in the case of a simple fruit the position of the embryo in relation to the carpel and its point of attachment to that carpel markedly affects the shape and development of a portion of the fruit. Thus, the dominating effect of the embryo upon fruit development is extended to even a portion of a carpel.

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SCIENTIFIC APPARATUS AND LABORATORY METHODS

A SIMPLIFIED AUTOMATIC RECORDER FOR IONOSPHERIC HEIGHT MEASUREMENT

THE purpose of this article is to describe a satisfactory method of photographically recording virtual heights of the various layers of the ionosphere without the use of complicated equipment. Errors of considerable magnitude which are likely to be overlooked by investigators, regardless of the nature of the recording equipment, are also discussed.

The general method of photographing radio pulse reflections from the ionosphere as seen on a cathode ray oscilloscope screen is not new, but usually the equipment is of special design and often quite complicated. The accuracy of the method described herein is practically as good as that of some of the intricate and expensive methods now in use.

A diagram of the oscilloscope screen (Fig. 1) shows from left to right the ground pulse, an E reflection and an F reflection, respectively. It will be observed that the entire screen is masked, with the exception of the base or zero-signal line. When a synchronous pulse is received, it causes the sweep line to be deflected upward behind the mask, leaving a blank space in the line.

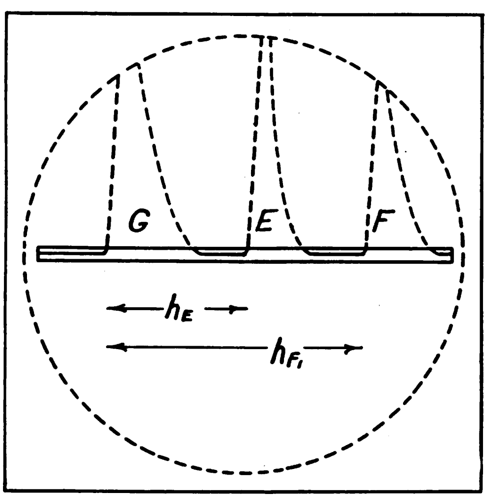

FIG. 1. Screen of oscilloscope showing ground pulse G with two reflected impulses E. and F.

The recording device consists of an ordinary camera focused on the oscilloscope screen and a hand-wound clockwork attached to the key for slowly winding up the film. It is obvious that if the clockwork runs at a constant rate, the time scale will not be linear, as the film will speed up with increasing roll diameter. After one film had been run through it was found that the speed at the end was practically double that at the beginning. In subsequent recordings, the governor on the clockwork was adjusted every half hour so that the film passed by the lens at nearly a constant rate. Also, a calibrating wave was introduced at half-hour intervals. Even this speed adjustment is an unnecessary refinement, since the time scale is marked off in desired intervals by the introduction of the calibrating wave or simply by closing the camera shutter for a few seconds.

The film from which the prints in Fig. 2 were made was driven at about six inches per hour, and each of the sections shown represents a fifteen minute observation. The distance between any two adjacent peaks on the 3,000 cycle calibrating wave shown at the end of the second recording represents a layer height of 50 km. The layer heights as measured at the beginning of the second recording are 115 km, 225 km and 355 km for the E, F-1 and F-2 layers, respectively. These particular runs were made soon after sunset on a frequency of 2,398 kc. Police stations operating on adjacent channels caused the five or six smears on the recordings. It is interesting to note that in the latter

