THE MAGNETIC STORM

OF SEPT. 25 1909

BY

DAVID STENQUIST

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On the 26th Sept. 1909 the following article, which gave origin to this paper, was to be read in the newspaper Stockholms Dagblad.

Magnetic storm over Scandinavia.

From noon on Saturday (the 25th Sept.) Stockholm's Telegraph Office was next to quite isolated from others offices in consequence of the unexempled extremely earth currents, that appeared at this time. At times these currents exceeded 150 milliamperes. Only at the nearest offices one was able to uphold the communications, while this has been impossible with more distant places. St. Petersburg is the only foreign office with which Stockholm had any communication, and this only at times. With the northerly offices, the forwarding of telegrams could, however, begin against seven o'clock, also with Göteborg; but on the other hand all communication with Malmö, Germany and Denmark was impossible.

By the kindness of the Royal Swedish Telegraph Direction I have been able to collect material for two articles (published in »Bilaga till Telegrafstyrelsens Månadscirkulär», 1909 and 1910), about this magnetic storm and similar interruptions in the telegraph-communications in Nov. 1906 — Okt. 1909. These points are to be found chiefly in chapter II of this paper.

By the Swedish Meteorological Central Office I have been invited to use its material of the aurora borealis on the 25th Sept. The results are to be found in a paper in Arkiv för Matematik, Astronomi och Fysik, 1910 and in chapter III of this paper.

In order to make a closer study of the magnetic storm I applied, in the year 1912, to a number of magnetic observatories spread over the whole world, and requested copies of the curves to be obtained from photographic registrating magnetic instruments. Such copies or originals of the photogrammes have been sent by the observatories mentioned below, to whom I now avail myself of the occasion to express my heartfelt thanks.

Mauritius, Royal Alfred Observatory, A. Walter.
Samoa, Observatorium der Königlichen preussischen Gesellschaft der Wissenschaften zu Göttingen. Dr. Kurt Wegener.
Batavia, Koninklijk Magnetisch en Meteorologisch Observatorium. Dr. W. van Bemmelen.
Kodaikanal, Toungoo, Barrackpore och Dehra-Dun, No. 18 Party (Magnetic), Survey of India, Captain R. H. Thomas. R.E.
Bombay, Government Observatory, N. Atmor.
Honolulu, Cheltenham, Baldwin and Sitka, Coast and Geodetic Survey Magnetic Observatories, O. H. Tittman.
Lu-kia-Pang, Observatoire magnétique, J. de Moidrey S. J.
Tokio, The Central Meteorological Observatory of Japan.
San Fernando (Cadiz) Instituto Y Observatorio de Marina, General T. de Alzcarate.
Toronto, The Central Office Meteorological Service of Canada.
Pola, K. u. K. Hydrographisches Amt. Abteilung »Geophysik», Fregattenkapitän W. v. Kesslitz.
München, Kgl. Erdmagnetisches Observatorium u. Erdbebenstation (Sternwarte) Dr. C. W. Lutz.
Falmouth, The Observatory, Edward Kitto, F. R. Met. Soc.
Uccle, Observatoire royal de Belgique.
Greenwich, Royal Observatory, London, S. E. W. F. Dyson.
De Bilt, Ned. Met. Institut te de Bilt, G. van Dyk.
Wilhelmshafen, K. Marine Observatorium, Korvettenkapitain H. Capelle.
Stonyhurst, College Observatory, W. Sidgreaves S. J.
Jekaterinburg, Obs. de l'Akad. imp. des sc. de Saint-Petersburg, Dr. P. Müller.

From the observatories with high latitudes in the southern hemisphere I have not got any records.

In drawing the magnetic maps, I have done as Adolf Schmidt in his paper, Über die Ursache der magnetische Stürme (Met. Zeitschrift *16*. 385—397, 1899). The same method has been used by Birkeland in his great treatise about magnetic storms. Other authors, who have written about these things, are C. Chree (Studies in Terrestrial Magnetism, London 1912) and L. A. Bauer (Papers in Terr. Magn. and Atm. Electr.)

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CHAPTER I

MAGNETIC RECORDS

I have made use of the records I received of the variations of the magnetic elements (declination, horizontal and vertical components) in the following manner. Firstly, a nought-line drawn on the curve-sheets, showing the undisturbed condition. This could really be done without difficulty, the magnetic condition. immediately before the outbreak of the storm being of an unusually calm character. From this nought-line (time-line) as absciss-axis, the ordinates of the curves were measured in 1/10 mm. The ordinates belonging to the curves for horizontal and vertical components are multipied by the constants k' and k''' respectively, which express the number of γ respondent to 1 mm of the ordinates. As to the curves for the magnetic declination, the millimeter numbers of the abscissae are multiplied by the expression

$$\frac{\pi}{180 . 60} \cdot H . k = k''$$

where H is the horizontal component, expressed in γ, of terrestrial magnetism for the place and time in question, and k is the constant, giving the value of 1 mm of the ordinata in minutes.

The following is to be observed in regard to the signs for k', k'' and k'''.

k' is positive, when increasing ordinates correspond to the increasing horizontal component.

k'' and k are positive, when increasing ordinates correspond to increasing easterly declination.

k''' has different signs, depending on the situation of the place of observation on the N or S-side of the equator. In the first case k''' is positive, if increasing ordinates correspond to increasing value of the vertical component, negative if increasing ordinates correspond to decreasing values of the same component.

The products thus received from the millimeter number of the measured ordinates, and k', k'', and k''' respectively, represent the disturbing vectors, which can be supposed to be superposed on the normal terrestrial field. The superposed disturbing vector in a vertical direction is marked by dZ (positive towards the centre of the earth), that in horizontal N.S. direction by dH (positive towards N), that in horizontal E.W. direction by dD, (positive towards E).

dH, dD and dZ are calculated for every half hour from 8 a.m. to 10 a.m. and every quarter of an hour from 10 a.m. to 10 p.m. on Sept. 25th. and for every hour from Sept. 25th. at 10 p.m. to Sept. 26th. 5 a.m.[1]) Only a part of these dates have been employed in this paper. Further hour-observations have been calculated for Tokio, Berlin and Baldwin from the different observatories' respective papers, up to and including the early hours of Septh. 30th. In the Berlin publication not the instantaneous but the average values for the whole hours are given. This causes a dissimilarity of little or no importance.

In order to give a surveyable picture of the distribution of disturbing forces over the globe, I have drawn arrows on twenty seven maps, each one corresponding to a definite time, which represent the disturbing force in horizontal direction (the resultant of dH and dD). In regard to the

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[1]) All times given in Chapter I are G. M. T., in Chapters II and III mid-European, excepting in table XXIII.

tables belonging some of these maps, the following remarks must be taken note of:

dH, dD and dZ have been tabulated in columns 2, 3 and 6. Further dH and dD (the projections of the disturbing vector on the magnetic north and east directions) have been transformed to dX and DY (the projections of the same vector on geographic north and east directions) and have been tabulated in columns 4 and 5. In order to transform dH and dD to dX and dY the following expressions are used:

if an easterly declination,

$$dX = dH \cdot \cos\delta - dD \cdot \sin\delta$$

$$dY = dH \cdot \sin\delta + dD \cdot \cos\delta$$

if a westerly declination,

$$dX = dH \cdot \cos\delta + dD \cdot \sin\delta$$

$$dY = -dH \cdot \sin\delta + dD \cdot \cos\delta$$

Further dX, dY and dZ have been projected on the axis of an orthogonal coordinate-system, with the origin in the centre of the earth. In this system x$'$-axis coincides with the earth's axis of rotation (positive towards the North Pole). The y$'$-axis coincides with the equatorial-axis, the longitude of which is 90° E, and z$'$-axis with the equatorial axis, the longitude of which is 0 (Greenwich' meridian). The components along the x$'$-, y$'$- and z$'$-axes are marked by dX', dY' and dZ' respectively, and are tabulated in columns 7, 8, and 9. If φ signifies the geographical latitude of the place of observation, and λ is the longitude of the same place, taken positive East of Greenwich, then the following formulae for the transformation just named is to be used.

$$dX' = dX \cdot \cos\varphi - dZ \cdot \sin\varphi$$

$$dY' = dX \cdot (-\sin\lambda \cdot \sin\varphi) + dY \cdot \cos\lambda - dZ \cdot (\sin\lambda \cos\varphi)$$

$$dZ' = dX \cdot (-\cos\lambda \cdot \sin\varphi) + dY \cdot (-\sin\lambda) - dZ \cdot (\cos\lambda \cos\varphi)$$

In column 12 the total disturbing vector R (the resultant of dX', dY' and dZ') is to be found. In column 10 the longitudes and in column 11 the latitudes are given for the points, where R cuts the surface of the earth.

TABLE I.

		Lat.	Long.
1	Mauritius	20° 5′ S	57°33′ E
2	Samoa	13°48′ S	171°44′ W
3	Batavia	6°11′ S	106°50′ E
4	Kodaikanal	10°14′ N	77°27′ E
5	Bombay	18°38′ N	72°52′ E
6	Toungoo	18°56′ N	96°27′ E
7	Honolulu	21°19′ N	158° 3′ W
8	Barrackpore	22°46′ N	88°22′ E
9	Dehra-Dun	30°19′ N	78° 3′ E
10	Lu-kia-Pang	31°21′ N	121° 1′ E
11	Tokio	35°41′ N	139°45′ E
12	San Fernando	36°28′ N	6°12′ W
13	Cheltenham	38°44′ N	75°50′ W
14	Baldwin	38°47′ N	95°10′ W
15	Toronto	43°40′ N	79°24′ W
16	Pola	44°52′ N	13°51′ E
17	München	48° 9′ N	11°37′ E
18	Falmouth	50° 9′ N	5° 5′ W
19	Uccle	50°48′ N	4°22′ E
20	Greenwich	51°29′ N	0°
21	De Bilt	52° 6′ N	5°11′ E
22	Wilhelmshafen	53°32′ N	8° 9′ E
23	Stonyhurst	53°51′ N	2°28′ W
24	Jekaterinburg	56°50′ N	60°38′ E
25	Sitka	57° 3′ N	135°20′ W

In table 1 the geographical co-ordinates of the different points of observations are arranged. In table II the values of k', k, k'', k''' are to be seen. In order to be able to calculate k'' it is necessary to know H. In those cases where the observatories themselves have not given the values, I have gathered information from Winkelmanns Handbuch der Physik and from Terrestrial Magnetism and Atmospheric Electricity.

On L. A. Bauer's initiative a great many observatories have with all possible accuracy fixed the time for two es-

TABLE II.

	k'	k	k''	k'''
Mauritius	5.17	1'.58	10.75	7.4
Samoa	5.07	0'.497	5.23	5.20
Batavia	2.29	0'.26	2.92	5.0
Kodaikanal	6.04	1'.01	10.99	6.37
Bombay	4.56	1'.028	11.06	9.29
Toungoo	5.32	1'.02	11.50	5.22
Honolulu	2.36	1'.00	8.49	2.36
Barrackpore	4.78	1'.01	10.87	4.45
Dehra-Dun	4.00	1'.01	9.79	5.00
Lu-kia-Pang	5.52	0'.48	4.32	6.55
Tokio	5.82	1'.33	11.26	7.12
San Fernando	7.75	1'.14	8.22	—
Cheltenham	1.70	1'.01	5.79	8.20
Baldwin	5.12	0'.99	6.21	2.96
Toronto	5.2	1'.28	5.97	—
Pola	5.16	1'.07	6.87	4.83
München	4.34	1'.23	7.52	—
Falmouth	5.3	1'.18	6.11	5.0
Greenwich	5.28	1'.095	4.91	6.4
Wilhelmshafen	4.45	1'.15	6.09	—
Stonyhurst	5.3	1'.128	5.6	4.5
Jekaterinburg	4.84	1'.02	5.20	4.86
Sitka	2.95	1'.01	4.57	2.57

pecally prominent points in the magnetic records, and the results have been published in Terr. Magn. for the year 1912. The values of the second of these points of time, which can be considered as the beginning of the great disturbance of Sept. 25th, have been arranged by me in table III. From the *H.* records the storm is calculated to begin at $11^h\ 41,_{25}{}^m$. From the *D.* records $11^h\ 41,_{32}{}^m$ and from the *Z.* records $11^h\ 41,_{89}{}^m$. According to this the disturbance is said to have first shown in the *H*-curves, then in the *D*-curves and lastly in the *Z*-curves. As average value we have $11^h\ 41{,}_{49}^m$ G. M. T.

On the plates I—IX in the end of this paper the records which have been received from the different observatories are reproduced. A scale is given underneath every plate, the length of which is corresponding to 10 cm. When reproducing the curves they have

TABLE III.

	H	*D*	*Z*
	h m	*h m*	*h m*
Batavia	11 42.6	11 42.0	11 42.6
Kodaikanal	11 41.9	11 40.8	11 40.4
Bombay	11 42.2	11 41.4	11 41.2
Toungoo	11 40.2	—	11 41.6
Honolulu	11 45.4	11 46.3	11 49.0
Barrackpore	11 42.2	11 40.1	11 42.7
Dehra-Dun	11 41.5	11 41.7	—
Lu-kia-Pang	11 40.	11 38.	11 39.
Cheltenham	11 43.3	11 42.1	11 45.1
Baldwin	11 41.1	11 40.8	11 41.1
Toronto	11 41.5	11 39.7	—
Pola	11 39.4	11 42.4	11 39.0
München	11 39.0	—	—
Uccle	11 41.4	11 43.4	11 42.6
Greenwich	11 40.	11 40.	11 40.
De Bilt	11 41.0	11 41.5	—
Wilhelmshafen	—	11 39.4	—
Jekaterinburg	11 40.0	11 40.7	11 40.3
Sitka	11 39.8	11 42.2	—
Average value	11 41.25	11 41.32	11 41.89

been reduced to about 1/3 of the original. All measurement are made on the leaves of the original records. There is an arrow at the end of every curve giving the size and direction of the disturbing force. On *H* and *Z* plates the length of the arrow corresponds to 400 γ, and the direction of the same gives the direction of the increasing values of *H* and *Z*. On *D* plates the length of the arrow correspond to 1°. and direction of the same to the increasing values of an easterly declination. M indicates midnight. The distances between two marks belonging to the time-line are four hours.

All the records are, however, not complete, the greatest blanks occuring on the *H* curves. The only complete records have been obtained from Samoa, San Fernando, Greenwich and Jekaterinburg. The following values for maximum variation have been received from those observatories:

Samoa	730 γ
San Fernando	632 γ
Greenwich	1680 γ
Jekaterinburg	1840 γ

The spots of light have gone beyond the paper for the remaining stations. In one case — Bombay — however, it has been possible, by readjusting the instrument, to obtain the light spot again on the paper. The point in question is to be seen on plate marked with * and the change made here corresponds to 4.12 cm or 188 γ. In the following table the values of the variation are given, for which the light spots have gone beyond the paper:

Mauritius	660 γ
Kodaikanal	691 γ
Bombay	658 γ
Toungoo	486 γ
Honolulu	461 γ
Dehra-Dun	460 γ
Barrackpore	414 γ
Lu-kia-Pang	570 γ
Cheltenhamn	281 γ
Baldwin	734 γ
Toronto	718 γ
Pola	371 γ
München	607 γ
Falmouth	680 γ
Stonyhurst	689 γ

On plate D the maximum values of the variation can be obtained from the following stations

Mauritius	55′
Samoa	10′
Baldwin	17′
Kodaikanal	16′
Bombay	25′
Toungoo	26′
Honolulu	43′
Barrackpore	37′
Dehra-Dun	34′
Lu-kia-Pang	48′
San Fernando	1°33′
Pola	1°47′
München	2°20′
Jekaterinburg	3°44′

The light spot has left the paper at the values here given for the following observatories:

Tokio	44′
Cheltenham	1°22′
Toronto	2°38′
Falmouth	1°38′
Greenwich	3°54′
Wilhelmshafen	2° 9′
Stonyhurst	2°35′

The highest values are observed for Jekaterinburg (3°44′) and for Greenwich (3°54′), where the actual maximum variation has not been observed.

For the vertical component, the maximum values of the variation have been noted at the following places, where one must, however, notice an insignificant interruption in the Mauritius and Samoa records.

Mauritius	134 γ
Samoa	62.2 γ
Kodaikanal	274 γ
Bombay	158 γ
Toungoo	57.3 γ
Barrackpore	98.0 γ
Dehra-Dun	231 γ
Lu-kia-Pang	184 γ

Tokio	257 γ
Jekaterinburg	1470 γ

There has, on the other hand been an interruption for the following observatories for the values:

Batavia	510 γ
Honolulu	137 γ
Cheltenham	820 γ
Baldwin	196 γ
Pola	237 γ
Falmouth	461 γ
Greenwich	1020 γ
Stonyhurst	568 γ
Sitka	365 γ

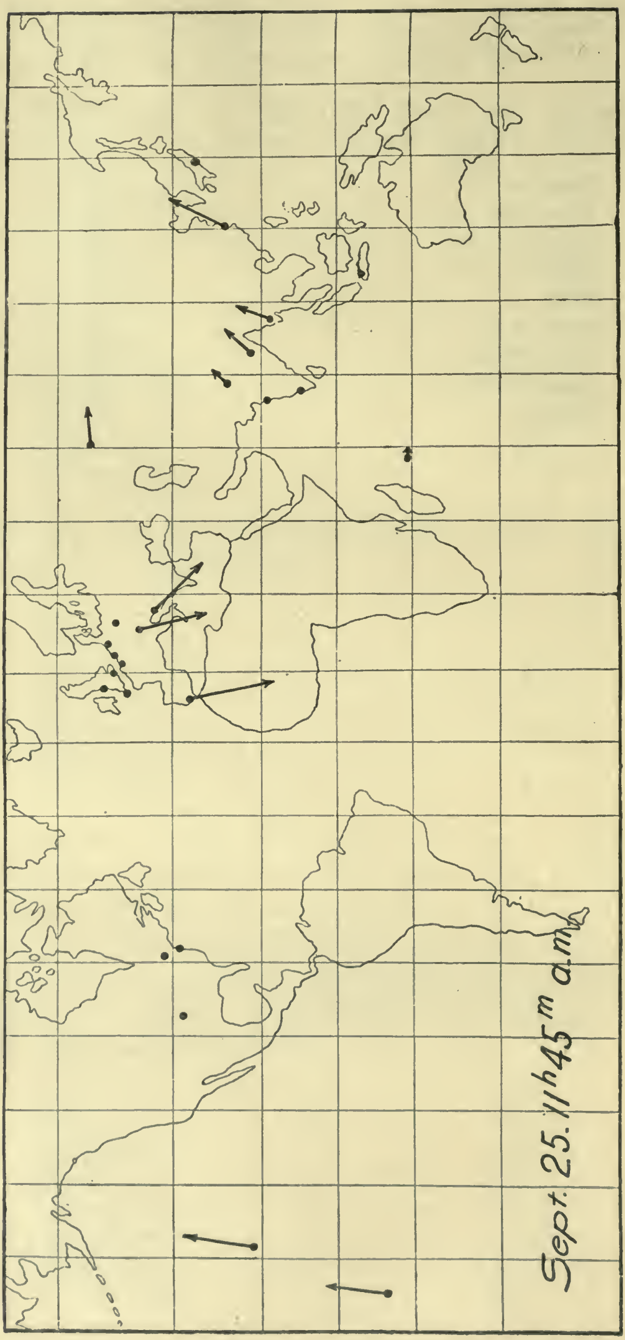

Fig. 1.

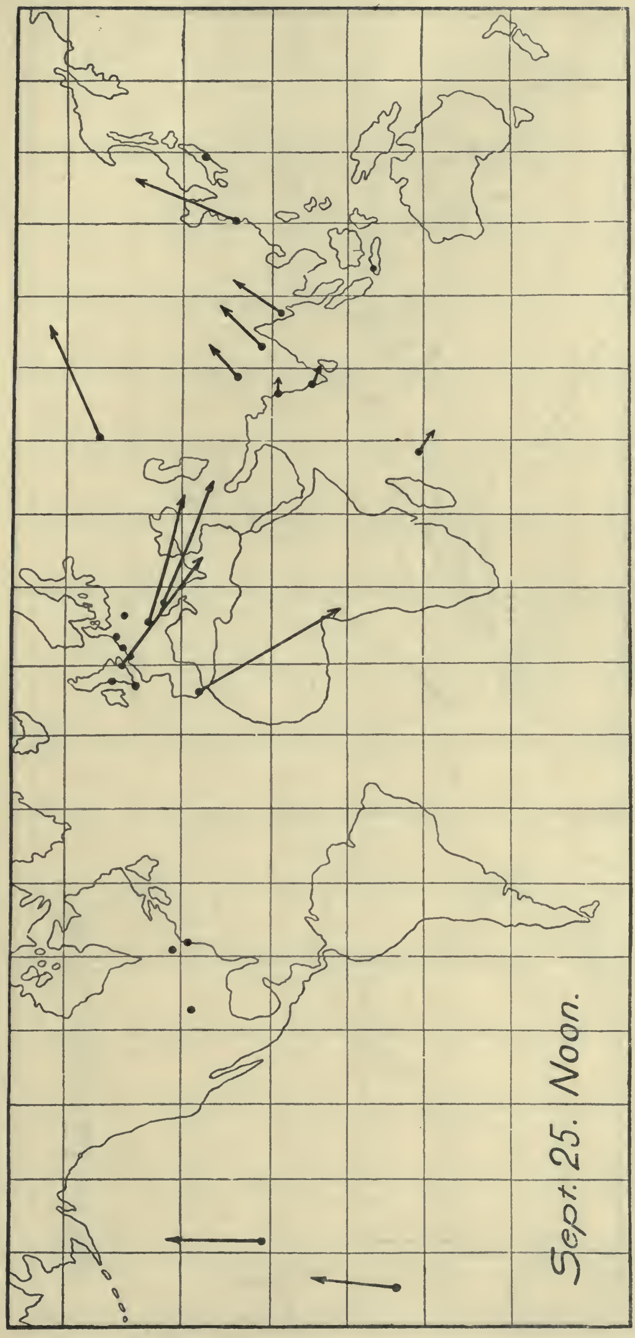

Fig. 2.

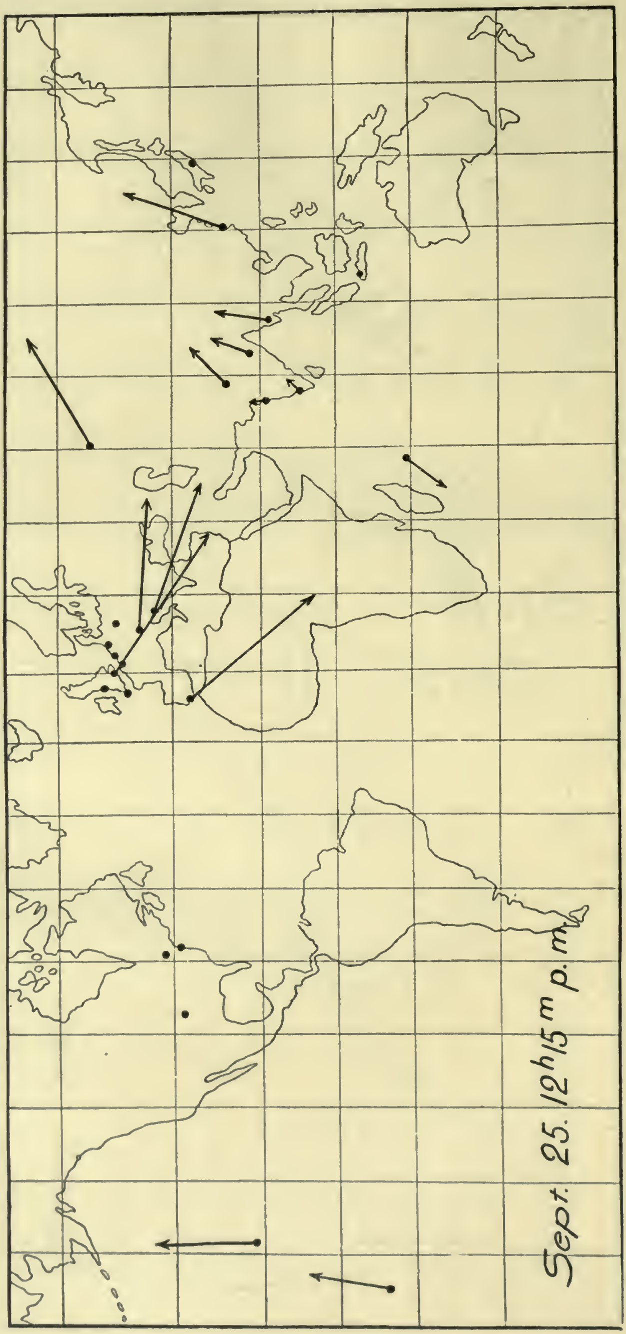

Fig. 3.

