THE MEASUREMENT OF THE INTENSITY OF ATMOSPHERICS (I)

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Summary—With the view of studying the nature of atmospherics, the measurement of the intensity of atmospherics over the range from 10 kc/s to 30 kc/s is now put into practice at the Research Institute of Atmospherics, Nagoya Univ. The integration method has been employed in measuring the atmospherics output of narrow-band receivers. The band-width of the receivers was 500 c/s at 6 db down point and the time of integration about one minute.

Diurnal and seasonal variations of the integrated level were described using the data from February to November 1953.

From these results obtained, some suggetions to the D-region of ionosphere were recognized and discussed.

The kown increase in the level of atmospherics on frequency 27 kc/s has been observed at the time of outburst on the sun, which occurred November 22nd, 1952 and October 15th, 1953.

I. Introduction

The measurement of the intensity of atmospherics has been continued since 1952 at the Research Institute of Atmospherics as a part of studying the nature of atmospherics in long wave region.

Though the work to measure atmospherics on long waves has been done by many observers using different methods and much useful information has been gained, it is desirable at this Institute that, as the work and the data of this kind was only rarely found in Japan, more observations should be made on atmospherics in long waves region for the purpose of obtaining the records in Japan.

This paper gives an outline of the equipment in use for recording the intensity of atmospherics continuously and automatically over long intervals of time and some of the results obtained at Toyokawa (137°22′ E, 34°50′ N) during the year 1953.

The purpose of this work involves not only studying the nature of atmospherics, but also getting some data regarding the D-region and investigating the ionospheric propagation on long waves. The attempt to the use of atmospherics to study the propagation of long waves has been done by many observers and some deductions have been made by Bureau and Gardner from observations of the integrated atmospherics level on a narrow-band receiver.

The results obtained were examined on the basis of these informations which were obtained by a vast amount of effort of many observers and some suggestions regarding both the propagation of atmospherics and the D-region were obtained by a short series of observations. However, in present state, it is completely inadequate to yield information. Hence, it is necessary to obtaine the data more in order to confirm the deductions, so the observation is going on even now.

II. Apparatus and Method of Observation

The apparatus which can select any three frequency components between 10 kc/s and 30 kc/s from the atmospherics arriving and record their integrated level by turns continuously and automatically over long intervals of time were produced by way of experiment at this Institute. It is also possible to record only one frequency component continuously. This apparatus is shown schematically in Fig. 1 and the photograph shown in Fig. 2 is the exterior of it.

A vertical antenna having about ten meters long is connected to the cathode-follower which is located just under the antenna so as to do the impeadance matching between the antenna and the input stage of receiver. The output of cathode-follower is connected to the common input of the various tuned receivers by the concentric cable. The output of any one receiver is then rectified and averaged with a time constant of about one minute and compressed logasumically for recording. The resulting voltage is recorded on paper moving two centimeters per hour.

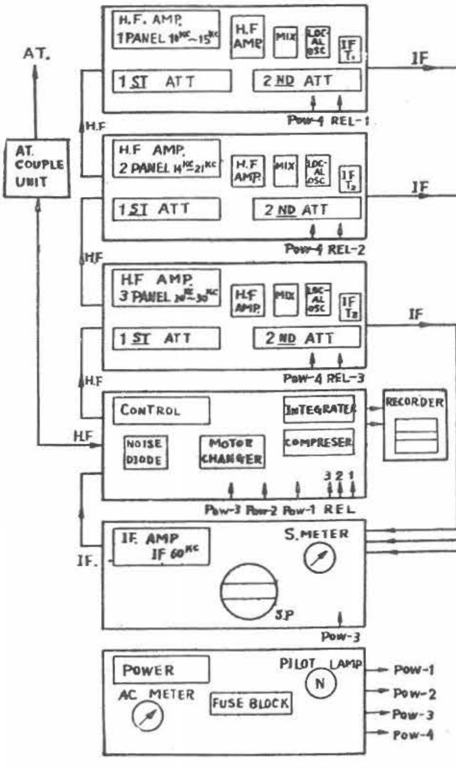

FIG. 1. Block diagram of apparatus.

