LETTERS TO THE EDITORS

RADIOPHYSICS

Group and Phase Velocities of a Travelling Disturbance in the *F* Region of the Ionosphere

A PUZZLING feature of the reported association[1] between travelling disturbances in the *F* region and the occurrence of sporadic *E* is that travelling disturbances move with a velocity of about 10 km./min. (ref. 2) whereas sporadic *E* patches have only about half this velocity[3]. However, the travelling disturbance velocity was measured using widely spaced stations ($\sim$ 1,000 km.) whereas that of the sporadic *E* patches was found using relatively close stations ($\sim$30 km.). Therefore whereas it is the group velocity of the travelling disturbances which has been measured, the sporadic *E* patches may be associated with a particular phase of the isoionic contours in the travelling disturbance and may thus appear to move with the phase velocity of the travelling disturbances.

To test this hypothesis, three methods have been used for measuring directly the phase velocity of a travelling disturbance, making use of existing records. The ionograms taken at one station have been reduced to give isoionic curves plotted against time. These curves are then used in the following ways:

(1) The radius of curvature of the isoionic contours in space may be estimated from the observed splitting of the echo. For example, when the second echo is split, but the first is not, the radius of curvature is between once and twice the height of the contour. When the radius of curvature at any time is known, the phase velocity may be estimated.

(2) The second echo virtual path is often less than twice the virtual path of the first echo, because of the different paths followed. If the isoionic contours are assumed to be concentric circles over short distances, it is possible to calculate the difference in terms of known quantities and the phase velocity.

(3) The wave-fronts of travelling disturbances are believed to be approximately along the Earth's magnetic field[3,4]. If this is assumed to be correct, a further estimate of phase velocity may be made using the isoionic curves.

One set of two-minute records taken at Brisbane has been found suitable for analysis. The group velocity of the disturbance was found from ionograms at this and other stations to be 10 km./min. All three methods gave a phase velocity between 4 and 6 km./min., confirming the hypothesis.

The difference in group and phase velocities may also explain the short apparent life-time ($\sim$30 min.) of phase-path irregularities[5] and the long life-time of disturbances on ionograms at spaced stations ($\sim$5 hr.). The form of the phase path irregularities changes rapidly due to the large dispersion.

'Satellite' traces on ionograms are due to sloping isoionic contours which are observed to move with a velocity of $\sim$4 km./min. (ref. 6). Because of the method used for measuring it, this velocity is evidently the phase velocity. Thus the one obstacle to the identification of the cause of satellite traces as travelling disturbances, that is, their different velocities, is removed.

The travelling disturbances discussed here are those which cause gross distortions of ionogram records. Small disturbances on $h':t$ records have been shown to move with speeds of nearly the same magnitude[7], but differing in direction by about 20°. This may be due to the influence of the phase velocity, which may have an east–west component not appearing in the group velocity which is nearly due north.

The reported dispersion does not agree with that given by Hines[8] for internal gravity waves which he regards as the cause of travelling disturbances.

Further details of the experimental method will be presented elsewhere.

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OCEANOGRAPHY

Evidence of an Eastward Equatorial Undercurrent in the Atlantic from Measurements of Current Shear

RECENTLY there has been speculation as to the existence of an equatorial countercurrent in the Atlantic Ocean similar to the Cromwell Current[1,2] in the Pacific. G. Neumann[3] has cited evidence for such a current from early observations (1911) of anomalous drift currents and from a re-analysis of dynamic heights from oceanographical data along the equator. In the first two weeks of March, 1961, during an extensive bathymetry survey of the mid-Atlantic Ridge along the equator, I was able to make a number of measurements of horizontal current shear in the upper 100 m. surface water. The shears obtained at different points over an area extending from 19° W. to 10° W. longitude and from the equator to 3° S. latitude do indicate the presence of an eastward flowing equatorial undercurrent. The measurements were made from the R.V. *Chain* during the first part of a three-month cruise to study oceanographical problems associated with the Romanche Trench and the equatorial mid-Atlantic Ridge.

The current shear was measured by a method suggested to me by W. S. Richardson of this Institution. Two pitotmeters were mounted at the top and bottom, respectively, of the 600-ft. towed chain which carried thermistor elements for the continuous temperature profiling system[4]. When the ship was under