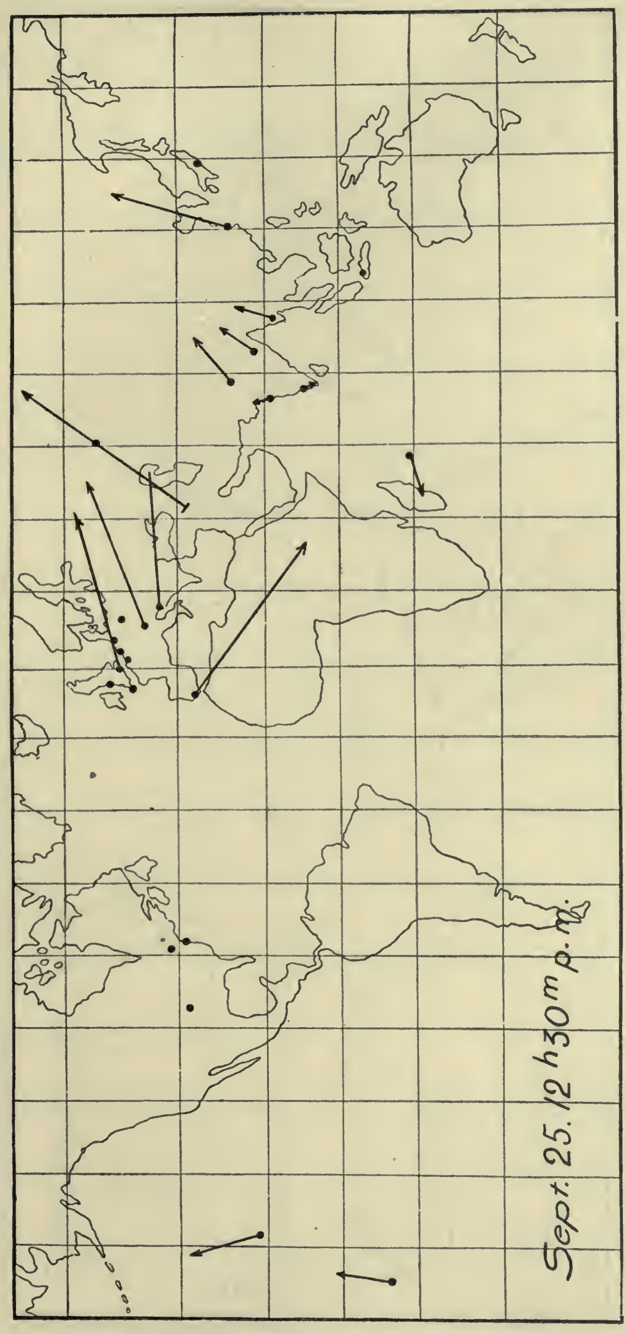

Fig. 4.

Fig. 5.

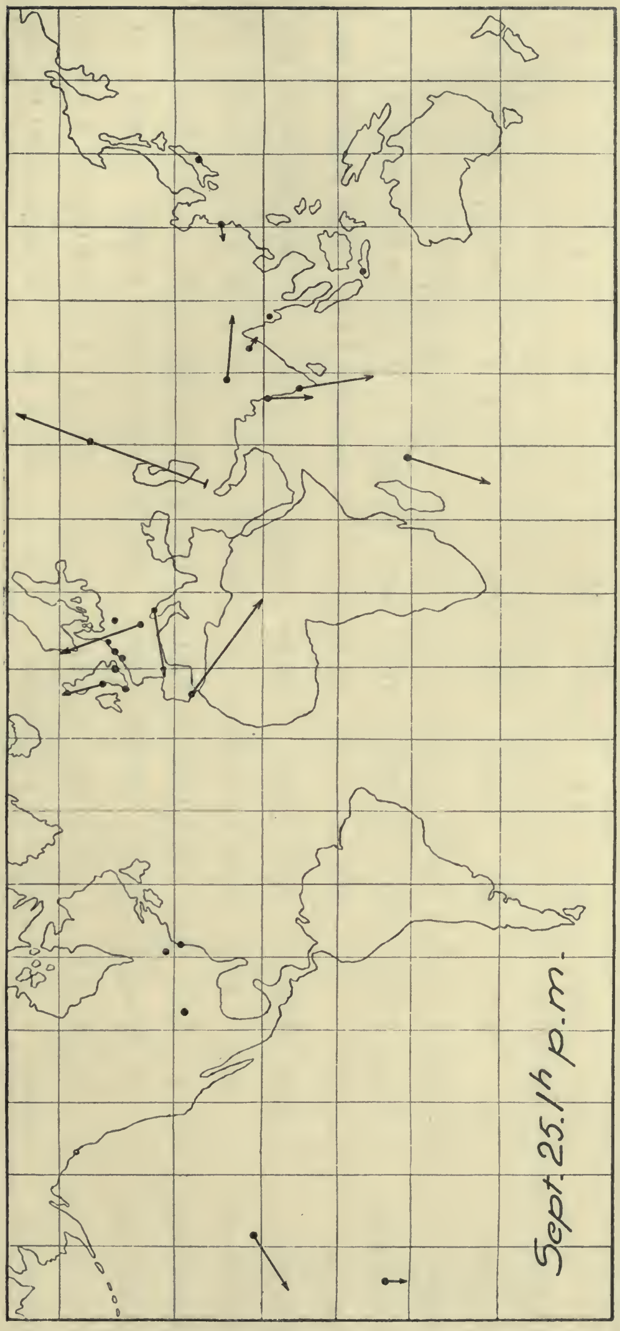

Fig. 6.

TABLE IV.

25 Sept. 1^h *p. m.*

	dH	dD	dX	dY	dZ	dX'	dY'	dZ'	φ	λ	R
Mauritius	—217.	*W*107.	—231.	— 69.9	— 22.2	—225.	— 87.5	+ 27.3	67°40′*S*	72°40′*W*	243.
Samoa	— 71.0	*E* 5.2	— 70.9	— 6.7	+ 9.4	— 66.6	+ 10.4	+ 24.7	67°20′*S*	23° 0′*E*	72.
Kodaikanal ..	—200.	*E* 22.0	—200.	+ 24.6	— 70.1	—185.	+107.	— 1.5	60° 0′*S*	90°50′*E*	214.
Bombay	—106.	0	—106.	— 1.8	+ 37.1	—112.	— 66.9	+ 1.4	50°20′*S*	88°50′*W*	130.
Honolulu	—112.	*W*138.	— 88.8	—155.	— 56.5	— 63.5	+112.	—136.	19°50′*S*	140°30′*E*	188.
Barrackpore ..	— 24.8	*E* 32.6	— 25.4	+ 32.2	+ 8.0	— 26.7	+ 3.3	— 32.2	35°50′*S*	174°10′*E*	42.
Dehra-Dun	0	*E*147.	— 5.9	+147.	— 10.0	— 0.1	+ 41.9	—142.	0°	163°40′*E*	148.
Lu-kia-Pang ..	0	*W* 60.3	— 2.4	— 60.1	+ 13.1	— 8.8	+ 22.5	+ 56.5	8°10′*S*	75°50′*E*	61.
Pola	0	*W* 90.6	— 13.6	— 89.7	+ 36.3	— 35.7	— 82.1	+ 5.7	23°30′*S*	86° 0′*W*	90.
Stonyhurst	+106.	0	+102.	— 31.8	+286.	—172.	— 20.7	—256.	33°50′*S*	175°20′*W*	309.
Jekaterinburg	+568.	*E*102.	+540.	+202.	+263.	+ 0.7	—422.	—467.	0°	137°50′*W*	630.

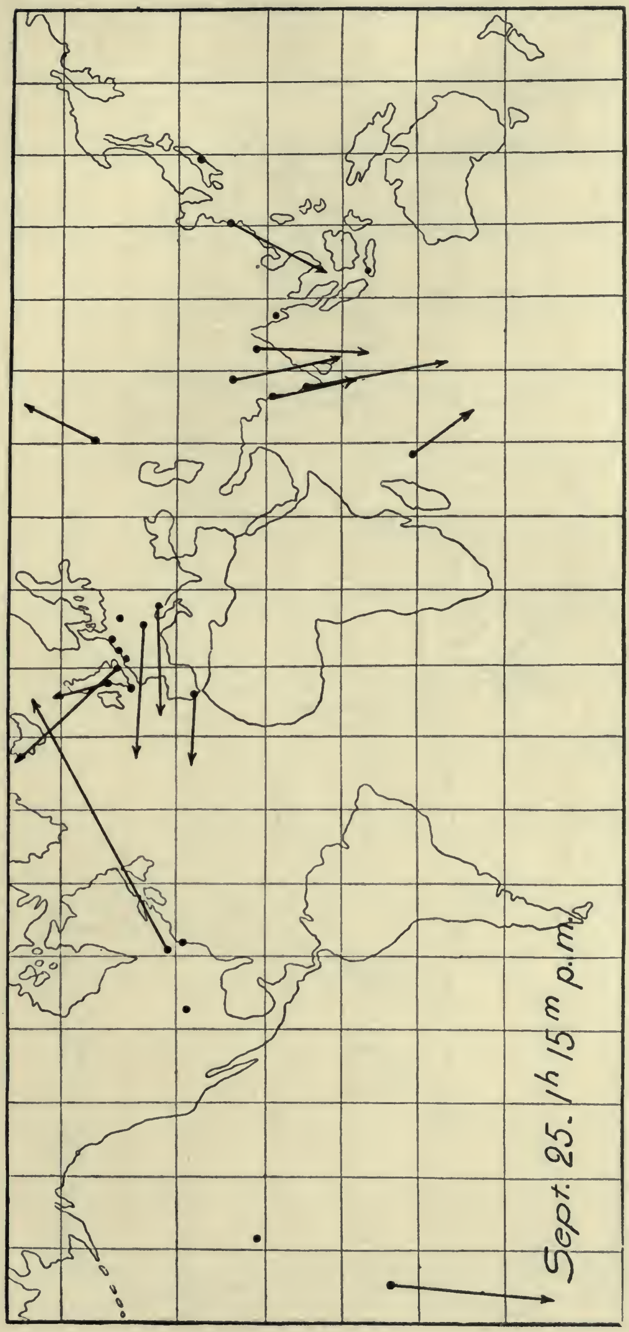

Fig. 7.

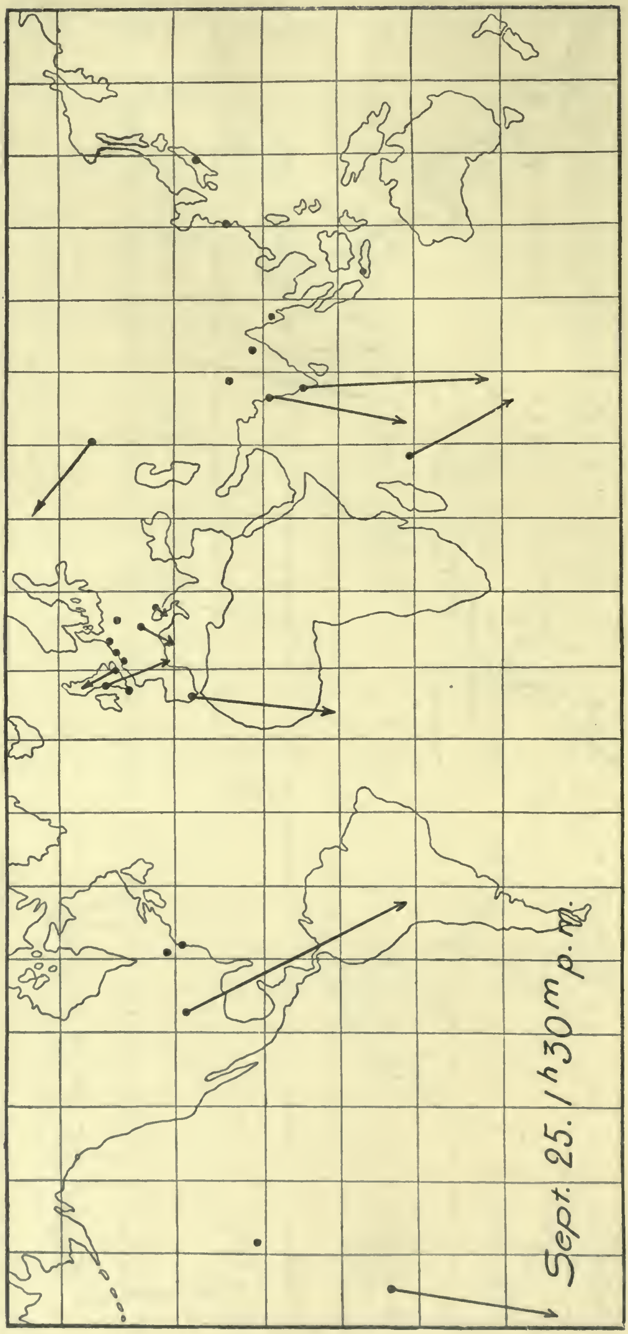

Fig. 8.

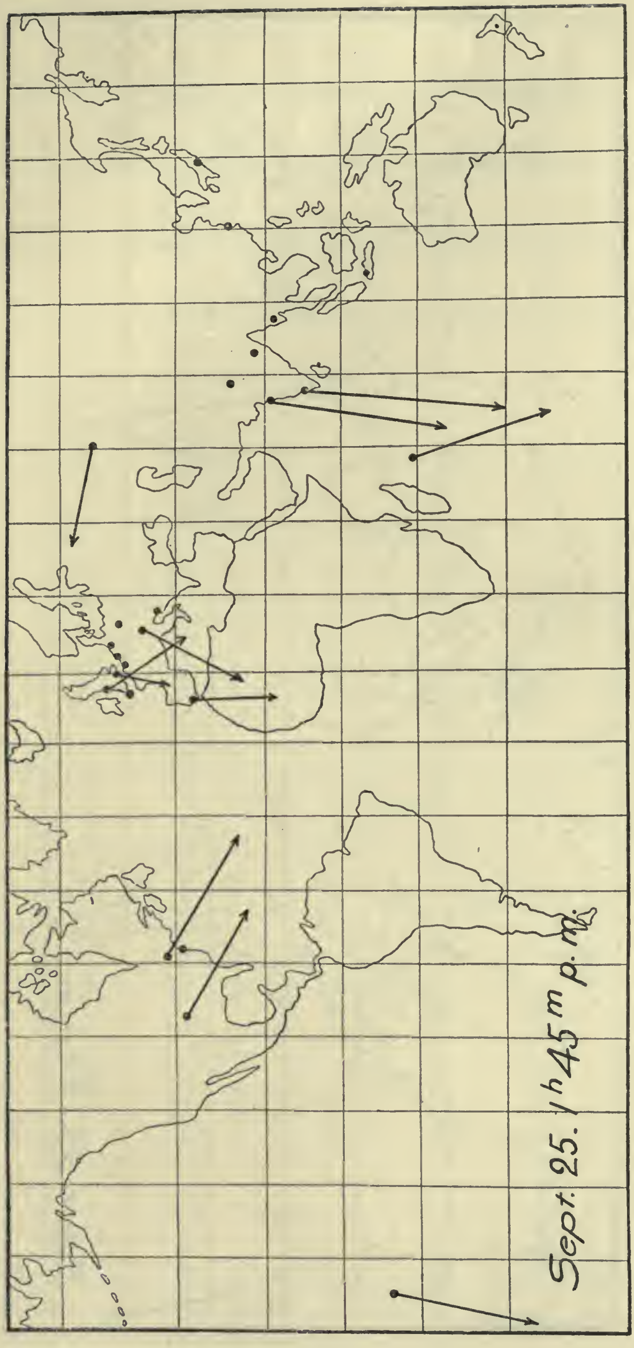

Fig. 9.

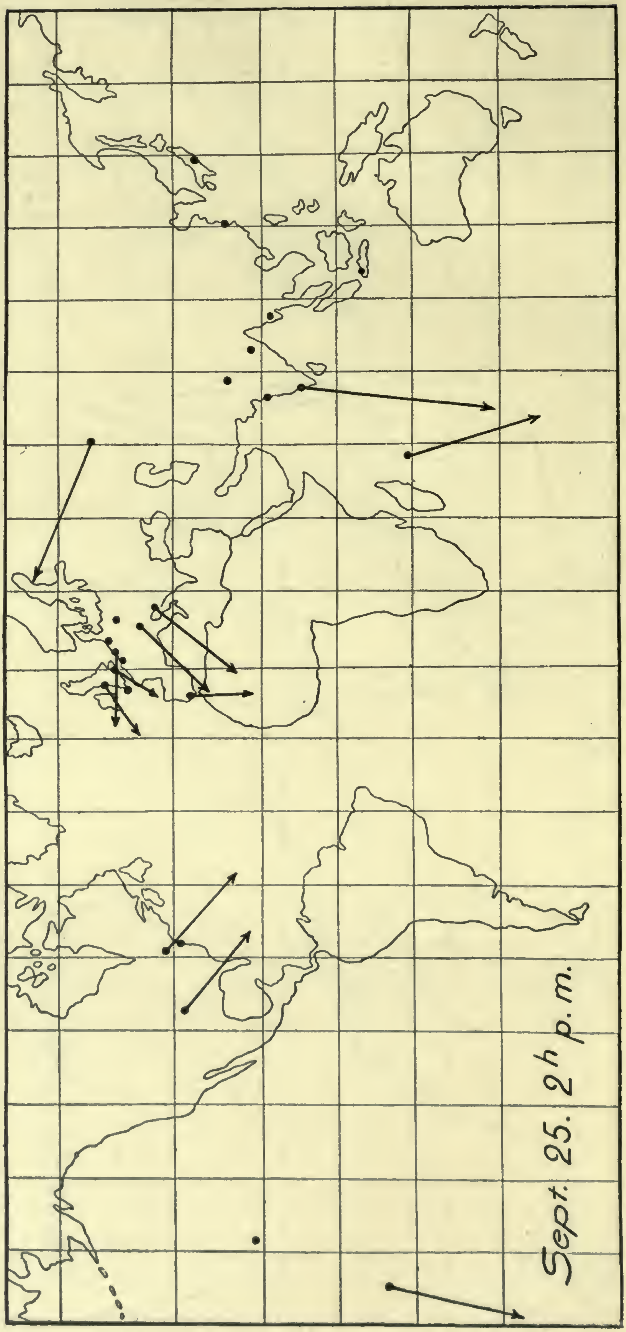

Fig. 10.

TABLE V.

25 Sept. 2^h p. m.

	$\triangle H$	$\triangle D$	$\triangle X$	$\triangle Y$	$\triangle Z$	$\triangle X'$	$\triangle Y'$	$\triangle Z'$	φ	λ	R
Mauritius	—356.	*E* 32.3	—345.	+ 90.2	— 25.8	—334.	— 32.3	—127.	68°30′*S*	165°40′*W*	359.
Samoa	—355.	*W* 15.6	—347.	— 75.0	+ 49.3	—325.	+ 93.2	+119.	65° 0′*S*	37°40′*E*	358.
Kodaikanal . .	—509.	*W* 55.0	—510.	— 49.8	—128.	—478.	+200.	+ 95.2	65°30′*S*	64°30′*E*	487.
Baldwin	—133.	*E* 236.	—168.	+213.	— 42.0	—105.	—157.	+200.	22°30′*S*	37°40′*W*	275.
Pola	—165.	*W* 190.	—191.	—163.	+ 24.2	—153.	—131.	+153.	37°10′*S*	40°30′*W*	253.
De Bilt	+ 25.0	*W* 205.	— 22.7	—204.	+218.	—186.	—214.	+100.	37°40′*S*	65° 0′*W*	301.
Stonyhurst	— 42.5	*W* 168.	— 91.1	—149.	+151.	—176.	—148.	+ 23.2	49°30′*S*	98°50′*W*	231.
Jekaterinburg	+ 67.5	*W* 399.	+137.8	—380.	+600.	—427.	—579.	+114.	35°50′*S*	78°50′*W*	729.

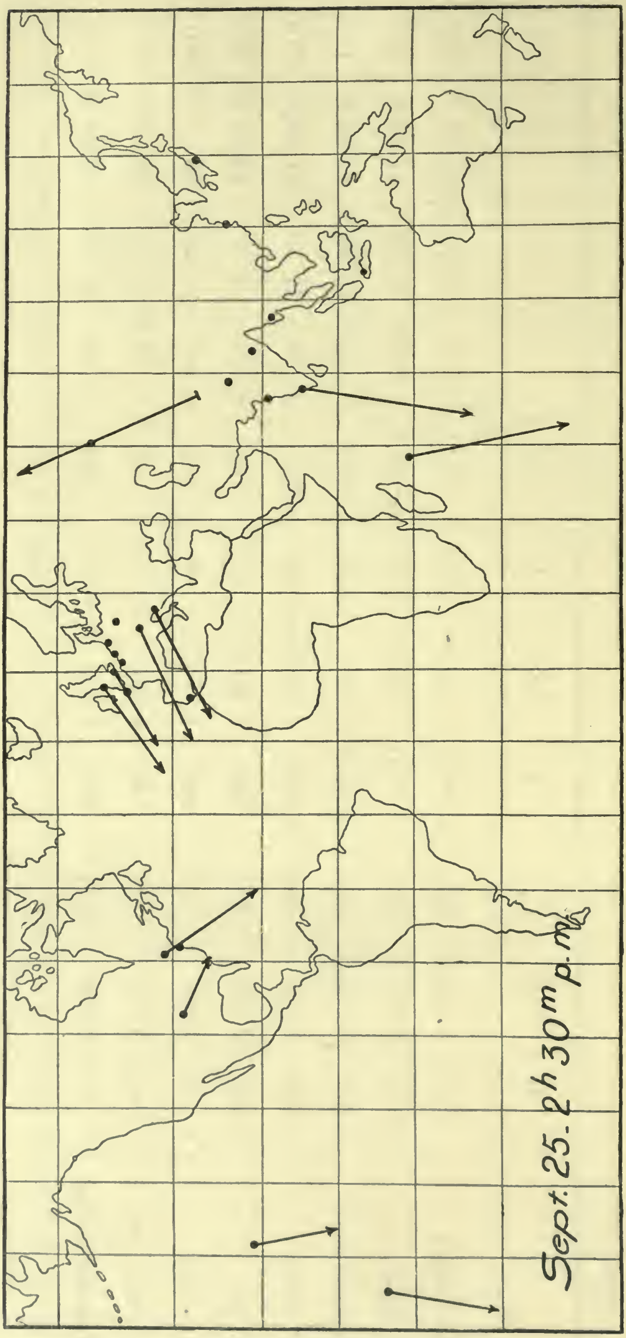

Fig. 11.

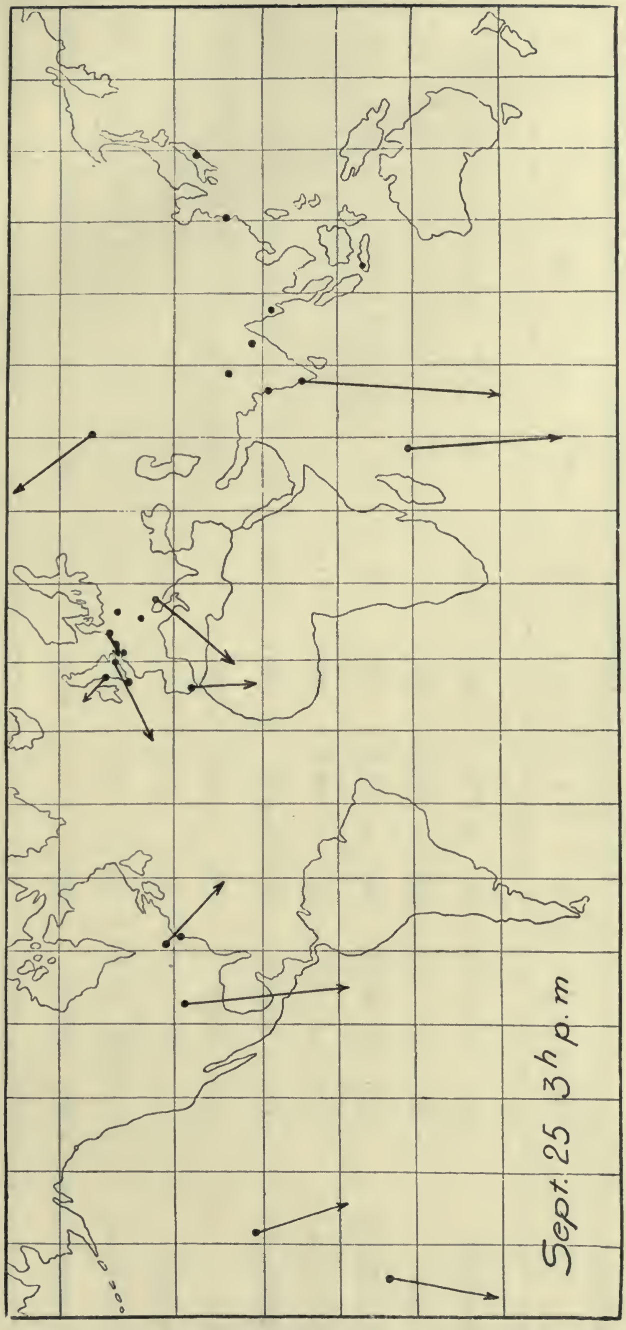

Fig. 12.

