Figure 4 shows the curves for shearing stress and for tensile stress calculated according to the formulas for one of the test specimens, marked 1B in Professor Hammond Smith's report. The dimensions of the plates and the straps as well as other data pertaining to the test are given in the figure. For the sake of clearness the curves for the tensile stresses are laid off above the axis of abscissae and the curves for shearing stress below the axis. There is added a curve (dotted) for the measured displacements as obtained from figure 10 of the report, reduced to such a scale that the ordinate at O is the same as in the curve for the calculated value of q. The close correspondence between these two curves, one representing q, the other μq, is obvious, and is found also for the other test pieces of narrow width.

The value of the displacement coefficient μ in those tests was found to vary from 0.3×10^{-7} to 0.4×10^{-7}. This coefficient is likely to be different in joints of different kind and as yet little is known of its value in various cases, but it is hoped that experiments now in progress at the Massachusetts Institute of Technology will throw further light on this subject.

[1] These PROCEEDINGS, November, 1930, p. 667.

[2] Report submitted to the Fundamental Research Committee of the American Bureau of Welding, *J. Am. Weld. Soc.*, **8**, Sept., 1929; "Stress Strain Characteristics of Welded Joints."

A RADIO SYSTEM FOR BLIND LANDING OF AIRCRAFT IN FOG

BY H. DIAMOND AND F. W. DUNMORE

NATIONAL BUREAU OF STANDARDS, WASHINGTON, D. C.

Read before the Academy, September 19, 1930

This sytem includes three elements in order to indicate the position of the aircraft in three dimensions as it approaches and reaches the point of landing.

1. *Lateral Position.*—Such position given for the purpose of keeping the airplane directed to and over the runway is indicated by two vibrating reeds on the pilot's instrument board, the driving electromagnets of which are connected to the output of the airplane's radio receiver. These reeds, one of which is mechanically tuned to 65 cycles and the other to 86.7 cycles, are actuated by a radio signal sent from two coil antennas crossed at 90°, the signal from one coil antenna being modulated at 65 cycles and that from the other at 86.7 cycles. On the course (i.e., along the line bisecting the angle between the two antennas) the reed vibration amplitudes are equal. Off the course they are unequal, the reed vibrating with the greater

amplitude being on the side to which the airplane has deviated. An automatic volume control feature is used to keep the reed amplitudes within bounds as the field is approached.

2. *Vertical Guidance.*—A high-frequency (100 megacycles, 3 meters)

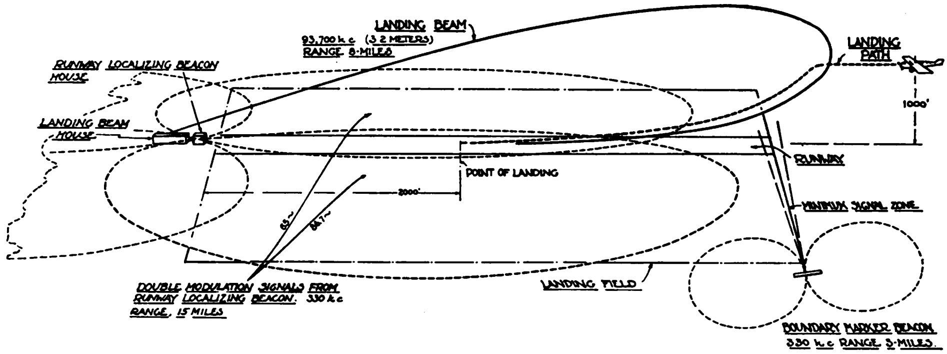

FIGURE 1

Three dimensional view showing radio system of blind landing aids.

