11. *Observations on Earth Current during the Solar Eclipse of June 19, 1936.*

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1. Variations in the intensity and direction of the earth current which are expected to accompany solar eclipses should be observed not only in the belt of total eclipse but also in zones of partial eclipse as well as in localities where the eclipse is invisible, although obviously, the amount of variation decreases with distance from the total eclipse belt. Since in the case of the total eclipse of June 19, 1936, totality in the Kwanto district was from 75 to 80%, it was decided to carry out simultaneous observations with instruments of increased sensitivity and recording speed at our permanent earth current stations that had been set up in different localities in the Kwanto district primarily with the object of detecting variations in the earth current in connexion with earthquakes and volcanic eruptions.

In conformity with this plan, Drs. T. Hagiwara, T. Minakami, W. Inouye, T. Nagata, and the writer took charge of the instruments respectively at Tukuba, Asama, Komaba and Kiyosumi.

2. All these stations had virtually the same equipment for observing the earth current. For electrode, a lead tube, with an inner diameter of from 1/2″ to 1/4″ and from 5 to 10 meters long, is bent in the form of a spiral and imbedded horizontally in the ground at a depth of 2 meters. The leading wire, usually rubber-covered copper, is soldered to the electrode. The junction of the copper wire and the lead tube is perfectly protected with a compound insulating material (asphalt). To minimize the thermoelectric effect caused by temperature variations, this junction is placed about 1·5 m below the ground surface. The leading wire is brougt to the ground surface through a conduit-tube filled with asphalt. The arrangement of the electrode is shown schematically in Fig. 1.

At Kiyosumi, each pole consisted of two such electrodes imbedded 5 meters apart from each other, and with a view to balance local polarization effects connected in parallel. At the other stations, each

pole consisted of only one electrode. Particular care was exercised in installing the electrodes in order to have the conditions at each pole the same as far as possible.

The distance between poles at the different stations differed with the topography of the particular station. The method of observation was almost the same in all the stations: a gavanometer was inserted between the poles, togather with a high resistance of $10^4 \sim 10^5$ ohms connected in series. The deflection of the galvanometer was recorded photographically on a sheet of bromide paper wound on a drum which revolved once a day. At the Asama Volcano Observatory, recording drums that revolved twice a day were used. Details of the apparatus at each station are given in the annexed table.

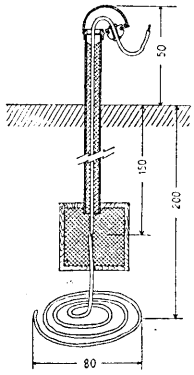

Fig. 1. The electrode.

Name of Station	Latitude	Longitude	Component	True Direction	Distance btw. Poles
					m
Kiyosumi	35°·2	140°·2	E-W	Due E	130
			N-S	Due N	150
Tukuba	36·2	140·1	N-S	Due N	65
Asama	36·4	138·5	E-W	E 10°S	80
			N-S	N 15°E	100
Komaba	35·6	139·7	N-S	Due N	50

3. Simultaneous observations were caraied out from June 17 to June 30. Parts of the records obtained at each station, and which correspond to several hours both before and after the eclipse are shown in Fig. 2, Pl. XI. The time shown in the figure is Japan Central Standard Time (135°E meridian). The beginning and ending of the eclipse are shown by white circles under the time marks, and the center of the eclipse by a black circle.

As will be seen from the figure, a remarkable earth current storm broke out on June 19 about 6 hours before the eclipse and lasted till 2 h the next day, that is, 8 hours after the end of the eclipse. The records of the E–W and N–S components obtained at Kiyosumi station closely resemble one another in form with respect to the variation, although in the N–S component there is a marked shift of zero (the daily variation). The corresponping pronounced peaks in each record are shown by capital letters.

It is worthy of note that the form of the record obtained at Tukuba station is identical with that obtained at Kiyosumi station, notwithstanding that a distance of 100 km separates the two stations. These variations are not therefore the result of local disturbances, but of some other general causes.

The form of the records obtained at the Asama Volcano Observatory somewhat resembles those obtained at Kiyosumi, although the former was disturbed severely by short-period disturbances that are probably due to the electric trains at Usui Pass, near Karuizawa.

The records of earth current obtained at Komaba turned out to be quite useless for the present purpose, owing to serious disturbances by the electric railway that passes within 100 meters of the station.

4. According to T. Okada[1], M. Hasegawa[2], S. Ono[3], T. Otagaki[4], S. Shinjo[5], and others, a remarkable magnetic storm was observed on June 19 for many hours both before and after the eclipse, in Hokkaido as well as in Manchoukuo. The forms of variations in these magnetic storm exhibit many similarities with those of the earth current observed by us, whence it is not possible to conclude that the observed variations in the earth current were all due to the eclipse, although it can be said that it is very intimately related to the magnetic storm. In this connection it will be noticed that a magnetic storm has usually little effect on the earth current at Kiyosumi and Tukuba. It is therefore worth noting that on the case of the solar eclipse, the earth current underwent a variation the same as did terrestrial magnetism.

If, however, the intensity and the height of the ionized layers in the upper atmosphere vary with the eclipse, there must necessarily occur variations in terrestrial magnetism as well, while at the same time the quantity of electric charge induced on the surface of the earth must also vary, resulting in variations in the earth current. According to the theory of Chapman[6], and others, these variations should be of comparatively simple forms. We understand from the Electrotechnical Laboratory, Ministry of Communication, that the ionic densities of the E and F_1 layers diminished during the eclipse, so that certain phases of the observed variation in the earth current may have been due to the eclipse.

