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PART 2 : SECTION 1

CHAPTER 2

TURN AND SLIP INDICATORS

**Purpose**

1. The turn and slip indicator, which is classified as a primary instrument, indicates to the pilot movement of the aircraft in the rolling and yawing planes.

2. It consists of two separate instruments contained in one case. The turn indicator applies the gyroscopic principles to indicate a rate of turn, either to the left or right, about the vertical axis of the aircraft. The slip indicator applies the pendulum principle to indicate lateral level while the aircraft is in straight and level flight, and the amount of slip and skid when the aircraft is turning.

TYPE B. MK. 1A

**Turn Indicator**

3. The turn indicator employs a rate gyro. This type of gyro has freedom about two of the three axes only, and is constructed to indicate rate of movement of the aircraft about the third axis.

4. In the system shown in Fig. 1, angular movement of the outer support in the horizontal plane will cause the gyro to precess until its plane of rotation is horizontal.

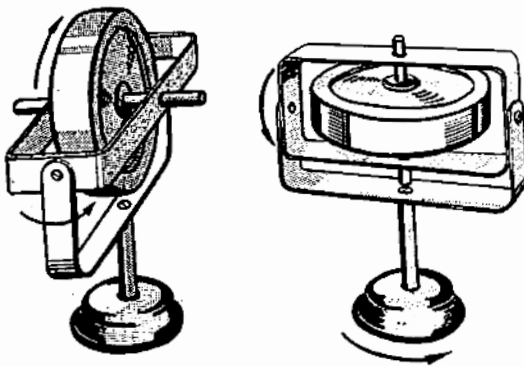


Fig. 1. Precession.

5. If some method of restricting this precession is fitted, such as the spring attachments in Fig. 2, any given rate of turn will cause a precessing force which will eventually be balanced by the tension of the spring. The amount by which precession

will overcome spring tension will depend on the rate of angular movement in the plane in which the gyro is fixed, and the strength of spring used. By attaching a pointer to the gimbal ring the rate of turn may be indicated on a suitable scale.

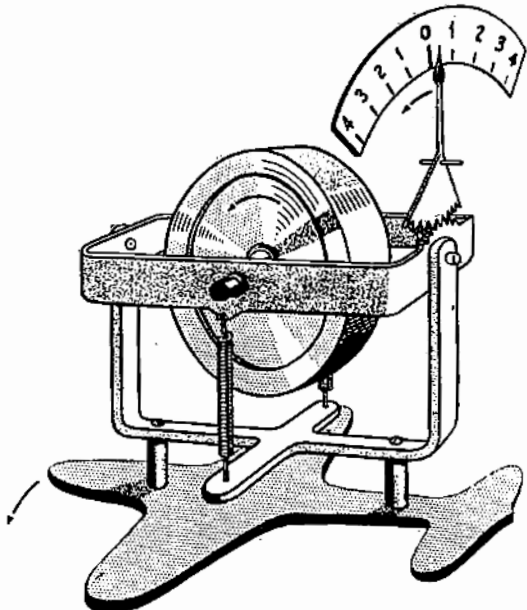


Fig. 2. Principle of the Turn Indicator.

**Construction of Turn Indicator**

6. The rotor is mounted with its axis athwartships in a horizontal gimbal ring with a fore-and-aft axis (see Fig. 3); it is rotated up and away from the pilot by an air jet impinging on buckets cut in the periphery. The air for driving the rotor is drawn in through the top of the casing by a suction of about 2½ inches of mercury inside the instrument casing. This suction is provided by a venturi or engine-driven pump via a reducing valve which maintains the correct suction. If the case is not air-tight, the suction inside the case will draw in air through any leaks and the efficiency of the jets will be reduced.

7. With the axis of the rotor athwartships, and the gimbal (which is attached to the case and thus to the aircraft) only free to move in one plane, it will be seen that when the aircraft heading is

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changed the gyro will precess. An application of the 90° rule will indicate that the gyro will tilt to one side or the other depending on the direction of the heading change. A spring of adjustable tension balances the precession of the rotor in proportion to the rate of change of heading, and a pointer shows the amount of tilt of the rotor against a scale at the bottom of the instrument.

