PART 2: SECTION 5

CHAPTER 4

LOW-LEVEL RADIO ALTIMETERS

A.Y.F.

Purpose

1. The A.Y.F. low-level radio altimeter provides a continuous indication of height above the earth's surface to a maximum of 4,000 feet. It is particularly useful for low flying over water and flat ground and can be coupled to an automatic pilot.

Implementation

2. The equipment embodies a transmitter which emits a radio wave the frequency of which is varied over a selected band at a constant rate. The transmitted wave is reflected from the earth's surface to the receiver. The A.Y.F. determines height by measuring the *frequency difference* between the transmitted and received waves. Height is shown by a pointer indication against a background scale calibrated for two ranges: a low range of 0 to 400 feet and a high range of 0 to 4,000 feet. In addition to the altitude indicator some A.Y.F. altimeters have an auxiliary device known as an altitude limit indicator (Fig. 1), designed to relieve the pilot of constantly having to watch the altitude indicator scale. The limit indicator consists of three coloured lamps,

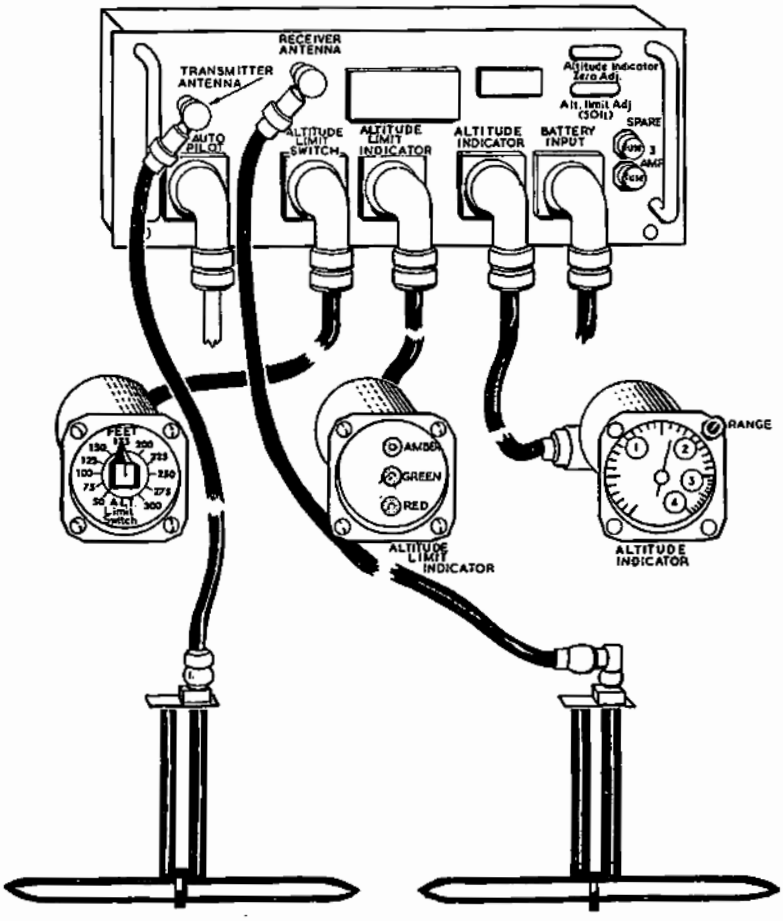

Fig. 1. A.Y.F. Equipment Layout.

one of which is illuminated for each of the three conditions of altitude flight. The normal system of lighting is as follows :—

(*a*) *Red.* Red indicates flight *below* the control range.

(*b*) *Green.* Green indicates flight *within* the control range.

(*c*) *White or Amber.* Either white or amber indicates flight *above* the control range.

Note : The "control range" is a narrow band of altitude (of the order of 5 to 10 feet of altitude on the 0 to 400-feet range and 50 to 100 feet on the 0 to 4,000-feet range) throughout which the green altitude limit indicator signal is obtained and no change of height is signalled by the indicator.

Construction

3. Constructional details are given in A.P. 2533.

Limitations and Performance

4. There are two main sources of inherent error in the equipment, namely, *fixed* error and *mushing* error. Apart from these, other errors may arise from faulty calibration and temperature or supply voltage changes. The accuracy of the equipment may be taken as being better than :—

(*a*) *Low Range.* ± (6 feet + 5 per cent. of altitude).

(*b*) *High Range.* ± (60 feet + 5 per cent. of altitude).

5. For a well-calibrated set the altitude indication on landing will most probably be accurate within 10 feet.

6. When the aircraft is stopped or taxying, the altitude indicator may not read zero. This may be due to reflections from nearby objects, and does not necessarily indicate incorrect calibration. In general, true altitude indication is given only after take-off.

7. **Fixed Error.** The source of fixed error is in the method by which the frequency difference between the transmitter and receiver is converted to a voltage proportional to altitude. On the 0 to 400-feet range, altitude indications change in steps of 6 feet, and on the 0 to 4,000-feet range in steps of 60 feet. The fixed error is noticed only in flight under ideal conditions. Generally, due to quite rapid changes of height, *e.g.* in bumpy air and over uneven terrain, the meter indications are averaged and the fixed error is not apparent.

8. **Mushing Error.** The mushing error occurs in flight, and varies with different types of aircraft owing to the varying heights and distances between transmitting and receiving aerials. Mushing error at 300 feet is removed by calibration and thus reduced considerably over the whole range.

