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Sect. 13, Chap.8)

ARTIFICIAL HORIZON, SPERRY, H.L.4

+ MK 1F

GENERAL AND TECHNICAL INFORMATION

BY COMMAND OF THE DEFENCE COUNCIL

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Chapter 1

DESCRIPTION

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Introduction

1. The artificial horizon, Type H.L.4 (Ref. No. 6A/3055), has been designed to meet the special requirements of the presentation of flight attitude in helicopter aircraft. It is an air-driven gyroscopic instrument which provides a continuous indication of the aircraft's roll and pitch attitudes relative to the horizon.

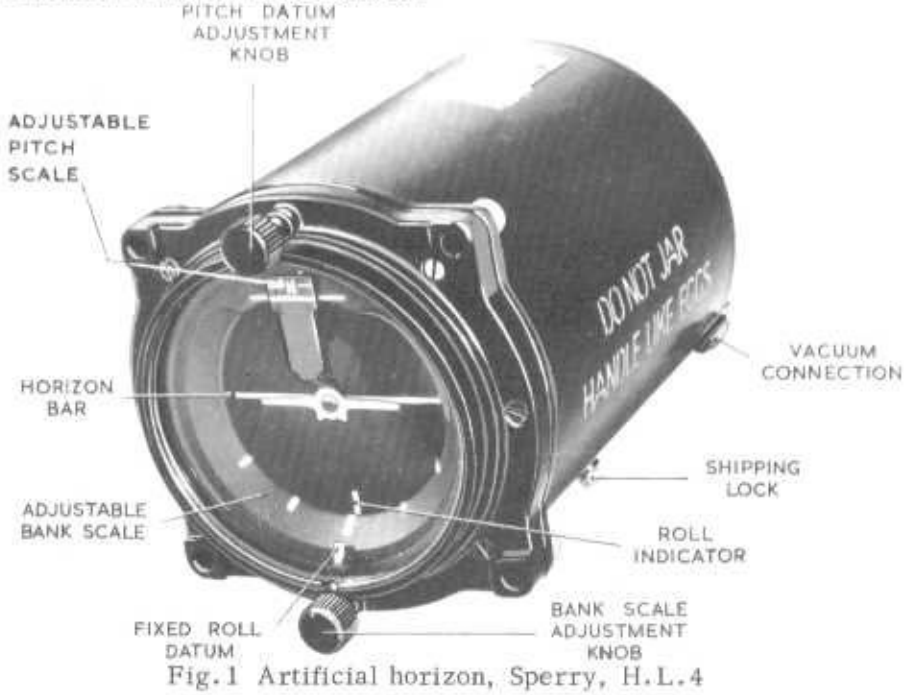

Fig.1 Artificial horizon, Sperry, H.L.4

2. A small image (fig. 1) representing the rear view of a conventional winged aircraft, is located near the centre of the dial. A moving bar behind the image, which represents the horizon, is controlled by a vertical axis gyroscope. To the pilot, a nose-down or nose-up attitude will be represented by the horizon bar moving respectively up or down behind the image. Similarly, when the aircraft itself is banking, the horizon bar will appear to tilt relative to the image, at an angle equal to the angle of bank of the aircraft. A pointer moves over a scale at the bottom edge of the dial whenever the horizon bar tilts, and indicates the actual bank angle.

