ON AN INVESTIGATION OF WHISTLING ATMOSPHERICS IN JAPAN

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Summary :

As part of the Study Program of I. G. Y., we have prepared an observation of whistling atmospherics.

Since Jan. 1956, continuous observations of whistlers have been made at Toyokawa (geomagnetic latitude 24.5°). Simultaneous observations at Toyokawa and Wakkanai (geomagnetic latitude 35.3°) were made for one month beginning 13 July 1956.

The results obtained in the analysis of the dispersion of whistlers were essentially similar to those reported by Storey.

But, at Toyokawa, long whistlers, whistler trains and whistler pairs have not been observed, only short whistlers being observed. The greater part of the observed whistlers occurred in winter; in other seasons it was scarcely possible to detect them.

At Wakkanai, long whistlers and whistler pairs have been observed this summer, but whistler trains have not been observed during this period.

I. Introduction

The audio frequency atmospherics, whistling atmospherics, have been studied by our Institute for two years.

At the beginning of this period, an observing apparatus for whistlers was constructed for the observation of I. G. Y. in co-operation with Australia.

Test observations were opened beginning Jan. 1956, and routine observations have been made from June 1956 continuosly.

A portable observing apparatus was constructed and was installed at Wakkanai; simultaneous observations at Wakkanai and Toyokawa were carried out for one month beginning 13 July 1956.

Foreign workers have studied the character of whistlers at higher geomagnetic latitude, discovering new phenomena such as nose whistlers. Our observations, being examples obtained at the lowest geomagnetic latitude in the world, are somewhat different from those obtained at higher geomagnetic latitudes.

We have not as yet sufficient data on whistlers to give the exact character of occurrence, dispersion, multiple, etc. The first part of our work, which is now being continued, is reported below.

II. Observing Apparatus

The block diagram of this apparatus is shown in Fig. 1, and it consists of a pre-amplifier, a main-amplifier, low and high pass filters, a magnetic tape recorder of three elements and accessories.

The whistlers are received by means of a straight amplifier with an available gain of 60-110 db, its input being connected to a vertical antenna 10 meters high and its output to a magnetic tape recorder. The frequency

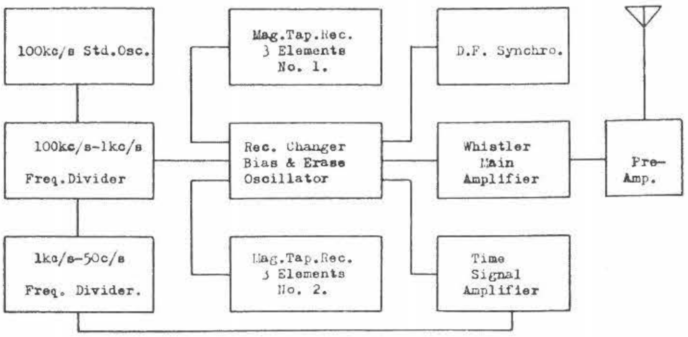

Fig. 1. Block Diagram of Observing Apparatus of Whistler.

response is limited by filters from 400 c/s to 10 kc/s.

Details of this apparatus are shown in the circuit diagrams described below.

1). Antenna, main amplifier

As described above, an antenna 10 meters high is used. It is necessary that the antenna be untuned and that its natural resonant frequency be well above the operating range. For this reason, the antenna is terminated to a capacity load. The overall impedance of this antenna system is so high that it is subjected to considerable precipitation static by rain, to intense induction interference from the power line and to no small disturbance from the near-by radio broadcasting station. An investigation to reduce these difficulties regarding the antenna must be the subject of future research.

By a pre-amplifier, the signal induced across the antenna coupled capacitor is amplified, transformed to a low impedance and introduced to a main amplifier. To reduce the interfering disturbances, the antenna and the pre-amplifier are installed about 100 meters away from the main apparatus.

Then, the signal is amplified by the main amplifier which consists of two feed-back amplifier stages, low and high pass filters and a monitor amplifier. The maximum gain through both amplifiers is 110 db, the minimum being 60 db and the intermediate gain between both values is varied in 2 db intervals by two attenuators.

The frequency response is limited by filters which are inserted between two feed-back amplifier stages. The cut-off frequencies of high pass filters are 400 c/s, 800 c/s, 1200 c/s and one of these is employed according to the conditions to be met at the observing point. On the other hand, the cut-off frequency of the low pass filter is fixed in 10 kc/s. Besides, to reject the interference from the high power station of V. L. F. Yosami, the band elimination filter of 17,44 kc/s is inserted in the input circuit of the main amplifier.

Then, the output from the main amplifier is introduced to the magnetic tape recorder through the compensation circuit.

Fig. 2 shows the circuit diagram of the pre-amplifier and the main-amplifier.

Fig. 3 shows the characteristic curves of the main-amplifier.

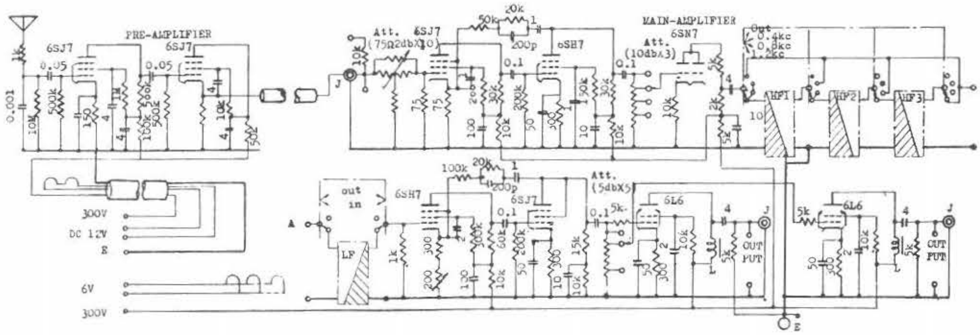

Fig. 2. Circuit Diagram of Pre-amplifier and Main-amplifier.

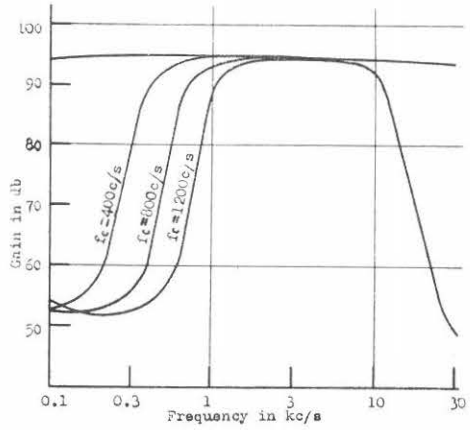

Fig. 3 a. Frequency Characteristic Curve of Main Amplifier.

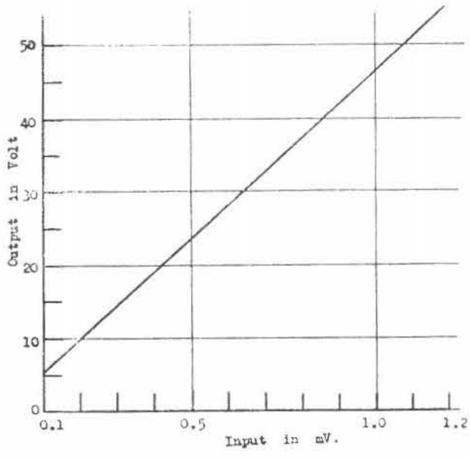

Fig. 3 b. Amplitude Characteristic Curve of Main Amplifier.

