

DEPARTMENT OF COMMERCE AND LABOR
COAST AND GEODETIC SURVEY

O. H. TITTMANN, SUPERINTENDENT

RESULTS OF OBSERVATIONS MADE AT THE COAST AND
GEODETIC SURVEY MAGNETIC OBSERVATORY
AT VIEQUES, PORTO RICO
1903-1904

BY

DANIEL L. HAZARD

Computer, Division of Terrestrial Magnetism



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CONTENTS.

	Page.
Introduction.....	5
Administration.....	6
Definitions.....	6
Methods.....	7
Location and buildings.....	8
Instruments.....	10
Instrumental constants of the magnetograph.....	12
Absolute observations and base-line values.....	12
Diurnal variation.....	17
Daily range of declination.....	21
Summary of monthly and annual means.....	24
Hourly values of declination.....	26
Hourly values of horizontal intensity.....	48
Magnetic storms.....	70

ILLUSTRATIONS.

Fig. 1.--Fort Isabel Segunda, south side.....	8
Fig. 2.--Ground plan of part of Fort Isabel Segunda.....	9

RESULTS OF OBSERVATIONS MADE AT THE COAST AND GEODETIC SURVEY MAGNETIC OBSERVATORY AT VIEQUES, PORTO RICO, 1903-1904.

INTRODUCTION.

The first magnetic observatory equipped with self-recording instruments established by this Survey was at Key West, Florida. At that place a Brooke magnetograph was in operation from 1860 to 1866. The same instrument was later mounted at Madison, Wisconsin, and kept running from 1876 to 1880. The records of the observations at these two observatories were not very satisfactory. In 1882 an observatory was constructed at Los Angeles, California, and there an Adie magnetograph was kept in operation from October, 1882, to October, 1889. The results of these observations have been discussed and published in the reports of the Survey for 1890, 1891, and 1892. In 1890 the same Adie magnetograph was installed in an observatory at San Antonio, Texas. In 1892 the observatory had to be moved to a new location outside the city on account of the disturbing effect of an electric car line, and in March, 1895, it became necessary to discontinue the observatory on account of insufficient appropriation for magnetic work. From this brief summary it will be seen that prior to 1900 the magnetic observatory work of the Coast and Geodetic Survey was very limited in extent and intermittent in character.

In 1899 a much more liberal appropriation made it possible to begin a systematic magnetic survey of the United States and in connection therewith to prepare for the establishment of several magnetic observatories.

As the magnetic observatory which had been operated in connection with the Naval Observatory, in Washington, District of Columbia, had been rendered useless by the encroachment of electric car lines, it was decided to erect the principal magnetic observatory of the Coast and Geodetic Survey at Cheltenham, Maryland, about 14 miles southeast of Washington. The necessary buildings were begun toward the end of 1900, and completed in time to begin observations in April, 1901. In order to provide the means for reducing to mean of day the field observations made in the Middle West, an Eschenhagen magnetograph was mounted at Baldwin, Kansas, in an existing structure fairly well adapted for the purpose, in June, 1900. In the autumn of 1901 observatories were constructed at Sitka, Alaska, and near Honolulu, Hawaii, and the records of these observatories begin with January, 1902. In February, 1903, the old Brooke magnetograph, somewhat modified and improved, was installed in a room in Fort Isabel Segunda, on Vieques Island, Porto Rico. Observations were continued there until the spring of 1907, at which time the instruments were transferred to a specially constructed building about five-eighths of a mile to the west of the old fort. Full details of the location and construction of the buildings at Cheltenham, Sitka, and near Honolulu will be found in Appendix 5, Coast and Geodetic Survey Report for 1902.

The present publication contains the results of the absolute and variation observations at the Porto Rico observatory for the two years 1903 and 1904. Owing to modifications in design of the instrument and delay on the part of the instrument maker, it was not possible to secure vertical force variometers of the improved Eschenhagen type until 1904, and one was not installed at Porto Rico until February, 1905. Consequently this publication contains no vertical intensity results, but the results of the dip observations are tabulated instead.

The preparation of the rooms in the fort for observatory purposes and the mounting and adjustment of the instruments were done under the personal direction of Dr. L. A. Bauer. The work of the observatory was carried on by R. F. Soper until August, 1903. After that time W. B. Keeling was observer in charge until July, 1904, when he was relieved by P. H. Dike.

ADMINISTRATION.

The direct supervision of the magnetic work of the Coast and Geodetic Survey is assigned to an assistant to the Superintendent, designated "Inspector of Magnetic Work." This position was filled by Dr. L. A. Bauer from 1899 to September 1, 1906. Under his able direction the sites for the observatories were selected, buildings designed and erected, instruments purchased and installed, and the work established on its present efficient basis. When Dr. Bauer resigned from the Coast and Geodetic Survey in 1906, Mr. R. L. Faris was appointed to succeed him as Inspector of Magnetic Work.

The field and observatory work is carried on by a force of eight or ten magnetic observers. At each observatory there is an observer in charge, assisted occasionally by one additional observer and usually by one helper to perform the manual work and assist in the scaling of ordinates and in the simpler forms of computation. The observers are transferred from one observatory to another or assigned to field work as the exigencies of the Survey demand.

The records of the various observatories are transmitted as promptly as possible to the office of the Coast and Geodetic Survey at Washington, and turned over to the Division of Terrestrial Magnetism for computation and discussion. The Inspector of Magnetic Work, who is also chief of this division, had at the beginning only one computer to assist him in the work of the division. At present the office force consists of three computers and a clerk.

When magnetic observatory work was resumed by the Coast and Geodetic Survey in 1900, the magnetic observers were without experience either in the operation of magnetographs or in the reduction of variation observations. Moreover, they had to work with a type of magnetograph which had been in use for so short a time that very little had been published concerning the practical questions involved in its operation. As a natural result, some time elapsed before the observatory records were entirely satisfactory and some of the earlier records were forwarded to the Office without the completion of the computations usually made at the observatory, thus throwing more work on the office force. In the Office it was necessary to solve many problems and devise new methods before the work of reducing the variation observations could proceed smoothly. Hence the limited computing force proved insufficient to advance the computations as rapidly as the records were received, and the publication of results has been delayed in consequence.

DEFINITIONS.

To avoid confusion, some of the terms used in this publication are here defined:

Magnetograph—An instrument giving a continuous photographic record of the variations of the earth's magnetism, consisting of a recording apparatus and one or more variometers.

Magnetogram—The sheet of paper having upon it the photographic record of the magnetograph.

Thermogram—The sheet of paper having upon it the record of the temperature changes made by the pen of the thermograph.

D—Declination, positive when east.

H—Horizontal intensity.

Z—Vertical intensity.

I—Dip.

F—Total intensity.

X—North-south component, positive when north.

Y—East-west component, positive when east.

γ —0.00001 C. G. S. unit of magnetic intensity.

D base-line value—The absolute value of declination corresponding to a zero ordinate. Similarly, *H base-line value*.

METHODS.

The program of observatory work includes absolute observations for declination, dip, and horizontal intensity twice a week for the purpose of reducing the variation observations to absolute measure. A set of declination observations usually consists of 8 pointings on the magnet, 4 erect and 4 inverted. Torsion is removed from the suspension fiber beforehand by the use of a brass weight of about the same mass as the magnet. Horizontal intensity (H) and the magnetic moment (m) of the magnet are determined by combining observations of oscillations and deflections, using the formulæ:*

$$mH = \frac{\pi^2 K}{T^2}$$

$$\frac{H}{m} = \frac{C}{\sin u}$$

in which--

K is the moment of inertia of the oscillation magnet and stirrup, determined by special observations using an auxiliary weight of known dimensions and mass.

T is the time of one oscillation, corrected for torsion, induction, and difference in the temperature of oscillations and deflections.

u is the deflection angle.

C is a factor which may be regarded as constant for a particular deflection distance and a particular temperature. Its determination requires deflection observations at 2 or 3 distances from which to compute the distribution coefficients, careful measurement of the deflection distances, and observations to determine the induction coefficient. The variation of C with temperature depends simply upon the temperature coefficient of the material (usually brass) of which the deflection bars are constructed.

A dip determination with a dip circle comprises observations with two needles, with the usual reversals of instrument, polarity of needle, and position of needle on the agate supports. In the case of dip circle No. 1, there was only a single needle, so two sets were made with that on each occasion.

Deflection observations were made about once in two months to determine the scale value of the horizontal intensity variometer. The magnetogram is usually changed between 4^h and 5^h p. m. In order to fix accurately the time scale on the magnetograms, the time is recorded of automatic or artificial time breaks occurring about 5 p. m., 9 a. m., and 4 p. m., as well as the times of starting and stopping the photographic record. To obtain the magnetograph temperatures from the record of the thermograph, the magnetograph thermometers are read about 9 a. m. and 4 p. m. In the morning a mark is made on the thermograph sheet to fix the time scale.

The observer in charge computes his absolute observations and scale value determinations, measures the ordinates from the magnetograms for each hour, local mean time, and for the times when the absolute observations were made, and computes therefrom the values of base line. He also derives the temperature of the magnetograph for each hour from the readings of the thermograph. The remainder of the computations is made by the computers in the Office.

For measuring the ordinates, a reading board † designed by W. B. Keeling, magnetic observer, and constructed in the instrument shop at the Office of the Survey, has proved of great assistance, and each observatory is provided with one. As it was not possible to secure clear, well-defined lines with the Brooke magnetograph, the practice was adopted of reading from the middle of the base line to the middle of the curve.

Early in the work it was found that a magnetogram is subject to variation in size, amounting to as much as 1 per cent, depending upon the amount of moisture in the atmosphere. In

* In the case of magnetometer No. 3, $\tan u$ must be substituted for $\sin u$ in the second formula.

† For an illustration and description see "Results of Observations made at the Coast and Geodetic Survey Observatory at Cheltenham, Md., 1901-1904."

order to be able to correct for this, each observatory is provided with a narrow strip of wood, as long as the magnetogram is wide, with a needle point fastened in each end. The distance between the points is accurately measured. As soon as a magnetogram is removed from the drum it is laid on its face and the strip of wood is pressed down on it near each end and small holes are made by the needle points. A comparison of the distance between these holes at any future time with the distance between the needle points at the time they were made serves to determine the amount of shrinkage or expansion.

LOCATION AND BUILDINGS.

Latitude: $18^{\circ} 08'.9$ N. Longitude: $65^{\circ} 26'.4$ W. Altitude: 40 meters (130 feet).

When planning for the expansion of the magnetic work of the Coast and Geodetic Survey, the desirability of having a magnetic observatory in Porto Rico was recognized, but its establishment had to be postponed until the construction and equipment of the other magnetic observatories had been completed. At the time of the eruption of Mont Pelée on May 8, 1902, there was a magnetic disturbance of considerable magnitude, the beginning of which very nearly coincided with the beginning of the eruption. The possibility of a recurrence of

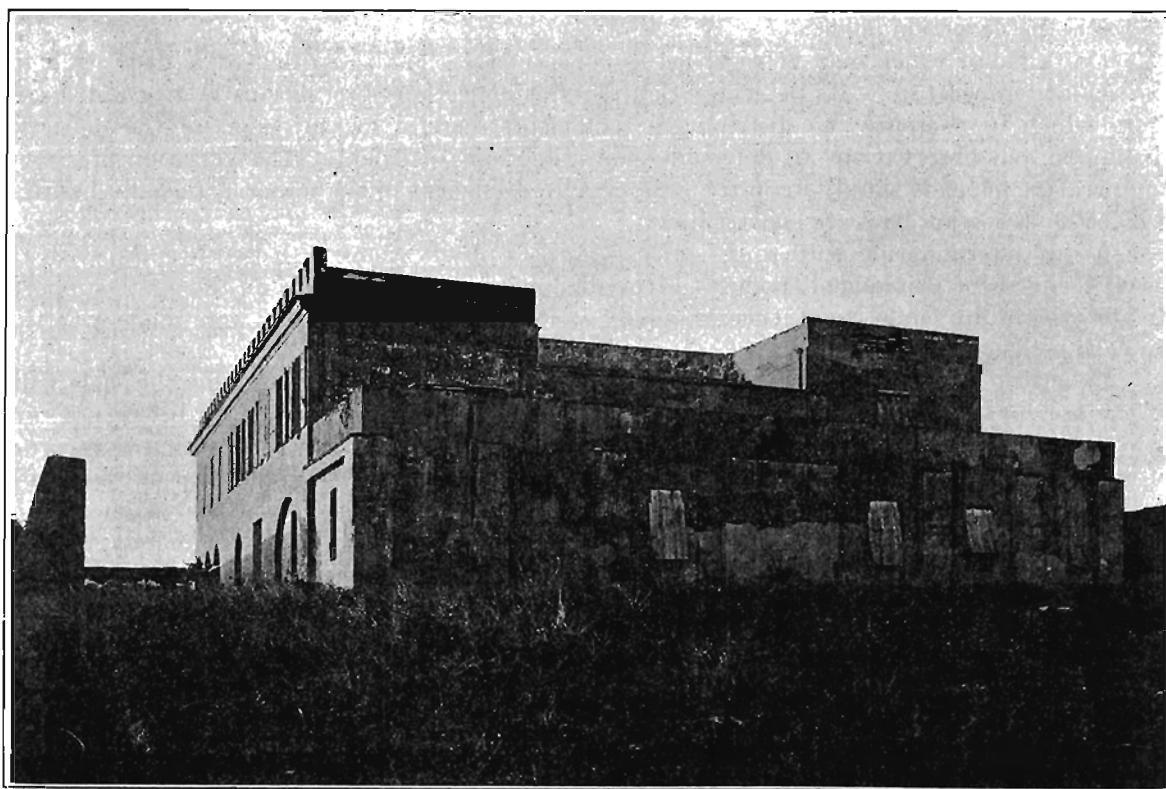


FIG. 1.—Fort Isabel Segunda, south side.

such outbreaks in the West Indies increased the desirability of having a continuous record of the variations of the earth's magnetism in that region, in order that a closer study might be made of the relation between the two phenomena. Arrangements were therefore made for the establishment of a temporary magnetic observatory on Vieques Island, a small island to the east of the island of Porto Rico. Through the courtesy of the insular government, several rooms on the ground floor of Fort Isabel Segunda were secured for the use of the observatory. This fort is a large stone building situated on a hill back of the town of Vieques, about half a mile from the north shore of the island. It is no longer armed or garrisoned, but while used for observatory purposes was in charge of and occupied in part by the insular police.

The rooms assigned for the work of the observatory were on the south and east sides of the fort, as shown in Fig. 2. The large room extending from the corner, along the south side, was divided by a partition into a small room at the corner for absolute observations, and a

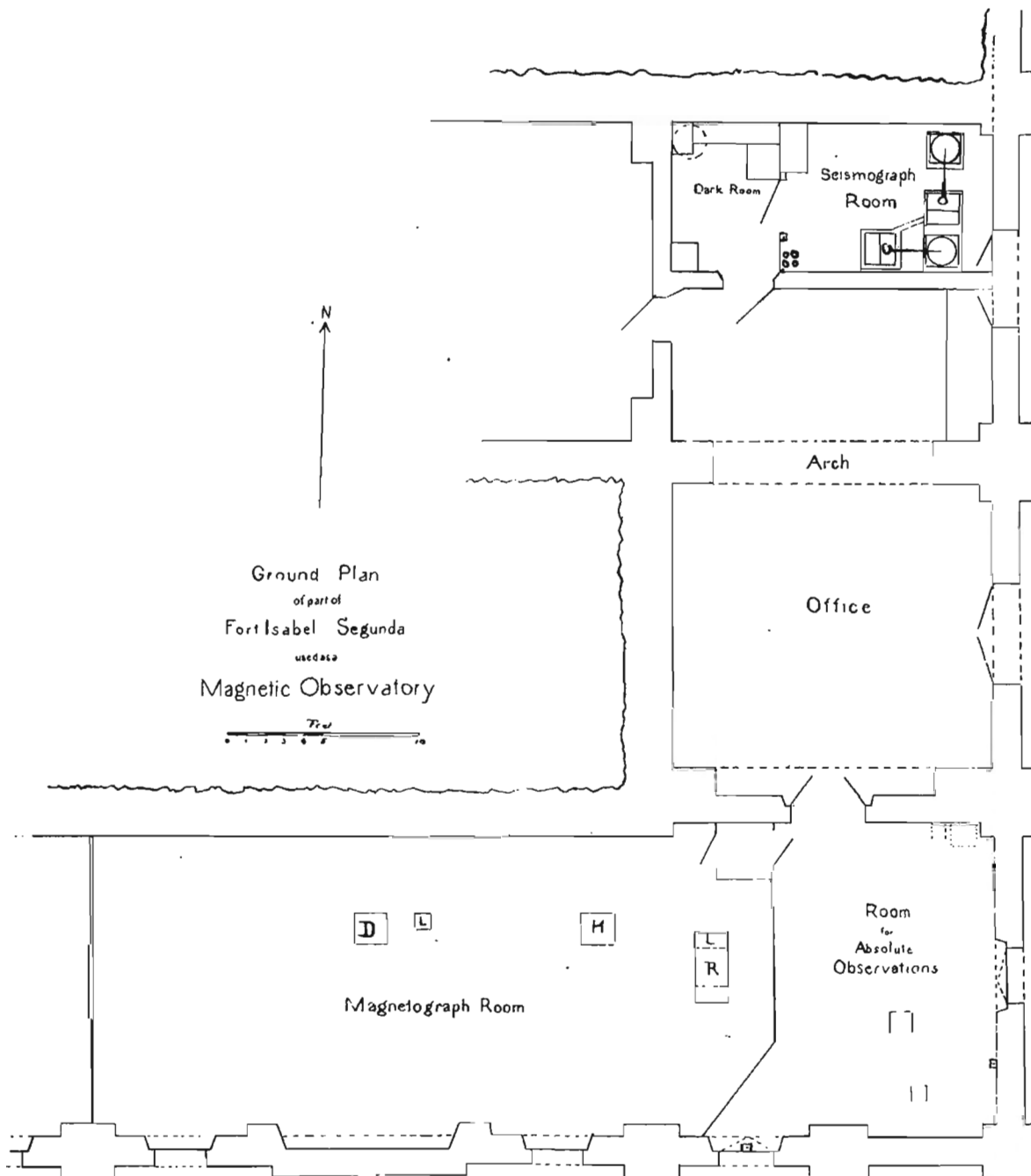


FIG. 2.—Ground plan of part of Fort Isabel Segunda.

room for the magnetograph, about 15 by 35 feet in size. The windows of this room were boarded up inside and out in order to keep out the light and reduce the temperature variations. No further steps were taken to insulate the magnetograph room, but the thick walls of the fort were sufficient to limit the diurnal range of temperature inside to 1°.2 Centigrade

on the average, as compared with about 6°.0 outside. The seasonal variation is very small, as will be seen from the following table:

Daily and monthly range in temperature (Centigrade).

Month.	1903.			1904.		
	Maximum.	Minimum.	Average daily range.	Maximum.	Minimum.	Average daily range.
January.....	o	o	o	29.5	25.8	1.1
February.....				28.9	26.0	1.4
March.....				29.0	25.4	1.2
April.....	30.4	27.3	1.3	29.0	25.9	1.4
May.....	30.1	27.7	1.2	29.3	26.4	1.3
June.....	30.4	27.6	1.1	29.9	27.0	1.0
July.....	30.8	28.3	1.2	30.0	27.1	1.2
August.....	31.4	27.2	1.3	30.8	27.7	1.2
September.....	31.3	27.9	1.3	30.1	26.7	1.1
October.....	31.3	27.3	1.1	31.0	25.8	1.1
November.....	30.8	27.1	1.1	30.1	26.8	1.0
December.....	29.1	26.4	1.0	29.2	27.0	1.1
Year.....	31.4	26.4	1.2	31.0	25.4	1.2

The magnetograph was mounted on solid stone piers, not in contact with the concrete floor of the room.

Absolute observations were made in the corner room in the fort up to the end of January, 1904. In that month an absolute observatory 10 by 12 feet in size was built on a hill about 500 feet southeast of the fort, and observations began there the end of January. For the support of the instruments three wooden posts were set firmly in the ground before the floor of the building was laid.

The room on the east side of the fort, adjoining the one in which absolute observations were made, was used as an office, and to the north of that was the dark room, part of which was afterwards converted into a seismograph room.

INSTRUMENTS.

VARIATION INSTRUMENTS.

The magnetograph operated at the Porto Rico magnetic observatory from February, 1903, to May, 1905, consisted of the declination (unifilar) and horizontal intensity (bifilar) variometers of the old Brooke magnetograph, which had been used at Key West, Fla., 1860-1866, Madison, Wis., 1877-1881, and Ooglamie, near Point Barrow, Alaska, 1882-1883, and an Eschenhagen recording apparatus arranged for running at two speeds, one revolution in 24 hours, or one revolution in 2 hours. Separate lamps were required for the two variometers. The relative positions of the different parts of the instrument are shown in Fig. 2. The variometers have large rectangular magnets suspended from brass tripods by means of silk fibers. A glass tube inclosing the fibers extends from the glass cylinder surrounding the magnet to the head of the tripod, and the torsion head is covered by a bell jar, so that all currents of air are excluded. For the *D* magnets a bundle of 20 fibers was used. Each fiber was stretched separately by means of weights, and then the 20 were tied into a bundle at intervals of a few inches. After the magnet was suspended the fibers continued to stretch, so that the torsion head had to be raised several times before a stable condition was reached. The horizontal intensity magnet was supported by 10 fibers doubled (over the pulley). The magnetograph was mounted in February, 1903, but several changes of adjustment were required

during March, so that the results given herewith begin with April. It was found impossible to secure a sharply defined record from these variometers. Nearly every day, shortly after midnight, the lines on the magnetogram made by the light from the mirrors attached to the magnets began to widen out and appear fuzzy and dim, the width increasing from a fraction of a millimeter to several millimeters. This condition lasted for several hours, gradually becoming less and less marked, and usually disappearing about 8 to 10 a. m. For the rest of the day the curves were satisfactory. When the recording cylinder was made to revolve once in two hours during the disturbed period, the horizontal intensity curve appeared as a comparatively regular series of waves and the declination curve as a series of serrations, showing that the magnets were in constant vibration. No such disturbance was shown by an Eschenhagen variometer mounted in the same room nor by the magnetometer in the adjoining room, so that the trouble was evidently peculiar to the Brooke variometers. Apparently the disturbance of the magnets was associated with decrease in temperature, as it occurred at the time of day when the temperature was falling, and on some days when the fall in temperature continued throughout the day, the disturbance continued also. While this broadening of the curves hides the small variation of D and H for a portion of each day, it does not appreciably reduce the accuracy of the measurement of the hourly ordinates, since the center of the curve can be determined with but little difficulty.

The variations in temperature in the magnetograph room were measured by a thermograph mounted on a wooden post near the H variometer.

ABSOLUTE INSTRUMENTS.

Up to the end of January, 1904, absolute observations of declination and horizontal intensity were made with an old magnetometer (No. 3), made by Jones of London, having a detached theodolite for pointing upon the suspended magnet. This is the same magnetometer that was used at the Baldwin magnetic observatory in 1901 and part of 1902, but it was repaired and improved in several ways before being sent to Porto Rico, especially by the substitution of a brass deflection bar for the wooden one which was used at Baldwin. Consequently the results obtained with it at Porto Rico were more accurate and consistent than those at Baldwin.

In January, 1904, magnetometer No. 31 took the place of No. 3. This is an instrument of the India Magnetic Survey pattern, illustrated and described in "Results of Observations made at the Coast and Geodetic Survey Magnetic Observatory at Baldwin, Kans., 1901-1904." No. 31 is provided with a vertical circle, so as to adapt it for use in astronomical observations.

Dip observations were made with Barrow dip circle No. 1 up to July, 1904, and after that time with Kew dip circle No. 18. Dip circle No. 1 was used at the Cheltenham magnetic observatory in 1901, and gave fairly consistent results. At Porto Rico, however, the results with it were not at all satisfactory. No. 18 is an old instrument, but it was overhauled by Dover in 1901 and provided with a new set of needles. It was an improvement over No. 1, but still left much to be desired. As no vertical force variometer was in operation, however, great accuracy of dip observations was not required.

SEISMOGRAPH.

In September, 1903, a Bosch-Omori seismograph, comprising two horizontal pendulums, was mounted in the room north of the office on stone piers.

ACCESSORIES.

Chronometers and meteorological instruments. Time observations were made with the theodolite of magnetometer No. 3, or with magnetometer No. 31, either noting the time of the sun's meridian passage or else using the method of equal altitudes.

