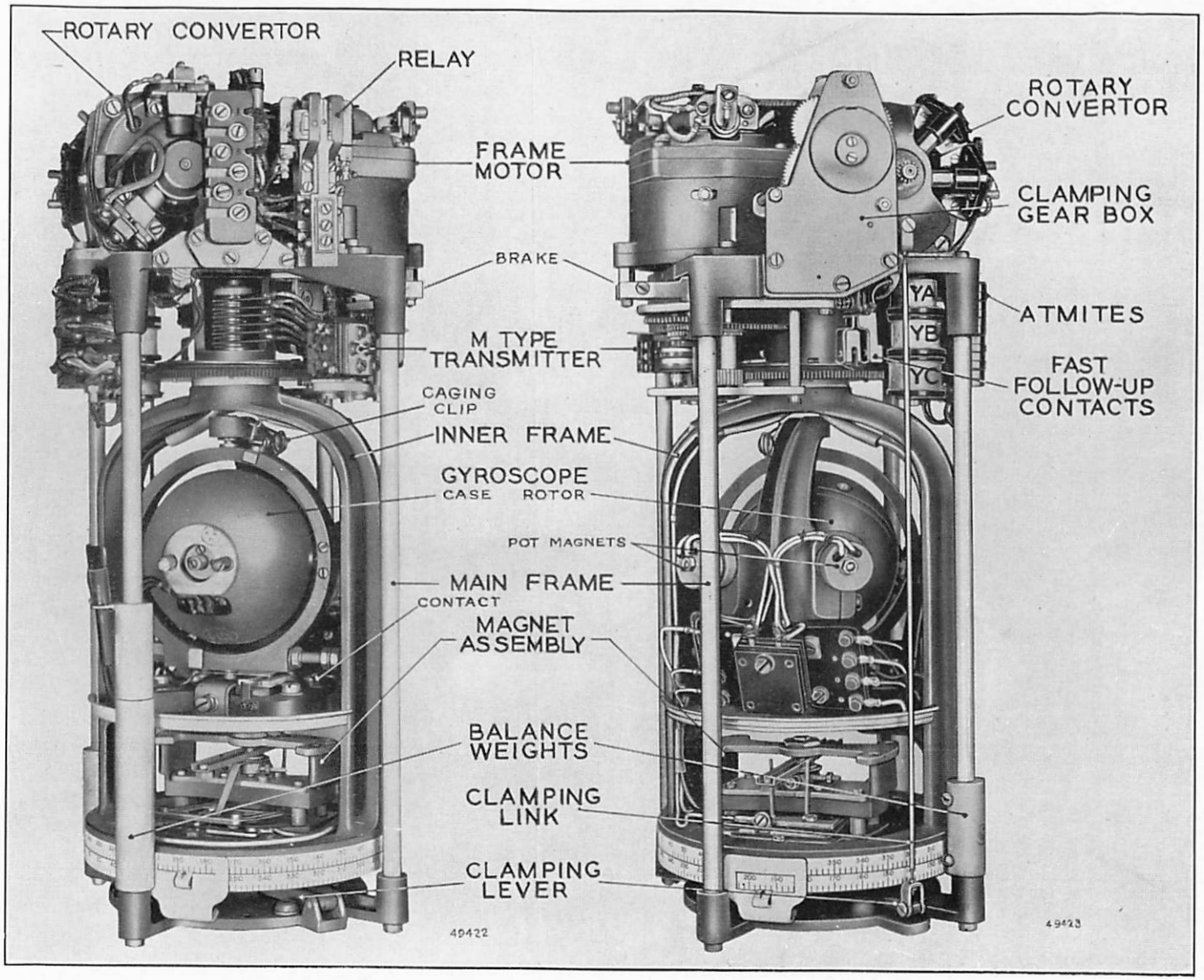

Fig. 3. Master Unit with Covers Removed.

ducing the direction and the amount of any change of heading measured by the master unit, may for various reasons become out of step with the master unit by any constant amount which is a multiple of 3° or 6°, depending on the type of repeater. *Synchronization of the repeaters with the master unit must therefore be checked at the beginning of every flight, and at intervals during flight.* Provided that this synchronization procedure is conscientiously carried out, the transmission system provides a reliable means of remote indication.

20. To avoid overloading the transmitter contacts in the master unit, the latter merely serves the motor of the V.S.C. The V.S.C. consists, in effect, of a repeater motor driving a further transmitter. This arrangement ensures a power output to the repeaters limited only by the capacity of the V.S.C. contacts to bear the required load. The system allows for up to six standard repeaters to be operated simultaneously, while with a further modification to the V.S.C. the Mk. 14 bombsight repeater can also be operated.