2). Magnetic tape recorder

The signal is recorded on the magnetic tape of the three elements recorder. The recorder employed is a magnetic tape recorder of the GT-6 type which is manufactured by Tokyo Tsushin Kogyo Ltd. Co. and which we reconstructed to three elements. The first track of the tape records the output signal of the main-amplifier, the second timing signal, the third synchronizing signal to other observation, respectively.

The principal features of this recorder are as follows:—

Medium:	Standard 1/4′ plastic based tape
Number of Tracks:	3
Operating Tape Speed:	7½′/sec. (0.5%)
Playing Time (2,500 ft. reel)	1 hour
Rewind Time	Less than 3 minutes

"WOW" and Flutter	Less than 0.5%
Erase Frequency	27 kc/s
Erase Current	1.5 A
Bias Frequency	80 kc/s
Bias Current	17 mA
Erase Head Impedance	7 ohms at 27kc/s
Record Head Impedance	50 ohms at 1kc/s
Reproduce Head Impedance	100 ohms at 1kc/s

Routine observations are made automatically for a period of two minutes at each half-hour every day continuosly. Operation at 7.5 in/sec. requires changing the tape every half a day; therefore, two recorders are used alternately.

Fig. 4a and Fig. 4b show the circuit diagrams of these recorders.

Fig. 5a and Fig. 5b show the overall characteristics of the recorder.

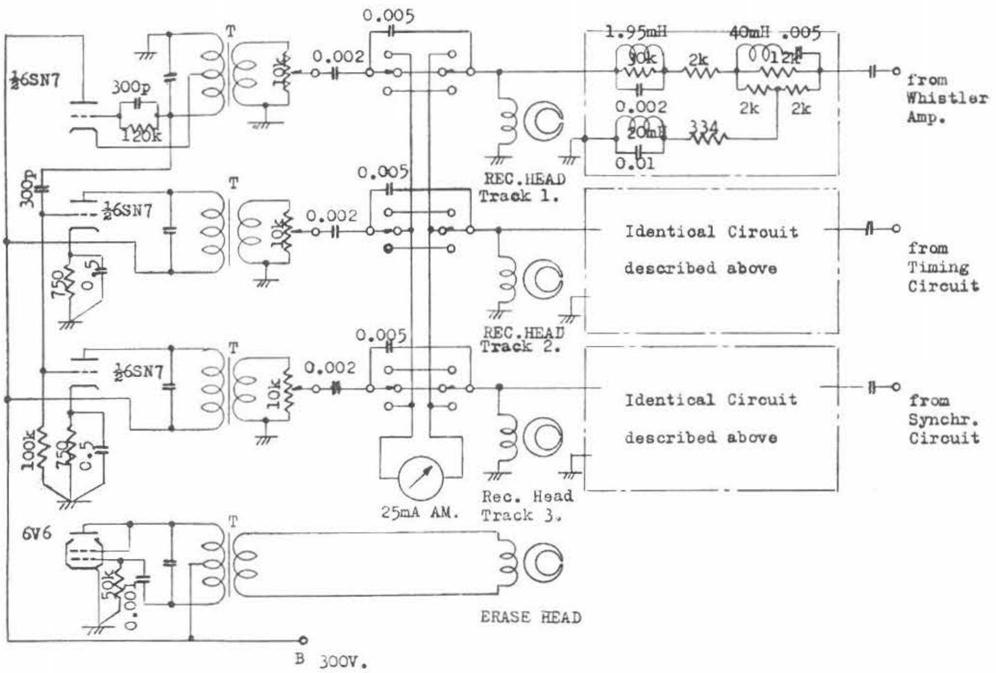

Fig. 4a. Compensating Circuit of Recorder, Bias Oscillator and Erase Oscillator.

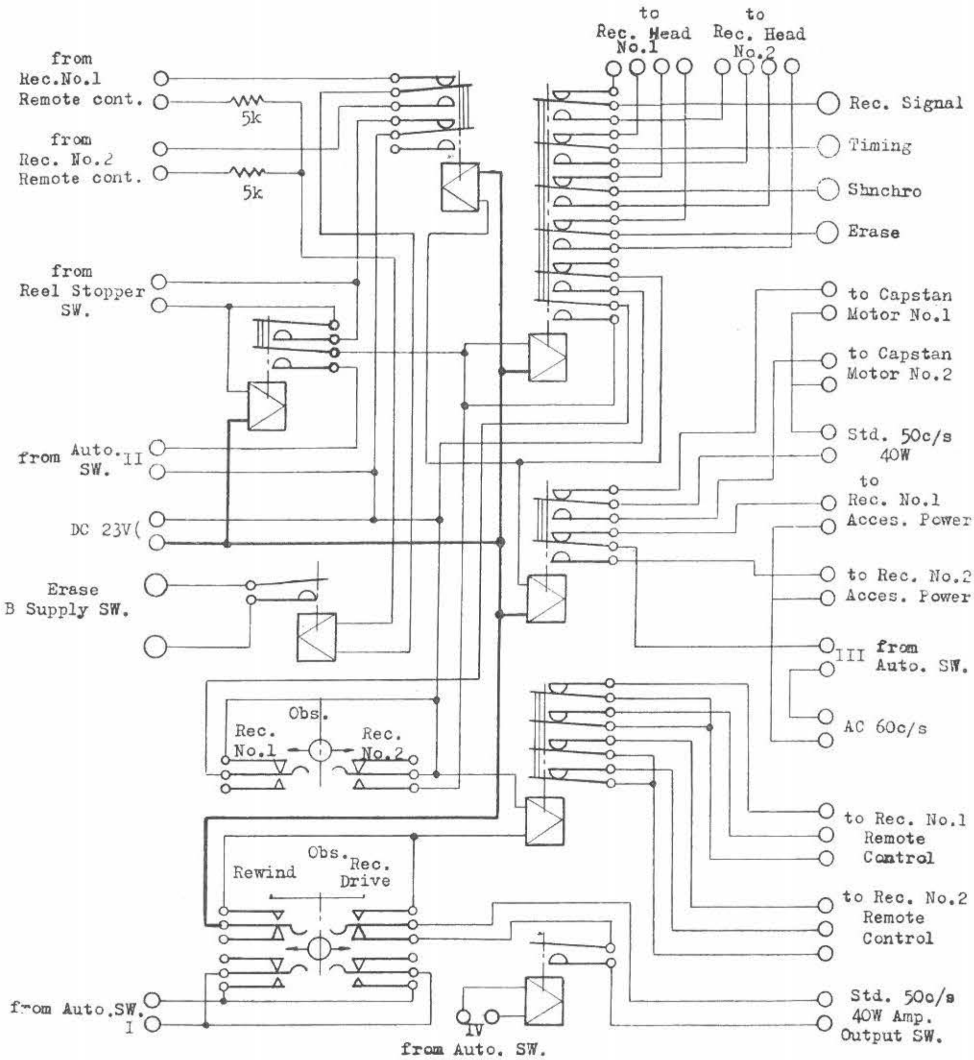

Fig. 4b. Automatic Recorder Changer.

