Results of Ionospheric Observation at Syowa Base, Antarctica, during the Solar Eclipse

Sadao HASEGAWA* and Nobuhiro KAWAJIRI*

昭和基地における日食観測結果

長谷川貞雄*・川尻矗大*

要　旨

1961年8月11日，昭和基地北方洋上に生じた金環食の際，基地において電離層観測を実施したので，その結果を報告する．

この日食時には太陽高度が非常に低く，しかも若干電離層擾乱を伴っていたために，電離層の下部領域即ちE層，F_1層は観測し得なかったが，F_2領域については明らかに日食の影響が認められた．この領域について得られた主な結果を次に示す．

1. F_2領域の電子消滅は主に付着作用によって行なわれ，その付着係数Bは高度300 km付近において，$1.5\sim2.0\times10^{-4}\,sec^{-1}$の値が得られた．

2. この付着係数Bの値を用いて求めた理論計算曲線は，食甚時まで観測値とよく一致するが，復円時には異常な電子密度増加が認められて，理論曲線とは一致しなかった．この原因として，荷電微粒子群の進入による電離を考え，日食期間のその電子生成率 q' を求めると，平均 $70\,cm^{-3}\,sec^{-1}$ の値が得られた．

3. 付着係数Bの値を各高度に対して求め，それにより scale height を求めた結果，高度300 km付近におけるF_2領域においては，酸素分子O_2に対する電子付着作用を仮定して，約30 kmであった．

Abstract: During the solar eclipse on August 11, 1961, the continuous recording of *h'-f* observation was made in vertical incidence at Syowa Base in Antarctica, and in spite of the period of very low solar zenith angle, it was possible to find the effect of the eclipse on the ionograms.

The recordings at this time were obtained of only the F2 region in the ionosphere, and the variation of electron density during the solar eclipse at a certain height of the F2 region was more remarkable than the variation of the critical frequency.

The results of analysis of the observations are summarized as follows:

(i) Electron in the F2 region seems to decrease by the attachment process, and the order of magnitude of the attachment coefficient can be estimated at 1.5×10^{-4} to $2.0\times10^{-4}\,sec^{-1}$ at 300 km.

(ii) On the assumption of the above-mentioned values as the attachment coefficient, the computed values of an electron density during the eclipse show a good agreement

* 郵政省電波研究所. Radio Research Laboratories, Ministry of Posts and Telecommunications.

with the observational values up to the maximum phase of the eclipse, but beyond the maximum phase, the observational values continue to increase rapidly in electron density until after the end of eclipse. It may be suggested that the phenomena of electron increase are due to an effect such as the ionization of charged particles.
(iii) In our observation, the value of scale height obtained, as the attachment process of electron to (O_2) oxygen, is about 30 km at 300 km levels of the F2 layer.

1. Introduction

Ionospheric observations at vertical incidence on the continuous basis were made at Syowa Base in Antarctica during the annular eclipse of the sun on August 11, 1961, as shown in Fig. 1. Geographical coordinates of Syowa Base and the various phases of the eclipse at 300 km are shown in Tables 1 and 2, respectively.

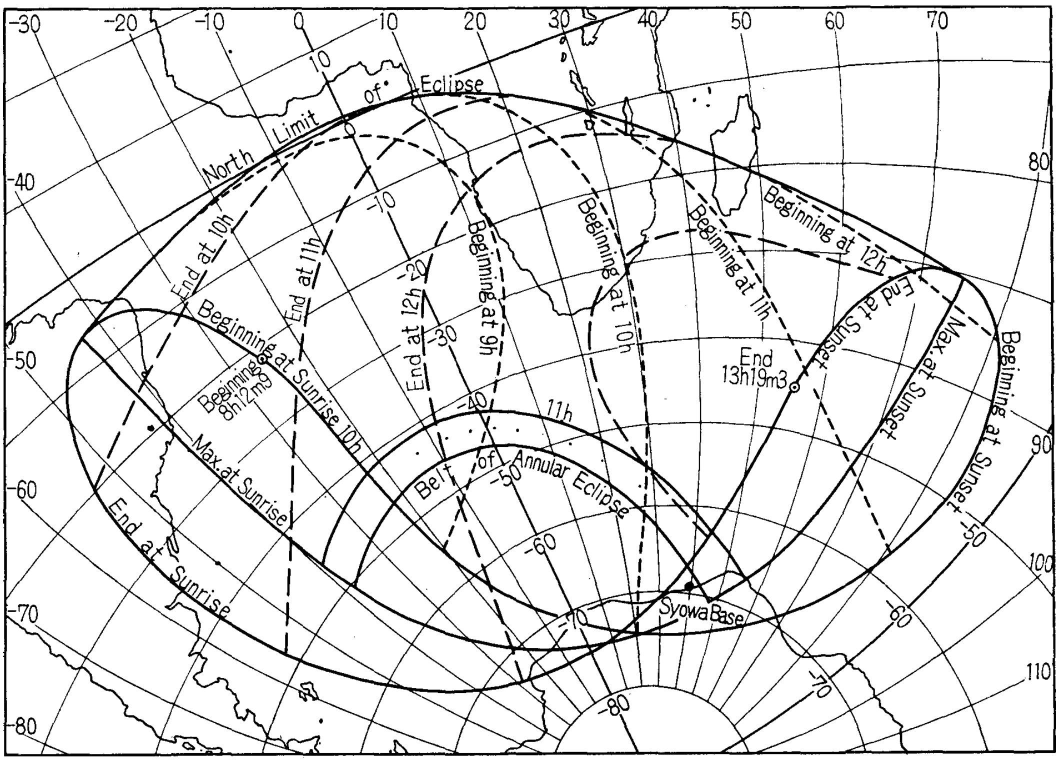


Fig. 1. Annular eclipse of the sun, August 11, 1961.

Since it was the winter season in the high-latitude region when we observed the solar eclipse at Syowa Base on August 11, the solar zenith angle was very low as shown in Fig. 2. It should be noted that the sunset (15^h01^m S.L.T.) came while the solar

Table 1. Co-ordinates of Syowa Base.

	Geographical co-ordinates	Geomagnetic co-ordinates
Latitude	69° 00′ 22″ S	−69° 42′
Longitude	39° 35′ 24″ E	77° 24′

Table 2. Times of contact at 300 km Syowa Base. Time = U.T. + 2^h 38^m 24^s

	Beginning of eclipse	Maximum of eclipse	End of eclipse	Sunset on the ground
U. T.	10^h 18^m	11^h 36^m	12^h 54^m	12^h 23^m
S. L. T.	12^h 56^m	14^h 14^m	15^h 32^m	15^h 01^m
Zenith angle	84° 26′	87° 26′	91° 57′	90° 00′

eclipse was recovering. Furthermore, during the solar eclipse, the ionospheric condition in the F2 region was somewhat affected by the magnetic disturbance. However, the ionospheric recording of the F2 layer was observed completely, and the effects of the eclipse on the variation of electron density in the ionosphere were recognized clearly during the eclipse which was the 80 percent eclipse at a height of 300 km.