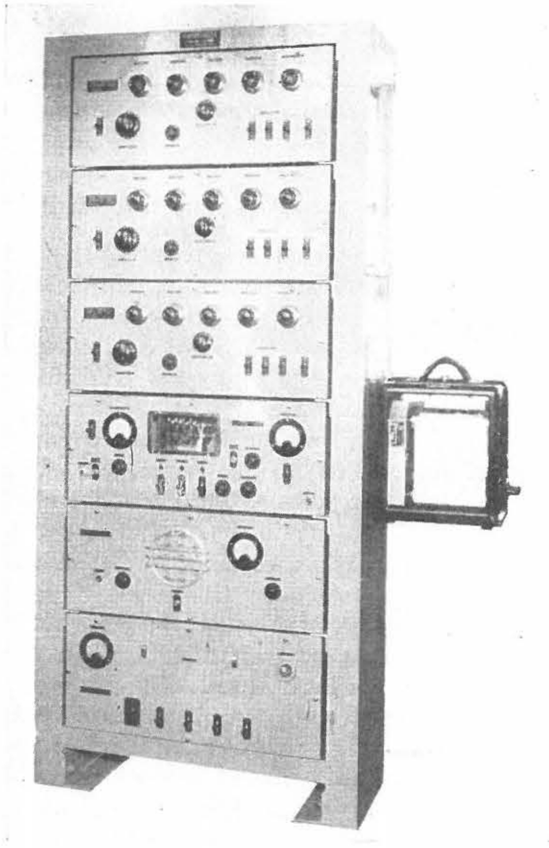

FIG. 2. Apparatus used.

The apparatus consist of four units, that is h-f amplifier unit, i-f amplifier unit, average detector and recording unit and power unit. The h-f amplifier unit

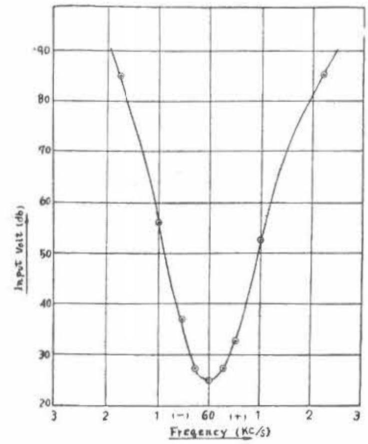

FIG. 3. Characteristic curve of *i-f* amplifier.

was divided into three panels owing to the difficulty to cover all required frequency ranges with the one tuned amplifier suit. Each panel has a frequency range from 10 kc/s to 15 kc/s, from 14 kc/s to 21 kc/s and from 20 kc/s to 30 kc/s respectively and consists of two tuned amplifier stages. The *i-f* amplifier unit consists of three stages to have the centre frequency of 60 kc/s and the band-width of 500 c/s at 6 db down point. The characteristic curve is shown in Fig. 3. This unit involves the monitoring circuit too.

The average detector and recording unit consist of the average detector, the switching equipment for the *h-f* amplifiers, the direct amplifier with the logasumic compressor to drive the recording meter and the noise generator for the calibration. Fig. 4 shows the character of compressor. The overall amplitude characteristic curve is shown in Fig. 5.