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CONTENTS.

	Page.
Introduction.....	5
Instruments.....	5
Instrumental constants of the magnetographs.....	6
Absolute observations and base-line values.....	8
Diurnal variation.....	14
Summary of monthly means.....	21
Hourly values of declination.....	22
Hourly values of horizontal intensity.....	46
Hourly values of vertical intensity.....	70
Earthquakes.....	92
Magnetic storms.....	97

ILLUSTRATIONS.

Figs. 1-26. Reproduction of magnetograms showing the principal magnetic disturbances in 1905 and 1906.....	98-110
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EARTHQUAKES.

In September, 1903, a Bosch-Omori seismograph comprising two horizontal pendulums, one recording north-south motion (N) and the other recording east-west motion (E), was mounted in the room north of the one occupied as an office on the ground floor of the old fort. It was supported by four stone piers, 20 inches square and 32 inches deep, with their tops just above the floor level. The following table is a register of the earthquakes recorded up to the end of 1906. The times are Greenwich mean time counted from midnight:

Register of earthquakes recorded at Vieques.

No.	Component	Date	First P. T.	Second P. T.	Large waves	Maximum	End of principal portion	End	Maximum amp.
			<i>h m s</i>	<i>h m s</i>	<i>h m s</i>	<i>h m s</i>	<i>h m</i>	<i>h m</i>	<i>mm</i>
1	N	1903. Sept. 7	7 36 18	.. .. .	.. .. .	.. .. .	.. .. .	9 47	.. .
2	N	Oct. 9	.. .. .	.. .. .	23 45 54	23 46 00	.. .. .	23 47	2.1
2	E	9	.. .. .	.. .. .	23 45 54	23 46 00	.. .. .	23 47	1.9
3	N	29	15 31 30	.. .. .	.. .. .	.. .. .	.. .. .	15 46	.. .
3	E	29	15 32 30	.. .. .	.. .. .	.. .. .	.. .. .	15 46	.. .
4	N	Nov. 28	10 49 48	.. .. .	.. .. .	.. .. .	.. .. .	10 56	.. .
4	E	28	10 50 18	.. .. .	.. .. .	.. .. .	.. .. .	10 57	.. .
5	N	Dec. 5	5 42 30	.. .. .	.. .. .	.. .. .	.. .. .	6 08	.. .
5	E	5	5 42 18	.. .. .	.. .. .	.. .. .	.. .. .	6 12	.. .
6	N	7	14 52 24	14 58 24	15 03 24	15 16 48	15 22	15 44	0.4
6	E	7	14 52 48	14 59 48	15 03 18	15 04 12	15 22	15 48	0.4
7	N	10	17 49 06	.. .. .	.. .. .	.. .. .	.. .. .	18 22	.. .
7	E	10	17 49 06	.. .. .	18 05 06	18 05 36	18 11	18 23	0.3
8	N	28	4 13 12	.. .. .	.. .. .	.. .. .	.. .. .	4 36	.. .
		1904.							
9	N	Jan. 20	14 56 36	.. .. .	15 00 06	15 00 12	.. .. .	15 07	15 ?
						15 04 48	.. .. .	16 07	13.8
						15 09 12	15 21	.. .. .	9.2
9	E	20	14 56 36	.. .. .	15 00 06	15 00 12	.. .. .	16 07	12 ?
						15 02 00	.. .. .	.. .. .	18.5
						15 07 30	15 16	16 20	12.0
10	N	Feb. 4	20 50 48	.. .. .	20 53 54	20 54 18	21 02	21 32	1.8
10	E	4	20 50 48	.. .. .	20 54 06	20 54 18	21 02	21 40	2.0
11	N	Mar. 4	10 29 36	10 34 48	10 42 36	10 35 36	10 49	10 55	0.4
11	E	4	10 28 36	10 34 54	.. .. .	10 35 00	10 47	11 01	0.3
12	N	19	6 36 30	6 43 30	6 52 18	6 57 48	7 02	7 18	0.6
12	E	19	6 37 00	6 43 48	6 52 30	6 57 48	7 03	7 18	0.6
13	E	Apr. 4	10 38 06	.. .. .	10 59 24	11 06 06	11 19	11 53	1.2
14	N	5	11 30 24	.. .. .	.. .. .	.. .. .	.. .. .	11 51	.. .
15	N	12	19 34 48	.. .. .	.. .. .	.. .. .	.. .. .	19 46	.. .
15	E	12	19 35 48	.. .. .	19 41 06	19 41 48	19 46	19 58	0.2
16	N	May 1	16 11 36	.. .. .	.. .. .	.. .. .	.. .. .	17 32	.. .
16	E	1	16 11 36	.. .. .	.. .. .	.. .. .	.. .. .	17 32	.. .
17	N	May 11	.. .. .	19 57 36	19 58 18	.. .. .	20 01	20 06	0.3
17	E	11	.. .. .	19 57 54	19 58 24	.. .. .	20 00	20 07	0.3
18	N	14	14 18 30	.. .. .	14 41 42	.. .. .	14 53	15 04	0.2
18	E	14	14 18 06	.. .. .	14 40 36	.. .. .	14 54	15 04	0.2
19	N	18	12 13 06	.. .. .	.. .. .	.. .. .	.. .. .	12 17	.. .
19	E	18	12 13 06	.. .. .	.. .. .	.. .. .	.. .. .	12 17	.. .
20	N	21	15 16 36	.. .. .	15 17 18	15 17 42	15 20	15 25	0.4
20	E	21	15 16 48	.. .. .	15 17 12	15 17 42	15 21	15 32	0.4
21	N	21	19 11 12	.. .. .	.. .. .	.. .. .	.. .. .	19 16	.. .
21	E	21	19 11 24	.. .. .	.. .. .	.. .. .	.. .. .	19 18	.. .
22	N	21	21 31 24	21 31 54	21 32 18	21 32 24	21 35	21 39	0.4
22	E	21	21 31 24	21 31 42	21 32 06	21 33 00	21 35	21 36	0.4
23	N	June 12	12 37 36	.. .. .	12 38 36	12 39 06	12 40	12 46	0.4
23	E	12	12 37 36	.. .. .	12 38 36	12 38 54	12 39	12 45	0.1
24	N	24	1 58 18	.. .. .	.. .. .	.. .. .	.. .. .	2 12	.. .
24	E	24	2 00 42	.. .. .	.. .. .	.. .. .	.. .. .	2 12	.. .
25	N	25	15 03 18	15 18 18	15 35 42	15 44 42	16 01	17 00	0.6
25	E	25	15 06 06	15 18 12	15 33 06	15 46 24	16 01	17 01	0.4
26	N	25	.. .. .	21 33 00	21 48 42	21 58 18	22 15	22 57	2.0
26	E	25	.. .. .	21 32 42	21 48 06	22 05 48	22 10	22 47	0.8
27	N	26	11 28 42	.. .. .	.. .. .	.. .. .	.. .. .	11 52	.. .
27	E	26	11 31 06	.. .. .	.. .. .	.. .. .	.. .. .	11 57	.. .
28	N	27	0 27 42	0 42 06	0 57 00	1 06 30	1 24	1 58	4.2
28	E	27	0 27 30	0 42 00	0 57 30	1 07 00	1 26	2 00	0.9

Register of earthquakes recorded at Vieques—Continued.

No.	Component	Date	First P. T.	Second P. T.	Large waves	Maximum	End of principal portion	End	Maximum amp.
		1904.	<i>h m s</i>	<i>h m s</i>	<i>h m s</i>	<i>h m s</i>	<i>h m</i>	<i>h m</i>	<i>mm</i>
29	N	July 10	23 00 16	.....	.....	.....	.....	23 15	.....
29	E	10	23 00 22	.....	.....	.....	.....	23 15	.....
30	N	24	11 37 00	.....	.....	.....	.....	11 53	.....
31	N	Aug. 24	21 55 00	.....	.....	.....	.....	22 55	.....
31	E	24	22 00 00	.....	.....	.....	.....	22 44	.....
32	N	27	22 08 34	.....	22 30 30	22 40 00	.....	24 00	20.0
32	E	27	22 08 38	.....	22 29 18	22 35 54	.....	24 09	16.5
33	N	30	.....	.....	12 45 00	.....	.....	13 27	0.4
33	E	30	.....	.....	12 47 00	.....	.....	13 21	.....
34	N	Sept. 3	17 16 00	.....	.....	.....	.....	17 22	.....
34	E	3	17 15 00	.....	.....	.....	.....	17 26	.....
35	N	Sept. 11	.....	.....	6 52 00	.....	.....	7 28	.....
35	E	11	.....	.....	6 47 00	.....	.....	7 26	.....
36	N	19	.....	.....	0 35 00	.....	.....	0 57	.....
36	E	19	.....	.....	0 32 00	.....	.....	1 02	.....
37	N	19	.....	.....	5 50 00	.....	.....	6 50	.....
37	E	19	.....	.....	5 48 00	.....	.....	6 48	.....
38	N	Oct. 3	3 51 00	.....	.....	.....	.....	4 37	.....
38	E	3	4 08 00	.....	.....	.....	.....	4 28	.....
39	N	9	14 09 00	.....	.....	.....	.....	14 48	.....
39	E	9	14 07 00	.....	.....	.....	.....	14 50	.....
40	N	25	9 55 00	.....	.....	.....	.....	10 20	.....
40	E	25	9 56 00	.....	.....	.....	.....	10 17	0.2
41	N	Nov. 1	9 29 08	.....	.....	9 29 26	.....	9 33	0.6
41	E	1	9 29 11	.....	.....	9 29 27	.....	9 33	0.4
42	N	21	13 16 40	.....	13 17 00	13 18 56	.....	13 27	.....
42	E	21	13 15 39	.....	13 17 15	13 17 23	.....	13 30	.....
43	N	24	12 29 00	.....	.....	.....	.....	12 42	.....
43	E	24	12 30 00	.....	.....	.....	.....	12 40	.....
44	N	Dec. 2	2 27 17	2 31 53	2 34 17	2 37 08	.....	3 05	2.0
44	E	2	2 27 10	2 31 48	2 35 48	2 39 14	.....	3 04	2.4
45	N	5	18 09 34	.....	.....	.....	.....	18 27	0.2
45	E	5	18 09 34	.....	.....	.....	.....	18 27	.....
46	N	11	17 15 20	.....	.....	.....	.....	17 45	.....
46	E	11	17 15 22	17 21 22	17 24 22	17 35 40	.....	17 50	0.4
47	N	20	5 50 10	.....	5 53 49	5 54 40	.....	7 21	28.0
47	E	20	5 50 10	.....	5 53 46	5 58 10	.....	7 24	35.0
48	N	21	1 41 27	.....	1 45 17	1 50 17	.....	2 20	0.4
48	E	21	1 41 28	.....	1 45 18	1 48 27	.....	2 18	0.4
49	N	28	21 09 12	.....	21 13 00	.....	.....	21 57	.....
49	E	28	21 09 20	.....	21 13 16	.....	.....	21 45	.....
		1905.							
50	N	Jan. 13	.....	.....	14 30 ..	.....	.....	15 00	.....
50	E	13	.....	.....	14 32 ..	.....	.....	14 56	.....
51	N	20	18 05 02	.....	18 08 40	18 09 04	.....	18 29	0.6
51	E	20	18 05 02	.....	18 08 44	18 09 08	.....	18 29	0.5
52	N	22	3 03 39	.....	3 27 37	.....	.....	4 48	.....
52	E	22	3 03 39	.....	3 27 37	.....	.....	4 47	.....
53	N	Feb. 14	9 10 37	.....	9 35 24	9 43 49	.....	10 21	1.1
53	E	14	9 11 01	.....	9 31 43	9 38 00	.....	10 45	0.5
54	E	19	.....	.....	5 38 ..	.....	.....	.....	.....
55	N	Mar. 5	.....	.....	0 28 ..	.....	0 55	.....	.....
55	E	5	.....	.....	0 28 ..	.....	0 55	.....	.....
56	N	6	.....	.....	1 46 43	.....	.....	2 07	.....
56	E	6	.....	.....	1 41 50	.....	.....	2 06	.....
57	N	19	0 21 32	.....	1 00 08	.....	.....	2 38	.....
57	E	19	0 21 14	0 37 54	0 59 54	.....	.....	2 21	.....
58	N	22	4 03 05	.....	4 26 05	4 36 25	.....	5 29	0.8
58	E	22	4 03 21	.....	4 29 31	.....	.....	5 24	.....
59	N	Apr. 4	1 10 26	1 26 48	1 50 48	2 10 48	.....	3 47	1.2
59	E	4	1 10 25	1 26 27	1 43 25	2 13 51	.....	3 38	1.6
60	N	19	.....	.....	9 52 00	.....	.....	10 54	.....
61	N	19	.....	.....	13 25 00	.....	.....	13 48	.....
62	N	26	21 50 04	21 56 12	.....	21 59 40	.....	22 30	0.7
62	E	26	21 51 07	21 56 07	.....	21 59 31	.....	22 20	0.7
63	N	May 9	.....	.....	6 56 26	.....	.....	7 32	.....
63	E	9	.....	.....	6 53 10	7 06 10	.....	7 24	0.4

Register of earthquakes recorded at Vieques—Continued.

No.	Component	Date	First P. T.			Second P. T.			Large waves			Maximum			End of principal portion		End	Maximum amp.	
			h	m	s	h	m	s	h	m	s	h	m	s	h	m			h	m	mm
1905.																			
64	N	May 12	..	..	..	..	..	..	15	40	00	..	..	..	..	16	06	..
64	E	12	..	..	..	..	..	..	15	45	30	..	..	..	..	16	10	..
65	N	15	9	08	44	..	..	..	..	..	..	9	08	46	..	9	10	0.5
65	E	15	9	08	46	..	..	..	..	..	..	..	..	..	..	9	10	..
66	N	18	..	..	..	..	..	..	14	06	00	..	..	..	..	15	42	..
67	N	23	..	..	..	..	..	..	6	54	00	..	..	..	..	7	09	..
67	E	23	..	..	..	..	..	..	6	54	37	..	..	..	..	7	14	..
68	N	June 14	..	..	..	..	..	..	11	59	00	..	..	..	..	12	43	..
68	E	14	..	..	..	..	..	..	11	59	00	..	..	..	..	12	41	..
69	N	30	..	..	..	..	..	..	17	30	30	..	..	..	..	19	48	..
69	E	30	..	..	..	..	..	..	17	31	30	..	..	..	..	19	40	..
70	N	30	20	20	24	..	..	..	..	..	..	..	..	..	..	20	58	..
70	E	30	20	21	24	..	..	..	..	..	..	..	..	..	..	20	58	..
71	N	July 6	17	22	32	..	..	..	..	..	..	17	31	45	..	18	03	0.3
71	E	6	17	22	14	..	..	..	..	..	..	17	34	18	..	18	00	0.2
72	N	9	9	59	37	10	38	36	10	45	03	10	53	12	38	4.8
72	E	9	10	07	48	10	31	11	10	33	11	11	04	12	11	1.2
73	N	14	..	..	..	..	..	..	9	28	..	..	..	..	..	9	55	..
73	E	14	..	..	..	..	..	..	9	21	..	..	..	..	..	9	52	..
74	N	23	3	05	49	3	45	21	4	03	12	4	16	6	07	28.6
74	E	23	3	05	54	3	44	49	3	49	04	4	09	6	06	6.0
75	N	Sept. 8	..	..	..	..	..	..	1	56	..	..	..	..	..	2	40	..
75	E	8	..	..	..	..	..	..	1	58	..	2	19	..	..	2	52	..
76	N	15	6	21	01	6	50	46	7	03	16	7	19	7	54	0.4
76	E	15	6	19	54	6	51	51	7	06	10	7	11	8	04	1.7
77	N	Oct. 12	22	27	12	..	..	..	..	..	..	..	..	..	..	22	38	0.3
77	E	12	22	27	49	..	..	..	..	..	..	..	..	..	..	22	38	0.4
78	N	14	14	38	48	14	41	48	14	44	28	14	45	15	04	0.8
78	E	14	14	38	45	14	41	52	14	43	10	14	45	15	14	1.4
79	N	15	10	43	09	..	..	..	..	..	..	..	..	..	..	10	50	0.1
79	E	15	10	43	23	..	..	..	..	..	..	..	..	..	..	10	50	0.1
80	N	15	21	44	52	21	46	51	21	47	59	21	50	28	21	55	22	49	2.1
80	E	15	21	44	55	21	47	28	21	48	13	21	49	40	21	53	22	47	2.7
81	N	24	17	57	00	..	..	..	..	..	..	..	..	..	..	18	17	..
81	E	24	17	57	50	..	..	..	..	..	..	..	..	..	..	18	17	..
82	N	Nov. 8	22	28	29	..	..	..	..	..	..	..	..	..	..	22	58	..
82	E	8	22	28	13	..	..	..	..	..	..	..	..	..	..	22	57	..
83	N	Dec. 10	12	57	38	13	19	48	13	22	43	13	28	13	44	0.1
83	E	10	12	57	39	13	17	58	13	23	17	13	29	13	46	0.5
84	N	17	5	40	13	5	46	18	5	54	57	6	00	25	6	05	6	34	0.1
1906.																			
85	E	Jan. 21	14	16	56	14	26	19	14	31	00	..	..	..	..	14	54	..
86	N	24	6	52	58	7	15	45	7	20	41	7	31
86	E	24	7	14	45	7	27
87	N	27	10	05	13	10	33	39	10	48	11	02	0.1
87	E	27	10	11	59	10	19	48	10	30	03	10	36	12	10	46	11	14	0.2
88	N	31	14	18	37	..	..	..	..	..	..	..	..	..	..	14	40	0.1
88	E	31	14	18	32	..	..	..	..	..	..	..	..	..	..	14	40	0.3
89	N	31	15	40	54	15	41	40	15	46	52	16	13	19	19	51.0
89	E	31	15	41	00	15	41	46	15	50	16	56.0
90	N	31	..	..	..	..	..	..	21	31	58	..	..	..	..	21	57	0.2
90	E	31	..	..	..	..	..	..	21	31	52	..	..	..	..	21	57	0.2
91	N	Feb. 1	6	34	23	..	..	..	..	..	..	..	..	..	..	6	54	0.1
91	E	1	6	34	51	..	..	..	..	..	..	..	..	..	..	6	58	0.2
92	N	1	23	30	50	..	..	..	..	..	..	..	..	..	..	24	00	0.1
92	E	1	23	30	25	..	..	..	..	..	..	..	..	..	..	23	58	0.2
93	N	2	16	58	36	17	02	36	..	..	..	..	..	..	..	17	22	0.2
93	E	2	16	58	38	17	02	30	17	05	15	..	..	..	..	17	28	0.4
94	N	2	17	55	15	..	..	..	..	..	..	..	..	..	..	18	05	..
94	E	2	17	55	26	..	..	..	..	..	..	..	..	..	..	18	12	..
95	N	2	19	00	40	..	..	..	..	..	..	..	..	..	..	19	09	..
95	E	2	19	03	40	..	..	..	..	..	..	..	..	..	..	19	22	..
96	N	3	4	01	46	..	..	..	..	..	..	..	..	..	..	4	15	..
96	E	3	4	01	38	..	..	..	..	..	..	..	..	..	..	4	19	..
97	N	6	1	39	50	..	..	..	..	..	..	..	..	..	..	2	02	..
97	E	6	1	41	00	..	..	..	..	..	..	..	..	..	..	1	58	..
98	N	16	17	40	12	17	41	30	17	43	22	17	50	18	18	4.2
98	E	16	17	40	00	17	41	28	17	42	32	17	53	18	21	5.9

Register of earthquakes recorded at Vieques—Continued.

No.	Component	Date	First P. T.	Second P. T.	Large waves	Maximum	End of principal portion	End	Maximum amp.
		1906.	<i>h m s</i>	<i>h m s</i>	<i>h m s</i>	<i>h m s</i>	<i>h m</i>	<i>h m</i>	<i>mm</i>
99	N	Feb. 19	2 25 00	..	..	..	..	3 42	0.1
99	E	19	2 22 52	..	..	..	..	4 23	0.2
100	N	28	6 23 55	..	..	6 29 20	..	6 42	0.1
100	E	28	6 23 58	..	..	6 30 09	..	6 43	0.3
101	N	28	13 31 30	..	..	..	..	13 43	..
101	E	28	13 25 06	..	..	..	..	13 48	0.1
102	N	Mar. 3	8 46 10	8 49 16	8 51 00	8 51 18	8 57	9 56	2.9
102	E	3	8 46 04	8 49 20	8 50 24	8 51 22	8 57	10 02	4.3
103	N	29	21 50 08	21 54 00	..	..	..	22 21	0.1
103	E	29	21 50 09	21 54 00	..	..	..	22 28	0.2
104	N	Apr. 10	21 30 28	21 37 10	21 44 09	21 50 09	21 56	22 41	0.8
104	E	10	21 30 20	21 37 00	21 42 33	21 46 23	21 51	22 40	1.6
105	N	18	13 21 45	13 29 25	13 42 13	13 48 47	14 01	16 12	24.2
105	E	18	13 21 54	13 29 20	13 42 42	13 50 42	14 05	16 31	30.5
106	N	28	..	..	7 54 ..	..	..	8 37	..
106	E	28	..	..	7 55 ..	..	..	8 20	..
107	N	May 5	0 29 36	..	0 33 55	0 38 04	..	1 04	0.2
107	E	5	0 28 54	..	0 33 40	0 37 23	..	1 05	0.6
108	N	June 1	4 54 30	..	5 19 ..	..	..	6 49	0.3
108	E	1	4 54 45	..	5 20 ..	..	..	6 41	0.2
109	N	20	2 31 37	2 36 50	2 39 38	2 41 14	2 46	3 05	0.5
109	E	20	2 31 26	2 35 25	2 38 32	2 41 02	2 46	3 07	0.6
110	N	22	3 22 10	..	..	..	..	3 34	0.2
110	E	22	3 21 38	..	..	..	..	3 32	0.2
111	N	22	6 56 15	..	..	..	..	7 32	0.2
111	E	22	6 57 20	..	..	..	..	7 29	0.3
112	N	22	7 43 30	..	..	..	..	8 10	0.1
112	E	22	7 45 24	..	..	..	..	8 08	0.1
113	N	26	12 23 31	..	..	..	..	12 49	0.2
113	E	26	12 23 48	..	..	..	..	12 48	0.2
114	N	July 13	18 52 00	..	..	..	..	19 33	0.5
114	E	13	18 49 04	..	..	..	..	19 38	0.2
115	N	16	21 19 46	21 23 36	..	21 30 48	..	21 44	0.2
115	E	16	21 19 35	21 23 50	..	21 32 08	..	21 45	0.2
116	N	20	13 29 44	..	..	13 32 20	..	13 55	0.4
116	E	20	13 31 09	..	..	13 33 54	..	..	0.1
117	N	Aug. 17	0 27 35	0 34 50	0 40 27	..	..	..	0.3
117	E	17	..	0 34 50	0 39 54	..	..	..	0.1
118	N	17	0 49 55	..	0 55 45	1 18 35	1 34	3 50	51.8
118	E	17	0 50 23	..	0 55 38	1 12 38	1 32	3 48	6.5
119	N	19	9 38 02	..	..	10 04 25	..	10 34	0.3
119	E	19	9 39 43	..	..	10 00 24	..	10 18	0.3
120	N	24	2 02 19	..	..	2 06 11	..	2 32	0.2
120	E	24	2 02 15	..	..	2 06 54	..	2 28	0.1
121	N	25	14 15 09	..	..	14 49 00	..	15 14	0.2
121	E	25	14 14 29	..	..	14 43 15	..	15 12	0.5
122	N	26	6 21 55	6 31 45	..	7 26 45	..	8 09	0.1
122	E	26	6 20 13	6 31 50	..	7 27 15	..	8 01	0.1
123	N	30	2 45 54	2 51 42	3 00 14	3 09 10	3 15	3 54	0.7
123	E	30	2 45 39	2 51 36	2 59 29	3 00 44	3 11	3 51	0.6
124	N	Sept. 7	..	..	18 48 58	20 05 59	..	20 41	0.2
124	E	7	..	..	18 52 00	20 07 45	..	20 41	0.2
125	N	13	..	..	9 56 33	10 07 44	..	10 16	..
125	E	13	..	..	10 02 01	10 07 35	..	10 11	0.1
126	N	14	0 12 05	..	0 12 20	..	..	0 18	0.1
126	E	14	0 12 05	..	0 12 17	..	..	0 18	0.1
127	N	14	..	..	13 15 45	..	..	14 28	0.1
127	E	14	..	..	13 26 09	..	..	14 26	0.1
128	N	14	16 24 23	..	17 05 31	17 21 39	17 48	18 46	1.4
128	E	14	16 24 34	..	16 52 33	17 23 28	17 51	18 42	1.7
129	N	27	14 41 51	..	14 42 04	14 42 08	14 43	14 53	8.0
129	E	27	14 41 47	..	14 42 04	14 42 07	14 43	14 56	5.6
130	N	28	15 29 54	..	15 34 01	15 35 08	15 40	16 40	3.4
130	E	28	15 29 52	..	15 33 39	15 35 25	15 40	16 31	5.7
131	N	Oct. 2	2 12 20	..	2 45 07	3 12 48	..	4 12	0.2
131	E	2	2 12 20	..	2 38 43	3 05 02	..	4 14	0.3
132	N	24	..	..	15 36 08	15 42 08	..	16 15	0.1
132	E	24	..	..	15 33 07	15 43 40	..	16 13	0.1
133	N	29	1 51 21	..	1 55 15	1 55 26	1 59	2 40	0.5
133	E	29	1 51 25	..	1 55 21	1 56 19	2 00	2 43	0.3

Register of earthquakes recorded at Vieques—Continued.