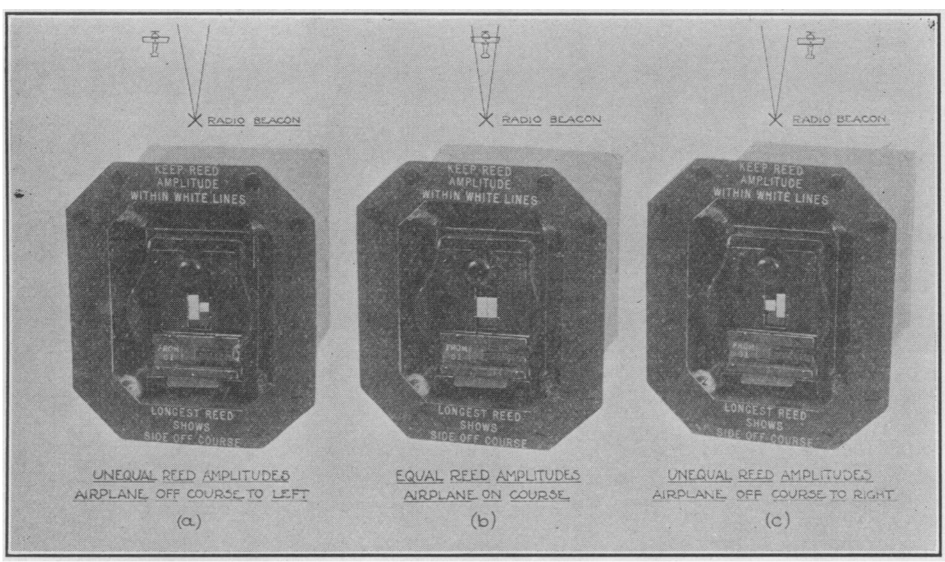

FIGURE 2

The tuned reed indicator used for giving horizontal guidance.

beam directed over the runway at an angle of 8° above the horizontal and located at the further end of the landing field is used for such guidance.

On the airplane, the signal current in the output circuit of the special high-frequency receiving set employed is rectified and passed through a d. c. microammeter mounted on the instrument board. The airplane does not fly on the axis of the beam, but on a curved path under the beam whose curvature diminishes as the ground is approached. The path is the line of equal intensity of received signal below the axis of the beam. The diminution of intensity as the airplane drops below the beam axis is compensated by the increase of intensity due to approaching the beam transmitter. Thus, by flying the airplane along such a path as to keep the de-

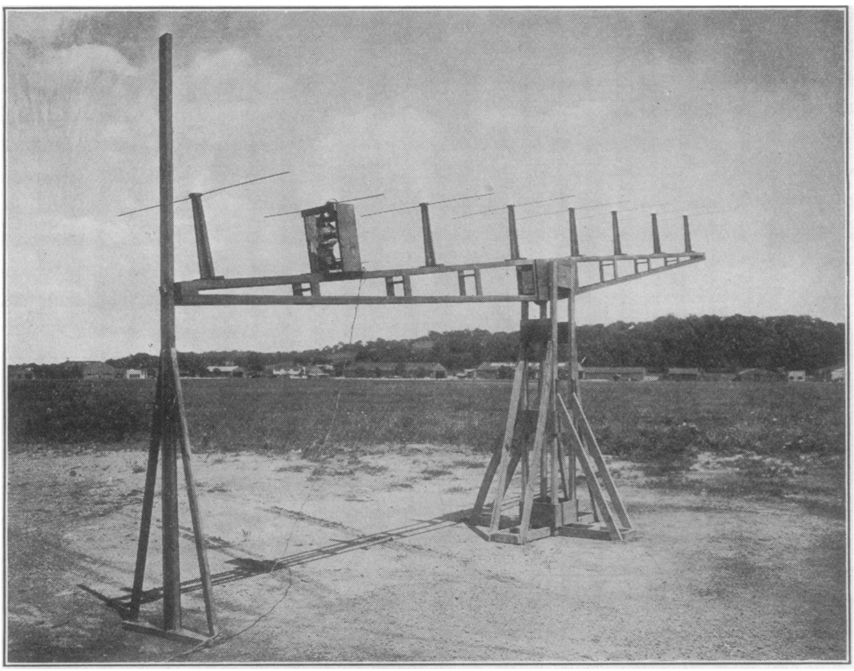

FIGURE 3

Antenna array for directing the ultra-high frequency landing beam used for vertical guidance.

flection of the microammeter on the instrument board constant, the pilot comes down to ground on a curved line suitable for landing.

No manipulations on the part of the pilot are required. The tuning is fixed. Since a line of constant field intensity is followed no control of volume is necessary.

3. *Longitudinal Guidance.*—A field boundary marker beacon is used for this purpose. It operates on the same carrier frequency as the runway localizing beacon and both beacons are received simultaneously on the medium-frequency receiving set. A modulation frequency of 1000 cycles is used. A coil antenna oriented to give a minimum signal zone along the