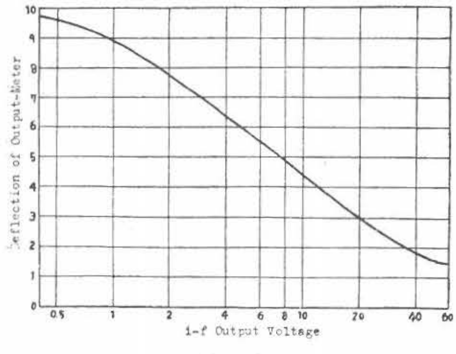

FIG. 4

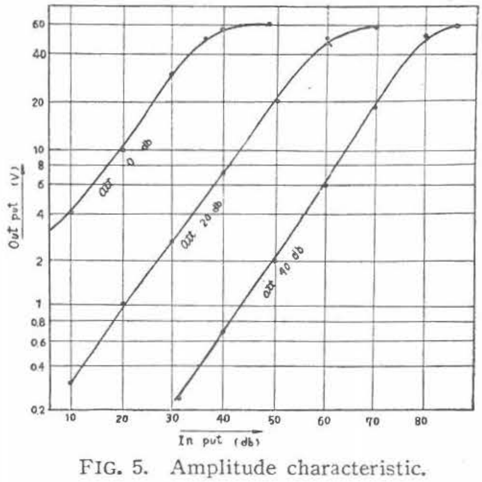

FIG. 5. Amplitude characteristic.

The "effective height" of the antenna used was calibrated by the relative calibration method to use the long radio waves (17.44 kc/s) emitted from Yosami station at 35 km apart from the receiving point. In 17.44 kc/s, the "effective height" is 4.5 meters.

In measuring the average value of the intensity of atmospherics, the integration method which had been employed by Gardner[1)] was used. Hence, the records obtained represent a runing mean of the input signal.

This intensity-meter was set up at the Research Institute of Atmospherics. The preliminary observation was carried out between September 1952 and December 1952. Records used in this paper were made between February and November 1953, at first on one frequency, and after April on three frequencies. The frequency component was selected 10 kc/s, 20 kc/s and 27 kc/s respectively from the atmospherics arriving. So as to threshold the background of receiver noise, zero calibration to the recording circuit was made every morning.

III. Results Obtained

In arranging the records obtained, the facts mentioned below have been noted.

(1) In the absence of near storm, the integrated level of atmospherics would be controlled by sources at a considerable distance.[1] Hence the day level would only show a comparatively small range of variations.

(2) Ionospheric propagation on long radio waves would be under the control of the D-region in daytime and the E-layer in night-time.

(3) The increase of day level in absence of S.I.D.'s would show the existence of local storm centre at a comparatively near distance.[1]

A. Diurnal Variation

Fig. 6 shows a typical record for diurnal variation on three frequencies when it was known by weather chart that there was neither thunderstorm, nor front, nor storm centre at any place to form the source of atmospherics within 1,000 km of Toyokawa.

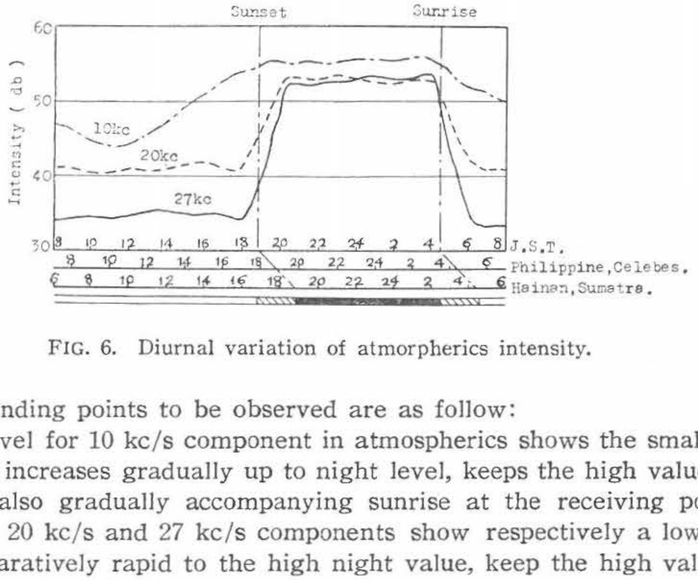

FIG. 6. Diurnal variation of atmorpherics intensity.

The outstanding points to be observed are as follow:

(a) The level for 10 kc/s component in atmospherics shows the smallest value at about noon, increases gradually up to night level, keeps the high value at night and decreases also gradually accompanying sunrise at the receiving point. The levels for both 20 kc/s and 27 kc/s components show respectively a low value in day, rise comparatively rapid to the high night value, keep the high value during night and fall rather sharply to the low day level. These are the well-known variation on long waves propagation. However, there is a fact to be noted that the limit of the appearence of effect accompanying sunise and sunset would be exist between 10 kc/s and 20 kc/s.