No.	Component	Date	First P. T.	Second P. T.	Large waves	Maximum	End of principal portion	End	Maximum amp.
		1906.	<i>h m s</i>	<i>h m s</i>	<i>h m s</i>	<i>h m s</i>	<i>h m</i>	<i>h m</i>	<i>mm</i>
134	N	Nov. 5	6 36 56	.. .. .	.. .. .	6 37 51	.. .. .	6 53	0.6
134	E	5	6 37 08	.. .. .	.. .. .	6 37 32	.. .. .	6 51	1.8
135	N	19	7 38 32	.. .. .	8 27 ..	8 37 ..	.. .. .	9 35	0.7
135	E	19	7 39 34	.. .. .	8 28 ..	8 37 ..	.. .. .	9 28	0.7
136	N	28	9 10 32	.. .. .	9 24 34	.. .. .	.. .. .	9 46	0.1
136	E	28	9 15 52	.. .. .	9 19 16	9 20 02	.. .. .	9 59	0.8
137	N	Dec. 3	.. .. .	.. .. .	23 00 48	23 02 04	23 04	23 54	10.0
137	E	3	.. .. .	.. .. .	23 00 50	23 01 52	23 04	23 53	10.0
138	N	19	1 33 43	1 43 21	1 54 53	2 13 28	.. .. .	3 41	0.3
139	N	22	18 41 40	.. .. .	19 15 31	19 23 18	19 41	20 16	0.5
139	E	22	18 41 52	.. .. .	19 10 54	19 32 16	19 43	20 06	0.4
140	N	23	17 42 11	.. .. .	17 50 53	18 15 43	.. .. .	18 45	0.5
140	E	23	17 32 39	.. .. .	17 46 39	18 08 32	.. .. .	18 50	0.8
141	N	26	6 00 24	.. .. .	6 06 07	6 06 15	.. .. .	7 02	1.5
141	E	26	6 00 34	.. .. .	6 06 01	6 06 06	.. .. .	6 59	1.0

REMARKS.

Steady mass..... 10 to 12 kg.
 Magnification..... 10
 Period of pendulums:
 September, 1903, to June, 1904..... N 26 sec. E 25 sec.
 July to December, 1904..... N 27 sec. E 23 sec.
 January to June, 1905..... N 24 sec. E 21 sec.
 July, 1905, to November, 1906..... N 21 sec. E 22 sec.
 November and December, 1906..... N 25 sec. E 25 sec.

No. 2: A local shock, felt by the observer.
 No. 9: At 15:00.2 there was a sudden displacement of N toward the south of 15 mm. and of E toward the east of 12 mm.
 Nos. 20, 21, 22, 41, 42: Small local earthquakes.
 Nos. 54, 55, 58, 60, 61, 66, 67: Probably principal portions of distant earthquakes.
 Nos. 77, 79: Local earthquakes.
 No. 89: Pointer of E went off the paper and caught at 15:50:16.
 No 105: San Francisco earthquake.
 No. 117: Aleutian earthquake. Ending obscured by No. 118.
 No. 118: Valparaiso earthquake.
 No. 126: Slight tremor, felt locally.
 No. 129: Local earthquake, distinctly felt for about 10 seconds, accompanied by low rumbling.
 Nos. 134, 137: Probably near-by earthquakes.

DEPARTMENT OF COMMERCE AND LABOR
COAST AND GEODETIC SURVEY
O. H. TITTMANN, SUPERINTENDENT

RESULTS OF OBSERVATIONS MADE AT THE COAST AND
GEODETIC SURVEY MAGNETIC OBSERVATORY
AT VIEQUES, PORTO RICO
1907 AND 1908

BY

DANIEL L. HAZARD
Computer, Division of Terrestrial Magnetism



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CONTENTS.

	Page.
Introduction.....	5
Location and buildings.....	6
Instruments.....	8
Instrumental constants of the magnetograph.....	8
Absolute observations and base-line values.....	10
Diurnal variation.....	16
Summary of monthly and annual means.....	23
Hourly values of declination.....	24
Hourly values of horizontal intensity.....	48
Hourly values of vertical intensity.....	72
Earthquakes.....	96
Magnetic storms.....	98

ILLUSTRATIONS.

	Page.
FIG. A. Plan of observatory grounds.....	5
FIG. B. Variation building.....	6
FIG. C. Seismograph house and office building.....	7
FIGS. 1-18. Reproductions of the magnetograms showing the principal magnetic disturbances in 1907 and 1908.....	98

RESULTS OF OBSERVATIONS MADE AT THE COAST AND GEODETIC SURVEY MAGNETIC OBSERVATORY AT VIEQUES, PORT RICO, 1907-8.

INTRODUCTION.

Latitude, $18^{\circ} 08' .8$ N. Longitude, $65^{\circ} 26' .9$ W. Elevation, 20 meters (65 feet).

In February, 1903, a magnetograph was installed in a room in Fort Isabel Segunda, on Vieques Island, Porto Rico, and observations were continued there until April, 1907. At that time suitable buildings had been constructed for the observatory work, and the magnetograph was transferred to the new site, about five-eighths of a mile to the west of the old fort. A

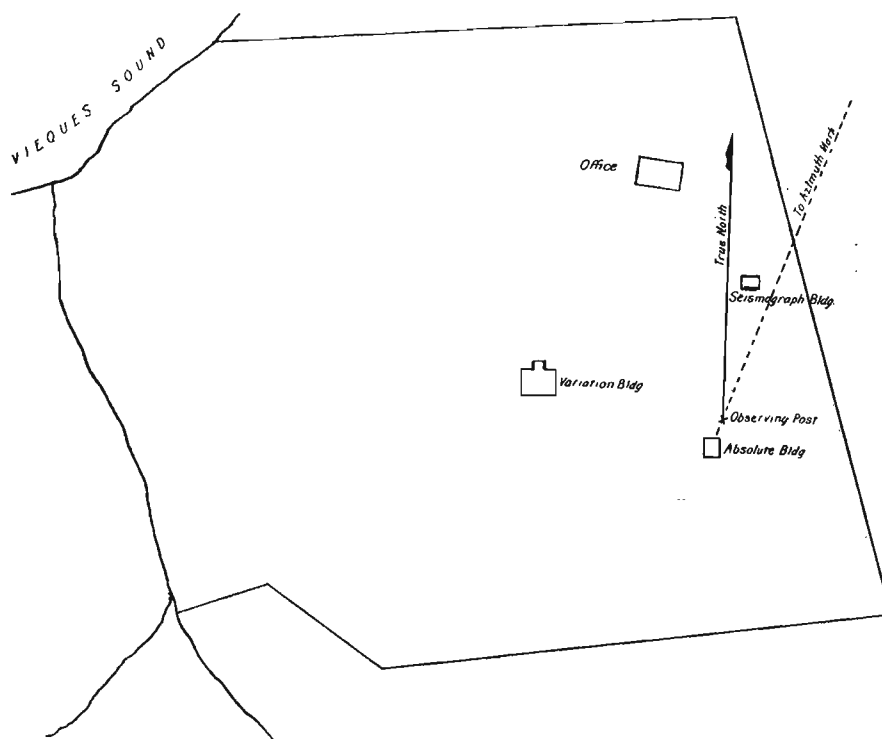


Fig. A.—Plan of observatory grounds.

general description of the portion of the fort occupied will be found in "Results of Observations made at the Coast and Geodetic Survey Magnetic Observatory at Vieques, Porto Rico, 1903-4."

The direct supervision of the magnetic work of the Coast and Geodetic Survey is assigned to an assistant to the superintendent, designated "Inspector of Magnetic Work." This position has been held by Mr. R. L. Faris since September 1, 1906. The work of the Porto Rico Observatory was carried on during 1907 and 1908 by the following magnetic observers: W. B. Keeling, January, 1907, to August, 1908; George Hartnell, from August to December, 1908.

LOCATION AND BUILDINGS.

Early in 1906 the Insular Government gave notice that the old fort would be needed for other purposes in the near future. After a careful examination and magnetic survey of several tracts in the vicinity, a suitable site for a magnetic observatory was found about five-eighths of a mile west of the old fort, on the shore of Vieques Sound. A piece of land was secured, containing about five acres, roughly rectangular in shape, and the necessary buildings were erected in 1907. The relative position of the various buildings is shown in figure A.

The *variation building* (Fig. B.) is a triple-walled wooden structure and is entirely above ground. The outer dimensions of the building are 16 by 22 feet. The instrument room is $7\frac{1}{4}$ by $12\frac{1}{4}$ feet and $8\frac{1}{2}$ feet high. As the daily and seasonal variations in temperature in Porto Rico are small, it was possible to secure a sufficiently uniform temperature in the instrument room by the following system of insulation, starting from the outside: Weather-boarding, building paper, 28 inches free-air space, boarding, building paper, 17 inches dead-air space, boarding, building paper, 4 inches dead-air space (between studs), building paper, boarding. The

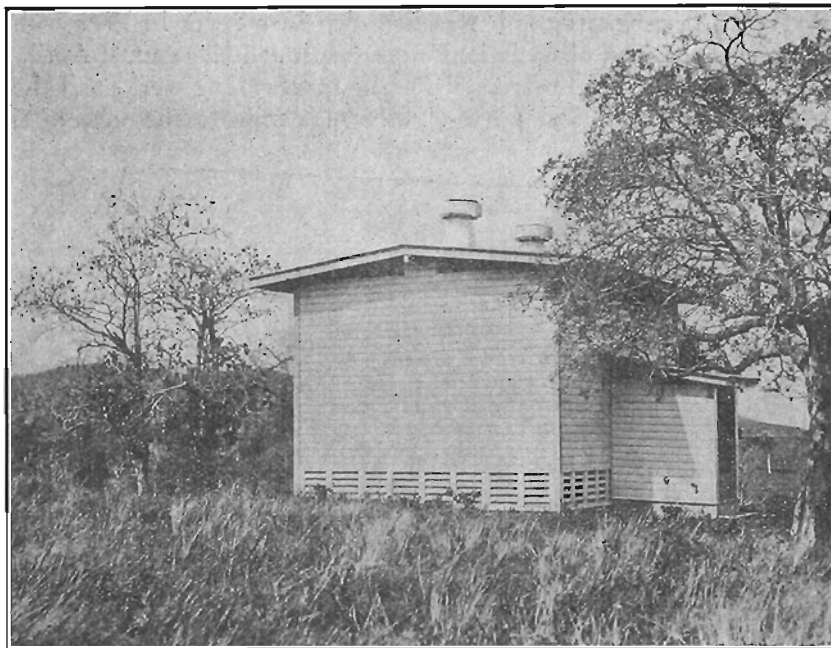


Fig. B.—Variation building.

overhead insulation is practically the same as on the sides. The roof is nearly flat and the under side of the rafters are covered with building paper to within 18 inches of the ridge pole. A 4-inch pipe allows the gases of combustion to escape from the instrument room to the free-air space, and a good circulation of air through the free-air space is secured by louvre windows at the bottom of the outside walls and two ventilators in the roof. From the ground up there is a free-air space of about 18 inches, rough flooring, building paper, 4 inches dead-air space, rough flooring, building paper, 4 inches dead-air space, surfaced flooring, building paper, matched flooring. The entrance to the building is on the north side and the double doors to the instrument room are on the west side. At opposite corners of the instrument room are air ducts with suitable shutters for regulating the intake of fresh air from the free-air space. The magnetograph is mounted on three stone piers resting on a concrete foundation. The variation building was begun on February 1, 1907, and was near enough to completion to permit the installation of the magnetograph early in April. With the above system of insulation the daily variation of temperature seldom exceeds a few tenths of a degree centigrade and the seasonal variation is correspondingly small. The figures for the first three months of 1907 in the following table are for the room in the old fort:

Monthly and annual range of temperature (centigrade).

Month.	1907			1908		
	Maximum.	Minimum.	Range.	Maximum.	Minimum.	Range.
	°	°	°	°	°	°
January.....	27.2	24.5	2.7	28.6	26.9	1.7
February.....	28.2	24.5	3.7	28.3	25.9	2.4
March.....	28.4	25.8	2.6	28.3	26.8	1.5
April.....	28.4	26.0	2.4	29.0	27.7	1.3
May.....	28.7	25.9	2.8	30.0	27.9	2.1
June.....	29.1	27.4	1.7	30.3	28.9	1.4
July.....	29.8	27.8	2.0	30.5	28.9	1.6
August.....	30.0	28.1	1.9	31.3	29.9	1.4
September..	30.6	28.3	2.3	31.4	29.1	2.3
October.....	30.4	28.0	2.4	30.6	29.1	1.5
November...	29.7	28.0	1.7	30.5	28.8	1.7
December...	29.2	27.6	1.6	30.2	28.8	1.4
Year...	30.6	24.5	6.1	31.4	25.9	5.5

The absolute building, which was erected on the hill near the old fort in January, 1904, was moved to the new site in March, 1907. It is a wooden building 10 by 12 feet in size, with

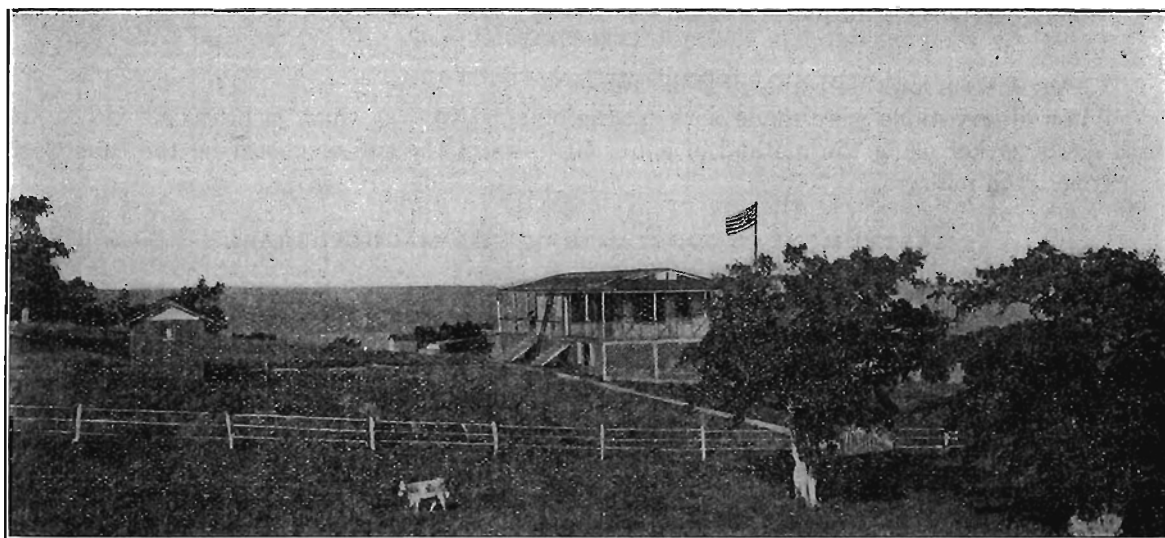


Fig. C.—Seismograph house and office building.

three wooden posts on which to mount the instruments. Outside the building and exactly in line from the declination post to the tower of the light house at Point Mulas is a wooden post for azimuth and time observations. The adopted azimuth of the light-house tower is $199^{\circ} 20' .0$.

The seismograph house (Fig. C), $8\frac{1}{2}$ by 11 feet outside dimensions, is built of brick. One corner of the interior is separated from the instrument room by wooden partitions to form a vestibule $3\frac{1}{2}$ by $4\frac{1}{2}$ feet in size, which is provided with facilities for smoking the seismograph paper. An office and quarters for the observer (Fig. C) are provided in a one-story wooden house, which stands about $7\frac{1}{2}$ feet above the ground. The space underneath is utilized for storage and work rooms.

The various buildings were designed by Mr. W. B. Keeling, magnetic observer, and constructed under his direction.

INSTRUMENTS.

VARIATION INSTRUMENTS.

The magnetograph is of the Eschenhagen pattern and consists of D , H , and Z variometers and a recording apparatus. Much difficulty was experienced in keeping the H variometer in good adjustment, due partly to deterioration of the control magnets. In January, 1907, the old ones were found to be very badly rusted and were replaced by new ones. A change of control magnets was made also in January, 1909. The variometers are mounted east of the recording apparatus. Increasing ordinates (upward motion of the curves) correspond to increasing west declination, increasing H , and increasing Z .

The variations in temperature were obtained from the record of the thermograph inclosed in the Z variometer.

ABSOLUTE INSTRUMENTS.

India magnetic survey pattern magnetometer No. 31 and Schulze earth inductor No. 1.

SEISMOGRAPH.

A Bosch-Omori seismograph was kept in continuous operation except for the time of removal from the old fort to the new observatory site. The recorded seismic disturbances will be found tabulated on pages 96 and 97.

ACCESSORIES.

Chronometers and meteorological instruments.

Time observations were made with magnetometer No. 31, which is provided with a vertical circle, either using the method of equal altitudes of the sun or observing the time of the sun's meridian passage.

INSTRUMENTAL CONSTANTS OF THE MAGNETOGRAPH.

DECLINATION.

The removal of the magnetograph to the new observatory in April, 1907, and the insertion of a new fiber in the D variometer in November, 1908, produced small changes in the scale value. Both fibers were rather coarse, the average effect of 15° of torsion being $41'.6$ up to November, 1908, and $38'.9$ after that date. The adopted scale values are—

January 1 to April 4, 1907.....	1 mm.=1'.007.
April 10, 1907, to November 19, 1908.....	1 mm.=1'.013.
November 28 to December 31, 1908.....	1 mm.=1'.010.

HORIZONTAL INTENSITY.

Scale value.—Deflection observations for the determination of the scale value of the H variometer were made about twice a month. The results obtained from May, 1907, to January, 1908, show a relation between change of scale value and change of ordinate represented by the formula:

$$\epsilon_h = 2.087 + .005 h$$

During 1908 the readjustments became too frequent to trace such a relation. From the middle of September to the end of the year the scale values resulting from the deflection observations are so large and so divergent and the deflections themselves were so unsymmetrical that it is evident that the magnet was not entirely free. At the same time the curves show diurnal and disturbance variations and it has been thought best not to reject the record for this period, but instead to adopt scale values which would give approximately the diurnal range to be expected at that season of the year.

EARTHQUAKES.

In September, 1903, a Bosch-Omori seismograph comprising two horizontal pendulums, one recording north-south motion (N) and the other recording east-west motion (E), was mounted in a room on the ground floor of the old fort. In March, 1907, it was transferred to the seismograph house at the new observatory site. It is mounted on four stone piers, 20 inches square and 32 inches deep. The following table is a register of the earthquakes recorded during 1907 and 1908. The times are Greenwich mean time, counted from midnight. From March 19 to April 12, 1907, the instrument was being moved to the new site, and hence no record was obtained.

Magnification..... 10
Steady mass..... 10-12 kg.

Period of pendulums.

N.			E.	
1907.		<i>s</i>	1907.	
January to March.....	25		January to April.....	25
April to November.....	27		May to June.....	23
December.....	30		July to September.....	25
			October to December.....	24
1908.			1908.	
January to December.....	25		January to December.....	24

Register of earthquakes.

No.	Date	Component	First P. T. begin	Second P. T. begin	Large waves begin	Maximum	End of principal portion	End	Maximum amplitude
			<i>h m s</i>	<i>h m s</i>	<i>h m s</i>	<i>h m s</i>	<i>h m</i>	<i>h m</i>	<i>mm</i>
142	1907. Jan. 2	N	12 25 ..	.. .. .	.. .. .	12 55 ..	.. ..	14 45	0.2
		E	12 17 ..	.. .. .	.. .. .	12 55 ..	.. ..	15 28	0.2
143	4	N	5 39 02	.. .. .	6 33 58	6 50 38	.. ..	8 03	1.0
		E	5 38 52	.. .. .	6 32 00	6 49 24	.. ..	8 25	1.0
144	Apr. 15	N	6 14 06	6 14 34	6 19 50	6 26 22	.. ..	.. ..	80.0
	15	E	6 14 07	6 14 40	6 20 19	6 26 15	6 34	7 52	67.0
145	June 1	N	8 45 30	.. .. .	8 49 26	8 49 52	9 08	11 00	4.2
	1	E	8 45 26	.. .. .	8 49 26	8 49 54	9 05	11 00	6.4
146	5	N	3 26 26	.. .. .	3 30 34	3 30 54	.. ..	4 41	6.8
	5	E	3 26 26	.. .. .	3 30 40	3 31 02	.. ..	4 33	2.6
147	13	N	10 06 30	10 14 06	10 26 06	10 30 46	.. ..	11 04	0.5
	13	E	10 07 04	10 14 18	10 20 50	10 21 10	.. ..	11 08	0.5
148	July 1	N	13 12 00	13 16 06	13 17 38	13 19 22	13 25	14 36	12.1
	1	E	13 11 58	13 16 02	13 17 10	13 21 54	13 24	14 32	40.0
149	4	N	0 22 00	.. .. .	.. .. .	.. .. .	.. ..	0 22	0.2
	4	E	0 22 00	.. .. .	.. .. .	.. .. .	.. ..	0 22	0.2
150	29	N	.. .. .	.. .. .	1 12 ..	.. .. .	1 32	.. ..	0.1
	29	E	.. .. .	.. .. .	1 13 ..	.. .. .	1 39	.. ..	0.1
151	Aug. 5	N	6 46 49	.. .. .	.. .. .	6 56 27	.. ..	7 18	1.0
	5	E	6 47 30	.. .. .	.. .. .	6 56 19	.. ..	7 08	2.1
152	Sept. 2	N	16 14 03	16 26 10	16 39 26	17 01 48	17 06	19 12	10.4
	2	E	16 14 56	16 26 08	16 39 06	16 55 20	17 03	19 22	4.9
153	4	N	14 45 15	.. .. .	14 45 39	.. .. .	14 46	14 47	0.2
	4	E	14 45 15	.. .. .	14 45 39	.. .. .	14 46	14 47	0.2
154	6	N	12 51 58	12 52 46	.. .. .	12 53 10	.. ..	13 03	0.2
	6	E	12 51 57	12 52 47	.. .. .	12 53 23	.. ..	12 58	0.2
155	Oct. 16	N	.. .. .	.. .. .	14 20 51	14 23 16	14 31	15 16	6.0
	16	E	14 03 25	14 12 10	14 21 22	14 27 22	14 35	15 35	1.6
156	17	N	11 26 04	.. .. .	11 30 05	11 38 10	.. ..	11 54	0.5
	17	E	11 26 02	.. .. .	11 29 59	11 32 45	.. ..	11 47	0.2
157	Dec. 22	N	10 02 56	.. .. .	.. .. .	.. .. .	.. ..	10 03.3	0.1
	22	E	10 02 56	.. .. .	.. .. .	.. .. .	.. ..	10 03.3	0.1
158	30	N	5 31 42	.. .. .	5 36 24	5 42 38	5 50	6 56	22.0
	30	E	5 31 44	5 35 55	5 37 38	5 43 39	5 50	6 52	12.1
159	1908. Feb. 1	N	23 17 04	.. .. .	23 21 19	23 27 07	.. ..	24 03	0.5
	1	E	23 16 56	.. .. .	23 21 17	23 27 23	.. ..	24 04	0.6
160	9	N	3 29 11	3 33 04	3 34 58	3 40 11	.. ..	3 58	.. ..
	9	E	3 29 09	3 32 54	3 35 20	3 39 15	.. ..	4 00	.. ..
161	9	N	9 10 43	9 14 40	.. .. .	9 23 15	.. ..	9 42	0.2
	9	E	9 10 53	9 15 10	.. .. .	.. .. .	.. ..	9 30	.. ..