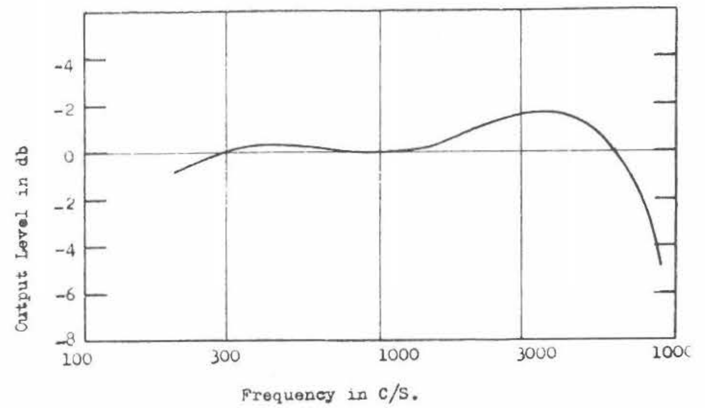

Fig. 5a. Overall Frequency Characteristic Curve of Recorder.

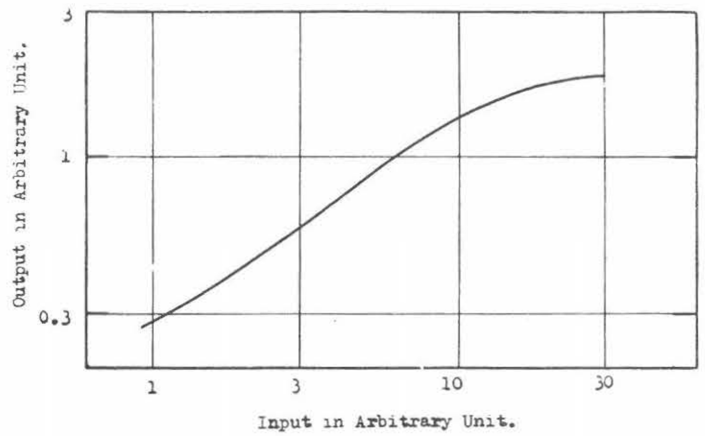

Fig. 5b. Overall Amplitude Characteristic Curve of Recorder.

3). **Accessories**

Automatic routine observations in co-operation with Australia require an accurate clock, by which automatic switching equipments are driven, because accurate timing is important to identify simultaneous events at the various stations. A 50 c/s standard signal, driving the clock, can be obtained by dividing down from a 100 kc/s crystal standard oscillator, giving typical accuracy of 10^{-8}. For this purpose, a frequency divider of the phantastron type which divides the frequency 100 kc/s into 50 c/s is employed, because the divider of this type cannot give any spurious output when no input signal is supplied.

Fig. 6. shows the circuit diagram of 50 c/s standard signal generator.

Fig. 7. shows the circuit diagram of the automatic switching equipment.

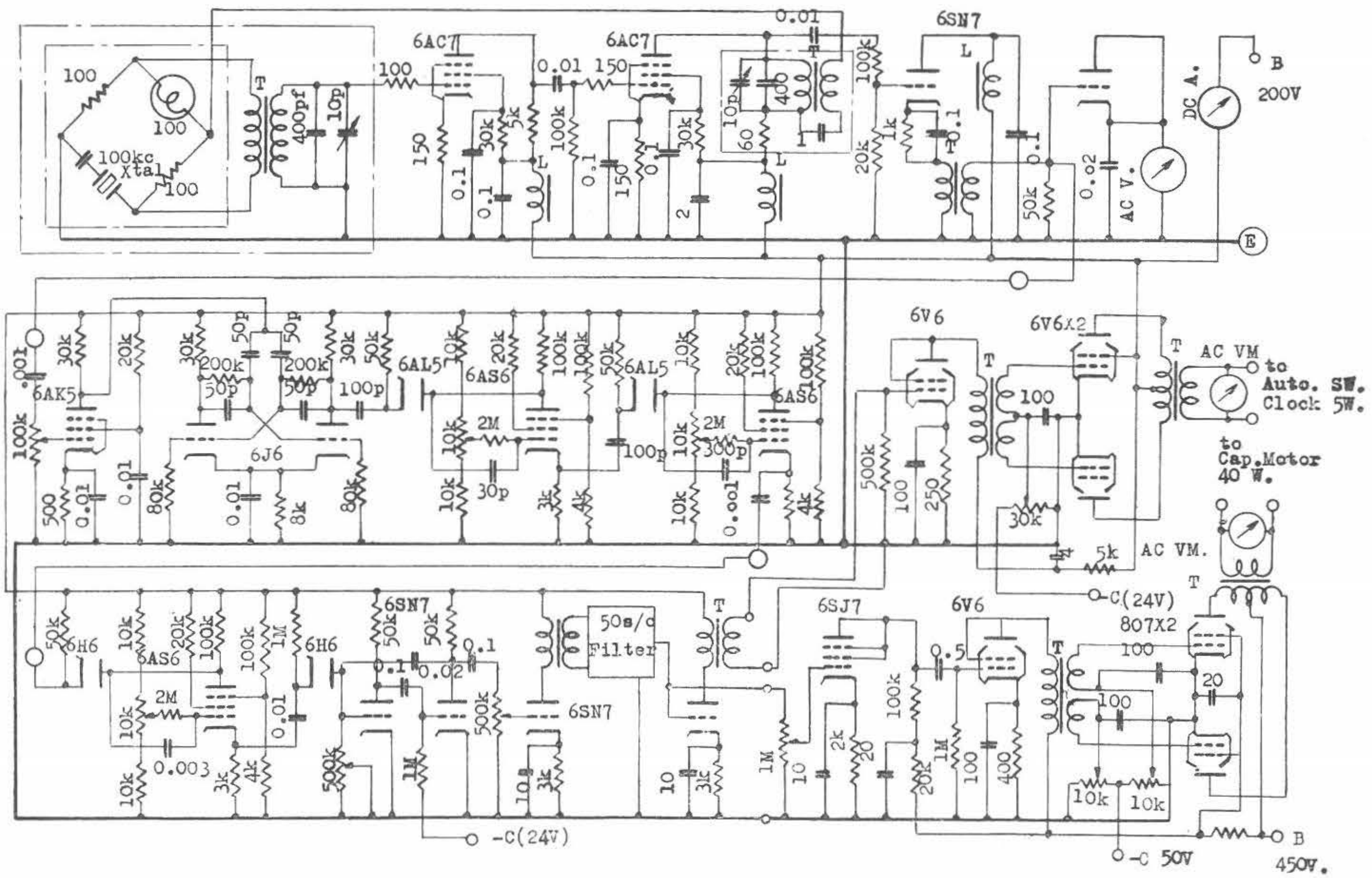

Fig. 6. 50c/s Standard Signal Generator.