TABLE VI.

25 Sept. 3^h p. m.

	$\triangle H$	$\triangle D$	$\triangle X$	$\triangle Y$	$\triangle Z$	$\triangle X'$	$\triangle Y'$	$\triangle Z'$	φ	λ	R
Mauritius . . .	—415.	*W* 32.3	—357.	+100.	— 44.3	—350.	— 15.4	—128.	69°50′*S*	173°20′*W*	373.
Samoa	—304.	*W* 5.2	—291.	— 56.1	+ 40.5	—273.	+ 71.3	+ 99.2	69°50′*S*	35°40′*E*	299.
Kodaikanal . .	—545.	*W* 66.0	—546.	— 65.3	— 63.7	—526.	+141.	+ 98.0	72° 0′*S*	55°10′*E*	554.
Honolulu	—236.	*E* 85.7	—248.	+ 46.9	+ 59.0	—254.	— 55.1	— 11.5	77°40′*S*	101°40′*W*	260.
Baldwin	—425.	*E* 99.2	—152.	+155.	— 36.0	—304.	—292.	— 0.3	46°10′*S*	90°40′*W*	421.
Pola	—170.	*W*208.	—199.	— 81.0	+ 60.7	—185.	— 55.0	+114.	55°40′*S*	25°50′*W*	224.
De Bilt	— 14.	*W* 55.0	— 27.	— 49.8	+216.	—187.	— 59.0	—125.	62°50′*S*	154°40′*W*	233.
Stonyhurst	+ 68.8	*W* 39.2	+ 43.	— 58.0	+192.	—129.	— 51.4	—151.	39° 0′*S*	161°50′*W*	205.
Jekaterinburg	+203.	*W*215.	+238.	—175.	+486.	—273.	—498.	—142.	27°50′*S*	105°50′*W*	585.

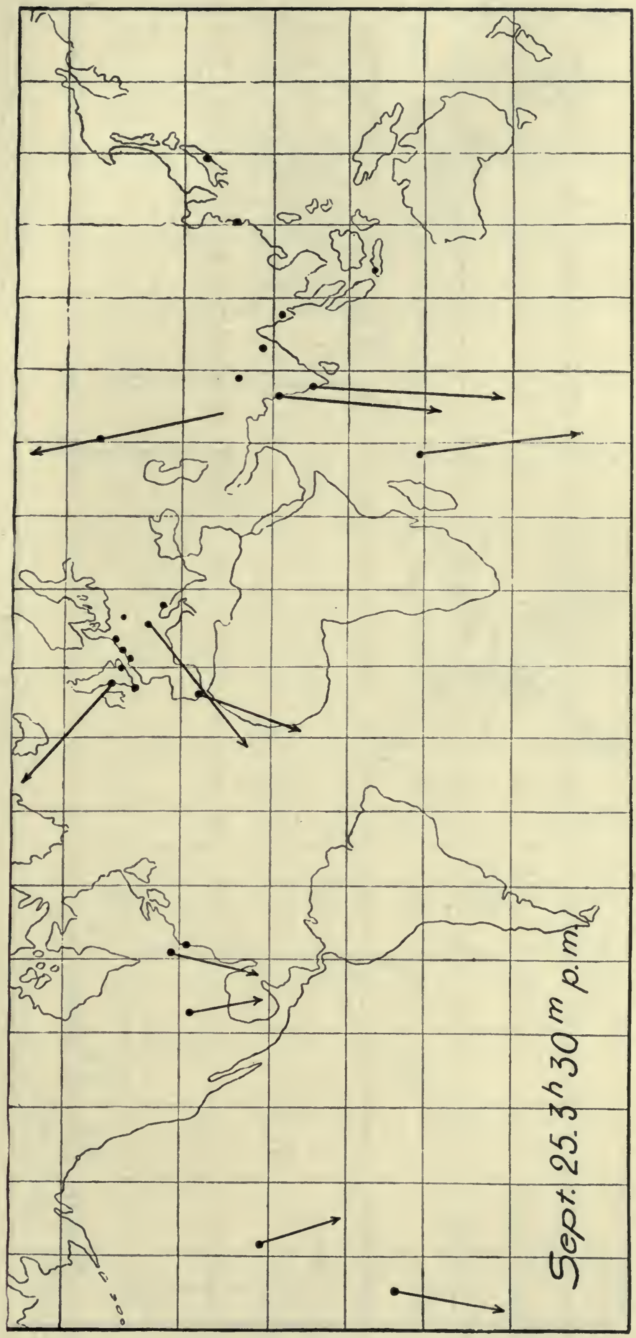

Fig. 13.

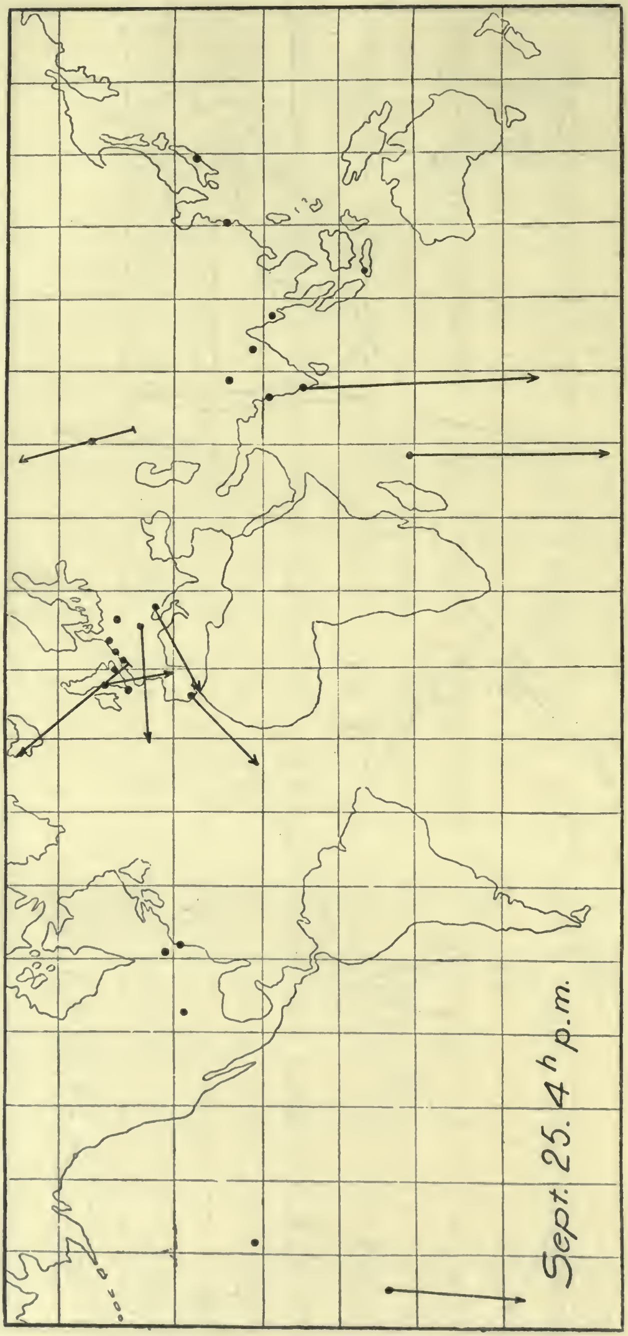

Fig. 14.

TABLE VII.

25 Sept. 4^h *p. m.*

	$\triangle H$	$\triangle D$	$\triangle X$	$\triangle Y$	$\triangle Z$	$\triangle X'$	$\triangle Y'$	$\triangle Z'$	φ	λ	R
Mauritius	—540.	*W* 75.2	—542.	+ 45.0	— 51.4	—524.	+211.	—112.	64°40′*S*	118° 0′*E*	576.
Samoa	—370.	*E* 36.5	—373.	— 27.0	+ 37.5	—354.	— 11.	+120.	71°10′*S*	5°20′*W*	374.
Kodaikanal ..	—611.	*W* 11.0	—611.	— 5.	— 57.1	—610.	—155.	+ 17.	74°10′*S*	83°70′*W*	614.
Lu-kia-Pang ..	—240.	*W* 25.8	—241.	— 17.	+ 98.2	—255.	—169.	— 5.	56°30′*S*	91°40′*W*	306.
Pola	— 82.1	*W*230.	—115.	—216.	+ 88.2	—144.	+118.	+ 70.	46°20′*S*	59°20′*E*	199.
Stonyhurst....	—170.	*W* 22.4	—168.	+ 30.	+235.	—289.	— 11.	— 3.	87°50′*S*	105°20′*W*	289.
Jekaterinburg	+289.	*W*128.	+309.	— 74.	+200.	+ 2.	+191.	+136.	0°40′*N*	54°30′*E*	234.

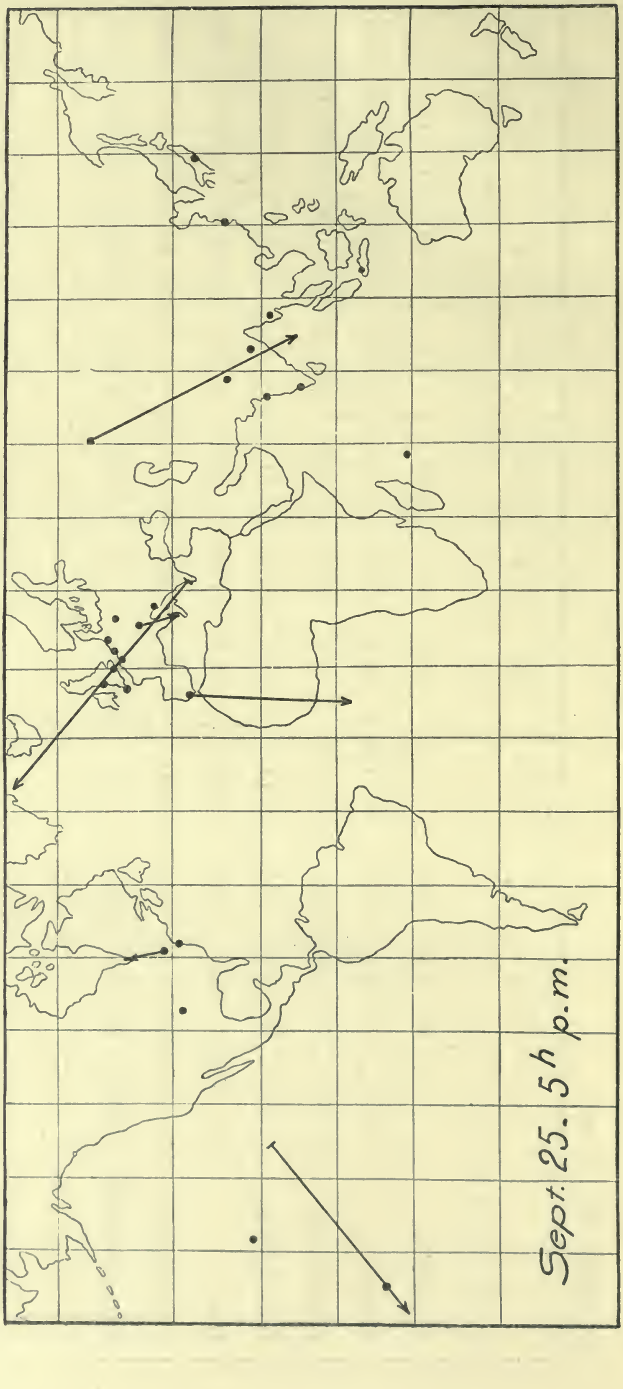

Fig. 15.

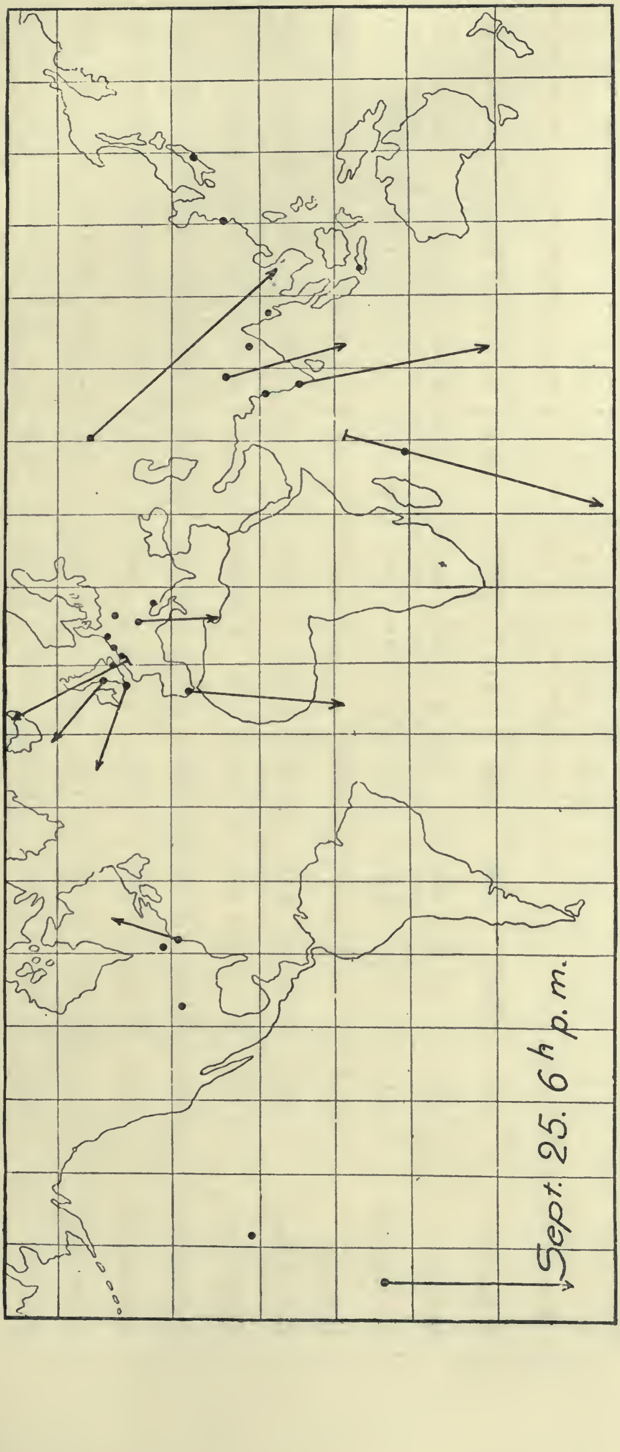

Fig. 16.

TABLE VIII.

25 Sept. 6^h *p. m.*

	$\triangle H$	$\triangle D$	$\triangle X$	$\triangle Y$	$\triangle Z$	$\triangle X'$	$\triangle Y'$	$\triangle Z'$	φ	λ	R
Mauritius	—640.	*W* 290.	—680.	—185.	—111.	—677.	—.210	+ 85.7	71°30′*S*	67°50′*W*	714.
Samoa	—461.	*E* 72.9	—469.	— 0.3	+ 46.8	—455.	+ 23.3	+156.	70°30′*S*	8°30′*E*	472.
Kodaikanal ..	—545.	*E* 44.0	—545.	+ 49.4	+ 70.0	—548.	+ 37.7	— 42.4	84° 0′*S*	138°20′*E*	551.
Bombay	—462.	*E* 44.2	+461.	+ 36.5	+ 4.6	—438.	+150.	+ 7.6	71°10′*S*	63°10′*E*	463.
Dehra-Dun ..	—308.	*E* 97.9	—312.	+ 96.7	+115.	—327.	+ 77.3	— 82.3	70°50′*S*	136°40′*E*	346.
Cheltenham .	+166.	*E* 60.0	+167.	+ 44.1	0	+131.	+119.	+ 17.6	47°30′*N*	81°30′*E*	178.
Falmouth	+159.	*W* 208.	+ 88.6	—246.	+330.	—196.	—123.	—292.	32°40′*S*	157°10′*W*	372.
Greenwich	+344.	*W* 93.0	+306.	—182.	+551.	—242.	—182.	—274.	36°30′*S*	146°20′*W*	408.
Stonyhurst	+212.	*W* 134.	+161.	—192.	— 8.4	+102.	—185.	—133.	24° 0′*N*	126°10′*W*	250.
Jekaterinburg	—428.	*E* 539.	+324.	—606.	—312.	+438.	—114.	+ 3.1	75°20′*N*	88°30′*W*	452.

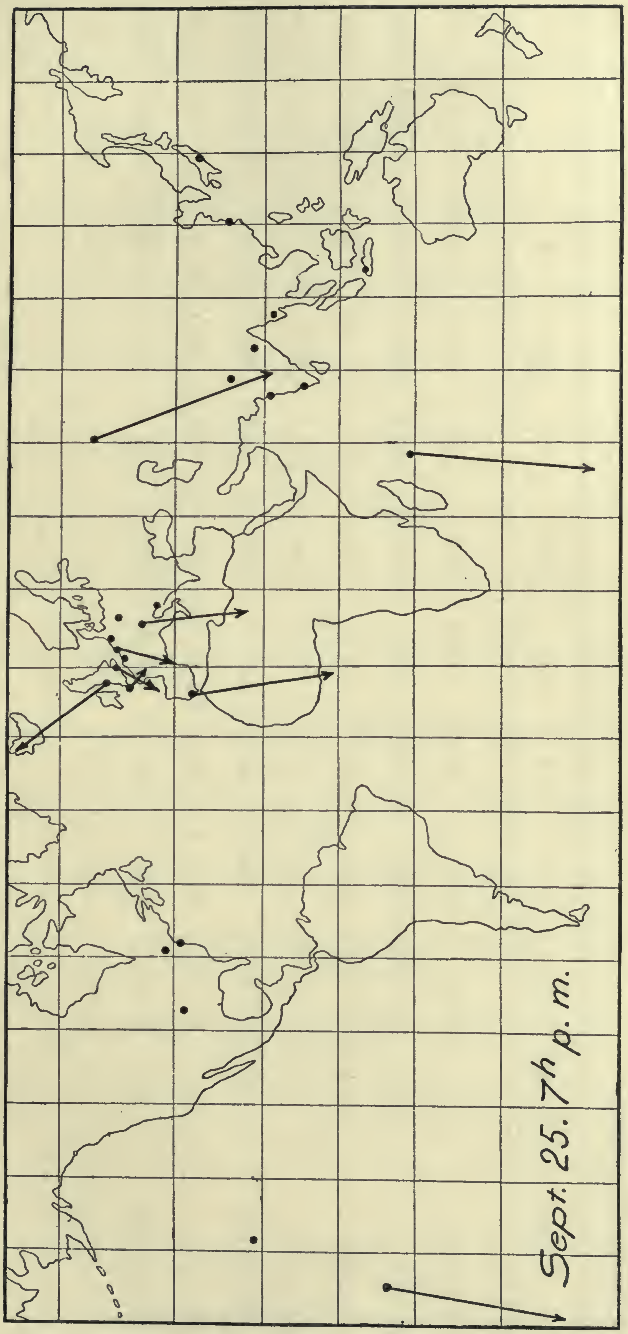

Fig. 17.

TABLE IX.

25 Sept. 7^h p. m.

	$\triangle H$	$\triangle D$	$\triangle X$	$\triangle Y$	$\triangle Z$	$\triangle X'$	$\triangle Y'$	$\triangle Z'$	φ	λ	R
Mauritius . . .	—481.	*W* 107.	—394.	— 29.0	— 76.8	—397.	—110.	— 9.8	74°30′*S*	95° 0′*W*	412.
Samoa	—379.	*E* 52.0	—383.	— 13.0	+ 48.2	—361.	+ 33.1	+137.	68°40′*S*	13°40′*E*	388.
Bombay	—480.	*E* 52.5	—480.	+ 44.2	+ 25.4	—458.	+154.	+ 0.8	70°30′*S*	89°40′*E*	487.
Falmouth . . .	— 37.3	*E* 36.8	— 24.5	+ 46.2	+ 9.3	—300.	+ 65.1	—213.	53°20′*S*	163° 0′*E*	374.
Greenwich . . .	— 68.5	*W* 74.0	— 85.7	— 52.5	+518.	—460.	— 52.5	—256.	60°30′*S*	168°10′*W*	529.
De Bilt	—141.	*W* 87.2	—156.	— 54.5	+220.	—270.	— 55.3	+ 36.1	76°10′*S*	57° 0′*W*	278.
Stonyhurst . .	+335.	*W* 112.	+289.	—208.	— 88.0	+243.	—200.	—190.	41°40′*N*	133°30′*W*	368.
Jekaterinburg .	—443.	*E* 261.	—482.	+176.	—107.	—175.	+487.	—172.	18°50′*S*	70°30′*E*	545.

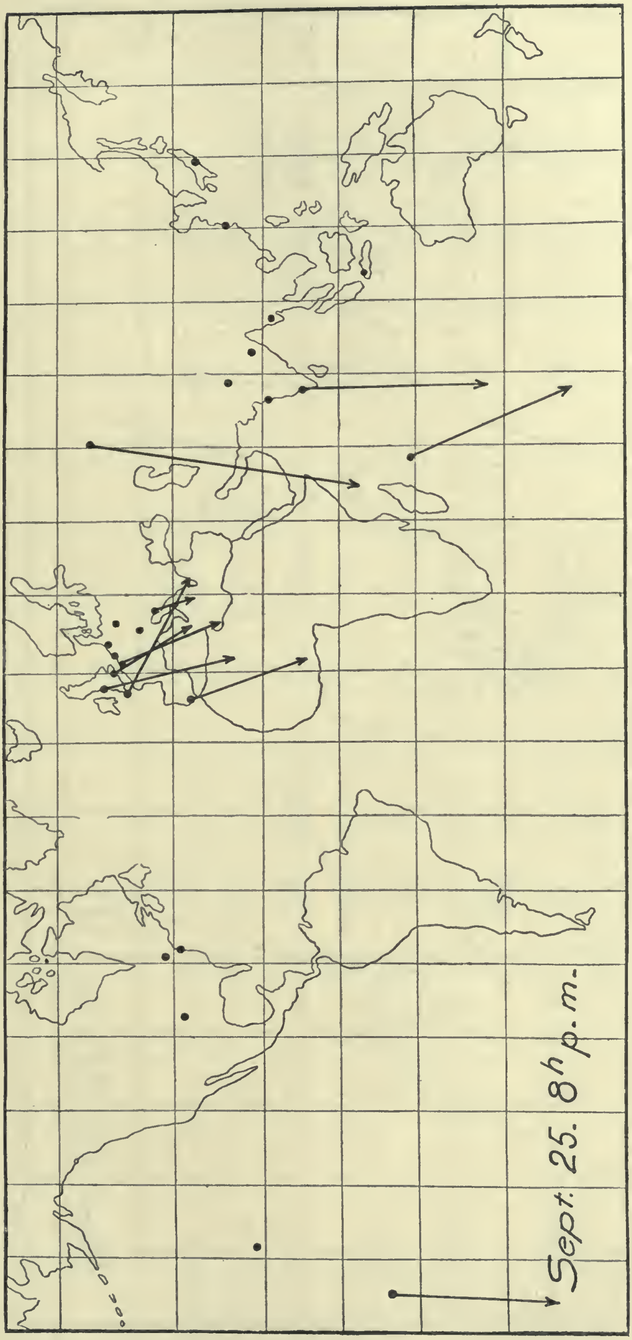

Fig. 18.