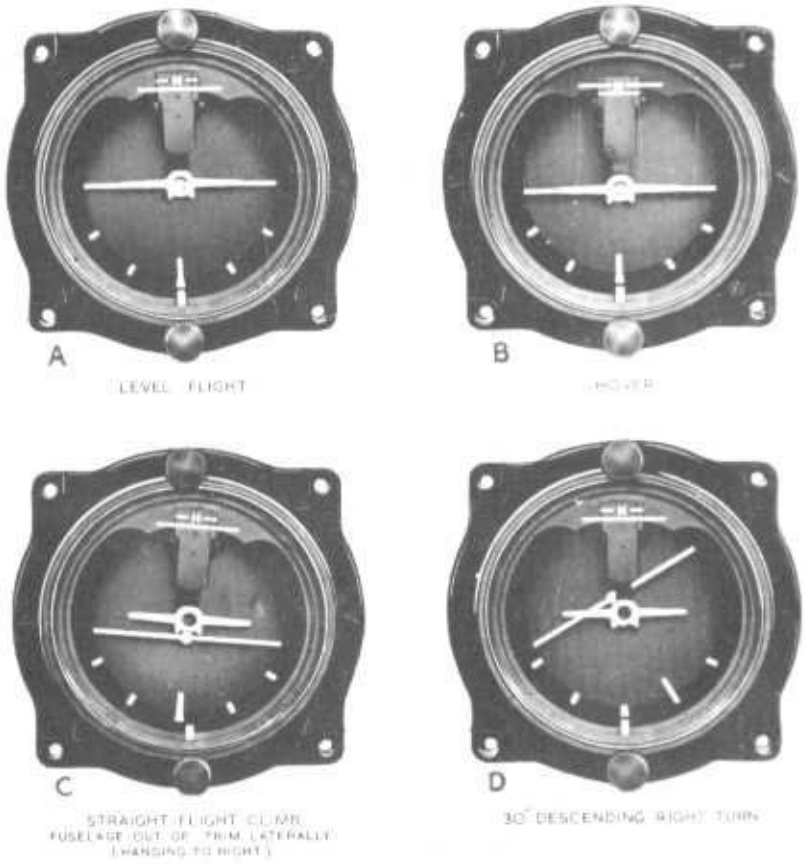

Fig. 2 Presentation during flight

3. To cater for the flight attitudes peculiar to helicopters, two knobs on the front of the instrument allow the pitch and roll datums to be adjusted during flight. The roll datum, namely the scale at the lower edge of the dial, can be rotated 5 deg either side of the vertical centre of the case by the knob at the bottom of the bezel. The bracket holding the aircraft image is connected to the scale ring, and will therefore rotate with the scale ring whenever the roll datum is altered.

4. The pitch datum is adjusted by the knob at the top of the bezel. Rotation of this knob will raise or lower the aircraft image with respect to the horizontal centre line of the instrument.

5. Fixed datum points indicate the positions to which the adjustable components must be set for level flight. For the roll indications it consists of a mark on a fixed disc outside the movable bank angle scale. For the pitch indications it consists of two short horizontal lines on the bank scale ring on either side of the movable bracket carrying the aircraft image. A single horizontal line on this movable bracket is brought into line with the two shorter lines to position the image so that the horizon bar will indicate deviations from level flight, and a broken line, marked with a letter H, is brought into line with the two shorter lines to position the image to indicate deviations from the nose-up attitude of the aircraft required for hovering. Fig. 2 shows the datum set for different flight conditions.

6. On later models the pitch datum is engraved with a broken line with L inserted, which is adjusted to line up with the two fixed marks for level flight. Above this, five other broken lines are engraved, each representing two degrees of nose-up attitude when brought into line with the two fixed marks. The number 10 is engraved between the top broken line to represent ten degrees. Thus the pitch datum can be set so that the horizon bar will indicate deviations from the attitude required for hover flight for the particular helicopter in which the instrument is installed.

Principle

7. The principle of the gyroscope and its application to artificial horizons is fully described in A.P.3280B, Sect.1, Chap.6. which explains how the horizon bar is made to represent changes in the aircraft's attitude with respect to a fixed aeroplane image.