Switching On, Testing, and Operation

21. **Pre-Flight Procedure.** Pilots should complete the following procedures before flight :—

(*a*) Ensure that a compass corrector key is carried in the aircraft.

(*b*) When the aircraft engines are running, and not before, put the compass switch to "ON", and the precession-rate switch to "SETTING". The repeaters will then be seen to surge, until after a few minutes, when the gyro has stabilized, they settle down and oscillate over a range of 8° to 10°.

(*c*) When the repeaters are oscillating steadily about a definite heading (and in any case at least two minutes after switching on) put the precession-rate switch to "NORMAL" at the instant the repeater card is in the middle of an oscillation.

(*d*) Wait for two or three minutes, then check that the master unit scale is hunting steadily through about ±½°, and that the repeaters are steady.

(*e*) Set the V.S.C. to zero.

(*f*) Read the master unit scale.

(*g*) Using the corrector key, set all repeaters to reproduce as nearly as possible the master unit reading. Ensure that all repeaters now read the same ; *i.e.* that they all over-read or under-read by the same amount. (A repeater can be synchronized by means of the corrector key only to within 1½° or 3°, according to the type of repeater.)

(*h*) Turn the V.S.C. control knob until all repeaters indicate the exact heading shown by the master unit.

(*j*) Loosen the two holding screws and adjust the V.S.C. until the lubber line is again opposite zero on the variation scale. Re-tighten the screws.

(*k*) Check that all repeaters read the same and that the readings correspond with the master unit reading.

(*l*) Set on the V.S.C. the local mean variation and any residual deviation appropriate to the first course to be flown.

22. **Airborne Checks and Procedures.** Pilots should ensure that the following checks and procedures are carried out during flight :—

(*a*) After take-off and when in level flight, check the synchronization of the repeaters, using the Heading Indicator Mk. 1 if necessary. It is not necessary to set the V.S.C. to zero for the check, as the required repeater reading can be ascertained quickly since it is known to be equal to the master unit reading plus the easterly or minus the westerly V.S.C. setting.

(*b*) Repeat the synchronization check frequently during flight.

(*c*) If re-synchronization is required during flight, the Air Position Indicator should be ignored and the V.S.C. set to zero. The A.P.I. should be reset from a fix when the process is completed.

(*d*) The V.S.C. should be reset to conform with changing local variation.

(*e*) If the gyro should be toppled by exceeding the limiting angles of 75° bank or pitch, straight and level flight should be resumed. The precession-rate switch should then be turned to "SETTING" until the inner frame oscillates evenly about a steady heading, after which the switch should be returned to "NORMAL". Synchronization of the repeaters with the master unit should then be checked by reference to the latter or with the help of the heading indicator mounted above the pilot's repeater.

(*f*) To set a course on the pilot's repeater, the course-setting knob (Fig. 4) should be turned gently until the pointer indicates the required heading. Subsequently, the aircraft should be turned until the set-in heading is opposite the lubber line with the pointer parallel to the grid lines. Thereafter the course-setting pointer and grid lines should be kept parallel by appropriate movement of the flying controls to maintain the set-in course. On some installations the pilot's repeater can be adjusted so as to eliminate parallax error.

23. **Procedure After Flight.** The following procedure should be carefully followed after flight :—

(*a*) When the aircraft has finished taxying and is stationary at its dispersal point and unlikely to be moved again, the compass should be switched off. (Switching off the compass before the aircraft is stationary is likely both to damage the master unit and to de-synchronize the system.)

(*b*) Should it become necessary to move the aircraft after the compass has been switched off, six minutes should be allowed to elapse from the time of switching off the compass before the movement occurs, to enable the gyro to run down.

(*c*) Should it be necessary to move the aircraft before the six-minute period has elapsed, the compass must be switched on again before the movement occurs.

Heading Indicator Mk. 1

24. In aircraft whose D.R. compass master unit cannot be read in flight, neither full synchronization nor re-synchronization is possible while airborne without some means of ascertaining the actual reading of the master unit scale. A unit known as the Heading Indicator Mk. 1 has been designed to meet this need in the form of a small attachment to the pilot's repeater which gives a visual indication when the master unit reading is 000°, 045°, 090°, etc. The indicator (Fig. 5) comprises a small oblong box mounted on top of the pilot's repeater and having two arrow-shaped lamps with an on-off switch and a dimmer control to adjust the illumination for day or night use.

