

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

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RESULTS OF OBSERVATIONS MADE AT THE COAST AND  
GEODETIC SURVEY MAGNETIC OBSERVATORY  
NEAR TUCSON, ARIZONA  
1909 AND 1910

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BY

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RESULTS OF OBSERVATIONS MADE AT THE COAST AND GEODETIC SURVEY MAGNETIC  
OBSERVATORY NEAR TUCSON, ARIZONA, IN 1909 AND 1910.

INTRODUCTION.

Latitude,  $32^{\circ} 14' .8$ . Longitude,  $110^{\circ} 50' .1$ . Elevation, 770 meters (2,525 feet).

As the improvised building for the variation instruments at Baldwin, Kans., was of such a character as to detract seriously from the accuracy and value of the results obtained, and as the increasing density of population in that region presaged the introduction of electric car lines in the near future, it was decided to transfer the variation instruments from Baldwin to some place in the southwestern part of the United States. After an examination of numerous localities a site was selected about 8 miles (12.9 km.) east of the city of Tucson, Arizona.

By Executive order of June 3, 1909, the northwest quarter of section 5, township 14 south, range 15 east, Gila and Salt River meridian, containing about 173 acres, was set apart for the

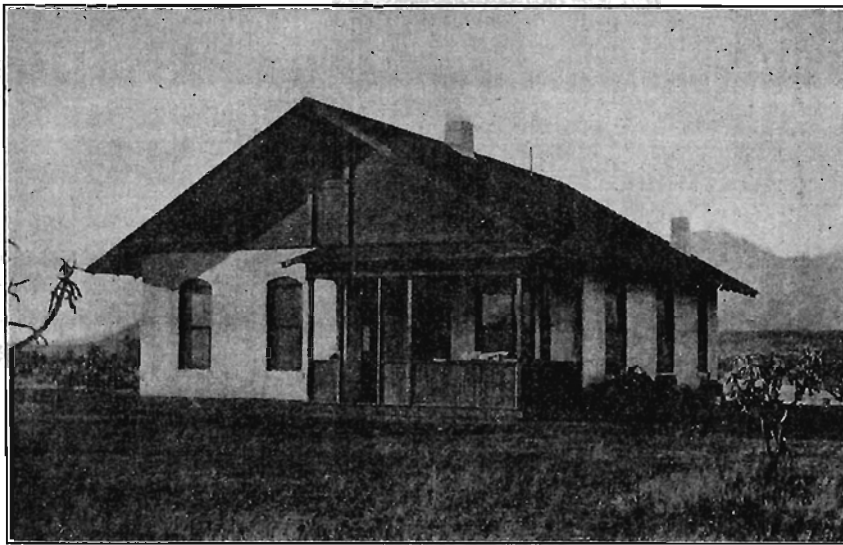


FIG. A.—Office.

use of the observatory. It is in a comparatively level and open country, rising gradually to mountains on the north and west. The plans for the observatory buildings were prepared by W. B. Keeling, magnetic observer, and their construction was begun under his direction in the latter part of June, 1909. After the death of Mr. Keeling early in July the work was put in charge of E. Mueller, assistant, and the buildings were completed under his direction. The instruments were installed by W. F. Wallis, magnetic observer, and put in operation on November 16, 1909, and he had charge of the observatory work up to the end of August, 1910, when he was relieved by L. W. Weed, magnetic observer.

BUILDINGS.

The building used as an office and quarters for the observer in charge is a little southwest of the center of the tract. It is a one-story brick building about 30 by 40 feet in size (Fig. A).

The variation building (Fig. B) is about 700 feet west of the office. It is above ground, made of wood, of the same general design as the one at Sitka, Alaska. It is 28 by 32 feet, with a vestibule on the west end 10 by 12 feet. The wall insulation, beginning from the outside, is

as follows: Six-inch free-air space (between studding); 40 inches of sawdust; 6-inch dead-air space; 26-inch air space (corridor); 15 inches of sawdust. The instrument room is 12 by 16 by 7 feet. Below this room the insulation consists of 24 inches of sawdust and a 12-inch air space next to the ground. Above the room: Two-inch air space; 13 inches of sawdust; 32-inch air space connected with the corridor; 24 inches of sawdust; open loft. To enter the instrument room one must pass through six doors, two at the entrance to the vestibule, two at the entrance of the building, and two at the entrance to the instrument room.

By this means the average diurnal variation of temperature in the instrument room is kept down to about  $0.1^{\circ}$  C., as compared with about  $20^{\circ}$  outside, but the effect of a prolonged change of temperature is more marked and the annual range is about  $15^{\circ}$ . The outer sawdust packing was not put in place until August, 1910, and its insulating effect on the inside temperature was not as much as had been expected.

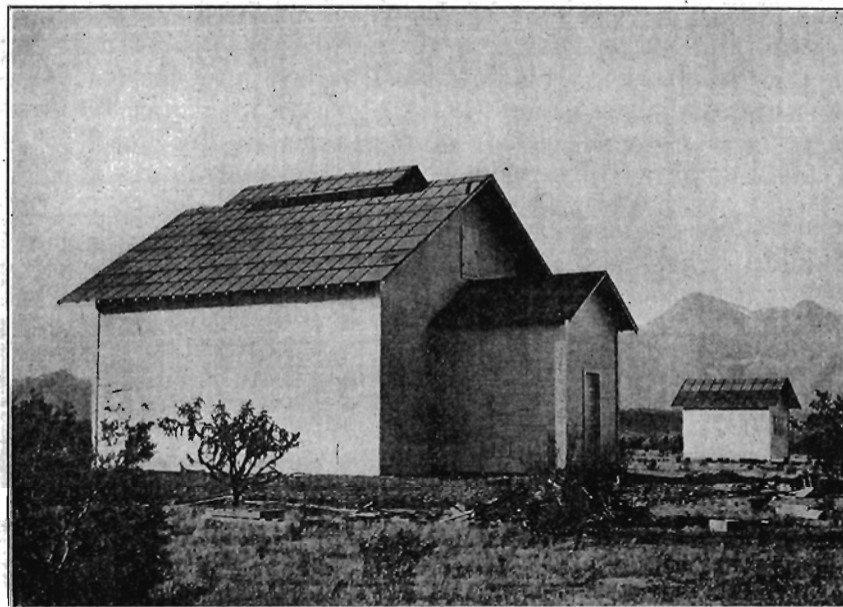


FIG. B.—Variation and absolute buildings.

*Monthly and annual range in temperature (Centigrade).*

Month	Inside of variation building				Outside of variation building		
	Maximum	Minimum	Range	Mean	Mean	Range	Average daily range
1910	°	°	°	°	°	°	°
January.....	17.8	13.3	4.5	15.9	10.3	32.4	14.5
February.....	16.4	14.2	2.2	15.2	10.8	32.6	18.3
March.....	21.6	16.5	5.1	19.6	17.5	31.1	19.3
April.....	23.7	18.8	4.9	20.8	19.5	32.4	21.1
May.....	27.0	22.6	4.4	23.9	24.0	37.8	22.4
June.....	28.5	26.7	1.8	27.7	27.8	30.9	21.3
July.....	30.4	27.8	2.6	29.2	29.6	26.4	17.2
August.....	30.8	28.9	1.9	29.9	29.9	24.2	15.4
September...	29.4	28.1	1.3	29.0	28.2	30.5	18.8
October.....	28.7	23.7	5.0	26.6	21.6	37.7	19.8
November....	24.5	21.1	3.4	22.8	15.3	36.1	20.2
December....	21.0	17.1	3.9	19.3	12.3	34.3	19.7
Year.....	30.8	13.3	17.5	23.3	20.6	52.8	19.0

The absolute building (Fig. B) is about 100 feet north of the variation building. It is built of wood, with double walls separated by an air space of 24 inches, the inner dimensions being 8 by 12 feet.



## EARTHQUAKES.

A Bosch-Omori seismograph was mounted in the seismograph house in September, 1910. It consists of two horizontal pendulums, one recording east-west motion (E), and the other recording north-south motion (N). Below are tabulated the earthquakes recorded up to the end of 1910:

Period of pendulums:	s	s.
September.....	N, 7;	E, 22
October, November.....	N, 11;	E, 18
December.....	N, 20;	E, 20
Magnification.....	10	
Steady mass.....	10-12 kg	

*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
	1910.		<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	Sept. 22	N	12 47 33	12 50 23	12 52 29	12 52 59	12 54	12 59	0.3
1	22	E	12 47 33	12 50 33	12 52 28	12 53 03	12 54	13 00	0.4
2	24	N	3 37 35	3 41 43	3 44 38	3 47 18	3 51	4 06	5.0
2	24	E	3 37 23	3 41 41	3 44 39	3 48 09	3 51	4 05	4.8
3	24	N	4 06 51	.. .. .	4 07 31	4 08 00	4 11	4 22	2.1
3	24	E	4 06 43	.. .. .	4 07 23	4 08 15	4 12	4 20	2.4
4	Oct. 4	N	23 10 54	.. .. .	23 19 45	23 20 50	.. ..	23 45	0.1
4	4	E	23 11 00	.. .. .	23 19 42	23 20 36	.. ..	23 45	0.1
5	Nov. 6	N	20 36 08	20 40 44	20 45 18	20 46 35	20 51	21 56	1.1
5	6	E	20 36 00	20 40 30	20 45 19	20 46 13	20 50	21 25	2.3
6	9	N	6 16 22	6 26 18	6 39 32	7 02 45	.. ..	.. ..	0.3
6	9	E	6 15 00	6 25 51	6 43 40	7 02 10	.. ..	.. ..	0.1
7	9	N	.. .. .	.. .. .	8 16 24	8 36 10	8 49	.. ..	0.2
7	9	E	.. .. .	.. .. .	8 15 46	8 36 00	.. ..	.. ..	0.1
8	26	N	4 58 48	5 04 56	5 18 23	5 42 12	5 45	.. ..	0.4
9	Dec. 10	N	9 40 02	9 50 51	10 04 36	10 11 46	10 24	10 52	0.3
9	10	E	9 40 00	9 50 47	10 08 01	10 11 40	10 30	11 05	0.2
10	13	N	11 59 41	.. .. .	12 36 43	12 53 56	13 04	13 54	0.4
10	13	E	11 59 43	.. .. .	12 36 58	12 55 52	13 02	13 50	0.4
11	16	N	15 05 08	15 14 46	.. .. .	15 39 56	.. ..	16 56	0.3
11	16	E	15 04 50	15 14 46	15 40 31	15 50 26	.. ..	17 02	0.6
12	28	N	16 25 17	.. .. .	16 25 54	16 26 30	16 28	16 35	0.2
12	28	E	16 25 07	.. .. .	16 26 01	16 26 17	.. ..	16 37	0.2
13	28	N	17 30 28	.. .. .	17 31 17	17 31 53	17 34	17 40	0.4
13	28	E	17 30 32	.. .. .	17 31 17	17 32 09	17 33	17 42	0.3
14	28	N	18 05 26	.. .. .	18 06 04	18 06 36	18 08	18 15	0.3
14	28	E	18 05 17	.. .. .	18 06 11	18 06 33	18 08	18 18	0.2

## REMARKS.

Nos. 6 and 7: Apparently two earthquakes overlapping, the end of the first being confused by the beginning of the second.

No. 8: Apparently a very distant earthquake. Nothing shown on E.

No. 11: Paper changed between 15.26 and 15.36, and instrument not working well for a short time thereafter. Beginning of large waves and maximum doubtful.

Nos. 12, 13, 14: Very similar to each other, and probably of common origin.

## MAGNETIC STORMS.

Magnetic disturbances of considerable magnitude were recorded on the days tabulated below. The relative magnitudes are indicated by the numbers 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 7<sup>h</sup> 23<sup>m</sup>.

On the succeeding pages 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. Upward motion of the curves corresponds to decreasing east declination, increasing *H* and decreasing *Z*.

DEPARTMENT OF COMMERCE

U. S. COAST AND GEODETIC SURVEY

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**EARTHQUAKES.**

A Bosch-Omori seismograph has been in continuous operation since September, 1910. It consists of two horizontal pendulums, one recording east-west motion (E) and the other recording north-south motion (N). The times in the table below are Greenwich mean time, counted from midnight.

*Period of pendulums.*

	N	E		N	E
	s	s		s	s
Jan. to June, 1911.....	20	21	Sept. 24 to Nov. 10, 1912.....	27	18
July to Dec., 1911.....	29	24	Nov. 10 to Dec. 20, 1912.....	22	19
Jan. to Aug. 21, 1912.....	19	26	Dec. 20-31, 1912.....	18	18
Aug. 21 to Sept. 24, 1912.....	24	26			

Magnification, 10; steady mass, 10-12 kg.