8. In British instruments this scale usually reads from 1 to 4 each side of a zero mark. The spring tension is adjusted to balance the precession so that when the aircraft is turning at 3° per second the pointer will indicate a RATE ONE turn on the scale. In other instruments the pointer may be at the top of the instrument, the scale of which may have no rate-of-turn markings other than a central zero. In such cases, movement of the pointer a distance equal to its width usually corresponds to a RATE ONE turn.

9. To ensure smooth operation the gimbal ring carries a damping device—a piston, cushioned by air, in a cylinder. Stops limit the movement of the gimbal ring to a tilt equal to a turn of about 20° per second. On reaching the stops, the gyro will not topple as it is free to move in only one plane.

10. The turn indicator will indicate rates of turn around the vertical axis of the aircraft, *i.e.* in the yawing plane. Movement of the aircraft in the looping plane will have no precessing effect on the gyro, because the aircraft is, in effect, turning about the axis of the rotor. If the rotor is tilted,

however, as it will be during a yaw, positive movements in the looping plane will set up a precession causing it to tilt further. Negative looping movements will act in the reverse sense. In turns (where there is a movement of the aircraft in both the yawing and looping planes), as the angle of bank and the rate of turn increase, movement of the aircraft in its yawing plane decreases while the movement in the looping plane increases. At low rates of turn the tilting of the gyro and thus the position of the turn pointer depends mainly on the movement in the yawing plane. As the angle of bank increases, movement in the looping plane tilts the gyro further and precession continues. At steep angles of bank, where large movements in the looping plane are necessary, the tilt may continue to the limit of the stops.

11. This phenomenon is noticeable in manoeuvres involving large movements in the looping plane, *e.g.* loops, recovery from dives, spins, and unusual attitudes. In these instances, the indication of slight yaw may be considerably exaggerated by the forces due to looping movement.

12. Erroneous indications by the turn indicator are usually caused by too high or too low rotor speeds. The speed of the rotor depends on the suction. This in turn is affected if the filter is dirty, or if the pump is being run too slowly, as might occur when taxiing; or, in a venturi-operated instrument, if the speed of airflow through the venturi is too low. If the rotor speed

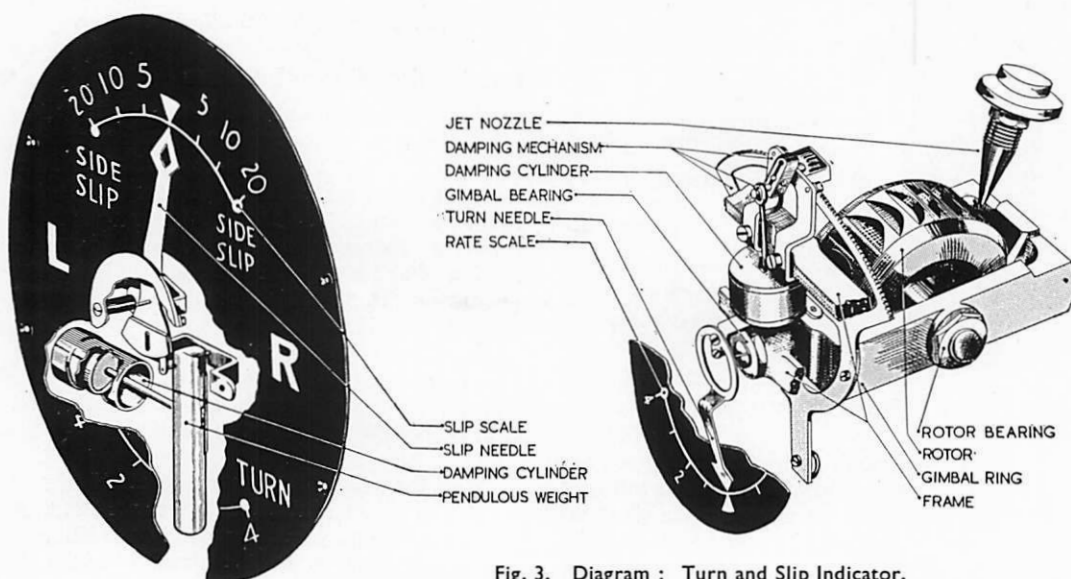


Fig. 3. Diagram : Turn and Slip Indicator.

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is too high, the turn pointer will indicate a higher rate of turn than is actually being made, and vice versa.