9. **"Drop Out".** At heights considerably above the upper limit of either range of the altimeter, the pointer may be expected to fall back from its position against the stops. This is known as "drop out". The following table gives the minimum drop out heights for both ranges.

Type of Surface	*Min. "Drop Out" Height in Feet*	
	Low Range	*High Range*
Calm Water	1,500	8,000
Land of Average Conductivity	800	6,000

Operation

10. The A.Y.F. is operated in the following manner :—

(*a*) Master power-supply switch—ON.

(*b*) ON/OFF switch on altitude indicator—ON.

(*c*) Select range scale—HIGH or LOW.

(*d*) Select altitude limit switch (Fig. 1) setting for desired height.

11. The equipment requires about one minute to warm up, after which the indicator pointer should rise from its sub-zero stop position.

12. It is important to note that the HIGH range of the altimeter must never be used when flying at altitudes within the LOW range (below 400 feet), or when landing. The HIGH range is not calibrated for such use and an accurate zero altitude indication would not be obtained.

13. **Flight Tests.** A short initial flight test of the altimeter is desirable for checking its general operation and the calibration of both the altitude indicator and the altitude limit indicator (where fitted). If possible, the tests should be made in smooth air and the following points should be checked on both high and low ranges :—

(*a*) Check "drop out" by climbing gradually to above the height corresponding to full-scale deflection on the indicator. The pointer should remain against the upper stop up to the minimum altitude (indicated by the pressure altimeter), as shown in the table in para. 9, before "dropping out".

(*b*) If an altitude limit indicator is fitted, check, at appropriate altitude steps, that the "ON ALTITUDE" signal (green limit indicator light) is obtained when the corresponding approximate height is indicated on the meter, and that the red and white or amber (low or high) signals are obtained at height indications slightly below and above the height settings for which the altitude limit switch is set.

(*c*) When preparing to land, set the range switch (Fig. 1) to "LOW". If the altimeter is correctly calibrated the pointer should indicate approximately zero at the instant of touchdown. A higher indication may be due to false reflections from nearby objects.

14. **Unserviceability in the Air.** If the equipment becomes unserviceable during flight, little can be done to remedy the defect except a fuse check. The fuse is located at the bottom right-hand corner of the front panel of the transmitter/receiver (Fig. 1), with a spare fuse nearby.

Interference

15. There are two main sources of interference which may affect the satisfactory operation of the equipment. These are noise interference and interference from intermittent reflections.

16. **Noise Interference.** Noise interference may arise from poor or loose connections and is evidenced by :—

(*a*) Erratic altitude readings (200 to 400 feet jumps in altitude indicator readings) when flying over land at heights from 400 to 4,000 feet.

(*b*) A marked increase in height indication on switching over to high range while in flight at a height of 400 feet, as indicated on the low-range scale (assuming that both scales have been correctly calibrated).

17. **Interference from Intermittent Reflections.** Interference from intermittent reflections, *e.g.* from propellers, loose fairings, and trailing aerials, cause overreadings on the indicator. This condition is most pronounced on the low-altitude portion of the high-range band.

18. **Arctic Operation.** The A.Y.F. will have lower drop out heights than those shown in the table in para. 9 when used over large lakes in the Arctic, owing to poor reflection. For the same reason the radio altimeter might be inaccurate or ineffective during flight over snowfields and inland ice-caps, especially when operating at the upper end of the HIGH range.

MK. 5

Range and Accuracy

19. The Mk. 5 low-level radio altimeter provides a continuous indication of height above the earth's surface over a range of 50 to 5,000 feet, and is accurate to within ± 3 per cent., but as the indicator responds to changes in 5-feet steps, a further error of ± 5 feet must be expected at any height.

Implementation

20. The Mk. 5 determines height in the same manner as the A.Y.F. model, *i.e.* by measuring the frequency difference between transmitted and reflected waves. The frequency difference is used to operate either one or two height indicators (Fig. 2) as required. When two height indicators are used, they are known as master and slave indicators. A further visual indicator termed the limit-height indicator shows the aircraft preselected height relationship by means of the following light signals :—

Amber—Above preselected height.
Green—At preselected height.
Red—Below preselected height.

Fig. 2.
Mk. 5 Low-Level Radio Altimeter—Height Indicator.

Operation

21. **Switching On.** The only controls that the pilot or crew have to operate are the ON/OFF switch and the limit-height preselector switch.

22. **Warming-Up Period.** A 10-minute warming-up period is required after the power supply has been switched on. Should the equipment be used before this period has elapsed the percentage error of the height readings will be slightly larger than that specified, although the equipment will function normally in all other respects.

23. **Reading the Height Indicator.** The height indicator (Fig. 2) has a pointer which travels 360° clockwise for every 1,000 feet of height, and a veeder counter to show the number of completed thousands. It is important to read the *counter* first and then add the pointer reading to the counter reading; *e.g.* the height indicator reading in Fig. 2 is 2,340 feet. Over rough terrain the pointer does not give a steady reading, and under such conditions no attempt should be made to read height to the specified accuracy. At heights above the range of the altimeter the veeder counter shows the word "OFF", and the instrument serves merely as an indicator to show that the height is greater than 5,000 feet.

24. **Limit-Height Indicator Operation.** The limit-height preselector switch may be set at any time during flight to 0, 50, 100, 200, 300, 400, 500, 600, 700, 800, or 1,000 feet.

25. **Power Failure Indication.** Power failure within the Mk. 5 equipment is indicated by the red and amber lights coming on simultaneously.

Fig. 3. Limit-Height Preselector Switch.