*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
			h m s	h m s	h m s	h m s	h m	h m	mm
15	Jan. 3	N	23 44 00	23 53 42	24 15 48	24 34 18	24 46	25 56	6.5
		E	23 43 54	23 53 24	24 15 24	24 27 21	24 45	25 23	1.6
16	10	N	10 45 10	.. .. .	.. .. .	10 46 59	.. ..	10 52	0.3
		E	10 44 59	.. .. .	.. .. .	10 46 35	.. ..	10 50	0.3
17	21	N	15 09 05	15 09 16	15 09 31	15 09 59	15 10	15 15	0.1
		E	15 09 05	15 09 15	15 09 29	15 09 36	15 11	15 17	0.2
18	Feb. 5	N	.. .. .	4 29 35	4 34 28	4 37 40	.. ..	4 43	0.1
		E	4 26 50	4 29 16	.. .. .	4 37 50	.. ..	4 43	0.1
19	18	N	1 55 23	.. .. .	1 59 28	2 00 57	2 02	2 24	0.2
		E	1 54 05	.. .. .	1 58 31	1 59 12	2 02	2 21	0.2
20	18	N	18 28 38	.. .. .	18 40 58	18 48 16	18 53	19 15	0.5
21	Mar. 13	N	7 24 08	7 24 21	7 24 43	7 24 58	7 26	7 35	0.6
		E	7 24 18	7 24 29	7 24 50	7 25 15	7 27	7 37	0.5
22	15	N	2 14 27	2 14 42	2 15 11	2 16 43	2 17	2 20	0.2
		E	.. .. .	2 14 43	2 15 11	2 15 37	2 18	2 21	0.2
23	Apr. 7	N	18 26 54	18 27 27	18 27 43	18 27 50	18 29	18 39	0.6
		E	.. .. .	18 27 19	18 27 42	18 28 11	18 29	18 39	1.7
24	May 4	N	23 47 28	23 55 54	24 03 45	23 56 02	.. ..	25 48	0.5
		E	23 47 36	23 56 18	24 04 10	23 56 27	.. ..	24 46	0.6
25	10	N	0 25 50	.. .. .	0 32 08	0 32 33	.. ..	0 45	0.1
		E	0 25 51	.. .. .	0 32 22	0 34 22	.. ..	0 46	0.1
26	June 7	N	11 06 37	.. .. .	11 10 13	.. .. .	.. ..	.. ..	35+
		E	11 06 42	.. .. .	11 10 10	.. .. .	11 31	13 10	40+
27	15	N	5 31 53	5 32 08	5 33 02	5 33 26	5 36	5 42	0.4
		E	5 32 03	5 32 21	5 33 30	5 33 54	5 35	5 39	0.2
28	15	N	14 39 17	.. .. .	14 49 45	15 07 02	15 24	16 51	7.9
		E	14 39 24	.. .. .	14 49 48	14 52 00	15 23	15 51	0.6
29	July 1	N	22 02 22	22 03 43	22 04 55	22 06 45	22 18	22 48	5.4
		E	22 02 35	22 03 40	22 04 41	22 07 29	22 17	22 48	1.2
30	4	N	.. .. .	.. .. .	14 01 47	14 03 07	14 47	14 59	0.3
		E	.. .. .	.. .. .	13 59 40	14 45 26	14 48	15 40	0.3
31	12	N	4 27 36	4 30 35	4 36 07	4 43 39	5 21	6 26	0.2
		E	4 27 17	4 30 06	4 36 49	5 01 10	5 39	6 36	0.3
32	Aug. 16	N	22 59 42	23 09 02	23 14 46	23 38 37	24 03	25 02	0.6
		E	22 59 38	23 09 00	23 14 50	23 47 32	24 11	25 49	1.1
33	21	N	16 40 44	16 50 33	17 02 03	17 02 57	.. ..	.. ..	0.2
		E	16 40 57	16 50 33	17 02 13	17 03 09	.. ..	.. ..	0.1
34	Sept. 4	N	.. .. .	.. .. .	5 45 54	5 48 26	5 53	.. ..	0.1
		E	.. .. .	.. .. .	5 46 04	5 47 30	5 54	.. ..	0.1
35	15	N	13 21 10	13 29 50	13 37 07	13 45 23	13 50	14 02	0.4
		E	13 21 18	13 29 34	13 38 44	13 44 54	13 50	14 01	0.1
36	17	N	3 39 19	.. .. .	3 51 12	3 56 10	4 04	5 23	1.0
		E	3 39 37	.. .. .	3 50 40	3 58 52	4 06	5 19	0.1

## 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
37	1911. 22	N	<i>h m s</i> 5 09 07	<i>h m s</i> 5 14 55	<i>h m s</i> 5 19 21	<i>h m s</i> 5 23 55	<i>h m</i> 5 25	<i>h m</i> .. ..	<i>mm</i> 0.2
38	Oct. 6	N	5 10 33	5 15 02	5 19 53	5 22 35	5 26	.. ..	0.2
39	10	N	10 23 57	10 28 22	10 35 19	10 39 30	10 49	11 09	1.8
40	29	N	10 23 49	.. .. .	10 35 39	10 43 31	10 48	11 05	0.5
41	Nov. 1	N	.. .. .	.. .. .	13 26 05	13 35 17	13 39	14 05	0.5
42	18	N	18 14 37	18 18 47	18 20 53	18 24 ..	18 34	18 53	0.3
43	20	N	9 33 15	9 39 48	9 44 18	9 47 56	9 53	10 26	0.6
44	21	N	9 33 20	9 39 30	9 44 00	9 45 32	.. ..	10 02	0.1
45	25	N	7 37 20	.. .. .	7 42 19	7 44 25	7 48	8 10	2.9
46	Dec. 2	N	7 37 21	.. .. .	7 42 21	7 43 33	7 49	8 18	3.8
47	6	N	.. .. .	13 59 43	14 03 26	14 08 25	14 09	14 20	0.3
48	16	N	.. .. .	13 59 47	14 03 19	14 06 41	14 08	14 19	0.6
49	17	N	18 38 57	.. .. .	18 39 51	18 40 34	18 45	18 54	0.4
50	22	N	18 38 49	.. .. .	18 39 44	18 40 09	18 45	18 54	0.5
51	23	N	19 33 30	.. .. .	19 34 20	19 35 00	19 39	19 58	1.2
52	23	N	19 33 28	.. .. .	19 34 26	19 34 26	19 38	19 55	1.8
53	Jan. 4	E	.. .. .	.. .. .	3 51 38	3 53 52	3 54	4 07	1.1
54	16	N	.. .. .	.. .. .	3 51 56	3 52 44	3 55	4 08	1.8
55	16	N	.. .. .	.. .. .	23 31 00	23 36 43	23 52	.. ..	0.2
56	31	N	23 15 22	23 22 51	23 33 55	23 35 30	23 47	21 10	33+
57	31	N	19 19 09	19 22 45	.. .. .	.. .. .	19 47	21 20	45+
58	Feb. 15	N	19 19 18	19 22 47	.. .. .	.. .. .	.. ..	21 18	0.3
59	19	N	.. .. .	.. .. .	2 04 44	2 06 28	2 08	2 17	0.3
60	Mar. 11	N	.. .. .	.. .. .	2 04 08	2 06 24	2 08	2 17	0.3
61	Apr. 17	N	13 00 05	.. .. .	13 05 13	13 07 20	13 16	13 42	2.6
62	20	N	13 00 05	.. .. .	13 05 29	13 07 45	13 18	.. ..	1.6
63	May 6	N	.. .. .	19 50 18	19 50 44	19 51 22	19 55	20 07	0.4
64	June 7	N	.. .. .	.. .. .	19 50 26	19 51 24	19 55	20 06	0.6
65	7	N	21 13 50	.. .. .	21 22 48	21 23 52	21 38	21 53	0.3
66	7	N	21 14 04	21 19 24	21 22 22	21 24 14	21 38	21 51	0.3
67	7	N	.. .. .	.. .. .	.. .. .	.. .. .	.. ..	.. ..	.. ..
68	7	N	.. .. .	.. .. .	.. .. .	.. .. .	.. ..	.. ..	.. ..
69	8	N	.. .. .	.. .. .	.. .. .	.. .. .	.. ..	.. ..	.. ..
70	8	N	.. .. .	.. .. .	.. .. .	.. .. .	.. ..	.. ..	.. ..
71	8	N	.. .. .	.. .. .	.. .. .	.. .. .	.. ..	.. ..	.. ..
72	8	N	.. .. .	.. .. .	.. .. .	.. .. .	.. ..	.. ..	.. ..
73	8	N	.. .. .	.. .. .	.. .. .	.. .. .	.. ..	.. ..	.. ..
74	8	N	.. .. .	.. .. .	.. .. .	.. .. .	.. ..	.. ..	.. ..
75	8	N	.. .. .	.. .. .	.. .. .	.. .. .	.. ..	.. ..	.. ..
76	8	N	.. .. .	.. .. .	.. .. .	.. .. .	.. ..	.. ..	.. ..
77	8	N	.. .. .	.. .. .	.. .. .	.. .. .	.. ..	.. ..	.. ..
78	8	N	.. .. .	.. .. .	.. .. .	.. .. .	.. ..	.. ..	.. ..
79	8	N	.. .. .	.. .. .	.. .. .	.. .. .	.. ..	.. ..	.. ..
80	8	N	.. .. .	.. .. .	.. .. .	.. .. .	.. ..	.. ..	.. ..
81	8	N	.. .. .	.. .. .	.. .. .	.. .. .	.. ..	.. ..	.. ..
82	8	N	.. .. .	.. .. .	.. .. .	.. .. .	.. ..	.. ..	.. ..
83	8	N	.. .. .	.. .. .	.. .. .	.. .. .	.. ..	.. ..	.. ..
84	8	N	.. .. .	.. .. .	.. .. .	.. .. .	.. ..	.. ..	.. ..
85	8	N	.. .. .	.. .. .	.. .. .	.. .. .	.. ..	.. ..	.. ..
86	8	N	.. .. .	.. .. .	.. .. .	.. .. .	.. ..	.. ..	.. ..
87	8	N	.. .. .	.. .. .	.. .. .	.. .. .	.. ..	.. ..	.. ..
88	8	N	.. .. .	.. .. .	.. .. .	.. .. .	.. ..	.. ..	.. ..
89	8	N	.. .. .	.. .. .	.. .. .	.. .. .	.. ..	.. ..	.. ..
90	8	N	.. .. .	.. .. .	.. .. .	.. .. .	.. ..	.. ..	.. ..
91	8	N	.. .. .	.. .. .	.. .. .	.. .. .	.. ..	.. ..	.. ..
92	8	N	.. .. .	.. .. .	.. .. .	.. .. .	.. ..	.. ..	.. ..
93	8	N	.. .. .	.. .. .	.. .. .	.. .. .	.. ..	.. ..	.. ..
94	8	N	.. .. .	.. .. .	.. .. .	.. .. .	.. ..	.. ..	.. ..
95	8	N	.. .. .	.. .. .	.. .. .	.. .. .	.. ..	.. ..	.. ..
96	8	N	.. .. .	.. .. .	.. .. .	.. .. .	.. ..	.. ..	.. ..
97	8	N	.. .. .	.. .. .	.. .. .	.. .. .	.. ..	.. ..	.. ..
98	8	N	.. .. .	.. .. .	.. .. .	.. .. .	.. ..	.. ..	.. ..
99	8	N	.. .. .	.. .. .	.. .. .	.. .. .	.. ..	.. ..	.. ..
100	8	N	.. .. .	.. .. .	.. .. .	.. .. .	.. ..	.. ..	.. ..

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>
71	1912 June 8	N	.. .. .	.. .. .	13 17 56	13 20 04	13 28	.. .. .	0.2
		E	.. .. .	.. .. .	13 17 30	13 22 18	13 27	.. .. .	0.1
72	10	N	16 15 53	.. .. .	16 25 ..	16 23 27	16 40	17 08	0.3
		E	16 13 33	.. .. .	16 26 ..	16 23 45	16 40	17 36	0.4
73	12	N	12 49 01	.. .. .	12 54 ..	13 00 38	13 06	13 27	0.8
		E	12 49 06	.. .. .	12 54 ..	13 00 34	13 08	13 34	0.5
74	July 7	N	8 04 39	8 10 31	8 15 59	8 20 47	8 31	10 01	6.0
		E	8 05 07	8 11 09	8 16 19	8 21 15	8 34	9 54	8.4
75	8	N	22 01 04	.. .. .	22 15 00	22 20 30	22 23	23 00	0.4
		E	22 01 31	.. .. .	22 14 58	22 18 58	22 23	23 00	0.8
76	22	N	9 53 25	.. .. .	9 55 05	9 55 17	.. .. .	10 03	0.2
		E	9 53 50	.. .. .	9 54 41	9 56 05	.. .. .	10 04	0.2
77	23	N	.. .. .	22 47 10	22 48 48	22 49 24	22 50	23 03	0.2
		E	.. .. .	22 47 42	22 48 16	22 48 40	22 50	22 58	0.4
78	24	N	12 07 24	12 14 58	12 22 32	12 24 58	12 31	13 00	0.2
		E	12 08 14	12 15 02	12 22 34	12 26 02	12 34	12 56	0.2
79	25	E	23 24 10	23 39 28	23 52 50	24 01 28	24 18	24 45	0.1
80	31	N	.. .. .	9 38 13	9 38 43	9 39 03	9 40	9 44	0.2
81	Aug. 6	N	21 24 48	21 34 08	21 48 10	22 12 24	22 15	22 34	0.1
		E	21 24 57	21 34 12	21 40 56	22 07 56	22 15	22 29	0.1
82	9	N	1 44 00	1 53 34	2 11 38	2 32 20	2 55	3 51	1.4
		E	1 47 32	1 54 06	2 10 10	2 23 38	2 58	3 56	3.0
83	17	N	.. .. .	.. .. .	20 06 21	20 16 14	20 30	21 10	0.1
		E	19 37 30	.. .. .	20 04 10	20 08 50	20 35	21 09	0.3
84	18	N	21 11 43	.. .. .	21 12 39	21 13 07	21 16	21 31	2.5
		E	21 11 29	.. .. .	21 12 21	21 12 29	21 15	21 29	4.0
85	Sept. 10	N	16 15 17	.. .. .	.. .. .	16 18 00	.. .. .	16 30	0.1
		E	16 14 12	.. .. .	.. .. .	16 17 00	.. .. .	16 33	0.1
86	14	N	.. .. .	.. .. .	0 30 ..	.. .. .	0 41	.. .. .	0.1
87	29	N	21 10 03	21 29 14	21 43 27	21 48 30	22 07	22 38	0.2
		E	21 10 20	21 19 32	21 40 30	21 52 30	22 11	22 48	0.8
88	Oct. 18	N	12 04 11	12 12 11	12 20 15	12 24 26	12 32	12 51	0.1
		E	12 04 16	12 12 11	12 26 50	12 32 02	12 35	12 56	0.1
89	25	N	15 21 34	.. .. .	.. .. .	.. .. .	.. .. .	15 38	0.1
		E	15 21 03	.. .. .	.. .. .	.. .. .	.. .. .	15 47	0.1
90	Nov. 7	N	7 47 43	7 53 44	7 59 22	8 00 30	8 02	9 11	0.4
		E	7 47 41	7 53 43	7 59 11	8 00 06	8 03	9 08	0.4
91	7	N	16 51 04	.. .. .	17 03 16	17 07 16	.. .. .	17 22	0.1
		E	16 50 17	.. .. .	17 02 26	17 08 36	.. .. .	17 22	0.1
92	7	N	17 36 02	17 43 08	17 48 03	17 51 10	17 58	18 10	0.2
		E	17 36 01	17 42 01	17 47 23	17 48 32	17 55	18 12	0.2
93	19	N	13 58 46	14 00 01	14 03 06	14 04 01	14 12	14 43	15.4
		E	13 58 48	14 00 20	14 02 53	14 04 03	14 14	14 45	19.0
94	22	N	5 50 26	5 53 59	5 58 03	5 56 40	5 59	6 08	0.2
		E	5 50 25	5 53 37	5 54 54	5 55 44	5 58	6 14	0.2
95	25	N	9 04 55	9 09 17	9 14 40	9 15 50	9 19	9 38	0.1
		E	9 04 43	9 09 09	9 16 11	9 13 47	9 19	9 31	0.1
96	25	E	19 11 58	.. .. .	19 16 56	19 17 36	19 19	20 37	0.1
97	Dec. 5	N	12 34 44	12 40 36	12 46 00	12 36 44	12 50	13 04	0.2
		E	12 34 46	12 40 42	.. .. .	12 36 48	.. .. .	13 02	0.2
98	5	N	17 49 38	.. .. .	17 53 44	17 56 46	17 57	18 22	0.2
		E	17 49 03	.. .. .	17 54 04	17 56 48	17 59	18 18	0.2
99	7	N	22 57 20	.. .. .	23 06 32	23 06 37	23 10	.. .. .	0.9
		E	22 57 45	.. .. .	23 06 27	23 06 33	23 10	23 39	0.4
100	9	N	8 37 33	8 42 01	8 45 25	8 48 35	8 51	9 42	12.8
		E	8 37 36	8 42 10	8 45 30	8 46 04	8 51	9 45	7.0
101	17	N	10 40 31	.. .. .	10 42 00	10 42 28	10 46	.. .. .	0.1
		E	10 35 54	.. .. .	.. .. .	10 40 35	10 46	.. .. .	0.1
102	22	N	.. .. .	.. .. .	21 12 54	21 15 27	21 17	.. .. .	0.1
		E	.. .. .	.. .. .	21 12 45	21 15 29	21 17	21 26	0.2
103	22	N	23 29 23	.. .. .	23 29 48	23 30 08	23 33	23 44	0.3
		E	23 29 12	.. .. .	23 29 19	23 29 35	23 33	23 47	0.3
104	31	N	6 45 11	.. .. .	6 50 50	6 51 51	.. .. .	6 55	0.1
		E	6 44 44	.. .. .	6 50 44	6 51 16	.. .. .	6 55	0.1
105	31	N	6 55 35	.. .. .	6 56 09	6 56 14	6 57	7 00	0.1
		E	6 55 35	.. .. .	6 56 00	6 56 12	6 57	7 01	0.2