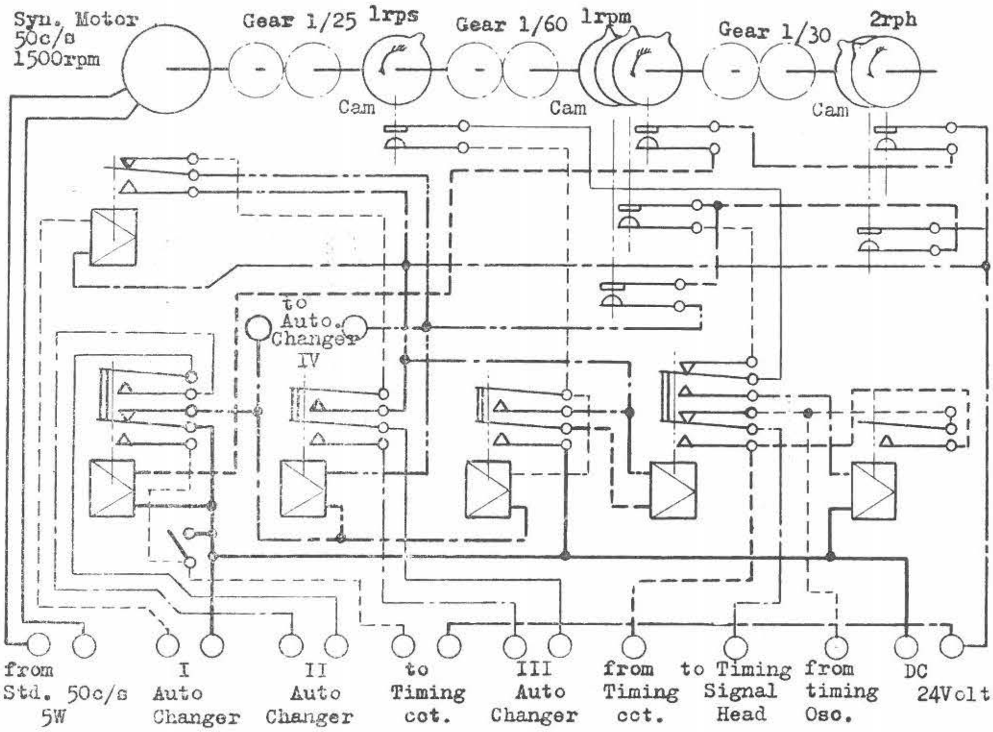

Fig. 7. Automatic Switching Equipment.

4). **Analysing apparatus.**

The magnetic tapes recorded are played back and listened to at leisure. The whistlers recorded on the tape are picked out and are introduced to the frequency analyser. At present, the "Sona-graph" is used to analyse the whistler. Because of the inconvenience of measuring the dispersion of whistlers from sonagrams, we have constructed a

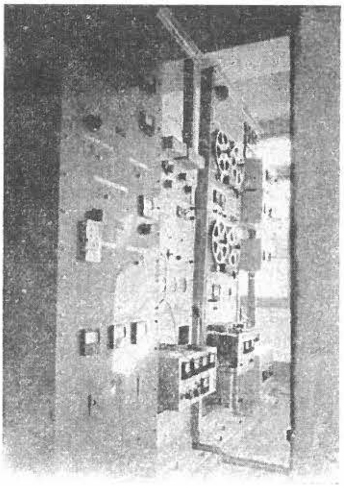

Photo. 1. Observing Apparatus of Whistler.

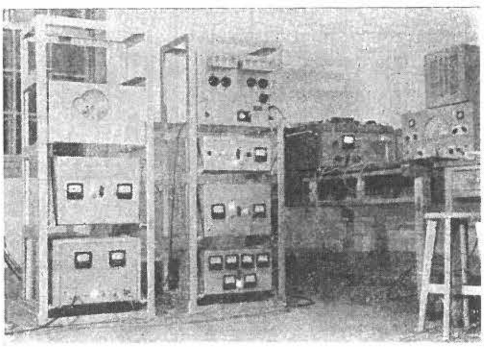

Photo. 2. Portable Observing Apparatus of Whistler (installed at Wakkanai)

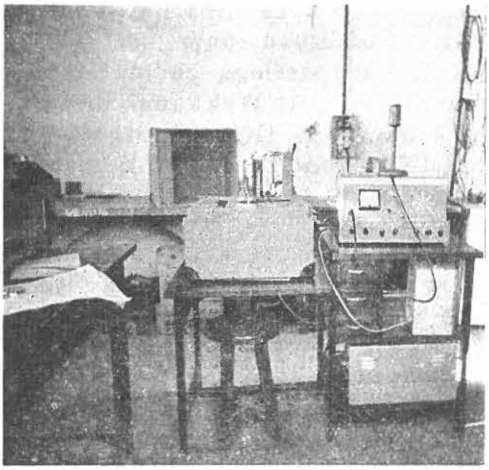

Photo. 3. Sona-graph.

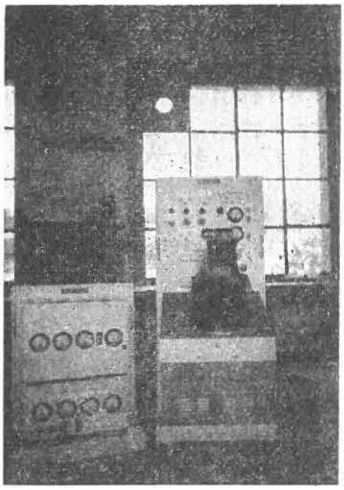

Photo. 4. Analysing Apparatus of Whistler.

frequency analyser by which a linear graph of frequency against time is recorded on a long persistent fluorescent screen of C. R. T.

Photo. 1. shows the observing apparatus installed at Toyokawa.

Photo. 2. shows the portable observing apparatus installed at Wakkanai.

Photo. 3. shows the "Sona-graph".

Photo. 4. shows the analysing apparatus for whistlers.

III. Results and Discussion

The results reported here are derived from the data obtained in two observations, one of which was made as a test at Toyokawa (geogra. lat. 34.8°N) from 20 Jan. to 28 Feb. 1956, and the other carried out simultaneously at Toyokawa and Wakkanai (geogra. lat. 45.4°N) in Hokkaido District (1,230 km away), from 13 July to 14 Aug. 1956. The former observation was irregular in observational time and length, while the latter was made regularly for a period of two minutes from 10 and 40 minutes past every hour J. S. T., except for two times stoppages because of electric current, which had little effect on the results of the observation.

One of the interesting facts was that 93 whistlers were observed during 14 days at Wakkanai, but no whistler was received at Toyokawa during the period of simultaneous observation. Therefore, the following describes the results obtained at Toyokawa in the winter and at Wakkanai in the summer of 1956. Since these observations only cover one or two moths of the year, they provide a partial picture of statistical aspects of whistlers, and they are especially imperfect at Toyokawa, owing to the irregular observation there.

1). Dispersions and kinds of whistlers

A). Short and long whistlers

Whistlers recorded on magnetic tapes are analysed with a Sona-graph, which has a frequency band of 85c/s-8,000c/s. The dispersions of the whistlers were determined within accuracies of ± 2.5 for loud whistler of pure tone and ± 5.0 for weak whistlers or whistlers of broad tone.

The results analysed showed that the dispersions could be divided into two classes according to their magnitudes. At Wakkanai, dispersions ranged from 40 to 70 in one class and from 80 to 110 in another, and at Toyokawa, they ranged from 22.5 to 30 in one and from 35 to 45 in another. Storey's theory explains that the dispersion of long whistlers is twice as large as that of short whistlers, therefore whistlers in these two classes seems to correspond to short and long whistlers, respectively. But this is not always true, for dispersions varied greatly from day to day. It is necessary to classify whistlers according to values of their dispersions observed within one day. At Wakkanai, whistlers observed within a day were generally found in both classes and the dispersion ratios of whistlers in one class to another were always nearly 1:2 (see Table 1); therefore, it may be decided that both kinds of whistlers are detected there. On the other hand, at Toyokawa, dispersions of whistlers detected within a day were almost equal and the dispersion ratios never exceeded 1.2 on any day of the observation, so it may be certain that any long whistler was not detected there. Larger dispersions at Toyokawa were probably due to a rise of electron density in the outer ionosphere.

Table 1. Day-to-day Variations of kind and dispersion of whistlers, Wakkanai.

