THE IONOSPHERE OVER NORTHERN CANADA

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COMMUNICATION problems in northern Canada, as elsewhere, are primarily a matter of cost. In densely populated areas the great volume of communications justifies expenditures for telephone, telegraph, and multi-channel radio-relay networks, supplemented by the broadcast facilities of AM and FM radio and of television. In the north the present population is too small and widely scattered and the potential volume of communications too little to justify the expense of elaborate facilities. The most economical method of providing fast communication for the area is by short-wave radio via sky-wave transmission, as the installation and the electrical power required are relatively small. More specifically, short-wave radio means propagation via the ionosphere, an electrified reflecting layer between 60 and 200 miles above the earth's surface, on radio frequencies between 3 and 30 megacycles. Today, most of the small northern settlements of Canada possess short-wave radio equipment.

Short-wave radio systems, although reliable most of the time, suffer from occasional failures owing to disturbances in the ionosphere. Unfortunately, the ionosphere over a great part of northern and central Canada is often more disturbed than it is over most other regions of the earth because the earth's magnetic field approaches the vertical, allowing charged particles from the sun to penetrate more deeply into the earth's atmosphere over these regions. The auroral, or northern light zone, coincides with the southerly two-thirds of this region. Although auroral and magnetic phenomena are often associated with ionospheric radio disturbances the aurora is rarer farther north, but the ionosphere is still very much disturbed. Short-wave radio therefore suffers from interruptions throughout the auroral zone and into the polar area.

The pressing economic need to make the best possible use of short-wave radio in Canada has led to intensive observation and study of the ionosphere, and has stimulated research into other phases of the physics of the upper atmosphere. To study ionospheric changes, the Telecommunications Division of the Department of Transport, in cooperation with the Radio Physics Laboratory of the Defence Research Board, has established eight ionospheric recording observatories.[1] Four of these, at St. John's, Newfoundland, Ottawa,

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[1]Another ionospheric station was set up by the Carnegie Corporation at Clyde in 1943 and was taken over by the Department of Transport in 1945; it has now been discontinued.

Winnipeg, and Prince Rupert, skirted the southern part of the auroral zone from east to west. Stations at Churchill and Fort Chimo were near the line of maximum auroral occurrence, and those at Baker Lake and Resolute Bay extended the line of observations from Winnipeg, in the south, to a point north of the magnetic pole. For several years measurements of the height and electrical density of the three main levels of the ionosphere have been continuously recorded by means of variable frequency radar at all of these stations. In 1954 the stations at St. John's, Fort Chimo, and Prince Rupert were discontinued.

From observations already obtained it is possible to predict the average height and electrical density of the ionosphere for a given time of day and season of the year, and therefore to select the best radio frequencies for specific short-wave paths over most of Canada. Studies of ionospheric disturbance have also shown that interruptions to short-wave radio are more frequent in the spring and fall than in the winter and summer. They are also more frequent in years of high sunspot activity, such as 1947–9, than they are in years of minimum activity, such as 1954–5. Some success has now been achieved in forecasting ionospheric disturbances as much as a month in advance.

The radio-noise level of northern Canada is low compared with that of southern Canada, which in turn is lower than that of tropical regions. Weaker radio signals can be detected and used in the north than elsewhere, so that relatively little transmitter power is required. One reason for the absence of noise is that intense radio energy from the numerous tropical thunderstorms diminishes rapidly at a distance of 4,000 miles. Noise from local thunderstorms, and from machinery and radio equipment is also low in the north, even during the summer, when the general noise level is higher.

This relative lack of noise and the improved methods for selecting radio frequencies, have made short-wave communications in northern Canada reliable about ninety per cent of the time. Unfortunately, the failures may occur in periods of one to three days at a time. This is not important for ordinary traffic since delays of this order are infrequent, but for urgent traffic, such as reports on sickness or weather, it is a serious handicap. Any short-wave circuit which is less dependable than ninety per cent should be checked for the condition of the equipment and the suitability of the radio frequency. If the frequency is too high for a given path the receiving station will be within the "skip-distance" of the sending station. If the frequency is much below the correct value its energy may be absorbed in the lower atmosphere instead of being reflected. Advice on the best radio frequencies and times of day for specific paths can be obtained from the Radio Physics Laboratory of the Defence Research Board at Ottawa.

Ionospheric research has also opened up a wide range of theoretical and experimental problems, particularly in high magnetic latitudes. The science of the physics of the upper atmosphere, of which the ionosphere is a part, is being given increasing attention in Canada and is bringing closer cooperation between theoretical and experimental physicists and radio engineers. Intensive research on the spectra, luminosity, height, and electron density of the aurora is being made at the Physics Department of the University of Saskatchewan. The correlation between auroral, ionospheric, and magnetic disturbances is also being investigated at this university in cooperation with the Radio Physics Laboratory in Ottawa. It is hoped that a spectrograph of very high dispersion designed by the Radio Physics Laboratory for use at Churchill, will give much more detailed auroral spectra than have previously been obtained, and will enable more exact determinations to be made of the constitution, energy changes, and temperatures at different levels in the upper atmosphere. Parallel with these auroral measurements, a laboratory study is being made of artificial aurora produced in discharge tubes.

A joint project of the Dominion Observatory and the Radio Engineering Division of the National Research Council is yielding interesting information on meteor showers and the ionization produced by meteors in the lower atmosphere. Investigations of aurora and other ionization processes of the upper atmosphere are being extended northward and should give further information about one of the most complex regions of the ionosphere. It is hoped that the formation of the advisory committee on radio science by the National Research Council will stimulate further interest in the ionosphere.

Three main problems of the ionosphere over northern Canada, as elsewhere, remain unsolved.[1] Each is complex, and requires subsidiary investigations employing radar, spectroscopy, and magnetic and radio-signal strength recording. First is the problem of forecasting storm conditions in the ionosphere in order to improve radio communications. While the complete solution of this problem is not urgent in low latitudes, it is very important for Canada. Second, the nature of the extreme ultra-violet radiation of the sun is not sufficiently understood, and should be thoroughly investigated in the ionosphere and other parts of the upper atmosphere. Improved techniques of rocket measurements made by United States engineers should be very helpful in this regard, and may even bring our knowledge of extreme ultra-violet radiations in the upper atmosphere near completion. Third is the puzzling problem of winds and tidal effects in the upper atmosphere. In several countries radar techniques for measuring winds in the ionosphere have yielded challenging results. Continued investigations will undoubtedly throw increasing light on this interesting question.

[1]For a discussion of subsidiary problems *see* Mitra, S.K. 1952. 'The upper atmosphere'. Calcutta: The Asiatic Society, 713 pp.