Register of earthquakes—Continued.

No.	Date	Component	First P. T. begin	Second P. T. begin	Large waves begin	Maximum	End of principal portion	End	Maximum amplitude
			<i>h m s</i>	<i>h m s</i>	<i>h m s</i>	<i>h m s</i>	<i>h m</i>	<i>h m</i>	<i>mm</i>
	1908.								
162	Feb. 11	N	13 03 09	.. .. .	.. .. .	13 06 36	.. ..	13 30	0.2
	11	E	13 02 51	.. .. .	.. .. .	13 06 37	.. ..	13 30	0.1
163	14	N	8 56 09	.. .. .	9 00 38	9 00 58	9 05	9 27	1.0
	14	E	8 56 10	.. .. .	9 00 40	9 01 02	9 04	9 30	0.7
164	20	N	10 35 14	.. .. .	.. .. .	.. .. .	.. ..	10 36	.. ..
	20	E	10 35 05	.. .. .	.. .. .	.. .. .	.. ..	10 36	.. ..
165	20	N	22 22 10	.. .. .	.. .. .	22 28 40	.. ..	22 30	0.2
	20	E	22 23 30	.. .. .	.. .. .	22 28 30	.. ..	22 29	0.2
166	22	N	17 35 31	.. .. .	.. .. .	.. .. .	.. ..	17 36	.. ..
	22	E	17 35 30	.. .. .	.. .. .	.. .. .	.. ..	17 36	.. ..
167	22	N	18 37 34	.. .. .	.. .. .	.. .. .	.. ..	18 38	.. ..
168	Mar. 5	N	2 47 40	.. .. .	3 31 ..	3 36 42	.. ..	4 04	0.2
	5	E	.. .. .	.. .. .	3 31 ..	3 37 ?	.. ..	3 50?	.. ..
169	25	N	18 59 55	.. .. .	19 04 53	19 11 00	.. ..	.. ..	1.1
	25	E	19 00 00	.. .. .	19 04 12	19 07 30	.. ..	19 45	0.3
170	26	N	22 48 33	.. .. .	.. .. .	.. .. .	.. ..	22 51	.. ..
	26	E	22 48 32	.. .. .	.. .. .	.. .. .	.. ..	22 50	.. ..
171	26	N	23 09 45	23 15 07	23 18 47	23 21 34	.. ..	.. ..	40.9
						23 25 40	23 31	25 05	36.9
	26	E	23 09 47	23 15 14	23 18 57	23 21 50	.. ..	.. ..	15.2
						23 24 30	23 30	25 06	23.4
172	27	N	3 54 01	3 59 00	4 02 20	4 10 30	.. ..	4 51	1.2
	27	E	3 53 44	3 58 52	4 02 58	4 08 54	.. ..	4 48	0.6
173	Apr. 23	N	.. .. .	.. .. .	0 33 50	0 51 33	.. ..	1 09	0.1
	23	E	.. .. .	.. .. .	0 34 ..	0 44 30	.. ..	1 12	.. ..
174	30	N	4 57 59	.. .. .	5 02 40	5 08 10	.. ..	5 33	0.1
	30	E	4 58 00	.. .. .	5 03 32	5 10 10	.. ..	5 26	0.1
175	May 5	N	6 38 ..	.. .. .	.. .. .	7 46 35	.. ..	8 30	0.1
	5	E	6 31 ?	.. .. .	.. .. .	7 45 50	.. ..	8 20	.. ..
176	11	N	20 05 21	.. .. .	20 06 27	20 06 37	.. ..	20 20	.. ..
	11	E	20 05 23	.. .. .	20 06 27	20 06 35	.. ..	20 18	.. ..
177	May 11	N	21 09 47	21 10 09	21 10 57	21 11 13	21 12	21 29	0.2
	11	E	21 09 30	.. .. .	21 10 53	21 11 09	21 12	21 20	0.2
178	15	N	8 51 51	.. .. .	9 04 ..	9 14 38	.. ..	10 36	0.4
	15	E	8 51 33	.. .. .	9 02 ..	9 06 09	.. ..	10 44	0.2
179	17	N	21 42 04	.. .. .	.. .. .	21 47 04	.. ..	21 58	0.1
	17	E	21 42 04	.. .. .	.. .. .	21 46 50	.. ..	21 51	.. ..
180	Aug. 2	N	5 55 53	.. .. .	.. .. .	5 57 01	.. ..	6 03	0.3
	2	E	5 56 01	.. .. .	.. .. .	5 57 05	.. ..	6 03	0.2
181	14	N	0 49 34	0 56 52	.. .. .	1 06 38	.. ..	1 29	0.4
	14	E	0 50 44	0 56 52	.. .. .	1 07 18	.. ..	1 26	0.1
182	17	N	10 50 18	11 00 27	11 16 27	11 34 37	.. ..	12 21	2.1
	17	E	10 50 24	11 00 20	11 18 35	11 21 54	.. ..	12 00	0.8
183	20	N	9 20 ..	.. .. .	.. .. .	9 58 10	.. ..	10 33?	0.1
	20	E	9 19 ..	9 31 20	.. .. .	9 53 52	.. ..	10 44?	0.1
184	Sept 5	N	16 11 01	.. .. .	.. .. .	.. .. .	.. ..	16 11.4	0.3
	5	E	16 10 45	.. .. .	.. .. .	.. .. .	.. ..	16 11.4	0.2
185	21	N	6 59 14	.. .. .	.. .. .	.. .. .	.. ..	7 35	0.1
	21	E	6 59 06	.. .. .	.. .. .	7 23 08	.. ..	7 35	0.1
186	Oct. 13	N	5 13 51	5 18 29	5 24 17?	5 25 41	5 30	6.14	0.7
	13	E	5 13 19	5 18 41	5 24 31	5 27 23	5 31	6 08?	0.7
187	20	N	?	.. .. .	.. .. .	15 31 03	.. ..	15 34?	0.1
	20	E	15 17 47	15 27 51	.. .. .	15 31 41	.. ..	15 36	0.1
188	Nov. 2	N	5 58 34	.. .. .	6 46 04	7 03 34	.. ..	7 24	0.1
189	6	N	8 00 ..	.. .. .	.. .. .	8 18 43	.. ..	8 37	0.1
	6	E	8 01 ..	.. .. .	.. .. .	8 15 ..	.. ..	8 26	0.1
190	Dec. 17	N	15 55 ..	.. .. .	.. .. .	.. .. .	.. ..	15 59	0.1
	17	E	15 55 ..	.. .. .	.. .. .	.. .. .	.. ..	15 59	0.3
191	28	N	4 31 45	4 39 58	.. .. .	4 55 00	.. ..	5 42	0.7
	28	E	4 31 41	4 41 06	.. .. .	4 55 00	.. ..	5 58	0.6

REMARKS.

No. 144: Tracing stylus of N went off the paper at maximum.

Nos. 149, 153, 154, 157, 170, 184: Local shocks.

No. 155: First and second phases on N indeterminate on account of faint trace.

Nos. 164, 166, 167: Very rapid minute vibrations; possibly local shocks.

No. 171: Two well-defined maxima. The recorded time of the second P. T. may be the beginning of the large waves

Nos. 176, 177: Small, not far distant.

Nos. 183, 189: Beginning and end uncertain.

No. 188: Impossible to distinguish phases on E.

No. 190: Series of long waves.

DEPARTMENT OF COMMERCE AND LABOR
COAST AND GEODETIC SURVEY
O. H. TITTMANN, SUPERINTENDENT

RESULTS OF OBSERVATIONS MADE AT THE COAST AND
GEODETIC SURVEY MAGNETIC OBSERVATORY
AT VIEQUES, PORTO RICO
1909 AND 1910

BY

DANIEL L. HAZARD
Computer, Division of Terrestrial Magnetism



WASHINGTON
GOVERNMENT PRINTING OFFICE
1912

CONTENTS.

	Page.
Introduction.....	5
Instruments.....	5
Constants of the magnetograph.....	6
Absolute observations and base-line values.....	7
Diurnal variation.....	13
Summary of monthly and annual means.....	19
Hourly values of declination.....	20
Hourly values of horizontal intensity.....	44
Hourly values of vertical intensity.....	68
Earthquakes.....	92
Magnetic storms.....	94

ILLUSTRATIONS.

Figs. 1-19. Reproductions of the magnetograms showing the principal magnetic disturbances in 1909 and 1910..	94
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EARTHQUAKES.

A Bosch-Omori seismograph comprising two horizontal pendulums, one recording north-south motion (N) and the other recording east-west motion (E), has been in operation since September, 1903. In the following register of earthquakes the times are Greenwich mean time, counted from midnight.

Magnification..... 10
Steady mass..... 10-12 kg.

Period of pendulums.

N.			E.	
1909.		s.	1909.	
January and February.....	25		January to February.....	24
March to October.....	21		March to April.....	33
November to December.....	22		May to June.....	29
1910.			July to September.....	25
January to December.....	22		October to December.....	22
			1910.	
			January to December.....	21

Register of earthquakes.

No.	Date	Component	First P. T. begin	Second P. T. begin	Large waves begin	Maximum	End of principal portion	End	Maximum amplitude
	1909.		<i>h m s</i>	<i>h m s</i>	<i>h m s</i>	<i>h m s</i>	<i>h m</i>	<i>h m</i>	<i>mm</i>
192	Jan. 12	N	.. .. .	.. .. .	12 27 ..	12 27 38	.. ..	12 42	0.1
193	Jan. 23	N	3 15 43	.. .. .	.. .. .	3 41 36	.. ..	4 27	0.2
193	23	E	3 17 24	.. .. .	.. .. .	3 41 24	.. ..	4 26	0.4
194	Feb. 1	N	8 42 32	.. .. .	8 42 52	8 43 07	.. ..	8 46	0.4
194	1	E	8 42 32	.. .. .	8 42 52	8 43 07	.. ..	8 46	0.3
195	17	N	6 50 48	.. .. .	6 50 58	6 50 58	6 52	6 53	1.1
195	17	E	6 50 48	.. .. .	6 50 59	6 50 59	6 52	6 54	1.6
196	22	N	9 40 34	.. .. .	.. .. .	9 56 08	.. ..	10 14	0.4
196	22	E	9 40 32	.. .. .	.. .. .	9 45 20	.. ..	10 02	0.1
197	26	N	16 52 36	.. .. .	16 57 58	17 01 28	17 12	17 16	1.5
197	26	E	16 52 16	.. .. .	16 57 34	17 00 48	17 10	17 23	1.1
198	Mar. 8	N	4 56 24	.. .. .	4 56 52	4 57 13	4 58	5 01	0.3
198	8	E	4 56 20	.. .. .	4 56 57	4 57 08	4 58	5 00	0.4
199	18	N	.. .. .	.. .. .	0 19 ..	0 35 ..	0 53	.. ..	0.1
199	18	E	.. .. .	.. .. .	0 19 ..	0 40 ..	0 58	.. ..	0.1
200	Apr. 10	N	5 54 08	.. .. .	.. .. .	6 24 38	.. ..	6 52	0.1
200	10	E	5 52 28	.. .. .	.. .. .	6 26 16	.. ..	7 09	0.2
201	10	E	19 09 54	19 19 26	19 27 02	19 30 30	.. ..	20 42	0.2
202	27	N	.. .. .	.. .. .	13 57 ..	14 08 ..	.. ..	14 51	0.2
202	27	E	.. .. .	.. .. .	13 54 ..	.. .. .	.. ..	14 58	0.1
203	May 12	N	0 11 14	0 15 52	0 21 02	0 16 06	0 27	0 50	0.6
203	12	E	0 11 16	0 15 52	0 19 12	0 16 02	0.23	0 50	0.4
204	13	N	13 43 00	13 47 24	13 52 24	13 47 54	.. ..	14 06	0.4
204	13	E	13 43 01	13 47 24	.. .. .	13 47 58	.. ..	14 09	0.2
205	17	N	8 09 53	8 15 31	8 18 47	8 19 01	8 32	9 20	4.6
205	17	E	8 10 47	8 15 27	8 18 31	8 19 01	8 38	9 57	7.5
206	23	N	5 36 20	.. .. .	5 40 34	5 41 07	.. ..	5 59	0.3
206	23	E	5 36 18	.. .. .	5 40 45	5 41 29	.. ..	5 58	0.1
207	June 3	N	19 02 46	.. .. .	19 56 06	20 19 01	20 29	20 55	1.2
207	3	E	19 05 09	.. .. .	19 57 10	20 05 27	20 15	20 55	0.8
208	8	N	5 54 48	6 01 11	6 08 37	6 13 37	6 20	7 13	2.2
208	8	E	5 55 35	6 01 23	6 08 51	6 05 28	6 19	7 08	4.3
209	July 7	N	21 56 41	22 04 04	.. .. .	22 13 25	22 18	22 57	0.5
209	7	E	21 56 41	.. .. .	.. .. .	22 12 23	.. ..	22 56	0.5
210	30	N	10 58 28	11 03 44	11 07 28	11 12 14	11 39	12 06	1.4
210	30	E	10 58 34	11 04 04	11 08 14	11 14 42	11 43	12 06	1.9
211	31	N	19 30 42	.. .. .	.. .. .	19 35 50	.. ..	19 56	0.5
211	31	E	19 30 46	.. .. .	.. .. .	19 35 48	19 44	19 56	0.4
212	Aug. 16	N	7 04 19	7 08 19	7 13 27	7 17 33	7 20	7 26	0.4
212	16	E	7 04 19	7 08 41	7 15 33	7 16 10	7 19	7 26	0.7

Register of earthquakes—Continued.

No.	Date	Com- po- nent	First P. T. begin	Second P. T. begin	Large waves begin	Maximum	End of principal portion	End	Maximum amplitude
			<i>h m s</i>	<i>h m s</i>	<i>h m s</i>	<i>h m s</i>	<i>h m</i>	<i>h m</i>	<i>mm</i>
	1909.								
213	Oct. 31	N	10 35 29	10 38 31	.. .. .	10 45 55	.. ..	11 05	0.3
213	31	E	10 35 47	.. .. .	.. .. .	10 40 59	.. ..	11 04	0.2
214	Nov. 18	N	20 40 26	.. .. .	.. .. .	.. .. .	.. ..	20 41	0.1
214	18	E	20 40 26	.. .. .	.. .. .	.. .. .	.. ..	20 41	.. .
215	18	N	20 55 26	.. .. .	20 55 41	20 55 45	20 56	20 58	0.6
215	18	E	20 55 26	.. .. .	20 55 45	20 55 53	20 56	20 58	0.6
	1910.								
216	Jan. 1	N	11 05 58	.. .. .	11 09 16	11 21 44	11 40	11 58	1.0
216	1	E	11 06 06	.. .. .	11 09 09	11 23 14	11 38	11 58	0.5
216a	22	N	.. .. .	.. .. .	9 01 42	9 06 26	9 32	.. ..	0.1
217	23	N	18 51 25	18 53 03	18 53 53	18 55 25	19 04	19 20	1.1
217	23	E	18 51 32	.. .. .	18 53 24	18 58 17	19 02	19 10	0.5
218	Mar. 25	N	.. .. .	.. .. .	15 35 21	15 42 07	16 06	.. ..	0.1
218	25	E	.. .. .	.. .. .	15 37 00	15 41 53	16 02	.. ..	0.2
219	May 11	N	7 27 59	7 28 12	7 28 25	7 28 53	7 30	7 36	0.5
219	11	E	7 27 47	7 28 31	7 28 43	7 29 11	7 31	7 35	0.2
220	31	N	5 02 04	.. .. .	5 07 19	5 18 35	5 19	5 23	0.4
220	31	E	.. .. .	.. .. .	5 15 20	5 18 12	.. ..	5 23	0.1
221	June 14	N	19 46 40	.. .. .	19 47 30	19 48 58	19 52	19 57	0.2
221	14	E	19 46 20	.. .. .	.. .. .	19 48 20	19 49	.. ..	0.1
222	16	N	6 51 12	.. .. .	7 24 16	7 35 21	7 37	8 44	0.9
222	16	E	6 52 50	.. .. .	7 32 04	7 32 35	7 35	7 44	0.3
223	29	N	11 36 04	.. .. .	11 41 43	11 48 45	11 51	.. ..	0.2
224	July 10	N	15 11 35	.. .. .	15 16 22	15 20 04	15 22	15 32	0.2
224	10	E	15 17 16	.. .. .	15 21 17	15 23 43	15 26	15 31	0.1
225	Aug. 3	N	.. .. .	.. .. .	22 50 41	22 51 09	22 52	22 54	0.4
225	3	E	.. .. .	.. .. .	22 50 39	22 51 35	22 52	22 54	0.1
226	11	N	16 34 08	.. .. .	16 39 52	16 41 36	16 43	17 01	0.5
226	11	E	16 34 25	.. .. .	16 41 19	16 43 27	16 44	16 51	0.2
227	Sept. 10	N	1 56 30	.. .. .	1 56 50	1 57 01	1 58	2 02	0.6
227	10	E	1 56 31	.. .. .	1 57 00	1 57 21	1 58	2 02	0.2
228	24	N	.. .. .	.. .. .	3 44 16	3 50 48	3 54	4 04	0.3
229	Oct. 4	N	.. .. .	.. .. .	23 13 20	23 16 35	23 18	23 34	0.2
229	4	E	23 07 50	.. .. .	23 13 01	23 16 33	23 18	23 33	0.2
230	Nov. 9	N	6 23 15	.. .. .	6 36 45	6 46 20	.. ..	.. ..	0.2
230	9	E	6 22 15	.. .. .	6 36 27	.. .. .	.. ..	.. ..	0.1
231	9	N	.. .. .	.. .. .	7 39 45	7 50 30	.. ..	8 45	.. .
231	9	E	.. .. .	.. .. .	7 38 10	.. .. .	.. ..	8 15	.. .
232	Dec. 6	N	13 47 28	.. .. .	13 47 44	13 47 56	13 48	13 51	0.2
232	6	E	13 47 28	.. .. .	13 47 38	13 47 57	13 49	13 51	0.2
233	10	N	9 48 56	.. .. .	10 21 48	10 23 28	.. ..	11 42	0.1
233	10	E	9 48 35	.. .. .	10 20 00	10 30 00	.. ..	11 36	0.1
234	13	N	12 06 00	.. .. .	12 20 48	12 29 56	12 39	13 30	0.2
234	13	E	12 01 30	.. .. .	12 21 30	12 30 00	12 38	13 25	0.6
235	16	N	15 05 30	15 28 37	15 39 27	16 14 40	.. ..	17 00	0.2
235	16	E	15 06 27	15 28 42	15 45 47	16 11 00	.. ..	17 00	0.2
236	21	N	10 28 33	.. .. .	10 34 35	10 28 40	.. ..	10 50	0.2
236	21	E	10 28 28	.. .. .	10 35 35	10 28 47	.. ..	10 50	0.2
237	25	N	3 11 28	.. .. .	.. .. .	3 11 39	.. ..	3 13	0.2
237	25	E	3 11 00	.. .. .	.. .. .	3 11 45	.. ..	3 14	0.2

REMARKS.

Nos. 192, 199, 202: Series of long waves of small amplitude.

No. 195: Local; felt at Vieques, accompanied by a rumbling sound.

Nos. 200, 207, 209, 211, 213: Phases not well marked.

No. 208: Possibly the principal portion began at 6:04:45.

Nos. 214, 215: Probably local.

Nos. 227, 232, 237: Local.

Nos. 230, 231: The two earthquakes overlap and none of the phases are well defined. There is some indication of a beginning of No. 230 as early as 6:12, but it is very indistinct.

The pendulums were not in good adjustment during 1910, and it was difficult to determine the times of the different phases.

DEPARTMENT OF COMMERCE

U. S. COAST AND GEODETIC SURVEY

O. H. TITTMANN, SUPERINTENDENT

RESULTS OF OBSERVATIONS MADE AT THE U. S. COAST
AND GEODETIC SURVEY MAGNETIC OBSERVATORY
AT VIEQUES, PORTO RICO
1911 AND 1912

BY

DANIEL L. HAZARD

Computer, Division of Terrestrial Magnetism



WASHINGTON
GOVERNMENT PRINTING OFFICE

1914

CONTENTS.

	Page.
Introduction.....	5
Instruments.....	5
Constants of the magnetograph.....	6
Absolute observations and base-line values.....	9
Diurnal variation.....	14
Summaries of monthly and annual means.....	27
Hourly values of declination.....	28
Hourly values of horizontal intensity.....	52
Hourly values of vertical intensity.....	76
Earthquakes.....	100
Magnetic storms.....	102

ILLUSTRATIONS.

Figs. 1-13. Reproductions of magnetograms showing principal magnetic storms.....	102
--	-----

EARTHQUAKES.

A Bosch-Omori seismograph comprising two horizontal pendulums, one recording north-south motion (N) and the other recording east-west motion (E), has been in operation since September, 1903. In the following register of earthquakes the times are Greenwich mean time, counted from midnight.

Magnification: 10.

Steady mass: 10-12 kg.

Period of pendulums.

N.		E.	
January to July, 1911.....	s. 22	January, 1911, to January, 1912.....	s. 21
August and September, 1911.....	20	April to September, 1912.....	24
October to December, 1911.....	21	October to December, 1912.....	20
January to December, 1912.....	20		

Register of earthquakes.

No.	Date	Component	First P. T. begin	Second P. T. begin	Large waves begin	Maximum	End of principal portion	End	Maximum amplitude
	1911.		<i>h m s</i>	<i>h m s</i>	<i>h m s</i>	<i>h m s</i>	<i>h m</i>	<i>h m</i>	<i>mm</i>
238	Jan. 3	N	23 45 00	23 54 36	24 18 00	24 25 24	24 39	25 56	1.9
		E	23 45 00	23 54 36	24 17 30	24 25 12	24 39	25 51	1.8
239	Feb. 5	N	4 29 53	.....	4 34 18	4 35 36	4 36	4 45	0.2
		E	4 30 10	.....	4 34 50	4 37 00	4 39	4 48	0.2
240	18	N	.....	.....	19 31 37	19 40 35	19 49	20 24	0.2
		E	.....	.....	19 29 19	19 37 05	19 48	20 25	0.2
241	27	N	10 51 22	.....	10 51 52	10 52 10	.....	10 54	0.1
		E	10 51 40	.....	10 51 56	10 52 08	.....	10 54	0.1
242	Mar. 1	N	19 18 45	.....	.....	19 21 37	.....	19 26	0.1
		E	19 18 07	.....	.....	19 24 07	.....	19 26	0.2
243	3	N	3 48 36	.....	3 49 15	3 49 17	3 51	3 59	0.9
		E	3 48 42	.....	3 49 00	3 49 22	3 51	3 58	1.0
244	Apr. 10	N	18 45 08	.....	18 48 24	18 50 24	19 00	19 22	0.5
		E	18 45 20	.....	18 48 12	18 50 14	18 57	19 15	0.9
245	28	N	9 59 09	.....	10 01 29	10 01 45	10 05	10 20	0.8
		E	9 59 16	.....	10 01 26	10 01 36	10 05	10 17	0.2
246	May 4	N	.....	23 52 27	24 01 22	24 09 28	.....	24 58	0.1
		E	.....	23 51 17	24 01 49	24 08 58	.....	24 48	0.5
247	June 2	N	14 18 22	.....	.....	14 18 44	.....	14 20	0.1
		E	14 18 07	.....	.....	14 18 31	.....	14 20	0.1
248	2	N	19 26 45	.....	19 27 05	19 28 23	19 29	19 31	0.2
		E	19 27 10	.....	19 27 22	19 27 38	19 28	19 32	0.2
249	7	N	11 09 41	11 15 38	11 18 34	11 29 02	11 53	13 45	3.5
		E	11 09 48	11 15 24	11 20 08	11 27 54	11 51	13 46	1.6
250	15	N	14 44 57	14 48 20	15 05 34	15 34 38	15 47	16 42	7.1
		E	14 45 02	14 48 30	15 05 38	15 25 40	15 42	16 39	0.5
251	July 12	N	4 27 12	.....	.....	5 36 36	.....	5 57	0.4
		E	4 27 47	.....	.....	5 26 48	.....	5 55	0.5
252	Aug. 16	N	23 00 40	.....	.....	23 57 05	24 08	24 40	0.4
		E	23 00 55	.....	.....	23 55 40	24 07	24 46	0.4
253	Sept. 15	N	13 18 54	13 23 10	13 30 30	13 34 47	13 41	13 50	0.3
		E	.....	13 23 11	13 29 34	13 34 53	.....	.....	0.1
254	17	N	.....	3 52 57	4 15 06	4 22 28	4 29	5 00	0.2
		E	.....	.....	4 15 46	4 22 24	4 29	4 55	0.1
255	22	N	.....	.....	5 40 40	5 42 00	5 50	.....	.....
256	Oct. 6	N	10 17 40	10 18 42	10 19 12	10 23 ..	10 25	11 14	65+
		E	10 17 34	10 18 38	10 19 20	10 28 00	10 29	11 00	64.0
257	10	N	.....	.....	9 24 50	9 25 30	9 26	.....	0.1
		E	.....	.....	9 24 43	9 25 20	9 27	.....	0.2
258	10	N	13 17 20	13 20 47	13 23 40	13 27 20	13 33	13 45	0.5
		E	13 17 03	13 20 43	13 23 30	13 27 10	13 33	13 44	0.2
259	Nov. 20	N	.....	14 00 55	14 02 25	14 08 23	14 09	14 15	0.3
		E	13 57 43	14 00 34	14 03 44	14 07 15	14 10	14 17	0.3
260	Dec. 6	N	.....	.....	23 22 13	23 24 20	23 31	.....	.....
261	16	N	19 20 41	.....	19 28 30	19 31 08	19 37	20 10	0.5
262	23	N	21 06 32	21 09 56	21 14 22	21 21 43	21 30	21 50	0.2

Register of earthquakes—Continued.