Date	A.M.	P.M.
7.16	S (50.0)	
17		L (90.0)
19	S (50.0) L (97.5)	
20	S (50.0)	
28	S (52.5)	L (85.2)
29	S (40.0)	S (45.0) L (92.1)
30	not clear	not clear
31	not clear	
8. 1		not clear
2	L (105.0)	
3	L (107.5)	S (52.5) L (100.0)
4	S (50.0) L (97.5)	L (97.5)
6	S(not clear)	
7	S (57.5)	
		S, S* (60.6)
9	S, S* (59.1)	

S : Short whistler.
L : Long whistler.
S* : Whistler pair of short whistler.
Numerals in round brackets show average values of dispersion.

The preceding atmospheric click, reported by Storey, was heard at Wakkanai in about half of the cases of long whistlers, when the clicks were louder than other atmospheric clicks. Some of them were analysed and were found out in correct positions in the sonagrams. But in general, it is very difficult to detect the preceding click owing to many other clicks of nearly the same intensity around it. Examples of sonagram are shown in. Fig. 8 (short Toyokawa), Fig. 9 (short, multiple-flash type group, Toyokawa), Fig. 10 (short, Wakkanai), Fig. 11 (long, accompanied by a preceding click, Wakkanai), Fig. 12 (long, accompanied by a preceding click, Wakkanai).

A chance to detect short and long whistlers during a two-minute observation in generally rare, and only three chances occurred at Wakkanai. Data obtained in these cases are given in Table 2, and one of them

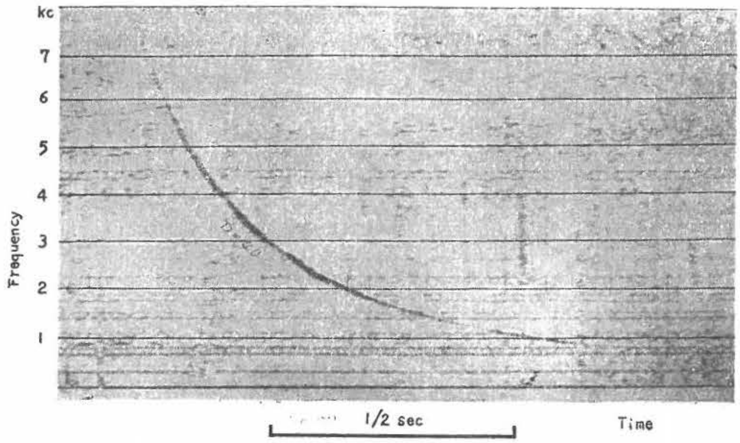

Fig. 8. Sonagram of short whistler. (17h 15m 23. Feb. 1956, Toyokawa) disperrion : 40.

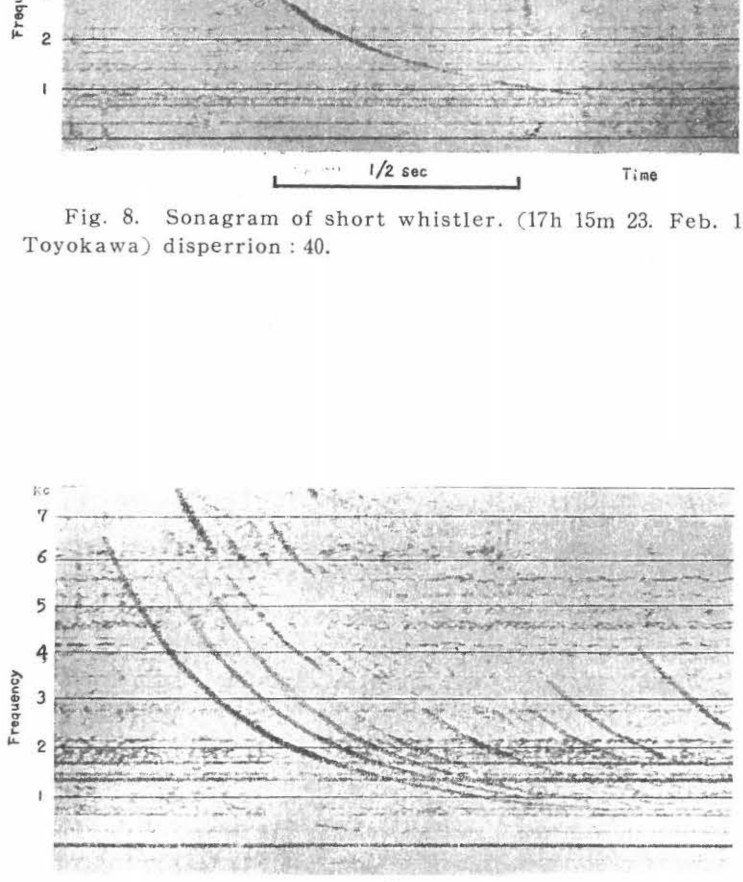

Fig. 9. Sonagram of short whistler, multi-flash type group, (17h 20m 23. Feb. 1956, Toyokawa) dispersion 40.

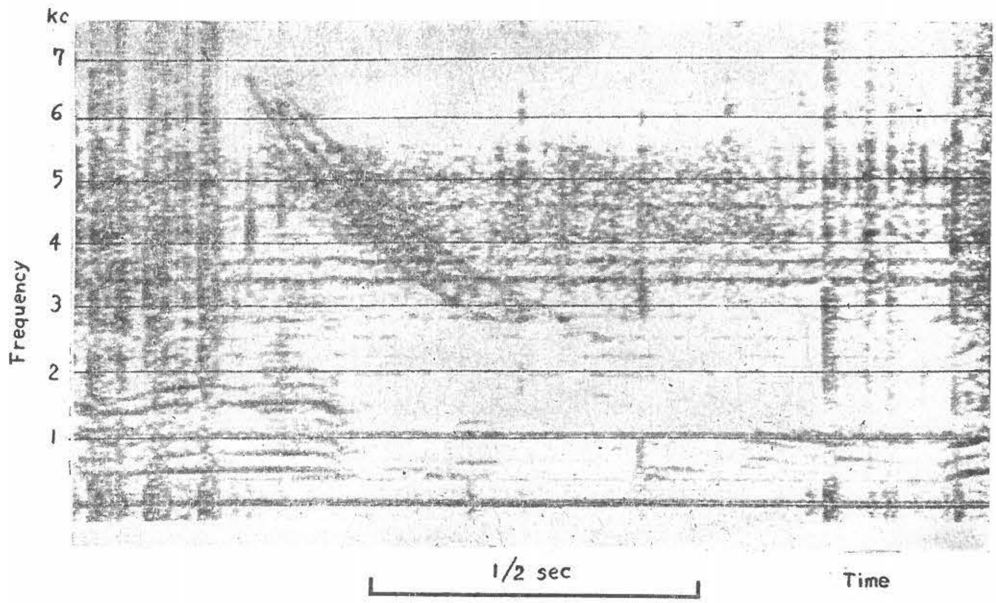

Fig. 10. Sonagram of short whistler (20h 26m 3 Aug. 1956, Wakkanai) dispersion : 50~55.

