take of tritium and protium by the algae. The results are presented in Table 1. They show that approximately the same isotope effect was obtained at each concentration of tritium.

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Extended-Range High-Frequency Radio Communication at Relatively Low Power, by Means of Overlapping Oblique Reflections from Meteor Ionization Trails[1]

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At radio frequencies customarily used for long-range radio communication (6–25 mcs), the following mechanisms are known whereby reasonably consistent signals can be propagated from transmitter to receiver: (1) ground wave, (2) space wave, (3) anomalous tropospheric propagation, (4) ionospheric sky wave, reflected by both regular and "abnormal" layers, and (5) indirect sky-wave transmission, involving backscattering from the earth (*1*). Recently, a new type of transmission explained as ionospheric forward scattering has been demonstrated at a frequency of 50 megacycles, with the aid of transmitting equipment of relatively high power (order of tens of kw), and antennas of high gain (*2*).

It is the purpose of this note to suggest that at frequencies of the order of 15 megacycles and lower, still another mechanism may largely account for a consistent type of propagation which has been found to exist between low-power stations (order of 1 kw) separated by distances of roughly 800 miles. The mechnism proposed is that of overlapping reflections from the large numbers of meteor ionization trails which are present in the E-region of the ionosphere at any given time.

It has been predicted on theoretical grounds (*3*), and demonstrated experimentally to a first approximation (*4*), that the duration of an echo from the most common type of meteor trail is considerably increased when the reflection takes place at oblique, rather than perpendicular incidence. A perpendicular-incidence echo decays in intensity and falls below the threshold of detection not because the causative ionization has disappeared, but rather because contributions to the echo from various portions of the expanding cylindrical disturbance begin to cancel each other out as soon as the separation between any two portions approaches a half wavelength. The onset of this cancellation is considerably delayed when oblique geometry is involved, because the trail must expand further before the pertinent portions become separated by an amount which produces a half-wavelength change in length of path.

The numbers of meteors detectable at vertical incidence at 15 megacycles with continuous-wave powers of the order of one kw, is such that the individual meteor echoes are usually well separated in time.

Over an oblique path of the order of 800 miles, however, the mean duration of received echoes may be expected to be considerably lengthened. For the most favorably situated trails, the increase may be as much as 20 times. When the pertinent statistical and geometrical factors are taken into account, the probability of at least one echo of detectable strength being present at any given time can be shown to be very high.

In order to verify this expectation experimentally, it is necessary so to choose the wavelength, time of day, and season of the year that transmission possibilities (4) and (5) above are ruled out. Elimination of possibility (5) is important, since sporadic-E clouds of ionization located to one side of the transmission path of interest (and so not readily detectable as such) can nevertheless make a perceptible contribution to the total signal observed over the desired path by indirect backscattering from the ground. Over a path of 800 miles, at the frequencies of interest, mechanisms (1), (2), and (3) may not be expected to be of significance.

Experiments have been conducted over paths of approximately this length, at a frequency close to 14 megacycles, with possibilities (4) and (5) ruled out with the aid of a scatter-sounding apparatus which has been described elsewhere (*1, 5*). Background transmission, having characteristics consistent with the meteoric echo explanation, has been found on all occasions on which the experiment could be conducted without ambiguity. Transmitted powers of the order of 500 w were used, together with antenna gains of 6–8 db. With standard communications equipment, at locations reasonably free of noise and reasonably favorable to low-angle radiation, a signal well above receiver noise level may be expected at the distant point.

This signal is subject to strong fading. It will be found to dip occasionally into the noise level, yet often rise very far above. It is consistent enough, however, for hand-keyed telegraphy provided that suitable automatic volume control or limiting circuits are used.

Appreciable increases in transmission distance and

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transmission frequency have been found to cause the continuous background signal to disappear, leaving only isolated meteor echoes, or bursts.