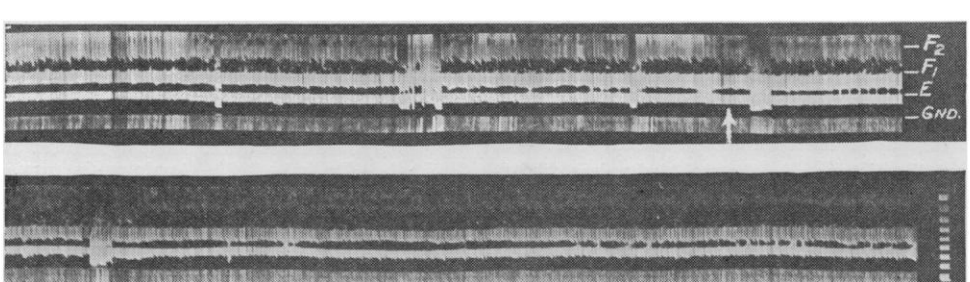

FIG. 2. Photographic records of ionospheric heights made shortly after sunset.

part of the second recording (Fig. 2) the F-1 layer is composed of a wide band of reflections extending nearly up to the F-2 region. The boundary line of the E layer is quite distinct at all times, but this is not true of the F layers on the second recording. Rapid changes in signal strength and fluctuations of layer height were the causes of this condition. In other words, there was no sharp boundary existing at the time mentioned.

The heights of the layers are obtained from the recordings by measuring the distance between the edges of the unexposed portions of the film with a traveling microscope. The edges from which measurements are made are indicated in Fig. 2 by the letters Gnd, E, F_1, F_2. It is preferable to use the negatives directly for this purpose, since they are somewhat sharper than the positives.

This recording system has one inherent error which is common to all others with which the writers are familiar, namely, that changes in the strength of a received reflection produce what appears to be a change in the virtual height of the layer. This error arises because the time taken for the signal to pass through the receiver changes with input signal strength. The time lag is measured as shown in Fig. 3 by impressing the radio frequency pulse directly upon the deflecting plates of the oscilloscope. The pulse, after passing through the receiver, appears slightly to the right of the r.f. pulse. The distance D-1 is a measure of the time lag of a strong pulse and the distances D-2, and D-3 those of weaker ones.

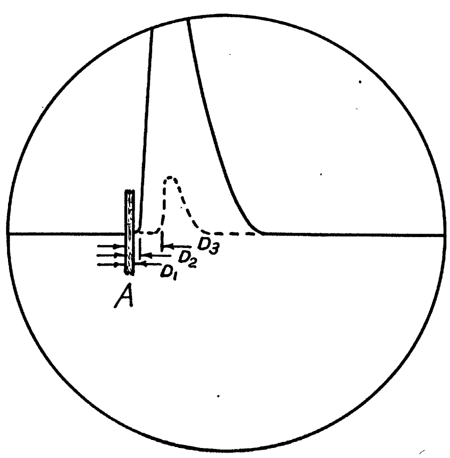

FIG. 3. *A* marks the position of a pulse which is impressed directly upon the oscilloscope itself. D-1, D-2, D-3 represent the distances to the right of pulses of different strengths which have passed through the receiver.

In the case of the National Fb-7 receiver, which is generally considered to be very satisfactory for ionospheric work, the lag is about 5 km for a strong pulse and about 20 km for a weak one. The effect of layer height apparently changing with variations in signal strength is clearly shown in Fig. 2 at the point indicated by the arrow. In this case the reflection became very weak and vanished for a short period of time. The height apparently changed from 127 km to 119 km in less than half a minute, but actually very little if any change took place.

This error may be largely eliminated by calibrating the receiver so that the lag for any value of signal strength is known. A correction can then be applied to the recorded data.

The error just discussed has seemingly been neglected by many investigators. A recent paper by E. C. Halliday[1] is of interest due to the high accuracy claimed ($\pm$ 0.5 km). In the method described, the time scale was greatly expanded to permit ease of measurement and the front edges of the pulses were caused to intersect the sweep line at a definite angle. While these are decided improvements, they do not correct the error due to receiver lag. Statements have been made that the layer heights will change as much as ten kilometers in less than one minute. Such changes are probably caused by variations in the signal strength of the reflections and not by sudden fluctuations in the height of the layer.

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[1] E. C. Halliday, *Proc. Phys. Soc. London*, 48: 421, 1936.

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