No.	Date	Component	First P. T. begin	Second P. T. begin	Large waves begin	Maximum	End of principal portion	End	Maximum amplitude
			<i>h m s</i>	<i>h m s</i>	<i>h m s</i>	<i>h m s</i>	<i>h m</i>	<i>h m</i>	<i>mm</i>
263	1912. Jan. 4	N	.. .. .	.. .. .	16 36 04	16 37 ..	17 00	.. ..	.. .
		E	.. .. .	.. .. .	16 36 46	16 44 58	16 54	.. ..	0.1
264	Apr. 17	N	3 54 27	3 58 05	4 01 00	4 03 06	4 03	4 13	0.2
		E	3 54 32	3 58 16	4 01 02	4 01 27	4 03	4 08	0.1
265	May 6	N	19 17 40	19 21 46	19 25 40	19 26 40	19 28	20 14	0.5
		E	19 17 36	.. .. .	19 24 32	19 26 36	19 28	.. ..	0.1
266	14	N	14 49 52	.. .. .	14 50 27	14 51 32	14 53	15 02	0.3
		E	14 49 42	.. .. .	14 50 07	14 51 07	14 54	14 56	0.3
267	19	N	2 17 46	.. .. .	2 23 46	2 23 58	2 25	2 38	0.3
		E	2 17 54	.. .. .	2 23 34	2 24 16	2 24	2 30	0.2
268	23	N	3 04 31	3 20 47	3 24 38	3 43 00	3 57	4 14	0.7
		E	3 04 25	3 20 49	3 25 28	3 31 40	3 57	4 14	0.7
269	June 8	N	5 00 34	.. .. .	.. .. .	5 01 04	5 04	5 09	0.1
270	8	N	7 31 52	7 57 28	8 16 24	8 23 42	8 26	9 45	0.6
271	8	N	13 37 52	13 40 56	13 42 54	13 45 24	13 46	14 01	0.2
272	10	N	16 27 18	16 37 55	16 48 30	16 51 04	17 02	17 19	0.4
		E	.. .. .	.. .. .	16 48 12	16 53 33	16 58	17 18	0.2
273	12	N	12 49 12	12 52 44	12 56 42	12 58 05	13 01	13 12	1.9
		E	12 48 32	12 52 48	12 56 16	12 57 12	13 00	13 11	1.7
274	July 7	N	8 09 11	8 18 19	8 29 11	8 39 55	8 47	9 33	2.8
		E	8 09 23	8 18 35	8 30 00	8 38 47	8 50	9 12	0.5
275	20	N	13 38 08	.. .. .	13 52 20	13 53 10	13 57	14 11	0.7
		E	13 38 08	.. .. .	13 51 20	13 53 08	13 57	14 10	0.5
276	24	N	12 04 56	12 07 08	12 09 32	12 10 24	12 21	12 38	1.0
		E	12 05 00	12 08 08	12 09 28	12 10 20	12 16	12 30	0.5
277	Aug. 5	N	7 20 32	7 20 48	7 21 06	7 21 12	7 23	7 26	0.9
		E	7 20 30	7 20 50	7 21 08	7 21 10	7 23	7 28	0.8
278	9	N	1 52 06	.. .. .	2 06 10	2 22 33	2 33	2 41	0.4
		E	1 51 20	.. .. .	2 04 34	2 10 48	2 26	2 44	0.5
279	17	N	19 35 48	19 56 16	20 30 12	20 34 00	20 42	21 16	0.1
		E	19 36 44	.. .. .	.. .. .	.. .. .	.. ..	21 03	0.1
280	31	N	12 00 19	.. .. .	.. .. .	12 00 32	.. ..	12 04	0.5
		E	12 00 16	.. .. .	.. .. .	12 00 33	.. ..	12 05	0.2
281	Sept. 29	N	21 11 03	.. .. .	22 00 26	22 06 20	22 11	22 32	0.5
		E	21 10 49	.. .. .	22 01 50	22 13 30	22 20	22 35	0.2
282	Oct. 18	N	.. .. .	.. .. .	12 41 20	12 54 12	12 56	13 10	0.2
		E	.. .. .	.. .. .	12 41 20	12 50 00	12 59	.. ..	0.1
283	Nov. 7	N	.. .. .	.. .. .	0 19 36	0 19 45	0 21	.. ..	0.1
		E	.. .. .	.. .. .	0 19 38	.. .. .	0 21	.. ..	0.1
284	7	N	7 51 58	8 01 28	8 10 52	8 21 28	8 31	8 56	0.3
		E	7 51 55	8 01 15	8 10 55	8 15 00	8 32	8 55	0.2
285	7	N	16 50 00	.. .. .	16 54 00	17 00 25	17 02	17 10	0.5
		E	16 49 22	16 51 40	16 53 34	17 00 08	17 02	17 10	0.2
286	7	N	.. .. .	17 38 48	17 41 10	17 44 26	17 50	18 00	0.9
		E	17 34 44	17 38 36	17 41 16	17 44 08	17 50	17 55	0.4
287	19	N	14 03 00	.. .. .	14 12 34	14 16 06	14 22	14 40	0.3
		E	14 02 45	.. .. .	14 10 45	14 14 42	14 24	14 37	0.1
288	Dec. 9	N	8 37 43	8 41 46	8 45 16	8 47 48	8 53	9 17	0.7
		E	8 37 39	8 41 05	8 44 36	8 48 48	8 53	9 20	2.2

REMARKS.

For most of the earthquakes during the first half of 1911 the recorded motion was very small, and the phases were not well defined.

Nos. 241, 243, 247, 248.—Local shocks.

No. 249.—Mexican earthquake.

For the greater part of the last half of 1911 the pendulums were not in very good adjustment, and the phases were therefore not well defined. The E-W component was undergoing repairs during December.

Nos. 255 and 260.—Only a few long waves.

No. 256.—The stylus of N went off the paper at 10:22 and did not return until 10:24:15.

No. 257.—Probably a slight local shock.

No. 265.—Barely perceptible on E.

Nos. 269, 271. —No distinct phases.

Microseismic tremors were present on April 4, 10, 16, 20; May 16; June 2, 17, 1912.

From January 14 to March 1, 1912, the N component was not recording.

No. 274.—Times uncertain on account of error in recording times of starting and stopping.

No. 279.—Phases not well defined, especially on E.

MAGNETIC STORMS.

In the table below the magnitude of a storm is indicated by one of the figures 1, 2, 3, 4. When a storm began abruptly, the time of beginning is given to the nearest minute.

On the succeeding sheets will be found reproductions of the magnetograms showing the principal storms, reduced to three-fourths the original size. A storm selected for reproduction is indicated in the table by an asterisk after the date. An upward motion corresponds to increasing west declination, increasing H and increasing Z . For convenience in comparing with similar reproductions from other observatories, the time scale has been marked for Greenwich mean time

Principal magnetic disturbances.

Date	L. M. T. of beginning		Duration in hours	Relative magnitude	Date	L. M. T. of beginning		Duration in hours	Relative magnitude
1911.	<i>h</i>	<i>m</i>			1911.	<i>h</i>	<i>m</i>		
Jan. 1	21		49	1	Aug. 23*	3		52	2
8	12		72	1	Sept. 15	20		28	1
15	1		38	1	19*	12		67	2
24	1		120	2	Oct. 9*	23		32	2
30	9		78	1	17	5		38	1
Feb. 4	12		33	1	Dec. 6	5		17	1
12	19		58	2	10*	11		35	2
15	22		74	1					
20*	17		216	3	1912.				
Mar. 4	9		48	1	Jan. 12	16		30	1
13	12		37	1	25	19		21	1
19*	20	26	219	3	Mar. 7	20		30	1
Apr. 8*	6	59	25	3	Apr. 14*	15		63	1
9	17	59	28	1	May 4	18		22	1
15	17		183	2	11	17		58	2
May 6	12		44	1	June 7	14		83	1
14*	12		72	2	July 3	16		54	1
29	20		60	1	30	20		30	1
June 4	12		24	1	Aug. 5*	12		38	1
9	12		134	2	Sept. 17	9		24	1
20	17		39	1	22	14		54	1
30	20		33	1	Oct. 14*	0		47	1
July 6	4		70	1	Dec. 6*	17		36	1
17	5		71	1	22	9		40	1
27	12		89	1					

Serial No. 33

DEPARTMENT OF COMMERCE

U. S. COAST AND GEODETIC SURVEY

E. LESTER JONES, SUPERINTENDENT

RESULTS OF OBSERVATIONS MADE AT THE UNITED STATES
COAST AND GEODETIC SURVEY MAGNETIC OBSERVATORY
AT VIEQUES, PORTO RICO
1913 AND 1914

BY

DANIEL L. HAZARD

Chief, Division of Terrestrial Magnetism



WASHINGTON
GOVERNMENT PRINTING OFFICE
1916

CONTENTS.

	Page.
Introduction.....	5
Instruments.....	5
Constants of the magnetograph.....	6
Absolute observations and base-line values.....	8
Diurnal variation.....	14
Summaries of monthly and annual means.....	27
Hourly values of declination.....	28
Hourly values of horizontal intensity.....	52
Hourly values of vertical intensity.....	76
Earthquakes.....	100
Magnetic storms.....	102

ILLUSTRATIONS.

FIGS. 1-15. Reproductions of magnetograms showing principal magnetic storms.....	facing..	102
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EARTHQUAKES.

A Bosch-Omori seismograph has been in operation since September, 1903. It consists of two pendulums, one recording north-south motion (N) and the other recording east-west motion (E). In the following table the times are Greenwich mean time counted from midnight.

Period of pendulums.

	N	E
	<i>s</i>	<i>s</i>
January to March, 1913.....	20.0	20.0
May, 1913, to April, 1914.....	19.4	19.9
May to December, 1914.....	21.1	21.4

Magnification: 10.

Steady mass: 10-12 kg.

Register of earthquakes recorded at Porto Rico.

No	Date	Component	First P. T. begin	Second P. T. begin	Large waves begin	Maximum	End of principal portion	End	Maximum amplitude
			<i>h m s</i>	<i>h m s</i>	<i>h m s</i>	<i>h m s</i>	<i>h m</i>	<i>h m</i>	<i>mm</i>
289	1913. Jan. 16	N	18 57 54	19 01 47	19 05 33	19 10 23	19 13	19 26	0.2
		E	18 58 00	19 01 85	19 04 51	19 08 25	19 14	...	0.1
290	Mar. 8	N	...	16 02 21	16 05 15	16 10 30	16 14	16 22	0.5
		E	16 00 03	16 02 44	16 05 00	16 10 19	16 13	16 19	0.4
291	14	N	9 05 16	9 09 25	9 15 35	9 29 35	9 52	10 50	0.5
		E	9 05 49	9 09 46	9 15 15	9 34 52	10 18	10 55	1.0
292	31	N	...	...	4 31 56	4 35 54	4 45	...	0.2
		E	...	...	4 27 25	4 42 33	4 51	...	0.2
293	May 15	N	6 39 18	...	6 39 30	6 39 50	6 40	6 46	0.6
		E	6 39 14	...	6 39 26	6 39 42	6 40	6 46	0.5
294	24	N	23 39 30	23 43 04	23 49 36	23 50 45	23 56	...	0.2
		E	23 39 22	23 42 36	23 47 14	23 48 28	23 52	...	0.3
295	June 14	N	8 36 02	8 47 42	8 53 00	8 54 12	9 05	...	0.2
296	14	N	...	10 09 00	10 13 25	10 15 50	10 18	...	0.1
297	21	N	...	...	5 04 55	5 04 56	5 05	...	0.3
		E	...	...	5 04 55	5 04 56	5 05	...	0.5
298	22	N	14 13 57	14 24 14	14 33 40	14 46 51	14 48	15 17	1.0
		E	14 13 44	...	14 34 00	14 41 42	14 49	15 09	0.4
299	26	N	5 17 18	5 25 04	5 32 50	5 33 42	6 26	7 35	0.8
		E	5 16 44	5 25 56	5 32 24	5 33 14	6 04	7 26	1.9
300	July 24	N	8 59 11	...	8 59 27	8 59 36	9 00	9 08	8.4
		E	8 59 08	...	8 59 24	8 59 36	9 00	9 07	6.6
301	28	N	5 51 05	5 54 09	5 55 49	6 01 05	6 07	6 16	0.6
		E	...	...	5 56 33	5 58 00	6 04	...	0.2
302	Aug. 6	N	22 21 44	22 27 16	22 32 26	22 37 33	22 43	23 23	70+
		E	22 22 42	22 27 24	22 32 58	22 37 33	22 40	23 05	14.5
303	Oct. 2	N	4 22 27	4 25 56	4 28 15	4 29 35	4 34	5 00	0.9
		E	4 22 27	4 25 54	4 28 05	4 29 03	4 33	4 45	1.2
304	4	N	22 09 44	22 13 08	22 17 20	22 18 20	22 23	...	0.1
305	14	N	8 25 32	...	...	9 05 00	...	...	0.2
		E	8 25 15	...	...	9 05 00	...	...	0.2
306	1914. Jan. 30	N	3 45 20	3 52 55	4 03 40	4 11 24	4 13	4 48	2.9
		E	3 45 48	3 56 54	4 04 54	4 06 47	4 12	4 32	0.5
307	Feb. 26	N	5 06 14	5 10 37	5 13 35	5 24 24	5 27	5 30	0.2
		E	...	5 10 37	5 13 35	5 14 00	5 17	5 21	0.3
308	28	N	5 07 38	...	5 09 42	5 12 00	5 14	5 19	0.5
		E	5 07 40	...	5 10 00	5 10 28	5 12	5 18	0.2
309	Mar. 30	N	0 48 03	0 52 16	0 58 11	1 00 40	1 10	1 32	3.8
		E	0 47 55	0 53 18	0 57 45	1 00 40	1 11	2 00	14.8
310	Apr. 11	N	...	...	17 35 40	...	18 10	...	0.1
		E	16 52 54	...	17 42 30	...	17 48	...	0.1
311	20	N	13 27 20	13 30 55	13 33 42	13 34 52	13 41	14 10	0.4
		E	13 27 38	13 31 40	13 34 46	13 35 16	13 40	14 20	0.8
312	May 26	N	14 20 58	14 35 56	14 45 10	15 37 55	16 02	16 30	2.1
		E	14 21 09	14 36 29	14 47 10	15 39 35	16 05	16 20	0.2
313	28	N	3 27 35	3 30 19	3 32 56	3 37 50	3 39	4 00	0.6
		E	3 27 24	3 30 24	3 32 15	3 32 55	3 38	3 50	0.1
314	June 25	N	19 52 04	...	20 23 30	20 44 00	20 48	21 00	0.4
		E	19 52 05	...	20 24 45	20 34 00	20 48	21 00	0.2
315	Aug. 3	N	11 28 56	11 30 02	11 31 16	11 31 35	11 36	11 50	0.3
		E	11 28 45	11 30 06	...	11 33 30	11 36	11 45	0.1
316	4	N	...	...	23 36 ..	23 47 05	23 58	...	0.1
		E	...	...	23 35 20	23 40 04	23 53	...	0.1
317	Oct. 3	N	17 23 50	...	17 24 38	17 25 00	17 31	17 40	5.0
		E	17 23 50	...	17 24 38	...	17 32	18 18	69+
318	Nov. 18	N	9 43 12	9 47 27	...	9 53 15	9 55	10 10	0.5
		E	9 43 01	9 47 21	9 51 52	9 53 01	9 58	10 10	0.1

REMARKS.

- No. 291.—Phases indistinct. There is some indication of the beginning of a second earthquake toward the end.
 No. 292.—Beginning and end obscured by wind tremors.
 No. 294.—End obscured by wind tremors.
 No. 297.—Felt in Vieques.
 No. 300.—Local shock, felt distinctly in Vieques.
 No. 302.—Stylus went off the paper at maximum.
 No. 303.—On N the maximum amplitude (2.0 mm) occurred at 4:26:13 during second P. T.
 No. 304.—Nothing on E. Maximum on N occurred at beginning of second P. T.
 No. 305.—No distinct phases; time of beginning may be second P. T.
 No. 311.—The actual maximum on N (0.9 mm) occurred at 13:31:03, during second P. T.
 No. 313.—Amplitudes of 1.2 mm on N and 0.5 mm on E occurred just after the beginning of second P. T.
 No. 316.—Only a few long waves.
 No. 317.—E stylus was off the paper from 17:27.0 to 17:30.5. Martinique earthquake.

MAGNETIC STORMS.

Magnetic disturbances of considerable magnitude were recorded on the days tabulated below. Where a storm began abruptly the time of beginning is given to the nearest minute.

On the succeeding sheets will be found reproductions of the magnetograms showing the principal magnetic storms, reduced to three-fourths the original size. A storm selected for reproduction is indicated in the table by an asterisk after the date. An upward motion of the curves corresponds to increasing west declination, increasing H , and increasing Z . For convenience in comparing with similar reproductions for other observatories, the time scale has been marked for Greenwich mean time.

Principal magnetic disturbances.

Date	L. M. T. of beginning		Duration in hours	Relative magnitude	Date	L. M. T. of beginning		Duration in hours	Relative magnitude
1913.					1914.				
Jan.	h	m			Feb.	h	m		
17	20		25	1	28	13		26	1
29	19	02	20	1	Mar.	5	20	57	1
Feb.	1		46	1	17	14		11	1
24	21		52	1	31	21		23	1
Mar.	14*	0 04	98	2	Apr.	5*	19	75	3
29	19		54	1	15	19		30	1
Apr.	8*	15 32	106	2	May	15	0	32	1
14	21		72	1	16	17		31	2
May	4	1	96	2	26	2		24	1
June	1	0	94	1	31	1		45	2
28	13		39	1	June	19	14	24	1
July	12	3	46	1	24*	21 41		136	2
24	10		63	1	July	4*	21 05	53	2
Aug.	8	20	83	1	24	16		66	1
Sept.	5*	17	135	2	23*	17		151	2
22	3		30	1	Aug.	18	17	48	1
Oct.	4*	17	155	2	23	0		20	1
18	3 16		67	1	28	16		64	1
Nov.	1	20	38	1	Sept.	17	19	19	1
6	18		56	1	22	17		40	1
27	8		60	1	27*	0		72	1
Dec.	4	5	24	1	30	17		31	1
24	21		33	1	Oct.	27*	17	46	2
1914.					Nov.	3	0	48	1
Jan.	4	15 42	35	1	10	13		59	1
21	13		35	1	26*	13 22		21	1
					Dec.	26	20	38	1

Serial No. 90

DEPARTMENT OF COMMERCE
U. S. COAST AND GEODETIC SURVEY

E. LESTER JONES, SUPERINTENDENT

RESULTS OF OBSERVATIONS MADE AT THE UNITED
STATES COAST AND GEODETIC SURVEY MAGNETIC
OBSERVATORY AT VIEQUES, P. R.
1915 AND 1916

BY

DANIEL L. HAZARD
Chief, Division of Terrestrial Magnetism



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CONTENTS.

	Page.
Introduction.....	5
Instruments.....	6
Constants of the magnetograph.....	6
Absolute observations and base-line values.....	8
Diurnal variation.....	12
Summaries of monthly and annual means.....	25
Hourly values of declination.....	26
Hourly values of horizontal intensity.....	50
Hourly values of vertical intensity.....	74
Earthquakes.....	98
Magnetic storms.....	100

ILLUSTRATIONS.

Figs. 1-21. Reproductions of magnetograms showing principal magnetic storms.....	100
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EARTHQUAKES.

A Bosch-Omori seismograph has been in operation since September, 1903. It consists of two pendulums, one recording north-south motion (N) and the other recording east-west motion (E). In the following tables the times are Greenwich mean time counted from midnight.

Period of pendulums:

N, 21.1 sec.; E, 21.4 sec.; January, 1915, to October, 1916.

N, 19.5 sec.; E, 18.0 sec.; November and December, 1916.

Magnification: 10.

Steady mass: 10-12 kg.

The nomenclature of the International Seismological Association has been used to designate the different phases:

P=Beginning of first preliminary tremors.

S=Beginning of second preliminary tremors.

L=Beginning of long waves of principal portion.

M=Time of greatest amplitude of motion.

C=End of principal portion.

F=End of visible record.

A=Maximum amplitude or one-half the maximum range. The quantities given indicate the actual movement of the stylus as measured on the seismogram.

Register of earthquakes.

No.	Date	Component	P	S	L	M	C	F	A
			<i>h m s</i>	<i>h m s</i>	<i>h m s</i>	<i>h m s</i>	<i>h m</i>	<i>h m</i>	<i>mm.</i>
319	1915 June 6	N	21 37 16	21 42 03	21 45 05	21 46 14	21 55	22 40	1.8
		E	21 37 38	21 41 54	21 44 54	21 45 58	21 57	22 42	3.5
320	29	N	...	...	0 35 37	0 35 40	0 36	...	0.1
		E	...	...	0 35 37	0 35 43	0 36	...	0.1
321	July 31	N	...	...	2 22 24	2 29 10	2 38	...	0.5
		E	...	...	2 20 ..	2 26 10	2 33	...	0.1
322	Sept. 7	N	...	...	...	...	...	...	...
		E	1 25 57	1 27 57	1 30 15	1 34 53	1 50	2 18	75+
323	Oct. 3	N	7 02 10	7 09 04	7 16 28	7 22 43	7 35	8 10	7.5
		E	7 02 04	7 09 20	7 16 25	7 20 00	7 34	8 10	4.7
324	11	N	19 34 04	...	19 34 43	19 35 12	19 39	19 47	24.0
		E	19 34 02	...	19 34 52	19 35 16	19 39	19 57	19.0
325	Nov. 21	N	...	...	0 38 40	0 45 00	0 58	...	0.1
		E	0 29 12	0 33 06	0 37 56	0 48 04	0 58	1 17	0.2
326	Dec. 12	N	...	...	21 11 04	21 13 52	21 21	...	0.4
		E	...	...	21 10 50	21 13 54	21 20	...	0.2
	1916								
327	Jan. 1	N	...	...	14 28 02	14 37 58	14 48	15 19	1.5
		E	...	...	14 27 36	14 40 22	14 51	15 15	0.8
328	7	N	...	...	15 04 36	15 04 42	15 05	...	1.0
		E	...	...	15 04 36	15 04 39	15 05	...	0.8
329	13	N	...	...	9 25 ..	9 45 40	10 24	...	0.8
		E	...	...	9 04 ..	9 55 ..	10 30	...	0.2
330	Feb. 6	N	...	...	22 41 55	22 44 20	...	23 05	0.3
		E	...	...	22 36 28	22 45 00	...	23 08	0.1
331	27	N	20 26 12	20 30 20	20 33 42	20 38 30	20 45	21 07	24.0
		E	20 26 11	20 30 35	20 33 37	20 36 10	20 46	21 23	9.0
332	Apr. 18	N	4 13 07	4 23 37	...	4 24 00	...	...	1.1
		E	...	4 24 27	...	4 25 05	...	5 10	1.2
333	24	E	4 27 23	...	4 27 55	4 28 15	4 35	4 49	13.0
334	24	E	8 06 29	8 10 31	8 11 53	8 13 01	8 23	8 40	13.4
335	26	N	2 26 38	...	2 30 24	2 30 40	2 36	2 50	2.5
		E	2 26 18	...	2 29 44	2 30 30	2 35	2 50	2.0
336	May 10	N	21 41 11	21 44 43	...	21 53 30	...	22 07	0.1
		E	21 41 17	21 44 49	21 48 33	21 49 20	...	22 04	0.1
337	13	N	5 23 30	...	...	5 24 10	...	5 29	1.2
		E	5 23 42	...	5 24 02	5 24 08	...	5 31	3.0
338	13	N	6 34 32	...	...	6 35 02	...	6 39	0.5
		E	6 34 36	...	...	6 35 04	...	6 40	0.7
339	June 21	N	21 40 17	21 46 09	21 49 34	21 49 58	21 53	...	0.2
		E	...	21 45 58	21 48 52	21 49 44	21 57	...	0.5

Register of earthquakes—Continued.