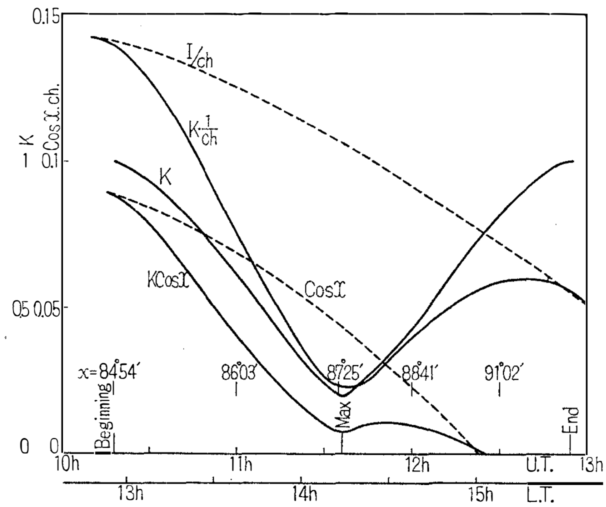


Fig. 2. Solar zenith angle, percentage of eclipse and ch-factor at Syowa Base on August 11, 1961.

2. Outline of observations

The equipment used during the solar eclipse was a completely automatic ionospheric sounder in use for the routine observation of the ionosphere at Syowa Base. The electrical characteristics of the equipment are as follows:

(i) Transmitting unit

Item	Value	Remarks
Frequency sweep range	1-15 Mc	Can select the sweeping frequency range
Frequency sweep time	30 seconds	Can select the time
Pulse recurrence frequency	50 c/s	
Transmitted pulse width	100 μs	
Transmitted peak power	10 kw	Under the load of 600 ohms
Height ranges	0 to 1100 km	
Height intervals	100 km	

(ii) Receiving unit

Item	Value	Remarks
Frequency bandwidth	28 kc	
Total gain	120 db	
Deviation of gain	4 db	Over 1 to 15 Mc
Means of recording		On film

(iii) Antenna system

Item	Value	Remarks
Transmitting antenna	Top height 20 m Base 80 m	Delta type
Receiving antenna	Top height 15 m Base 44 m	Delta type

The ionospheric observation during the solar eclipse was carried out every 4 minutes during the period from $04^{h}00^{m}$ August 10 to $13^{h}30^{m}$ (U.T.) August 12, 1961, but the continuous recording was made for about half an hour of about the maximum of the main phase of the eclipse.

3. Observational results

From the $h'-f$ curves obtained during the solar eclipse, the values of the critical

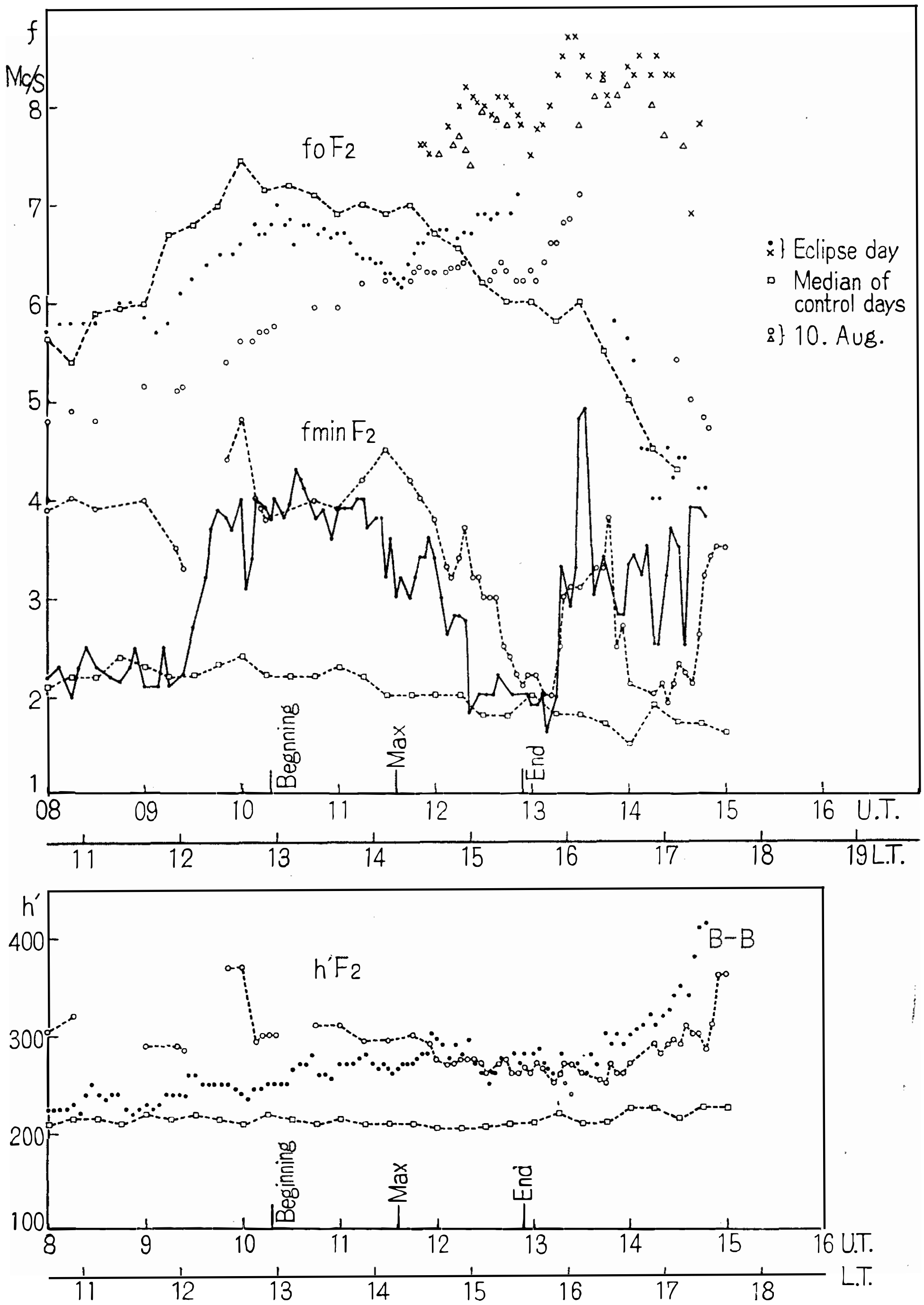


Fig. 3. Observational values of foF2, fminF2, and h'F2 during the eclipse on August 11, 1961, at Syowa Base.

frequency *fo*F2, the minimum frequency f_{min}F2 and the virtual height *h*'F2 are scaled and shown in Fig. 3 respectively.

i) Maximum electron density of the F2 layer

The variation of *fo*F2 proportional to the maximum electron density shows that the values began to decrease at about 10^h30^m, when it is later than the start of the eclipse at 10^h18^m. The variation in *fo*F2 was, however, similar to the eclipse up to the maximum phase. The time of initial rise of electron density was at almost the same time as the maximum phase of the eclipse, and there followed a continued rapid increase in ionization with the recovery of the solar eclipse. Furthermore, the extreme increase in *fo*F2 which appeared from about 11^h50^m, after the maximum eclipse seems to be due to some other layer than what was mentioned above.

ii) $f_{min}F2$

The curves of f_{min}F2 in Fig. 3 show that its values extremely increased at approximately 45 minutes before the beginning phase of the eclipse, and decreased gradually till the end of the eclipse as if the eclipse had an effect on f_{min}F2. Furthermore, there was again a rapid increase after the end of the eclipse.

