X VIII[5] indicate periods in which magnetic irregularities of 10^5–10^8 km exist. If 10^5 km is the minimum extent of the fluctuations, then the mechanism will be operative and will be independent of energy. Should smaller irregularities occur an energy dependence would be expected.

(2) The direction of minimum intensity will be that of the field lines at any instant, and since their direction changes over periods of a few minutes to a few hours $\left[\frac{10^5 \sim 10^7 \text{ km}}{450 \text{ km/sec}}\right]$ there will be a broadening of the minimum and perhaps a difference in the recorded time of minimum even for stations whose cones of acceptance do not greatly differ.

(3) Changes in direction of the 'average' spiral field on a day-to-day basis will be responsible for part of the spread in direction of T_{min} as observed in Figs. 1*a* and *b*. Such fluctuations would be related to changes in solar wind velocity.

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Frequency Spectrum of Doppler-shifted Whistler-mode Signals

To further our knowledge of very-low-frequency signals received via the whistler mode of propagation we have constructed a 25-channel spectrum analyser. Other work[1,2] has shown the existence of apparent Doppler shifts on these signals of up to two or three parts in 10^5 of the carrier frequency; but the equipment used did not allow the variations of doppler shift with time to be resolved to better than 30 min. It sometimes appeared that there could be large positive and negative shifts occurring within a single 30-min period.

The new equipment consists of 25 filters, of the coherent detector–low pass amplifier type, in which the filter is tuned to the reference frequency supplied to the coherent detector and the band-width is determined by the low-pass amplifier. Use of this type of circuitry reduces the problem of the alignment of a bank of closely spaced filters to one of frequency synthesis, which in this case is done electro-mechanically. One filter is at the nominal carrier frequency and the others are disposed about this, 12 above and 12 below at a nominal spacing of 2 parts in 10^6 of the carrier frequency. Each channel has a band-width of approximately 0·5 parts in 10^6.

In the short time that the equipment has been operating whistler-mode activity has been seen fairly frequently at off-sets of several parts in 10^6. Occasionally events such as those shown in Fig. 1 are seen in which the Doppler shifts are oscillatory in nature. This is shown more clearly in Fig. 2 where the median frequency shift is plotted as a function of time. It is probable that it was events of this nature

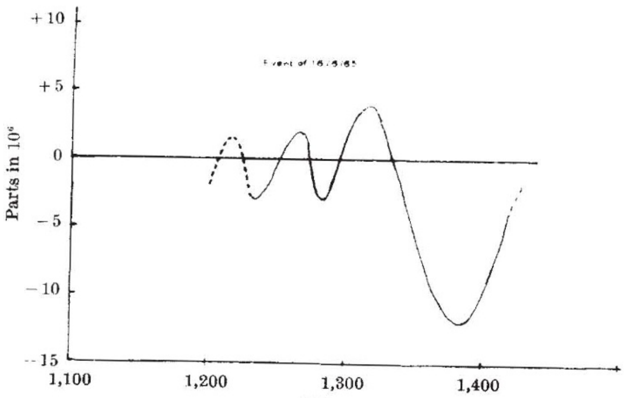

Fig. 2

which, when recorded on the original equipment, indicated the possibility of simultaneous positive and negative Doppler shifts.

The signals in this case are from station *NPG* at Seattle on a frequency of 18·6 kc/s. It will be noticed that there is a short period of 'key-up' followed by a period of 'key-down' just prior to the beginning of each hour. The loop aerial was turned to obtain a minimum of the direct or ionospheric signal, this being done to limit the spill-over of this component into the filters adjacent to the centre frequency. The large-amplitude slow-period beat on the centre channel is the result of a perfect null not being obtained. The period of the beat indicates the difference between the carrier frequency, as received, and the local standard.

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GEOCHEMISTRY

Radioactive Elements in the Continental Crust

THE radioactive elements are particularly useful as indicators of the chemical composition of the deeper parts of the crust. Thorium, uranium, and potassium show a strong concentration towards the surface of the Earth and are enriched in the continental crust. The abundance of thorium, uranium and potassium can be estimated by two independent methods; a physical method based on heat-flow data, and a geochemical method based on geological premises. These estimates differ by a factor of two (Table 1). The estimates for the heat-flow data are from Clark and Ringwood[1], and are based on a 37-km-thick two-layer crust. The upper layer is 16 km thick, resting on a layer 21 km thick. Calcu-

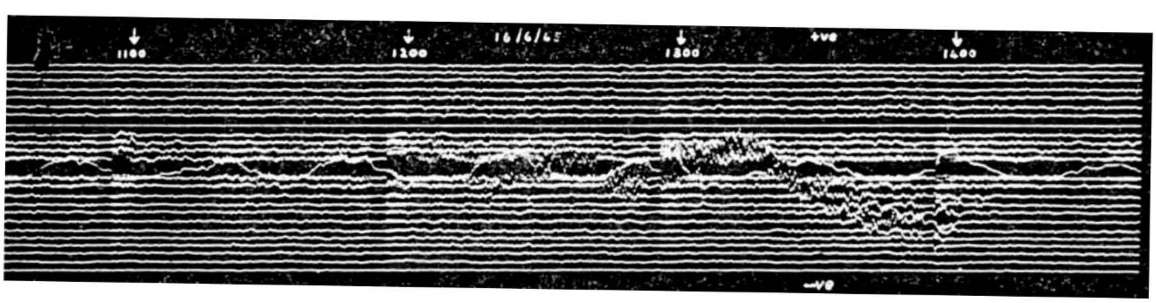

Fig. 1