The difficulties at present in identifying such phases in the records

1), 2), 3), 4), 5), Preliminary short reports of magnetic and electric observations made in the Far-East during the total solar eclipse of June 19th, 1936. Communication by the National Committee of Japan on Terrestrial Magnetism and Electricity.

6) S. CHAPMAN, *Terr. Mag.*, **38** (1933), 175.

of the earth current are however so great that conclusive discussions will have to await publication of the detailed observational data of terrestrial magnetism and of the ionospheric phenomena.

In conclusion, the writer wishes to express his sincere thanks to Professer M. Ishimoto, the director of this Institute, for his encouragement, and also to Drs. T. Hagiwara, T. Minakami, W. Inouye and T. Nagata, who have put the results of their observations at the writer's disposal.

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11. 昭和 11 年 6 月 19 日の日食時に於ける地電流の觀測

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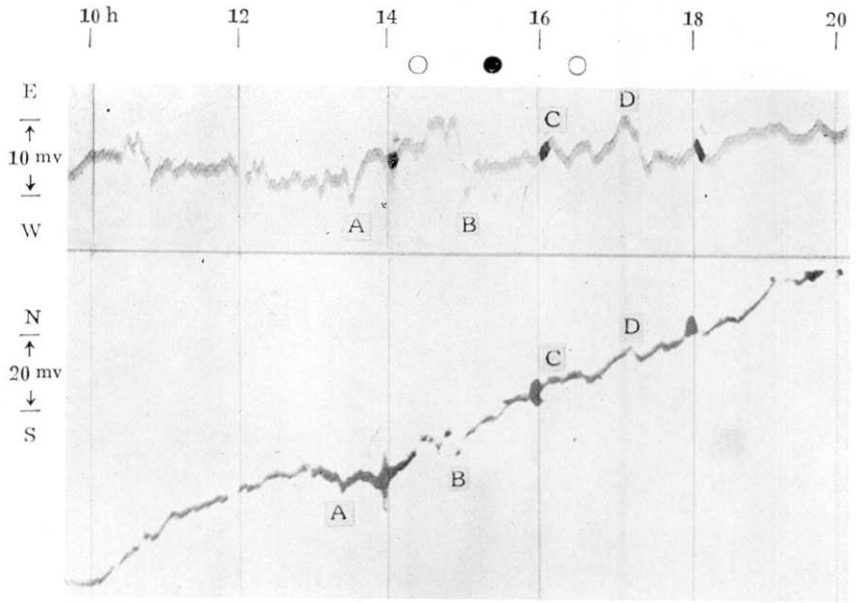
昭和 11 年 6 月 19 日北海道に於ける皆既日食に際し，關東地方に於ては大凡 80% の食分なりしを以て，地震研究所支所の內，地電流觀測設備を有す所に於ては，平常よりも器械の感度を增大し，記錄速度を增大して，日食に原因する地電流の變化を觀測せんと試み，同時觀測を行ひたり．本文第 2 圖は其の記錄の一部分にして日食の前後數時間に相當するものなり．

各地に於ける地電流の變化の模樣は大凡相似なれども，生憎日食當日は日食の數時間前より日食後十數時間に亘りて地磁氣亂ありて第 2 圖に示せる地電流の變化が悉く日食に原因するものと言ふ可からず．此の內に日食と直接關係を有するもの有りや無しやは他日地磁氣，イオン層等に關する觀測結果の發表を俟ちて更に是を研究せんとす．



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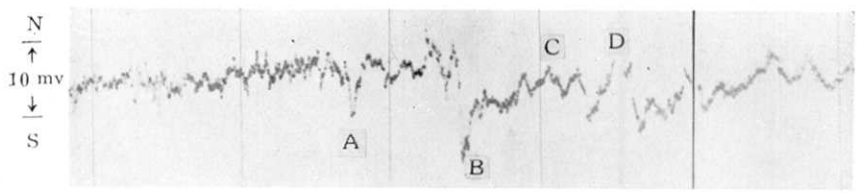
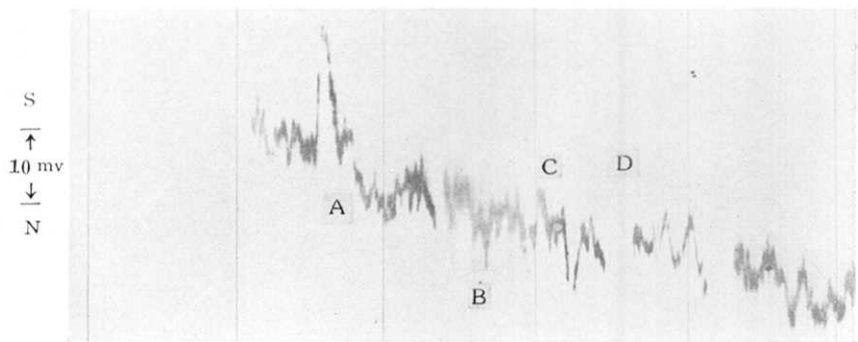


TUKUBA.



ASAMA.

(震研彙報 第十五號 圖版 高橋)

Fig. 2. Records of the earth current obtained at Kiyosumi, Tukuba and Asama, during the solar eclipse of June 19, 1936.