Such variation in f_{min}F2 is due to the definite effect of the ionospheric disturbance. Fig. 4 shows the variation of the earth's magnetic field during the solar eclipse associated with normal conditions.

It shows that the magnetic disturbance-like phenomena (a variation of H about 100

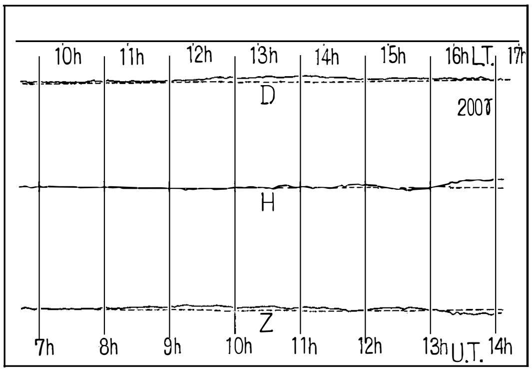


Fig. 4. Geomagnetic variations on August 11, 1961, at Syowa Base.

to 200 gammas) occurred during the solar eclipse, but in the neighbourhood of the auroral zone, it seems that the variation of this amount in the magnetic records was nearly in the normal condition.

The variation of f_{min}F2 has a good agreement with H-component of the earth's magnetic records.

iii) Minimum virtual height of the F2 layer

Fig. 3 shows also the variation of minimum virtual height h'F2 during the solar eclipse. The variation of h'F2 has a tendency to gradual increase in the level from before the beginning till after the end of the eclipse.

The ionospheric record of h'F2 does not seem to be agected by the solar eclipse owing to the magnetic disturbance mentioned above.

An ionospheric record in the neighbourhood of the auroral zone is very complex owing to the presence of "spread" echoes. So the effects of eclipse on the ionosphere are usually obscured by these anomalous phenomena.

In order to compare the records on the day of eclipse with the ionograms recorded every 15 minutes on the control days before and after the eclipse day, the median values on the control days are plotted in Fig. 3. The f_{min}F2 and h'F2 on the day of eclipse show values higher than on the control days. Furthermore, the values of foF2 on the control days do not agree with the tendency of variation of foF2 on the day of eclipse.

In comparison with the values of the control days, it can be found that the F2 layer is affected by the eclipse in any way, although the values on the control days are not suitable because of the lower solar zenith angle.

Since the ionospheric records on August 10 seem to show the same tendency as the variation on the day of eclipse, we used the tendency of variation on August 10 as a control value to be used hereinafter.

The results of our observation show that the time of minimum foF2 almost coincides with the maximum phase of the eclipse. Furthermore, from the tendency of variation of foF2 as the control value and the facts mentioned in the following section, it seems that this eclipse had a distinct effect on the F2 layer.

4. Analysis and discussion of the results

It is well known that a solar eclipse provides many important factors for analysis of the ionization mechanism of the ionosphere.

The most general equation of the time variation in number of the electron density in the ionosphere, if the digusion is disregarded, is given approximately as follows:

$$\frac{dN}{dt}=Q-L \qquad (1),$$

where N is the electron density, Q and L are the rates of electron production and of electron loss, respectively. The following two equations are derived to be expressive of the condition of equilibrium of ionization.

$$\frac{dN}{dt}=Q-\alpha N^2 \quad (2),$$

$$\frac{dN}{dt}=Q-BN \quad (3).$$

The equation (2) shows the case where the electron loss due to the recombination is predominant (α is the egective recombination coefficient) and the equation (3) corresponds to the case where the attachment to the neutral atoms and molecules is in dominant action (B is the attachment coefficient).

During the eclipse, assuming that the solar radiation is uniformly distributed over the solar disk, and that the intensity of the ionizing radiation is proportional to the fraction, K, of the exposed solar disk, we may write:

$$Q=q_0K\cos X \quad (4),$$

where X is the solar zenith angle, q_0 is the rate of ion production, and Q is the value when $X=0$ and $K=1$.

4.1 On the behaviour of disappearance of electron

Although the solar zenith angle was considerably low when we carried out the observation, it could be considered from the daily observation of variation in foF2 that the ionosphere had the value of dN/dt nearly negligible.

As is well known (NAKATA, 1954), neglecting dN/dt in the equation (1), we can write approximately as follows:

$$L=Q \quad (5).$$

Since the value of N is proportional to the square of the ordinary wave frequency f which is reflected at the level of electron density N, we have

$$f=\text{const.}\ (Q)^{1/m} \quad (6),$$

applying the above relationship into N of equation (2) and equation (3), where

$m=4$ for the recombination process, and

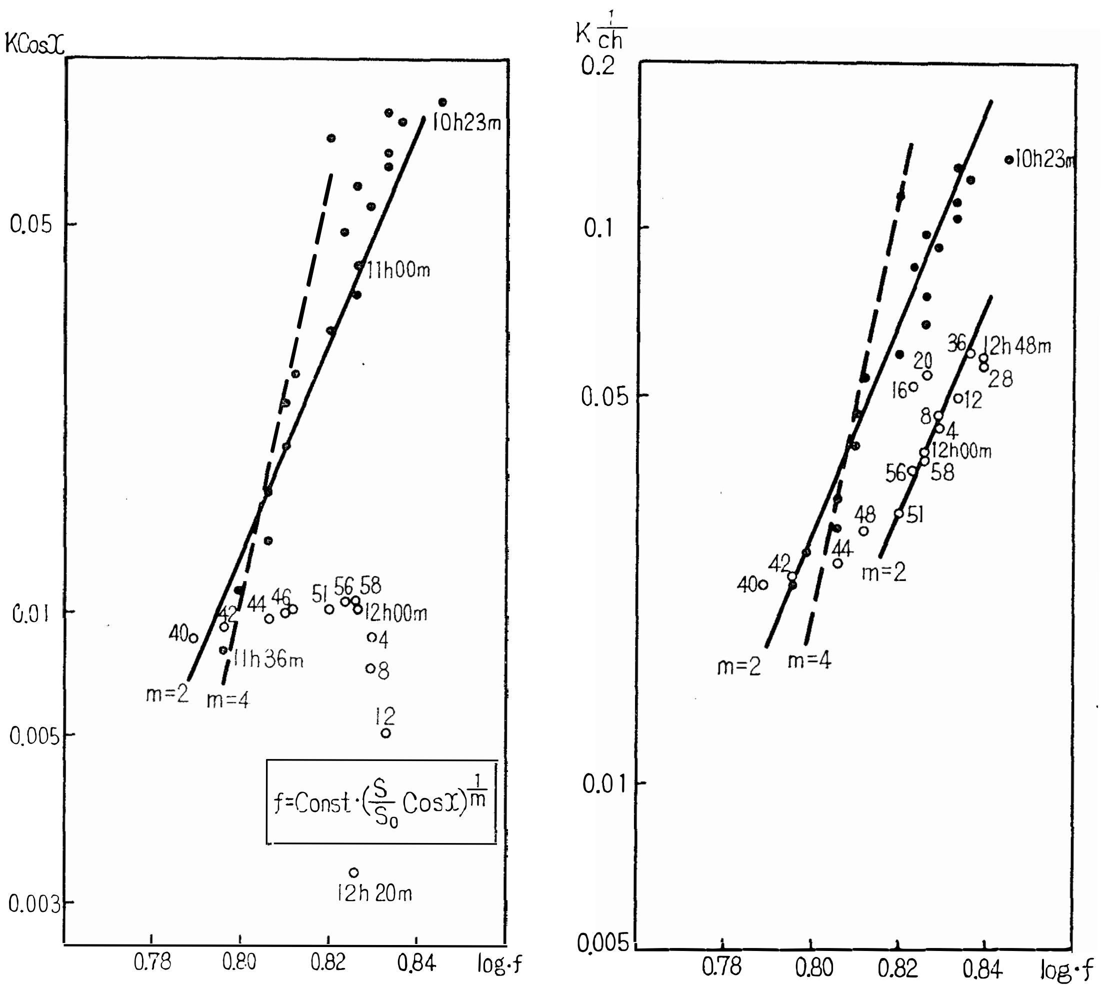
$m=2$ for the attachment process.

