Flight-deck Displays

Left, one of the earliest known altimeters, vintage 1912. Centre, an instrument in use around 1930; above 20,000ft height was read off the inner scale. Right, notorious for its potential ambiguity when used in high-performance aircraft, the three-pointer altimeter was introduced in 1935 and is still in use today

Evolution of the Modern Altimeter

By A. N. du FEU*

THE BAROMETRIC ALTIMETER is one of the two most important single instruments fitted to aircraft. Despite many attempts during the last 50 years to displace it by altitude measuring equipment depending on other principles, there is no sign that any of these methods will eclipse it during the foreseeable future. This article reviews its past and present status and indicates the likely lines of future development.

Probably the first suggestion that atmospheric pressure decreased with altitude came from Isaac Beeckman (1588-1637), but this had to await the invention of the mercury barometer by Torricelli about 1644 before being verified by Pascal in 1648. The altitude of free balloons was measured by portable mercury barometers some time after 1783. Although the aneroid barometer had been invented by Zaiken in 1758, it did not reach a practical form until improved by Bourdon, in about 1845, from which time it was used both in free balloons and dirigibles.

Thus, a practical altimeter existed long before the Wright brothers' first flight in 1903, but it is curious that no well authenticated record exists of altimeters being carried in aeroplanes before about 1913. This was probably due to concentration on the immense problem of practical flight, and it was not until flights involving crossing relatively high ground started to become other than a major adventure that the need for altitude measurement arose.

The mechanism of early altimeters was essentially similar to that of present day household barometers, which themselves have changed little since Bourdon's day.

The pointer made one revolution over the full range, which varied from 0-7,000ft in 1914 and 0-20,000ft in about 1920. By 1925 the range requirements were 0-30,000ft; the pointer then performed one and a half revolutions, being read against an inner scale for altitudes in excess of 17,000ft. Rotatable scales were introduced at that time—so that the scale-zero could be aligned with the pointer before take off.

Though this altimeter performed fairly well under static conditions, it was of little use in the critical landing phase because of the change of indication with attitude, inertial forces, hysteresis and because the indicated altitude on landing depended on the height above sea-level of the landing field relative to the take-off field and the differences in barometric pressure between them.

From 1928 onwards flying in bad weather began to be tackled scientifically, and the altimeter was developed to become a useful landing instrument. Apart from improvement in accuracy at low altitudes the mechanism was fitted with automatic temperature compensation and static balance to eliminate attitude and inertial effects. In the mid-thirties when radio links were established a baro-set adjustment was provided to allow the datum to be changed. Landing requirements also started the trend to pointer indications of 1,000ft per revolution, necessitating two or even three pointers. The culmination of this development was the three-pointer sensitive altimeter, with a range of 0-35,000ft, introduced in 1935.

This altimeter set the pattern for the next 20 years, during which time the mechanism was improved and the range extended to 0-60,000ft, and even, in some instruments, 0-80,000ft. Although improvements were made to the presentation, it was never free from possibilities of misreading. Extensions of the range resulted in loss of, rather than gain, in accuracy, because of the excessive work which the capsules were asked to perform. It was technically superseded by the servo altimeter in 1958 although it still survives in large numbers. Its inadequacy for high-altitude jet flight points to its decline for all but light or low performance aircraft.

The principle of the servo altimeter, introduced by Smiths Industries in 1958, was that aneroid capsules were relieved of all but the lightest mechanical work involved in the electrical detection of their position. The operation of the instrument was performed by an electrically powered servo. This resulted in significant gains in accuracy, the possibility of extension of the range to 100,000ft, and the use of five-digit counter presentation making misreading virtually impossible. This conformed to the conclusions reached by the UK Altimeter Committee. In spite of these advantages, and apparent complexity, the servo altimeter has achieved a consistent reliability well above that of mechanical altimeters.

Other methods of altitude measurement

It is sometimes asserted that the continued dominance of the barometric altimeter is because of a lack of development effort devoted to alternative systems. This is quite untrue. In fact a great deal of work has been done since 1915 onwards. The following list of methods tried and abandoned together with brief reasons, should dispel notions that the field has been insufficiently investigated.

Method	*Disadvantages*
Capacitance	Altitude limited to about 200ft: unreliable below 10ft.
Sonar	Low signal/noise ratio, excessive transmission time except at very slow speeds.
Gravimeter	Rate of change small in relation to absolute value. Excessive influence of centrifugal and coriolis forces.

*Head of Barometric Studies Group, Smiths Aviation Division.