No.	Date.	Component.	P	S	L	M	C	F	A
	1916		<i>h m s</i>	<i>h m s</i>	<i>h m s</i>	<i>h m s</i>	<i>h m</i>	<i>h m</i>	<i>mm</i>
340	June 30	N	.. .. .	.. .. .	3 09 26	3 09 54	3 14	3 24	1.0
		E	.. .. .	3 05 42	3 09 54	3 10 16	3 13	3 28	1.2
341	Aug. 11	N	8 18 58	.. .. .	.. .. .	.. .. .	.. .. .	8 19	.. .. .
		E	8 18 56	.. .. .	.. .. .	.. .. .	.. .. .	8 19	.. .. .
342	28	N	.. .. .	.. .. .	7 46 53	.. .. .	7 50	.. .. .	0.1
		E	.. .. .	.. .. .	7 46 43	7 48 10	7 59	.. .. .	0.1
343	Sept. 23	N	5 47 58	5 52 31	5 54 47	5 58 50	6 05	6 18	0.2
		E	5 48 02	5 52 20	5 54 ..	5 57 30	6 05	6 17	0.3
344	Oct. 3	N	1 33 08	.. .. .	.. .. .	1 50 40	.. .. .	2 17	0.2
		E	1 33 10	.. .. .	.. .. .	1 48 30	.. .. .	2 28	0.2
345	Nov. 12	N	.. .. .	.. .. .	13 10 03	13 10 08	13 11	13 14	4.0
		E	.. .. .	.. .. .	13 10 03	13 10 08	13 11	13 14	5.5
346	25	N	13 14 38	.. .. .	13 14 51	13 15 08	.. .. .	13 18	0.4
		E	13 14 38	.. .. .	13 14 51	13 15 09	.. .. .	13 20	0.3
347	25	N	13 46 30	.. .. .	13 46 44	13 47 02	.. .. .	13 50	0.4
		E	13 46 31	.. .. .	13 46 45	13 46 57	.. .. .	13 50	0.4
348	30	N	.. .. .	.. .. .	3 19 03	3 20 15	3 25	3 37	9.0
		E	3 18 46	.. .. .	3 19 03	3 20 52	3 26	3 46	3.0
349	Dec. 23	N	9 32 06	9 38 10	9 43 ..	9 55 00	10 00	10 25	1.2
		E	9 32 20	9 38 08	.. .. .	.. .. .	.. .. .	.. .. .	.. .. .

REMARKS.

- No. 320.—Felt by persons in Vieques.
- No. 321.—Only a few long waves.
- No. 322.—N not recording. Stylus passed off the paper on E.
- No. 324.—Felt on the island of Porto Rico.
- No. 326.—Only a few long waves.
- No. 328.—Felt in Vieques.
- No. 333.—Felt in Vieques and San Domingo.
- Nos. 333 and 334.—Record of N accidentally burned.
- No. 335.—Time of phases uncertain on account of time-marking clock being out of adjustment.
- Nos. 337 and 338.—Felt in San Juan.
- No. 339.—End uncertain on account of wind tremors.
- No. 340.—Beginning and end uncertain on N.
- No. 341.—Local. Felt in Vieques. Vertical force variometer disturbed. Waves of very short period and small amplitude.
- No. 342.—Barely perceptible on N.
- No. 344.—Phases uncertain.
- No. 345.—Local. Felt in Vieques.
- No. 349.—No long waves on E.

Serial No. 168

DEPARTMENT OF COMMERCE

U. S. COAST AND GEODETIC SURVEY

E. LESTER JONES, Director

**RESULTS OF OBSERVATIONS MADE AT THE UNITED STATES
COAST AND GEODETIC SURVEY MAGNETIC OBSERVATORY
AT VIEQUES, P. R., 1917 AND 1918**

BY

DANIEL L. HAZARD

Assistant Chief, Division of Terrestrial Magnetism



PRICE, 25 CENTS

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**WASHINGTON
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1922**

CONTENTS.

	Page.
Introduction.....	3
Instruments.....	4
Constants of the magnetograph.....	5
Absolute observations and base-line values.....	7
Diurnal variation.....	12
Summaries of monthly and annual means.....	26
Hourly values of declination.....	28
Hourly values of horizontal intensity.....	52
Hourly values of vertical intensity.....	76
Earthquakes.....	100
Magnetic storms.....	104

ILLUSTRATIONS.

Figs. 1-23. Reproductions of magnetograms showing principal magnetic storms	104
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EARTHQUAKES.

A Bosch-Omori seismograph has been in operation since September, 1903. It consists of two pendulums, one recording north-south motion (N) and the other recording east-west motion (E). In the following tables the times are Greenwich mean time counted from midnight.

Period of pendulums—N, 18 to 20 sec.; E, 17 to 18 sec. Magnification, 10. Steady mass, 10 to 12 kg.

Register of earthquakes.

No.	Date.	Component.	P	S	L	M	C	F	A
			<i>h. m. s.</i>	<i>h. m. s.</i>	<i>h. m. s.</i>	<i>h. m. s.</i>	<i>h. m.</i>	<i>h. m.</i>	<i>mm.</i>
350	1917. Jan. 6	N	.. .. .	.. .. .	21 42 13	21 42 35	21 46	.. .. .	0.2
		E	.. .. .	.. .. .	21 42 03	21 42 28	21 46	.. .. .	0.4
351	Jan. 30	N	.. .. .	3 10 ..	3 17 04	3 46 45	3 52	5 11	7.5
		E	.. .. .	3 10 ..	3 16 45	3 38 00	3 51	5 05	6.0
352	Feb. 9	N	7 15 16	.. .. .	.. .. .	7 15 30	.. .. .	7 18	0.2
		E	7 15 16	.. .. .	.. .. .	7 15 30	.. .. .	7 17	0.2
353	Feb. 12	N	.. .. .	.. .. .	20 06 28	20 06 40	.. .. .	20 10	0.3
		E	.. .. .	.. .. .	20 06 31	20 06 42	.. .. .	20 09	0.4
354	Feb. 15	N	0 57 ..	.. .. .	.. .. .	1 19 30	.. .. .	1 32	0.2
		E	0 57 ..	.. .. .	.. .. .	1 18 00	.. .. .	1 38	0.1
355	Feb. 20	N	19 32 40	.. .. .	19 35 25	.. .. .	.. .. .	21 45	65+
		E	19 32 35	.. .. .	19 35 29	19 38 40	19 42	21 35	33.8
356	Mar. 6	N	.. .. .	.. .. .	3 20 24	3 23 58	.. .. .	4 13	0.3
		E	3 12 36	.. .. .	3 20 34	3 24 26	.. .. .	4 13	0.2
357	Mar. 29	N	2 07 05	2 11 50	2 16 00	2 21 30	.. .. .	2 51	0.3
358	May 1	N	18 46 43	18 56 27	19 22 27	19 25 27	.. .. .	.. .. .	2.7
		E	18 37 35	18 56 25	19 21 50	19 22 55	.. .. .	.. .. .	1.3
359	May 9	N	16 35 ..	.. .. .	.. .. .	17 12 30	.. .. .	18 08	0.3
		E	9 09 10	.. .. .	.. .. .	9 33 45	9 42	10 30	1.8
360	May 31	N	9 09 10	.. .. .	.. .. .	9 33 40	9 39	10 25	0.3
		E	9 09 10	.. .. .	.. .. .	9 33 40	9 39	10 25	0.3
361	June 8	N	.. .. .	0 59 18	1 01 05	1 08 00	1 14	2 05	1.1
		E	0 56 51	0 59 18	1 01 05	1 05 00	1 11	1 57	1.0
362	June 13	N	7 09 44	7 18 48	7 39 ..	7 40 ..	8 00	9 03	0.1
		E	7 07 15	7 18 36	7 38 ..	7 40 ..	8 00	9 03	0.2
363	June 26	N	6 09 36	6 16 54	6 40 48	6 43 28	.. .. .	.. .. .	0.7
		E	6 09 01	6 15 11	6 40 45	6 43 00	7 04	9 04	4.0
364	June 30	N	17 54 30	17 57 38	18 00 13	18 06 31	.. .. .	18 26	0.1
		E	17 54 33	17 57 37	18 00 15	18 03 20	.. .. .	18 20	0.1
365	July 13	N	5 14 25	5 14 48	5 15 20	5 15 43	5 17	5 26	1.0
		E	5	5 14 55	5 15 20	5 15 35	5 17	5 26	0.9
366	July 27	N	1 02 02	1	1 02 26	.. .. .	1 10	1 45	68+
		E	1 02 02	.. .. .	1 02 20	.. .. .	1 11	2 40	70+
367	July 27	N	16 16 02	16 16 38	16 16 54	16 17 08	16 20	16 26	7.2
		E	16 16 04	16 16 38	16 16 54	16 17 26	16 21	16 ..	9.2
368	July 29	N	6 10 52	.. .. .	6 11 02	6 11 10	6 12	6 17	0.5
		E	6 10 50	.. .. .	6 11 06	6 11 25	6 12	6 18	0.7
369	Aug. 7	N	11 27 53	.. .. .	11 28 40	11 28 50	.. .. .	11 35	0.2
		E	11 28 15	.. .. .	11 28 40	11 28 55	.. .. .	11 34	0.2
370	Aug. 9	N	16 15 26	16	16 16 25	16 16 50	16 20	16 26	0.4
		E	16 15 31	16	16 16 35	16 16 40	16 20	16 26	0.5
371	Aug. 30	N	.. .. .	.. .. .	3 33 ..	3 35 20	3 40	3 52	0.2
		E	3 28 18	.. .. .	3 33 33	3 34 24	3 41	3 52	0.7
372	Aug. 31	N	11 40 17	11 43 42	11 45 23	11 48 10	11 53	.. .. .	30.9
		E	11 40 23	.. .. .	11 44 15	11 49 55	12 00	.. .. .	35.2
373	Oct. 19	N	16 48 36	.. .. .	16 53 00	16 56 32	.. .. .	17 07	0.1
		E	16 47 50	.. .. .	16 52 43	16 55 32	.. .. .	17 12	0.2
374	Oct. 19	N	16 28 ..	16 39 ..	16 48 ..	16 57 ..	17 00	17 06	0.2
		E	16 29 ..	16 38 ..	16 43 ..	16 55 30	17 02	17 14	0.4
375	Oct. 22	N	7 24 12	.. .. .	7 27 56	7 28 30	.. .. .	7 33	0.1
		E	7 24 20	.. .. .	7 27 52	7 28 16	.. .. .	7 50	0.3
376	Oct. 22	N	.. .. .	.. .. .	.. .. .	7 28 25	.. .. .	7 ..	0.1
		E	7 20 ..	7 24 15	7 28 00	7 28 35	7 37	7 50	0.4
377	Nov. 16	N	3 48 ..	.. .. .	4 17 ..	4 19 30	4 38	5 01	0.4
		E	.. .. .	.. .. .	4 15 ..	4 18 30	4 38	4 55	0.6
378	Dec. 21	E	.. .. .	.. .. .	18 24 55	18 36 ..	18 48	19 05	0.4
379	Dec. 29	N	22 57 20	.. .. .	23 02 00	.. .. .	.. .. .	.. .. .	.. .. .
		E	22 57 05	.. .. .	23 02 07	23 14 40	23 17	23 56	0.3

Register of earthquakes—Continued.

No.	Date.	Com- ponent.	P	S	L	M	C	F	A
			<i>h. m. s.</i>	<i>h. m. s.</i>	<i>h. m. s.</i>	<i>h. m. s.</i>	<i>h. m.</i>	<i>h. m.</i>	<i>mm.</i>
380	1918. Jan. 4	N	.. .. .	.. .. .	4 42 16	4 48 05	4 51	4 57	0.2
		E	4 36 53	.. .. .	4 42 21	4 48 50	4 54	5 03	0.6
381	Jan. 16	N	.. .. .	.. .. .	13 33 ..	13 35 20	.. .. .	13 47	0.1
		E	.. .. .	.. .. .	13 33 ..	13 37 15	.. .. .	13 57	0.2
382	Jan. 25	N	1 25 35	1 29 35	1 32 20	1 36 15	1 38	1 57	0.2
		E	1 25 20	.. .. .	1 32 15	1 35 20	1 42	1 55	0.5
383	Feb. 24	N	.. .. .	.. .. .	23 02 25	23 06 50	23 07	23 17	0.3
		E	.. .. .	.. .. .	23 03 50	23 05 20	23 07	23 16	0.1
384	Mar. 13	N	14 49 55	.. .. .	.. .. .	14 50 43	.. .. .	14 54	0.1
		E	14 49 55	.. .. .	.. .. .	14 50 43	.. .. .	14 54	0.1
385	Mar. 21	N	22 43 12	.. .. .	23 00 40	23 03 57	23 12	23 50	0.4
		E	22 41 17	.. .. .	23 01 20	23 09 06	23 12	23 50	0.4
386	Apr. 22	N	4 15 50	.. .. .	.. .. .	4 15 57	.. .. .	4 21	0.4
		E	4 15 52	.. .. .	.. .. .	4 16 02	.. .. .	4 21	0.4
387	May 20	N	14 42 31	14 47 38	14 49 37	14 49 57	14 57	15 33	1.8
		E	14 42 30	14 47 30	14 49 16	14 52 26	14 55	15 22	3.3
388	May 20	N	18 05 55	.. .. .	18 14 ..	.. .. .	.. .. .	18 35	0.1
		E	.. .. .	.. .. .	18 13 30	18 14 42	.. .. .	18 35	0.2
389	May 25	N	19 38 54	.. .. .	19 46 25	.. .. .	.. .. .	20 00	....
		E	.. .. .	.. .. .	19 46 21	.. .. .	.. .. .	20 00	....
390	June 7	N	.. .. .	.. .. .	.. .. .	.. .. .	.. .. .	.. .. .	....
		E	.. .. .	.. .. .	21 50 35	21 51 20	21 52	.. .. .	0.1
391	June 11	N	.. .. .	.. .. .	12 39 03	12 39 17	.. .. .	12 50	0.9
		E	.. .. .	.. .. .	12 39 03	12 39 41	.. .. .	12 50	1.7
392	June 22	N	22 10 17	.. .. .	.. .. .	.. .. .	.. .. .	22 25	0.1
		E	22 10 28	.. .. .	.. .. .	.. .. .	.. .. .	22 27	0.1
393	July 3	N	7 11 59	.. .. .	.. .. .	8 42 00	.. .. .	9 07	0.1
		E	7 12 21	.. .. .	8 33 48	8 42 16	8 48	9 04	0.3
394	July 8	N	10 45 01	.. .. .	.. .. .	.. .. .	.. .. .	10 52	....
		E	10 45 12	.. .. .	.. .. .	.. .. .	.. .. .	10 52	....
395	July 31	N	14 41 38	.. .. .	.. .. .	14 52 53	.. .. .	15 02	0.1
		E	14 41 26	14 46 09	14 48 06	14 54 10	14 57	15 02	0.2
396	Aug. 8	N	.. .. .	.. .. .	10 59 ..	11 03 ..	11 12	.. .. .	0.1
397	Aug. 15	N	12 39 05	12 45 28	13 33 00	13 38 48	13 51	14 44	0.6
		E	12 39 03	12 45 40	13 22 15	13 08 35	13 51	14 46	1.2
398	Aug. 23	N	.. .. .	.. .. .	7 44 ..	7 52 ..	7 54	.. .. .	0.1
		E	.. .. .	.. .. .	7 44 ..	7 50 ..	7 55	.. .. .	0.1
399	Sept. 7	N	17 35 29	.. .. .	18 07 38	18 25 16	18 39	20 28	4.0
		E	17 35 50	17 43 14	18 13 ..	18 32 14	18 37	20 19	4.8
400	Oct. 11	N	14 15 06	.. .. .	14 15 12	.. .. .	.. .. .	14 27	16 18
		E	14 15 08	.. .. .	14 15 08	.. .. .	14 27	16 32	....
401	Oct. 11	N	15 50 51	.. .. .	15 51 20	15 51 34	.. .. .	15 56	0.6
		E	15 50 54	.. .. .	.. .. .	15 51 54	.. .. .	15 55	0.4
402	Oct. 11	N	16 02 27	.. .. .	16 02 51	16 03 03	.. .. .	16 10	1.8
		E	16 02 29	.. .. .	16 02 28	16 03 13	.. .. .	16 10	1.7
403	Oct. 11	N	17 04 18	.. .. .	17 04 36	17 05 13	.. .. .	17 33	32.4
		E	17 04 16	.. .. .	17 04 26	17 06 38	.. .. .	17 33	12.5
404	Oct. 11	N	.. .. .	.. .. .	17 18 54	.. .. .	.. .. .	17 24	0.2
		E	17 18 28	.. .. .	.. .. .	17 19 28	.. .. .	17 23	0.2
405	Oct. 11	N	17 24 33	.. .. .	.. .. .	.. .. .	.. .. .	17 30	0.2
		E	17 24 20	.. .. .	.. .. .	.. .. .	.. .. .	17 28	0.2
406	Oct. 11	N	18 26 52	.. .. .	.. .. .	18 27 02	.. .. .	18 31	0.3
		E	18 26 50	.. .. .	.. .. .	.. .. .	.. .. .	18 31	0.1
407	Oct. 11	N	19 09 01	.. .. .	19 10 03	19 10 20	.. .. .	19 18	0.4
		E	19 08 58	.. .. .	19 10 06	19 10 26	.. .. .	19 18	0.4
408	Oct. 11	N	20 07 06	.. .. .	.. .. .	20 07 35	.. .. .	20 17	1.7
		E	20 06 53	.. .. .	.. .. .	20 07 53	.. .. .	20 17	0.6
409	Oct. 11	N	21 51 55	.. .. .	.. .. .	.. .. .	.. .. .	21 57	0.1
		E	21 51 47	.. .. .	.. .. .	.. .. .	.. .. .	21 56	0.1
410	Oct. 11	N	23 32 15	.. .. .	.. .. .	.. .. .	.. .. .	23 39	0.2
		E	23 32 11	.. .. .	.. .. .	.. .. .	.. .. .	23 38	0.2
411	Oct. 11	N	23 48 57	.. .. .	.. .. .	.. .. .	.. .. .	23 51	0.1
		E	23 49 00	.. .. .	.. .. .	.. .. .	.. .. .	23 51	0.1
412	Oct. 11	N	23 58 42	.. .. .	.. .. .	.. .. .	.. .. .	24 00	0.2
		E	23 58 46	.. .. .	.. .. .	.. .. .	.. .. .	24 00	0.1
413	Oct. 12	N	0 00 12	.. .. .	.. .. .	.. .. .	.. .. .	0 09	0.4
		E	0 00 00	.. .. .	.. .. .	0 04 14	.. .. .	0 09	0.4
414	Oct. 12	N	.. .. .	.. .. .	0 16 37	.. .. .	.. .. .	0 26	1.2
		E	0 16 10	.. .. .	0 16 38	0 16 56	.. .. .	0 26	0.7
415	Oct. 12	N	.. .. .	.. .. .	0 28 45	.. .. .	.. .. .	0 34	0.2
		E	0 28 18	.. .. .	0 28 42	0 29 02	.. .. .	0 33	0.3

Register of earthquakes—Continued.

No.	Date.	Component.	P	S	L	M	C	F	A
			<i>h. m. s.</i>	<i>h. m. s.</i>	<i>h. m. s.</i>	<i>h. m. s.</i>	<i>h. m.</i>	<i>h. m.</i>	<i>mm.</i>
416	1918. Oct. 12	N	0 33 16	...	0 33 40	...	...	0 45	0.3
		E	0 33 16	...	0 33 46	...	...	0 44	0.2
417	Oct. 12	N	1 03 21	...	...	...	...	1 06	0.1
		E	1 03 14	...	1 03 34	1 03 56	...	1 10	0.2
418	Oct. 12	N	4 31 49	...	...	...	...	4 33	0.1
		E	4 31 43	...	...	...	...	4 33	0.1
419	Oct. 12	N	4 33 43	...	4 34 12	...	...	4 44	0.2
		E	4 33 43	...	4 34 07	4 34 43	...	4 41	0.2
420	Oct. 12	N	6 58 30	...	...	...	...	7 01	0.2
		E	6 58 27	...	...	...	...	7 02	0.2
421	Oct. 12	N	8 09 42	...	8 10 04	...	...	8 14	0.2
		E	8 09 42	...	8 10 02	8 10 24	...	8 14	0.2
422	Oct. 12	N	8 19 39	...	8 20 02	8 20 24	8 23	8 41	5.5
		E	8 19 34	...	8 19 52	8 20 40	8 23	8 41	3.5
423	Oct. 13	N	4 52 19	...	4 52 39	4 54 17	...	5 04	1.9
		E	4 52 11	...	4 52 14	4 53 00	...	5 04	0.9
424	Oct. 13	N	18 19 38	...	...	...	...	18 25	0.2
		E	18 19 45	...	...	...	...	18 25	0.1
425	Oct. 13	N	20 23 47	...	20 24 11	20 25 20	...	20 30	0.4
		E	20 23 56	...	20 24 14	20 24 43	...	20 32	0.3
426	Oct. 14	N	0 25 18	...	0 25 42	0 26 05	0 28	0 40	9.0
		E	0 25 18	...	...	0 26 00	0 28	0 40	2.0
427	Oct. 14	N	2 16 20	...	2 16 48	2 18 00	...	2 22	0.2
		E	2 16 22	...	2 16 42	2 17 04	...	2 24	0.2
428	Oct. 14	N	4 53 27	4 53 47	...	...	...	5 03	0.3
		E	4 53 25	4 53 48	...	...	...	5 01	0.4
429	Oct. 15	N	0 13 54	...	0 14 13	...	...	0 24	0.2
		E	0 13 54	...	0 14 14	...	...	0 22	0.2
430	Oct. 15	N	3 15 46	3 16 13	3 16 26	3 17 25	...	3 29	0.7
		E	3 16 02	3 16 15	3 16 36	3 16 55	...	3 28	0.7
431	Oct. 16	N	19 20 25	...	19 20 47	...	...	19 31	0.2
		E	19 20 17	...	19 20 45	...	...	19 31	0.2
432	Oct. 17	N	8 19 40	...	8 20 00	8 20 44	...	8 26	0.4
		E	8 19 39	...	8 19 58	8 20 16	...	8 28	0.4
433	Oct. 17	N	21 29 29	...	...	...	...	21 36	0.2
		E	21 29 35	...	...	...	...	21 36	0.2
434	Oct. 18	N	19 22 35	...	19 23 19	...	...	19 29	0.2
		E	19 22 53	...	...	...	...	19 29	0.2
435	Oct. 18	N	21 34 17	...	21 34 35	21 35 51	21 37	21 58	3.7
		E	21 34 13	...	21 34 42	21 35 00	21 37	21 58	6.2
436	Oct. 19	N	3 28 12	...	3 35 28	3 37 13	3 39	3 54	0.2
		E	3 28 59	...	3 35 29	3 40 00	3 42	3 56	0.3
437	Oct. 19	N	7 05 48	...	7 06 24	7 07 14	...	7 14	0.2
		E	7 05 57	...	7 06 37	7 06 41	...	7 18	0.3
438	Oct. 21	N	6 44 48	...	...	...	...	6 49	0.2
		E	6 44 50	...	...	...	...	6 48	0.2
439	Oct. 21	N	6 49 12	...	...	...	...	6 55	0.1
		E	6 49 12	...	...	...	...	6 53	0.1
440	Oct. 21	N	13 08 59	...	...	...	...	13 11	0.1
441	Oct. 23	N	14 31 09	...	...	...	...	14 38	0.1
		E	14 31 12	...	...	...	...	14 38	0.1
442	Oct. 24	N	22 59 38	...	...	...	...	23 04	0.1
		E	22 59 37	...	...	...	...	23 04	0.1
443	Oct. 25	N	3 43 26	...	3 43 29	...	...	4 38	...
		E	3 43 29	...	3 43 29	3 44 05	3 48	4 55	70+
444	Nov. 7	N	9 33 56	...	...	9 34 14	...	9 38	0.1
		E	9 33 59	...	...	9 34 23	...	9 38	0.2
445	Nov. 8	N	4 56 58	5 12 34	5 35 26	5 46 48	5 52	6 01	0.7
		E	4 57 00	5 12 37	5 35 30	5 36 08	5 54	6 15	0.4
446	Nov. 12	N	12 02 27	...	12 02 52	12 03 05	...	12 12	2.0
		E	12 02 24	...	12 02 48	12 03 04	...	12 09	0.8
447	Nov. 12	N	21 45 13	...	21 45 34	21 46 01	21 49	22 19	33.4
		E	21 45 15	...	21 45 33	21 46 03	21 49	22 17	63.8
448	Nov. 18	N	19 01 50	...	19 58 00	20 05 12	20 08	20 34	0.1
		E	19 02 25	...	19 47 10	20 03 08	20 08	20 42	0.3
449	Nov. 21	N	7 21 44	...	...	7 22 20	...	7 28	0.2
		E	7 21 57	...	...	7 22 15	...	7 24	0.3
450	Dec. 2	N	9 52 50	9 56 52	...	9 58 14	10 00	10 50	3.0
		E	9 52 44	9 56 52	...	9 57 50	10 00	10 50	0.2

Register of earthquakes—Continued.