Taking the logarithm of the equation (6), we get

$$\log f\propto(1/m)\cdot\log Q \quad (7).$$

This equation indicates a straight line relation between $\log f$ and $\log Q$, and the value of $1/m$ will be the slope of the line when $\log f$ is plotted to $\log Q$.

On the assumption that Q is denoted by the equation (4) during the eclipse, the relationship between $K\cos X$ and foF2 is shown in Fig. 5-1. The points of the observational values in Fig. 5-1 lie almost on the straight line whose slope is nearly of magnitude of $m=2$ for the F2 layer. During the recovery of the solar eclipse, however, it can be seen that the points for the same layer do not coincide with either line of $m=2$ or m=4. This disagreement during the recovery period shows that there exists, the remarkably rapid increase of ionization due to other effects as follows:



(1) (2)

Fig. 5. Relation between log f *and* log$K\cos X$ *or* log$K1/ch$ *for the F2 layer ($m=2$, slope of the straight line for attachment and $m=4$, that for recombination).*

We shall discuss the phenomena of increased ionization as to why the straight line of $m = 2$ or $m = 4$ does not coincide with the experimental results. At first, in the case of small value of cos X, i.e., cos $X < 0.1$ as shown in Fig. 2, it will be better from theoretical considerations to use $1/ch\ (x, X)$ instead of cos X, where $1/ch\ (x, X)$ is Chapman's function in the case of grazing incidence, and

$$x = \frac{a+Z}{H} \qquad (8),$$

where a: radius of the earth (6,370 km);
Z: height of the ionized layer;
H: scale height at the height z.

It is assumed that Z of the F2 layer is about 300 km above the ground surface, and H can be estimated at about 60 km in the F2 layer at Syowa Base in reference to the data of Fort Churchill and C.I.R.A.[11] In calculation of the value of x by the use of numerical values of H and Z, $x \fallingdotseq 108$ can be obtained for the F2 layer. The result of calculation is shown in Fig. 2 in comparison with cos X also.

By replacing cos X with $1/ch\ (x, X)$, the estimated values for the F2 layer during the eclipse are shown in Fig. 5–2. The points of the observational values in Fig. 5–2 fit to the straight line of $m = 2$ better than in Fig. 5–1 during the covering phase of the eclipse. During the recovery period, however, the points lie almost on the straight line of $m = 2$ also, except for the early phase of recovery.

These results may indicate that the electron at the level of maximum density in the F2 layer disappears by the attachment process, and the variation of this process is affected by the solar eclipse until it reaches about the maximum phase. However, it can be found that during the phase of recovery of the eclipse, the electron in the F2 layer shows remarkably rapid increase, which can not be explained even by the use of the *ch*-factor. There seems to be no relation to the solar eclipse, but the increase is due to other abnormal phenomena.

4.2 Determination of the attachment coefficient

On the assumption that the electron at the level of maximum density in the F2 layer disappear by the attachment process as mentioned above, we obtained the following results:

It is also assumed that the virtual height at the level of maximum density h'_{max} is constant at 300 km during the eclipse. It is necessary to know about the characteristics of *fo*F2 on a control day for comparison with the value on the day of eclipse. We take the data on August 10 for a control day's data instead of the median value for ten control days for the following reasons:

(i) In the auroral zone, we have frequently the ionospheric and magnetic disturbances and the daily variation of *fo*F2 shows considerably large value.

(ii) Since the solar zenith angle is very low, *fo*F2 differs much in value before and after the eclipse. Therefore, as the value of *fo*F2 near to the day of eclipse should be used the value on a control day, August 10.

(iii) The ionospheric and magnetic conditions on August 10 showed a good agreement with those on the day of eclipse.

Thus, the control values were obtained from the data on August 10 as shown in Fig. 6.

4.2.1 In the case of considering the rays only from the sun as the source of ionization

Although the mechanism of ion production in the F2 layer is more complicated than in other layers, it is simply assumed that ionization of the layer is due only to the radiation energy from the sun. Also, on the assumption that *B* does not change so

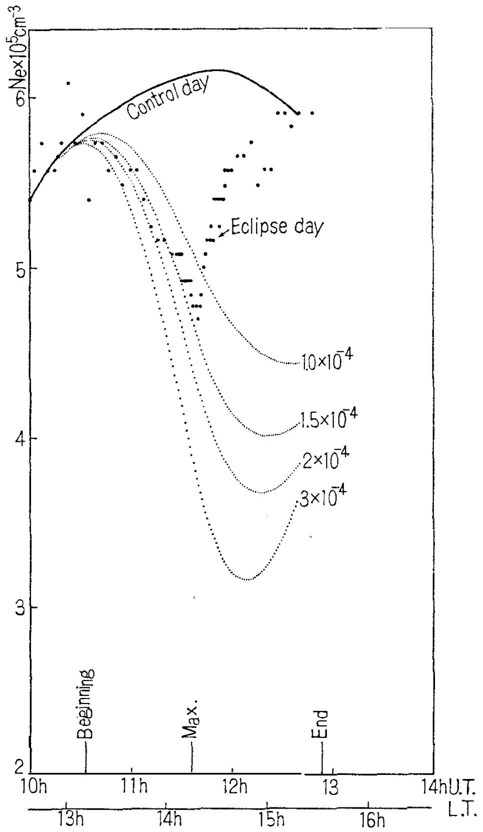


Fig. 6 Theoretical curves for F2 layer.

much at the fixed height of the layer, the equations (3) and (4) may be modified as follows:

$$\frac{dN}{dt} = Kq_0 \cos X - BN \qquad (9).$$

As the result of numerical integration of equation (9) by the use of the observational results and the estimated control values on August 10, we can obtain a number of calculated curves for any different values of B.