## REMARKS.

Nos. 16, 17, 18 Near-by earthquakes. - Short period waves of small amplitude. Phases not well defined.

No. 20. E-W driving clock not running.

No. 26. Mexican earthquake. The E-W stylus was off the paper from 11:10 to 11:23. The N-S stylus went off at 11:12 and did not come back. Recorded also on magnetogram.

No. 33. Actual maximum at 16:50:35; 0.9 mm. on N. 0.4 mm. on E.

No. 39. No apparent motion of E.

No. 40. Phases of E could not be determined.

No. 48. Principal portion lost on account of pointers going off the paper.

Nos. 53 and 62. N record indistinct.

No. 64. Nothing on E.

No. 76. Phases not well marked.

No. 79. Motion on N too slight to distinguish phases.

No. 80. Beginning uncertain. E not running.

No. 81. Phases not distinct.

No. 82. Beginning on E doubtful.

No. 83. Phases on N very doubtful.

No. 84. Felt at Flagstaff, Ariz.

No. 88. Phases not well defined. Possibly microseismic tremors at the beginning.

No. 93. Near Mexico City. Recorded also on magnetogram.

No. 96. This may be partly microseismic tremors. Nothing on N.

Nos. 101, 102. Phases doubtful.

During July and August, 1912, the time-marking device was out of order and a uniform rate of driving clocks was assumed.

Microseismic tremors were present on October 26 and 27, November 17, 18, and 22, 1912.

## MAGNETIC STORMS.

In the table below the relative magnitude of the disturbances 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 7<sup>h</sup> 23<sup>m</sup>.

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. Upward motion of the curves corresponds to decreasing east declination, increasing *H* and decreasing *Z*.

Serial No. 23

DEPARTMENT OF COMMERCE

U. S. COAST AND GEODETIC SURVEY

F. LESTER JONES, SUPERINTENDENT

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RESULTS OF OBSERVATIONS MADE AT THE UNITED  
STATES COAST AND GEODETIC SURVEY MAGNETIC  
OBSERVATORY NEAR TUCSON, ARIZONA  
1913 AND 1914

---

BY

DANIEL L. HAZARD

Assistant Chief, Division of Terrestrial Magnetism



WASHINGTON  
GOVERNMENT PRINTING OFFICE

1916

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**EARTHQUAKES.**

A Bosch-Omori seismograph has been in continuous operation since September, 1910. It consists of two horizontal pendulums, one recording east-west motion (E) and the other recording north-south motion (N). The times in the table below are Greenwich mean time, counted from midnight.

*Period of pendulums.*

	N	E
	s	s
Jan. 1-Feb. 8, 1913.....	18	18
Feb. 21-Mar. 3, 1913.....	20	23
Mar. 8-May 30, 1913.....	21	15
June 1-Oct. 2, 1913.....	21	17
Oct. 11-Dec. 6, 1913.....	19	16
January-December, 1914.....	19	16

Magnification, 10; steady mass, 10-12 kilograms.

*Register of earthquakes.*

No.	Date	Component	First preliminary tremors begin			Second preliminary tremors begin			Large waves begin			Maximum			End of principal portion		End	Maximum amplitude
			h	m	s	h	m	s	h	m	s	h	m	s	h	m		
106	Jan. 5	N	...	...	...	...	...	...	7 44 23	7 44 23	7 44 36	7 46	7 49	0.1				
		E	...	...	...	...	...	...	7 44 23	7 44 44	7 46	7 50	0.2					
107	15	N	18 58 35	19 03 46	19 10 08	19 12 04	19 18	19 52	0.4									
		E	18 58 42	19 04 24	19 10 28	19 12 04	19 16	19 47	0.2									
108	19	E	...	...	...	1 45 11	1 51 02	1 58	...	0.1								
109	31	N	22 51 32	22 55 02	22 57 25	22 57 58	23 00	23 51	0.3									
		E	22 51 29	22 55 00	22 57 23	22 58 45	23 00	23 54	0.2									
110	Feb. 8	N	...	...	...	2 50 43	2 51 30	2 53	...	0.1								
		E	...	...	...	2 50 39	2 51 22	2 52	...	0.2								
111	21	N	...	...	...	19 07 35	19 08 00	19 09	...	0.1								
		E	...	...	...	19 07 47	19 08 00	19 09	...	0.2								
112	23	N	3 10 00	...	...	3 20 28	3 20 43	3 23	3 47	0.1								
		E	3 09 19	3 12 58	3 15 42	3 16 34	3 18	3 41	0.1									
113	Mar. 3	N	3 07 33	3 09 51	3 13 31	3 13 53	3 14	3 27	0.2									
		E	3 07 41	3 10 43	3 13 29	3 13 44	3 14	3 35	0.1									
114	8	N	15 58 58	16 03 40	16 06 51	16 09 10	16 13	16 34	0.5									
		E	15 58 48	16 03 17	16 06 54	16 09 24	16 12	16 35	1.8									
115	14	N	9 05 43	...	...	9 14 10	9 16 36	9 17	...	0.1								
		E	9 05 34	9 11 08	9 14 12	9 16 32	9 17	...	1.2									
116	14	N	...	...	...	9 32 58	9 34 09	9 41	...	0.2								
		E	...	...	...	9 32 42	9 57 14	9 40	10 51	0.5								
117	15	N	...	...	...	14 24 18	14 26 29	14 28	...	0.1								
		E	...	...	...	14 24 41	14 26 54	14 28	14 35	0.2								
118	15	N	22 20 09	...	...	22 20 56	22 22 21	22 23	22 36	1.0								
		E	22 20 05	...	...	22 20 56	22 21 52	22 26	22 35	1.9								
119	31	N	3 50 05	3 53 37	4 03 07	4 12 46	4 32	8 00	0.1									
		E	3 50 19	3 53 00	4 05 00	4 12 00	4 23	8 40	0.3									
120	Apr. 26	E	...	...	...	12 49 50	12 55 05	12 57	...	0.2								
121	May 6	N	...	...	...	0 38 10	0 38 19	0 43	...	0.1								
		E	...	...	...	0 38 43	0 39 23	0 41	0 46	0.1								
122	8	E	18 47 08	18 51 04	18 55 29	18 57 21	19 01	19 24	0.2									
123	17	N	...	...	...	9 44 27	9 44 36	9 46	...	0.6								
		E	9 43 32	9 43 58	9 44 12	9 44 23	9 47	10 05	1.0									
124	30	E	...	...	...	12 33 02	12 40 06	12 44	13 31	0.4								
125	June 14	N	8 42 00	8 46 02	8 48 43	8 51 45	8 54	9 24	4.6									
		E	8 40 40	8 44 52	8 47 53	8 48 20	8 52	...	2.8									
126	22	N	14 07 00	...	...	14 14 37	14 16 52	14 25	15 17	0.3								
		E	14 06 59	14 10 57	14 16 38	14 21 46	14 26	15 17	0.2									
127	26	N	5 09 26	5 19 44	5 28 35	5 34 54	5 37	7 50	0.4									
		E	5 09 39	5 19 34	5 34 34	5 40 45	5 47	7 48	0.3									
128	July 4	E	6 54 55	6 57 56	7 01 29	7 01 40	7 02	7 18	0.2									
		N	...	...	...	0 18 52	0 20 40	0 24	0 35	0.1								
129	9	E	0 10 03	...	...	0 18 44	0 20 34	0 22	0 32	0.1								
		N	...	...	...	6 09 31	6 12 04	6 17	6 55	0.1								
131	Aug. 6	N	22 23 58	22 32 03	22 43 15	22 49 52	22 50	23 39	11.6									
		E	22 23 40	22 33 04	22 42 39	22 47 30	22 52	...	2.0									
132	Oct. 2	N	4 32 12	4 35 54	4 42 34	4 47 49	4 53	5 36	0.4									
		E	4 32 15	4 36 34	4 42 37	4 44 25	4 54	...	0.1									