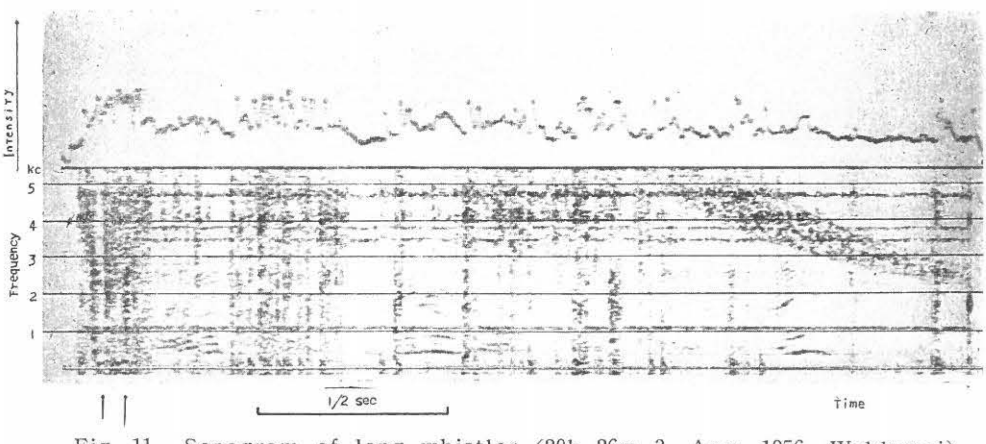

Fig. 11. Sonagram of long whistler (20h 26m 3. Aug. 1956, Wakkanai) dispersion : 105~115.

↑, ↑ shows the position of preceding atmospheric click corr esponding to the dispersion 105~115.

A curve in the upper part shows the quasi-peak values from 400c/s to 8,000c/s.

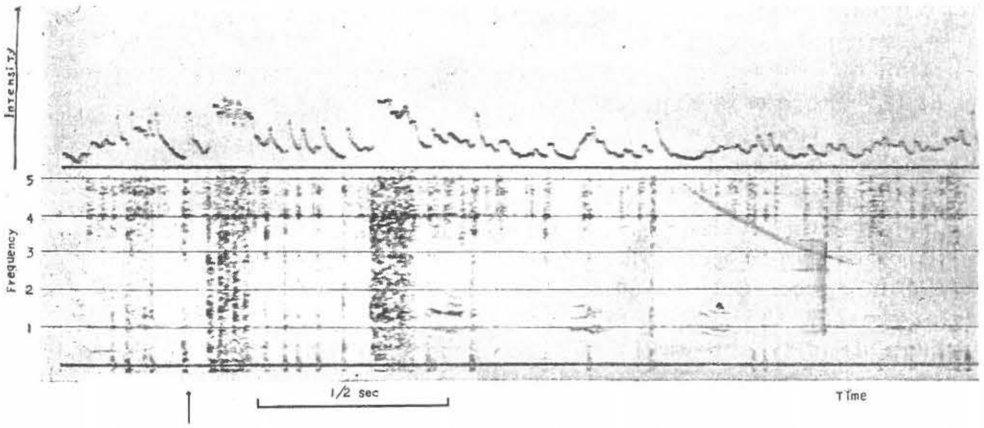

Fig. 12. Sonagram of long whistler (20h 40m, 28. July. 1956, Wakkanai) dispersion 90.

Arrow mark and a curve in the upper part mean same as in Fig. 11.

is shown in Fig. 10 and 11. The dispersion ratios of the short to long whistlers in Table 2 are seen to be nearly 1:2. This fact supports Storey's theory that a long whistler propagates two times along the path of a short whistler, while it seems to indicate that the asymmetry of the whistler path with respect to the magnetic equator is fairly less than expected at Wakkanai from results recently calculated by Maeda and Kimura.

Date	Short	Long
3h 10m 19 Jul.	50	95~100
*20h 16m 3 Aug.	50~55	105~115
2h 10m 4 Aug.	50	95~100

Table. 2. Dispersions of short and long whistlers observed during a two-minute observation.

*: Sonagrams of these whistlers are shown in Fig. 10. and 11.

B). Reason for no occurrence of a long whistler at Toyokawa.

It is an interesting fact that long whistlers were not heard at Toyokawa, while heard at Wakkanai, and in general, they have been reported to be detected at higher geomagnetic latitudes. This seems to indicate that there is a limit in geomagnetic latitude to detect long whistlers. We now consider the reason for no occurrence of a long whistler at Toyokawa and explain the possibility of the existence of such a limit.

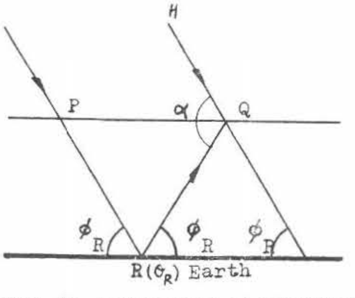

Fig. 13. Reflection of whistler on the earth. HQ is diretion of geomagnetie force. PR is direction of down-coming whistler. RQ is direction of reflected whistler.

In Fig. 13, R is a point on the earth to which a whistler comes down and θ_R and ϕ_R are geomagnetic latitude and dip at R respectively. P and Q are points on the base of the ionosphere through which the whistler goes down and up. HQ is a line of geomagnetic force through Q. And it is assumed here that a whistler propagates along a line of geomagnetic force, and dips at P and Q have same value as at R.

ϕ_R and θ_R are related in Eq. (1),

$$\tan \phi_R = 2\tan\theta_R \quad \ldots\ldots\ldots\ldots\ldots (1)$$

The whistler coming down through P to R reflects at R as a reflection on the surface of a perfect conductor, and propagates towards Q. The direction of propagation of the reflected whistler makes an angle α with HQ at Q, where α is expressed as

$$\alpha = 2\phi_R \qquad \cdots\cdots (2)$$

The reflected whistler could not penetrate into the ionosphere through Q, unless the direction of propagation satisfies the quasi-longitudinal condition of the magneto-ionic theory. Under this condition α can not be smaller than a certain angle greater than 90° which is determined by electron density and collisional frequency of an electron with neutral molecules at Q. Using Eq. (1) and (2) the variation of θ_R with α is plotted in Fig. 14, which shows that θ_R increases as α increases and the value of θ_R can not be smaller than a certain value greater than 26.5° which is the value of θ_R corresponding to 90° in α. This means that a whistler coming down to a point lower than 26.5° in geomagnetic latitude can not propagate back through the ionosphere to the opposite hemisphere. Consequently, no long whistler is heard in the regions lower than 26.5° in geomagnetic latitude. This result makes the reason clear, why long whistler were not heard at Toyokawa while heard at Wakkanai, because the geomag. lat. of Toyokawa and Wakkanai are 24.4° and 34.2°, respectively. However, since we have not considered the deviation of propagation direction of the whistler from the line of geomagnetic force and the difference from the geomagnetic field of a magnetic dipole and the actual magnetic field of the earth, the limited geomag. lat. 26.5° is not a decided one. It is interesting to know the limited magnetic latitude in practice.

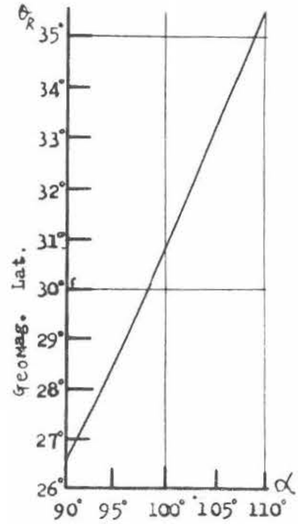

Fig. 14. Relation of geomagnetic latitude at a point to which a whistler goes down to the angle between the propagation direction of the reflected whistler and the direction of geomagnetic force.