The results of calculation of several values of B are shown in Fig. 6, and in comparison with the observational results, the calculated values of foF2 are given in the same figure.

As seen in this figure, the calculated curve for $B = 1.5 \sim 2.0 \times 10^{-4}$ sec^{-1} nearly agrees with the experimental results until about the maximum phase of the eclipse. In all cases the minima of the theoretical curves occur after the obserevd minimum; in other words, it seems that the observational results show the extreme increase of electron density from about the maximum phase, lasting beyond the end of eclipse. This

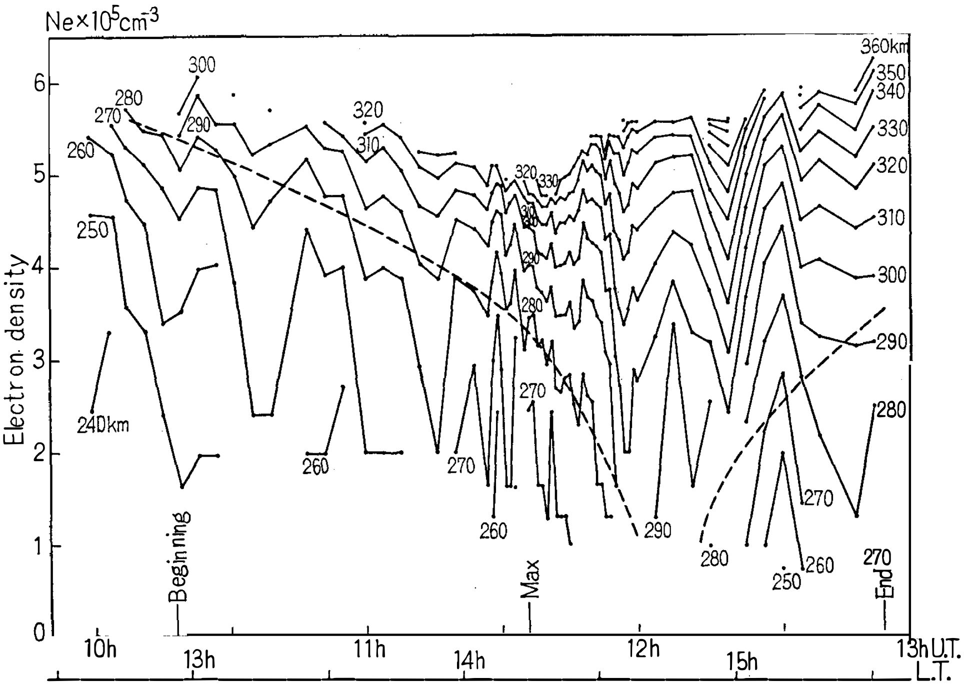


Fig. 7. Variation of the electron density N at various true heights during the eclipse on August 11, 1961, at Syowa Base.

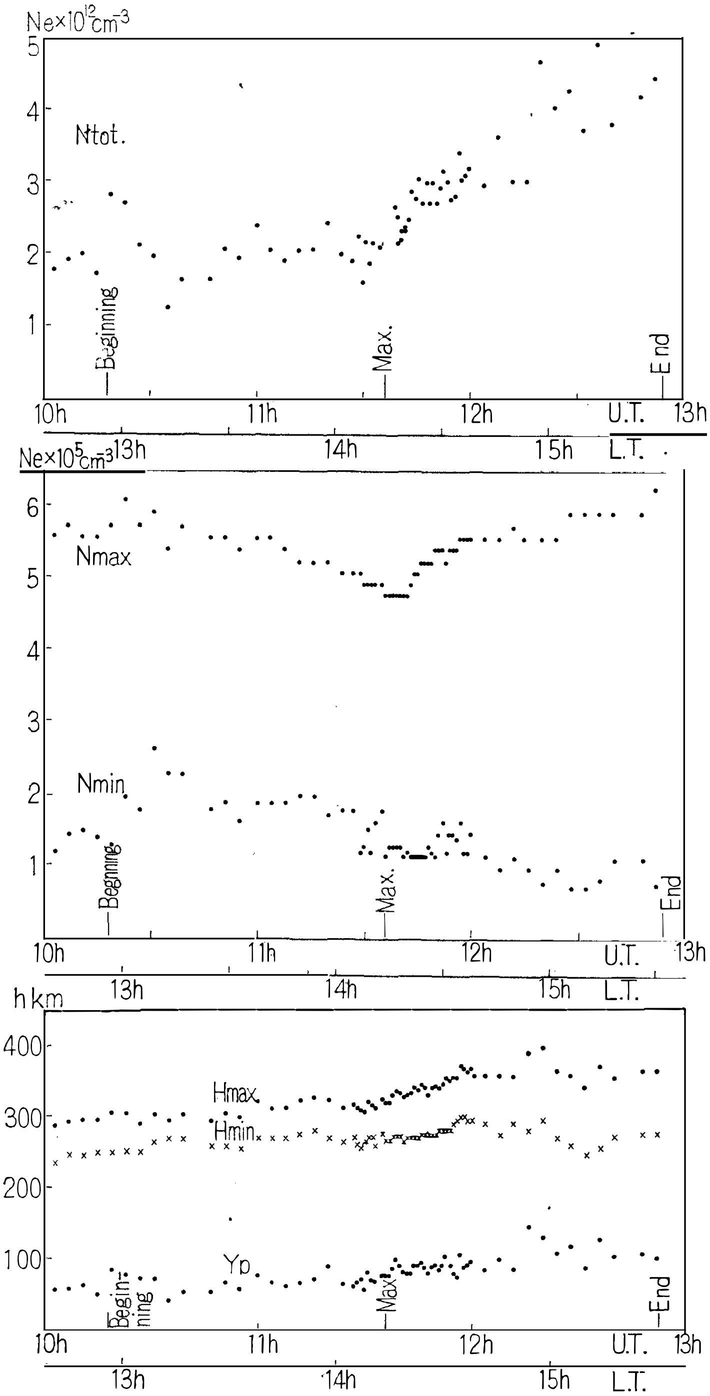


Fig. 8. Variation of NTOTAL, Nmax at Hmax, Nmin at Hmin, and Y_p at true heights during the eclipse on August 11, 1961, at Syowa Base.

rapid increase of electron density is supposed to be due to ionization by some other energy, e.g., high energy charged particles. Several reasons are given below:

(i) Fig. 7 gives the N (h) profile calculated from the h'-f record during the solar eclipse. It is indicated that during the covering phase of the eclipse, the electron density at each of the heights of N (h) profile is decreasing by the effect of the eclipse apparently, though the lower parts of the heights are associated much more with the effect of the eclipse than the upper parts. During the recovering phase, however, the upper parts, which correspond to the maximum height h_{max}, indicate the rapid increase of electron density immediately after the maximum phase of the eclipse, but it seems that conversely the variation in the lower parts, largely increasing and decreasing, almost agrees with the theoretical curves in Fig. 6, if consideration is given to the smoothed curve in dotted line at 280 km in Fig. 7.