No.	Date	Compo- nent	First prelimi- nary tremors begin	Second prelimi- nary tremors begin	Large waves begin	Maximum	End of principal portion	End	Maxi- mum ampli- tude
			<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>
133	1913. 11	N E	.. .. .	.. .. .	4 48 43	4 49 53	4 53	5 32	0.2
134	14	N E	8 21 44	8 28 44	8 32 08	8 34 08	8 36	9 10	0.4
135	26	E	8 21 46	8 28 52	8 33 30	8 35 30	8 36	9 16	0.2
136	Dec. 6	E N E	13 35 52	13 36 01	13 36 20	13 36 30	13 37	14 04	0.4
			0 16 10	.. .. .	0 17 00	0 17 50	0 19	0 30	1.4
			0 16 16	.. .. .	0 17 52	0 17 28	0 18	0 31	1.9
137	1914. Jan. 30	N E	.. .. .	.. .. .	4 10 04	4 15 58	4 28	.. .. .	0.1
			.. .. .	.. .. .	4 14 51	4 15 11	4 25	.. .. .	0.2
138	Feb. 28	N E	5 20 40	5 22 50	5 23 59	5 27 36	5 30	5 39	0.2
			5 20 44	5 22 59	5 24 45	5 27 57	5 29	.. .. .	0.2
139	Mar. 9	N E	.. .. .	.. .. .	3 25 15	3 25 39	3 28	.. .. .	0.1
			.. .. .	.. .. .	3 25 16	3 25 38	3 28	.. .. .	0.1
140	9	N E	.. .. .	.. .. .	5 09 37	5 10 08	5 11	5 19	0.1
			.. .. .	.. .. .	5 09 37	5 10 20	5 11	5 19	0.1
141	24	N E	16 21 48	.. .. .	16 23 09	16 24 59	16 26	16 38	0.2
			16 21 48	.. .. .	16 23 08	16 23 21	16 26	16 40	0.3
142	30	N E	0 45 50	0 50 14	0 52 08	0 56 12	0 59	2 03	35+
			0 45 50	0 50 08	0 52 36	0 54 13	0 58	2 03	36+
143	Apr. 20	N E	13 39 26	13 43 58	13 46 54	13 55 56	14 00	14 17	0.2
			13 39 32	13 44 00	13 47 10	13 50 57	13 57	14 17	0.2
144	24	N E	8 39 28	8 39 51	8 40 06	8 40 53	8 42	8 50	1.1
			8 39 39	8 39 52	8 40 07	8 40 49	8 41	8 53	1.4
145	May 26	N E	4 17 12	.. .. .	4 17 20	4 17 27	4 19	.. .. .	0.1
			4 17 16	.. .. .	4 17 28	4 17 59	4 19	.. .. .	0.1
146	26	N E	14 50 ..	.. .. .	15 06 ..	15 33 ..	.. .. .	16 48	0.2
			14 42 ..	.. .. .	15 15 ..	15 28 ..	.. .. .	16 47	0.3
147	26	N E	.. .. .	.. .. .	22 28 05	22 28 31	22 33	.. .. .	0.1
			.. .. .	.. .. .	22 28 02	22 29 18	22 31	.. .. .	0.1
148	28	N E	18 04 00	18 07 19	18 10 03	18 12 04	18 14	18 37	1.3
			.. .. .	18 07 29	18 10 01	18 12 07	18 15	18 37	1.3
149	28	N E	18 56 51	19 01 25	19 03 51	19 06 23	19 09	19 31	0.6
			18 56 54	19 01 15	.. .. .	19 06 38	19 09	19 32	0.7
150	June 20	E	7 33 15	.. .. .	7 43 33	7 44 49	7 49	8 31	0.1
151	25	N E	19 26 51	.. .. .	19 30 22	19 30 40	19 32	19 43	0.2
			19 26 18	.. .. .	19 30 20	19 30 27	19 31	19 53	0.2
152	25	N	20 06 ..	.. .. .	20 11 04	20 32 ..	20 41	20 56	0.1
153	26	N E	.. .. .	.. .. .	.. .. .	.. .. .	.. .. .	.. .. .	.. .. .
154	July 6	N E	3 06 00	.. .. .	3 06 38	3 06 49	3 08	3 23	0.1
			3 06 01	.. .. .	.. .. .	3 07 19	3 10	3 28	0.1
155	6	N E	4 00 11	.. .. .	4 00 33	4 01 04	4 05	.. .. .	0.2
			4 00 11	.. .. .	4 00 28	4 01 25	4 05	.. .. .	0.3
156	21	N E	9 58 12	.. .. .	9 58 39	9 58 52	10 00	10 06	0.3
			9 58 13	.. .. .	9 58 36	9 58 55	10 00	10 06	0.2
157	21	N E	22 36 48	22 40 44	22 45 25	22 46 22	22 50	.. .. .	0.1
			22 36 34	22 40 53	22 45 23	22 45 57	22 50	.. .. .	0.1
158	Aug. 4	N E	.. .. .	.. .. .	23 31 ..	23 44 58	24 00	.. .. .	0.2
			.. .. .	.. .. .	23 31 ..	23 45 05	23 55	.. .. .	0.1
159	8	N E	19 11 48	19 13 13	19 15 12	19 16 29	19 20	19 50	2.5
			19 11 48	.. .. .	19 15 12	19 17 55	19 21	19 50	4.1
160	13	N E	15 33 38	.. .. .	15 34 06	15 34 14	15 38	.. .. .	0.2
			15 33 36	.. .. .	15 34 00	15 34 24	15 38	.. .. .	0.3
161	22	N E	5 32 50	5 36 30	5 38 52	5 43 32	5 47	6 00	0.6
			5 32 50	5 36 33	5 38 43	5 41 15	5 45	5 56	0.3
162	Sept. 10	N E	1 06 05	.. .. .	.. .. .	1 06 23	.. .. .	1 08	0.1
			1 05 59	.. .. .	1 06 12	1 06 29	.. .. .	1 08	0.1
163	10	N E	1 41 31	.. .. .	1 41 41	1 42 06	1 43	1 47	0.3
			1 41 12	.. .. .	1 41 31	1 41 58	1 43	1 50	0.5
164	10	N E	.. .. .	.. .. .	1 58 12	1 58 38	.. .. .	1 59	0.1
			1 57 46	.. .. .	1 57 58	1 58 22	.. .. .	2 00	0.2
165	10	N E	9 55 37	.. .. .	9 56 13	9 56 28	9 58	10 04	0.7
			9 55 33	.. .. .	9 56 02	9 56 21	9 59	10 05	1.5
166	Oct. 3	N E	17 31 18	17 37 50	17 43 36	17 52 46	17 57	18 27	0.3
			17 30 51	17 37 49	.. .. .	17 56 40	18 05	18 20	0.1
167	22	N E	6 44 16	.. .. .	6 45 08	6 46 21	6 48	6 56	0.8
			6 44 09	.. .. .	6 44 53	6 45 42	6 47	6 55	0.8
168	Nov. 1	N E	.. .. .	.. .. .	5 53 24	5 54 06	5 56	.. .. .	0.1
			.. .. .	.. .. .	5 53 30	5 54 10	5 56	.. .. .	0.1
169	18	N E	.. .. .	.. .. .	9 58 09	10 04 23	10 16	.. .. .	0.5
			.. .. .	.. .. .	9 58 42	9 59 52	10 18	.. .. .	0.1
170	24	N E	.. .. .	12 16 32	12 26 30	12 32 12	12 38	.. .. .	0.2
			12 06 12	12 16 30	12 26 40	12 37 20	12 50	13 13	0.1



## REMARKS.

- No. 130. E not in proper adjustment.  
 No. 132. Actual maximum (0.2 millimeter) on E occurred at 4:32:42 during first preliminary tremors.  
 No. 135. Drum of N disconnected.  
 No. 142. Maximum amplitudes greater than the values given. Both pendulums struck the limiting brushes on both sides.  
 No. 146. Phases indistinct.  
 No. 150. No definite phases on N; only a few small waves.  
 No. 152. Barely perceptible on E.  
 No. 153. Faint indications of a distant earthquake from 5.10 to 5.40 on both seismograms.  
 No. 166. On E the actual maximum (0.8 millimeter) occurred at 17:38:04.  
 No. 170. The actual maximum occurred at 12:17:11, 0.8 millimeter on N and 3.5 millimeters on E.  
 Microseismic tremors were present on July 19, 22-26; August 6, 7; September 7, 11-14, 19, 20; October 28, 29; December 18, 1913.

## MAGNETIC STORMS.

In the following table the relative magnitude of the disturbances is indicated by the figures 1, 2, 3. 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 7<sup>h</sup> 23<sup>m</sup>.

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. Upward motion of the curves corresponds to decreasing east declination, increasing *H* and decreasing *Z*.

*Principal magnetic disturbances.*

Date	Local mean time of beginning	Duration in hours	Relative magnitude	Date	Local mean time of beginning	Duration in hours	Relative magnitude
1913.	<i>h m</i>			1914.	<i>h m</i>		
Jan. 2*	3 51	31	2	Feb. 28	7	45	1
9	4	34	1	Mar. 5	17	32	1
17	17	39	1	15	4	20	1
29	16 01	20	1	17	11	16	1
Feb. 11	18	111	2	31	18	23	1
24	18	58	2	Apr. 5*	19	78	3
Mar. 13*	21 03	109	2	15	14	32	1
20	19	33	1	18	12	15	1
28	23	72	1	May 14	21	32	1
Apr. 8*	12 30	109	3	16	16	30	1
14	18	77	1	25	11	41	1
May 3	20	101	2	30	22 33	43	2
31	22	94	2	June 19	10	30	1
June 28	10	44	1	24*	18 37	132	2
July 12	0	50	1	July 4*	18 03	58	2
19	23 06	27	1	24	13	62	1
23	23	48	1	28*	12	160	2
Aug. 8	19	103	1	Aug. 5	18	30	1
Sept. 5*	18	181	2	19	12	15	1
22	0	30	1	22	21	21	1
Oct. 4*	10	156	2	28	12	64	1
18	0 15	36	1	Sept. 17	16	15	1
Nov. 1	18	38	1	22	14	35	1
6	17	31	1	26*	21	27	2
27	7	48	1	30	14	33	1
Dec. 4	1	25	1	Oct. 26*	16	84	2
24	17	42	1	Nov. 2	21	48	1
				10	10	60	1
1914.				26*	10	42	1
Jan. 4	12 38	36	1	Dec. 16	8	22	1
21	10	35	1	26	23	40	1

Serial No. 75

DEPARTMENT OF COMMERCE  
U. S. COAST AND GEODETIC SURVEY

F. LESTER JONES, SUPERINTENDENT

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RESULTS OF OBSERVATIONS MADE AT THE UNITED  
STATES COAST AND GEODETIC SURVEY MAGNETIC  
OBSERVATORY NEAR TUCSON, ARIZONA  
1915 AND 1916

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BY

DANIEL L. HAZARD  
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EARTHQUAKES.

A Bosch-Omori seismograph has been in continuous operation since September, 1910. It consists of two horizontal pendulums, one recording east-west motion (E) and the other recording north-south motion (N). The times in the table are Greenwich mean time, counted from midnight.

*Period of pendulums.*

	N	E
January to December, 1915.....	19.6	16.0
January 15 to March 31, 1916.....	19.0	15.2
April 2 to December 31, 1916.....	19.0	14.0

Magnification, 10; steady mass, 10 to 12 kg.

The nomenclature of the International Seismological Association has been used in the table 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.

C=End of principal portion.

F=End of visible record.

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

*Register of earthquakes.*

No.	Date.	Comp.	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>
171	1915 Jan. 12	N	...	...	4 35 36	4 36 01	4 39	...	0.1
		E	...	...	4 35 18	4 36 30	4 39	4 46	0.3
172	13	N	...	...	7 35 ..	7 38 ..	7 48	...	0.1
		E	...	...	7 35 ..	7 38 ..	7 57	...	0.1
173	Feb. 14	N	...	...	11 34 09	11 35 54	11 37	...	0.1
174	25	N	...	...	20 57 04	20 57 24	21 00	...	0.1
		E	...	...	20 57 06	20 57 27	21 01	...	0.5
175	Mar. 5	N	...	...	4 23 06	4 25 04	4 28	4 34	0.3
		E	...	...	4 22 46	4 23 36	4 28	4 39	1.0
176	28	N	19 52 10	...	19 56 23	19 57 23	20 00	20 06	0.2
		E	19 52 07	...	19 55 22	19 57 08	20 02	20 10	0.3
177	Apr. 10	N	...	...	0 52 37	0 53 33	0 56	...	0.1
		E	...	...	0 52 18	0 54 28	1 00	...	0.1
178	23	N	...	...	15 44 49	15 44 55	15 47	15 52	0.1
		E	...	...	15 44 49	15 44 53	15 47	15 55	0.2
179	May 1	N	5 11 20	5 20 32	5 29 20	5 36 40	5 39	7 35	0.4
		E	5 11 18	5 20 20	5 29 12	5 35 23	5 44	7 36	1.0
180	6	N	12 12 41	...	12 17 42	12 18 54	12 26	12 58	1.1
		E	12 12 43	...	12 18 41	12 19 38	12 27	13 08	1.0
181	27	N	...	...	14 22 06	14 23 10	14 25	...	0.1
182	27	N	...	...	14 39 20	14 40 14	14 43	...	0.1
		E	...	...	14 39 20	14 40 24	14 46	...	0.1
183	27	N	...	...	16 39 00	16 39 30	16 41	...	0.1
		E	...	...	16 38 54	16 40 05	16 42	...	0.1
184	27	N	...	...	19 27 00	19 27 40	19 30	...	0.1
		E	...	...	19 27 06	19 28 16	19 30	...	0.1
185	27	N	...	...	19 32 12	19 32 48	19 34	...	0.4
		E	...	...	19 32 00	19 33 01	19 34	...	0.5
186	27	N	...	...	19 49 50	19 51 08	19 53	...	0.3
		E	...	...	19 50 00	19 51 10	19 54	...	0.3
187	29	N	...	...	6 49 42	6 50 04	6 53	...	0.7
		E	...	...	6 49 47	6 50 36	6 51	...	0.9
188	29	N	...	...	8 33 40	8 34 16	8 36	...	0.2
		E	...	...	8 33 27	8 34 05	8 36	...	0.2
189	June 1	N	15 03 49	...	15 15 48	15 22 42	15 28	15 47	0.8
		E	15 03 09	...	15 15 50	15 18 08	15 22	15 50	1.2