**Slip Indicator**

13. The slip indicator in this type of instrument is the top pointer of the combined turn and slip indicator. The pointer is operated by a pendulous weight, so geared that when the left wing is low the pointer moves to the left, and vice versa (Fig. 3). The gearing is arranged to give large indications for small changes in lateral level. The pointer moves over a scale graduated in degrees left and right of a central zero. A damping device, similar to that incorporated in the turn indicator, is attached to the pendulous weight to ensure smooth operation.

14. **Indications.** In straight flight the slip indicator is central whenever the aircraft is laterally level. If a wing is lowered, the pointer is deflected in the direction of the lower wing by an amount proportional to the tilt.

15. During a turn, the pendulous weight is acted on by gravity and centrifugal force and

takes up a position which, in a correctly balanced turn, is in the vertical plane of the aircraft.

16. The centrifugal force acting on the pendulous weight depends on the speed of the aircraft and the rate of turn, and thus for any given rate of turn at a given speed the pendulous weight takes up a given position regardless of the angle of bank. If the turn is unbalanced the vertical plane of the aircraft does not coincide with the line which is the resultant of the centrifugal force and gravity on the pendulous weight, and a slip towards the lower or a skid towards the upper wing is indicated, as appropriate to the nature of the unbalanced turn.

**TYPE TN.300**

17. The Type TN.300 turn and slip indicator is functionally similar to the Type B. Mk. 1A. The rotor is driven by air which enters the case through two filters, suction being provided either by an engine-driven vacuum pump or by a venturi head.

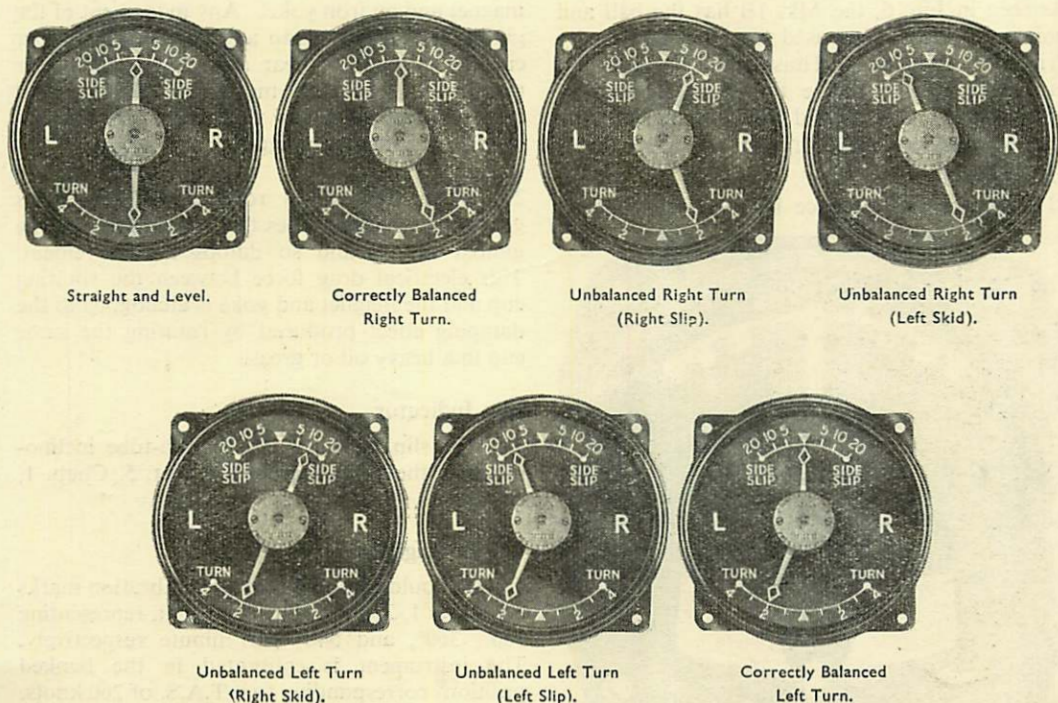


Fig. 4. Turn and Slip Indicator—Indications.

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18. The dial presentation (Fig. 5) is in the form of two pointers moving over scale arcs, the upper of which indicates *slip* with data  $20^\circ$  either side of a central zero mark, while the lower indicates *rate of turn* left and right. All essential markings are fluorized. This instrument is fully described in A.P. 1275A, Instrument Manual.