(b) Both the increase of level at sunset and the decrease at sunrise are exponential to the time. But the inclination is slow to the former and sharp to the latter.

(c) In general, the level is greater on the lower frequency. Especially it is evident in the daytime.

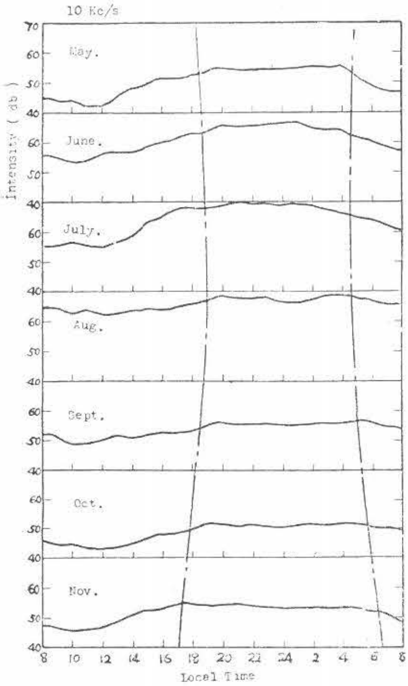

FIG. 7

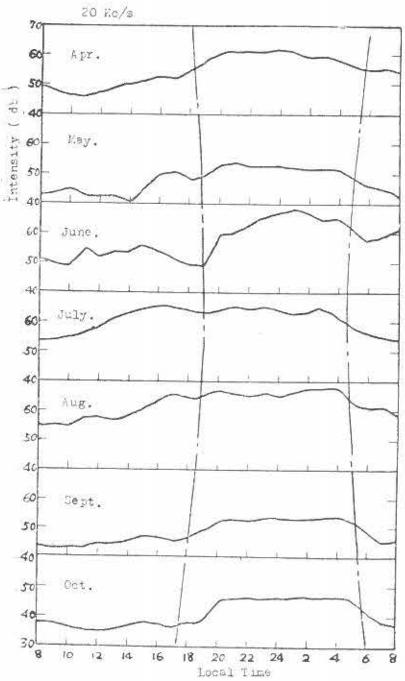

FIG. 8. Seasonal variation.

B. Seasonal Variation

Curves showing the diurnal variation in level to each frequency observed for each month of the year as well as the variations of sunset and sunrise are shown in Fig. 7, 8 and 9. Each curve is the avarage of all the measurments.

The outstanding points to be observed are as follow:

(a) As is already known,[2] the night level is similar to the frequency observed in respect to the high value through the year.

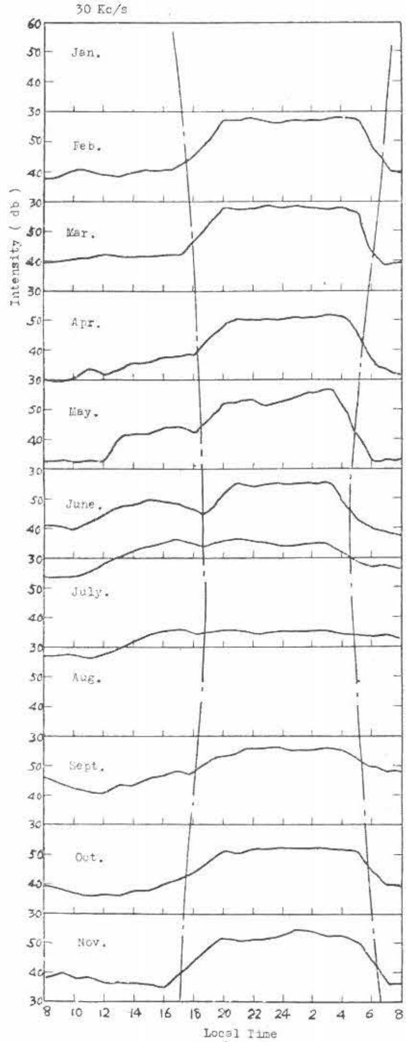

FIG. 9

(b) In Toyokawa, during the summer months the rise in night-level starts at about sunset and reaches high night level about two hours after, whereas in the winter seasons, the level begins to rise about one hour before sunset and reaches high night level about two hours later. The reduction of level sets in during the summer months about one hour before sunrise and reaches low day level about an hour later, and in the winter the reduction starts about one hour before sunrise and reaches low day level at about sunrise. This phenomena is rarely found in the records on 10 kc/s component.