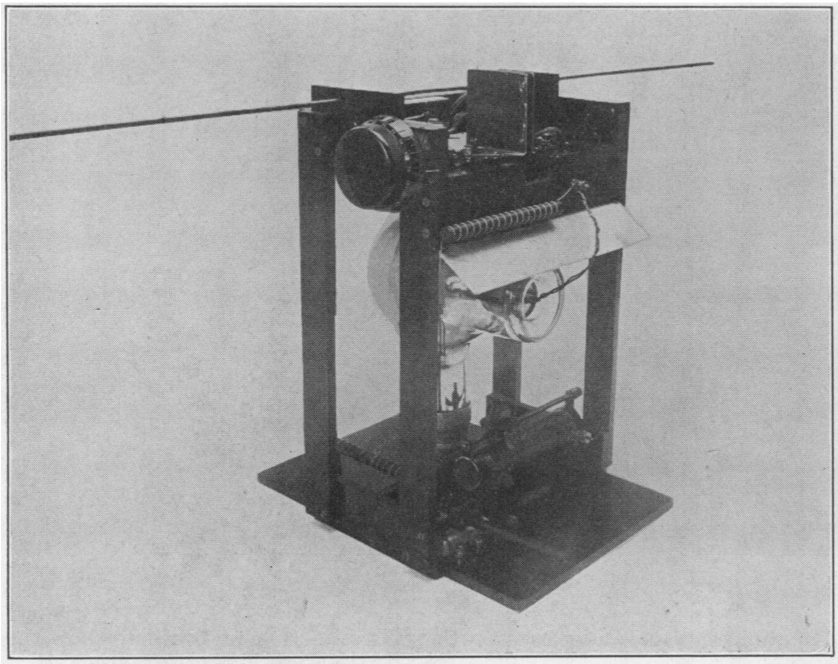

FIGURE 4

The ultra-high frequency transmitting tube and associated circuit.

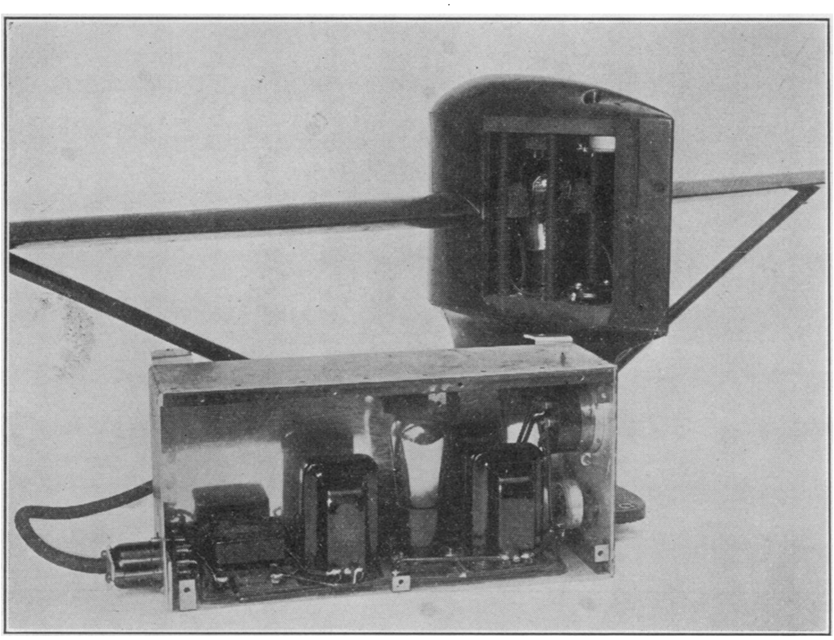

FIGURE 5

Equipment for receiving the ultra-high frequency landing beam signals.

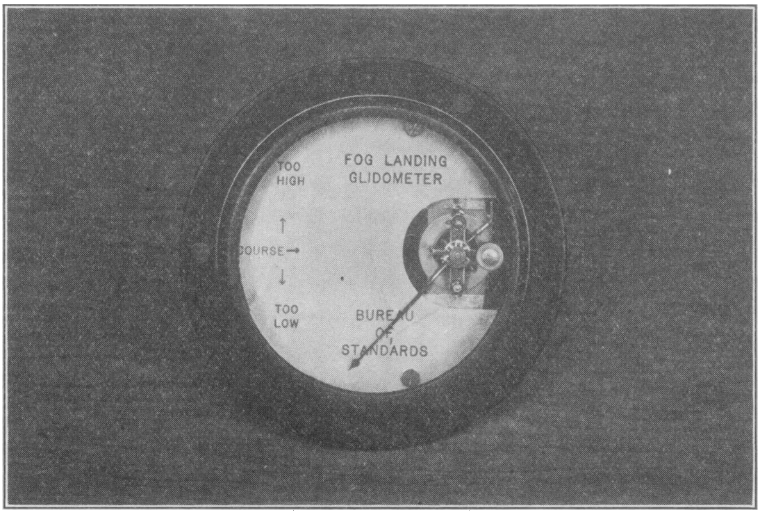

FIGURE 6

Landing beam indicator used on the pilot's instrument board to show the relative position of the airplane with respect to the proper landing path.