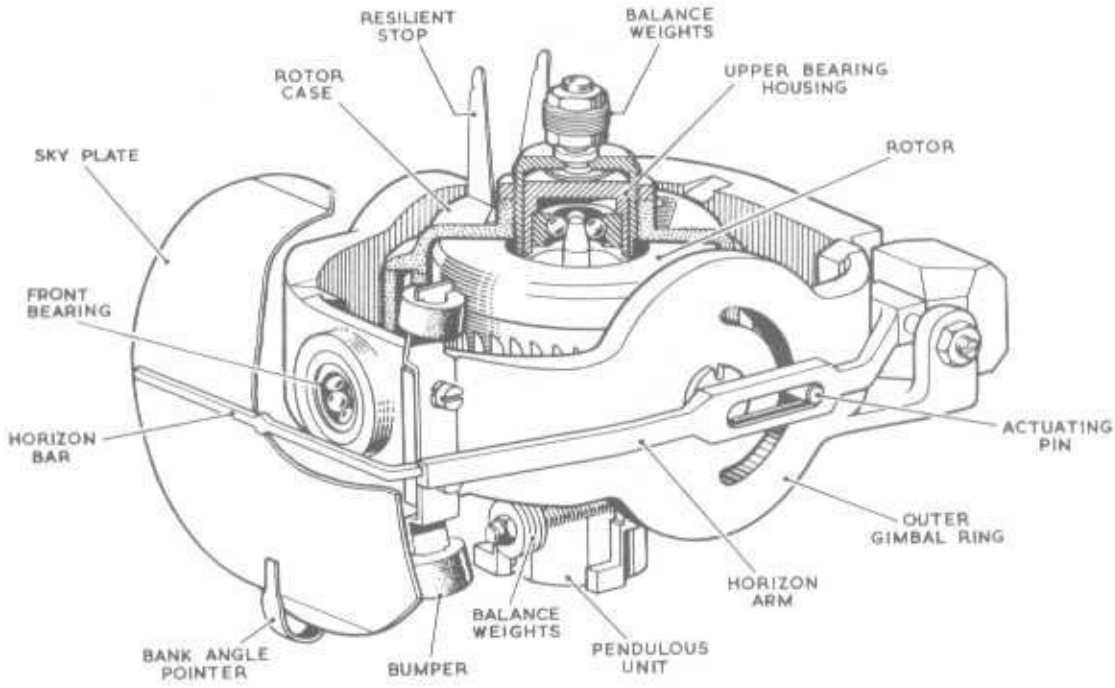

Fig.3 Gimbal and gyro assembly

DESCRIPTION

8. The mechanism is shown in fig.3. The rotor is a dynamically balanced heavy wheel on a vertical shaft, and is contained in the rotor case, which is also the inner gimbal ring of the gyroscope. The rotor shaft is carried in grease-lubricated ball races. The upper bearing housing is spring-loaded to compensate for differential expansion between the rotor shaft and the rotor case.

9. At the base of the rotor case is a pendulous unit which erects and maintains the rotor axis vertical. The pendulous unit consists of two pairs of diametrically opposed pendulous vanes which control the emission of exhausted air through slots in the pendulous body to precess the gyro assembly should it deviate from the vertical.

10. The rotor case is pivoted laterally in the outer gimbal ring, which is itself pivoted in the instrument case with its pivoting axis parallel to the longitudinal axis of the instrument case, and hence of the aircraft. The front mounting of the gimbal ring is formed by a pivot, screwed into a bracket which forms part of the case, engaging a ball race in the front end of the gimbal ring just behind the sky plate. The rear mounting is by means of a pivot, at the end of the gimbal ring, carried in a ball race accommodated in an integral boss at the centre of the rear cover. All pivots and ball bearing races are grease-lubricated.

11. The horizon is represented by the horizon bar which moves over the curved sky plate attached to the outher gimbal ring. The arm carrying the horizon bar is pivoted at the rear of the gimbal ring and counterbalanced, and a slot in this arm engages an actuating pin projecting from the rotor case, through a radial slot in the side of the outer gimbal ring.

12. The sky plate has an integral pointer which indicates the angle of bank against a scale marked around the lower part of the bezel ring. The dial graduations represent 30 deg and 60 deg bank on either side of the zero.

1 DRIVING GEAR
2 IDLER GEAR
3 METAL FRICTION DISCS
4 LUG ON SCALE RING
5 SLIDER
6 IMAGE BRACKET
7 AIRCRAFT IMAGE
8 SCALE RING
9 ROLL DATUM KNOB
10 SLOTTED ARM