(c) As L. Espenshied and others mentioned on their reports,[2] it is the facts surely noted that the sunset and sunrise at the receiving point do not directly control the leap of level. For, this phenomena could afford the suggestion to the seasonal sources of atmospherics and to the absorption of D-region. This aspect is illustrated in Fig. 10.

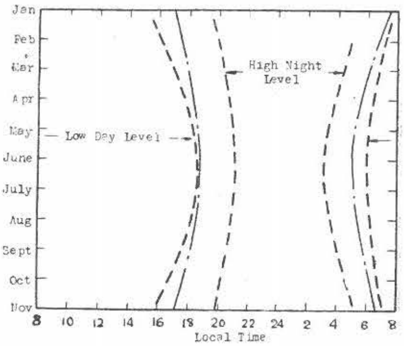

FIG. 10. Relation between the level and the sunrise and sunset line.

C. Frequency and Monthly Distribution

The distribution as a function of frequency is shown in Fig. 11 and the monthly distribution of level is shown in Fig. 12.

A tendency shown in Fig. 11 is similar to that obtained in England. The differece in the order of intensity of our results, as the different method has been used, seems to indicate the facts that the level of atmospherics is proportional to the inverse order of latitude and the major sources of atmospherics in the world are surely concentrated to the tropical zone.

In Fig. 12, the monthly distribution of level in the year shows two maximums and minimums. The level is almost the same order in the summer months on each frequency recorded. This shows that the level in the summer is mainly controlled by the near local thunder storms.

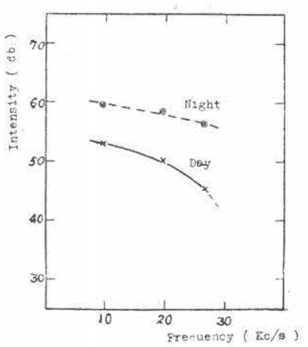

FIG. 11

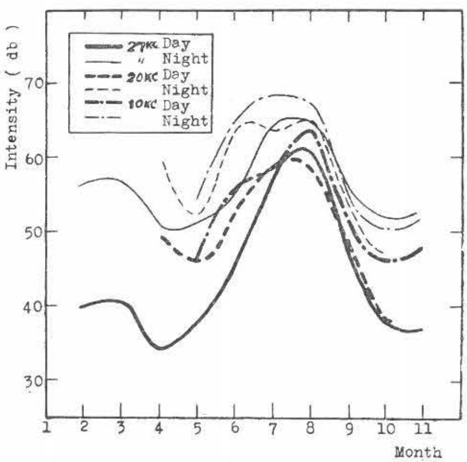

FIG. 12

D. Phenomena Occuring Near Sunrise

The phenomena occuring almost regularly near sunrise was described in Section A and B. The other phenomena observed at about sunrise is the secondary rise in the way of the reduction to low day level. This phenomena was observed frequently on frequency 20 kc/s and 27 kc/s until now and occurred more frequently in the latter frequency. In the propagation of long radio waves emitted from the station, this phenomena has already been observed in the case of the oblique incidence and considered that it can be attributed to twice reflected waves.[3] However, this subject seems to involve an outstanding question.

The ratios of the secondary rise to night level and the times of commencement are shown in Table 1.

