

## THE ABSOLUTE ALTIMETER

by

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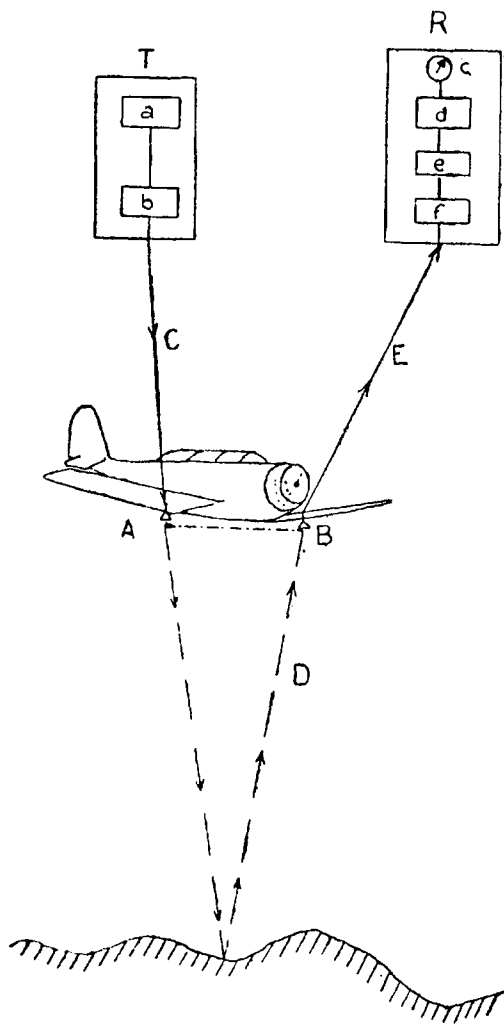
There is in radio the corresponding phenomenon of an echo, an electric wave reflection. When one realizes that a radio wave travels at 186,000 miles/sec., he readily sees that any echo effect would be practically instantaneous. This electric wave reflection is the basis of the theory of the *absolute altimeter*, or as called by the inventors a "Terrain Clearance Indicator". Lloyd Espenschied and R.G. Newhouse of the Bell Laboratories were chiefly responsible for its development. R.G. Newhouse was the recipient of the Lawrence Sperry award for his work on this instrument.

Imagine a plane in flight, continuously sending to the earth beneath it a beam of very short radio waves. It is a wide beam, such as will insure that a part of it will always strike the earth, irrespective of the "attitude" of the plane. The earth reflects back a portion of this beam with more or less effectiveness, depending on the physical character of the terrain. The waves reflected back from the earth are compared to the outgoing. A measure of the distance is the time it took for the wave to travel to the earth and return. This is continually indicated on a meter calibrated in feet.

A special radio transmitter is provided on the plane which sends a continuous signal toward the earth, the frequency of this signal changing at a definite rate with respect to time. This frequency change or sweep is in the neighbourhood of 25 megacycles to provide measurements down to the present minimum of 20 feet. This signal is reflected by the earth after a time delay equal to twice the height divided by the velocity of propagation. During this interval the frequency of the transmitter has changed and now differs from the echo by an amount equal to the product of the rate of change of frequency, and the time it took the original signal to go to the earth and return. The reflected wave is combined in the plane received with some of the outgoing wave energy and the difference or "beat" frequency is measured by the frequency meter. Since the reading of the frequency meter is that of the "beat" frequency, it is proportional to the time delay of the echo and hence to height, and thus can be calibrated in feet. The schematic diagram shows the complete system.

The use of ultra-high frequency has the advantage of requiring small antennas and will cause little drag upon the plane. Another advantage of the ultra-high frequency is that in order to have a high antenna efficiency, it is necessary, that the percentage variation from the average frequency during the modulation cycle be small. The average frequency employed is 450 megacycles.

The meter calibrated in feet has 2 scales, the upper extending from 0 to 5,000 feet and the lower, 0 to 1,000 feet. A switch determines the scale to be used. Dipole type antennas are used. The signal is not particularly directional. The signal is radiated approximately the whole hemisphere below the wing, centered on the transmitting antenna. Naturally the strength of the signal is greatest directly downward but it does not fall off rapidly in other directions. The tremendous advantage of this is that the distance to the nearest reflecting surface is measured regardless of whether it is directly beneath, or to the front or side. As a result very little change in reading occurs when the airplane banks steeply. Some advance indication also is given when the airplane in level flight approaches higher terrain.



T = Transmitter — Emetteur.

a = Frequency modulator. — Modulateur de fréquence.

b = Oscillator (ultra high frequency). — Oscillateur (extra haute fréquence).

C = Frequency modulated signal. — Signal à fréquence modulée.

R = Receiver. — Récepteur.

c = Dial. — Cadran. d = Frequency meter circuit. — Circuit de fréquence mètre.

e = Amplifier. — Amplificateur. f = Detector. — Détecteur.

E = Incoming signal. — Arrivée de signal.

D = Reflected signal. — Signal réfléchi.

TAKING AN "AIR SOUNDING". — PRISE D'UNE SONDE AERIENNE.



An indication of the physical character of the terrain is given by variations in the meter reading. A city usually causes rapid fluctuations of the order of 50 feet, depending of course upon the height and spacing of the buildings. Cultivated farmland causes fluctuations of lower frequency and amplitude. An isolated high object causes a slight meter kick which may not be noticed by the observer. If the top of the high object is large enough to contribute momentarily most of the echo signal received by the plane, the indication is unmistakable and the correct distance to the object is indicated by the meter. In this manner the instrument may be employed very usefully as a position indicator. This use may be incorporated for instrument approaches to airports and may prove to be one of the altimeter's most valuable applications.

As it is constructed at present, the altimeter indicates altitudes above the ground between approximately 20 to 5,000 feet. It is subject to errors as are all instruments, yet the errors of this instrument if all errors were simultaneously in the same direction will not exceed a total of plus or minus 9 per cent.