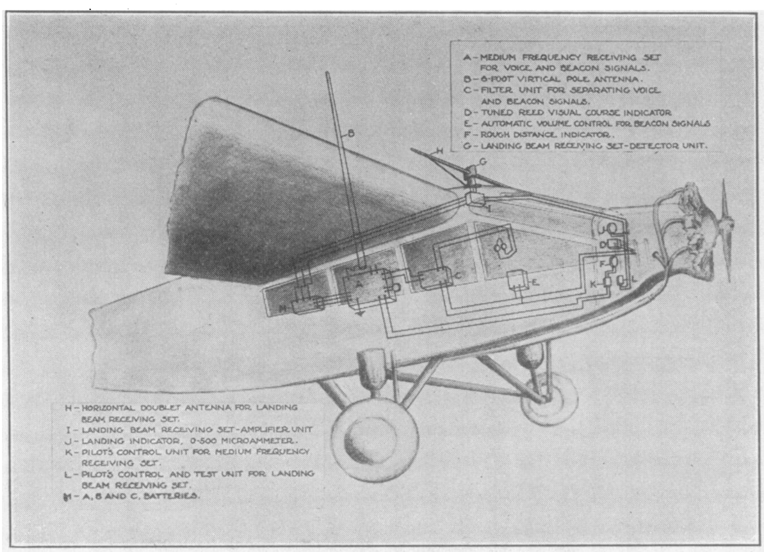

FIGURE 8

Skeleton view of Bureau of Standards airplane showing complete receiving apparatus for blind landing system.

border of the field is used, the minimum signal indicating to the pilot that he is over the edge of the field.

Figure 1 outlines the complete landing system. The airplane is kept horizontally in line with, and over the runway, by means of the 65 and 86.7 cycle signals shown by the light-dotted ellipses. Along the line of the runway these two signals are of equal strengths giving equal reed amplitudes. The heavy solid line indicates the high frequency beam oriented vertically at 8° to the horizontal. The heavy dotted line shows the vertical landing path as followed by the airplane, when the pilot keeps the received signal at a constant value. As the source is approached it is necessary to continually drop under and out of the beam to hold a constant received signal.

Figure 2 shows the tuned reed indicator for giving horizontal guidance. The three views show how the reed indicator looks to the pilot when on course and off course to the right or left.

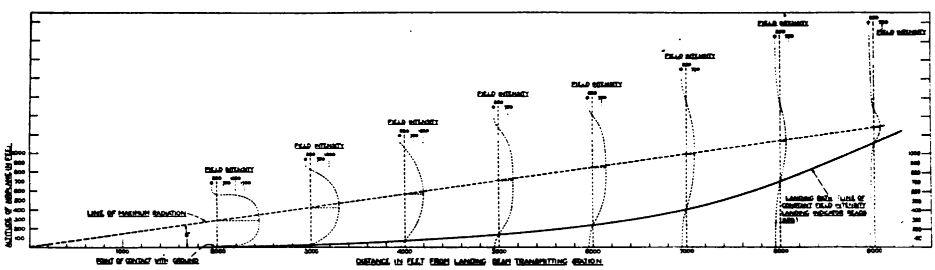

FIGURE 7

True landing path as determined experimentally.

Figure 3 shows the antenna array for directing the 100 megacycle (3 meters) beam at an angle of 8° with the horizontal. A 500-watt transmitting tube is used.

Figure 4 is a close-up view of the 500-watt tube and associated circuit. To adjust this circuit to the desired frequency a dial is provided which moves one of the plates of the air condenser shown above the tube.

Figure 5 is a view of the equipment for receiving the 100-megacycle signal. The detector tube may be seen in the stream-lined box. The horizontal doublet antenna is in the horizontal stream-lined wooden section. The one-stage audio amplifier and rectifier unit is shown below. This unit is placed inside the airplane.

Figure 6 shows the indicating instrument which is connected to the output of the amplifier-rectifier unit just shown. This is a 0–500 d.c. microammeter, and the needle is held in the horizontal position when the airplane is following the landing path. If the airplane goes above the landing path the signal increases and the needle rises. If it goes below, the reverse is true.