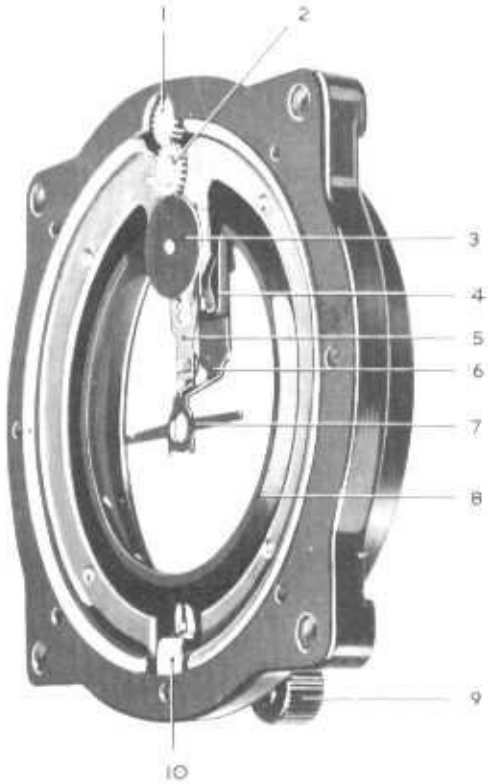

Fig.4 Bezel mechanism

Bezel mechanism

13. A rear view of the bezel assembly (fig.4) illustrates the operation of the variable datums. The lower knob (9) rotates a shaft at the end of which a slotted arm (10) is riveted. The slot engages with a pin secured to the scale ring (8) which is free to rotate in the bezel. Thus rotating the knob will rotate the scale over a small arc in either direction.

14. Rotation of the pitch datum adjustment knob will rotate a small gear wheel (1) which, through an idler gear (2), rotates two metal friction discs (3), so positioned that they grip the edge of the idler. A small gear, secured to the shaft on which the friction discs are riveted, engages a rack machined in the slot of a slider (5), and, as the knob is rotated, this slider is constrained to move vertically in a slot on a lug of the bezel casting. A horizontal slot at the lower end of the slider engages a peg attached to the aircraft image (7), thus the image is raised or lowered with the slider. The slot permits the image to rotate with the scale ring (8) when the bank datum is changed, since the image is carried on the image bracket (6) which has two pegs engaging in a lug (4) which is part of the scale ring.

15. To enable small pitch attitude changes between the horizon bar and the miniature aircraft to be easily observed, a "ring and bead sight" is formed by means of a hole through the centre of the miniature aircraft and a dot at the centre of the horizon bar. The bar, pointers, and dial markings are coated with fluorescent compound in contrast to the matt-black finish of the sky plate.

Shipping lock

16. The instrument is accommodated in a cylindrical case enclosed by the bezel at the front and rear cover. A shipping lock is provided for use during transit (fig.1). The lock consists of a flat leaf spring riveted at one end to the inside of the case. When not in use the spring lays against the case, clear of the mechanism. The shipping lock can be applied by centralizing the gyro assembly and substituting the short blanking screw on the underside of the case by the longer locking screw. When the locking screw is fitted it distorts the leaf spring until the latter clamps against a rubber pad on the bottom of the pendulous unit.

Air supply

17. The rear cover of the case (fig.5) has three alternative connection ports by which the instrument can be connected to the vacuum source. Attached to the rear cover is the filter unit over the air intake of the instrument. A gauze and tissue filter is retained by a circlip within the filter unit. Thus the air intake is complete in itself but in addition, a threaded bore provides for connecting the instrument to a central air filter. The filter assembly on later models is of more conventional design and is not adaptable for connection to a centralized filter system. This later type filter assembly is fitted with a V.P.I. impregnated filter.