TABLE 1

Date	Reductios Time	Increasing Time	Max / Nightlevel	Duration	Date	Reductios Time	Increasing Time	Max / Nightlevel	Duration
(27 kc)	h m	h m		h m	(27 kc)	h m	h m		h m
2. 4	6.00	6.40	0.50	0.10	5. 6	4.45	5.20	0.30	0.45
12	5.30	6.00	0.70	0.05	8	4.20	4.30	0.65	0.10
13	6.20	7.00	0.54	0.20	15	4.53	4.45	0.90	0.05
15	6.25	6.40	0.97	0.10	16	5.00	5.05	0.74	0.05
16	6.50	7.00	0.48	0.10	6. 2	4.35	5.15	0.44	1.00
20	6 30	6.45	0.36	0.05	11	4.30	4.40	0.80	0.02
21	6.10	6 20	0.83	0.10	12	4.30	5.10	0.28	1.00
23	6.20	7.00	0.47	0.15	13	4.10	4.20	0.60	0.02
24	6.00	6.30	0.17	0.25	7. 21	4.40	4.45	0.50	0.15
25	6.00	6.20	0.65	0.10	9. 2	5.30	6.00	0.55	0.10
26	6.00	6.50	0.20	0.15	10	5.45	5.50	0.80	0.30
27	6.10	6.40	0.35	0.15	23	5.25	5.35	0.66	0.10
28	6.00	6.20	0.45	0.05	24	5.30	5.32	0.60	0.10
3. 1	6.00	6.15	0.79	0.10	10. 1	5.30	5.35	0.70	0.05
4	4.00	4.30	0.35	0.25	2	5.30	5.35	0.70	0.05
5	6.15	6.30	0.37	0.10	4	5.40	5.40	0.50	0.30
6	6.00	6.10	0.82	0.05	12	5.45	6.00	0.58	0.45
7	5.40	6.05	0 86	0.10	13	5.40	6.00	0.60	0.50
9	5.45	6.00	0.95	0.10	14	6.00	6.20	0.55	0.25
11	6.00	6.20	0.37	0.20	17	5.30	6.30	0.66	0.45
12	5.50	6.40	0.12	0.15	18	6.00	6.10	0.72	0.25
13	5.45	6.25	0.25	0.15	23	5.50	6.10	0.50	0.10
15	5.40	6.30	0.16	0.10	24	5.50	6·20	0.30	0.10
16	5.45	6.20	0.30	0.20	25	5.50	6.00	0.79	0.15
26	5.40	5.55	0.80	0.05	26	5.55	6.05	0.65	0.03
27	5.30	6.02	0.56	0.35	29	6.07	6 22	0.47	0.25
4. 2	5.20	5.50	0.28	0.10	30	5.45	5.55	0.68	0.10
3	5.20	6.00	0.80	0.25	(20 kc)				
4	5.45	6.10	0.37	0.05	7. 9	5.15	4.35	0.69	1.15
5	5.50	5.55	0.95	0.05	17	4.25	5.00	0.72	0.30
6	4.40	4.45	0.70	0.05	29	4.45	4.55	0.48	0.05
7	5 20	5.50	0.63	0.05	8. 29	5.00	5.25	0.88	0.45
8	5.20	5.50	0.90	0.25	9. 20	5.45	5.50	0 45	0.10
13	5.15	5.30	0.44	0.10	10. 10	5.30	6.05	0.90	0.15
14	5.15	5.30	0.90	0.10	11	5.45	5.55	0.62	0.40
15	5.10	5.30	0.15	0.10	19	5.45	6.10	0.60	0.30
16	5.20	5.45	0.14	0.30	20	5.50	6.05	0.78	0.10
17	5.20	5.45	0.37	0.05	21	5.45	6.45	0.36	0.30
18	5.45	5.55	0.50	0.05	22	5.45	6.15	0.50	0.25
19	4.40	4.45	0.60	0.05					

E. Abnormal Increase at Solar Flare

Bureau (1937) has shown that a abnormal increase of the level of atmospherics recorded on frequencies in the range 20-40 kc/s very often occurs at the time of S.I.D.'s associated with solar flare. We have also confirmed his observation on frequency 27 kc/s, however, for want of the sufficient data to discuss this phenomena, we can only report a fact that the commencement of the increase of atmospherics level would have a tendency to occur before (about twenty minute observed in Oct. 15th 1953) the "Dellinger Fadeout".