After all, the variation in electron density is remarkable and has especially severe tendency at the recovery phase, though apparently affected by the eclipse. It is thought that the variation of electron density was due to some ionizing energy but the radiated ray from the sun.

(ii) Fig. 8 shows the total density N_{TOT}, maximum electron density N_{MAX} at H_{MAX}, minimum desity N_{MIN} at H_{MIN}, and semi-thickness Y_P, obtained by calculation of the N (h) profile on the assumption of Chapman's distribution.

It is indicated that, although N_{MAX} has the same variation as in Fig. 3, N_{TOT} and Y_P have more rapid increase of the electron density and of variation of H_{MAX} and H_{MIN}, after the maximum of the eclipse, that is, during the recovery phase.

(iii) The layer that had larger electron density and appeared at about 11^h48^m in the F2 layer, as shown in Fig. 3, seems to be quite different from the normal one.

(iv) As seen in Fig. 5, although the variation of electron density agrees well with the straight line of $m = 2$, it indicates a rapid increase of electron in disagreement with the line for the recovery phase of the eclipse. The phenomena of increase can not be explained by $1/ch\ (x, X)$ instead of $\cos X$.

In consideration of some quantity proportional to the solar radiative production, different from what was mentioned above, we have

$$\frac{dN}{dt} = Kq + q' - BN \qquad (10),$$

where $q = q_0 \cos X$.

If $q' = aq$, we have

$$\frac{dN}{dt} = Kq\ (1+a) - BN \qquad (11),$$

where a is a constant coefficient.

In the case of the value $a = 0.2$, the theoretical curve calculated by the equation

(11) for $B = 5 \times 10^{-4}$ sec^{-1} does not agree with the experimental result completely as shown in Fig. 9.

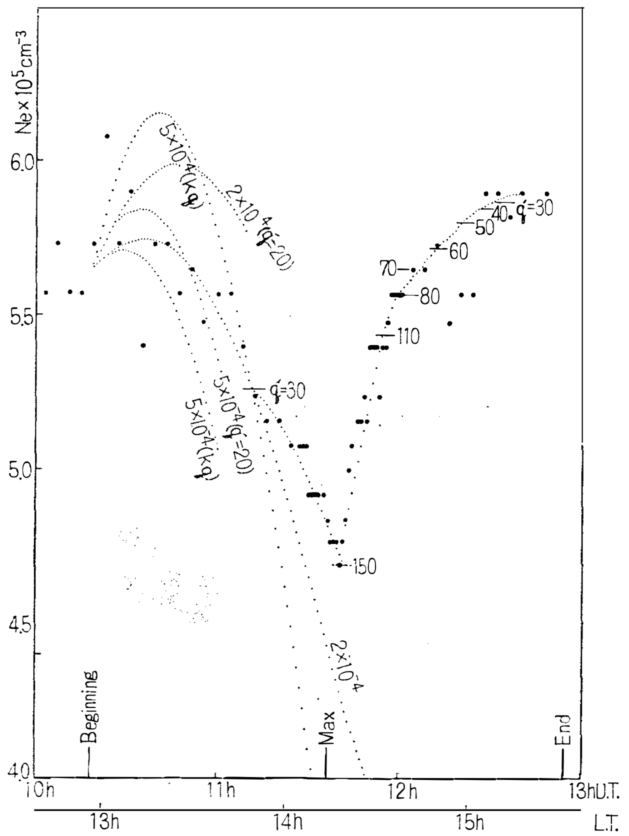


Fig. 9. Theoretical curves for F2 layer for various value of q'.

Even if there are calculated smaller values of B than the above, the theoretical curves will indicate as much disagreement as the above, because it has larger values of electron density than disappearance of electrons by $B = 5 \times 10^{-4}$ sec^{-1} at the initial phase of the eclipse and has a gradient of slower decrease of electron density than the observational value.

Conversely, the theoretical curves for larger values of B also do not agree, because they have a very steep gradient in rapid decrease. Therefore, it is supposed that some quantity q' proportional to q, the rate of electron production by the solar radiation, does not exist in the F2 layer.

4.2.2 In the case of exist random q' independent of the salar radiation

(i) If it is assumed that q' has an ability of electron production independent of the solar radiation and exists at all times constantly, we can calculate the theoretical curves for various q' and B from the equation 10.

Fig. 9 shows two theoretical curves for $B = 2$ and 5×10^{-4} sec^{-1} on the assumption of $q' = 20$ (small values comperad with q). It is indicated that each theoretical curve does not agree with the experimental result, and it has exactly the same variation as mentioned above. After all, the constant rate of electron production q' independent of the solar radiation cannot explain the variation in the F2 layer.

(ii) By considering something that has the rate of electron production as mentioned above, it is impossible to explain that the theoretical curves agree exactly with the experimental results during the recorvery phase of the solar eclipse.

Fig. 10 shows the ionograms throughout the time of the solar eclipse. The ionogram at 09^h30^m, before the beginning of the eclipse, shows that the normal ionospheric condition is quiet. However, the ionograms after the beginning show the occurrence of "spread" echoes in the F2 layer as time goes on. After 11^h48^m the ionograms have layers in fork-like shape and show the appearance of layers supposed to be other layers than normal over the ending phase, as shown in Fig. 3.

Fig. 11–1 shows the ionograms in the very quiet condition of the ionosphere on August 1, in order to interpret the effect of the solar eclipse at about the same time. In this condition, the ionospere has clearly no spread echoes and is in a state similar to 09^h30^m in Fig. 10.

However, Fig. 11–2 shows the ionograms in similar condition on the day of eclipse accompanied with some disturbances in the ionosphere. Especially, the condition of spread echoes indicates a good agreement with the data of the eclipse after about 11^h50^m.

Fig. 12 also gives the ionograms with aurora at Wakkanai and Kokubunji in Japan in September, 1957, when the charged particles invaded the upper atmosphere with the aurora. These conditions agree well with those in Figs. 10 and 11–2.

It has been suggested that some "charged particles" like q' which is deduced in comparison with the types of the F2 layer in a number of figures above, brought an extremely rapid increase in electron density that does not agree with the theoretical curves for the recovery phase. Therefore, it will be assumed that q' exists after about 11^h12^m in Fig. 10, and causes disagreement in the lower part of the theoretical curve $B = 2 \times 10^{-4}$ sec^{-1}. At first, the value $q' = 30$ cm^{-3} sec^{-1} of rates of electron production will be put into equation (11) at 11^h12^m. Successively, if some values of q' are put in as shown in Fig. 9, we can get a theoretical curve (for $B = 2 \times 10^{-4}$ sec^{-1}) indicating a good agreement with the observational value.

