Alaska to New Zealand whistler-mode transmission at 6.8 kHz

OBSERVATIONS of whistler-mode signals from v.l.f. communications transmitters have been used[1,2] to study the magnetosphere in a way similar to the use of naturally occurring whistlers from lightning. Existing naval communications transmitters provide high radiated power (up to 1 MW) but are restricted to transmission at allocated frequencies mostly above about 15 kHz, are not well located geographically for this work and are not often available to transmit special programmes.

We report here one result of an experiment for which we set up a transportable v.l.f. transmitter in Alaska and a receiving station in New Zealand located so as to be approximately geomagnetically conjugate. Since the Otago group already had v.l.f. receiving facilities at Dunedin, New Zealand, the transmitter was set up (by the Aerospace group) at Port Heiden, Alaska, about 200 km from Dunedin's conjugate. The transmitter antenna was a vertical monopole lifted to 1,000 to 1,500 m by balloon. The transmitter and all associated equipment (including power generator) are mounted on trailers so that the installation can be set up or removed in a matter of days. Although transmitter location and frequency are quite flexible, radiated power obtainable is quite low. This varies from a few kW at 21 kHz to about 100 W at 7 kHz. During the event described here the radiated power was only 13 W.

The event occurred about 1 h after local midnight on (Greenwich date) August 27, 1972. The transmitter operated at 6.8 kHz (at 13 W) from approximately 1307 to 1342 GMT. Whistler-mode signals were first detected at Dunedin at about 1324 GMT. Signal strength increased with some variation to a maximum of 35 μV m^{-1}, before fading again to below detectability at about 1330 GMT.

During this period of good reception, the transmitter was keyed on for 0.5 s in each second from 1326 to 1327:41 and then continuously ("c.w.") to 1329:10 GMT. Before 1326 and after 1329:10 the transmitter sent pulses of varying length and separation. From these the one-hop delay was measured as 1.13 ± 0.01 s. Maximum signal strength (35 μV m^{-1}) occurred between about 1328:20 to 1328:40 during c.w. transmission. A short section is shown in Fig. 1.

Twelve whistlers were received at Dunedin during the period 1325 to 1330. Most reached up to 8 kHz and were strongest between 5 and 6 kHz. Eight of these whistlers were 'short' or one-hop and the other four were 'long' or two-hop. None showed echoes beyond 2-hop, or any associated hiss or triggered emission, or any other evidence that duct amplification might be higher than typical.

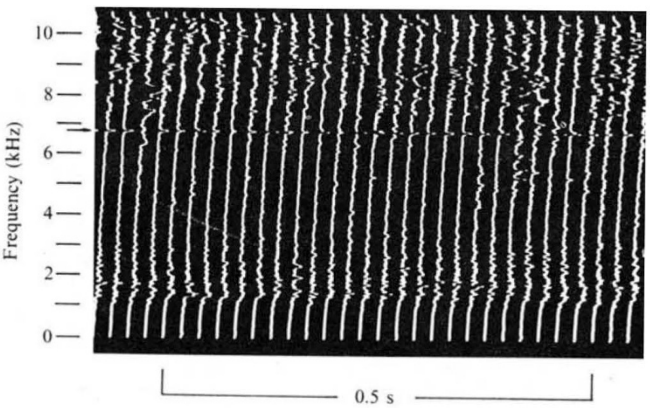

FIG. 1 Dynamic spectrogram of a short section near 1328:30 UT, using a Rayspan scanning at 48 sweeps s^{-1}. Trace separation corresponds to about 40 μV m^{-1}. Signal at 6.8 kHz is indicated by arrow.

Although no whistler reached the nose frequency, dispersion analysis using the "linear-Q" technique[3] showed that all whistlers travelled in the one duct at $L = 2.92 \pm 0.04$ (invariant latitude 54.2°) with one-hop delay at 6.8 kHz of 1.13 ± 0.01 s. From this it can be safely assumed that the signals from our transmitter travelled in this duct also.

An estimate of the duct amplification can be made by comparing the observed signal strength with that calculated for no duct amplification. Helliwell provides analytic expressions and graphs for making such calculations on pages 64 to 81 of ref. 4. Briefly his method involves calculating the field of the wave transmitted into the duct, the effective cross section, trapping and transmission efficiency of the duct, the field at the duct output (Dunedin end), the absorption through the D, E and F region, and finally the waveguide loss from the duct exit region to the receiver (Dunedin). Although we know the duct latitude by dispersion analysis, we do not know duct longitude and hence the distances Port Heiden—duct entrance and duct exit—Dunedin. If the duct were fortuitously located to minimise these distances (100 km and 160 km respectively) the signal expected would be about 1.5 μV m^{-1} to within about 3 dB. The observed signal strength of 35 μV m^{-1} thus implies amplification of about 27 ± 3 dB for optimum duct longitude. Higher amplification would be needed for other duct longitudes. Thus if the duct exit had been a "reasonable" 1,000 km from Dunedin, an additional 20 dB of amplification would be required.

Since the observed whistlers were typical and unremarkable, we conclude that duct amplification at night is typically of the order of 30 dB per hop. As a consequence whistler mode signals can be obtained from quite low power transmissions at 'low' ($\sim$7 kHz) frequencies.

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Effect of atmosphere and ionosphere on magnetospheric micropulsation signals

THE large-scale structure of low frequency hydromagnetic waves in the magnetospheric plasma can be understood from observations of micropulsations at the Earth's surface. Signals have to penetrate the ionosphere and atmosphere and although the scale heights of these layers are much less than the scale lengths expected for the magnetospheric phenomena, the behaviour is not as simple as might be expected[1,2].

Recent computations[3] (also, W. J. Hughes, to be published) allow an analytical approach to the problem.