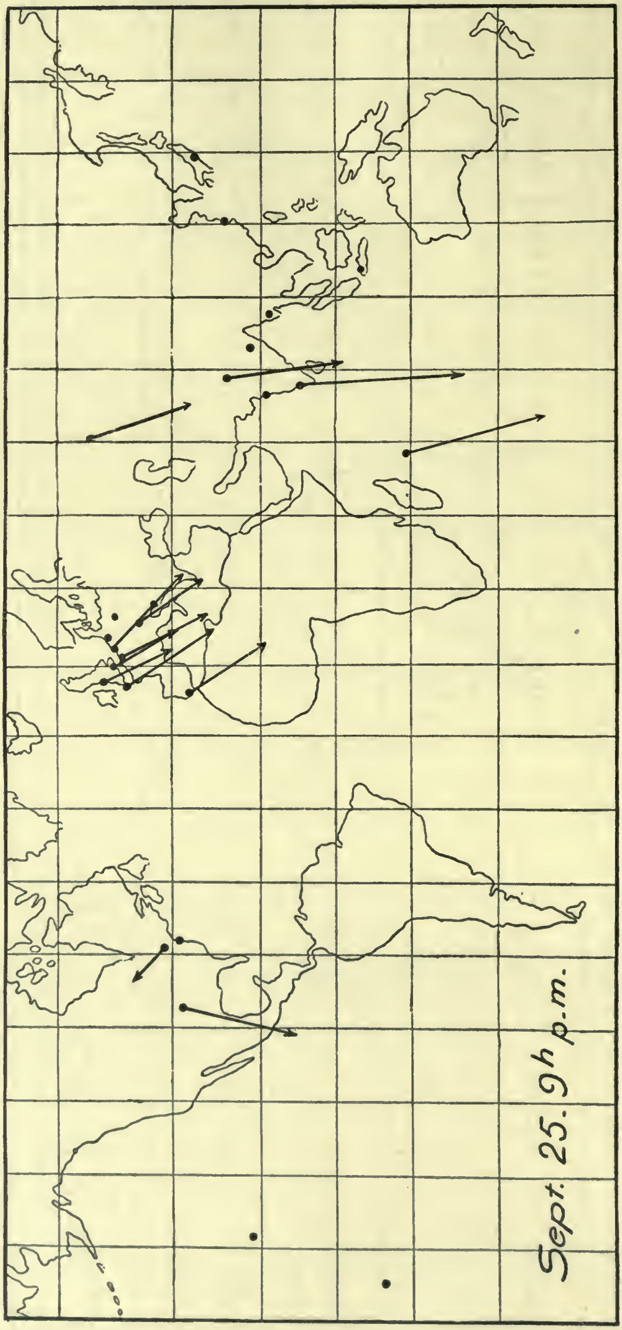

Fig. 19.

TABLE X.

25 Sept. 9^h p. m.

	$\triangle H$	$\triangle D$	$\triangle X$	$\triangle Y$	$\triangle Z$	$\triangle X'$	$\triangle Y'$	$\triangle Z'$	φ	λ	R
Mauritius . .	—394.	*E* 10.7	—389.	+ 73.6	— 44.9	—381.	— 39.	—112.	72°50′*S*	178° 0′*W*	399.
Kodaikanal . .	—418.	0	—418.	+ 4.1	+ 57.1	—421.	+ 18.4	— 0.3	87°30′*S*	91° 0′*E*	421.
Dehra-Dun . . .	—309.	*E* 48.9	—311.	+ 36.5	+ 65.0	—301.	+107.	— 14.5	70°20′*S*	97°40′*E*	320.
Baldwin	—317.	*W* 18.6	—311.	— 66.1	+ 27.0	—259.	—167.	— 81.3	54°30′*S*	101°40′*W*	319.
Falmouth	—249.	*E* 42.8	—223.	+116.	+100.	—220.	+107.	+116.	54°20′*S*	42°50′*E*	271.
Greenwich . . .	—227.	*E* 49.1	—205.	+108.	+141.	—239.	+108.	+ 73.2	62°30′*S*	54°10′*E*	273.
De Bilt	—229.	*E*145.	—189.	+194.	+ 89.	—186.	+202.	+ 76.0	40°50′*S*	74°40′*E*	285.
Jekaterinburg	—274.	*E* 97.1	—252.	+ 45.6	— 14.6	—126.	+213.	+ 67.1	29°40′*S*	72°30′*E*	256.

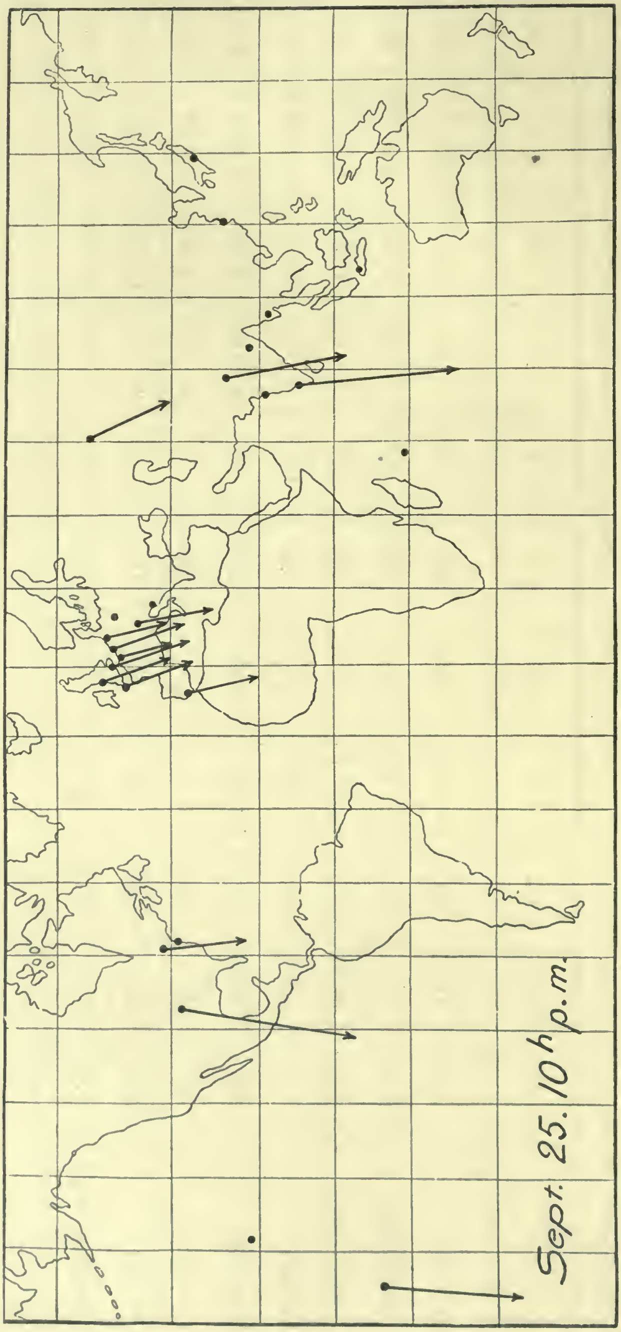

Fig. 20.

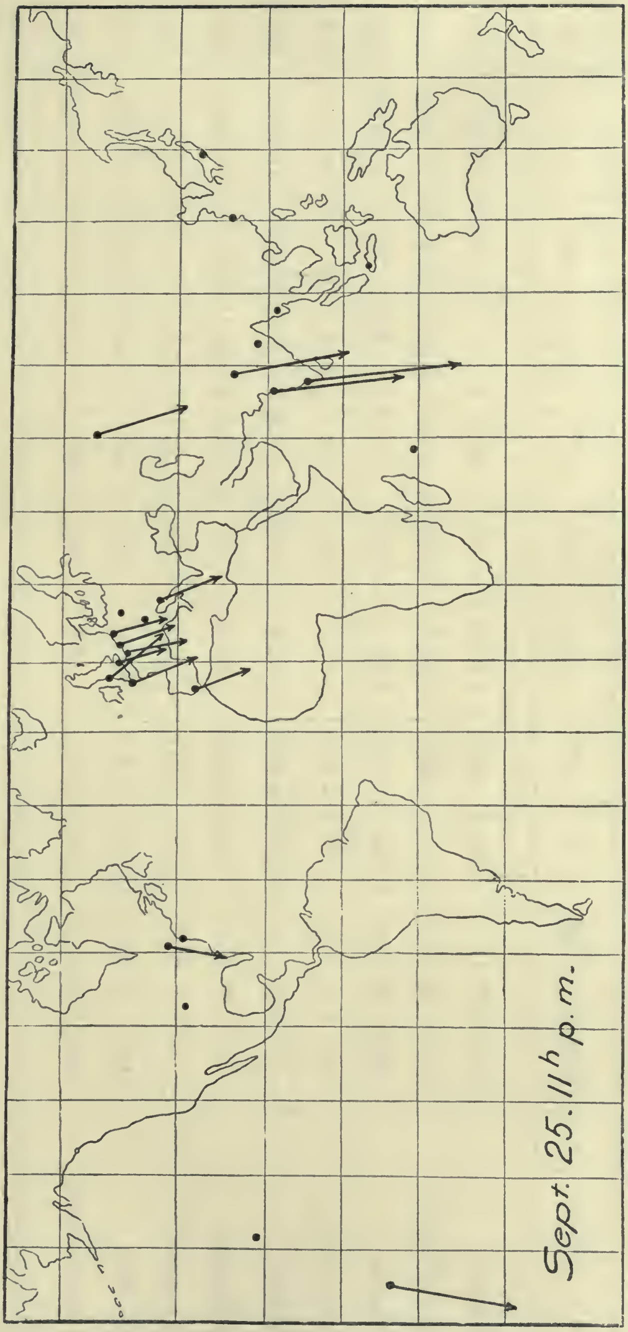

Fig. 21.

TABLE XI.

25 Sept. 11^h p. m.

	$\triangle H$	$\triangle D$	$\triangle X$	$\triangle Y$	$\triangle Z$	$\triangle X'$	$\triangle Y'$	$\triangle Z'$	φ	λ	R
Samoa	—330.	*W* 15.1	—324.	—70.1	+51.1	—303.	+ 87.7	+ 71.3	69°30′*S*	50°40′*E*	323.
Kodaikanal	—412.	*E* 22.0	—412.	—26.1	+44.6	—413.	+ 34.1	— 19.3	84°40′*S*	119°30′*E*	415.
Bombay	—334.	*E* 21.0	—334.	+16.4	+32.5	—327.	— 14.1	+ 6.9	87°10′*S*	63°50′*W*	328.
Dehra-Dun	—288.	*E* 48.9	—286.	+37.3	+55.0	—275.	+103.	— 16.2	69°10′*S*	99° 0′*E*	294.
Pola	—175.	*E* 27.8	—173.	+43.8	+77.4	—178.	+ 58.4	+ 55.2	65°50′*S*	46°40′*E*	195.
Falmouth	—181.	*E* 6.1	—174.	+60.0	+75.0	—170.	+ 52.3	+138.	49°20′*S*	20°50′*E*	225.
Greenwich	—134.	*E* 14.7	—132.	+50.4	+98.2	—159.	+ 50.4	+ 42.8	67°30′*S*	40°20′*E*	172.
De Bilt	—150.	*E* 20.5	—151.	+54.4	+86.0	—161.	+ 60.1	+ 60.5	62°10′*S*	44°50′*E*	182.
Jekaterinburg ..	—226.	*E* 87.0	—238.	+44.4	+58.2	—179.	+167.	+ 43.4	46°10′*S*	75°20′*E*	248.

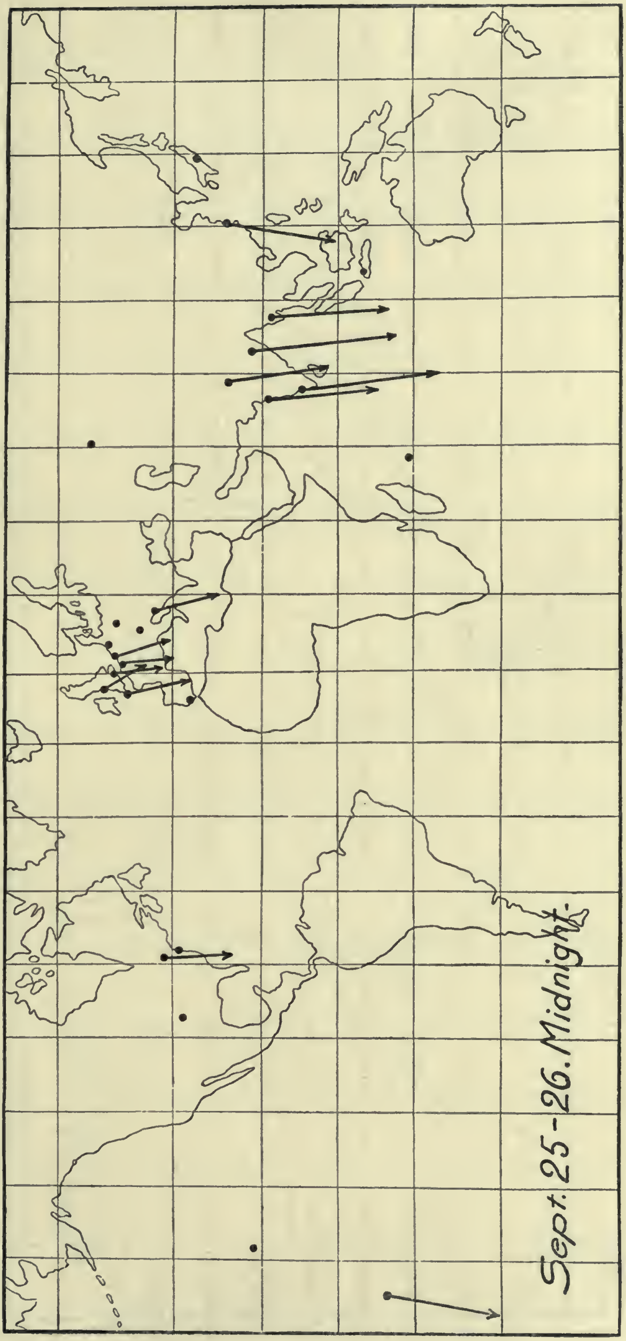

Fig. 22.

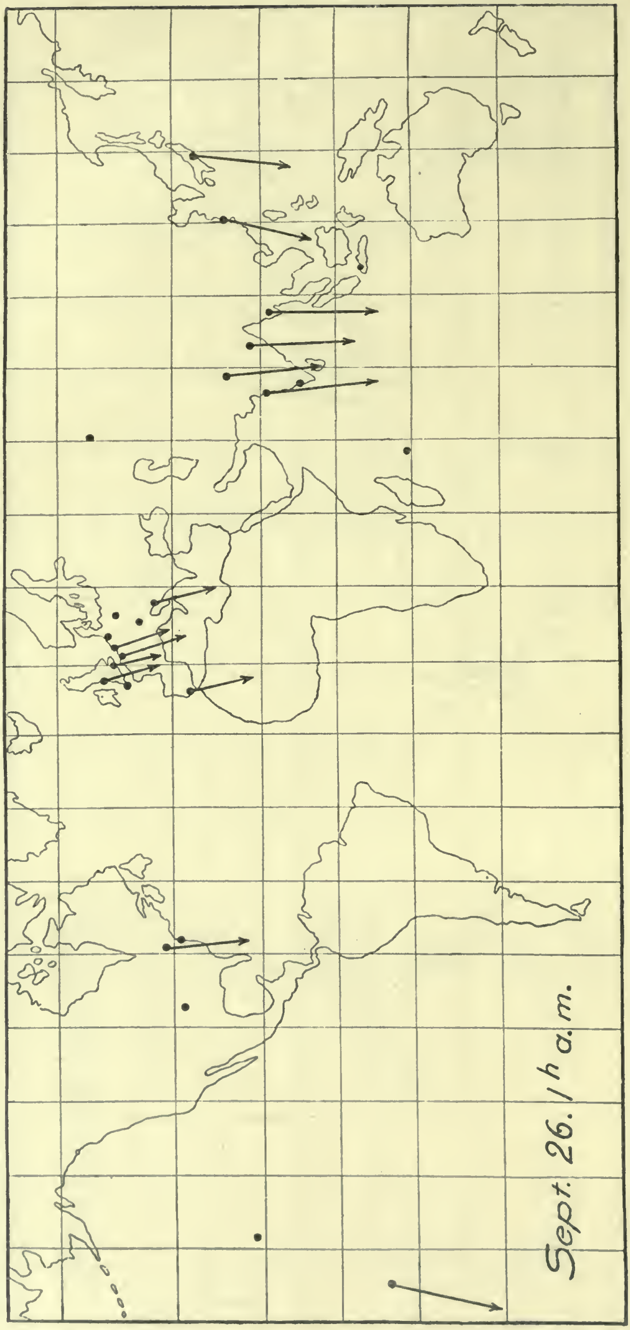

Fig. 23.

TABLE XII.

26 Sept. 1^h a. m.

	$\triangle H$	$\triangle D$	$\triangle X$	$\triangle Y$	$\triangle Z$	$\triangle X'$	$\triangle Y'$	$\triangle Z'$	φ	λ	R
Samoa	—299.	*W* 7.8	—296.	—58.5	+51.0	—275.	+75.4	+111.	64°10′*S*	34°10′*E*	306.
Bombay	—294.	*E* 16.0	—294.	+10.1	+23.4	—286.	+72.9	+ 11.8	75°30′*S*	80°50′*E*	295.
Toungoo	—272.	0	—272.	— 2.7	0	—257.	+88.2	— 7.4	70°50′*S*	94°50′*E*	272.
Barrackpore	—278.	*E* 21.8	—282.	+16.3	+24.6	—251.	+89.8	+ 18.8	70° 0′*S*	78°10′*E*	267.
Dehra-Dun	—257.	*E* 39.2	—258.	+29.0	+40.0	—243.	+99.3	— 8.3	67°40′*S*	94°40′*E*	262.
Lu-kia-Pang	—254.	*W* 34.6	—255.	—24.4	+60.0	—249.	+81.7	— 20.9	71°20′*S*	105°20′*E*	263.
Tokyo	—227.	*W* 45.0	—231.	—26.9	+35.5	—209.	+89.2	— 63.5	62°30′*S*	125°30′*E*	236.
Pola	—164.	*E* 27.8	—167.	+52.0	+65.2	—164.	+67.5	+ 56.3	61°50′*S*	52°50′*E*	186.
Greenwich	—132.	*W* 14.7	—131.	+21.5	+75.2	—141.	+21.5	+ 56.2	66°50′*S*	21° 0′*E*	153.
De Bilt	—154.	*E* 25.0	—143.	+59.7	+90.0	—159.	+64.8	+ 51.5	62°30′*S*	38°40′*E*	179.

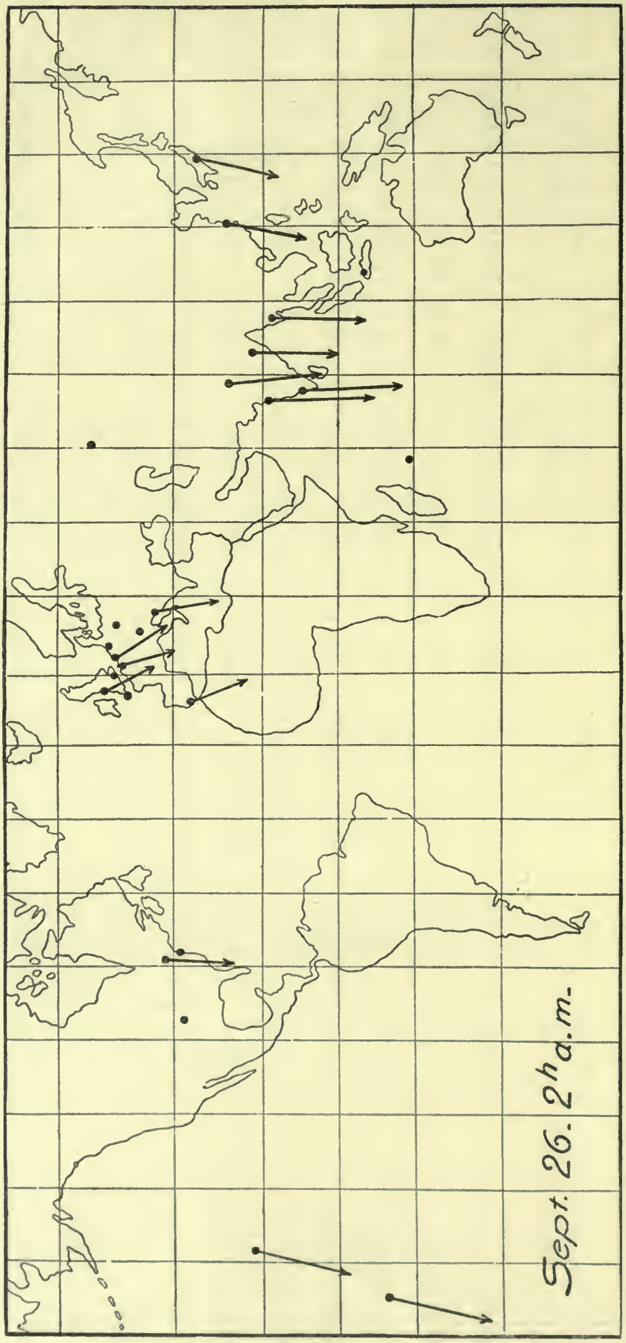

Fig. 24.

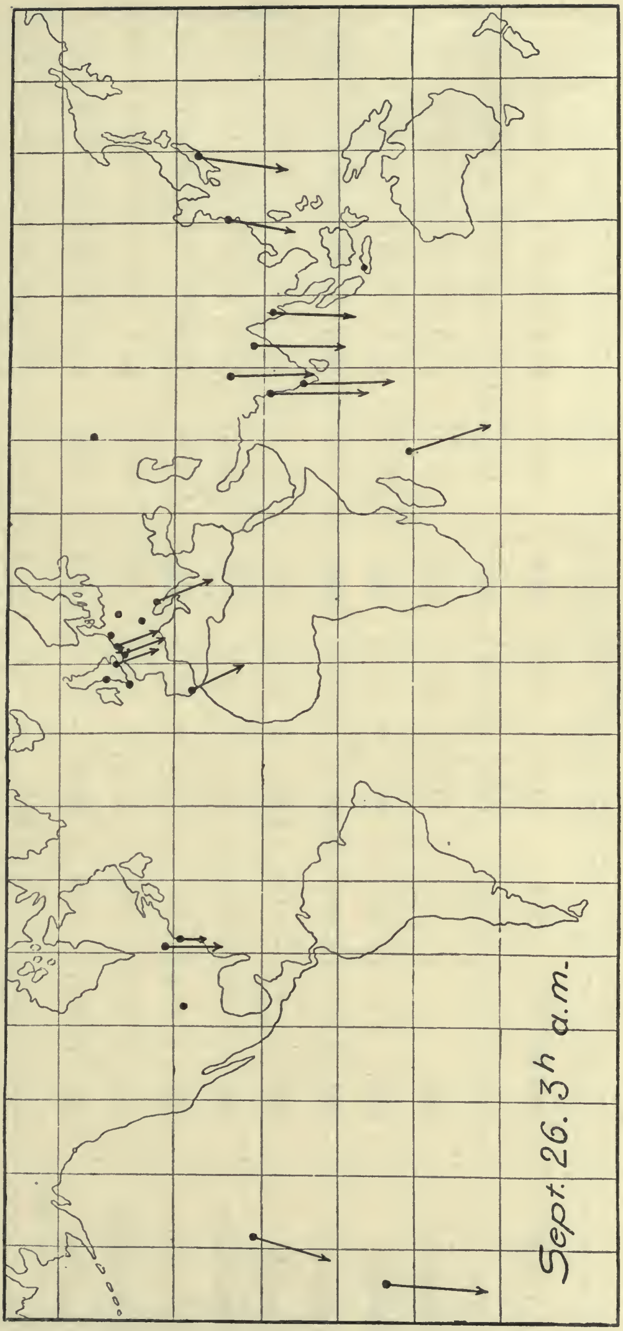

Fig. 25.

TABLE XIII.

26 Sept. 3^h a. m.

	$\triangle H$	$\triangle D$	$\triangle X$	$\triangle Y$	$\triangle Z$	$\triangle X'$	$\triangle Y'$	$\triangle Z'$	φ	λ	R
Mauritius	—259.	*E* 22.6	—260.	— 62.8	— 34.6	—256.	— 82.3	+ 22.2	62°40′*S*	75° 0′*W*	278.
Samoa	—277.	*E* 5.2	—273.	+ 72.0	+ 54.7	—252.	— 53.9	+127.	61°10′*S*	15°50′*W*	287.
Kodaikanal ..	—248.	0	—249.	+ 63.5	+ 22.5	—249.	— 35.2	— 57.3	75° 0′*S*	148°40′*W*	258.
Bombay	—261.	0	—259.	+ 80.2	+ 11.2	—249.	+ 93.9	— 55.1	66°20′*S*	151°20′*E*	272.
Toungoo	—224	*W* 11.5	—224.	+ 25.2	— 10.4	—209.	+ 79.4	— 34.4	67°40′*S*	154°10′*E*	224.
Honolulu	—236.	*W* 8.5	—248.	+122.	+ 33.6	—245.	— 31.1	— 3.5	82°50′*S*	96°20′*W*	247.
Barrackpore ..	—244.	*E* 5.4	—243.	+ 59.1	+ 17.8	—231.	+ 94.2	— 56.8	64°30′*S*	121° 0′*E*	256.
Dehra-Dun...	—224.	*E* 19.6	—223.	+ 31.4	+ 40.0	—212.	+ 82.8	— 14.3	68°20′*S*	99°50′*E*	218.
Lu-kia-Pang ..	—182.	*W* 43.2	—185.	+ 47.4	+ 65.5	—192.	+ 10.1	— 61.1	72° 0′*S*	170°40′*E*	202.
Tongo.......	—185.	*W* 50.7	—189.	+ 30.2	+ 49.8	—182.	+ 22.3	— 72.8	67°10′*S*	162°50′*E*	197.
Pola	—160.	*E* 38.4	—180.	+182.	+ 63.0	—172.	+197.	+ 36.2	40°50′*S*	79°40′*E*	264.
Greenwich	—116.	*E* 7.3	—172.	+192.	+116.	—198.	+192.	+ 62.7	44°30′*S*	71°50′*E*	283.
De Bilt	—137.	*E* 25.0	—146.	— 22.1	+113.	—179.	— 17.9	+ 42.6	75°30′*S*	22°40′*W*	185.