## Register of earthquakes—Continued.

No.	Date.	Comp.	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>
190	1915. June 6	N	21 40 01	21 48 31	21 56 18	22 09 28	22 11	22 27	0.2
		E	21 39 59	21 48 33	21 56 16	22 00 12	22 10	22 35	0.3
191	23	N	3 59 47	...	4 00 42	4 01 04	4 02	4 27	6.8
		E	3 59 46	...	4 00 57	4 01 58	4 02	4 32	3.0
192	23	N	4 56 35	...	4 57 25	4 57 38	4 59	5 25	3.0
		E	4 56 31	...	4 57 28	4 57 35	4 59	5 25	5.1
193	July 31	N	1 41 56	1 50 29	...	2 08 50	2 10	2 41	0.1
		E	1 41 51	1 50 25	2 02 38	2 05 07	2 09	2 46	0.3
194	Sept. 7	N	1 26 37	1 31 30	1 35 11	1 41 42	1 42	2 23	11.7
		E	1 26 37	1 31 16	1 35 06	1 38 23	1 43	3 05	22.8
195	7	N	...	...	4 35 20	4 44 50	5 09	...	0.1
		E	...	...	4 35 22	4 41 46	4 56	...	0.1
196	Oct. 2	N	...	...	23 44 31	23 46 20	23 51	...	0.2
		E	...	...	23 44 39	23 45 30	23 50	...	0.6
197	3	N	1 53 00	...	1 53 50	1 54 02	1 56	2 04	2.5
		E	1 52 51	...	1 53 41	1 53 51	1 56	2 08	3.3
198	3	N	6 55 22	...	6 58 21	6 59 58	7 06	8 11	49.0
		E	6 55 40	...	6 58 25	6 59 39	7 13	8 50	43+
199	12	E	...	...	2 24 14	2 24 44	2 29	...	0.1
200	28	N	...	...	16 05 10	16 05 50	16 11	...	0.2
		E	...	...	16 05 16	16 06 55	16 08	...	0.3
201	Nov. 21	N	0 14 52	...	0 15 57	...	0 24	1 26	38+
		E	0 14 44	...	0 15 58	0 16 38	0 19	1 25	46.1
202	21	N	...	...	3 46 52	3 47 18	3 52	...	0.1
		E	...	...	3 46 55	3 47 50	3 50	...	0.2
203	Dec. 13	N	...	...	5 13 28	5 14 04	5 16	...	0.1
		E	...	...	5 13 30	5 14 10	5 16	...	0.1
204	31	N	...	...	12 29 24	12 29 36	12 31	12 36	0.4
		E	12 23 36	...	12 29 06	12 29 38	12 30	13 02	4.7
205	1916 Jan. 1	E	...	...	14 05 35	14 13 50	14 25	15 57	5.0
206	13	E	...	...	7 13 48	7 24 00	7 35	...	0.1
207	13	N	...	...	8 56 ..	9 28 39	...	10 21	0.1
		E	...	...	8 55 50	9 15 35	...	10 37	0.6
208	15	N	10 00 27	...	10 01 17	10 01 53	...	10 08	0.1
		E	10 00 27	...	10 01 17	10 01 26	...	10 08	0.3
209	24	N	...	...	7 48 25	7 57 15	8 12	...	0.2
		E	...	...	7 46 ..	7 56 55	8 15	...	0.1
210	Feb. 3	N	5 05 42	...	5 06 45	5 07 38	...	5 19	0.3
		E	5 05 48	...	5 06 44	5 06 50	...	5 18	0.2
211	6	N	22 00 06	22 08 30	22 16 06	22 23 11	22 30	23 38	0.2
		E	22 00 26	22 08 28	22 18 14	22 26 06	22 30	23 37	0.4
212	15	N	...	...	11 42 34	11 48 04	12 20	...	0.1
		E	...	...	11 49 17	11 59 47	12 18	...	0.1
213	20	N	17 56 20	...	18 07 00	18 09 22	18 20	19 12	0.3
		E	...	...	18 06 26	18 15 46	18 22	19 14	0.2
214	27	N	20 27 38	...	20 37 42	20 46 21	20 57	21 59	20.7
		E	20 27 46	...	20 38 59	20 41 20	20 48	22 28	10.4
215	Mar. 12	N	7 36 40	...	7 40 44	7 45 22	...	7 52	0.1
		E	...	...	7 41 38	7 46 38	...	7 55	0.1
216	25	N	...	...	0 03 22	0 04 49	...	0 07	0.1
		E	...	...	0 04 14	0 04 40	...	0 06	0.1
217	31	E	11 20 26	...	11 25 21	11 25 46	11 26	11 34	0.6
218	Apr. 2	N	...	...	8 35 ..	8 37 32	...	8 43	0.1
		E	...	...	8 35 ..	8 36 40	...	8 42	0.1
219	2	N	...	...	18 58 42	18 59 19	...	19 07	0.1
		E	...	...	18 58 43	18 59 08	...	19 07	0.4
220	14	N	20 36 01	...	20 42 05	20 42 34	20 46	20 54	0.4
		E	20 35 57	...	20 41 35	20 42 27	20 46	20 53	0.5
221	16	N	22 31 27	...	22 36 24	22 38 37	22 41	23 05	1.5
		E	...	22 33 57	22 36 30	22 38 37	22 39	22 55	0.5
222	18	E	4 10 07	4 17 03	...	4 32 25	4 44	6 56	0.1
223	21	E	11 54 48	...	12 14 18	12 17 15	12 23	12 47	0.2
224	24	N	...	...	4 40 14	4 43 42	5 07	...	0.1
		E	...	...	4 36 05	4 45 10	5 14	...	0.1
225	24	N	8 08 52	...	8 17 46	8 28 01	8 36	9 07	0.9
		E	8 08 52	...	8 17 12	8 29 39	8 35	9 22	0.6
226	26	N	2 28 22	...	2 38 56	2 41 55	...	3 10	0.4
		E	2 28 26	...	2 39 02	2 43 03	...	3 07	0.6
227	May 11	N	10 08 11	...	10 09 20	10 09 34	10 17	10 51	2.3
		E	10 07 14	...	10 08 40	10 08 58	10 17	10 29	3.8
228	26	E	...	...	21 01 50	21 03 43	21 04	21 08	0.2

Register of earthquakes—Continued.

No.	Date.	Comp.	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>
229	June 2	N	14 03 56	.. .. .	14 07 46	14 07 49	14 15	.. ..	0.5
		E	14 04 00	.. .. .	14 07 46	14 07 54	14 15	.. ..	0.6
230	19	N	.. .. .	.. .. .	1 34 23	.. .. .	.. ..	1 36	0.1
		E	.. .. .	.. .. .	1 33 36	.. .. .	.. ..	1 42	0.1
231	21	N	.. .. .	.. .. .	21 52 16	.. .. .	.. ..	21 58	.. .
		E	.. .. .	.. .. .	21 52 24	.. .. .	.. ..	21 56	.. .
232	25	N	.. .. .	.. .. .	18 25 28	18 26 24	18 31	18 36	0.6
		E	.. .. .	.. .. .	18 25 39	18 26 ..	18 27	18 30	4.0
233	30	N	3 12 57	.. .. .	3 21 21	3 26 36	3 27	3 42	0.9
		E	.. .. .	3 18 38	3 21 30	3 25 43	3 27	3 49	1.3
234	Aug. 2	N	20 36 34	.. .. .	.. .. .	.. .. .	.. ..	20 48	.. .
		E	20 37 13	.. .. .	.. .. .	20 42 30	.. ..	20 48	0.1
235	3	N	9 01 39	.. .. .	9 04 11	9 04 40	9 07	9 13	0.1
		E	9 02 20	.. .. .	9 04 10	9 05 10	9 07	9 12	0.1
236	3	N	.. .. .	.. .. .	.. .. .	14 26 29	.. ..	14 35	0.2
		E	14 25 03	.. .. .	14 25 49	14 25 49	.. ..	14 33	0.4
237	6	N	19 44 13	.. .. .	.. .. .	19 45 26	.. ..	19 52	0.1
		E	19 44 23	.. .. .	.. .. .	19 46 25	.. ..	19 52	0.1
238	25	N	9 55 18	10 04 ..	.. .. .	10 18 28	10 22	.. ..	0.1
		E	9 55 28	10 04 02	.. .. .	.. .. .	10 19	.. ..	0.1
239	28	N	.. .. .	.. .. .	7 51 48	7 54 18	.. ..	8 08	0.1
		E	.. .. .	.. .. .	7 45 26	7 55 46	.. ..	8 04	0.1
240	Sept. 21	N	.. .. .	.. .. .	18 50 34	18 51 25	18 57	.. ..	0.2
		E	.. .. .	.. .. .	18 50 27	.. .. .	18 55	.. ..	.. .
241	23	N	5 49 13	.. .. .	.. .. .	6 05 28	.. ..	6 20	0.1
		E	5 49 18	.. .. .	5 59 ..	6 02 51	.. ..	6 22	0.2
242	Oct. 3	N	.. .. .	.. .. .	1 56 ..	2 01 ..	.. ..	2 13	0.2
		E	.. .. .	.. .. .	1 55 ..	.. .. .	.. ..	2 10	.. .
243	3	N	.. .. .	.. .. .	4 49 04	4 50 04	5 03	.. ..	0.4
		E	.. .. .	.. .. .	4 49 04	4 50 20	4 53	.. ..	1.0
244	23	N	.. .. .	.. .. .	2 47 33	.. .. .	2 50	.. ..	.. .
		E	.. .. .	.. .. .	2 47 28	2 48 22	.. ..	2 59	0.2
245	Nov. 10	N	9 14 01	.. .. .	9 15 30	9 16 05	9 16	9 31	2.7
		E	9 14 04	.. .. .	9 15 29	9 15 38	9 17	9 34	3.5
246	12	N	.. .. .	.. .. .	11 09 34	11 10 14	11 22	.. ..	0.2
		E	.. .. .	.. .. .	11 09 30	11 10 12	11 24	.. ..	0.1
247	19	N	.. .. .	.. .. .	20 55 42	.. .. .	.. ..	21 00	0.1
		E	.. .. .	.. .. .	20 55 33	.. .. .	.. ..	21 00	0.1
248	21	N	6 30 41	6 34 39	6 37 45	6 40 18	6 41	6 56	7.2
		E	6 30 49	6 34 44	6 37 38	6 38 05	6 41	7 10	7.0
249	Dec. 12	N	.. .. .	.. .. .	12 44 45	12 45 10	12 49	.. ..	0.1
		E	.. .. .	.. .. .	12 44 45	.. .. .	12 49	.. ..	.. .

REMARKS.

- No. 190. Actual maximum, 0.5 mm. during S at 21:49:31.
- No. 195. Probably recurrence of No. 194.
- No. 197. Recorded on magnetograph.
- No. 198. Stylus of E went off the paper. Recorded on magnetograph.
- No. 199. Nothing apparent on N.
- No. 201. Stylus of N went off the paper from 0:16:16 to 0:22:24.
- No. 202. Probably recurrence of No. 201.
- No. 203. Recorded by the magnetograph at 5:15.
- No. 217. Times doubtful on N because of clock stopping.
- No. 222. An amplitude of 0.5 mm. occurred at 4:21:10 on E. N clock stopped.
- No. 223. N not recording.
- No. 227. Times doubtful on N.
- No. 228. N driving clock stopped shortly after the earthquake, making times uncertain.
- No. 229. End probably occurred while paper was being changed.
- No. 235. P doubtful.
- No. 236. Began while changing paper on N.
- No. 239. Some earlier motion, probably microseismic.

Serial No. 155

**DEPARTMENT OF COMMERCE**

**U. S. COAST AND GEODETIC SURVEY**

**E. LESTER JONES, Director**

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**RESULTS OF OBSERVATIONS MADE AT THE UNITED STATES  
COAST AND GEODETIC SURVEY MAGNETIC OBSERVATORY  
NEAR TUCSON, ARIZONA  
1917 AND 1918**

---

BY

**DANIEL L. HAZARD**

**Assistant Chief, Division of Terrestrial Magnetism**



**PRICE, 20 CENTS**

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## EARTHQUAKES.

A Bosch-Omori seismograph has been in continuous operation since September, 1910. It consists of two horizontal pendulums, one recording east-west motion (E) and the other recording north-south motion (N). The times in the table are Greenwich mean time counted from midnight.

Period of pendulums—N. 18-19 sec.; E. 14 sec.

Magnification, 10.

Steady mass, 10 to 12 kg.

The nomenclature of the International Seismological Association has been used in the table to designate the different phases. The quantities given in the last column denote the actual movement of the stylus (one-half the maximum range) as measured on the seismogram.

*Register of earthquakes.*

No.	Date.	Component.	P	S	L	M	C	F	A
	1917.		<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>
250	Jan. 30	N	2 56 08	3 04 32	3 13 33	3 30 09	3 37	5 02	1.4
		E	2 56 08	3 04 37	3 13 35	3 23 17	3 34	5 06	2.1
251	Feb. 20	N	19 36 13	19 43 30	19 50 12	19 51 30	19 58	20 44	3.2
		E	19 36 10	19 43 ..	19 50 20	19 55 10	19 59	20 38	1.9
252	Mar. 6	N	3 11 10	3 15 23	3 18 36	3 20 50	3 23	3 59	2.3
		E	3 11 10	3 15 23	3 18 42	3 19 30	3 23	3 59	7.3
253	Mar. 26	N	14 04 16	.. .. .	.. .. .	14 05 20	.. ..	14 13	0.2
		E	14 04 09	.. .. .	.. .. .	14 05 04	.. ..	.. ..	0.8
254	Mar. 26	N	14 28 58	.. .. .	.. .. .	14 29 54	.. ..	14 40	0.1
		E	14 28 47	.. .. .	.. .. .	14 29 56	.. ..	14 38	0.2
255	May 1	N	18 39 36	18 50 08	19 02 41	19 08 43	19 42	22 46	1.7
		E	18 39 40	18 50 01	19 03 01	19 29 52	19 42	22 45	2.8
256	May 25	N	14 42 33	.. .. .	.. .. .	14 43 50	.. ..	15 02	1.0
		E	14 42 45	.. .. .	.. .. .	14 44 05	.. ..	14 57	1.4
257	May 28	N	6 06 46	.. .. .	.. .. .	6 08 10	.. ..	6 15	0.2
		E	6 06 42	.. .. .	.. .. .	6 08 05	.. ..	6 13	0.1
258	May 31	N	8 55 24	9 01 41	9 04 40	9 09 57	.. ..	10 56	0.9
		E	8 55 39	9 01 41	.. .. .	9 08 26	.. ..	10 52	0.2
259	June 1	N	16 50 51	.. .. .	16 51 20	16 51 46	.. ..	17 05	0.5
		E	.. .. .	.. .. .	16 51 20	16 51 40	.. ..	16 57	0.4
260	June 3	N	6 49 39	.. .. .	6 50 22	6 50 39	.. ..	7 02	0.5
		E	6 49 34	.. .. .	.. .. .	6 51 27	.. ..	6 52	0.2
261	June 3	N	11 11 15	.. .. .	.. .. .	11 11 50	.. ..	11 19	0.2
262	June 8	N	0 57 30	1 02 21	1 06 53	1 10 58	1 19	3 39	36.8
		E	0 57 32	1 02 31	1 07 00	1 08 53	1 17	3 34	8.9
263	June 10	N	4 36 23	.. .. .	4 40 00	4 43 07	.. ..	5 41	0.3
		E	4 38 08	.. .. .	.. .. .	4 43 13	.. ..	5 33	0.2
264	June 13	N	7 05 10	.. .. .	.. .. .	7 43 46	.. ..	8 27	0.4
		E	7 05 21	.. .. .	.. .. .	7 42 38	.. ..	8 31	0.2
265	June 26	N	6 01 33	6 11 41	6 24 56	6 32 57	6 45	9 00	5.8
		E	6 01 37	6 11 26	6 24 50	6 26 02	6 45	8 38	3.4
266	June 29	N	16 09 58	.. .. .	16 14 46	16 15 58	.. ..	16 54	0.2
		E	16 11 43	.. .. .	16 15 47	16 16 19	.. ..	.. ..	0.4
267	June 30	N	18 00 40	.. .. .	.. .. .	.. .. .	.. ..	18 28	.. ..
268	July 27	N	.. .. .	.. .. .	1 09 28	1 27 20	.. ..	3 50	1.0
		E	.. .. .	.. .. .	1 08 26	1 34 24	.. ..	4 03	0.6
269	July 29	N	.. .. .	.. .. .	.. .. .	23 05 28	.. ..	24 22	0.1
		E	.. .. .	.. .. .	22 11 15	22 57 54	.. ..	23 33	0.1
270	Aug. 30	N	.. .. .	.. .. .	4 28 44	4 45 04	.. ..	5 45	0.1
		E	.. .. .	.. .. .	4 28 22	5 09 04	.. ..	5 36	0.1
271	Aug. 31	N	11 44 35	11 51 20	11 58 00	12 03 49	12 17	12 54	0.2
		E	11 44 35	11 51 20	11 59 02	11 59 43	.. ..	13 04	0.3
272	Sept. 11	N	.. .. .	.. .. .	9 35 50	9 36 42	.. ..	9 44	0.3
		E	.. .. .	.. .. .	9 35 45	9 36 34	.. ..	9 44	0.2
273	Sept. 21	N	.. .. .	.. .. .	8 44 26	8 45 17	.. ..	8 53	0.2
		E	.. .. .	.. .. .	8 44 26	8 45 04	.. ..	8 53	0.2
274	Sept. 21	N	.. .. .	.. .. .	21 24 00	21 24 50	.. ..	21 31	0.2
		E	.. .. .	.. .. .	21 23 57	21 25 03	.. ..	21 33	0.2
275	Oct. 13	N	4 24 40	.. .. .	4 29 20	4 30 23	.. ..	4 42	0.1
		E	4 24 41	.. .. .	4 29 20	4 29 57	.. ..	4 41	0.2
276	Oct. 19	N	.. .. .	.. .. .	16 47 36	16 54 37	.. ..	17 04	0.2
		E	.. .. .	.. .. .	16 46 34	16 52 42	.. ..	17 10	0.1
277	Nov. 7	N	.. .. .	.. .. .	1 36 31	1 38 01	.. ..	1 47	0.2
278	Nov. 8	N	.. .. .	.. .. .	5 34 16	5 52 46	.. ..	6 07	0.2
279	Nov. 16	N	3 32 20	.. .. .	3 56 ..	4 20 58	.. ..	5 15	0.2