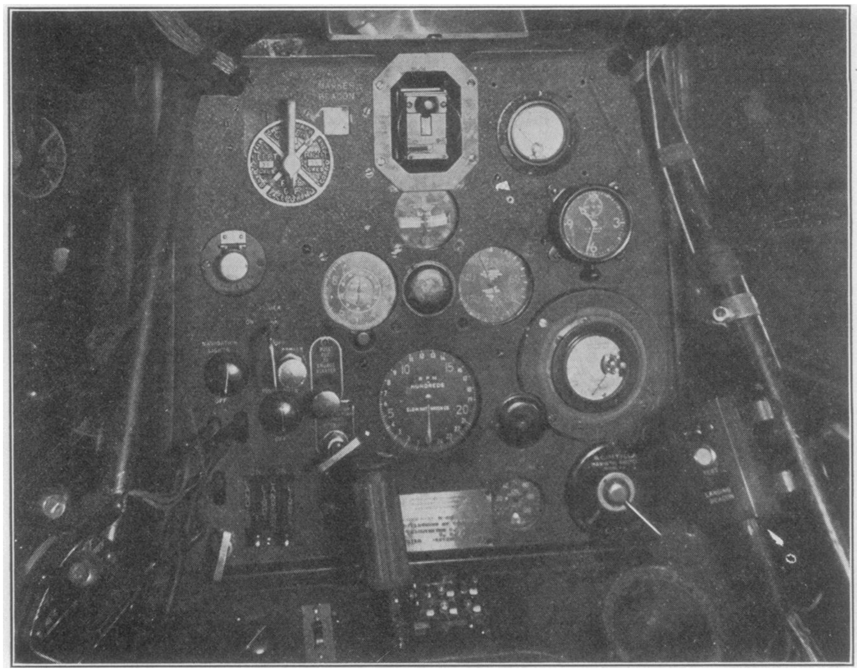

FIGURE 9

Instrument board on Bureau of Standards' airplane.

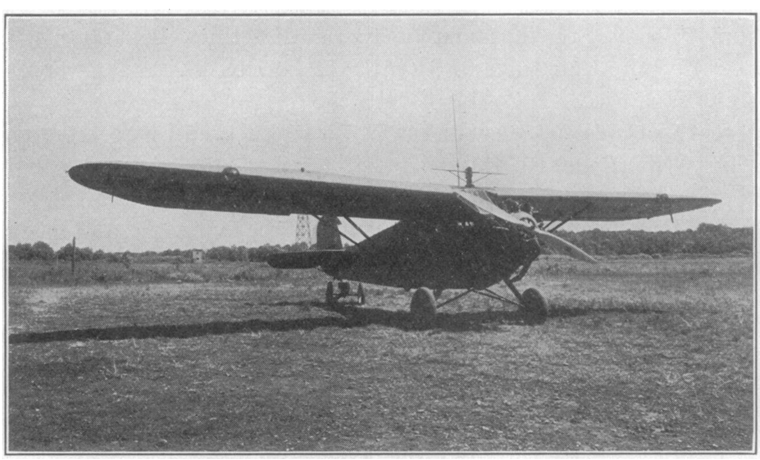

FIGURE 10

Vertical pole antenna and horizontal doublet antenna used in reception of blind landing system signals.

Figure 7 shows the true landing path as determined experimentally. Here the landing glide starts at 1100 feet altitude, 9000 feet from the landing beam transmitting set, the airplane coming to rest on the ground 2000 feet in front of the beam transmitting set. It will be noted that the landing indicator reads 250 ($^1/_2$ scale) during the whole of the glide.

Figure 8 is an inside view of the Bureau of Standards airplane showing the location of the blind landing apparatus.

Figure 9 shows the instrument board of the airplane. The tuned reed indicator is shown at the top and the landing beam indicator at the right center.

Figure 10 is a view of the airplane showing the vertical pole antenna for receiving the runway localizer signal for horizontal guidance and the horizontal doublet antenna for receiving the high-frequency beam signal for vertical guidance.

A SENSITIVE INDUCTION BALANCE FOR THE PURPOSE OF DETECTING UNEXPLODED BOMBS

By Theodore Theodorsen

The National Advisory Committee for Aeronautics

Read before the Academy April 29, 1930

Introduction.—In connection with the construction of a channel for the testing of seaplane floats at the Langley Field laboratories of the National Advisory Committee for Aeronautics, the Committee was recently confronted with the problem of locating unexploded bombs buried in the earth.

The site of the channel was located in close proximity to an area which had previously been used by the Army Air Corps for target practice.

The Committee made a careful survey of the situation and requested information from all organizations which it was believed might be able to render assistance. None of the proposed methods proved to be satisfactory and had to be abandoned.

The Laboratory, after trying various proposed schemes, succeeded in devising an instrument which possessed the necessary properties. This instrument is of a very simple design and is very convenient in operation.

The entire site of the channel has been scanned with this detector with good results. The instrument is perfectly fool-proof and requires, for its operation, no skilled operators. It was felt that this paper might be of interest to those confronted with similar problems. The question is also of some theoretical interest, and it is this aspect of the problem which will be taken up in the present paper.