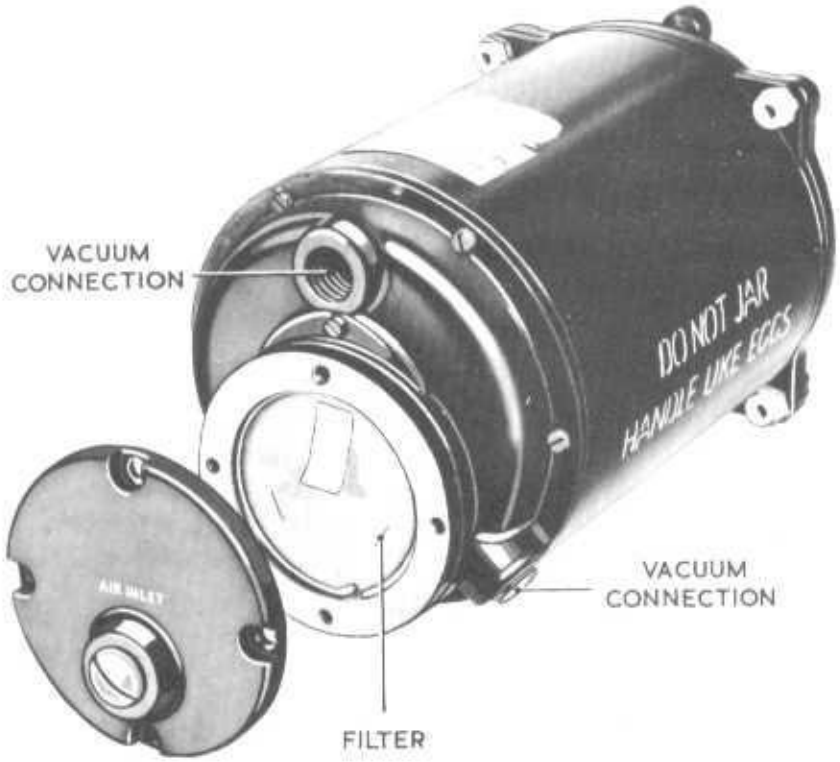

Fig.5 Rear view, filter cover removed

18. When the instrument is connected to a vacuum source the case is evacuated and air is drawn in through the filter. This air passes around the rear pivot into a channel in the outer gimbal where, via the pivot on the left-hand side of the rotor case, it passes into two channels in the rotor case which terminate in two diametrically opposite ports. The air issuing from these ports impinges on the buckets of the periphery of the rotor thereby spinning the rotor. After driving the rotor, the air passes down into the pendulous unit where it is drawn out of the slots controlled by the vanes, and into the instrument case which is evacuated by the vacuum source.

Note; "VPI" means a saturated "Vapour Phase Indicator" powder impregnated filter.

ARTIFICIAL HORIZON, Mk.1F (SPERRY, TYPE H.L. 4C)

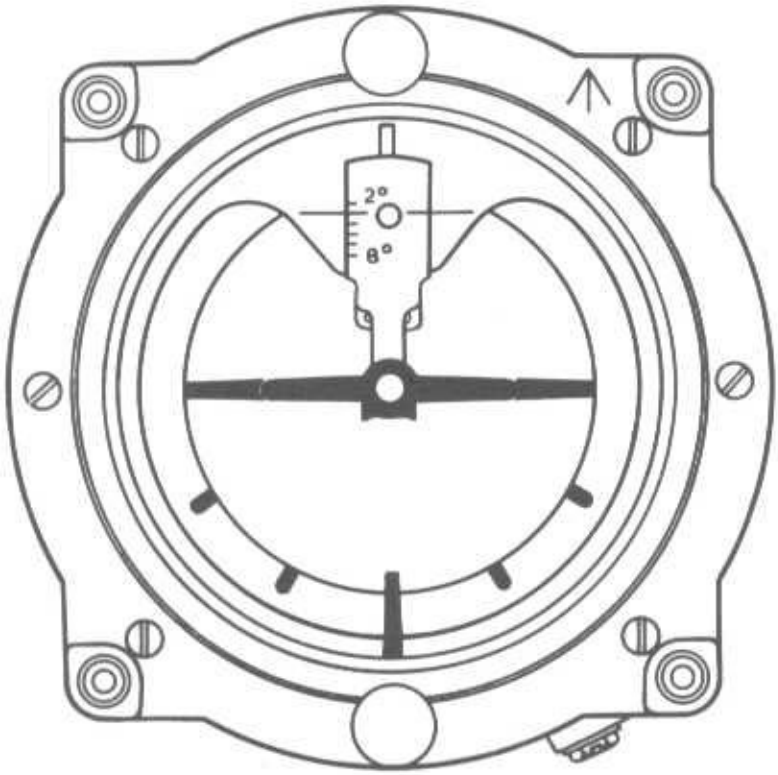

Fig.6 Artificial horizon, Mk.1F

19. This is basically the same instrument as the artificial horizon, Sperry H.L.4, but includes the following modifications.

20. The variable pitch datum has a range of 12 deg with the variable pitch scale calibrated from 2 deg nose-up to 8 deg nose-down, with divisions every 2 deg (fig.6). Thus there is 1 deg of free movement at each end of the scale. The instrument has freedom from topple of $\pm$ 40 deg about the pitch axis and $\pm$ 110 deg about the roll axis.

21. Modifications to the mechanisms include toroidal rotor bearings and a spring stop to limit the freedom in roll, in lieu of the rubber buffers previously used.

OPERATION

22. The gyroscope is designed to operate at a vacuum of $3\frac{1}{2}$ in mercury, when the rotor will attain a speed of approximately 12,000 rev/min revolving in a counter-clockwise direction when viewed from above. Upon starting, the horizon bar may be observed to sweep across the dial and then shimmy slightly, but this movement should disappear as the rotor attains normal running speed. The actual erection time for the instrument will depend upon the attitude of the gyro assembly upon starting, but should never be more than 5 minutes.

