LIGHT SIGNALS IN AVIATION AND NAVIGATION

(Extract from an article by I. LANGMUIR and W. F. WESTENDORP (*Physics*, Nov. 1931), reviewed in the *Journal of the Franklin Institute*, January 1932)

Laboratory experiments have been devised to make measurements of the visibility of light signals under conditions essentially similar to those encountered by the aviator or the navigator. Data have been collected on the direct visibility of flashing point sources of light of different colors, flash lengths and intervals, against different backgrounds; the time it takes to locate a visible beacon was studied as a function of the beacon intensity and frequency of flashing. The threshold candle power C required for visibility of a point source at distance D (cm.) against a background of brightness H (candles $\times$ cm.^{2}) is given by the empirical equation $C/D^2 = 3.5 \times 10^{-9} H^{\frac{1}{2}}$. Colored point sources were not found to be useful except in the case of red lights with background intensities above moonlight. For an airplane approaching a beacon it is advantageous to use frequencies of flashing as high as 12 to 30 per minute, although with exceptionally clear atmosphere lower frequencies may be better.

In a study of the visibility of flashes of diffuse light superimposed on a steady white background, white light flashes gave the best results. The sensitivity of the eye to light from point sources is from 10,000 to 170,000 times as great as from diffuse sources, this range corresponding to an increase in background brightness from 0.1 starlight up to moonlight. A selective differential photoelectric receiver is described which detects signals of *modulated diffuse light* of an intensity of only 4×10^{-11} candles $\times$ cm^2. This sensitivity is independent of the steady background brightness up to 100 times moonlight, and is from 6 to 13,000 times as great as that of the eye in the range of background intensity from darkness up to moonlight.

The greatest difficulty in transmission of light signals through fog lies in the loss of advantages of the point source. Dense fog may increase the distances at which *diffuse light signals* may be detected. The range depends to a considerable extent on the reflectivity of the ground. A theoretical treatment of the diffusion of light through fog, based on the scattering of the light rays by fog particles, indicates that airplanes can be guided through fog at distances of several miles by means of diffuse modulated light acting on a differential photoelectric receiver.