Although the maximum value of $q' = 150$ cm^{-3} sec^{-1} is somewhat larger than q, it seems that the value of q' is appropriate in the case of "charged particles" at high latitudes in Antarctica. After all, we shall take $q' \fallingdotseq 70$ cm^{-3} sec^{-1} as the mean value during the solar eclipse.

4.2.3 On the scale height

Although the attachment coefficient B mentioned above differs by the height, it was taken for the level of h assumed to be constant in height until the maximum phase of the elipse in this analysis. By the use of Fig. 7 which shows N (h) profile, if we obtain the values of B by the method of running average at each true height, it is shown nearly as follows:

Altitude (km)	Value of $B \times 10^{-4}$ sec^{-1}
310	2
300	3
280	5

where the altitude of h_{max} is assumed to be 310 km by N (h) profile. The relationship of B to the height is plotted in Fig. 13. Now, it is attempted to get the scale

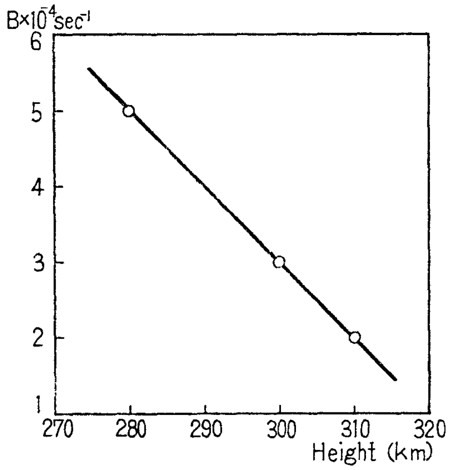


Fig. 13. Relationship between B and height.

height in use of the result of N (h) profile. The attachment B is a function of height as follows:

$$B(Z) = \beta n \quad (12),$$

where β......the real coefficient of attachment for value of B

n......the density of neutral molecules

From equation (12),

$$\frac{B(Z_1)}{B(Z_0)} = \frac{n(Z_1)}{n(Z_0)} \quad (13).$$

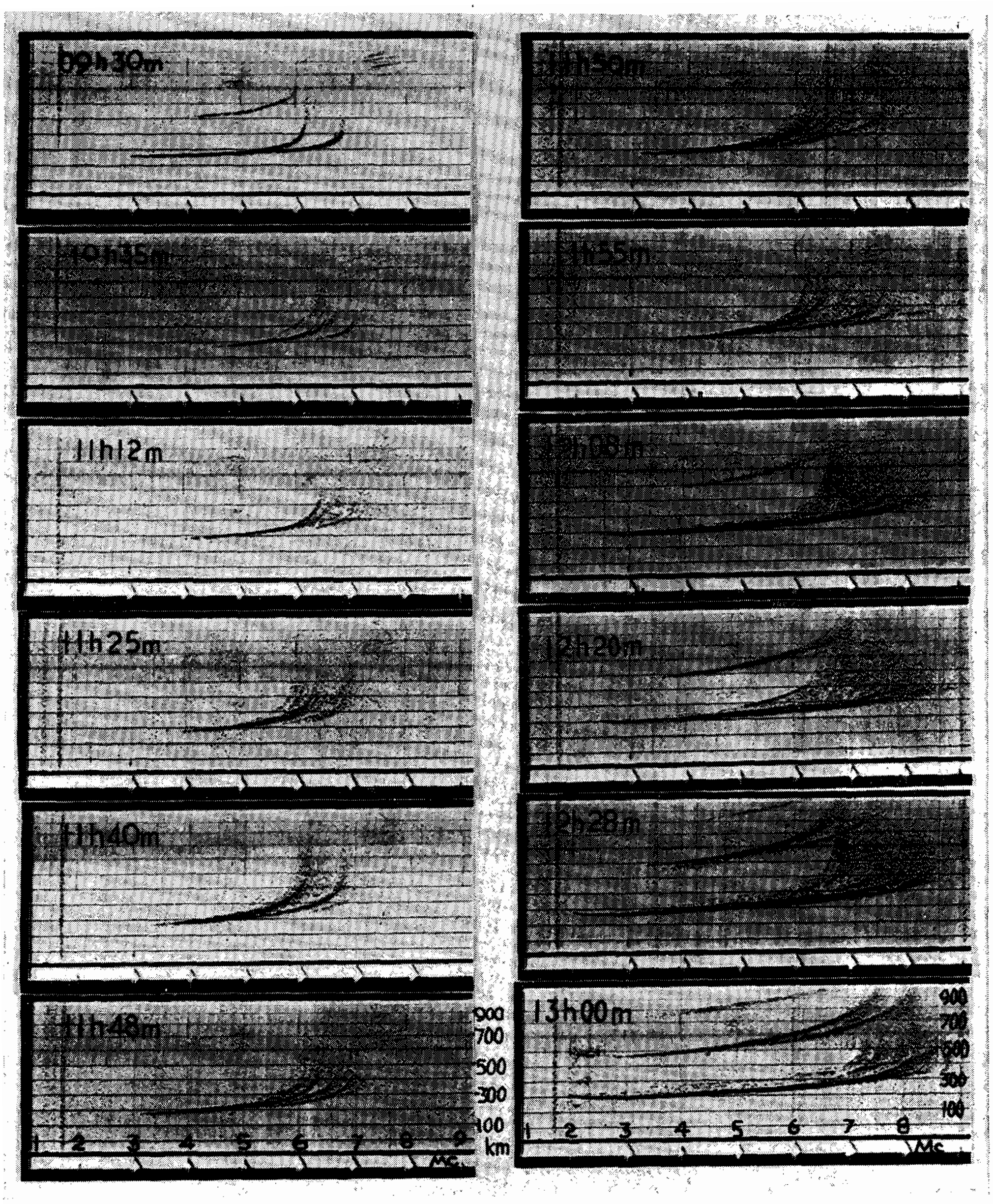


Fig. 10 h'-f records during the eclipse on August 11, 1961, at Syowa Base.