No.	Date.	Com- ponent.	P	S	L	M	C	F	A
	1918.		<i>h. m. s.</i>	<i>h. m. s.</i>	<i>h. m. s.</i>	<i>h. m. s.</i>	<i>h. m.</i>	<i>h. m.</i>	<i>mm.</i>
451	Dec. 4	N	11 55 59	12 03 52	12 12 20	12 19 01	12 25	12 57	12.0
		E	11 56 12	12 10 30	12 14 30	12 14 30	12 25	14 02	2.4
452	Dec. 6	N	8 51 32	8 59 08	9 09 50	9 16 04	9 20	9 34	0.2
		E	.. .. .	8 59 02	9 09 11	9 16 31	9 20	9 32	0.2
453	Dec. 21	N	.. .. .	.. .. .	9 29 54	9 35 03	.. ..	9 42	0.1
		E	.. .. .	.. .. .	9 30 25	9 37 09	.. ..	9 50	0.1
454	Dec. 23	N	19 49 40	19 55 50	20 00 20	.. .. .	.. ..	20 05	....
		E	19 49 31	.. .. .	20 00 11	20 00 25	.. ..	20 08	0.1

REMARKS.

354. Phases not well defined.
355. The stylus of N was off the sheet from 20:39:40 to 20:50:30. The maximum tabulated is the distance to the edge of the paper.
356. Preliminary phases uncertain.
357. Barely perceptible on E; no distinct phases.
- 358 and 362. Phases not well defined.
363. Beginning uncertain; N paper so thinly smoked that part of the record could not be seen.
366. Both needles off sheet from 1^h 03^m to 1^h 06^m.
369. Initial phases disturbed by wind tremors.
372. F lost on account of removing paper from cylinders at that time.
376. Very faint on N.
378. No record on N.
379. N not recording properly.
381. Unimportant; phases not distinct.
- 388, 389. No well-defined phases.
390. Only a few long waves on E; nothing on N.
391. Began while the paper was being changed; new sheets started at 12:39:03.
393. This may be the record of two earthquakes.
394. P is the only distinct phase.
397. S and L uncertain; a phase at 13:08:06 on N and 13:07:54 on E may be S.
399. The phase tabulated as P may be PR₁.
400. Within 15 seconds after the beginning the pendulums swung against the stops with sufficient force to jar the stylus points from their bearings. E was replaced at 14:21 and N at 14:24. The large number of small shocks recorded during the rest of the month were of the same general character, beginning with waves of 1 to 2 seconds period and ending with waves of 4 to 6 seconds period. In a few cases there appear to be two or three longer waves of 10 to 12 seconds period, with the short period waves superimposed upon them.
- 400, 401, 402, 403, 406, 408, 414, 422, 423, 426, 435, and 443 were also recorded on the magnetograph, as well as secondary shocks at about 14:40 and 14:53.5 on October 11.
428. Possibly two or three separate shocks.
443. Stylus of N jarred from bearings at 3:42:50 and replaced at 3:53.
445. Phases doubtful; the one recorded as P may be PR and S may be SR. On E there are two long waves, period 28 seconds, beginning at 5:22:10, and four waves period, about 40 seconds, beginning at 5:26:30.
- 446, 447, 449. Probably of same origin as those in October. No. 447 was felt at Vieques.
451. Phases uncertain and difficult to correlate with other stations; one at 12:06:56 on N and 12:06:40 on E; possibly two earthquakes.
452. P and S very faint; L uncertain.

Serial No. 239

DEPARTMENT OF COMMERCE
U. S. COAST AND GEODETIC SURVEY
E. LESTER JONES, DIRECTOR

**RESULTS OF OBSERVATIONS MADE AT THE UNITED
STATES COAST AND GEODETIC SURVEY MAGNETIC
OBSERVATORY AT VIEQUES, P. R.,
1919 AND 1920**

BY

DANIEL L. HAZARD

Assistant Chief, Division of Terrestrial Magnetism



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1923

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CONTENTS.

	Page.
Introduction.....	1
Instruments.....	2
Constants of the magnetograph.....	2
Absolute observations and base-line values.....	4
Diurnal variation.....	9
Summaries of monthly and annual means.....	24
Hourly values of declination.....	25, 61
Hourly values of horizontal intensity.....	37, 73
Hourly values of vertical intensity.....	49, 85
Earthquakes.....	97
Magnetic storms.....	99

ILLUSTRATIONS.

Figs. 1-20. Reproductions of magnetograms showing principal magnetic storms.

INTRODUCTION.

[Latitude 18° 08'.8 N; longitude, 65° 26'.9 W; elevation, 20 meters (65 feet)]

In February, 1903, a magnetograph was installed in a room in Fort Isabel Segunda, on Vieques Island, P. R., and variation observations were continued there until April, 1907. At that time, suitable buildings having been constructed for the observatory work, the instruments were transferred to the new site, about five-eighths of a mile (1 km.) west of the old fort. A general description of the new building will be found in the Results for 1907 and 1908. The methods of observing are explained in Directions for Magnetic Measurements by D. L. Hazard, published in 1911 (second edition in 1921).

The division of terrestrial magnetism of the U. S. Coast and Geodetic Survey, of which N. H. Heck, hydrographic and geodetic engineer, is chief, includes both the office and field work. The office computations and preparation of the results for publication were in charge of the writer, assisted by W. N. McFarland, Frank Neumann, and O. S. Hill, computers. The work of the observatory was carried on by Wallace M. Hill, magnetic observer, for all of 1919 and 1920, except for two months in 1920, when W. W. Merrymon, magnetic observer, was in charge.

Up to the end of 1914 each hourly value of declination, horizontal intensity, or vertical intensity in the monthly tabulations represented the momentary value of the quantity for the specified hour, local mean time. Beginning with 1915 the published hourly values are average values for successive periods of an hour, beginning at midnight of the specified standard meridian (sixtieth in the case of Vieques). Thus, a value in the column headed 1 represents the

EARTHQUAKES.

A Bosch-Omori seismograph has been in operation since September, 1913. It consists of two horizontal pendulums, one recording north-south motion (N) and the other recording east-west motion (E). The following tables the times are Greenwich mean time, counted from midnight.

Period of pendulums: N, 19 sec.; E, 17 sec.
 Multiplication, 10.
 Steady mass, 10 to 12 kg.

Register of earthquakes.

Date.	Component.	P.	S.	L.	M.	C.	F.	A.
		<i>h. m. s.</i>	<i>h. m. s.</i>	<i>h. m. s.</i>	<i>h. m. s.</i>	<i>h. m.</i>	<i>h. m.</i>	<i>mm.</i>
Jan. 1. 1919.	N	3 19 18	3 30 06	3 35 36	3 35 52	3 37	4 19	1.9
	E	3 19 15	3 29 19	3 35 35	3 30 05	3 40	4 30	2.0
Mar. 2.	N			4 05 32	4 08 31		4 10	.2
	E			3 59 39	4 03 30		4 10	.2
Mar. 2.	N			12 23 10	12 25 43	12 27	12 30	.6
	E	11 58 46		12 18 12	12 21 56	12 30	12 37	.7
Mar. 9.	N			3 56 56	3 57 36		4 01	.1
	E			3 49 58	3 51 50		4 00	.2
Mar. 24.	N	20 29 33			20 30 07		20 33	.2
	E	20 29 39			20 30 16		20 34	.1
Apr. 17.	N	20 59 17	21 04 26	21 06 15	21 06 45	21 17	21 29	1.0
	E	20 58 44	21 03 44	21 06 42	21 12 44	21 19	21 44	1.6
Apr. 21.	N	11 31 43	11 38 12		11 43 25		12 01	.1
	E	11 31 35	11 35 30	11 37 35	11 42 40		11 59	.1
Apr. 28.	N	6 55 32		6 58 53	7 01 48		7 11	.1
Apr. 30.	N	7 35 31		8 14 50	8 16 25	8 46	9 55	1.2
	E	7 36 31	7 46 13	8 12 27	8 31 17		10 29	1.8
May 1.	N	2 41 12					2 42	.....
	E	2 41 12					2 42	.....
May 2.	N			3 04 28			3 12	.1
May 3.	N	1 11 48	1 21 27	1 54 30	2 00 58	2 01	2 18	.3
	E	1 11 39		1 43 40	1 54 07	2 11	2 18	.2
May 6.	N	20 02 05		20 40 46	20 40 20	21 11	21 54	.6
	E	20 01 58	20 04 44	20 40 15	21 00 02	21 21	22 05	1.2
May 23.	N	3 18 10					3 44	.1
June 28.	N	1 45 39			1 40 14		1 51	1.2
	E	1 45 40			1 40 10		1 51	.8
June 29.	N	23 19 27	23 23 43	23 26 07	23 30 01	23 31	23 44	3.2
	E	23 19 12	23 23 11	23 25 26	23 29 40	23 34	23 50	1.6
July 6.	N			7 16 18	7 16 34		7 22	.1
	E	7 13 05		7 18 15			7 25	.1
July 8.	N			21 54 10	21 59 10	22 01	22 09	.2
July 11.	N	0 35 57					0 50	.....
	E	0 36 31	0 37 38	0 38 48	0 38 58	0 41	0 45	.1
July 17.	N	16 27 50		16 35 43	16 36 53		16 45	.1
July 22.	N	22 06 06					22 13	.....
	E	22 06 08		22 10 48	22 12 43	22 14	22 21	.1
Aug. 3.	N	16 38 26		16 38 46	16 38 58	16 40	16 43	.6
Aug. 9.	N	11 49 34					11 54	.2
	E	11 49 35					11 53	.2
Aug. 22.	N	8 50 57		8 51 20	8 51 28	8 55	8 59	1.3
	E	8 50 57		8 51 21	8 51 34	8 55	8 58	.9
Aug. 30.	N	6 04 48		6 05 14	6 05 38	6 07	6 14	1.3
	E	6 04 49		6 05 12	6 05 35	6 07	6 13	1.1
Sept. 5.	N	19 03 02		19 03 44	19 04 02	19 05	19 11	.8
	E	19 03 02		19 03 15	19 04 02	19 05	19 11	.8
Sept. 6.	N	9 30 15			9 31 18	9 34	10 06	18.9
	E	9 30 16			9 31 23	9 34	10 05	15.0
Sept. 11.	N	13 50 10		13 50 36	13 50 55	13 52	13 57	.6
	E	13 50 13		13 50 27	13 50 50	13 52	14 00	.9
Sept. 11.	N	14 12 00		14 12 06	14 12 46	14 14	14 19	1.3
	E	14 12 01		14 12 07	14 12 40	14 14	14 23	1.2
Sept. 13.	N	12 32 00			12 38 40		12 58	.2
Sept. 13.	N	21 49 51		21 50 22	21 50 28	21 51	21 57	.4
	E	21 49 52		21 50 09	21 50 27	21 51	21 57	.6
Sept. 25.	N	16 21 46			16 21 49		16 25	.5
	E	16 21 46			16 21 48		16 25	.3
Oct. 14.	N			17 03 17	17 05 35		17 15	.1
Nov. 6.	N	7 15 00	7 16 23	7 17 19	7 18 02	7 19	7 24	.5
	E	7 15 00		7 17 27	7 18 05	7 20	7 24	.6
Nov. 8.	N	3 45 18					3 47	.1
	E	3 44 39					3 47	.....
Nov. 22.	N	1 08 42			1 10 06		1 14	.2
	E	1 09 02			1 09 43		1 14	.2
Dec. 5.	N	0 25 35		0 33 00	0 33 30		0 35	.2
	E	0 20 59	0 24 39	0 25 53	0 25 59		0 36	.2

Register of earthquakes—Continued.

No.	Date.	Com- ponent.	P.		S.		L.		M.		C.	F.
			<i>h. m. s.</i>	<i>h. m. s.</i>	<i>h. m. s.</i>	<i>h. m. s.</i>	<i>h. m. s.</i>	<i>h. m. s.</i>	<i>h. m.</i>	<i>h. m.</i>		
	1920.											
492	Jan. 4.	N	4 28 45									4 50
		E	4 28 32				4 36 50					4 50
493	Jan. 15.	N	16 26 30			16 26 56	16 27 21	16 27 21	16 30			16 38
		E	16 26 30			16 26 51	16 27 33	16 27 33	16 28			16 38
494	Jan. 26.	N	21 23 51			21 24 23	21 24 47	21 24 47	21 26			21 34
		E	21 23 51			21 24 22	21 24 54	21 24 54	21 27			21 43
495	Jan. 28.	N	23 02 38			23 03 01	23 03 24	23 03 24	23 04			23 11
		E	23 02 37			23 03 01	23 03 29	23 03 29	23 04			23 12
496	Jan. 30.	N	18 31 32									18 38
		E	18 31 33		18 35 24	18 39 30	18 39 45	18 39 45	18 51			18 51
497	Feb. 2.	N	11 45 32					13 22 55				13 30
		E	11 45 39				12 38 15	13 10 58				13 50
498	Feb. 10.	N	22 07 48				22 08 02					23 03
		E	22 07 48				22 08 02		22 16			23 03
499	Feb. 10.	E	22 37 34				22 37 56					22 42
500	Feb. 11.	F	0 10 53					0 11 39				0 17
501	Feb. 11.	N	8 13 15			8 13 38	8 14 16	8 14 32	8 16			8 20
		E	8 13 15			8 13 38	8 14 16	8 14 16	8 17			8 22
502	Feb. 12.	N	0 26 58				0 27 34	0 28 14	0 30			0 30
		E	0 26 58			0 27 11	0 27 11	0 28 14	0 30			0 30
503	Feb. 12.	N	15 39 37					15 40 30				15 44
		E	15 39 35					15 40 30				15 44
504	Feb. 12.	N	17 49 52		17 50 08			17 50 29	17 52			18 00
		E	17 49 49		17 50 08			17 50 45	17 52			18 00
505	Feb. 12.	N	22 39 48									22 43
		E	22 39 38					22 40 10				22 42
506	Feb. 21.	N	13 54 11		13 54 27			13 54 47	13 56			14 02
		E	13 54 11		13 54 21			13 54 50	13 56			14 02
507	Mar. 20.	N	18 42 56		18 51 38	19 06 30	19 09 25	19 13 10	19 13			19 19
		E	18 44 42		18 51 36	19 03 50	19 04 54	19 16	19 16			19 52
508	Mar. 31.	N	23 13 22			23 13 45	23 14 28					23 10
		E	23 13 22			23 13 41	23 14 32					23 19
509	Apr. 12.	N	17 39 15			17 39 26			17 40			17 43
		E	17 39 18			17 39 21	17 39 47		17 49			17 43
510	Apr. 19.	N		21 18 10								21 27
		E	21 13 02	21 18 00	21 22 25	21 23 35	21 23 35	21 32	21 32			21 36
511	May 7.	F			22 37 10	22 38 50	22 46					22 50
512	May 29.	N	21 24 40									21 20
		E	21 24 33									21 28
513	June 5.	N	4 42 57			5 39 07	5 41 20	5 47	5 52			5 52
		E	5 26 10			5 40 25	5 54		5 54			6 24
514	July 7.	N	0 44 54			0 45 20	0 45 40					0 49
		E	0 44 44				0 45 45					0 50
515	Aug. 3.	N	20 12 06		20 12 17	20 21 47	20 26 25	20 29	20 26			20 36
		E	20 12 13		20 12 17	20 20 17	20 22 18	20 27	20 27			20 45
516	Aug. 7.	N	2 41 21									2 47
		E	2 41 41									2 45
517	Aug. 20.	N			16 33 09	16 42 00	16 46 50	16 52				16 56
		E										17 10
518	Sept. 8.	N	2 06 34		2 15 06							2 20
		E	2 06 52									2 29
519	Sept. 20.	N	15 01 36			15 41 12	15 42 59	15 49	15 58			16 50
		E	15 01 35			15 49 06	15 42 01	15 58				17 17
520	Sept. 24.	N	21 59 46	22 03 45	22 05 13	22 05 24	22 06	22 06	22 06			22 11
		E	21 59 16	22 03 45	22 05 13	22 05 24	22 06	22 06	22 06			22 28
521	Oct. 2.	N	15 47 48			15 47 52	15 47 53	15 48	15 48			15 53
		E	15 47 48			15 47 52	15 47 53	15 48	15 48			15 53
522	Oct. 7.	E	10 57 21	17 00 57		21 00 03						21 21
523	Oct. 8.	N	12 22 47	12 26 45		12 26 53						12 40
524	Oct. 22.	E	12 23 35	12 26 53		12 27 46						12 41
525	Oct. 27.	N	11 45 21			11 45 50	11 46 10	11 59				11 59
		E	11 45 21				11 46 21	11 59				11 59
526	Oct. 27.	N	11 54 10				11 54 57	11 58				12 08
		E	11 54 08				11 55 09	11 59				12 12
527	Oct. 28.	N	12 58 41	13 00 22	13 08 48	13 00 40						13 16
		E	12 58 41	13 05 08	13 08 48	13 00 40						13 13
528	Nov. 4.	N	2 12 38			2 13 38						2 23
		E	2 12 38			2 13 24						2 22
529	Nov. 6.	N	10 45 26			10 45 52	10 46 08	10 49	10 55			10 54
		E	10 45 24				10 46 14	10 49	10 54			10 54
530	Dec. 10.	N	4 43 27			5 00 45						5 17
		E	4 43 22	4 40 59	4 57 39	4 58 10	5 00					5 31
531	Dec. 11.	E	21 36 39			21 38 35						21 46
532	Dec. 16.	N	12 38 12	12 49 10	13 03 30	13 17 45	13 28	13 28	14 22			14 32
		E	12 36 50			12 59 40	13 16 24	13 33	14 32			14 32

Note by W. R. McCann:

The Maximum Amplitudes for Seismic Station VQS in this report are at times impossible to photocopy or scan. This is due to the fact that the bulletin was printed on very small format paper and later bound along with much larger format paper. The binding process therefore obscures the amplitude data. In some case the binding material, string, passes through the pages destroying the amplitude information. Data from the affected pages (pages 96, and 98) were written down, where possible, and are found in the table below.

Page 98, Data for 1920

VQS Amplitudes

Event Number	Maximum Amplitude (mm)
492	---
	0.1
493	1
	0.8
494	1.4?
	0.?
495	2.6
	0.2
496	---
	0.2
497	0.1
	0.?
498	85+
	84+
499	0.1
500	0.2
501	0.4
	0.3
502	3.3
	1.?
503	---
	0.1
504	1.1
	0.8?
505	---
	0.1
506	1

	0.8
507	0.3
	.4?
508	0.1
	0.1
509	---
	0.1
510	---
	.2?
511	0.3
512	0.1
	0.1
513	0.8
	0.2
514	0.2
	0.2
515	0.3
	2.5
516	0.2
	0.2
517	0.1
	0.2
518	---

519	0.6
	0.7
520	---
	0.3
521	13.5
	3
522	0.3
523	0.1
524	0.1
	0.5
525	4.4
	3.2
526	1.9
	2.2
527	0.1
	0.1
528	1.5
	0.7
529	4

	1.2
530	0.2
	0.2
531	---
532	1.6
	3.4

Page 96, Data for 1921-1922

VQS Amplitudes

Event Number	Maximum Amplitude (mm)
1	1.4
	2.7
2	0.2
	0.2
3	0.4
	0.8
4	2.5
	33.0
5	0.4
	0.3
6	0.5
	1.0
7	---
	0.?
8	0.1
	0.5
9	0.1
	0.2
10	0.2
11	0.2
	0.1
12	2.5
	5.0
13	1.0
	0.6
14	0.8
	0.3
15	0.?
	0.5
16	2.2

	1.4?
17	12.8
	6.7
18	0.6
	2.0
19	0.4
	1.0
20	0.2
	0.2
21	---

22	0.6
	0.5
23	1.3

24	---
	0.1
25	2.0
	0.9
26	0.2

27	0.?
	0.1
28	0.9
	0.7
29	0.2
30	6.4
	6.8

REMARKS.

133. Waves of irregular period and amplitude. Apparently two earthquakes with waves of different periods.
134. Local, probably from Porto Rico.
135. Rarely perceptible on N.
136. Four long waves on N beginning at 8:03 may be L. The phase tabulated as P may be PR₁. A second occurring on N at 7:52:45 and on E at 7:52:28 is probably SR₁.
137. Local, felt at Vieques, windows rattled.
138. The phase tabulated as P may be PR₁.
139. P not well defined.
140. Felt in Porto Rico.
141. Phases uncertain on account of wind tremors.
142. Preliminary phases uncertain.
143. N not recording.
144. Felt in Porto Rico.
145. Felt by a few persons in Vieques.
146. Recorded on magnetograph also.
147. Times uncertain because of absence of time marks.
148. Time marks missing. Times interpolated over an interval of 12 hours.
149. Felt at several places in Porto Rico.
150. P well marked on E; other phases uncertain.
151. Very faint; no definite phases.
152. Felt strongly in Porto Rico. At 21:23:27 on N there is a faint but definite disturbance.
153. Felt strongly in Porto Rico.
154. P well defined; other phases not distinct.
155. Caused much alarm in Porto Rico. At 22:08:34 the stylus of N was carried beyond the edge of the paper by the swing of the pendulum and did not return. E went off at 22:09:08 but came back at 22:14:20. Tabulated maxima were measured to the edge of the paper.
156. P doubtful.
157. P and L doubtful.
158. Reported from Formosa. The phase tabulated as P is probably PR. L indefinite.
159. Of the numerous near-by shocks the second phase has sometimes been tabulated as S and sometimes as P according to the appearance of the record.
160. A phase on N at 20:07:12 is probably PR₁. SR₁ is well marked on E at 20:15:33 and on N at 20:15:50.
161. Apparently a slight local shock.
162. L uncertain.
163. The phases tabulated as P may be PR₁.
164. The phases tabulated as P may be PR₁. There is another phase on E at 15:05:20 and one at 15:18:09, latter probably SR₁; also L repeated at 16:44.
165. Very strongly felt at Vieques; similar to two underground explosions.
166. Phases not well defined. Time uncertain.
167. The end overlaps the beginning of 526.
168. Faint and indefinite.
169. P and S faint and hard to place. Other phases at 12:43:11 on E and 12:44:10 on N.

MAGNETIC STORMS.

In the table below the relative magnitude of the disturbance is indicated by the figures 1, 2, 3, 4. When a storm began abruptly, the time of beginning is given to the nearest minute. For comparison with similar data for other observatories the Greenwich mean time may be found by adding four hours.

On the succeeding sheets will be found reproductions of the magnetograms showing the principal storms reduced to one-half the original size. A storm selected for reproduction is indicated in the table by an asterisk after the date. Upward motion of the curves correspond to increasing west declination, increasing H , and increasing Z .