## 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>
280	1917. Dec. 21	E	18 01 24	18 07 34	18 13 00	18 25 59	.. ..	19 08	0.2
281	Dec. 26	N	.. ..	.. ..	5 31 11	5 37 50	.. ..	5 51	0.1
		E	.. ..	.. ..	5 31 06	5 37 07	.. ..	5 51	0.1
282	Dec. 28	N	21 21 57	.. ..	21 34 30	21 45 30	.. ..	22 04	0.2
		E	21 21 57	.. ..	21 36 29	21 42 51	.. ..	22 04	0.1
283	Dec. 29	N	22 55 22	22 59 36	23 02 12	23 06 ..	23 10	1 15	60.0+
		E	22 55 18	22 59 30	23 02 12	23 03 ..	23 09	1 15	62.6+
	1918.								
284	Jan. 4	N	4 36 54	4 42 20	4 46 32	4 47 13	.. ..	5 04	0.2
		E	.. ..	.. ..	4 46 ..	4 47 26	.. ..	5 04	0.3
285	Jan. 25	N	1 26 07	.. ..	.. ..	1 39 01	.. ..	2 03	0.4
		E	1 25 38	.. ..	.. ..	1 36 00	.. ..	2 13	0.6
286	Feb. 12	N	1 25 50	.. ..	1 26 08	1 26 16	1 34	.. ..	1.5
		E	1 25 24	.. ..	1 25 36	1 26 08	1 34	.. ..	1.2
287	Feb. 12	N	.. ..	.. ..	1 39 20	1 39 45	1 43	.. ..	0.4
		E	.. ..	.. ..	1 39 20	1 39 36	1 43	.. ..	0.1
288	Feb. 12	N	.. ..	.. ..	2 05 ..	.. ..	2 08	.. ..	0.1
		E	.. ..	.. ..	2 05 ..	.. ..	2 08	.. ..	0.1
289	Feb. 12	N	.. ..	.. ..	19 19 08	19 19 32	.. ..	19 25	1.1
		E	.. ..	.. ..	19 19 02	19 19 45	.. ..	19 28	0.8
290	Feb. 12	N	.. ..	.. ..	19 30 38	19 31 32	.. ..	19 35	0.6
		E	.. ..	.. ..	19 30 52	19 32 24	.. ..	19 36	0.5
291	Feb. 12	N	20 05 19	.. ..	20 05 31	20 05 40	20 07	20 16	5.9
		E	20 04 52	.. ..	20 05 20	20 05 40	20 07	20 16	7.1
292	Apr. 17	N	6 49 18	.. ..	.. ..	6 52 23	6 54	7 06	0.2
		E	6 49 14	.. ..	.. ..	6 52 30	6 54	7 06	0.5
293	Apr. 21	N	22 33 50	.. ..	22 35 10	.. ..	22 40	23 14	89.0+
		E	22 33 58	.. ..	22 35 19	22 36 34	22 39	23 34	69.0
294	Apr. 27	..	.. ..	.. ..	.. ..	.. ..	.. ..	.. ..	.. ..
		E	14 56 45	.. ..	.. ..	15 02 ..	.. ..	15 04	0.3
295	May 1	N	4 33 50	.. ..	.. ..	4 34 55	.. ..	4 43	0.6
		E	4 34 12	.. ..	.. ..	4 34 45	.. ..	4 36	0.4
296	May 6	N	4 59 10	.. ..	.. ..	5 00 35	5 02	5 12	1.2
		E	4 59 51	.. ..	.. ..	5 00 28	5 02	5 07	1.3
297	May 20	..	.. ..	.. ..	.. ..	.. ..	.. ..	.. ..	.. ..
		E	14 46 ..	14 57 ..	15 11 ..	15 19 05	15 22	15 44	0.5
298	May 23	N	11 58 52	.. ..	12 00 12	12 03 ..	12 06	13 00	32.0+
		E	11 59 12	.. ..	12 00 20	12 03 ..	12 06	13 20	60.0+
299	June 7	N	21 31 03	.. ..	21 35 47	21 37 42	21 40	22 00	8.6
		E	21 31 02	.. ..	21 35 17	21 37 01	21 40	22 06	12.3
300	June 12	N	4 28 50	.. ..	4 33 58	4 35 ..	.. ..	4 45	0.1
		E	4 28 44	.. ..	4 33 56	4 35 ..	.. ..	4 58	0.1
301	.....	N	.. ..	.. ..	.. ..	.. ..	.. ..	.. ..	.. ..
		E	.. ..	.. ..	.. ..	.. ..	.. ..	.. ..	.. ..
301	July 3	E	7 15 49	.. ..	7 39 ..	7 59 ..	.. ..	9 23	0.1
302	July 8	N	.. ..	.. ..	11 22 37	.. ..	11 37	.. ..	.. ..
		E	10 43 12	.. ..	11 17 50	11 26 17	.. ..	12 08	0.1
303	July 14	N	18 21 05	.. ..	.. ..	18 22 50	.. ..	18 26	0.1
		E	18 21 00	.. ..	.. ..	18 22 40	.. ..	18 25	0.1
304	July 15	N	0 26 42	0 29 37	0 30 53	0 32 30	0 37	1 18	3.4
		E	0 26 42	0 29 41	0 30 47	0 33 12	0 40	1 25	3.6
305	July 21	E	6 27 15	6 35 50	6 54 35	7 00 35	7 16	7 53	0.2
306	July 31	N	.. ..	.. ..	14 57 ..	15 00 ..	15 15	.. ..	0.1
		E	.. ..	.. ..	14 55 ..	15 10 ..	15 15	.. ..	0.1
307	Aug. 8	E	.. ..	.. ..	10 33 20	10 41 37	10 45	10 55	0.1
308	Aug. 15	N	12 39 40	12 48 26	13 16 24	13 47 24	13 56	14 09	0.2
		E	12 38 30	12 48 23	13 14 37	13 26 30	13 53	14 08	1.5
309	Aug. 23	E	.. ..	.. ..	7 18 46	7 40 49	7 43	8 05	0.1
310	Sept. 4	N	19 56 13	.. ..	19 57 09	19 57 46	19 58	19 59	0.0
		E	19 56 01	.. ..	19 56 49	19 57 46	19 58	19 59	0.1
311	Sept. 7	N	17 28 10	17 37 16	17 52 ..	18 06 04	18 23	20 27	1.2
		E	17 28 12	17 37 12	17 51 ..	18 11 57	18 23	20 30	8.5
312	Sept. 11	N	3 48 31	.. ..	3 49 20	3 49 55	3 51	3 58	.. ..
		E	3 48 31	.. ..	3 49 20	3 50 41	3 51	3 53	.. ..
313	Oct. 13	N	14 22 26	14 28 47	14 34 15	14 42 30	14 47	15 30	4.8
		E	14 22 22	14 28 52	.. ..	14 48 12	14 51	16 03	4.4
314	Oct. 14	E	.. ..	.. ..	12 37 15	12 41 ..	12 43	12 47	0.1
315	Oct. 19	N	2 08 44	.. ..	2 10 00	2 13 ..	2 14	2 17	0.1
		E	2 07 13	.. ..	2 07 54	2 03 ..	2 14	2 24	0.1

Serial No. 248

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

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RESULTS OF OBSERVATIONS MADE AT THE  
U. S. COAST AND GEODETIC SURVEY MAGNETIC  
OBSERVATORY NEAR TUCSON, ARIZ.,  
IN 1919 AND 1920

BY

DANIEL L. HAZARD

Assistant Chief, Division of Terrestrial Magnetism



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WASHINGTON  
GOVERNMENT PRINTING OFFICE  
1924

# RESULTS OF OBSERVATIONS MADE AT THE U. S. COAST AND GEODETIC SURVEY MAGNETIC OBSERVATORY NEAR TUCSON, ARIZ., IN 1919 AND 1920.

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## INTRODUCTION.

[Latitude, 32° 14' 8; longitude, 110° 50' 1; elevation, 770 meters (2,526 feet).]

The Tucson Magnetic Observatory is about 8 miles (12.9 kilometers) east of the city of Tucson, Ariz., in a comparatively level country rising gradually to mountains on the north and west. The buildings were erected in the summer of 1909, and the instruments were installed and put in operation in November of that year. A description of the buildings will be found in the first volume of observatory results, for 1909 and 1910. The relative position of the office and variation buildings is there incorrectly stated, however. The variation building is about 700 feet east of the office, and the vestibule is on the east end of the variation building.

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 William H. Cullum, magnetic observer.

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 (one hundred and fifth in the

EARTHQUAKES.

A Bosch-Omori seismograph has been in continuous operation since September, 1910. It consists of two horizontal pendulums, one recording east-west motion (E) and the other recording north-south motion (N). The times in the following table are Greenwich mean time counted from midnight.

Period of pendulums: N., 18 sec.; E., 14 sec., January to June, 1919; 17 sec., July, 1919; 15 sec., August to October, 1919; 17 sec., November, 1919, to December, 1920.

Multiplication, 10.  
Steady mass, 10 to 12 kg.

The nomenclature of the International Seismological Association has been used to designate the different phases. The quantities given in the last column denote the actual movement of the stylus (one-half of the maximum range) as measured on the seismogram.

Register of earthquakes.

No.	Date.	Component.	P			S			L			M			C			F			A
			h.	m.	s.	h.	m.	s.	h.	m.	s.	h.	m.	s.	h.	m.	s.	h.	m.	s.	
1910.																					
329	Jan. 1	N	3	12	28	3	22	20	3	22	30	3	22	30	3	22	30	4	22	14.0	
330	Jan. 17	N	11	54	17	11	58	29	12	00	19	12	01	39	12	04	12	08	1.8		
		E	11	54	28	11	58	40	12	00	28	12	01	48	12	03	12	06	6.8		
331	Jan. 31	N	..	..	..	..	..	..	23	52	29	23	52	45	..	..	24	03	0.1		
		E	..	..	..	..	..	..	23	51	55	23	54	..	..	..	24	01	0.2		
332	Feb. 16	N	16	01	30	..	..	..	..	..	..	..	..	..	..	..	16	02	..		
		E	16	01	39	..	..	..	..	..	..	16	02	02	..	..	..	16	04	..	
333	Mar. 9	N	4	42	00	..	..	..	..	..	..	..	..	..	..	..	4	45	0.1		
		E	4	42	00	..	..	..	..	..	..	..	..	..	..	..	4	45	0.1		
334	Apr. 17	N	20	58	29	21	03	06	21	06	35	21	10	05	21	14	21	19	66.5		
		E	20	58	48	21	03	11	21	06	40	21	09	50	21	14	21	26	1.3		
335	Apr. 18	N	21	04	37	..	..	..	21	09	00	21	11	20	21	14	21	31	3.0		
		E	..	..	..	21	07	23	21	08	30	21	10	23	21	11	21	15	3.2		
336	Apr. 19	N	3	08	23	..	..	..	..	..	..	..	..	..	..	..	3	13	0.5		
		E	3	08	37	..	..	..	..	..	..	..	..	..	..	..	3	14	0.3		
337	Apr. 30	N	7	29	22	..	..	..	7	54	15	8	13	44	8	19	10	22	4.4		
338	May 3	N	..	..	..	1	14	15	..	..	..	..	..	..	..	..	1	42	0.1		
339	May 6	N	..	..	..	..	..	..	20	21	30	20	23	20	20	32	21	05	1.0		
340	June 29	N	0	55	41	..	..	..	0	57	50	0	58	00	..	..	..	1	02	0.2	
341	do.	N	23	26	00	23	30	54	23	39	00	..	..	..	..	..	23	52	0.1		
342	July 1	N	21	55	16	..	..	..	21	57	21	21	57	32	21	58	22	00	0.1		
		E	21	55	22	..	..	..	..	..	..	..	..	..	..	..	21	59	..		
343	July 6	N	7	09	22	7	13	33	7	16	38	..	..	..	7	21	7	32	..		
		E	..	..	..	..	..	..	7	20	33	..	..	..	..	..	7	28	..		
344	July 9	N	19	23	14	19	27	20	19	29	51	19	30	14	19	34	19	41	..		
		E	..	..	..	19	27	14	19	28	50	..	..	..	..	..	19	35	..		
345	Aug. 29	N	..	..	..	..	..	..	6	38	50	6	48	20	7	00	7	11	0.2		
346	do.	E	23	10	30	..	..	..	..	..	..	..	..	..	..	..	23	16	0.1		
347	Aug. 31	E	17	34	01	17	45	01	18	07	20	18	15	20	18	20	18	31	0.1		
348	Sept. 11	E	21	32	05	..	..	..	21	32	28	..	..	..	..	..	21	36	0.4		
349	Sept. 15	E	17	36	15	..	..	..	17	37	11	17	38	30	17	40	17	50	0.2		
350	Sept. 19	E	3	27	30	..	..	..	3	28	59	3	30	00	..	..	3	33	0.6		
351	Sept. 30	E	7	38	28	..	..	..	7	39	06	7	39	55	7	44	7	56	2.8		
352	Oct. 1	E	18	43	15	..	..	..	18	44	13	..	..	..	..	..	18	45	0.1		
353	do.	E	19	32	16	..	..	..	19	33	12	19	33	55	19	35	19	45	2.3		
354	do.	E	21	48	40	..	..	..	..	..	..	21	49	07	..	..	21	53	0.1		
355	Oct. 10	E	2	11	09	..	..	..	2	17	30	2	17	38	..	..	2	27	0.2		
356	Nov. 14	E	6	48	36	..	..	..	..	..	..	6	49	20	..	..	6	53	0.2		
357	Dec. 18	N	1	24	40	..	..	..	1	29	09	1	29	40	1	31	1	33	0.3		
		E	1	24	43	..	..	..	1	29	13	1	29	44	1	33	1	38	0.2		
1920.																					
358	Jan. 1	N	2	36	12	..	..	..	2	36	46	2	36	46	..	..	2	40	0.2		
		E	2	35	41	..	..	..	2	36	22	2	37	11	2	38	2	41	0.5		
359	Jan. 4	N	4	25	44	4	29	14	4	31	00	4	33	05	4	37	4	43	4.0		
		E	4	25	33	4	29	03	4	31	00	4	33	15	4	39	5	00	7.2		
360	Jan. 12	N	23	04	38	..	..	..	..	..	..	23	10	35	..	..	23	18	0.5		
361	Jan. 25	N	0	13	35	..	..	..	..	..	..	..	..	..	..	..	0	28	0.1		
362	do.	N	20	25	01	..	..	..	..	..	..	20	37	55	..	..	20	42	0.2		
363	Feb. 10	E	..	..	..	..	..	..	9	55	38	..	..	..	..	..	10	12	0.1		
364	do.	E	22	14	50	22	21	00	22	26	50	22	37	32	22	46	23	24	0.2		