### PILOT'S SERVICEABILITY CHECKS

19. A rough test for serviceability of turn and slip indicators of the types described in this chapter may be made by turning through a few degrees while taxiing. The turn needle should then indicate the direction of the turn, while the slip indicator should register a skid. The turn indicator may also be checked by hand pressure on one corner of the flight instrument panel. As the panel is mounted on sorbo rubber, any movement of the panel should be indicated on the turn needle. When the aircraft is standing on level ground, both the slip and the turn pointer should be central. In the air, the aircraft should turn through  $180^\circ$  in one minute with the turn indicator indicating a Rate One turn.

### General

#### TYPE 1B

20. The Mk. 1B turn and slip indicator is a later design than the TN.300, and replaces the latter. As seen in Fig. 6, the Mk. 1B has the ball and pointer presentation used on the electrically driven instruments. Thus all turn and slip indicators are to utilize the same method of presentation. It should be noted that the instrument is graduated only up to Rate 3.

### Description

21. The major difference between the Mk. 1B

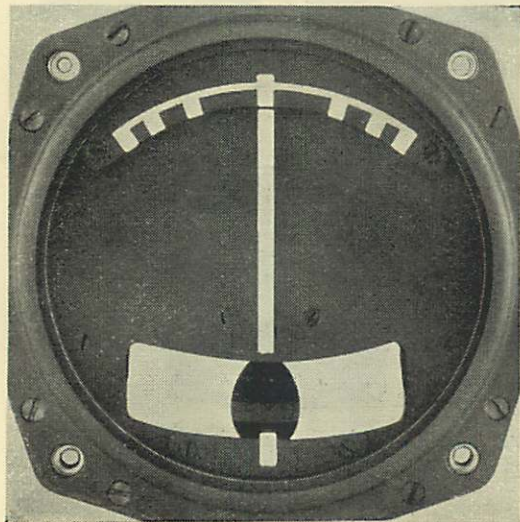


Fig. 6. The Mk. 1B Turn and Slip Indicator.

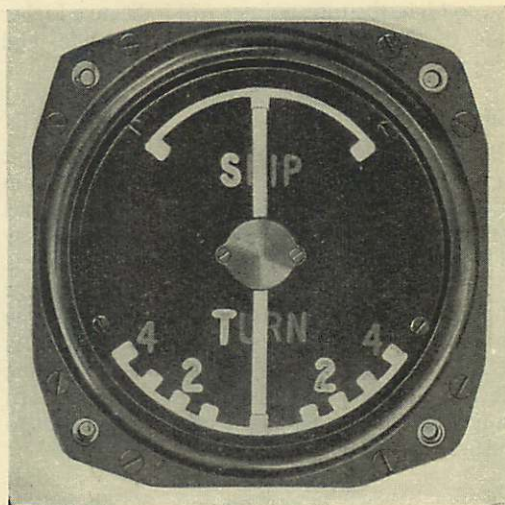


Fig. 5. Type TN.300 Turn and Slip Indicator.

and the Type TN.300, apart from the presentation, is the use of a magnetic damping unit instead of the piston and cylinder arrangement described in para. 9.

22. The magnetic damping unit consists of a copper cup which is spun between a permanent magnet and an iron yoke. Any movement of the gimbal is transmitted to and rotates the copper cup via a quadrant gear and pinion. The gear ratio is 11 : 1 and any movement of the gimbal system therefore causes the copper cup to spin rapidly between the magnet and yoke.

23. When the cup is rotated, an E.M.F. is generated which opposes the driving force of the gimbal system and so damps the movement. This electrical drag force between the rotating cup and the magnet and yoke is analogous to the damping effect produced by rotating the same cup in a heavy oil or grease.

### Slip Indicator

24. The slip indicator is a ball-in-tube inclinometer of the type described in Sect. 5, Chap. 1, para. 7.

### Use in Flight

25. It should be noted that the calibration marks are Rates 1, 2, and 3, left and right, representing  $180^\circ$ ,  $360^\circ$ , and  $540^\circ$  per minute respectively. The instrument is calibrated in the banked positions corresponding to a T.A.S. of 260 knots. At any other airspeed there will be errors, but these do not exceed 5% at any airspeed between 85 and 350 knots.

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