ON PREPARATORY OBSERVATIONS OF ATMOSPHERICS ON THE RYUKYUS

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1. Introduction

By the term atmospherics, or spherics briefly, we mean electromagnetic waves of natural origin. In accordance with the appearance the term bears various names: "hiss", "whistler", "slowtail", "tweek", and so forth. They are generated mostly in the earth's atmosphere or some in the space straying down into the atmosphere.
The atmospherics of earth origin are emitted through lightning discharges which are but a simple process of electric discharges between clouds or cloud and ground. The nature of the emission mechanism being such that the paths of lightning discharge act as a very long antenna. The spectrum of the emitted waves ranges from decimal fraction Hz to very high frequencies to be counted in unit of GHz. As is shown in Fig.1, the spectrum has a peak at around 10KHz and the field intensity goes down as the

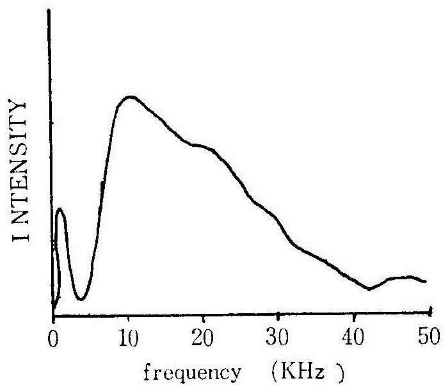

Fig. 1.

frequency departs from the maximum. However, observations are usually made in the low frequency range possibly because of physical interests or historical reasons.

The electromagnetic waves emitted through lightning discharges sometimes travel along geomagnetic lines of force and due to the frequency dependence of their propagation the higher components of the waves arrive at the antenna earlier than the lower components. Thus, when received, such waves are heard in a whistling tone. In the

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low latititudes they are heard as a simple downward tone but in the high latitudes the waves often show a complete feature of whistler with an upward tone as well as a down-ward tone. The junction of the two varying tones is called as nose frequency which furnishes us with very important information about the electron density at the height of the line of force through which whistlers propagate. Their sonographic display shows a nose-like visage as shown in Fig.2.

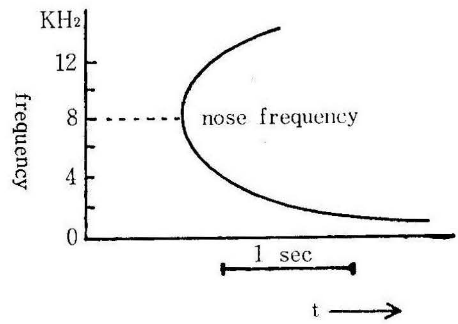

Fig. 2.

From this appearance this type of atmospherics is called as nose whistler. Whistlers observed in the low latitudes are only the lower tail of complete whistlers.
Other atmospherics show different sonographic aspects, but in the present situation no further mention will be made of them.

Study of atmospherics started as early as the birth of wireless communication and the importance of the research came to be emphasized in World War I. Later, the research of atmospherics made a remarkable progress because of physical or more narrowly geophysical interests Also in Japan the research has been made at many institutions and the contributions made by Japanese scientists to this field of research are of great worth. Lately, however, observations of atmospherics in the mainland of Japan have become difficult because of its progressively increasing noise level due to wide-spread industrial facilities and everextending urban districts all over Japan.

The Ryukyus, occupying a wide oceanic area in the southernmost part of Japan, consist of some sixty islands some of which are not inhabited, and hence no power system is found in these islands. Thus, in such uninhabited islands one can easily find favorable sites for observation of weak atmospherics. Even in some inhabited islands, electricity is supplied only at night for lighting, and thus some kind of observations can be carried out in these islands. Thus, all over the Ryukyus atmospherics are waiting for being observed with most favorable condition.

Further, the geographic position of the Ryukyus ranges down to 24° N Lat., or approximately 15° geomagnetic latitude. Thus, the line of force connecting the Ryukyus and the geomagnetic conjugate point in the southern hemisphere or narrowly in the middle part of Australia is rather short and the top of the line of force comes, therefore, to an approximate height of 1000 km or less. Hence, the observations of whistlers in the Ryukus may reveal the information about the physical state of the line of force at this altitude and the number density of electron in the line.

Availing ourselves of such a favorable situation for observations of atmospherics in the Rynkyus, various measurements are being carried out or under planning at the University of the Ryukyus. In this report a brief description of these observations will be made.

2. Observing site

The population in Okinawa concentrates in the southern half of the main island. This directly means that civil activities in the Ryukyus are centered around this area and hence generation of heavy city noise is foreseen there.

Early in October, 1972, a measurement of 9.6 kHz noise emission was made at Shuri where the Electrical Engineering Department building is situated. The building is besieged by various noise sources: a high tension power line and an adjacent workshop where many electric machine tools are working. Besides, an antenna tower of a commercial broadcasting station at 780 kHz is seen in the vicinity of the department which makes a very strong field to disturb the measurements. Thus, the worst S/N ratio is brought about in this region.

Early in November another investigation of noise distribution was made at 6.6 kHz in the northern part of Okinawa Main Island. In this investigation the result was found almost satisfactory since even though power lines were in the sight the output meter readings for respective measurement were found almost the same at several observing points which means no local effect due to unwanted interference exsisted and thus it was concluded that the receiver output was due to natural electromagnetic waves picked up by the antenna. This was quite encouraging since the interference due to A.C. lines in the sight did not affect the measurement if only the distance from the line is taken long enough — say 1000 meters or so.