## Register of earthquakes—Continued.

No.	Date.	Component.	P			S			L			M			C		F		A		
			h.	m.	s.	h.	m.	s.	h.	m.	s.	h.	m.	s.	h.	m.	h.	m.		mm.	
365	1920. Mar. 20.....	N E	17 17	56 54	05 35	..	..	..	..	..	..	..	..	..	..	..	..	..	17 18	58 01	0.1 0.1
366	.....do.....	E N	18 15	51 26	21 55	..	..	..	18 15	59 34	00 19	19 15	00 34	30 22	..	..	..	..	19 15	34 37	0.2 0.2
367	.....do.....	E N	15 15	26 26	49 22	..	..	..	15 5	33 23	44 14	15 5	34 23	32 30	15 5	37 25	5 5	28 27	15 5	41 27	0.3 0.6
368	Mar. 29.....	E E	5 5	13 13	21 22	5	17	47	5	21	10	5	23	30	5	28	5	28	5	54	1.3 0.6
369	Apr. 6.....	E	16	54	38	..	..	..	16	54	49	16	55	12	16	68	17	01	0.1	0.5	
370	Apr. 19.....	E	21	10	51	21	14	29	21	16	40	21	17	41	21	19	21	28	1.2	0.3	
371	May 7.....	E	..	..	..	..	..	..	22	14	43	22	16	17	22	29	22	49	0.1	0.1	
372	May 13.....	E	..	..	..	..	..	..	2	36	30	2	41	..	2	56	3	21	0.1	0.2	
373	May 20.....	E	7	49	50	..	..	..	8	06	54	8	09	..	8	17	8	34	0.2	0.3	
374	May 30.....	E N	20 20	51 51	26 40	..	..	..	20 20	51 56	20 52	52 35	20 20	54 54	20 20	54 54	21 20	00 58	0.6 0.3	0.3	
375	.....do.....	E N	21 21	13 13	19 18	..	..	..	..	..	..	..	..	..	..	..	..	..	21 21	18 18	0.1 5.0
376	June 2.....	E N	22 22	05 06	05 31	22	06	56	22	07	25	22	08	00	22	15	22	27	7.3	0.3	
377	June 4.....	E N	15	29	25	..	..	..	15	30	10	15	30	40	15	32	..	..	..	..	0.1
378	.....do.....	E N	..	..	..	..	..	..	15	37	30	15	38	05	15	41	15	47	0.5	0.5	
379	June 5.....	E N	4	39	28	..	..	..	4	46	27	5	11	03	5	16	5	49	0.4	0.1	
380	June 7.....	E N	9	57	48	..	..	..	9	59	04	9	59	00	10	00	10	02	0.1	0.1	
381	June 18.....	E N	..	..	..	10	12	01	..	..	..	..	..	..	..	..	..	10	16	0.1	
382	June 22.....	E N	10 2	11 51	29 24	..	..	..	2	51	52	2	52	24	2	55	3	01	0.6	0.4	
383	July 7.....	E N	..	..	..	..	..	..	18	59	10	19	01	10	19	04	19	12	0.1	0.1	
384	Aug. 3.....	E N	20 20	09 09	44 08	20	17	29	20	28	29	20	30	45	20	41	21	08	0.1	0.1	
385	Aug. 15.....	E N	8	29	27	8	40	13	..	..	..	..	..	9	20	..	..	..	..	..	
386	Aug. 20.....	E N	..	..	..	..	..	..	16	55	04	17	00	52	17	02	17	14	0.1	..	
387	Aug. 26.....	E N	23 23	08 08	24 25	..	..	..	23	23	50	23	27	25	23	32	23	12	0.1	0.1	
388	Aug. 29.....	E N	12	50	18	..	..	..	12	55	08	12	56	52	12	58	13	03	0.2	0.2	
389	Sept. 8.....	E N	..	..	..	2	08	38	..	..	..	..	..	..	..	..	..	2	17	0.4	
390	Sept. 20.....	E N	14 14	52 52	22 22	15	02	50	15	22	35	15	28	30	15	33	15	45	0.1	0.3	
391	Sept. 24.....	E N	22 22	02 02	18 15	22	08	11	22	13	45	22	17	27	22	18	22	27	0.2	0.2	
392	Sept. 27.....	E N	5 5	27 27	10 38	..	..	..	5	23	27	5	29	34	5	32	5	45	1.6	2.5	
393	Sept. 29.....	E N	12 12	01 01	04 57	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	
394	Oct. 1.....	E N	12 18	00 54	57 25	..	..	..	12	01	30	12	02	29	12	03	12	03	0.1	1.9	
395	Oct. 8.....	E N	16 16	56 56	14 14	16	59	59	17	02	50	17	03	45	17	08	17	08	0.5	0.5	
396	Oct. 18.....	E N	8 8	23 23	11 11	8	32	33	..	..	..	..	..	..	..	..	..	..	..	..	
397	Oct. 22.....	E N	12 12	20 20	47 48	12	29	36	..	..	..	..	..	..	..	..	..	..	..	..	
398	Oct. 28.....	E E	13 13	01 01	29 22	..	..	..	..	..	..	..	..	..	..	..	..	..	13	19	0.1
399	Nov. 18.....	E	8	45	14	..	..	..	8	52	33	8	54	02	8	55	9	07	0.3	0.3	
400	Dec. 10.....	E	..	..	..	..	..	..	5	00	00	5	08	35	5	11	5	59	0.4	0.4	
401	Dec. 11.....	E N	..	..	..	21	36	27	21	39	20	21	40	20	21	41	21	46	0.1	0.3	
402	Dec. 16.....	E N	21 12	30 24	54 16	21	36	52	21	38	15	21	49	30	13	11	13	13	0.2	4.4	
403	Dec. 20.....	E E	14 14	47 47	42 54	12	39	10	12	49	30	13	05	00	13	16	14	50	22.8	0.4	

## REMARKS.

329. E out of adjustment; no well-defined long waves on N.  
 332. Instrument not in good adjustment.  
 333. Probably a near-by quake.  
 334. Stylus of N was off the paper from 21:10:05 to 21:12:53; the amplitude was measured to the edge of the paper.  
 336. No distinct phases.  
 339. Only a trace on E; N not in good adjustment.  
 340. Times somewhat uncertain because of irregular spacing of time marks; N not in operation from Aug. 23 to Nov. 15.  
 343, 344. Phases uncertain; seismograph not in good adjustment.  
 347. S uncertain.  
 355. P uncertain.  
 346, 348-357. Probably near-by.  
 360, 361, 362. Irregular record, possibly not seismic; time marks missing and times, therefore, uncertain.  
 364. Reported from Porto Rico; PR plainly shown at 22:16:30.  
 368. Phases not distinct; the one tabulated as L may be S.  
 369. Phases not distinct; times uncertain because of missing time breaks.  
 370, 371. N not in operation.  
 376. P and S not well defined.  
 377, 378. The end of one overlaps the beginning of the other.  
 379. Reported from Formosa; P and S uncertain.  
 382. Reported from Los Angeles as felt at 2:47; the phase tabulated as P occurs at about the time when L would be expected at that distance.  
 384. P and S faint; times uncertain on account of failure of time-marking apparatus.  
 385. Nothing on N.  
 387. Preliminary tremors faint on both components.  
 389. No well-defined long waves.  
 391. Another phase, probably PR, occurred on N at 22:03:50 and on E at 22:03:42.  
 392, 393, 394. Beginning faint; probably not P.  
 396, 397, 398. No well-defined long waves.  
 400. Nothing on N.  
 401. Phases not well defined.  
 402. P and S not well defined; another phase at 12:31:48.

## MAGNETIC STORMS.

Magnetic storms of considerable magnitude were recorded on the days tabulated below. 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 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 decreasing east declination, increasing  $H$  and decreasing  $Z$ .

Serial No. 293

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

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**RESULTS OF OBSERVATIONS MADE AT THE UNITED  
STATES COAST AND GEODETIC SURVEY MAGNETIC  
OBSERVATORY NEAR TUCSON, ARIZ.**  
**1921 AND 1922**

BY

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# RESULTS OF OBSERVATIONS MADE AT THE UNITED STATES COAST AND GEODETIC SURVEY MAGNETIC OBSERVATORY NEAR TUCSON, ARIZ., IN 1921 AND 1922

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## INTRODUCTION

[Latitude 32° 14'.8; longitude 110° 50'.1; elevation, 770 meters (2,526 feet)]

The Tucson Magnetic Observatory is about 8 miles (12.9 kilometers) east of the city of Tucson, Ariz., in a comparatively level country rising gradually to mountains on the north and west. The buildings were erected in the summer of 1909 and the instruments were installed and put in operation in November of that year. A description of the buildings will be found in the first volume of observatory results for 1909 and 1910. The relative position of the office and variation buildings is there incorrectly stated, however. The variation building is about 700 feet east of the office, and the vestibule is on the east end of the variation building.

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, O. S. Hill, J. B. Goldsmith, and I. I. Kaplan, computers. The work of the observatory was carried on by William H. Cullum, magnetic observer, to the end of August, 1922. After that it was in charge of A. K. Ludy, magnetic observer.

## EARTHQUAKES

A Bosch-Omori seismograph has been in continuous operation since September, 1910. It consists of two horizontal pendulums, one recording east-west motion (E) and the other recording north-south motion (N). The times in the following table are Greenwich mean time counted from midnight.

Period of pendulums.—N., 18 sec. to May, 1922; 19 sec. after May, 1922. E., 17 sec.

Multiplication, 10.

Steady mass, 10 to 12 kg.

The nomenclature of the International Seismological Association has been used to designate the different phases. The quantities given in the last column denote the actual movement of the stylus (one-half of the maximum range) as measured on the seismograms.

