PART 2 : SECTION 2

CHAPTER 3

RATE OF CLIMB AND DESCENT INDICATORS

Purpose

1. The purpose of the rate of climb and descent indicator is to measure the vertical component of the aircraft's speed, and to indicate it to the pilot as a rate of ascent or descent in feet per minute. The instrument is particularly useful during controlled descents through cloud, as an aid to landing in bad visibility, and in certain circumstances as an aid to navigation when used in conjunction with other instruments.

Implementation

2. The instrument measures the rate of change of atmospheric pressure and registers the change in terms of rate of climb or descent. The principle employed is that of measuring the difference of pressure between two chambers, one within the other. The pressure of the atmosphere is communicated directly to the inner chamber, and through calibrated constrictions to the outer chamber. If the atmospheric pressure decreases, as when climbing, the lag rate between the outer and inner chambers is a measure of the rate of climb of the aircraft. Similarly, the lag rate that accompanies the pressure increase during descent is a measure of the rate of descent.

Mk. 1 Series

3. **Case.** The case is air-tight except for a union to which a tube from the A.S.I. static source is connected. A zero adjustment screw for setting the pointer is located at the front of the case, at the bottom centre of some instruments and at the lower right-hand corner of others.

4. **Pointer.** A single pointer indicates the rate of climb or descent by registering against a background dial. The position of the pointer when at zero is horizontal, pointing to "nine o'clock". Ascent is indicated by clockwise, and descent by anti-clockwise, pointer rotation.

5. **Dial.** The dials of Mk. 1 series instruments in service use are graduated for rates of ascent and descent up to 4,000 feet per minute, having equally spaced sub-divisions at 1,000 feet intervals. Most instruments of this series have the scale further sub-divided at 200-feet intervals.

6. **Illumination.** The pointer, numerals, and main graduations, are treated with either fluorescent or self-energizing luminous compound.

7. **Mechanism.** The mechanism consists, essentially, of a sensitive diaphragm or capsule, a metering unit, and a suitable magnifying mechanism (see Fig. 1). The diaphragm unit is connected by a link to the rocking shaft and sector, which meshes with a pinion carrying the pointer. Air in the static lines has free access to the inside of the diaphragm through the union attached to the instrument case ; but it can only pass in and out of the inside of the case via the metering unit. Diaphragm overload stops are fitted to prevent damage resulting from excessive positive or negative pressures. The pointer zero-setting arrangement is such that movement of the adjusting screw moves the diaphragm support towards or away from the remainder of the mechanism, according to the direction of screw rotation.

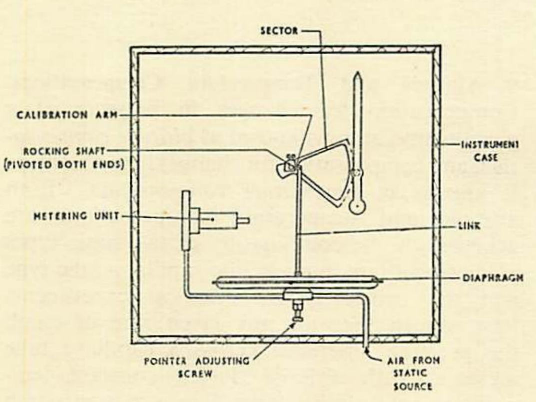

Fig. 1. Operating Principles of a Rate of Climb and Descent Indicator of the Mk. 1 Series.

8. **Operation.** Whenever air pressure varies with changing altitude, pressure within the case lags behind that within the diaphragm. The pressure lag is caused by the action of the metering unit, which restricts the flow of air into and out of the case. The resulting differential pressure actuates the mechanism, causing an appropriate degree of pointer movement. In level flight, the pressures inside the capsule and the case are the same and the pointer therefore remains stationary on zero ; but if the aircraft changes altitude, *e.g.* begins to climb, the static pressure decreases ; and so long as the climb is maintained the restricting action of the metering unit causes the pressure inside the instrument case to remain slightly greater than the static pressure through which the aircraft is flying. Since the static pressure is conveyed to the diaphragm by the static tube, the difference of pressures on the opposing sides of the diaphragm causes a diaphragm movement proportional to the pressure difference. This movement, magnified during transmission by the mechanical linkage and gearing, causes pointer movement appropriate to the initiating pressure difference, indicating to the pilot a climb in terms of feet per minute. During descent, movement of the diaphragm in the opposite direction to that described above causes a rate of descent to be indicated. It has been explained that the operation of this instrument is basically dependent on changes in air pressure due to changes in altitude, the relationship between air pressure and altitude being assumed to be standard ; but since the temperature, density, and viscosity of the air also change with altitude, and not necessarily in conformity with the standard I.C.A.N. atmosphere, certain mechanical refinements are necessary to produce accurate indications.