Late in November another test observation was carried out at the southern tip of the main island. It was found that, as had been feared, the place was the worst for such an observation as ours. A very strong interference in an intermittent form was experienced. The source for this interference has not been identified. One possibility is that this intermittent signal may be the direct straying of beacon signals transmitted by a nearby airfield, but this has not yet been discerned. Anyway, the southern part of the main land is, as was presumed, the nest of noise sources, and thus quite unsuitable for our purpose.

The circumstances found so far have driven us to seek for observing sites in the northern part of the island or in isolated islets where no manmade noise exists.

Early in December, an observing crew is to be dispatched to Yaeyama Islands for site finding and simultaneous observations between there and Okinawa Main Island. In Yaeyama area there are some islets without power system or with time-restricted supply of electricity for lighting only. These are hopeful places for installation of observing stations.

For multılateral simultaneous observations of a common source with direction finding are of vital importance for the Ryukyus since such observations help typhoon forecast from the earlystage of its development. Lightning discharges associated with a typhoon occur within a circle of some 400 km semidiameter with the typhoon in its center. Thus, a typhoon can be detected when it is still far from the observer since very low frequency waves propagate to a very long distance with little attenuation. For this purpose we are planning a triangular disposition of observing points at Daitoh Islands (Eastern) , Amami Islands (Northern position) , and Yaeyama Islands (Southern position) . After these islands' name the observations are called "Project DAY".

3. Whistler atmospherics

As was refered in the previous chapter, this type of atmospherics has a trend that the frequeucy of the waves goes down as time elapses. This whistling ends within a few seconds after its outbreak. Mention was made previously that generation of a whistler is explained by trapping of waves emitted from lightnings by the geomagnetic line of force and the waves propagate along the line of force. The time needed for wave propagation is written as $t=D/\sqrt{f}$, where t denotes the propagation time, f the wave frequency, and D the dispersion of whistler related only to the electron density in the path. From this relation it is seen that the high frequency component of the waves propagates faster than the low frequency component making a falling tone with time. In the low latitudes the dipersion D ranges from 20 to 50. Occurrence of whistlers has two maxima, one in the morning and another in the early evening. Also seasonal variations in occurrence are known and have a peak in winter.

Whistlers occur most often in the latitudinal range between 40° and 60° and are rarely found in the regions higher than 70° and lower than 20° From this fact it seems pretty difficult to detect whislers in the Ryukyus. The so-called nose whistler is the most interesting atmospherics by which the distribution of the geomagnetic line of force can be readily found, which lets one to evaluate the number density of eletrons in the path. Let the minimum cyclotron frequency f_H in the wave path be f_C. Then the minimum propagation time occurs at a frequency $f \simeq f_C/4$. The frequency f is called "nose freqency", with which one can determine along which line of force the nose whistler propagated. Little possibility can be expected in detecting the nose whistler in these low latitudes but it is worth trying. Therefore, emphasis will be put on the observation of this type of whistler.

For this purpose we are planning to set up a large antenna in an isolated and noise-free island. For simpliclty of installation a very long Erde Antenne is proposed.

4. Slowtail atomspherics

This type of atmospherics shows a time variation in amplitude as well as in wave frequency. as is shown in Fig. 3 .

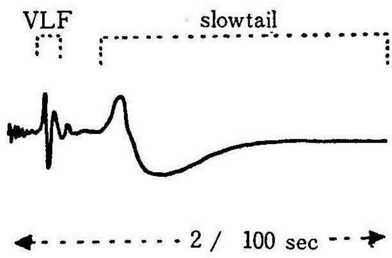

Fig. 3.

The atmospherics have precursory VLF waves immediately followed by ELF part. This wave form can also be explained, as was done in whistlers, by the difference in propgation velocity of the waves emitted by a single source: the high frequency component reaches the observer earier than the lower component from which one can find the distance between the observer and the emitting source as seismologists do in finding the distance from the seismic center to him by knowing the time difference of arrival between p and s waves. Thus, study of slowtail attmospherics can be used to find the position of the source. This method has already been put into practice by Sao Group of the Research Institute of atmospherics, Nagoya University. This method may take over other methods so far. in use

A receiver and an antenna system are now in constrution for receiving the slowtail atmospherics.

5. Schumann Resonance and ULF

A large cavity consisting of the ionosphere as its outer wall and the earth's surface as the inner wall gives rise to resonance lines with frequencies of 8, 14, 21, 28, …………Hz when excited by lightning dicharges. The big cavity may change its dimension diurnally, seasonally, or with solar activity. Longterm observations of the phenomena may give useful information about the physical or morphological state of the earth's atmosphere.

A swept frequency receiver covering the frequency range of about 5 to 50 Hz. is now being constructed.

Characteristic feature of ULF is its pulsating waveforms, and by its period it is devided into two types: P_c or continuous pulsation and P_i or irregular pulsation. The two are subdevided further into several types: P_c -1 with 0.2—5 second period, P_c -2 with 5—10 second period, and so forth; and P_i -1 with 1 — 40 sec priod and P_i -2 with 40 — 150 sec period.

Our object for the present observations is P_c -1 which includes "pearl", "sweeper", and HM emission. An antenna for this observation is now in preparation.

6. Muitilateral observations

For determining the position of the sources of atmospherics, at least three point simultaneous observations are required. As was mentioned previously, a large distance triangular arrangement of observing points are in consideration, This is called "Project DAY" as mentioned before. To put the project into operation the minimum requisite for manpower must be insured which may become a burden for this small project team. Therefore, the term for the observation must be limited to summar and fall in which typhoon generation is the most frequent.

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