C). Whistler pair and tone of whistlers

No whistler pairs were detected at Toyokawa, on the other hand, they were observed at Wakkanai in short whistlers. They generally consisted of more than two whistlers, and the dispersion of each whistler was either 50, 55, 60, 65, or 70, and dispersion 45 was observed only in one case. The dispersion ratio was between 1.1 to 1.56.

One example of a pair is sketched in Fig. 15, in which five whistlers are seen, but they are not constituents of one whistler pair, for the 2nd and 4th whistlers from the right side constitute another whistler pair and these two whistler pairs seem to have originated from a multiple-flash lightning.

The one of the whistler was pure at Toyokawa and was rather broad at Wakkanai (see Fig. 8, 9, 10, 11 & 12), but it is not so broad even at Wakkanai as what has been observed at higher geomagnetic latitudes. The broadness of tone is generally greater for a long whistler than for a short one, but it varies widely and cases were seen at Wakkanai where

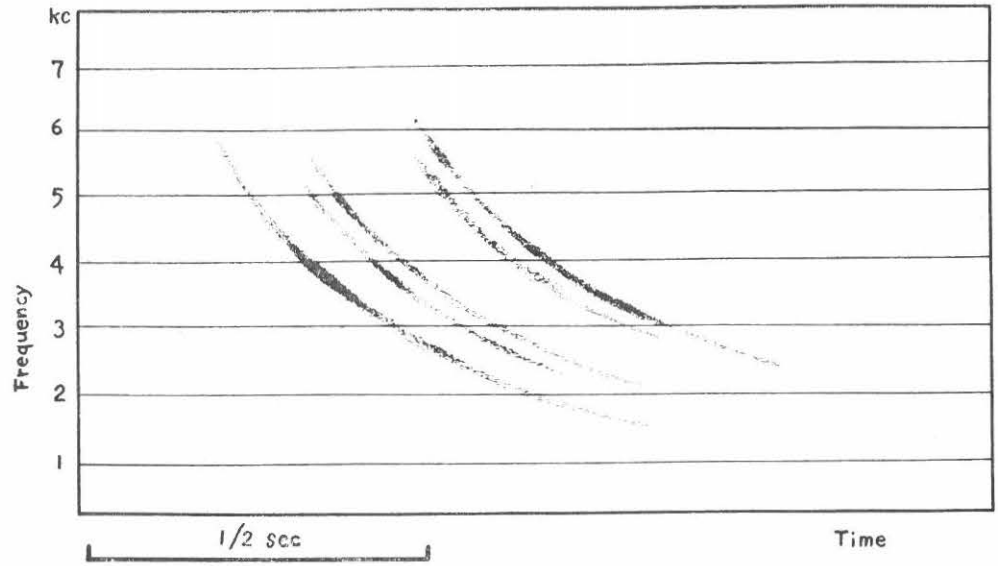

Fig. 15. Sketch of whistler pair (21h 13m 8 Aug. 1956, Wakkanai) 1st, 3rd and 5th whistlers from the right side belong to one whistler pair, and their dispersions are 70, 58 and 50 respectively. 2nd and 4th belong to another pair, and their dispersions are 70 and 60. The both pairs seem to be a multiple-flash type group.

long and short whistlers had almost a pure tone. A whistler of broad tone appears to be similar to a whistler pair, since the latter is able to shift to the former as the constituent whistlers of the latter become indistinguishable from each other. In fact, there were cases where it was difficult to discriminate between a whistler of broad tone and a whistler pair. Therefore, it may be reasonable to presume that the causes which produce these two types of whistlers must be the same in essential points. A possible explanation of the causes must be able to satisfy the fact that these two types of whistlers seldom occur in lower geomagnetic latitude. We have the prospect of answering these problems by studying the possibility of propagation of whistlers reflected on a surface of the earth between the earth and the ionosphere.

2). Relation between whistlers and solar activity

In order to study whether the sun has any effect on whistlers or not, it is generally more useful to examine the relation between solar activity and dispersion than occurrence of whistlers, because the latter depends not only upon propagation conditions in the outer ionosphere, but also upon activity of thunders as the origin of whistlers, while the former depends only upon propagation conditions.

However at first, we investigate the day-to-day variation of occurrence of whistlers observed at Wakkanai. It is indicated in Fig. 16. together with solar radio wave at 3750 MC/S observed at Toyokawa and with sum of the three-hour-range K indicies observed at Kakioka. Some correlations may be expected to exist between solar activity and the occurrence of whistlers from the fact that whistlers were detected during two terms

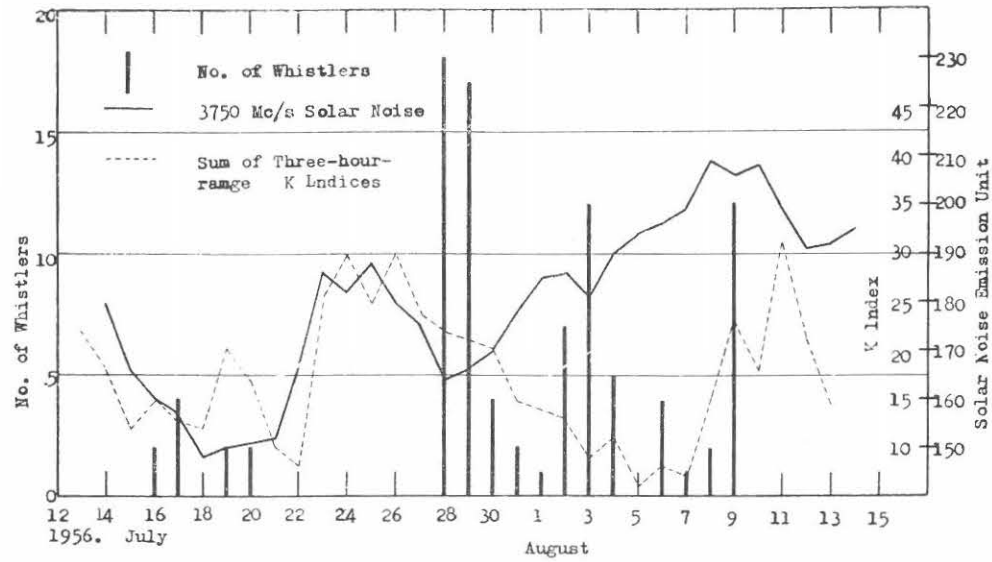

Fig. 16. Day-to-day variation of occurrence of whistlers observed at Wakkanai are shown together with solar radio wave at 3,750 Mc/s observed at Toyokawa and with sum of the three-hour-range K indices observed at Kakioka.

of successive days except one day in either term, one of which was from 16 to 20 July and another from 28 July to 9 Aug. But any relation can not clearly be found, owing to the complicated conditions for whistlers to occur as described above. To find out the relation it is necessary to have a knowledge of thunders occurring near the observation station and the geomagnetically conjugate point.