IV. Discussion of Results obtained

In starting the discussion, it is necessary to note the information described in Section III.

Considering from the figure shown in Fig. 6, 7, 8 and 9, the curve of diurnal variation in level seems to indicate a model of the ionization condition in the D-region. For, if it were assume that the radiation power emitted from a considerable distant source is constant and no absorption exist, the level should be maintained the constant value in absence of local storm-centre. However, so as to exist the D-region in daylight hours, the long waves are absorbed and the levels of their intensity are sustained the reduction. Hence it might be imagine that the degree of reduction in level would be proportional to the degree of absorption in D-region. If this assumption were correct in idea, phenomenon observed in this measurement could be illustrated to a certain extent.

It stands to reason that in regard to these phenomenon, it should be necessary to consider both the seasonal location and variation of the main sources of atmospherics and the relations between that variation and the inclination of shadow line on the earth's surface through the year.

Now we attempt to illustrate the phenomena of earlier rise and fall in near ground sunrise and sunset. This condition is shown in Fig. 13. In this figure, the source of atmospherics and receiving point are shown respectively as "*A*" and "*R*".

The ionization in the D-region is caused principally by ultraviolet radiation from the sun and the absorption varies in synchronism with the elevation of the

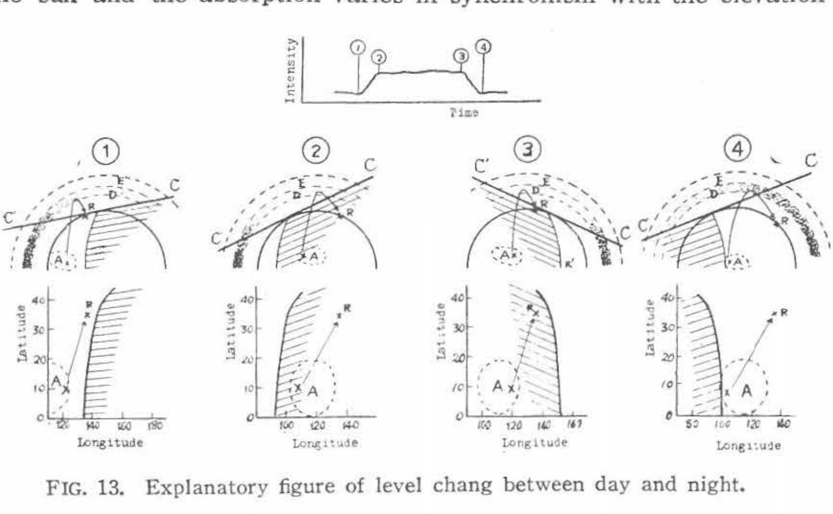

FIG. 13. Explanatory figure of level chang between day and night.

sun over the horizon.[3] Hence, in sunset, as shown in Fig. 13-1, as the propagation path between the seasonal source "*A*" and "*R*" (Toyokawa) is almost parallel to the sunset line throuh the year, the photon density per unit area above that path decreases and the density of ion of the D-region in this part gradually decreases. Then the absorption is less than that in the afternoon and the level begins to rise gradually. A similar effect is considered for the sunrise condition (see Fig. 13-3) wherein we supporse that the ionization process perform firster than in the sunset so as to be in additional condition to the photon from the sun. Hence the inclination of the leap of level is more sharp in the sunrise than in the sunset.

As D-region absorption is greatest at noon at latitudes directly beneath the sun,[3] it might be considered that 10 kc/s component having a poor absorption in D-region has only one minimumpoint at about noon in the level of atmospherics. This tendency is found out in Fig. 6 and 7.

In the abnormal increase at solar flare, we fall in with the views that there often occurs abnormally higher D-region ionization coincident with the appearence of solar flares and this increase in ionization makes the region a better conductor and so the intensities of long radio waves are increased.[3] More satisfactory information of D-region will have to explain these results.

References

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