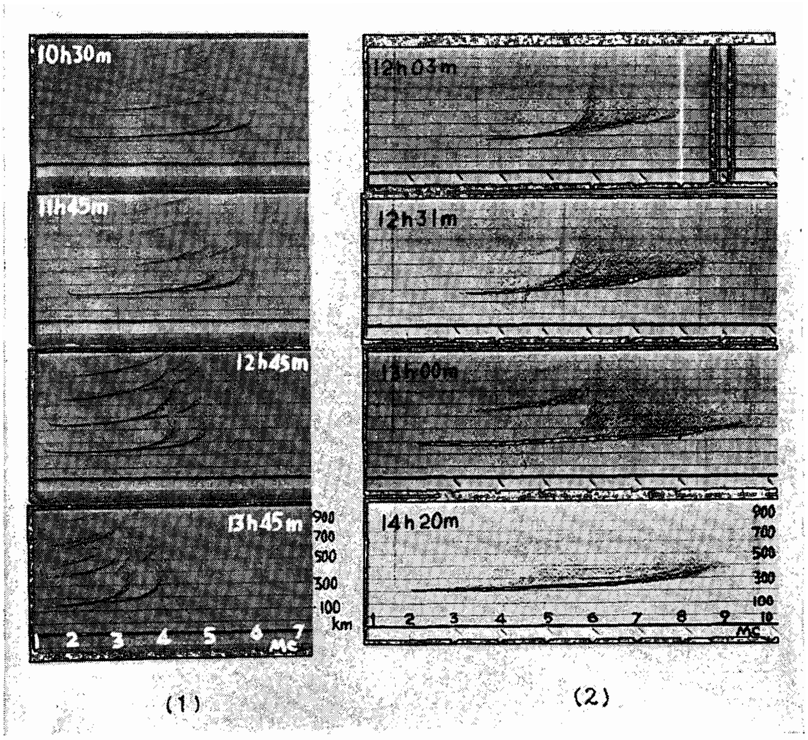


Fig. 11. (1) *Example of h'-f records in the very quiet condition of the ionosphere on August 1, 1961, at Syowa Base.*
(2) *Example of h'-f records with spread echos on August 10, at Syowa Base.*

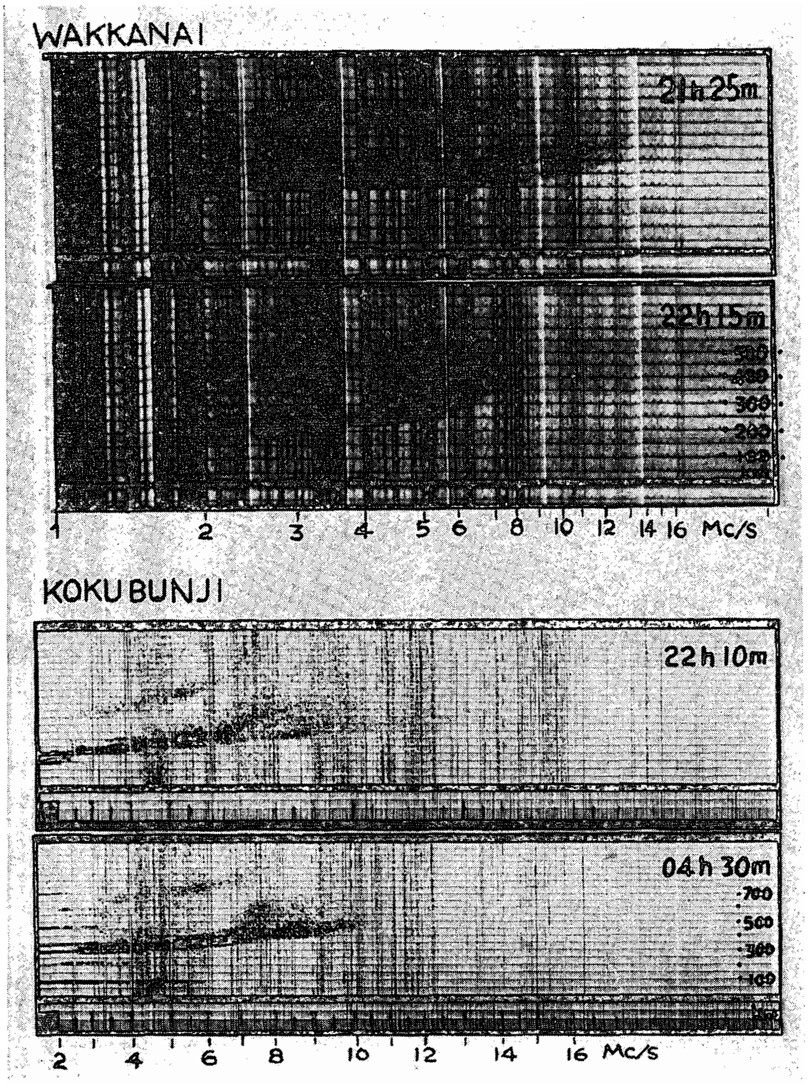


Fig. 12. Example of h'-f records with aurora at Wakkanai and Kokubunji, Japan, in September, 1957.

It is considered that the density n of atmosphere in the height of 300 km is the diffusive equilibrium. Therefore,

$$n(Z_1)T_1=n(Z_0)T_0 \exp\left[-\int_{Z_0}^{Z_1}\frac{dz}{H_0}\right]$$

$$n(Z_1)=n(Z_0)\frac{T_0}{T_1} \exp\left[-\int_{Z_0}^{Z_1}\frac{dz}{H_0}\right] \quad (14).$$

Since it is considered that the atmosphere in question is in the hydrostatic equilibrium, and the values of temparature and scale height are constant in a range of several tens kilometers of the height, the following equation may be obtained from equation (14)

$$\frac{n(Z_1)}{n(Z_0)}=\exp\left[-\frac{Z_1-Z_0}{H_0}\right] \quad (15),$$

where H_0......the value of scale height at a height of Z_0. Putting here $Z_1-Z_0=H_0$, from equation (15)

$$\frac{n(Z_1)}{n(Z_0)}=e^{-1} \quad (16).$$

Using Fig. 13 and equation (16), the value of B, which corresponds to e^{-1} at the height of 280 km, gives the height of 312 km. Therefore, the value of scale height in the F2 region at a height of about 300 km is obtained to be about 30 km for the molecular oxygen O_2, the value of which agrees very much better than the value of mean scale height of 60 km described in section 4.1.

Then, the expression of the scale height is shown as follows:

$$H=\frac{kT}{mg} \quad (17),$$

where, if each constant takes a value as follows, we can obtain the value of the temperature to be 1040°K for the F2 region at 300 km.

k: Boltzmann's constant 1.38×10^{-16} erg° K^{-1},
m: molecular mass of the constituent $32\times1.67\times10^{-24}$g,
g: acceleration due to gravity 894 cm sec^{-2}.

5. Conclusion

The results of analysis of the ionospheric observation made at Syowa Base, Antarctica, during the annular eclipse on August 11, 1961, bring about the conclusion as follows:

(i) Variation of electron density in the F2 region is influenced by the solar eclipse, but apparently any influence on the virtual heights can not be recognized during the eclipse.

(ii) Electrons in the F2 region disappear by attachment process, and the attachment coefficient of electron at 300 km is obtained at the values of 1.5×10^{-4} to 2.0×10^{-4} sec^{-1}.

(iii) The "charged particle"-like q' which has random ability of electron production exists in addition to direct effects of the solar radiation over the recovery phase of the eclipse, and the value is obtained at $q' \fallingdotseq 70\,cm^{-3}\ sec^{-1}$ as the mean value for the eclipse.

(iv) The value of scale height is, on the assumption of the attachment process of electron to oxygen molecule O_2, about 30 km at 300 km level in the F2 region, and the atmospheric temperature measures about 1040°K at that altitude.

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