23. The pitch freedom is reduced to a range of 40 deg climb and 40 deg dive by resilient stops on the rotor case contacting the outer gimbal ring. Freedom in roll is limited to 110 deg left and 110 deg right bank by rubber bumper stops on the outer gimbal ring contacting the support bracket integral with the instrument case.

INSTALLATION

24. The instrument must be mounted on an approved shock-proof panel within $\pm 1\frac{1}{2}$ deg in roll and pitch of the aircraft's normal flight attitude. It is essential that the instrument fits squarely against the panel and does not bind in the panel cut-out. The instrument is

mounted from the rear of the panel and four mounting screws are supplied for the anchor nuts secured to the bezel lugs. When securing the instrument to the panel, care must be taken not to distort the case. The four lugs on the instrument must seat squarely on the panel and the mounting screws must be taken-up evenly and diagonally until the instrument is secure. If necessary, shims must be inserted between the panel and one of the lugs to prevent distortion as the screws are finally tightened.

25. The installation may be checked for accuracy of alignment with a spirit level. With the aircraft support in the level flight attitude, the top surface of the case can be used as the reference for the fore-and-aft level and the fixing screws as the transverse level.

26. To connect the instrument to the vacuum source, remove the pipe plug from the most convenient of the three alternative connections on the rear cover. Connection between the vacuum pipe on the instrument panel and the vacuum pipe on the airframe must be made with a flexible hose, or alternatively, a flexible hose connected directly to the instrument from the vacuum supply pipe. All pipes must be free from sharp bends to ensure that the vacuum supply is not restricted, and the pipes must be of sufficient length so as not to foul equipment or limit the shock-mounting of the panel.

27. If a vacuum gauge is to be installed it should be tapped into the vacuum supply as close as possible to the instrument.

28. The screwed plug must be removed from the air inlet located in the rear cover of the instrument. If the air inlet is to be connected to a central air filter the pipe must be of sufficient length so as not to foul equipment or limit the shock-mounting of the panel.

29. Before the instrument is finally installed, release the shipping lock by removing the screw from the underside of the instrument and substituting the shorter blanking screw provided. The shipping lock should not be released until necessary. In some installations it may be necessary to release the lock before the instrument is fitted to the panel. In other cases the instrument can be fitted and connected before the lock is released.

30. The long shipping lock screw and the plugs removed from the rear cover should be kept in the small linen bag which should be attached to the rear of the instrument at all times.

Removal from aircraft

31. An unserviceable or time-expired instrument should be handled as carefully as a serviceable instrument. To remove the instrument, proceed as follows:-

(1) Disconnect pipe lines.

(2) Remove instrument from instrument panel.

(3) Apply a vacuum of approximately 3 to 4 in mercury to allow gyro assembly to erect and hold instrument so that pointers are at zero datum. Remove short blanking screw and fit the longer locking screw to operate the shipping lock. Ensure all connections are effectively blanked off and that the blanking screw is stored in the linen bag.

Chapter 2

STANDARD SERVICEABILITY TEST

Introduction

1. The tests in this Chapter must be applied to the instruments prior to installation in aircraft and whenever their serviceability is suspect. They are also to be applied at inspections made by Equipment Depots. The tolerances specified must not be exceeded.

TEST EQUIPMENT

2. The equipment required for the tests is a gyro instrument test table, Mk. 4 (Ref. No. 6C/790) with air adapter (Ref. No. 6C/868), or Mk. 4A (Ref. No. 6C/1566).

METHOD OF TEST

3. Unless otherwise stated the tests must be carried out with the instrument mounted in the normal position on the gyro test table. The normal position is that in which the plane of the mounting face of the fixing flange is vertical, and the centre line passing through the two top fixing holes is horizontal to within $\frac{1}{4}$ deg.

4. Except where detailed otherwise the suction in the instrument case is to be maintained at $3\frac{1}{2} \pm 1/8$ in Hg. A comparative check should be made, using a vacuum indicator Mk. 2A (Ref. No. 6C/526), connected to one of the unused connections at the rear of the instrument.