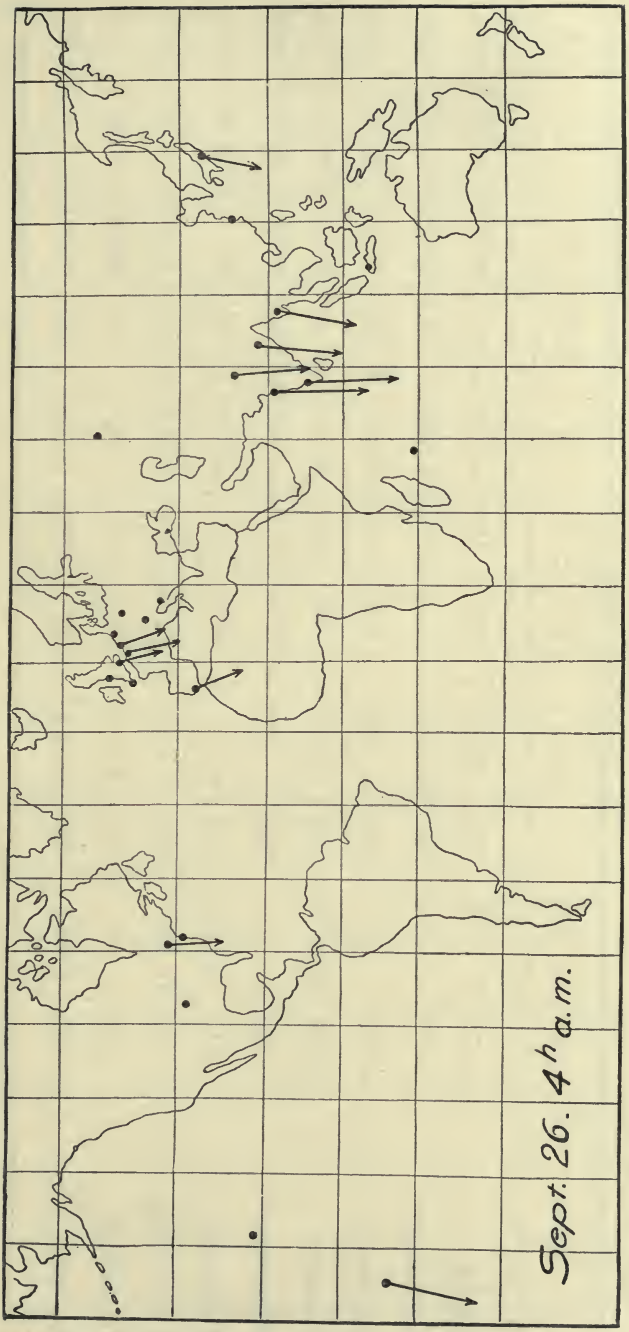

Fig. 26.

TABLE XIV.

26 Sept. 4^h *a. m.*

	$\triangle H$	$\triangle D$	$\triangle X$	$\triangle Y$	$\triangle Z$	$\triangle X'$	$\triangle Y'$	$\triangle Z'$	φ	λ	R
Samoa	—272.	*W* 7.8	—269.	—53.7	+ 51.0	—249.	+69.6	+105.	64°30′*S*	33°10′*E*	297.
Kodaikanal	—236.	0	—236.	+ 2.4	+ 11.4	—234.	+30.5	+ 4.3	82°30′*S*	82° 0′*E*	238.
Bombay.........	—247.	0	—247.	— 4.9	+ 9.3	—237.	+66.8	+ 25.6	73°50′*S*	69° 0′*E*	257.
Toungoo	—224.	*W* 11.5	—224.	—13.7	— 4.6	—210.	+78.2	+ 4.8	70°40′*S*	86°30′*E*	237.
Barrackpore	—235.	0	—235.	— 4.9	+ 17.8	—218.	+60.9	+ 8.2	75°30′*S*	82°20′*E*	243.
Dehra-Dun	—212.	*E* 19.6	—213.	+ 9.1	+ 40.0	—205.	+73.2	+ 6.5	71° 0′*S*	84°50′*E*	225.
Lu-kia-Pang	—160.	*W* 43.2	—162.	—35.2	+ 74.1	—176.	+36.0	+ 19.6	75°50′*S*	61°30′*E*	167.
Greenwich........	—108.	0	—104.	+38.0	+115.	—155.	+38.0	+ 10.0	69°20′*S*	75°10′*E*	149.
De Bilt	—133.	*E* 25.0	—123.	+54.4	+113.	—165.	+56.6	+ 22.1	61°50′*S*	68°40′*E*	137.

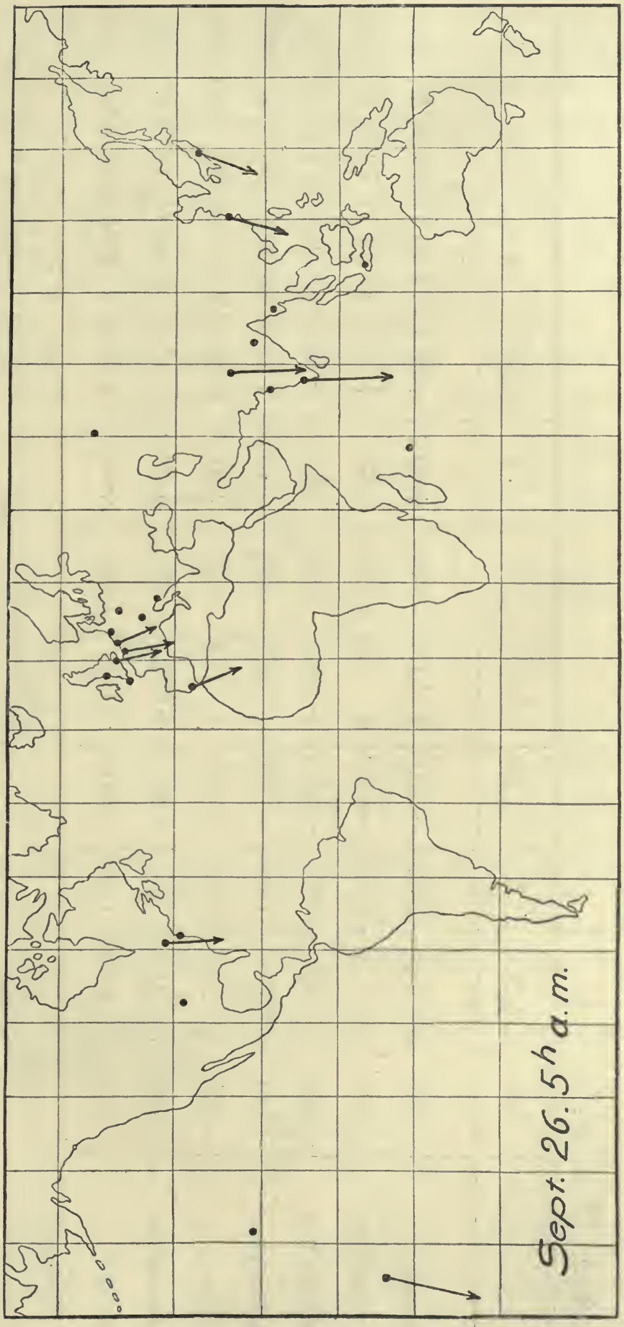

Fig. 27.

TABLE XV.

26 Sept. 5^h a. m.

	$\triangle H$	$\triangle D$	$\triangle X$	$\triangle Y$	$\triangle Z$	$\triangle X'$	$\triangle Y'$	$\triangle Z'$	φ	λ	R
Samoa	—262.	*W* 5.2	—259.	—49.6	+ 51.0	—240.	+65.3	+38.7	72°30′*S*	59°20′*E*	251.
Kodaikanal ..	—230.	*W* 5.5	—230.	— 3.2	+ 5.6	—227.	+33.7	+10.6	81°10′*S*	72°20′*E*	229.
Dehra-Dun ..	—208.	*E* 9.8	—208.	— 0.6	+ 35.5	—198.	+73.0	+16.2	69°20′*S*	77°30′*E*	211.
Lu-kia-pang ..	—144.	*W* 34.6	—146.	—27.5	+ 85.2	—168.	+16.6	+22.3	80°30′*S*	36°30′*E*	170.
Tokio	—154.	*W* 28.1	—156.	—15.8	+ 37.8	—149.	+51.3	—36.0	67°10′*S*	125° 0′*E*	162.
Greenwich	—106.	*W* 0.5	—102.	—28.0	+109.	—157.	+28.2	+ 6.0	79°30′*S*	71°50′*E*	159.
De Bilt	—125.	*E* 18.0	—118.	—46.4	+113.	—162.	+48.4	+18.9	72°20′*S*	68°40′*E*	170.

Most the diagrams sent to me cease on Sept 26th about 5^h a. m. As however the disturbance in regarding to H (X) had not ceased at this time, it was not uninteresting to continue to investigate the course of the disturbance. In this study I have — as said in the above — confined myself to three observatories namely, Tokio, Berlin and Baldwin. In fig. 28 I have reproduced the course of H for Tokio and Baldwin, just as the course of X for Berlin up to and including Sept. 30th 6^h a. m. The curves converge towards the normal values to almost reach them during the first hours of Sept. 30th. D (Y) and Z generally show little deviation from the normal values. On the

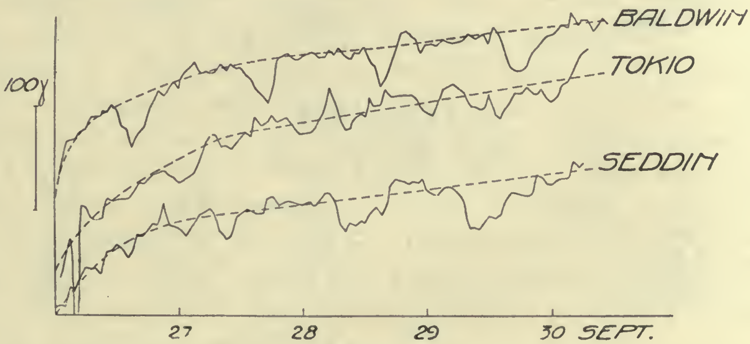

Fig. 28.

curves just mentioned the ordinates have been selected for certain points of time, for which the curves are fairly near their own average lines (the dotted lines). These four times are: Sept. 26th noon, Sept. 27th noon, Sept 28th—29th midnight and Sept. 30th 2^h a. m. For these four times I have calculated dX, dY and dZ and compared them in the following tables.

TABLE XVI.

Sept. 26th Noon.

	dX	dY	dZ
Tokio	—139.	— 7.6	—31.
Berlin	— 81.	+12.	+61.
Baldwin	—113.	—17.4	+17.

TABLE XVII.

Sept. 27th Noon.

	dX	dY	dZ
Tokio	—78.8	— 4.3	+22.
Berlin	—62.	—10.0	+50.
Baldwin	—71.6	—13.4	+15.

TABLE XVIII.

Sept. 28—29th Midnight.

	dX	dY	dZ
Tokio	—56.0	+ 4.5	—25.
Berlin	—41.	+10.0	+35.
Baldwin	—50.5	—10.7	+17.

TABLE XIX.

Sept. 30th 2^h a. m.

	dX	dY	dZ
Tokio	—29.0	— 9.5	—28.
Berlin	—28.	+ 6.0	+38.
Baldwin	—31.4	— 8.4	+26.

From the values in these tables, the most probable numbers for dX', dY' and dZ' have been calculated for each of the four points of time and are compared in the following table.

TABLE XX.

	dX'	dY'	dZ'
Sept. 26th Noon	—109.	— 1.9	—10.5
» 27th Noon	— 72.8	— 5.0	— 3.5
» 28-29th Midn.	— 44.0	+ 8.7	—15.6
» 30th 2^h a. m.	— 10.9	— 6.6	+ 8.0

For a more detailed analysis of the course of the storm, it would have been advantageous if Gauss' method, enlarged by Ad. Schmidt[1]), could have been used. The superposed, accidental field during the storm would then have been able to be divided up into 3 parts, as Schmidt does with the normal terrestrial magnetism, viz.

1) the part of the field, caused by electrical currents or magnets outside the earth.

2) That part of the field, caused by electrical currents or magnets inside the surface of the earth.

3) Electrical currents between the earth and the atmosphere, the vertical earth-air current.

The sources of observations that I have, however, had access to, do not permit of such a calculation. A net filled with observations-places would have been essential, that a magnetic map might have been constructed, with whose help series for the variation of the magnetic elements in a great number of latitudes might have been arranged. These series would have then formed the basis of the calculation, similar to Schmidt's. With so few places for observation as there really are, one can only with the help of tables, maps and diagrams, try to give as clear a picture of the course as possible.

Concerning the variation of the two horizontal components, it is possible, on studying the various maps on the previous pages to divide the disturbance for the sake of a better summary into certain subdivisions.

A) The horizontal disturbing vector in a nothern direction.

1) From 11^h 45^m a.m. till 1^h 15^m p.m.

The district of disturbance includes the observatories in the Pacific Ocean, also the stations of India and E. Asia. At 12^h 45^m p.m. even some stations in Europe and in E. Asia have notherly disturbing vectors, but not in India. Lastly at 1^h 15^m p.m. these are only noticed in N. Europe.

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[1]) Aus dem Archiv der Deutschen Seewarte, Hamburg, Jahrg. 12 (1889); 21 (1898).

2) 2^h 30^m p.m., 3^h p.m. and 3^h 30^m p.m. the maps again show a notherly disturbing vector at Jekaterinburg. At 4^h p.m. a similar vector is observed at Greenwich and at 5^h p.m. at Stonyhurst and Toronto. At 6^h p.m. the English as well as the Cheltenham observatories have a notherly vector, while at 7^h p.m. such is only to be observed at Stonyhurst.

B) The horizontal disturbing vector in SE and E direction.

1) 11^h 15^m till 12^h 30^m p.m. the maps show in European ES and E dist. vector. 12^h 45^m and 1^h the force has an other direction in notherly parts. Only in San Fernando a similar vector can be observed.

2) 1^h 45^m p.m.—2^h 30^m p.m. During this time the dist. vector has E direction in America.

C) The horizontal vector with W direction. 1^h p.m.—4^h p.m.

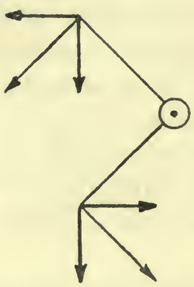

Fig. 29.

This part of the storm is to be seen at 1^h also in München and San Fernando 1^h 15^m. In the three following maps 1^h 30^m, 1^h 45^m and 2^h W vector can be observed in Jekaterinburg, 2^h 30^m, 3^h and 4^h for many european stations, 3^h 30^m only in Stonyhurst.

D. The horizontal vector with S direction.

It will be seen from the maps that the horizontal disturbing vectors with the exception of the cases mentioned in the above and especially during the latter and greater part of the storm went in a southerly direction.

Comparing the vertical vectors, one sees, that it has on the whole, rather high values at the observatories in higher latitudes, and is directed towards the centre of the earth, there to assume lower values, and in some cases nearest the magnetic equator even to change direction entirely. This indicates that outer electrical currents were prevalent (Compare fig. 29). It may be supposed that the magnetic storm was caused by currents circulating through a sollenoid in the interior of which the globe was situated, and the axis of which coincided with the direction of the total disturbing force. In the table XXI the averages for dX', dY' and dZ' are arranged for the times from Sept. 25th 1^h p.m. till Sept. 30th 2^h a.m. How the resultants of these have altered will be seen from the last column in this table and also from the curve in fig. 30.

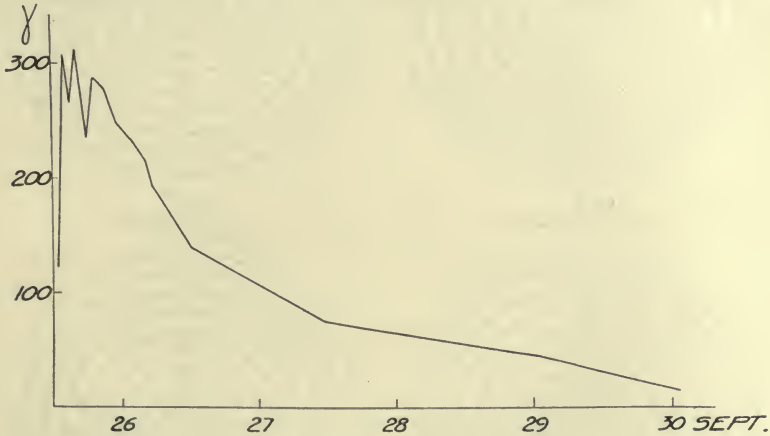

Fig. 30.

TABLE XXI.

		dX'	dY'	dZ'	R
Sept. 25th	1^h p.m.	— 81.4	— 34.6	—83.2	120.
	2	—273.	—121.	+84.5	310.
	3	—243.	— 90.8	—27.4	261.
	4	—310.	+ 24.8	+32.0	313.
	6	—222.	— 40.7	—55.4	233.
	7	—273.	+ 40.2	—83.2	289.
	9	—267.	— 68.4	+15.5	276.
	11	—240.	+ 54.5	+34.8	248.
26th	1^h a.m.	—223.	+ 75.0	+20.5	236.
	3	—218.	+ 42.4	— 3.4	222.
	4	—206.	+ 56.6	+22.8	215.
	5	—187.	+ 45.1	+10.9	193.
	Noon	—109.	— 1.9	—10.5	137.
27th	Noon	— 72.8	— 5.0	— 3.5	73.
28th-29th	Midnight	— 44.0	+ 8.7	—15.6	47.
30th	2^h a.m.	— 10.9	— 6.6	+ 8.0	16.

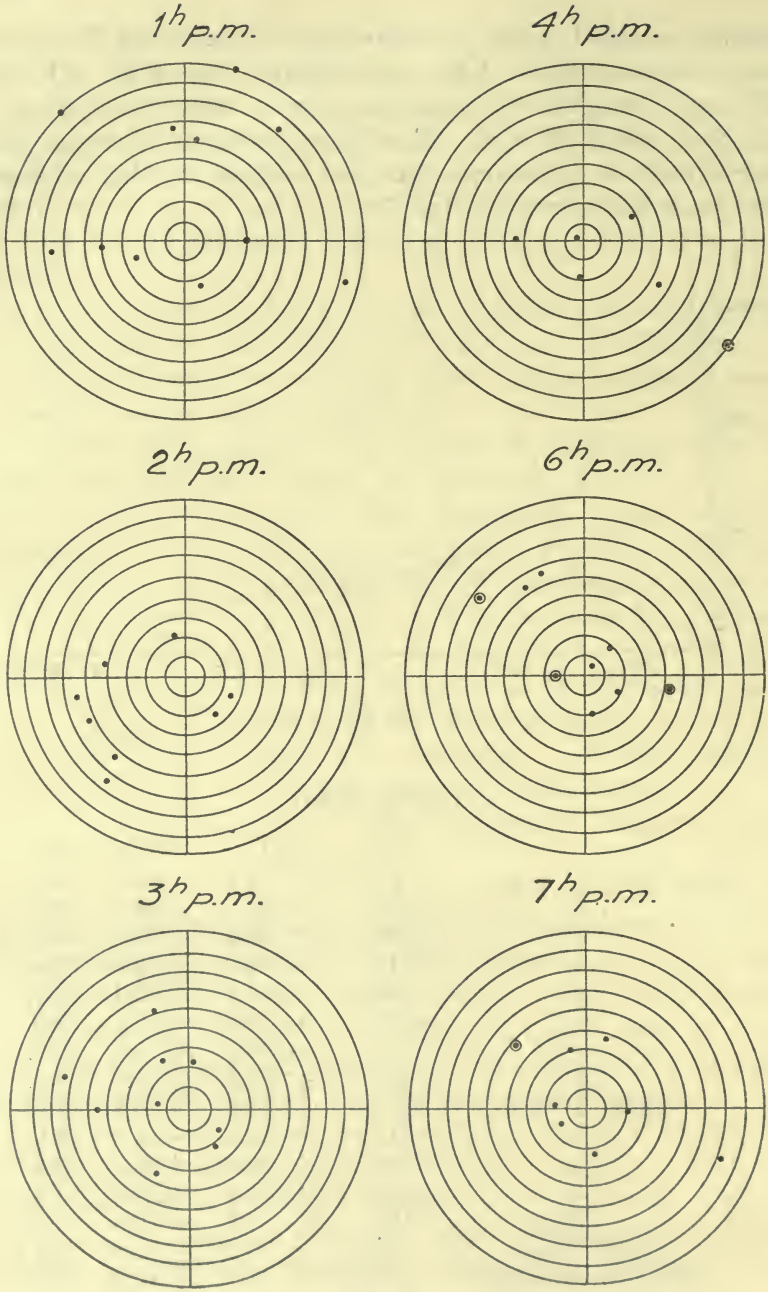

Fig. 31.

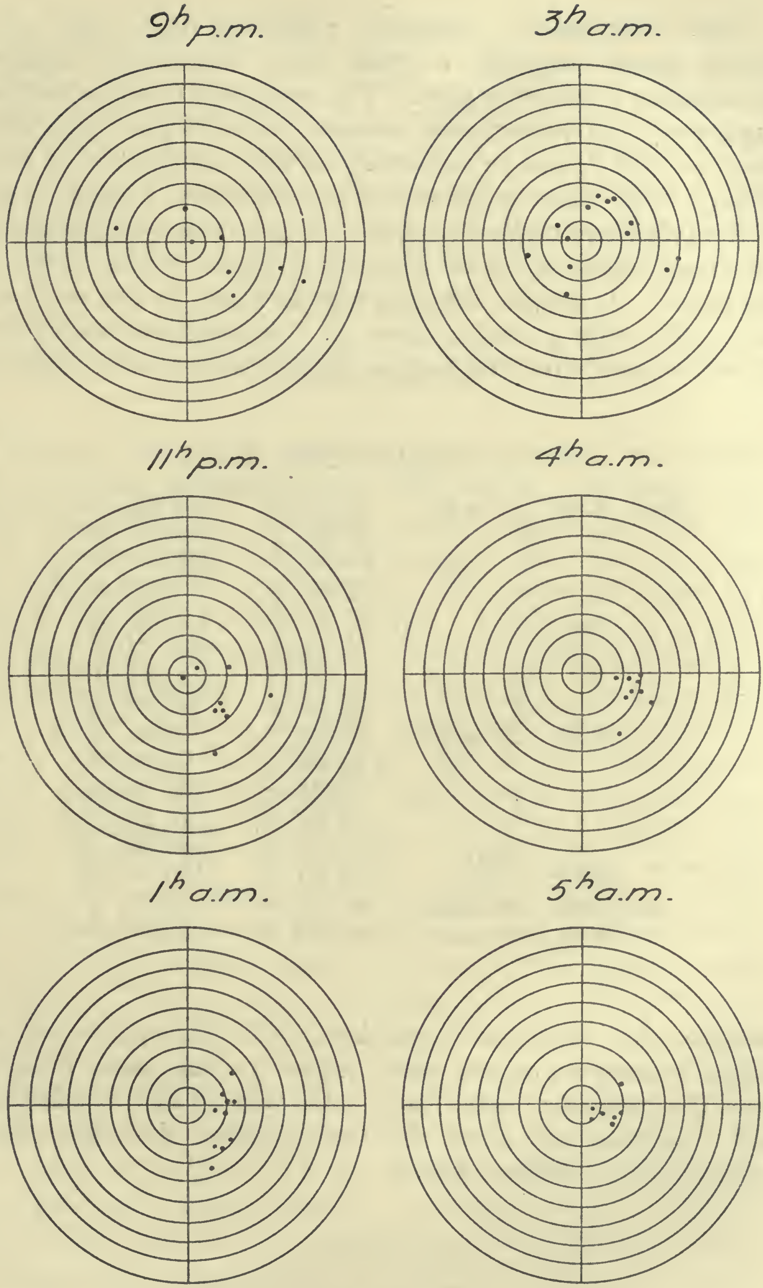

Fig. 32.