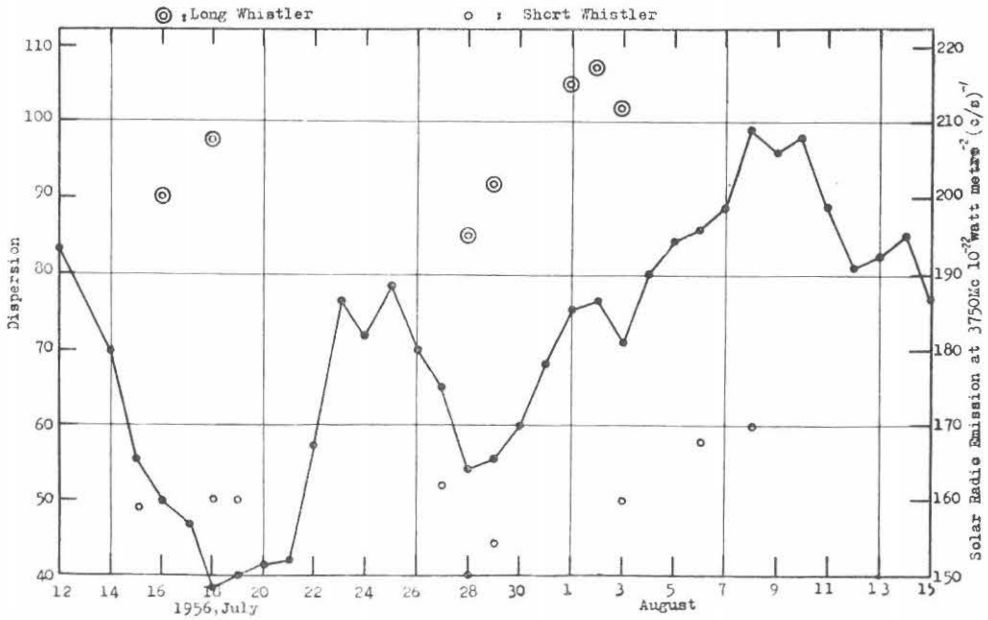

Fig. 17. Correlation between day-to-day variation of dispersions observed at Wakkanai and solar radio emission at 3750 Mc/s observed at Toyokawa.

Next, the day-to-day variation of dispersions observed at Wakkanai is shown in Fig. 17 again together with the solar radio wave. In this figure day-axis is shifted half a day to right for dispersions of whistlers, considering difference of observation times between whistlers and solar radio wave. As for short whistlers, the dispersions obtained during the time when the intensity of the solar radio wave continued over 180 in solar radio emission unit reached to 57-70 (average 60), while on reduced active days they showed 49 on the average.

Whistler pairs described above were all detected during the time of this high level of solar activity. For long whistlers, a similar tendency will be perceived, but not so clear as the case of short whistlers, owing to lack of data. In the case of Toyokawa, whistlers of dispersion 35-45 were observed during the intensity of solar radio emission remaining over 240 units; on the other hand, dispersions of 25-30 were generally detected on days lower than 180 units in the intensity of solar radio wave. These results, though not enough in data, may be taken to indicate that solar activity has a positive correlation with dispersions of whistlers, and has also a relation to the occurrence of whistler pairs.

3). Effect of S/N for observation of whistlers

Variations of S/N, i.e. intensity ratio of whistler to noise at an observing station, seems to be one of the important factors which influence the observation of whistlers, since the reason of no detection of whistlers during certain times and periods through these two observations can be reasonably explained by consideration of variation of S/N with season, day and geographic latitude. In the summer of 1956, whistlers were heard at Wakkanai from about one hour before sunset to two and half hours after sunrise and were not heard at all at Toyokawa. In the winter of 1956, they were heard mostly between about three hours before and two hours after sunset and were also heard between four and six o'clock at Toyokawa (see Table 3), but no observation has yet been made at Wakkanai in winter. As seen from Table. 3, the observation at Toyokawa in the winter was irregularly carried out and data were not enough statistically to discuss. Nevertheless, it seems to be fairly clear that no whistler ocurs in the day time in the winter there. The value of S/N greatly

Table. 3. Daily variation of occurrence of whistlers observed at Toyokawa in the winter 1956.

Time (J.S.T.)	No. of whisters	Sum of observation times	No./10m
0	0	15m	0
1	0	30	0
2	0	5	0
3	/	/	/
4	2	5	4.0
5	10	5	20.0
6	4	15	2.7
-sunrise-			
7	0	35	0
8	0	5	0
9	0	5	0
10	0	5	0
11	0	5	0
12	0	10	0
13	0	5	0
14	2	20	1.0
15	24	205	1.1
16	506	395	12.8
17	1,900	945	20.1
-sunset-			
18	415	327	12.7
19	9	65	1.4
20	0	5	0
21	0	10	0
22	0	5	0
23	0	5	0

depends upon the absorption of the ionosphere and distances from main active regions of thunders to the observing station.

The effect of absorption is greater for whistler than for ordinary atmospherics, because the former must go through the absorption layer at least two times, while the latter propagates between the ionosphere and the earth. And the absorption for whistler is indifferent to whether the observation is made in summer or winter, for whistler must penetrate the absorption layer at both hemispheres in which seasons are opposite each other. In the day time, the height of D layer, the main absorption layer in the ionosphere, is low, so the absorption by the layer is very great and the intensity of whistler is greatly reduced, consequently no whistler is heard. But as the sun declines westward, the height of D layer comes to rise and the absorption diminishes, accordingly S/N continues to increase for a while, but during one or two hours after sunset, the main active regions of thunders in low geographic latitudes become covered with the reduced absorptive layer, so that S/N ceases to rise and begins to decrease, therefore whistlers are detected during several hours before and after sunset. This occurs at Toyokawa only in winter, for S/N is generally small in summer owing to the going of main active region of thunders toward the north, while at Wakkanai even in summer, S/N continues a detectable value throughout the night, because the distance from the main active regions of thunders is longer and the effect of absorption is generally smaller at higher latitude. As described above, the effect of S/N is so serious for observation of whistlers, especially in lower geographic latitudes where the value of S/N is generally low, that very careful attention is necessary to diminish all sources of noise.

IV. Conclusion

Routine observations for the program of I.G.Y. have gotten into smooth running order. The general features obtained up to the present and the subjects of future research are as follows:——

1). At Wakkanai, long whistlers and whistler pairs have been observed, but whistler trains have not yet been observed; meanwhile, only short whistlers have been observed at Toyokawa. It is important to find out receiving limits of latitude with respect to various whistlers.

2). It is difficult to decide from the data obtained till now whether (a) or (b), described delow, generates the whistler.

(a). The electron density in the outer ionosphere always remains great enough to support the mode of propagation of Storey's theory. The whistler, however, can not be heard usually by attenuation at the lower ionosphere and being heard at the chance of decreasing the attenuation.

(b). The whistler can be heard only when the electron density increases temporarily accompanying abnormal phenomena.

Therefore, the data on the continuous observations of the level of atmospherics and the countings of lightning flashes near the conjugate points are necessary to deduce the cause of occurrence of whistler.

3). At Toyokawa, it is scarcely possible to detect whistlers except in the winter season; while, at Wakkanai, it may be possible through all seasons. So, it is desirable that routine observations be continued at Wakkanai.

At Toyokawa, it may be possible to measure the arriving direction, incidence angle and polarization of whistler, because the whistler observed there has the character of pure tone. One possible experimental method of investigating Storey's theory is to make clear the character of the down-coming wave of whistler by measuring these values mentioned above.

4). It is assumed from observing results of long whistler that unsymmetrical character of propagation path with respect to the magnetic equator may not be so great as those deduced from Maeda's theory. In order to measure the quantity of unsymmetry of the propagation path, the preceding atmospheric click must be fixed by C. R. D. F. network.

5). A program of two minutes recording every half an hour is decided under routine experiences. It is desirable that routine observations be continued as in the present program and special observations be added at the time of high activity of whistler.

6). The observing apparatus has operated almost satisfactorily up to the present, except disturbances due to the power line and the radio broadcasting. The investigation to eliminate these disturbances must be the subjects of future research.

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