5. Remove the shipping lock, if fitted, and substitute the short blanking screw. Set the adjustable datum to zero.

6. Examine the filter of the instrument for cleanliness, and change it if necessary. The pressure drop across the filter must not exceed $\frac{1}{4}$ in Hg.

EXERCISING

7. Before commencing the tests, exercise the instrument for 15 minutes under roll, pitch and yaw conditions of $\pm 7\frac{1}{2}$ deg at 6 - 10 oscillations per minute, with direction reversal every minute, using the automatic reversing switch.

TESTS

Rotor starting test

8. (1) With the rotor stationary, gradually apply suction to the instrument case and increase to 1 in Hg.

(2) Turn off the suction supply, remove the instrument from the test table and carefully roll it until the gimbal contacts the limit stop. If the rotor is running, further movement will result in the rise or fall of the horizon bar.

(3) The rotor must start and continue to run when the applied suction is not more than 1 in Hg.

Settling test

9. (1) With the rotor stationary and the instrument in the normal position, apply quickly a suction supply of $3\frac{1}{2}$ in Hg.

(2) The horizon bar and bank pointer must settle to within 3/32 in of their datums within 2 minutes.

Note...

If the instrument fails this test, two further tests should be made. If the instrument is within limits on both these tests, complete the remaining tests.

Erection test

10. Lock the gyro test table in the horizontal plane by means of knob A. Release knob B and proceed as follows:-

(1) Run the instrument with $3\frac{1}{2} \pm 1/8$ in Hg. for 10 minutes.

(2) Precess the gyro by rolling the case counter-clockwise until the horizon bar is raised approximately 1 in. Roll the case back to the normal position and replace the instrument on the test table.

(3) The horizon bar must return from 7/8 in to 5/16 in discplacement in $1\frac{3}{4}$ to 4 minutes and from 7/8 in to 1/16 in in under 6 minutes.

(4) Repeat operations (2) and (3) but roll the gyro in a clockwise direction to displace the horizon bar downwards. The same time limits apply.

Roll erection

11. (1) With the horizon bar and roll pointer on their respective datums, remove the instrument from the test table, turn it through 90 deg counter-clockwise about the vertical axis and then roll the case counter-clockwise until the horizon bar has been precessed upwards by 1 in from the datum.

(2) Roll and turn the case back to its original position, and replace the instrument on the test table.

(3) With no dive or climb indicated, check that the roll pointer returns from 30 deg left bank to 90 deg left bank in $1\frac{3}{4}$ to 4 minutes; also check that the time taken by the roll pointer to return from 30 deg to within 1/16 in of the datum is less than 6 minutes.

(4) Repeat operations (1), (2) and (3) but displace the bank pointer in the opposite direction. The same time limits apply, and the difference in times from 30 deg displacement in opposite directions must not be more than 80 seconds.

Datum adjustment test

12. (1) Rotate the knob at the top of the bezel to adjust the datum miniature aeroplane and check that it has full range of movement, but does not tend to slip from any set position. Leave it set at the zero (L or O) position.

(2) Rotate the knob at the bottom of the bezel to adjust the roll datum scale. Check that it can readily be moved between its stops but does not tend to slip from any set position.

13. The testing procedures for the artificial horizon Mk. 1F are exactly the same as those for the H.L.4.

14. If the instrument fails any of the above tests, it must be considered unserviceable and returned to Stores. No attempt should be made to remove the instrument from its case or adjust the mechanism in any way.

Chapter 3

SERVICING

1. The vacuum system of the aircraft should be checked to ensure that a vacuum supply of $4 \pm \frac{1}{2}$ in mercury is obtained when the engine is running at cruising rev/min. If the vacuum relief valve has been correctly set and the required vacuum is not obtained, then the installation should be checked for leaky connections, kinks in flexible hoses or choked filters.

2. With the correct vacuum the rotor should spin up to full speed and erect with the axis vertical within 5 min of starting as explained in para.22. When the axis is vertical the horizon bar and roll pointer will register on zero datum only when the aircraft is in the normal level flight attitude. Allowances will have to be made if the attitude of the aircraft on the ground is different from the normal level flight attitude.

3. Check the instrument and its installation for security and signs of damage, and ensure that the roll and pitch adjustable datums move smoothly over their range.

4. The filter must be changed periodically. To renew the filter unit, remove the four screws securing the cap over the air inlet, release the circlip and extract the filter. Fit new filter and replace circlip and cap.

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