The superposed, occasional magnetic field thus, after having passed through a great many consecutive changes, has assumed a calmer aspect. The superposed field which demagnetized the normal one, reached about 2^h p.m. Sept. 25 a value of 300 γ, and subsequently steadily diminished in force till Sept. 30th, when the value sank to nearly zero. In figs. 31 and 32 the points are marked on twelve degree-nets which state the directions where the total disturbing forces cut the surface of the earth. A simple dot indicates a place in the southern, and a dot with a ring a place in the northern hemisphere. As will be seen from the figures, the forces were chiefly directed

TABLE XXII.

Sept. 25th	1^h p.m.	42°20′ *S*	157°30′ *W*
	2	60°20′ *S*	55°10′ *W*
	3	68°30′ *S*	106°40′ *W*
	4	82°40′ *S*	37°50′ *E*
	6	72°40′ *S*	143°50′ *W*
	7	71°20′ *S*	154°10′ *E*
	9	75°20′ *S*	77°20′ *W*
	11	74°50′ *S*	57°20′ *E*
26th	1^h a.m.	70°40′ *S*	74°40′ *E*
	3	78°50′ *S*	94°40′ *E*
	4	73°30′ *S*	68° 0′ *E*
	5	74°10′ *S*	76°20′ *E*
	Noon	84°20′ *S*	169°50′ *W*
27th	Noon	85°10′ *S*	125° 0′ *W*
28th-29th	Midnight	66°40′ *S*	119°10′ *E*
30th	2^h a.m.	42°30′ *S*	39°30′ *W*

towards the southern hemisphere. As time advanced, the forces became more and more united in the same direction near the magnetic south pole. In table XXII the latitude and longitude are given for the resulting direction of the forces at the different times.

CHAPTER II.

EARTH-CURRENTS.

Strong earth-currents disturbed the telegraphic communications over the whole globe on Sept. 25 th. At Stockholms Telegraph office the currents began between 9^h and 10^h a.m.[1]) on the morning of the 25th inst. The did not exceed 10 milliamperes however before 12^h 50^m a.m. when the currents increased within a couple of minutes to a force exceeding 250 milliamperes on several wires, for instance Stockholm-Christiania. To proove this fact, we know that safety pieces made of Wood's metal melt at this force of current. Between 12^h 50^m p.m. and 5^h p.m. the force of current seldom fell under 250 milliamperes. On the wire named the resistance is 5,4 ohms per km and therefore the tension exeeded 1,35 volts pr km. Earth-currents were first observed at the Telephone office on the wires to Luleå. The operator on duty at these wires received a sudden shock, half her hand turning white and two of her fingers being paralyzed. Two or three minutes after 12^h 50^m p.m. particularly strong disturbances were also observed on most of the wires going southwards. The strong increase probably took place at exactly the same time in all directions. When taking hold of a microphone, both the instrument and the hand were surrounded with an intense, diffuse light, casting out sparks and causing blisters. A measurement on a double wired copper line of $4^1/_2$ mm between Stockholm and Luleå

[1]) In the following all times given are mid-European, excepting in table XXIII.

was taken in Stockholm, and showed 120 volts between the end of the line and the earth. On this occasion the line was isolated in Luleå. About 11^h p.m. the force of earth currents had decreased to 15 milliamperes, and at 1^h on the morning of Sept. 26 it only arose to 4 or 5 milliamperes, even on the longer wires. On the iron wire (4 mm) between Gellivara and Luleå, tensions going up to 350 volts were noticed on several occasions during that day. A force of 1.7 volt per km is obtained[1]).

The following observations were made in Göteborg[2]). At 12^h 50^m a.m. the anchors struck the electromagnets on the wires to Falköping, that is to say in N.W. direction. On the other hand on the lines to Strömstad and Helsingborg the earth currents were not so strong. It was observed and measured on the wire from Falköping to Göteborg, which had a resistance of 1000 ohms. The current noticed on the wire constantly varied in force, but seldom fell, however, below 40 milliamperes. The highest force measured was 135 milliamperes, thereby showing a potential difference of 135 volts or 1.18 volt per km. At the beginning; the current went in the direction of Falköping—Göteborg, but frequently changed afterwards, and during that time the index of the measuring instrument went slowly from one side to the other.

Proposed by Lektor, Dr T. Aurén, the Direction of the Swedish Telegraph requested particulars about this magnetic storm from all Telegraph offices in the kingdom. From this reports, which have been kindly placed at my disposal, I herewith give the following extracts (pag. 64—66).

Gellivara (C. O. L. Edstrand). Measurements were taken here 1^h—2^h p.m. and the tension rose at times to 350 volts on the line no. 95 Gellivara—Luleå.

Umeå (K. A. Bergström). On the 25th inst. about at noon a current of remarkable force was noticed on the telegraph wires no. 1a, 2a, 64a, 77a, 98, 1b, 2b, 77b. The currents were noticed first and strongest on the southern wires.

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[1]) This observation is kindly given me by Telegraphcomissary C. O. L. Edstrand.

[2]) According to a communication from Mr A. Blomgren to Met. Central Office.

Between 2^h and 2^h 30^m p.m. a current was noticed coming in on the lines no. 77a, 77b, and 2b with a force of +65 milliamperes and immediately changing to —5 milliamperes. The index of the ampèremeter constantly swung in an oscillating movement, first over the whole scale without shunt and after turned and fell below 0 and changing direction it rose again to 50 degrees without shunt. On the telephone lines no. 310 to Luleå and no. 1620 southwards it was at times impossible to telephone in consequense of the strong, crackling, thunderlike sound.

Later in the afternoon the following observations were made.

Wire	Time	Strength of current. Milliamperes
1a	4^h 20.0^m	+80
1a	4 20.5	—10
1a	7 45.	—70
1a	7 45.3	+ 2.5
2b	4 25	+ 3.
2b	4 26	— 6.
98	4 27	+13.
98	4 28	+20.
98	4 28	—40.
1b	4 29	— 7.
1b	4 30	+20.
1b	4 31	— 4.
77a	7 45	— 7.
77a	7 45	+ 8.
77a	7 46	+20.
77a	7 46	—30.
77a	7 50	+ 7.
77a	7 50	— 8.
77a	7 52	+10.
77a	7 52	—53.

Sundsvall (J. A. Svanberg). On one occasion when the undulating movement of the aurora borealis field was unusually strong, the current produced in the telegraph wires was measured at 76 milliamperes, but it is very probable that even higher values were reached.

Katrineholm (J. Olsson). In the course of the afternoon, about 10 different surveys of the current were taken, showing that it rose to a height of 122 milliamperes (on the Stockholm—wire).

Linköping (E. Wenström). According to observations made here about 2^h 30^m p.m., the storm then going on, was caused by a negative current, varying from 0 to 142 milliamperes, but keeping mostly between 70 and 140 milliamperes.

Växjö (E. A. Möller). At 8^h 50^m p.m. the current in the wire was estimated at 80—100 milliamperes. The earth currents at noon reached a maximum of 19 milliamperes.

Halmstad (A. Petri). The earth currents, whose directions were from N. to S., were first observed on wire no. 96 Halmstad—Helsingborg about 12^h 30^m p.m. The force however, was not greater than, that telegrams could be easely sent off up to 1^h 15^m p.m. when all the lines showed constant current. The force of current then increased gradually till 2^h 13^m p.m. when a current of 95 milliamperes was estimated on wire no. 42 Halmstad—Göteborg. At 2^h 40^m p.m. all the wires being almost clear, the dispatch of telegrams could be continued without difficulty, except for a short time about 5 o'clock, when the current on line no. 96 Halmstad—Helsingborg was estimated at 102 milliamperes.

Karlshamn (A. Hallström). The maximum force of current was reached about 3 o'clock, when 130 milliamperes was measured.

Malmö (K. J. V. Wikblad). The force of current varied between +100 and —145 milliamperes, the last named maximum being reached at 2^h 15^m p.m. and observed on wire no. 8.

In table XXIII the results of the measurements of the earth currents are compared.

TABLE XXIII.

G M T	Resistance of the wire Ohms	Strength of earth current Milliamperes	Potential diff. Volt	Distance between the places Kms	Potential diff. per km. Volts	
0 h 30 m	—	—	350.	180.	1.94	(1)
1 13	12 80.	95.	122.	125.	0.98	(2)
1 15	56 00.	100.	560.	510.	1.10	(3)
1 15	56 00.	145.	810.	510.	1.58	(3)
3 20	55 10.	80.	441.	510.	0.86	(4)
3 20,5	55 10.	10.	55.1	510.	0.11	(4)
3 25	20 30.	3.	6.1	290.	0.02	(5)
3 26	20 30.	6.	12.2	290.	0.04	(5)
3 27	32 40.	13.	41.5	220.	0.19	(6)
3 28	32 40.	20.	64.0	220.	0.29	(6)
3 28	32 40.	40.	128.	220.	0.58	(6)
3 29	20 30.	7.	14.1	290.	0.05	(5)
3 30	20 30.	20.	40.6	290.	0.14	(5)
3 31	20 30.	4.	8.1	290.	0.03	(5)
6 45	59 80.	7.	42.	510.	0.08	(4)
6 45	59 80.	8.	47.0	510.	0.09	(4)
6 45	55 10.	70.	386.	510.	0.76	(4)
6 45,3	55 10.	2.5	13.8	510.	0.03	(4)
6 46	59 80.	20.	120.	510.	0.23	(4)
6 46	59 80.	30.	180.	510.	0.35	(4)
6 50	59 80.	7.	42.0	510.	0.08	(4)
6 50	59 80.	8.	47.	510.	0.09	(4)
6 52	59 80.	10.	59.8	510.	0.12	(4)
6 52	59 80.	53.	318.	510.	0.62	(4)

(1) Luleå—Gällivara.
(2) Göteborg—Halmstad.
(3) Stockholm—Malmö.
(4) Stockholm—Umeå.
(5) Umeå—Haparanda.
(6) Umeå—Sundsvall.

In table XXIV the days are given for the years Nov. 1906 — Oct. 1909 when a earth-current of greater force than 15 milliamperes was observed at Stockholms Telegraph Office. It will be seen from this table that the magnetic storms, like the aurora, most often occurred in the vernal and autumnal months. The maxima during the spring and the autumn corresponds to the earth's greatest distance from the solar equator, and the minimum force during summer and winter to the passage of the earth through the sun's equatorial plane[1]). With the aurora the minimum was reached during the winter, on account of the influence of the seasons (the position of the earth-equator). The disturbances of the earth-currents usually extend over great portion of the earth. The seasons have consequently no effect on

TABLE XXIV.

Year	Jan.	Febr.	March	April	May	June	July	Aug.	Sept.	Okt.	Nov.	Dec.
1906	—	—	—	—	—	—	—	—	—	—	—	16
	—	—	—	—	—	—	—	—	—	—	—	22
1907	—	7	21	—	6	—	—	—	10	11	22	—
	—	9	22	—	—	—	—	—	—	14	—	—
	—	10	—	—	—	—	—	—	—	—	—	—
1908	—	—	26	16	25	—	—	19	5	5	8	5
	—	—	27	—	26	—	—	21	12	31	9	—
	—	—	28	—	—	—	—	—	28	—	17	—
	—	—	—	—	—	—	—	—	29	—	28	—
	—	—	—	—	—	—	—	—	30	—	—	—
1909	2	—	19	—	14	—	—	2	3	8	—	—
	3	—	22	—	15	—	—	—	4	19	—	—
	4	—	29	—	18	—	—	—	8	20	—	—
	31	—	—	—	—	—	—	—	25	23	—	—
	—	—	—	—	—	—	—	—	30	24	—	—
	4	3	8	1	6	—	—	3	11	9	5	3

[1]) Arrhenius, Lehrbuch der kosmischen Physik, pag. 822.

them and the summer minimum can be more strongly marked on account of the earth being further from the sun in summer than in winter. It is, however, evident that the present unimportant material for earth currents do not permit of any definite conclusions, but on the other hand, it is of interest to see, that so few observations can be ranged under the laws of other cosmical phenomena.

In table XXV I have given the distribution of the earth-currents in the hours of the day and in fig. 33 the

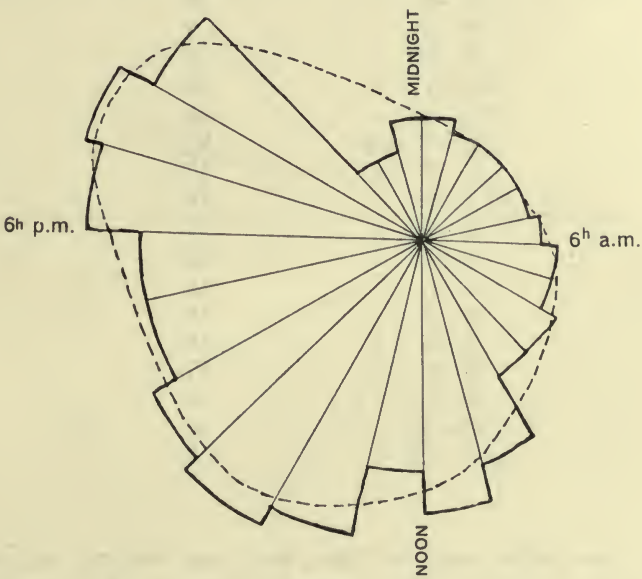

Fig. 33.

values from this table are arranged in form of a diagram. The 24 radii proceeding from the centrepoint represent the 24 hrs of the day. The lengths of the radii are proportional to the number of occasions that earth-currents were observed at the point of time in question. As will be seen from the diagram an the table earth currents are of more frequent occurrence during the day than during the night, something to be expected as the cause of these things is the sun and the dust it sends out. The maximum is reached

TABLE XXV.

Time M. E. T.	Number of occasions of earth-currents
12—1 a.m.	7
1—2 »	6
2—3 »	6
3—4 »	6
4—5 »	6
5—6 »	7
6—7 »	8
7—8 »	8
8—9 »	8
9—10 »	9
10—11 »	13
11—12 »	15
12—1 p.m.	13
1—2 »	17
2—3 »	18
3—4 »	17
4—5 »	15
5—6 »	15
6—7 »	18
7—8 »	19
8—9 »	17
9—10 »	5
10—11 »	5
11—12 »	7

during the latter part of the day and during an hour or two after sunset. The actual number of occasions for earth currents betwen 9^h p.m. and 11^h p.m. is most likely greater than those observed.

In table XXVI disturbances observed, are arranged with respect of the lines, in which they were observed.

TABLE XXVI.

Stockholm—Ånge	9
» —Kristiania	19
» —Göteborg	23
» —Malmö	18

In fig. 34 the same thing is graphically represented. NSEW indicate the four quarter. If Stockholm is considered as O the line OA shows the direction between Stockholm and Ånge. The length of the line gives in an arbitrary unit how often the disturbing earth current was observed on this wire. OB has the same relation to Kristiania, OC to Göteborg and OD to Malmö. The dotted line MM indicates the magnetic parallel through Stockholm. As will be

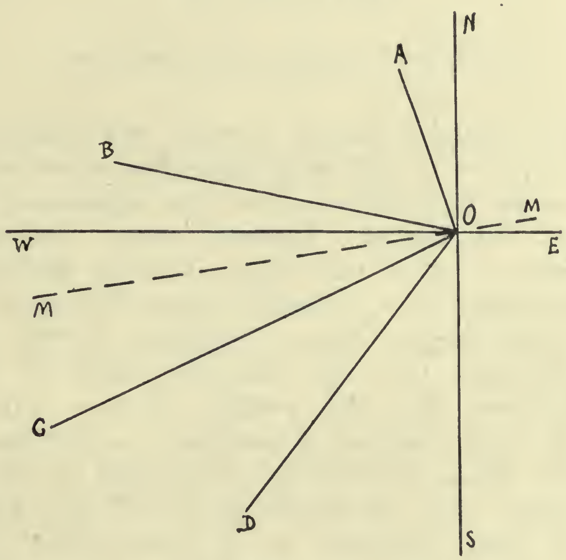

Fig. 34.

seen from the diagram, disturbances more often occur in the direction of the magnetic parallels than in that of the right angle. It is also generally acknowledged that disturbing earth currents are of more usual occurrence on East-Westerly than North-Southerly wires.

CHAPTER III.

AURORA BOREALIS AND AUSTRALIS.

A most splendid Aurora Borealis was observed from a number of places on the globe just after sunset Sept. 25th. In Sweden the light was observed from Karesuando to Karlshamn and Kristianstad. Distinct corona formations were seen a little south of the zenith at Särna, Bollnäs, Söderhamn, Mora, Stockholm, Helgesta, Dalarö, Uddevalla, Barnarp, Byarum and Berga. From Stockholm (59°21′ N. Lat. $1^h\ 12^m$ E from Gr.) and Helgesta (59°2′ N. Lat. and $1^h\ 7^m$ E. from Gr.) the position of the centre of the corona has been observed in reference to the stars. From both these places observations were made at two different times, namely from Stockholm at $7^h\ 45^m$ p.m. and $8^h\ 45^m$ p.m., and from Helgesta at 8^h p.m. and $9^h\ 55^m$ p.m. The four observations are drawn on a star-map (fig. 36) comprising the district between 20° and 50° declination and 19^h and 22^h right ascension. The positions of the lightest stars in the Swan are shown on the star-map. A shows the position the corona at the first observation from Stockholm, B its position at the second observation from Stockholm, C its position at the first, and D its position at the second observation from Helgesta[1]). In table XXVII the four observations are to be found. The following signs are used.

[1]) The first of these observations has been kindly given me by C. Landin, Chef-engineer of the Royal Patent Office, the second by Professor S. Arrhenius, and the third and fourth by E. Petri, Amanuensis at the Met. Centr. Institute.

φ = Latitude of place of observation.
λ = Difference of time between place of observation and Greenwich.
δ = Declination of the centre of the corona.
t = Hour angle » » » » » »
h = Altitude » » » » »
A = Azimuth » » » » » »

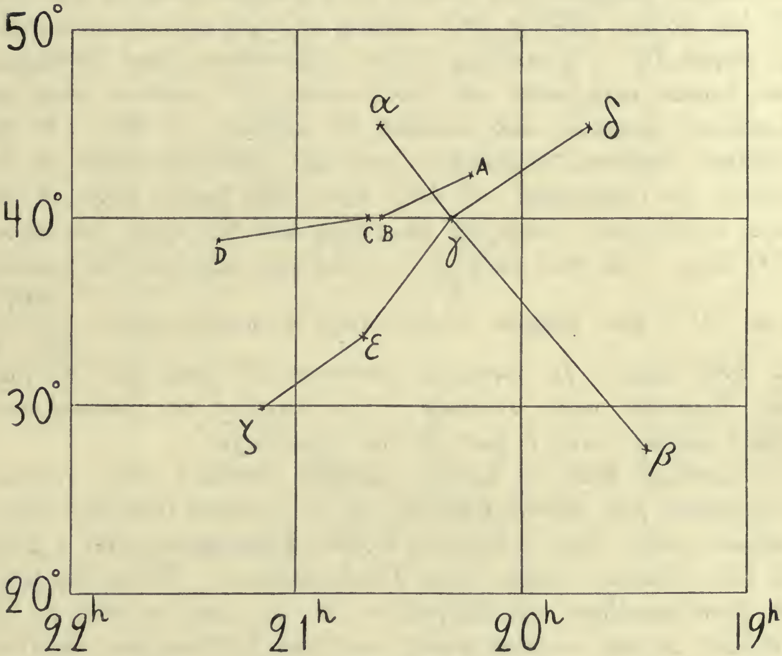

Fig. 35.

TABLE XXVII.

nr		φ	λ	δ	t	h	A
1	Sept. 25 7h 45m	59° 21′	1h 12m	41°,7	0h 5m W	70° 48′	2°50′W
2	» » 8h 55m	59° 21′	1h 12m	40°,0	0h 51m W	69° 3′	28°13′W
3	» » 8h	59° 2′	1h 7m	40°,0	0h 12m E	70° 52′	7° 1′E
4	» » 9h 55m	59° 2′	1h 7m	38°,8	1h 5m W	67° 16′	34°21′W

The average value of the altitude as seen by tab. XXVII = 69°30′. The inclination for Stockholm was Sept. 1st. 1892 70°51′,3*.

The aurora was observed in the northern sky from Slite, Västervik, Kristianstad and Göttingen, from the latter place in the form of an arch.

It will be seen from the above mentioned, that a field of almost parallel rays existed over Sweden from at least 62° N. Lat. to line AB (fig. 36), making an angle against the horizon of about 70°. According to the observations from Göttingen the lowest rays went out from about 10° altitude over the northern horizon and reached an altitude of 80°. If the distance between Göttingen and the southern limit of the aurora be estimated at 400 kms. the lower edge of the rays would have been 60 kms high and the upper one about 700 kms. As the declivity of the rays towards the horizon was 70°, the length of the rays is consequently $\frac{640}{\sin 70^\circ}$ or 680 kms. In Sweden between 63° and 66° N. Lat. the heavens were overcast. The rays of the aurora most likely spread over a part of the cloudlayer.

Another field of aurora borealis streched over Iceland, Greenland and North-America, as is evident from the observations made from Conquet, South Kensington and a point in the Atlantic Ocean, near Newfoundland. From the point of Newfoundland the amplitude of the bow as well as the altitude of the central point over the horizon was observed. From Conquet the amplitude was noted, and from South Kensington the altitude of the central point. But as Conquet is not far from South Kensington, it may be allowed that the observations made from both these places can be considered to have been taken from the same point. In this way we have two bows, so exactly determined, that calculation over their position and height above the ground is possible. The values observed are stated in the table XXVIII.

* Carlheim-Gyllensköld, Mémoire sur le magnétisme terrestre dans la Suède méridionale.

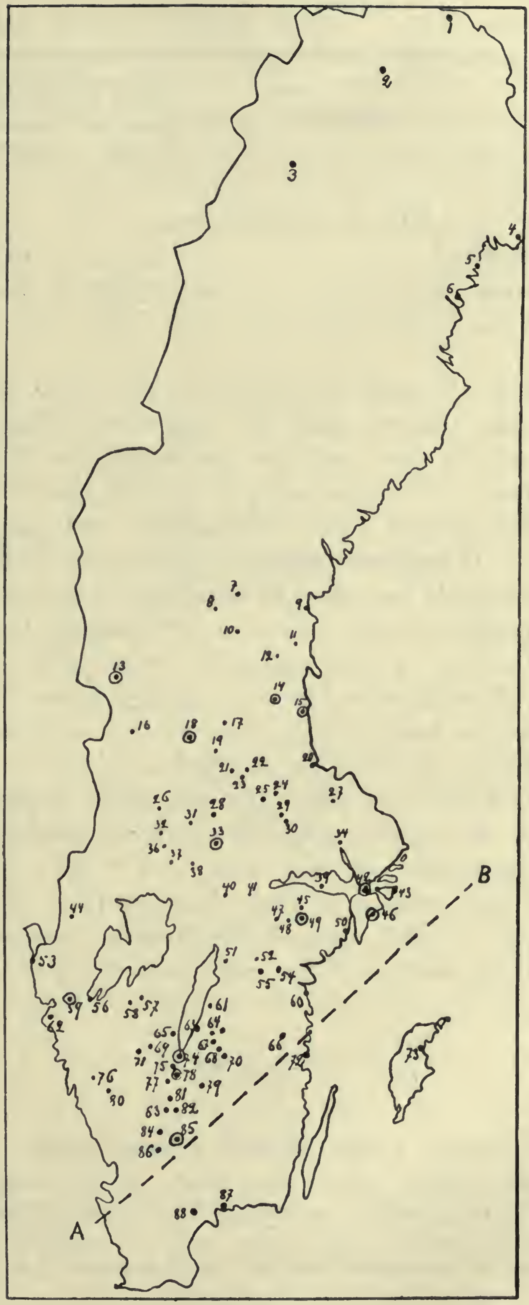

Fig. 36.

TABLE XXVIII.

	Place of observation	The azimuth of the central point	The altitude of the central point	The amplitude of the bow
1	44°50′ N. LAT.; 51°17′ W from Greenwich	11°,2	15°	90°
2	Conquet	22°,5	10°	45°

Assuming all parts of a bow to be at the same height (Z) above the ground and the angle (α) included between the plane of the bow and the horizon of the place of observation is known, it is possible to rekow how high the bow is above the ground (1). The angle α can be determined according to *Hansteen's* theory. α is equal to the radius to the circle touching the place of observation, and osculating the magnetic parallel circle. I have determined this angle by using the values of the magnetic elements to be found in Berghaus' Physikalisches Atlas, Justus Perthes, Gotha 1891. With regard to bow 1 it is clear in this way that $\alpha = 34°$. The calculation of this bow is then as follows. The earth's radius $R = 6360$ kms (fig. 37), the angle included between the bow of the aurora and the northern horizon $H = 15°$ and the amplitude of the bow $2\,a = 90°$. From these values we first reckon μ (the distance from the basepoint of the bow to the place of observation reckoned along a tangent to the surface of the earth) according to the formula:

$$\frac{\mu}{2\,R}\cot\alpha + \frac{\mu}{2\,R}\cot H = \cos a$$

This formula, which is only approximately correct, can not be used either when the bows of the northern lights are near the horizon, or when the vertical height of the

[1]) Bravais: Sur les aurores boréales vues à Bossekop et à Jupvig en 1838 et 1839.

bow over the ground is very great. Besides the preceding cases, this formula cannot be used when the amplitude ($2\,a$) is 180°, for in such a case $\cos a = 0$. In this case $\mu = 0{,}135 \times 2\,R = 1720$ kms. From μ and R the height of the bow over the ground is obtained according to the formula:

$$Z = \sqrt{R^2 + \mu^2} - R$$

According to this formula we can prove that the lower edge of the bow was 228 kms above the ground.