25. When the aircraft heading as determined by the master unit is one of the eight cardinal and quadrantal points, both lamps are illuminated. If the aircraft is heading to the left of the nearest of these check headings the left-hand lamp only is illuminated. Similarly, a heading to the right of the nearest check heading causes only the right-hand lamp to be illuminated. When only one lamp is illuminated, therefore, the

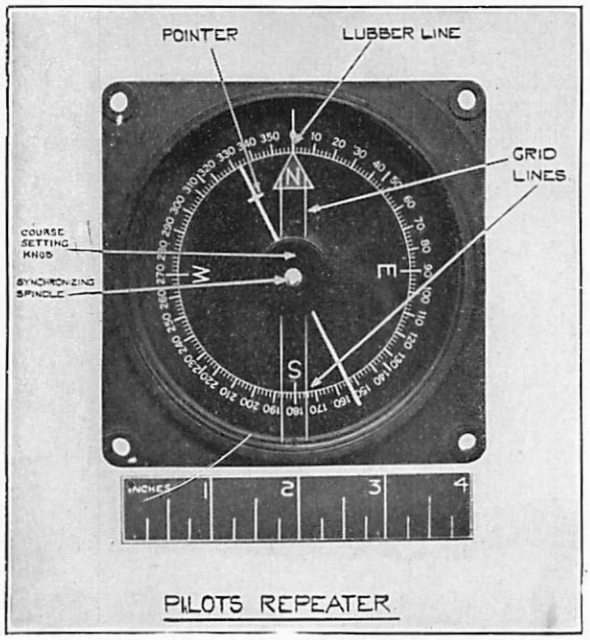

Fig. 4. Pilot-Type Repeater.

arrow indicates which way the aircraft should be turned to reach the nearest check heading. Ambiguity of heading is avoided by reference to the stand-by compass.

26. As the heading indicator must be immune from de-synchronization and must also be unaffected by variation and deviation set at the V.S.C., it is operated by a separate transmitter fitted in the master unit.

27. **Operation.** To use the heading indicator for airborne synchronization checks and repeater synchronization, the instrument is switched on and the dimmer control adjusted if necessary. In nearly all cases only one arrow will be illuminated, indicating which way to turn the aircraft to reach the nearest check heading. As soon as the other arrow lights up, the aircraft should be straightened out of the turn and flown so that both lamps remain on. If, when the instrument is switched on, neither arrow is illuminated, the aircraft is half-way between two check headings and may be turned in either direction. Thus it is never necessary to alter course by more than $22\frac{1}{2}°$ to check synchronization.

28. When the aircraft has settled down steadily with both arrows illuminated, the stand-by compass should be checked to ascertain which of the eight headings is being flown. Synchronization of the repeaters can then be checked and re-synchronization carried out if necessary. This method is as accurate and reliable as the direct reading of the master unit.

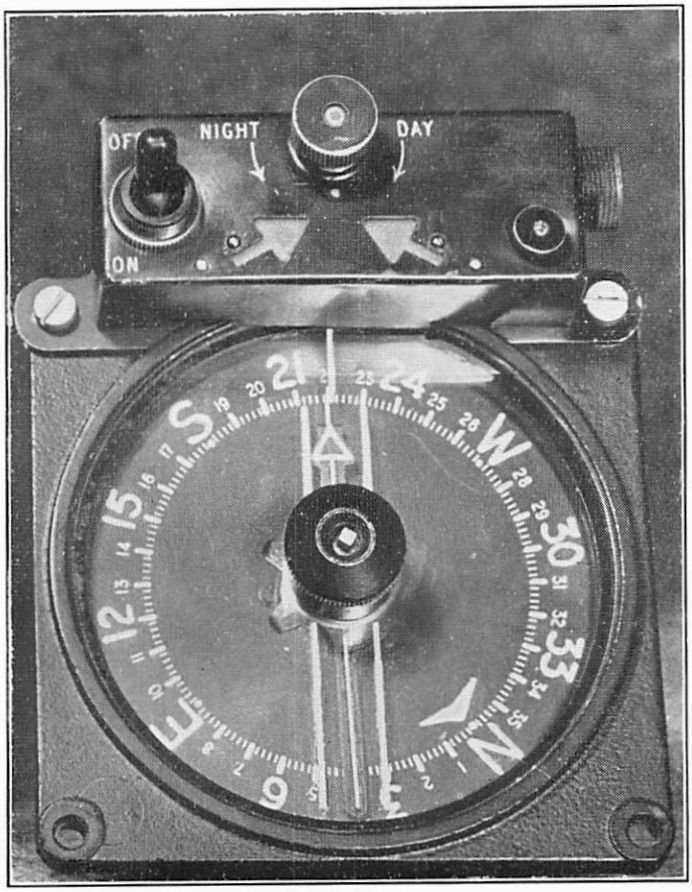

Fig. 5. Heading Indicator Mk. 1, Attached to Pilot's Repeater.