No. 292

DEPARTMENT OF COMMERCE

U. S. COAST AND GEODETIC SURVEY

E. LESTER JONES, DIRECTOR

RESULTS OF OBSERVATIONS MADE AT THE
UNITED STATES COAST AND GEODETIC SURVEY
MAGNETIC OBSERVATORY AT VIEQUES, P. R.,
IN 1921 AND 1922

BY

DANIEL L. HAZARD

Assistant Chief, Division of Terrestrial Magnetism



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1925

RESULTS OF OBSERVATIONS MADE AT THE UNITED STATES COAST AND GEODETIC SURVEY MAGNETIC OBSERVATORY AT VIEQUES, P. R., IN 1921 AND 1922

CONTENTS

	Page
Introduction.....	1
Instruments.....	2
Locations of the magnetograph.....	2
Observed values and base-line values.....	4
Diurnal variation.....	9
Summaries of monthly and annual means.....	23
Hourly values of declination, 1921.....	24
Hourly values of horizontal intensity, 1921.....	36
Hourly values of vertical intensity, 1921.....	48
Hourly values of declination, 1922.....	60
Hourly values of horizontal intensity, 1922.....	72
Hourly values of vertical intensity, 1922.....	84
Earthquakes.....	96
Magnetic storms.....	97

ILLUSTRATIONS

Figs. 1-10. Reproductions of magnetograms showing principal magnetic storms.....	facing-- 98
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INTRODUCTION

[Latitude $18^{\circ} 08.8' N.$; longitude, $65^{\circ} 26.9' W.$; elevation, 20 meters (65 feet)]

In February, 1903, a magnetograph was installed in a room in Fort Isabel Segunda, on Vieques Island, P. R., and variation observations were continued there until April, 1907. At that time, suitable buildings having been constructed for the observatory work, the instruments were transferred to the new site, about five-eighths of a mile (1 km.) west of the old fort. A general description of the new building will be found in the Results for 1907 and 1908. The methods of observing are explained in Directions for Magnetic Measurements, published in 1911 (second edition in 1921). The division of terrestrial magnetism of the U. S. Coast and Geodetic Survey, of which N. H. Heck, hydrographic and geodetic engineer, is chief, includes both the office and field work. The office computations and preparation of the results for publication were in charge of the writer, assisted by Frank Neumann, O. S. Hill, B. Goldsmith, and I. I. Kaplan, computers. The work of the observatory was carried on by Wallace M. Hill, magnetic observer, up to September, 1921. For the rest of the two years R. R. Bodle, magnetic observer, was in charge.

Up to the end of 1914 each hourly value of declination, horizontal intensity, or vertical intensity in the monthly tabulations represented the momentary value of the quantity for the specified hour, local mean time. Beginning with 1915 the published hourly values are average values for successive periods of an hour, beginning at midnight of the specified standard meridian (sixtieth in the case of Vieques). Thus a value in the column headed 1 represents the average value for the hour beginning at midnight and ending at 1 a. m., sixtieth meridian mean time.

Note by W. R. McCann:

The Maximum Amplitudes for Seismic Station VQS in this report are at times impossible to photocopy or scan. This is due to the fact that the bulletin was printed on very small format paper and later bound along with much larger format paper. The binding process therefore obscures the amplitude data. In some case the binding material, string, passes through the pages destroying the amplitude information. Data from the affected pages (pages 96, and 98) were written down, where possible, and are found in the table below.

Page 98, Data for 1920

VQS Amplitudes

Event Number	Maximum Amplitude (mm)
492	---
	0.1
493	1
	0.8
494	1.4?
	0.?
495	2.6
	0.2
496	---
	0.2
497	0.1
	0.?
498	85+
	84+
499	0.1
500	0.2
501	0.4
	0.3
502	3.3
	1.?
503	---
	0.1
504	1.1
	0.8?
505	---
	0.1
506	1

	0.8
507	0.3
	.4?
508	0.1
	0.1
509	---
	0.1
510	---
	.2?
511	0.3
512	0.1
	0.1
513	0.8
	0.2
514	0.2
	0.2
515	0.3
	2.5
516	0.2
	0.2
517	0.1
	0.2
518	---

519	0.6
	0.7
520	---
	0.3
521	13.5
	3
522	0.3
523	0.1
524	0.1
	0.5
525	4.4
	3.2
526	1.9
	2.2
527	0.1
	0.1
528	1.5
	0.7
529	4

	1.2
530	0.2
	0.2
531	---
532	1.6
	3.4

Page 96, Data for 1921-1922

VQS Amplitudes

Event Number	Maximum Amplitude (mm)
1	1.4
	2.7
2	0.2
	0.2
3	0.4
	0.8
4	2.5
	33.0
5	0.4
	0.3
6	0.5
	1.0
7	---
	0.?
8	0.1
	0.5
9	0.1
	0.2
10	0.2
11	0.2
	0.1
12	2.5
	5.0
13	1.0
	0.6
14	0.8
	0.3
15	0.?
	0.5
16	2.2

	1.4?
17	12.8
	6.7
18	0.6
	2.0
19	0.4
	1.0
20	0.2
	0.2
21	---

22	0.6
	0.5
23	1.3

24	---
	0.1
25	2.0
	0.9
26	0.2

27	0.?
	0.1
28	0.9
	0.7
29	0.2
30	6.4
	6.8

Number	Date	Component	P	S	L	M	C	F	Maximum amplitude
31	Oct. 11	E	14 56 47	15 02 13	15 08 50	15 05 00	-- --	15 26	.4
		N	14 56 41	15 02 06	15 08 58	15 11 20	-- --	15 20	.5
32	Nov. 4	E	-- -- --	-- -- --	5 38 17	-- -- --	-- --	5 41	.1
		N	-- -- --	-- -- --	5 37 57	-- -- --	-- --	5 42	.1
33	Nov. 11	E	4 41 11	4 48 12	4 56 28	5 02 20	5 03	8 00	32.0
		N	4 41 05	4 47 50	4 58 15	5 04 --	5 17	7 40	80.0
34	Nov. 19	E	-- -- --	-- -- --	9 57 48	-- -- --	-- --	9 58	-----
		N	-- -- --	-- -- --	9 57 48	-- -- --	-- --	9 58	.1
35	Dec. 18	E	12 35 31	-- -- --	12 35 43	12 36 19	-- --	13 12	7.8
		N	12 35 34	-- -- --	12 36 08	12 36 37	-- --	12 54	15.0
36	Dec. 27	E	-- -- --	-- -- --	3 42 38	-- -- --	-- --	3 48	-----
		N	-- -- --	-- -- --	3 42 38	-- -- --	-- --	3 49	-----

REMARKS

1. Phases well defined. $\Delta=2,560$ km. PR_1 at 3:29:00; SR_1 at 8:33:33 on E and 8:33:25 on N.
2. Phases obscured by wind tremors.
4. Preliminary phases well defined. $\Delta=2,400$ km. On N PR_1 appears at 7:54:52 and SR_1 at 7:59:17
5. Light local shock. Noticed at Vieques as similar to a distant explosion.
7. P and L interpretations doubtful.
9. Local shock.
10. S and L interpretations doubtful. Records partly obscured by wind tremors.
11. P interpretations doubtful.
12. Heavy microseism prevailing. Maximum occurs during S. No L waves evident.
13. $\Delta=400$ km.
14. Local shock. Felt by a few persons. Recorded on the magnetograph.
15. An emergence occurs at 14:42:01.
16. L not clear. Recorded on the magnetograph from 5:15 to 5:18.
17. Recorded on the magnetograph: P, 3:55; L, 3:58; F, 4:11. An emergence occurs on E at 3:58:28.
20. Local tremor. L doubtful.
21. Very slight tremor. L doubtful. An emergence occurs at 5:55:19.
22. Local. Recorded on the H variometer at 23:37.
23. An actual maximum of 0.4 mm. occurs at 4:11:07 on N. L weak.
24. Activity on N barely perceptible.
25. Local shock. Recorded on the H variometer at 20:24. L interpretation doubtful.
26. S interpretation doubtful. No definite maximum on N.
27. $\Delta=4,520$ km. $O=4:47:15$. PR_{1E} at 4:56:44; PR_{1N} at 4:56:33; L_{2E} at 5:08:05.
28. Felt in Vieques. Recorded on H variometer at 20:10. L interpretation doubtful.
30. Felt in Porto Rico. P interpretation doubtful. An impulse occurs at 23:22:22 on N.
31. $\Delta=3,620$ km. $O=14:49:51$. PR_{1N} at 14:57:51; SR_{1E} at 15:04:46; SR_{1N} at 15:04:51.
32. Local shock. Recorded on H variometer. L interpretations doubtful. An emergence occurs on N at 5:38:32.
33. $\Delta=5,050$ km. $O=4:32:34$. PR at 4:43:13; ev at 4:45:41; PS_2 (?) at 4:48:38; SR_{1E} at 4:51:15; cSR_{1N} at 4:51:37; L_{2E} at 4:58:12; eL_{2E} at 5:02:00; is at 4:59:35. N trace off paper. Recorded on the magnetograph.
34. Felt in Vieques. L interpretation doubtful.
35. Felt in Porto Rico. Recorded on the magnetograph. Tremors superimposed on the P waves.
36. Local tremors. L interpretation doubtful.

MAGNETIC STORMS

In the table below the relative magnitude of the disturbance is indicated by the figures 1, 2, 3, 4. When a storm began abruptly, the time of beginning is given to the nearest minute. For comparison with similar data for other observatories the Greenwich mean time may be found by adding 4 hours.

On the succeeding sheets will be found reproductions of the magnetograms showing the principal storms, reduced to one-half the original size. A storm selected for reproduction is indicated in the table by an asterisk after the date. Upward motion of the curves corresponds to increasing west declination, increasing H , and increasing Z .

RESULTS OF OBSERVATIONS
MADE AT
THE UNITED STATES COAST AND GEODETIC SURVEY
MAGNETIC OBSERVATORY AT VIEQUES, P. R.
IN 1923 AND 1924

U. S. DEPARTMENT OF COMMERCE
COAST AND GEODETIC SURVEY
WASHINGTON, D. C.

RESULTS OF OBSERVATIONS MADE AT THE UNITED STATES COAST AND GEODETIC SURVEY MAGNETIC OBSERVATORY AT VIEQUES, P. R., IN 1923 AND 1924

CONTENTS

	Page
Introduction.....	1
Instruments.....	1
Constants of the magnetograph.....	2
Absolute observations and base-line values.....	3
Diurnal variation.....	6
Summaries of monthly and annual means.....	25
Hourly values of declination, 1923.....	26
Hourly values of horizontal intensity, 1923.....	38
Hourly values of vertical intensity, 1923.....	50
Hourly values of declination, 1924.....	62
Hourly values of horizontal intensity, 1924.....	72
Hourly values of vertical intensity, 1924.....	82
Earthquakes.....	92
Magnetic storms.....	93

ILLUSTRATIONS

Figures 1-10. Reproductions of magnetograms showing principal magnetic storms.....	Facing... 94
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INTRODUCTION

[Latitude 18° 08'. 8 N.; longitude, 66° 26'. 9 W.; elevation, 20 meters (65 feet)]

In February, 1903, a magnetograph was installed in a room in Fort Isabel Segunda, on Vieques Island, P. R., and variation observations were continued there until April, 1907. At that time, suitable buildings having been constructed for observatory work, the instruments were transferred to the new site, about five-eighths of a mile (1 km.) west of the old fort. A general description of the new building will be found in the Results for 1907 and 1908. The methods of observing are explained in Directions for Magnetic Measurements, published in 1911 (third edition in 1930).

The division of terrestrial magnetism and seismology of the Coast and Geodetic Survey has supervision over the office, field, and observatory work in terrestrial magnetism. During the period covered by this report, N. H. Heck, hydrographic and geodetic engineer, was chief of this division. The work of the observatory was in charge of R. R. Bodle, magnetic observer, until June 13, 1924, and after that in charge of J. B. Goldsmith, magnetic observer, until the operation of the observatory was discontinued on October 31, 1924.

The office computations and preparation of the results for publication were in charge of the author and the assistant chief of the division, D. L. Hazard, assisted by F. Neumann, O. S. Hill, and Augustine McCarthy, mathematicians, and W. M. Hill, Louis P. Sissman, and John Hershberger, magnetic observers.

Up to the end of 1914 each hourly value of declination, horizontal intensity, or vertical intensity in the monthly tabulations represented the momentary value of the quantity for the specified hour, local mean time. Beginning with 1915 the published hourly values are average values for successive periods of an hour, beginning at midnight according to the mean time of the sixtieth meridian, in the case of Vieques. Thus a value in the column headed 1 represents the average value for the hour beginning at midnight and ending at 1 a. m., sixtieth meridian mean time.

INSTRUMENTS

VARIATION INSTRUMENTS

The magnetograph is of the Eschenhagen pattern and consists of a recording apparatus and declination (*D*), horizontal intensity (*H*), and vertical intensity (*Z*) variometers. Increasing ordinates (upward motion of the curves) correspond to increasing west declination, increasing horizontal intensity, and increasing vertical intensity. Vari-

EARTHQUAKES

A Bosch-Omori seismograph has been in operation since September, 1903. It consists of two horizontal pendulums, one recording north-south motion (N) and the other recording east-west motion (E). The constants of the instruments were as follows:

	E.	N.
Steady mass..... kilograms.....	10	10
Multiplication.....	10	10
Period from—		
Jan. 1, 1923..... seconds.....	17.3	19.2
Mar. 4, 1924..... do.....	17.8	19.2
June 19, 1924..... do.....	17.8	15.0

The following table is a register of the earthquakes recorded by the seismograph. The time is Greenwich mean time counted from midnight. In order to find a place in the table for impulses and emergencies which have not been identified with any phase of the seismogram, the times of their appearances have often been included in the column headed P, and sometimes in the columns headed S and L. The quantities given in the last column are the actual movement of the stylus (one-half of the maximum range) as measured on the seismogram.

On January 31, 1925, the President approved an act of Congress, which authorized the Coast and Geodetic Survey to make investigations and reports in seismology, and in accordance with the provisions of this act, the scope of the work of this bureau in seismology has been enlarged, and its importance has been felt to warrant the issuance of separate publications for the seismological reports.

Register of earthquakes

No.	Date	Com- ponent	P	S	L	M	C	F	A
			<i>h. m. s.</i>	<i>h. m. s.</i>	<i>h. m. s.</i>	<i>h. m. s.</i>	<i>h. m.</i>	<i>h. m.</i>	<i>mm.</i>
1	1923 Jan. 22	E	9 13 53	9 22 04	9 30 06	9 34 05	17 06	9 58	0.6
2	Feb. 3	E			16 52 15	9 40 23		9 58	0.6
3	Feb. 24	E			116 51 02			19 25	25.0
4	Mar. 16	E	16 03 43			8 31 42		8 53	0.2
5	May 4	E	16 03 43			8 32 10		8 51	0.1
6	May 4	E	17 40 49			6 04 33	6 06	6 18	3.3
7	June 10	E	17 42 43			6 04 26		6 18	4.5
8	Aug. 8	E	23 29 55					18 16	
9	Aug. 28	E	1 32 28	12 04 19	12 05 09	12 05 16		12 14	0.2
10	Sept. 1	E	1 32 21	12 04 03	12 05 10	12 05 16		12 16	0.2
11	Sept. 2	E	3 20 10	23 31 22	23 36 54	4 16 20	4 20	5 30	0.3
12	Sept. 2	E	3 19 20	3 27 10	3 47 42	4 11 55	4 22	5 19	2.5
13	Sept. 2	E	22 50 02	3 30 36	3 49 11	3 55 21		4 16	0.1
14	Sept. 30	E	22 49 43		22 52 32	22 50 07		23 02	0.4
15	Oct. 10	E	1 28 54	1 35 21	1 40 37	1 35 33	1 44	2 07	0.3
16	Nov. 2	E	7 22 43	7 29 28	7 40 27	22 15 57		22 32	0.5
17	Nov. 3	E	7 21 23		22 18 49	22 21 30	8 44	9 18	2.4
18	Nov. 4	E	8 39 01	8 40 34	8 40 58	8 41 54	8 43	8 57	9.8
19	Dec. 22	E	8 39 22		8 14 33			1 28	0.2
20	Mar. 4	E			1 15 48			1 28	0.1
21	Mar. 4	E			10 03 54	10 05 46		10 24	0.8
22	Mar. 4	E			10 05 42	10 06 22		10 16	0.1
23	Mar. 11	E	11 0 12 30	11 16 12	11 17 30	10 20 33	10 26		8.0
24	Mar. 11	E	11 0 12 30	11 16 18	10 17 47	10 18 47		10 42	3.6
25	Mar. 11	E	11 48 29	11 52 12	11 55 18	11 56 18		12 10	0.2
26	Mar. 11	E	10 45 49	10 49 39	10 54 40			12 09	0.1
27	Mar. 11	E	10 45 49	10 49 39	10 52 34	10 55 06		11 14	0.5
28	Mar. 11	E	10 45 49	10 49 39	10 51 51	10 50 06		11 06	0.3
29	Mar. 11	E	20 33 53	20 37 42		20 38 03		20 59	0.5
30	Mar. 11	E	14 11 27	14 15 18	14 19 02	20 38 00		20 46	0.2
31	Mar. 11	E	14 11 37	14 15 28	14 22 38			14 28	0.2
32	Mar. 25	E	1 28 50					1 38	0.2
33	Apr. 13	E	16 40 49		17 33 47	17 43 26	18 00	18 24	1.0
34	Apr. 14	E	16 40 37		17 36 35	17 42 58	18 00	18 16	2.1
35	Apr. 18	E	6 48 39	7 6 48 45	16 48 47	6 48 47		6 49	0.2
36	Apr. 18	E	6 48 39					6 49	0.2

Register of earthquakes—Continued

No.	Date	Com- ponent	P			S			L			M			O			F			A
			h.	m.	s.	h.	m.	s.	h.	m.	s.	h.	m.	s.	h.	m.	s.	h.	m.	s.		mm.
27	Apr. 21	E	20	07	54	20	13	06	20	18	48	15	43	22	20	32	20	32	20	32	0.2
28	Apr. 22	N	15	43	06	20	13	06	20	18	10	15	43	22	20	21	20	21	20	21	0.2
29	May 1	E	15	43	02				15	43	18	15	43	19	15	45	15	45	15	45	0.6
30	May 27	N	19	59	26	20	02	06	20	03	42	20	12	35	20	14	21	01	21	01	13.4
31	June 2	E	19	59	27	20	03	17	20	03	53	20	10	39	20	15	20	30	20	30	18.8
32	June 10	N	10	18	45				10	18	52	10	18	52	10	24	10	24	10	24	0.1
33	June 26	E	11	26	29	11	27	34	11	27	20	11	28	41	11	44	11	44	11	44	0.2
34	June 30	N	11	26	14	11	27	34				11	28	28	11	39	11	39	11	39	0.2
35	July 6	E	2	17	10							2	19		2	19	2	19	2	19	0.1
36	July 11	N	2	17	12	2	16	25	2	31	37	2	32	10	3	51	3	51	3	51	0.8
37	July 22	E	2	02	25	2	16	12													
38	July 22	N	16	10	34				16	42	38										
39	July 22	E	14	22	36	14	26	01	14	29	26	14	29	38	14	52	14	52	14	52	0.2
40	July 22	N	14	22	36	14	26	01	14	30	17	14	33	19	14	48	14	48	14	48	0.1
41	July 22	E				20	25	00	20	50	31	20	56	12	21	25	21	25	21	25	0.1
42	July 22	N				20	25	00	20	50	31				21	14	21	14	21	14	
43	Aug. 21	E	4	09	11							4	14	35	4	18	4	18	4	18	0.1
44	Aug. 21	N	16	47	31				16	48	08	16	48	15	16	49	16	55	16	55	0.3
45	Aug. 21	E	16	47	44				16	48	15	16	48	20	16	48	16	55	16	55	0.5
46	Sept. 17	N	7	05	13				7	05	54	7	06	02	7	14	7	14	7	14	0.5
47	Sept. 17	E	7	05	13				7	05	54	7	06	02	7	06	7	14	7	14	0.9
48	Oct. 14	N	5	04	46	5	08	06	5	08	41	5	09	54	5	30	5	30	5	30	0.6
49	Oct. 14	E	5	04	46	5	08	06	5	08	41	5	10	13	5	30	5	30	5	30	1.0
50	Oct. 18	N	23	10	11	23	14	02				23	14	15	23	41	23	41	23	41	0.8
51	Oct. 18	E	23	10	11	23	14	02				23	14	07	23	22	23	22	23	22	0.1
52	Nov. 1	N	5	00	47	5	04	50	5	10	00				5	15	5	15	5	15	0.1
53	Nov. 1	E	5	00	55	5	04	50	5	13	43				5	21	5	21	5	21	0.1

REMARKS

- O at 9:04:03, distance 6,240 km.; PR on E at 9:17:07; L₂ on E at 9:32:07 and on N at 9:36:46; preliminary phases very weak.
- e PR₁ on E at 16:19:33; SR₁ on E at 16:39:48 and on N at 16:39:44; e on E at 16:42:05 and on N at 16:45:36; N stylus off sheet at 16:55:13; paper changed during P, and pendulum adjusted during S.
- e on E at 8:24:18 and on N at 8:23:47.
- e on E at 6:04:59; L waves superimposed by tremors of 2 or 3 sec. period; felt in Porto Rico, especially near Mayaguez.
- Nothing definite.
- Local tremors.
- Barely perceptible; nothing on N; probably off end of Lower California.
- SR₁ on N at 3:35:43; no definite phases.
- Possibly a few long waves on N.
- i on both at 22:50:05; M₂ on E at 22:53:02.
- O at 1:20:45, distance 4,720 km.; PR₂ on N at 1:30:43; e on E at 1:38:40 and on N at 1:38:57; M₂ on N at 1:41:29.
- O at 7:11:04, distance 6,700 km.; activity barely perceptible; O based on S. and L.
- Tremors superimposed on the long waves.
- Heavy wind tremors.
- Wind tremors obscure preliminaries.
- O at 10:07:53, distance 2,220 km.; iSR on both at 10:16:40; M₂ on N at 10:23:38; tremors on E continue to next earthquake.
- O at 11:43:51, distance 2,230 km.; e on E at 11:53:24; no definite maximum on N.
- O at 10:41:01, distance 2,320 km.; no definite maximum during L on N component.
- O at 20:23:07, distance 2,300 km.; no definite L phase.
- O at 14:06:43, distance 2,300 km.; no definite maximum on E.
- Severe wind tremors prevailing.
- O at 16:20:23, distance 10,700 km.; PS on E at 16:54:46; SR₁ on E at 17:03:48 and on N at 17:05:39; SR₂ on E at 17:09:19; e on E at 17:24:04; L₂ on E at 17:39:09 and on N at 17:38:49; origin based on L₁₂ and SR₂₂.
- Felt by many in Vieques; noise as of explosion or escaping steam, according to some reports.
- O at 20:01:20, distance 3,420 km.; PR on E at 20:08:51.
- Felt by a few in Vieques.
- e on E at 20:06:12 and 20:09:24 and on N at 20:06:07; phases not characteristic; waves irregular in period and amplitude; gentle rocking motion felt at the local police station; S_N-P_N gives distance=2,320 km. and O, 19:54:38.
- At Port de Paix, Haiti.
- On Martinique.
- Vibrations very rapid, less than 1 second probably.
- N record incomplete.
- Only a few long waves; short waves barely perceptible.
- O at 14:18:20, distance 2,020 km.; e on E at 14:28:05 and on N at 14:28:33; L₂ on N at 14:33:07.
- e on E at 20:23:07 and 20:43:23; L₂ on E at 20:54:20 and on N at 20:53:40.
- E record obscured by ragged trace.
- i on N at 16:43:08; recorded on the magnetograph; LE and LN have tremors superimposed.
- Felt in Vieques and San Juan.
- O at 5:00:33, distance 1,970 km.; e on N at 5:08:30.
- O at 23:05:22, distance 2,330 km.
- O at 4:55:43, distance 2,470 km.; e on N at 5:03:56 and 5:05:43; record weak.

MAGNETIC STORMS

Magnetic disturbances of considerable magnitude were recorded at the times given in the following table. The times of beginning are the standard mean times of the sixtieth meridian. When a storm began abruptly, the time of beginning is given to the nearest minute.

The severity of magnetic disturbance is graded according to a scale running from 1 to 4. A moderate disturbance is given the characterization 1, while class 4 is reserved for