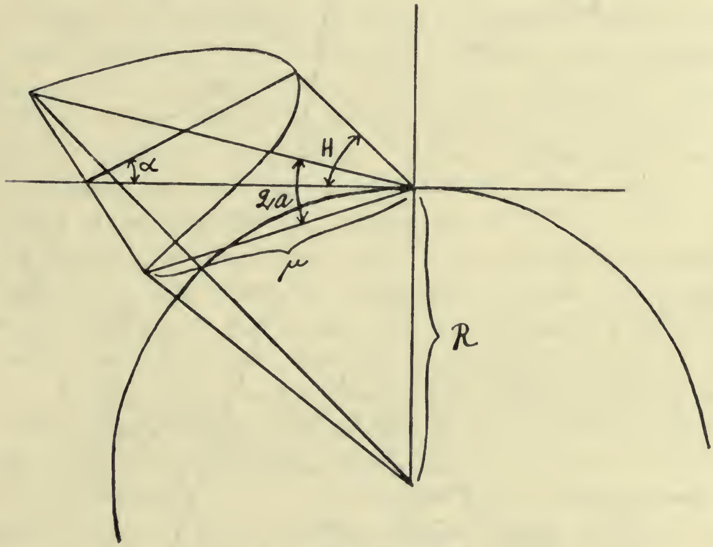

Fig. 37.

If the same calculation be made for bow 2, we can prove that

$$a = 65°$$
$$\mu = 2142 \text{ kms.}$$
$$Z = 249 \text{ kms.}$$

The limits towards the south of both districts of the aurora are marked on the map (fig. 38) by the lines CD and EF.

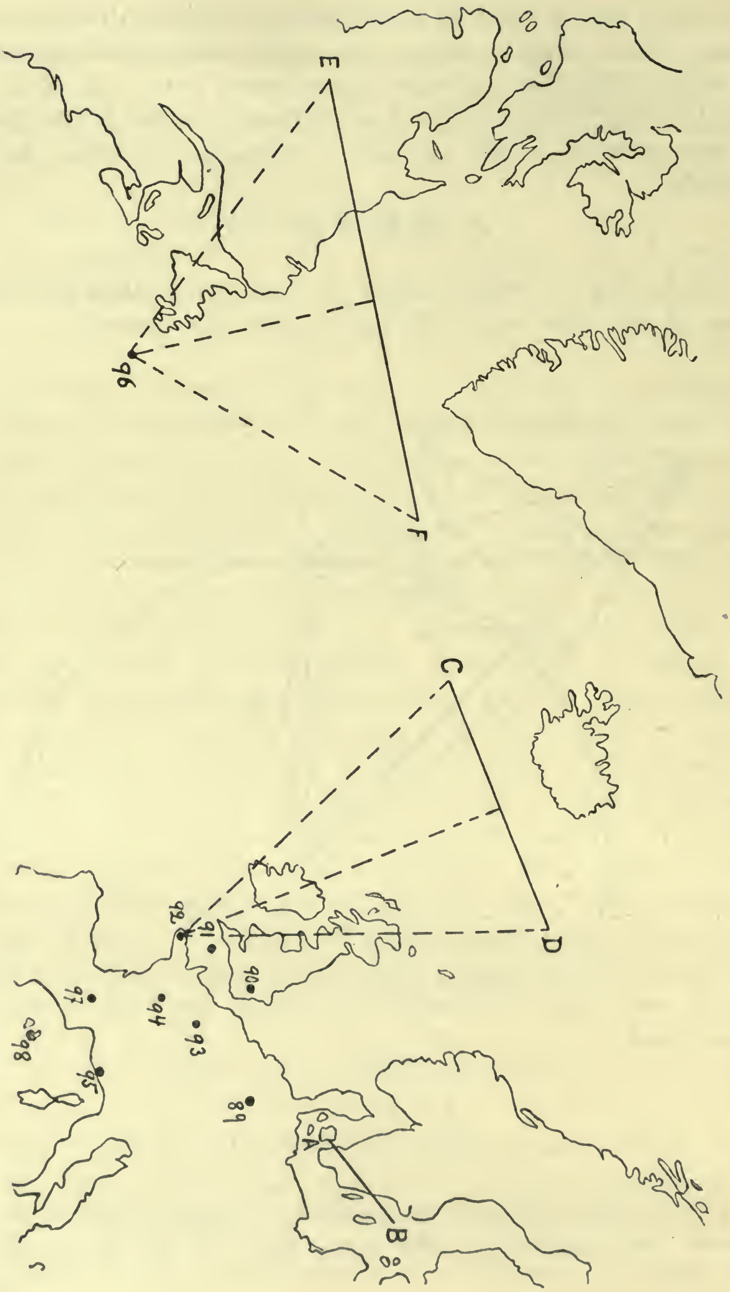

Fig. 38.

From Yerkes Observatory a rather strong auroral arch was observed low in the north, but no streamers.

Further aurora borealis was seen at Malorca.

According to information from Yokohama, auroral observations were made from the most northerly of the Japanish isles Sachalin and Jesso and also from Niigata in the north of Nippon. In the south and east of Nippon the aurora evidently escaped observation, on account of the overcast sky and heavy rains, as earth-currents disturbed the telegraphic communications in the whole Japan.

AURORA AUSTRALIS was observed in Fremantle (W. Australia) and Adalaïde (S. Australia), Batavia and Singapore. Singapore is situated 5° S. of the magnetic equator. On Sept. 25th, aurora was also been observed nearer the magnetic equator than ever before. The 2nd februar 1872 aurora was seen in Bombay (8° N. of the magn. equator) and Mauritius (30° S. of the m. e.)

In following the data of the separate observations, on which the preceding investigation depends, are grouped. The figures before the names of the different places correspondent to the figures on both the maps.

1. Karesuando ⌓. — 2. Kiruna. Rather plainly visible ⌓. Earth currents on the telegraph line Kiruna—Gällivara began about 1^h p.m. and ceased about 4^h p.m. (I. Wester). — 3. Kvickjock ⌓. — 4. Neder Kalix. The aurora was clearly visible in the evening. Slight earth currents began about 2^h p.m., ceasing about 6^h p.m. (L. Ringius). — 5. Luleå ⌓. — 6. Piteå. A strong ⌓ 8^h—9^h, ⌓ again, during the night. — 7. Ånge ⌓. — 8. Viken, Häfverö parish ⌓. — 9. Sidsjö, Sundsvalls parish ⌓. 10. Ramsjö ⌓. — 11. Bergsjö ⌓. — 12. Bjuråker. High and splendid ⌓ 8^h—10^h. — 13. Särna 7^h 30^m—10^h ⌓ with centre just south of the zenith. The radiation went in all directions almost down as far as the horizon, a dark violet colour in some places, especially towards the end of the phenomenon.

14. Bollnäs. At Bollnäs a softer ⌓ was observed shining over the zenith about 9^h and developing into a strong,

regular ring of light, from which rays were cast out in all directions, at a fairly regular distance from one another. For a time the whole phenomenon gave the appearance of a gigantic umbrella, covering four fifths of the heaven. ⌓ is even said to have been seen at midnight. (A. Boije).

15. Söderhamn. About 9^h when the sky was almost clear and the moon shining, flames resembling the aurora and beginning in the S. E. were to be seen rising up around the whole horizon. The rays meeting in the zenith formed a rosette of light clouds of many colours with soft and wavy coils of light. Shortly afterwards in both E and W the phenomenon was succeded by light clouds of a red-yellow colour, while a dark bank of clouds bounded the horizon on the N. The phenomenon is said to have been over abouth midnight. (G. A. Getzhult).

16. Transtrand ⌓. — 17. Östanviks by, Ore parish ⌓. 18. Mora. Just about 6^h ⌓ was seen gradually to increase in strength. From 9^h to 9^h 30^m it was strongest and then assumed a peculiar form. From a perfectly stationary point of radiation, a few degrees S. of the zenith, rays were cast out in all directions, extending right down to the horizon even on the S side. The point of radiation itself was for the most part dark, as the well defined tips of the flames, never once met there at the same time. The rays spread themselves out on all sides in the resemblance of a completely round fan or cornet, shining most brilliantly at the point of radiation. Nowhere in the horizon could any definite dark segment be observed. At times the rays were almost stationary and at other times varied both in breadth and force. Violent flames resembling concentric circles rose up from the horizon to the zenith, or perhaps in the opposite direction, but these seemed to me to be independent of the comparatively immovable radiating rays. The light was visibly stronger in NE and NW and in these quarters showed at times showed a rather strong reddish colour. ⌓ diminished at about 10^h. (A. Ideström).

19. Rättvik ⌓. — 20. Gäfle ⌓. — 21. Grycksbo ⌓. — 22. Sundborn ⌓. — 23. Falun ⌓. — 24. Stjärnsund ⌓.

— 25. Husby ⌓. — 26. Tyngsjö ⌓. — 27. Tierp ⌓. — 28. Grangärde, Nyhammar ⌓. — 29. By rectory. ⌓. — 30. Näs ⌓. — 31. Säfsnäs ⌓. — 32. Mokärnshyttan, Nordmark ⌓.

33. Ställdalen, Ljusnarsberg's Parish. An uncommonly strong and splendid ⌓ was observed at 8^h 40^m. The whole firmament in the N. semed to be covered with rays of light, meeting in the zenith, waves of light were also visible, coming first from N. W., then from N. and lastly from N. E. effusing a sulphurous yellow-green light and moving towards the zenith. In addition to this a reflex-like light was visible in the S. W., changing from a dull indefinable colour to an orange-purple shade. ⌓ was strongest between 8^h 40^m and 9^h 20^m. But even as late as 2^h a. m. on Sept. 26th rather strong flames of light were seen in the sky.

34. Uppsala, Meteorological Observatory ⌓. — 35. Uppsala, Ultuna ⌓. — 36. Nordmark's mine, Nordmark ⌓. — 37. Filipstad, Mining School ⌓. 38. Grythyttan ⌓. — 39. Öfver Selö ⌓. — 40. Kil ⌓. — 41. Götlunda ⌓. — 42. Stockholm ⌓. — 43. Djurön ⌓. — 44. Torrskog ⌓. — 45. Malmköping ⌓. —

46. Dalarö[1]). At 9^h a rather broad and extremely bright pillar of light was observed in the E. It was somewhat conical, with the broader part upwards, and clearly distinguishable from the surrounding light air. The cone of light was exceedingly brilliant, containing, besides colourless lights, even fine red and also greenish tints, and extending from the horizon a few degrees up towards the zenith. After a while, the cone expanded and resembled a fan without changing direction. At the same time a cluster of rays principally of a white-greenish colour were thrown from a point in the S. high up into the sky. The rays went first towards the E then towards the NE and N. The rest of the sky was hidden by a considerable cloud. At 9^h 15^m the whole sky was almost overcast, but between 9^h 15^m and 9^h 30^m ⌓ was however seen shining between the clouds.

47. Bie ⌓. — 48. Nygårds Floda ⌓.

[1]) This observation has been kindly given me by Mr. Nils Janzon.

49. Helgesta. ⌓ was first seen here 7^h 30^m in the form of narrow rays in a N. W. direction and extending right up to the zenith. It suddenly increased in strength taking the form of rather irregular draperies, consisting chiefly of straight rays of no great mobility. At 8^h a corona of the rays of the northern light was to be seen, whose centre lay about 2° E of γ Cygni, and whose rays in spite of the strong moonshine, were distinguishable at 30° or 40° down towards the southern part of the sky. About 8^h 30^m ⌓ had almost completely disappeared, but shortly before 10^h it was to be seen even more brillantly than before. The corona before mentioned was still visible, but its centre had moved, so that at 9^h 55^m it lay abouth 5° S. E of α Cygni. ⌓ had still the appearance of almost stationary draperies of slowly varying form, but in addition to this rather strong flames were now seen, rapidly moving from N.N.W. up towards the zenith and even visible a good way down towards S. ⌓ appeared, on the whole, to be purely white, but at about 10^h a reddish tint was observed in the N. E., and shortly after this, the sky became entirely overcast. (E. Petri).

50. Trosa ⌓. — 51. Godegård ⌓. — 52. Finspång ⌓. — 53. Grebbestad ⌓. — 54. Norrköping ⌓. — 55. Wånga ⌓. — 56. Venersborg. A brilliant ⌓ at 9^h. — 57. Skara ⌓. — 58. Saleby ⌓.

59. Uddevalla. Splended ⌓ at 7^h in the zenith, extending towards the N. E. and W. (Wykström).

60. S:t Anna ⌓. — 61. Åby ⌓. — 62. Stahla ⌓. — 63. Grenna ⌓. — 64. Linderås ⌓. — 65. Gustaf Adolf ⌓. — 66. Odensvi, Scharply defined rays were to be seen in the N.W. and N.E. — 67. Lommaryd, Strong ⌓ 7^h—9^h 30^m. — 68. Marbäck ⌓. — 69. Hössna ⌓. — 70. Askeryd ⌓.

71. Ulricehamn, a strong ⌓ 8^h; at 8^h 30^m a beautiful double bow was visible over the whole of the southern sky, which lessened for a moment, only to reappear in E. and thicken to a blood-red cloud; with golden rays, resembling a tremendous flame of fire, diminishing in brilliancy after a few seconds. (Nordlund).

72. Västervik, A strong ⌓ was observed in the N. 7^h 15^m—7^h 30^m; afterwards moving from the N. to the E. At the same time brilliant rays of light were seen in the N.W. and N.E. It became overcast about 8^h, but at 10^h exceptionally strong lights were again visible. (K. W. Starkenberg).

73. Slite. Faint white bands of light were observed in the northern sky. (A. H. Calissendorff).

74. Barnarp, ⌓ was seen at 9^h radiating from a corona in the zenith and extending over the sky in the N.E. and W.

75. Månsarp, 9^h—10^h ⌓ were seen coming principally from the N. and going upwards in wavy forms, partly colourless and partly flame-coloured.

76. Sättila ⌓. — 77. Tranemo ⌓.

78. Byarum. 9^h ⌓ appeared radiating from a corona in the zenith and extending over the sky in the N.E. and W.

79. Bringetofta ⌓. — 80. Öxabäck ⌓. — 81. Käfsjö. Strong ⌓. — 82. Värnamo ⌓. — 83. Herrestad ⌓. — 84. Bolmsö ⌓ 8^h.

85. Berga. Rays shone from a central point high in the sky.

86. Annerstad. At sunset an unusually strong flame shone in the sky, during 25 minutes. At 9^h 25^m light streaks of light went from W to E. The whole resembled a search-light and at times the whole horizon was illuminated.

87. Karlshamn. 8^h 30^m bow of light with rays was observed.

88. Kristianstad. Faint rays from the N.W. went up towards the zenith.

89. Göttingen[1]). 8^h light sections were seen in the northern sky, indicating the aurora, which suddenly became very brilliant. A bow of light appeared, having a breadth of several moon-diameters. Shortly after 8^h the rays began rising from the bow and attained of height of 65°. About 8^h 45^m the brilliancy hastily increased to such a force, that is seldom to be observed in so low a latitude. The whole

[1]) Elektrotechnische Zeitschrift, okt. 1909.

sky was illuminated by the rays from the bow, the longest proceeding from about a height of 10° above the northern horizon and reaching as far as 80°. At 9^h the phenomenon suddenly ceased. (Wiechert).

90. London, South Kensington[1]). Between 7^h 40^m and 8^h 30^m the whole firmament was filled by a faint light, with lighter spots here and there, but the strongest light was seen in the zenith. This light continued till 9^h. Between 9^h an 10^h the aurora was were slight; but after 10^h a bow of faint light was visible over the northern horizon. (Fowler).

91. Guernsey.[2]) At 9^h ⌓ was observed like a rose coloured, luminous part rather high in the sky, in the E.N.E. At 9^h 10^m it had totally disappeared. (Rowswell).

92. Conquet[3]) (Finestère). ⌓ here took the form of a depressed bow, whose highest point was in the N.N.W. and whose foot-points reached the horizon in the N. and N. W. Above this bow rays were seen some of which almost reached the zenith, there showing particularly red and violet colours.

93. Samt-Georges-sur-Cher (Loir-et-Cher[3]) ⌓ (de Tastes). — 94. Clamart (Seine) ⌓ (Stassano). — 95. Nisza ⌓.

96. 44° 50′ N. Lat. and 51° 17′ W. Long. from Greenwich[4]). At 8^h 30^m a strong ⌓ was seen to arise at clear moon-shine and in a starlight sky. At first a bow was formed, whose highest point was 15° above the horizon N. to W. The footpoints of the bow reached almost to the horizon at a distance of 4 compass-line on each side of the highest point of the bow. The bow suddenly became much clearer and more sharply defined. Faintly diverging rays proceeded from different points of the same to a height of about 45°. This phenomenon lasted about 8^h 38^m and then suddently disappeared. Betwen 8^h 30^m and 9^h 30^m the bow was to be seen three times, and although fainter, yet still in the same direction and height. On one of these occasions single

[1]) Nature, Sept. 1909.
[2]) Symon's Met. Mag. Okt. 1909.
[3]) C. R. 4 Okt. 1909.
[4]) Ann. der Hydr. Okt. 1909.

vertical rays were to be seen at the W-footpoint of the bow. At 11^h 30^m at two different times at sigle ray was observed in the N. to W., which reached a height of 40°.

97. Bagnères-de Bigorre ⌓[1]) 8^h 15^m—8^h 30^m and 9^h 10^m (Marchand). — 98 Mallorca[2]) Strong ⌓ 9^h—9^h 15^m.

99. Yerkes Observatory ⌓[3]). — 100. Sachalin ⌓[4]). — 100. Jesso ⌓[4]). — 101. Batavia ⌓[4]). — 102. Singapore ⌓[4]). — 103. Fremantle ⌓[5]) — 104. Adalaïde ⌓)[5].

On Sept. 18th.[6]) a large solar spot appeared on the eastern margin of the sun. It disappeared on the western side on Sept. 29th., passing the centre—meridian on Sept. 23rd about 7^h p.m., 42 hours before the outbreak of the magnetic storm.

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[1]) C. R. 11 Okt. 1909.
[2]) Symon's Met. Mag. Okt. 1909.
[3]) The Astrophysical Journal 1910.
[4]) Urania No 4, 1910.
[5]) Met. Zeitschrift 1909.
[6]) The Astrophysical Journal. Jan. 1910.