The practical usefulness of this form of transmission stems from the fact that for point-to-point communication between locations of the order of 800–1000 miles, the possibility of dispensing with the usual procedure of changing frequency two or three times a day in order to follow diurnal changes in the regular layers is offered. If a nominal increase in transmitted power over the value customarily used for layer-propagated transmission over circuits of this sort would be acceptable, it appears that meteor reflections could be relied on to provide usable transmission when other methods had failed. The use of one frequency throughout the 24 hr not only simplifies transmitter design and operation, but also conserves valuable space in the radio spectrum.

The signal obtained in the above-mentioned tests could be accounted for in part as another manifestation of the "ionospheric forward-scattering" suggested as taking place at 50 megacycles (*2*). It is too early to discuss this possibility in detail. However, it is clear that meteors play a very large part in the 15-megacycle experimental observations. On theoretical grounds, it appears that meteors alone could account for the observed signal.

A more detailed account of this work is published elsewhere (*4*).

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Comments and Communications

Rapid Aerial Survey of Gulf Stream with Camera and Radiation Thermometer[1]

During the cold half of the year a sharp discontinuity of surface temperature (often amounting to 20° F in less than 100 yd) occurs along the northern border of the Gulf Stream. The recent discovery (*1*) of meanders in the Gulf Stream has stimulated efforts to devise rapid means for surveying its course, and we (Parson and Stommel) decided to investigate the possibility of tracing the thermal discontinuity on the ocean surface by flying an infrared detector along it.

A Goylay detector (*2*) is exposed alternately to the sea surface and to a reference black body in the instrument by means of a rotating shutter. The temperature of the black body is adjusted by admitting hot or cold water into it until the chopped signal from the Golay cell is nulled. Were there no absorption and emission of thermal radiation by the atmosphere between the cell and the sea, the temperature of the black body would be that of the sea surface. In practice, however, a minimum altitude of 1000 ft is safe over long ocean flights. Enough radiation from the sea penetrates the lowest 1000 ft of the atmosphere to make the sharp thermal discontinuity easily detectible, although the actual temperature of the sea surface is not indicated by that of the black body.

To date three surveys have been made. Positions of the thermal discontinuity on Nov. 26, 1952 are shown in Fig. 1 by dots; the visual evidence of the northern edge of the Stream cited by Kielhorn (*3*) (contrast in color and sea-state) was confirmed. A wide angle (80°) time lapse (72 frames/min) motion picture camera directed straight ahead (von Arx) recorded visual evidence of the edge of the Stream at positions marked by segments of curves on the figure. The general appearance of the course of the Stream is similar to that obtained by ship (*4*).

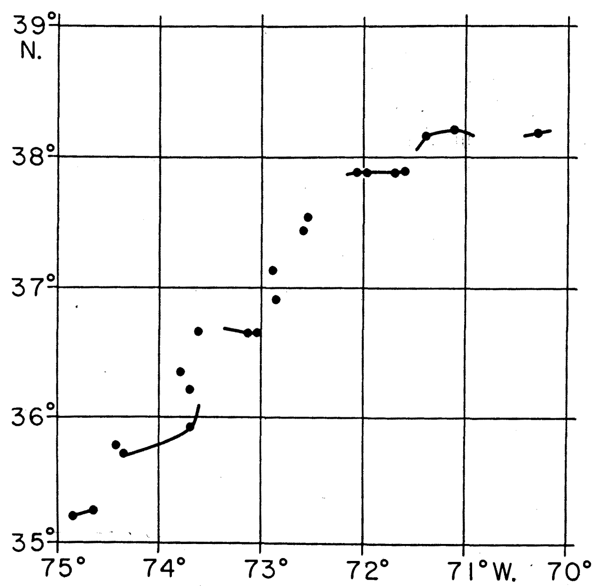

FIG. 1.

The primary obstacle to extending this type of survey to areas further to the east is the range and endurance of aircraft; but it does seem quite clear that

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