9. **Altitude and Temperature Compensations.** Compensation for changes in pressure at a given temperature is known as *altitude compensation*, and compensation for changes in temperature is known as *temperature compensation*. Both altitude and temperature compensations are achieved by the combination of two basic types of metering unit, namely, the capillary tube type and the orifice type. Practical experiments have shown that for any given rate of climb the pressure difference across a capillary tube increases with altitude during constant temperature conditions. Therefore a rate of climb and descent indicator dependent solely upon a capillary tube type metering unit would show a positive error at altitudes above sea level. Tests have also shown that in the case of a purely orifice type metering unit, the pressure difference for any given rate of climb decreases with increasing altitude ; *i.e.* causes an error of the opposite sign to the error of a purely capillary tube type unit. The reason for this difference in behaviour is that the air passing through the capillary tube is laminar, while that through an orifice is turbulent. The rate of flow of air through a capillary tube varies directly as the differential pressure, while the rate of flow through an orifice varies as the square root of the differential pressure. Therefore a combination of the two types of metering unit can be found to provide a satisfactory pressure compensation at a given temperature. With regard to temperature compensation, the pressure difference across the capillary tube depends on the viscosity of the air, which is proportional to the absolute temperature and therefore decreases with decreasing temperature. For an orifice, the pressure difference is inversely proportional to the temperature of the air and therefore increases when a decrease of temperature occurs. Since this effect is opposite to that of temperature on the capillary tube, compensation can be achieved by a suitable combination of the two types. In this instrument the sizes of the capillary tube and orifice are chosen so that the readings remain correct over a wide range of temperature and altitude conditions.

10. **Constructional Differences.** The instrument described in the foregoing paragraphs is the K.B.B., *i.e.* the Mk. 1 series instrument manufactured by Kelvin, Bottomley and Baird. Other manufacturers make instruments of this series for the Service, and while these differ from the K.B.B. in constructional detail in varying degree they operate on the same basic principles.

Mk. 3 Series

11. **Mk. 3A(P).** The mechanism and dial presentation (linear scale) of this instrument are similar to that of the Mk. 1 series instruments. The case is capable of withstanding an externally applied pressure of 15 lb./sq. in., and has a cover glass of non-splintering or toughened armour plate glass. The instrument is suitable for use with pressurized cabins.

12. **Mk. 3(P).** This instrument (Fig. 2) has a dial graduated to a logarithmic scale, rendering it more open and more easily readable at the lower vertical speeds. Otherwise the instrument is similar to the Mk. 3A(P) and is suitable for use with pressurized cabins.

Fig. 2. Mk. 3(P) Rate of Climb and Descent Indicator.

Errors

13. **Lag.** When an aircraft is suddenly put into a steady climb or descent a delay of a few seconds occurs before the pointer settles at the appropriate rate of climb or descent. This is because a time interval must elapse while a pressure difference develops between the capsule and air-tight casing.

14. **Pressure Error.** If the A.S.I. has a large pressure error the rate of climb and descent indicator wrongly indicates a climb or descent whenever a considerable change of airspeed occurs, especially during take-off.

15. **Static Line Blockage.** Blockage of the static line by ice or any other obstruction renders the instrument completely unserviceable, the pointer remaining at zero whatever the vertical speed.

Pilot's Serviceability Checks

16. **On the Ground.** Before flight, pilots should ensure that the pointer reads zero or that the index error, if any, is within the permissible limits. These are :—

(*a*) Plus or minus 200 feet per minute when the local air temperature is within the range −20°C. to +50°C., or

(*b*) Plus or minus 300 feet per minute when the local air temperature is outside the above range.

17. **In the Air.** Pilots should check that the instrument reads zero during level flight. The accuracy of the instrument indications may be checked by comparison with a stop-watch during steady climb or descent.


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