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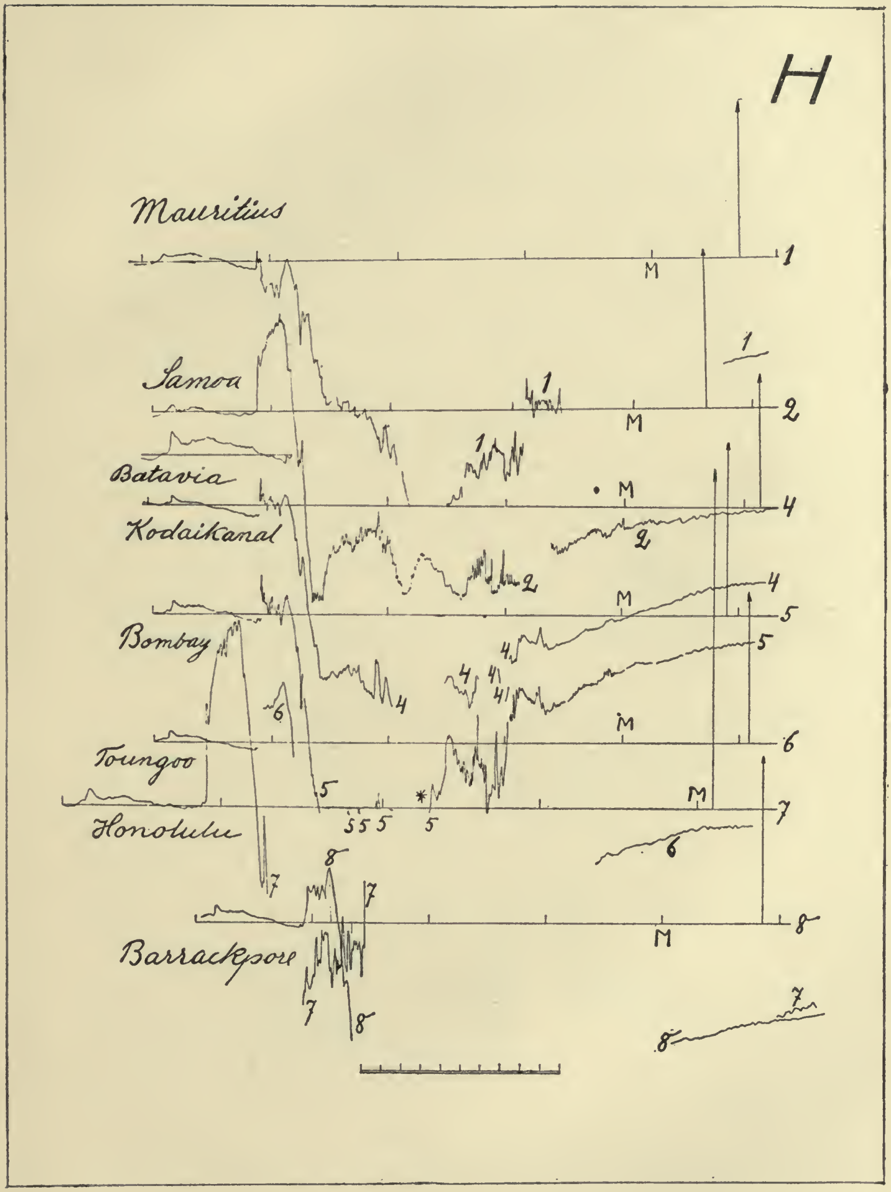
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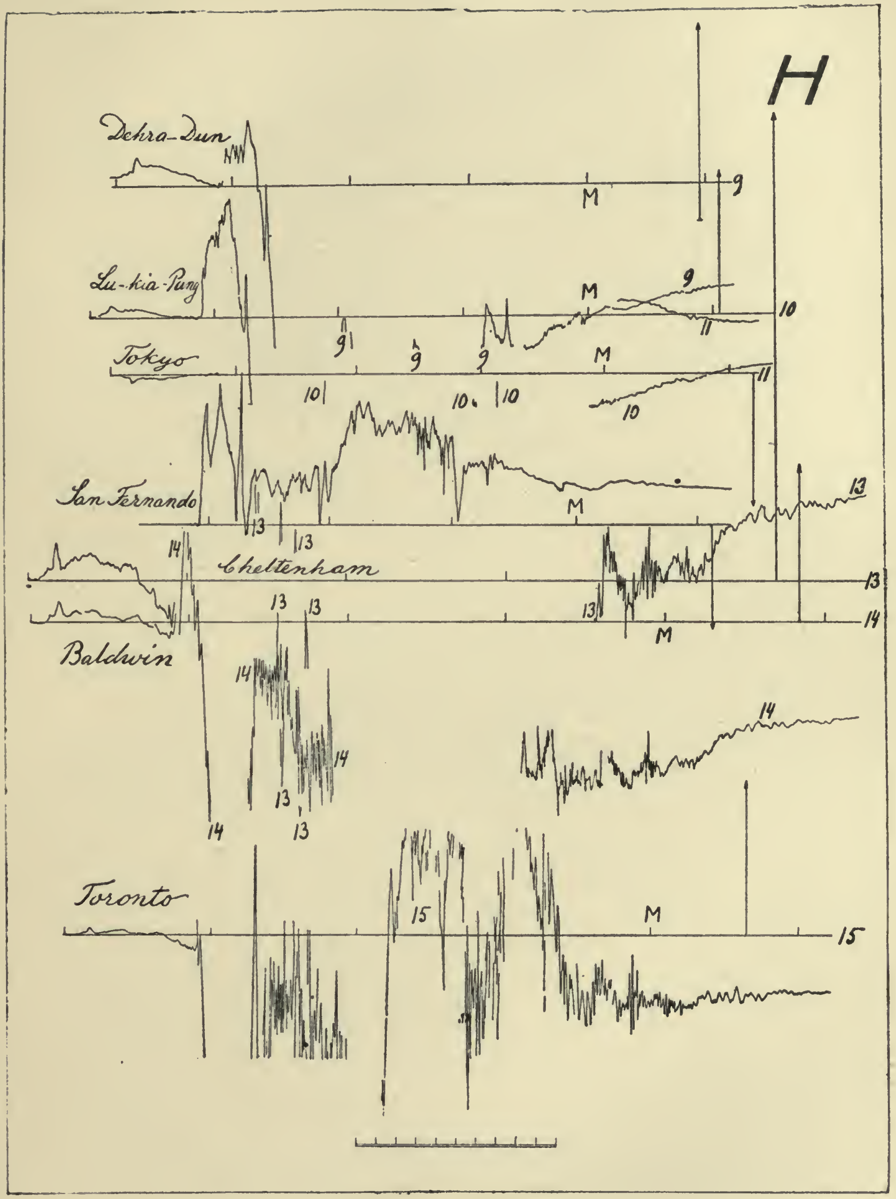
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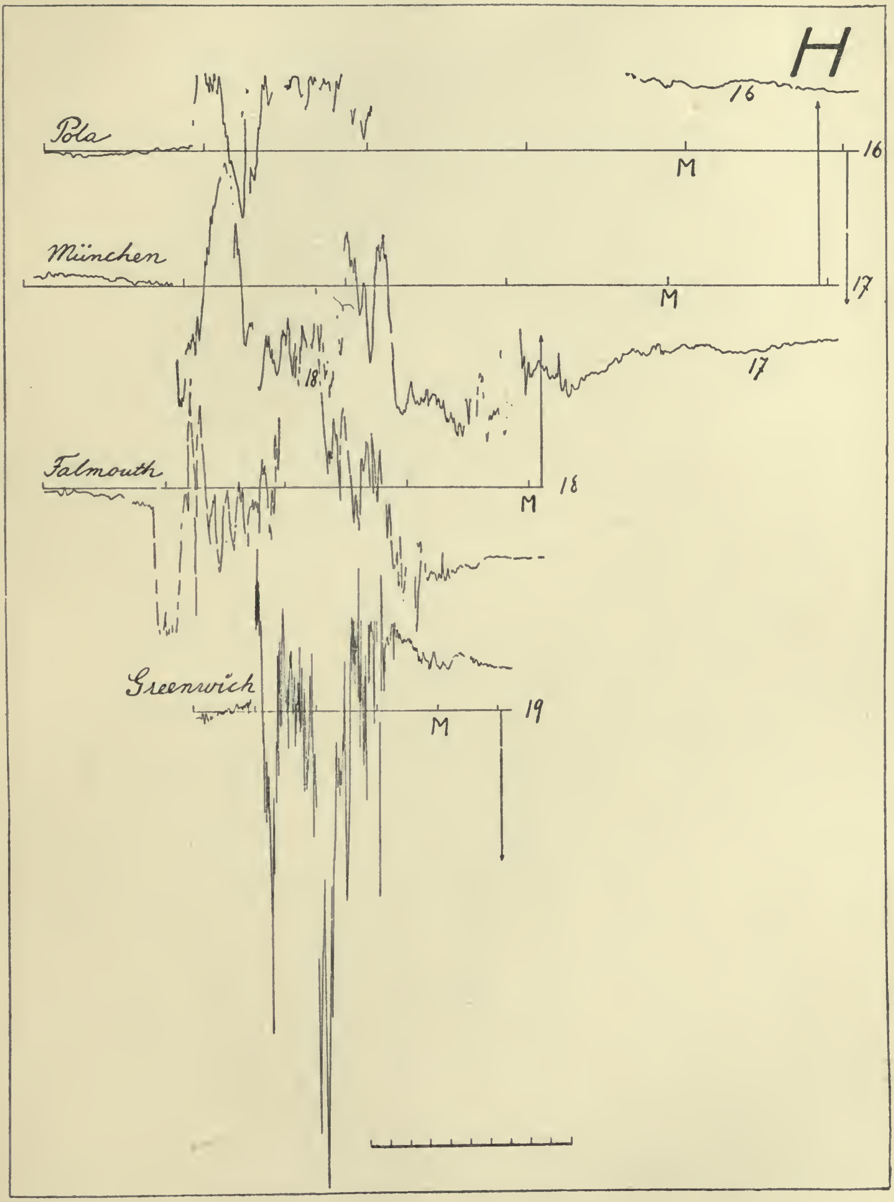
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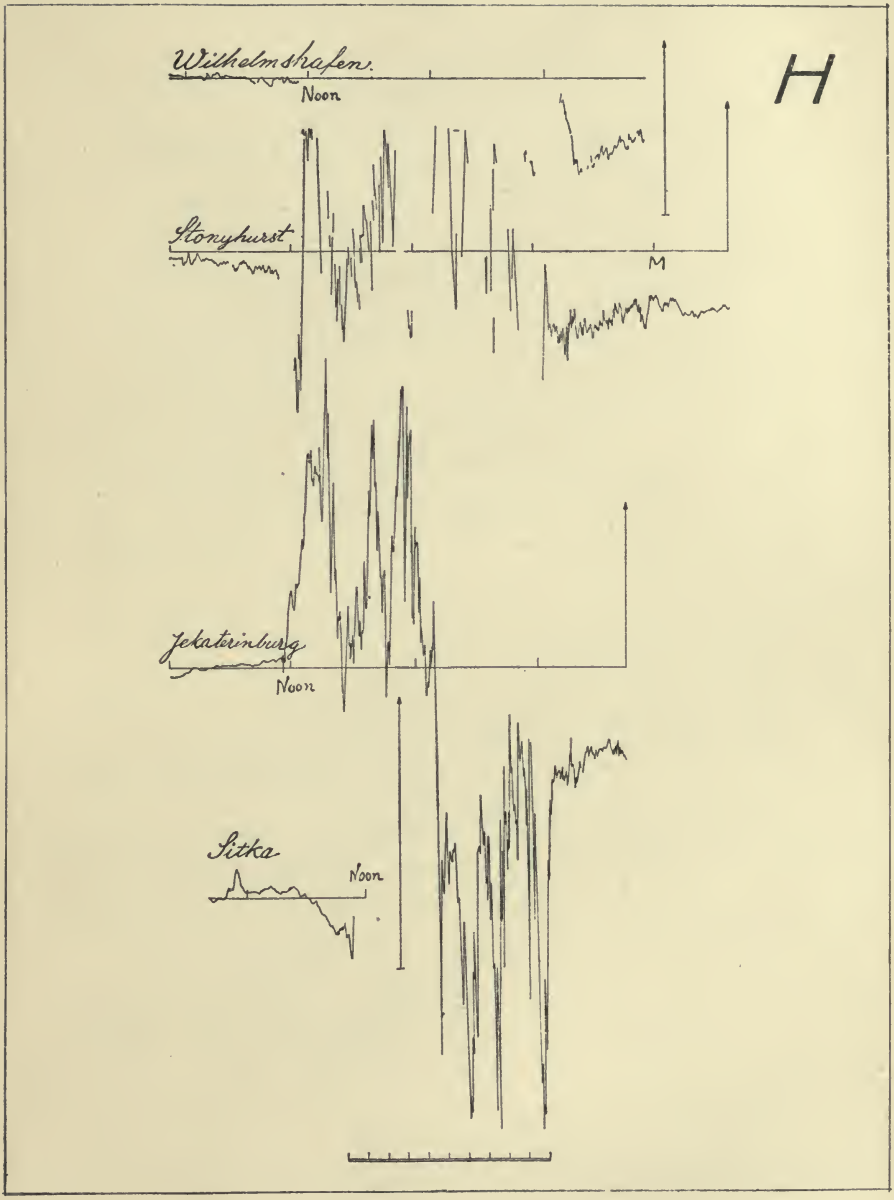
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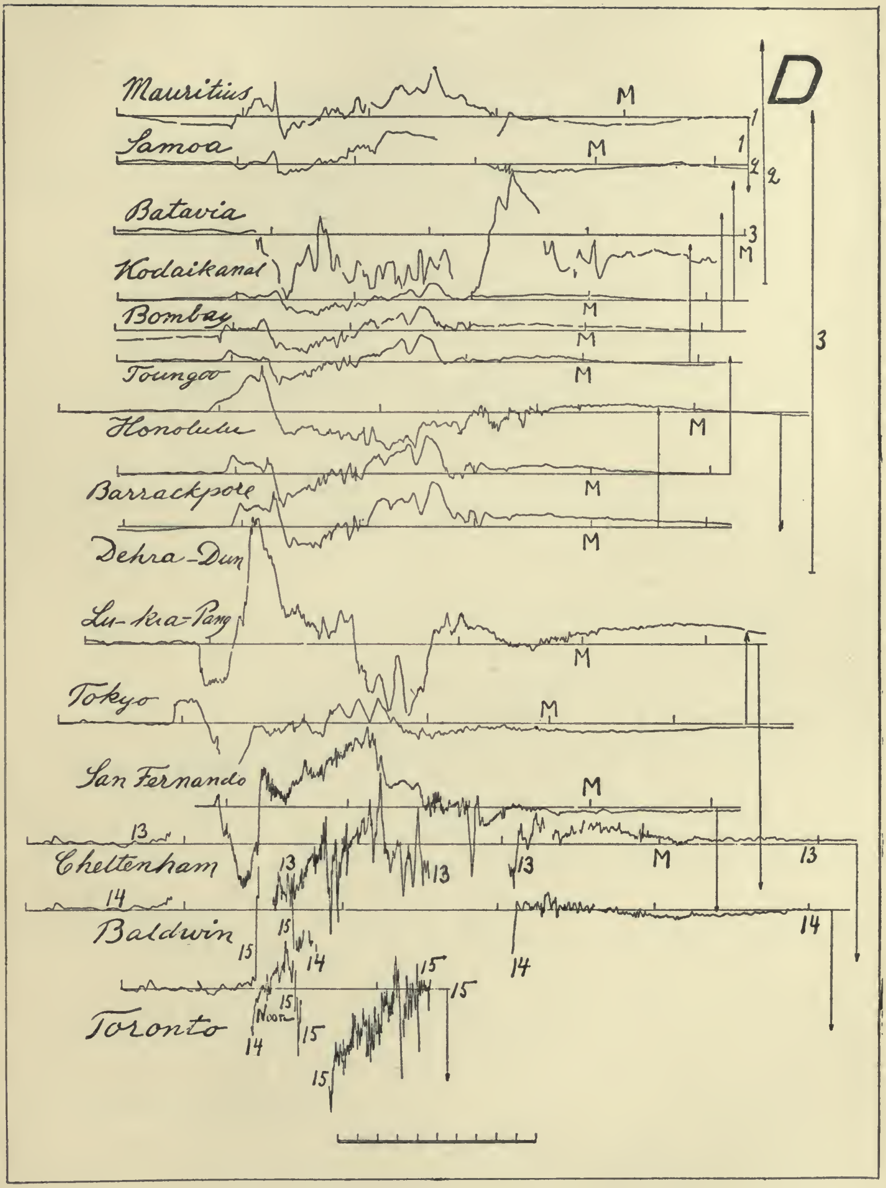
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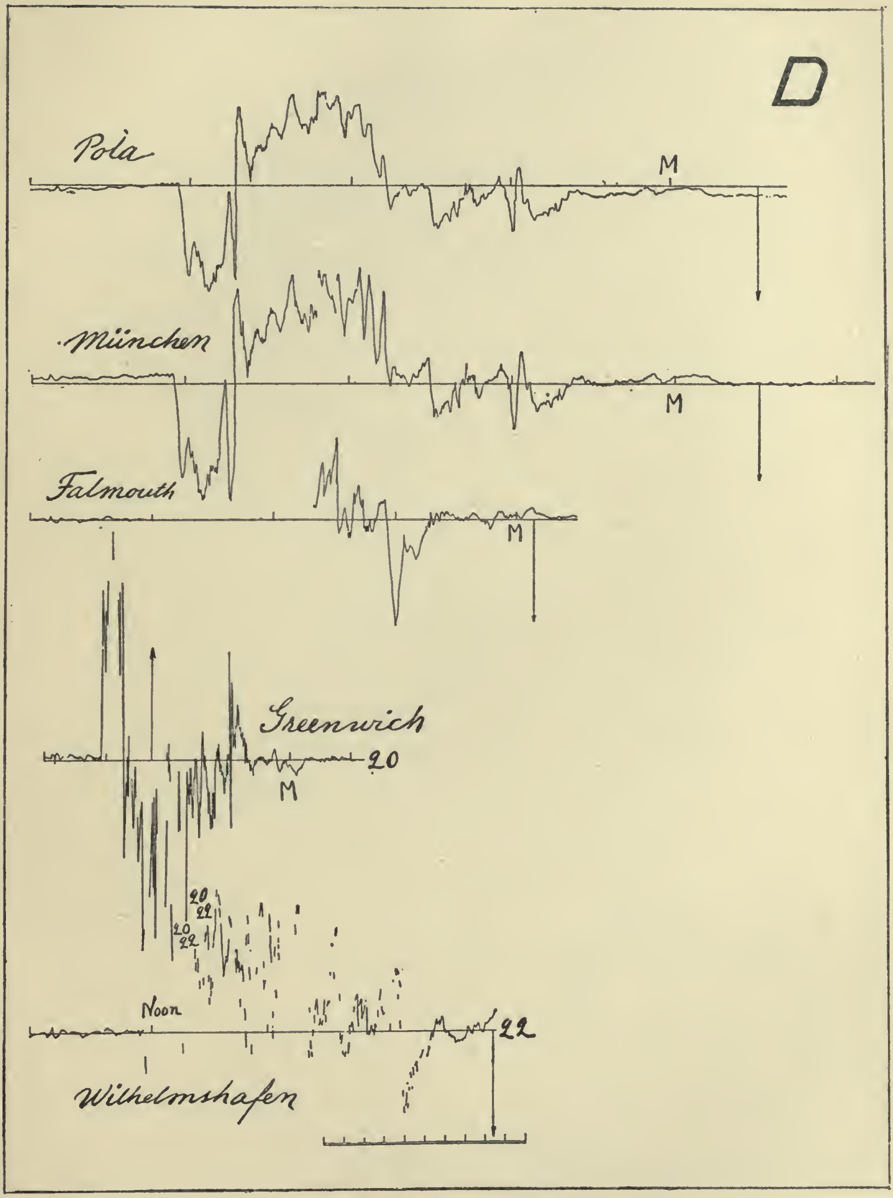
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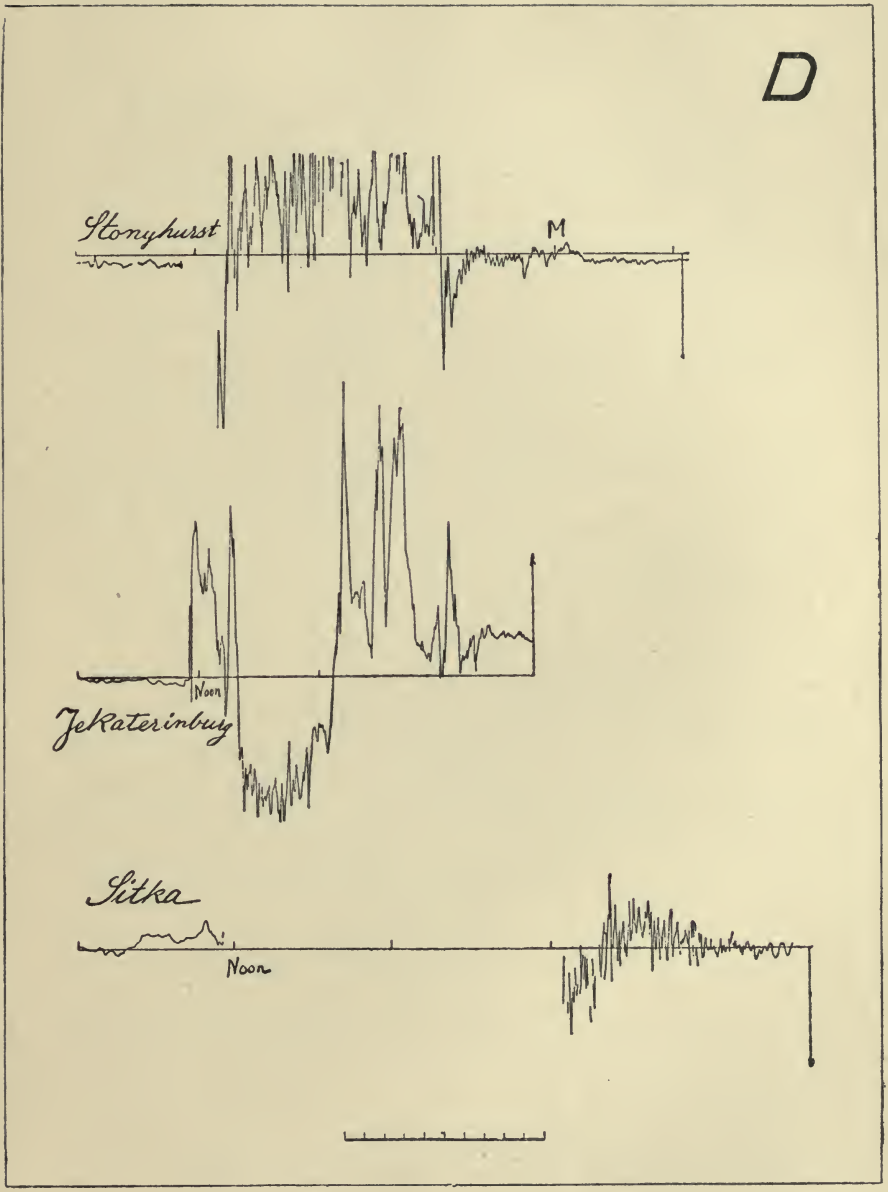
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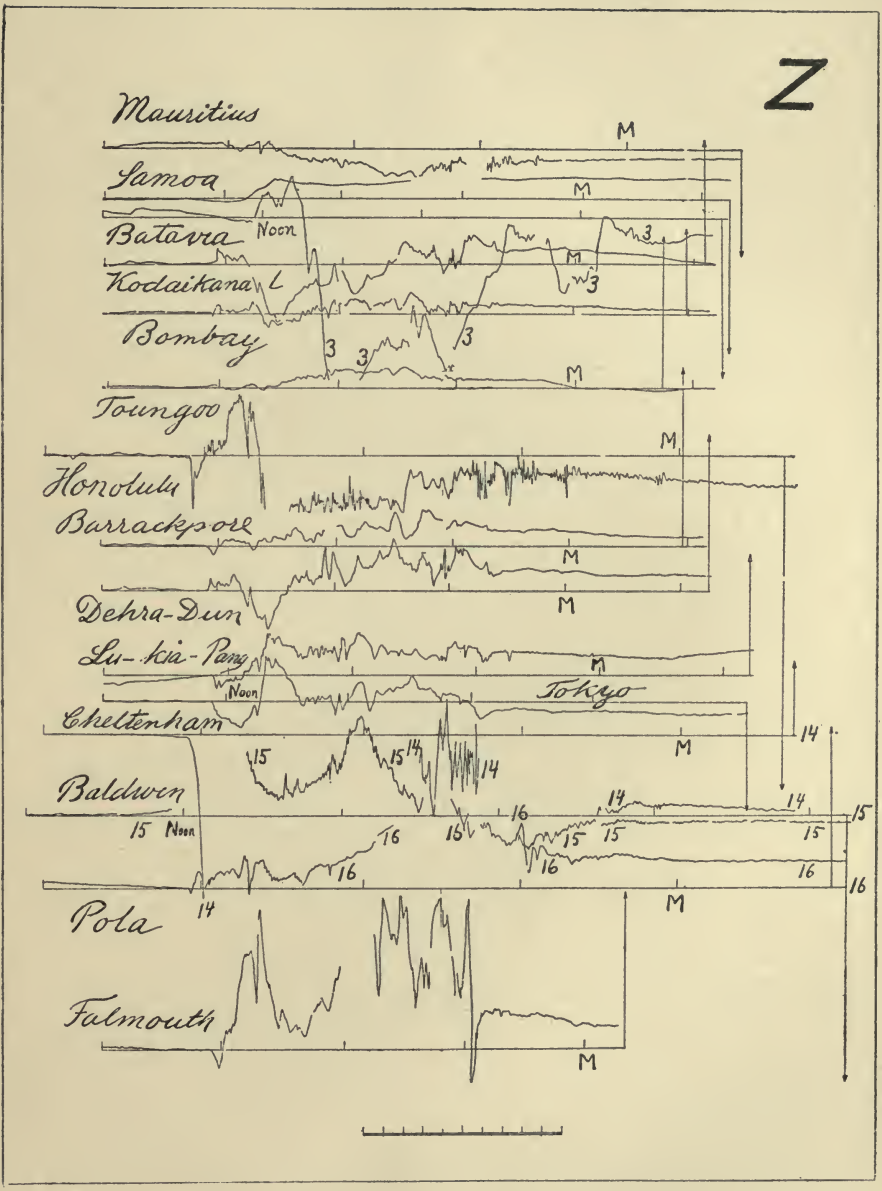
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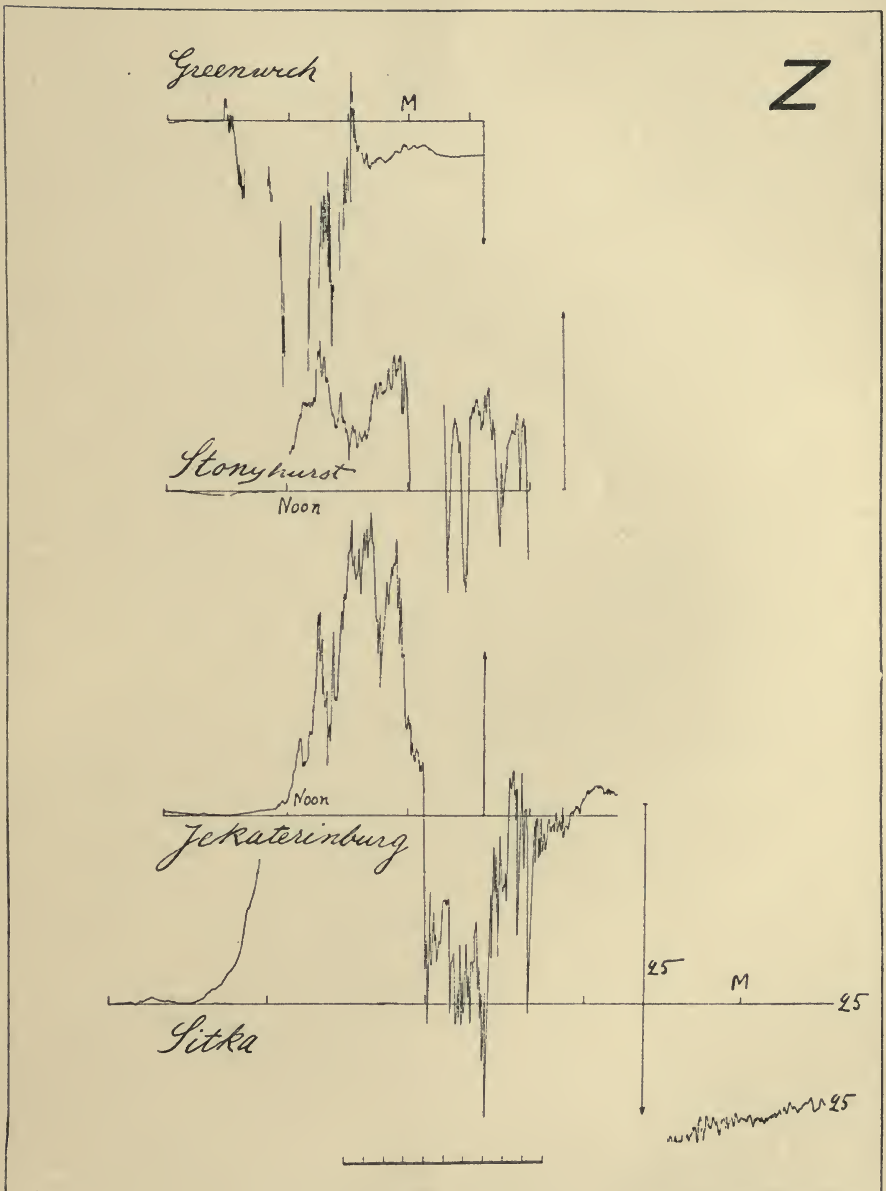
Mauritius
Samoa
Batavia
Noon
Kodaikana
Bombay
Toungoo
Honolulu
Barrackpore
Dehra-Dun
Lu-kia-Pang
Noon
Tokyo
Cheltenham
Baldwin
15
Noon
Pola
Falmouth
M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Greenwich
M
Stonyhurst
Noon
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Jekaterinburg
25
M
25
Sitka
25