## Register of earthquakes recorded at Tucson, Ariz.

No.	Date	Com- po- nent	P			S			L			M			C		F		Maxi- mum ampli- tude
			h.	m.	s.	h.	m.	s.	h.	m.	s.	h.	m.	s.	h.	m.	h.	m.	
1	Feb. 4	E	8	27	43	8	31	54	8	33	27	8	35	10	8	44	9	17	6.4
2	Feb. 19	N	8	27	43	8	31	54	8	34	43	8	35	43	8	44	9	08	2.1
3	Feb. 21	N	16	01	38				19	11	49				19	24	19	36	0.1
4	Feb. 27	E	18	35	35	18	45	29	16	10	45	16	11	20	16	12	16	18	0.2
5	Mar. 6	E	18	35	39				18	59	07	19	00	35	19	14	20	06	0.4
6	Mar. 25	E	0	33	15				19	03	35	7	28	35	7	35	8	05	0.1
7	Mar. 28	E	0	33	28				7	27	57	7	30	02	7	35	7	48	16.0
8	do.	E	7	55	28	8	00	10	0	33	51	0	34	38	0	37	0	52	4.0
9	Apr. 5	E	7	56	28	8	00	06	0	33	55	0	34	18	0	37	0	52	7.5
10	Apr. 12	E	22	24	09				8	08	08	8	06	00	8	16	8	55	7.8
11	May 1	E	22	24	15				8	05	10	8	06	00	8	11	8	30	2.5
12	May 14	E	0	21	29														1.5
13	June 17	E	0	21	29				0	22	09	0	22	28	0	23	0	29	0.2
14	do.	E	7	44	19				0	22	04	0	22	17	0	23	0	27	0.5
15	July 12	E	5	42	38	5	45	26	5	46	10	5	47	20	5	52	6	15	0.6
16	Aug. 23	E	5	42	38	5	45	47	5	47	07	5	48	30	5	53	6	07	5.0
17	Aug. 29	E	22	12	53				22	16	17	22	18	14	22	20	22	36	4.6
18	Sept. 8	E	22	12	53				22	17	32	22	18	26	22	21	22	26	0.9
19	Sept. 11	E	8	10	56	8	11	26	8	11	46	8	12	22	8	13	8	24	0.6
20	Sept. 29	E	10	20	47	8	11	41	8	11	46	8	12	07	8	13	8	28	1.0
21	Oct. 15	E	10	20	47				8	11	46	8	12	07	8	13	8	28	0.8
22	Oct. 20	E	20	06	28				10	21	05	10	21	19	10	22	10	30	0.2
23	Nov. 2	E	20	06	28				20	07	26	20	07	38	20	08	20	16	0.2
24	Nov. 15	E	20	06	28				20	07	26	20	08	08	20	08	20	21	0.3
25	Nov. 17	E	18	56	12				20	42	57	20	51	35	20	53	21	07	0.1
26	Nov. 17	E	19	24	40	19	25	17	18	57	02	18	57	31	18	58	19	03	0.2
27	Dec. 18	E	19	24	49				19	25	30	19	25	43	19	28	19	41	0.8
28	Jan. 17	E	4	21	09				19	25	30	19	25	58	19	29			0.7
29	Jan. 20	E	14	18	56				5	14	17	5	16	40			6	19	0.2
30	Jan. 22	E	14	19	31				14	20	55	14	20	55			14	24	0.1
31	Jan. 23	E	5	23	46	5	28	24	5	40	51	5	44	28	5	58	6	09	0.1
32	Jan. 24	E	6	13	55	6	22	08	6	31	17	6	31	54			6	51	0.2
33	Jan. 25	E	2	52	24	2	56	11	2	58	13	2	58	37	3	01	3	11	0.2
34	Jan. 26	E	3	42	28	3	46	05	3	48	02	3	50	40	3	52	4	13	1.0
35	Jan. 28	E	20	55	26	21	00	22	21	04	51	21	05	00			21	24	0.1
36	Jan. 31	E	22	15	37				22	16	11	22	16	11			22	21	0.2
37	Feb. 1	E	15	37	38	15	44	22				15	44	37			16	07	3.6
38	Feb. 1	E	3	58	53				4	07	30	4	07	45	4	10	5	01	2.5
39	Feb. 2	E	2	14	47				2	15	35	2	15	35	2	16	2	28	0.1
40	Feb. 3	E	4	31	23				4	31	36	4	31	54	4	33	4	48	0.5
41	Feb. 4	E												4	08	4	31		
42	Feb. 5	E	9	35	03	9	38	31	21	21	19	21	26	16	21	43	21	48	0.2
43	Feb. 6	E	13	20	59	13	24	07	9	40	04	9	46	55	9	49	10	02	0.3
44	Feb. 7	E	3	22	07	3	24	01	13	24	41	Note.			13	34	15	58	42.+
45	Feb. 8	E	3	22	07	3	24	01	3	32	41	3	34	19			4	03	0.3
46	Feb. 9	E	21	26	13	21	29	39	21	31	23	21	35	03			21	50	0.1
47	Feb. 10	E	11	19	54				11	21	23	11	22	40	11	23	11	37	10.8

Register of earthquakes recorded at Tucson, Ariz.—Continued

No.	Date	Component	P		S		L		M		C	F	Maximum amplitude mm.
			h. m. s.	h. m. s.	h. m. s.	h. m. s.	h. m. s.	h. m. s.					
38	Mar. 28	E	4 08 40	4 17 26	4 31 30							4 30	0.1
39	Apr. 2	N	1 54 51						1 55 07			4 26	0.1
		E	1 54 28						1 54 53			2 02	0.2
40	do.	N	19 26 12			19 30 10	19 44 48	19 44 48				2 00	0.2
		E	19 26 12			19 41 25	19 41 56	19 41 56				20 25	0.1
41	Apr. 8	N				21 14 04	21 20 44	21 20 44				21 34	0.1
42	Apr. 11	E				1 02 25	1 06 50	1 06 50				1 33	0.5
43	Apr. 20	E	6 00 15			6 00 44	6 00 51	6 00 51				6 10	1.3
		N	6 00 15			6 00 49	6 03 21	6 03 21				6 10	1.1
44	Apr. 25	E				22 03 15	22 30 52	22 30 52				22 55	0.2
45	May 12	E				19 23 00	19 30 13	19 30 13	19 33			19 45	0.4
46	June 12	E	4 49 46			4 52 08	4 54 47	4 54 47	4 57	5 51		5 51	10.0
	do.	N	4 49 46	4 51 55	4 52 08	4 53 37	4 56	4 56	5 50			5 50	6.0
47		E		10 48 46	10 49 19	10 49 19	10 51 05	10 51 05				11 18	2.0
		N	10 45 54			10 49 56	10 51 41	10 51 41				11 10	0.8
48	June 16	E	21 00 16			21 01 09	21 01 45	21 01 45				21 21	4.0
		N	21 00 26	21 00 54	21 01 09	21 01 22	21 01 22	21 01 22				21 21	4.4
49	June 17	E	23 44 56			23 45 02	23 45 08	23 45 08				23 47	0.5
		N	23 44 56			23 45 02						23 50	
50	July 2	E	13 42 53	13 49 59	13 59								0.1
		N		13 49 59	13 57								
51	Aug. 18	E				5 16 41	5 17 55	5 19	5 21				
		N				5 16 30	5 17 30		5 23				0.1
52	Aug. 30	E				22 46 55	22 47 20		22 53			22 56	0.3
		N				22 46 13	22 49 41		22 53			22 53	0.2
53	Sept. 1	E	20 00 47			20 07 27	20 08 20		20 50			20 50	0.1
54	Sept. 9	E	0 24 42				0 25 42		0 33			0 33	0.2
		N	0 25 22				0 27 42		0 34			0 34	0.1
55	Sept. 29	E	21 39 07				21 40 01	21 41	21 48			21 48	1.0
		N	21 39 07				21 39 21		21 48			21 48	0.5
56	Sept. 30	E	23 35 12				23 35 30	23 37	23 42			23 42	0.3
		N	23 35 03				23 35 30	23 37	23 37				0.2
57	Nov. 11	E	4 44 05	4 53 26	5 06 59	5 11 30	5 12		14.0				14.0
		N	4 44 05	4 53 26	5 07 18	5 11 17	5 14	7 05	8.3				8.3
58	Nov. 17	N				11 39 12			11 43				

REMARKS

1. P<sub>1</sub> at 8:28:08; S<sub>1</sub> on N at 8:32:22 Δ=2,580 km.
4. Phases ill-defined on N; P<sub>1</sub> on E at 18:38:31.
6. Beginning doubtful.
7. Δ=2,930 km.
- 8, 10. No definite phases.
12. Phases not well defined.
16. Wind tremors obscure record on N; L<sub>25</sub> doubtful.
17. N not operating.
19. P and L interpretations doubtful; e<sub>25</sub> at 4:25:10.
20. P interpretation doubtful.
21. P interpretation doubtful.
22. No definite L wave maximum; actual maximum at 6:23:39.
- 23, 24, 25, 26, 27. E not operating.
25. P doubtful.
26. P doubtful.
27. Recorded on magnetograph at 15:45.
- 28 to 37. N not in operation.
- 29, 30. P interpretation doubtful.
31. Record lost from 3:55 to 4:02.
33. A series of L waves begins at 9:26:47.
34. Stylus off paper from 13:28:03 to 13:29:39.
37. L doubtful. Recorded on the magnetograph.
38. No definite maximum during L; maximum on E occurs at 4:18:27; on N at 4:08:44.
- 39, 40. P interpretations doubtful.
41. Times of phases indeterminate on E on account of irregular motion of drum.
44. Additional L waves on E at 22:12:10 and 22:26:06
46. O=4:47:08; Δ=1,210 km.; additional L phase on N at 4:52:34. Recorded on the magnetograph from 4:51 to 5:01.
47. An emergence on E and N at 10:47:14.
48. O=20:59:20; Δ=500(?) km. Recorded on the magnetograph at 21:02. L<sub>25</sub> occurs at 21:01:32.
49. Local tremors.
50. P phases doubtful; eP<sub>1N</sub> occurs at 13:45:26; eP<sub>1N</sub> at 13:45:00; S<sub>1N</sub> at 13:53:31; S<sub>1N</sub> at 13:53:20. End lost in changing paper.
- 51, 52. L interpretations doubtful.
52. Emergence on N occurs at 22:47:39.
- 53, 54, 55, 56. P interpretations doubtful.
55. Recorded on the magnetograph.
56. End portion on E masked by wind tremors.
57. O=4:32:33; Δ=8,120 km.; P<sub>25</sub>(?) occurs at 4:54:07; S<sub>25</sub>(?) at 4:53:54; S<sub>25</sub> at 4:58:45; S<sub>25</sub> at 5:02:04; S<sub>25</sub> at 5:02:04; e<sub>25</sub> at 5:03:15; e<sub>25</sub> at 5:03:39; L<sub>25</sub> at 5:09:59; L<sub>25</sub> at 5:10:50; L<sub>25</sub> at 5:09:09. S<sub>1</sub> doubtful; F<sub>25</sub> indeterminate on account of irregular trace due to loose stylus. Recorded on the magnetograph.
58. Barely perceptible.

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**U. S. DEPARTMENT OF COMMERCE**

R. P. LAMONT, *Secretary*

**COAST AND GEODETIC SURVEY**

R. S. PATTON, *Director*

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**RESULTS OF OBSERVATIONS**

MADE AT

**THE UNITED STATES COAST AND GEODETIC SURVEY  
MAGNETIC OBSERVATORY NEAR TUCSON, ARIZONA  
IN 1923 AND 1924**

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BY

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## INTRODUCTION

[Latitude 32° 14'.8; longitude 110° 50'.1; elevation, 770 meters (2,526 feet)]

The Tucson Magnetic Observatory is about 8 miles (13 kilometers) east of the city of Tucson, Ariz., in a comparatively level country rising gradually to mountains on the north and west. The buildings were erected in the summer of 1909 and the instruments were installed and put in operation in November of that year. A description of the buildings will be found in the first volume of observatory results for 1909 and 1910. The relative position of the office and variation buildings is there incorrectly stated, however. The variation building is about 700 feet east of the office, and the vestibule is on the east end of the variation building.

The division of terrestrial magnetism and seismology of the United States Coast and Geodetic Survey has supervision of 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 Albert K. Ludy, magnetic observer, during all of 1923 and 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 O. S. Hill and Augustine McCarthy, mathematicians, and R. R. Bodle, Louis P. Sissman, and John Hershberger, magnetic observers. The methods of observing are explained in *Directions for Magnetic Measurements*, published in 1911 (third edition in 1930).

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 one hundred and fifth meridian. Thus, a value in the column headed 1 represents the average value for the hour beginning at midnight and ending at 1 a. m., one hundred and fifth 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. The variometers are mounted west of the recording apparatus. Upward motion of the curves on the magnetogram corresponds to decreasing east declination, increasing horizontal

EARTHQUAKES

A Bosch-Omori seismograph has been in continuous operation since September, 1910. It consists of two horizontal pendulums, one recording east-west motion (E) and the other recording north-south motion (N). The constants of the instruments were as follows:

		E.	N.
Steady mass.....	kilograms..	10	10
Multiplication.....	do.....	10	10
Period from.....			
Jan. 1, 1923.....	seconds..	16.7	19.4
May 1, 1923.....	do.....	16.9	18.5
Dec. 1, 1923.....	do.....	17.0	19.6

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 emergences 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. Accordingly the records of the operation of the seismograph at the Tucson Magnetic Observatory will be published hereafter in the seismological reports which are being issued, beginning with the first quarter of 1925.

Register of earthquakes

No.	Date	Component	P	S	L	M	C	F	A
			h. m. s.	h. m. s.	h. m. s.	h. m. s.	h. m.	h. m.	mm.
1	Jan. 11.....	E	e 4 35 18		4 35 41			4 40	0.1
2	Jan. 22.....	E	e 4 35 18		4 35 41	4 35 44		4 40	0.1
		N	i 9 07 38		9 10 43	9 13 12		10 02	20.8
3	Jan. 27.....	E	i 9 07 38	9 10 20	19 10 43	9 13 15	9 15	9 54	29.0
		N	7 59 47	8 01 12	8 02 04	8 02 05		8 14	1.5
4	Feb. 2.....	E		8 01 12	8 01 30	8 01 53		8 14	2.0
		N		5 27 05	5 41 41	5 44 10		6 10	0.2
5	Feb. 3.....	E	5 18 30	5 23 55	5 41			5 57	
		N	16 12 28	116 21 11	16 34 08			19 42	45.0
6	Feb. 8.....	E	16 12 28		16 35 02	16 39 35	16 40	19 42	37.5
		N	0 37 40		10 42 50	0 43 08		0 52	1.0
7	Feb. 8.....	E	0 37 40		10 42 50	0 43 29		0 52	1.6
		N	e 14 21 44					14 27	0.2
8	Feb. 24.....	E	e 14 21 44	7 52 27	8 04 15	8 21 08		9 04	0.3
		N		7 52 33	8 10 40	8 21 43		8 44	0.1
9	Feb. 27.....	E	e 20 39 41			20 41 21		20 47	0.1
		N	e 20 40 41			20 42 37		20 49	0.1
10	Mar. 7.....	E	5 02 58					5 08	0.1
		N	5 02 58	5 03 33	5 03 47	5 03 49		5 08	0.5
11	Mar. 18.....	E	20 29 54			20 30 27		20 35	0.2
		N	20 29 54		? 20 30 23	20 30 31		20 38	0.4
12	May 4.....	E	16 34 20	16 40 19	16 43 28	16 47 58		17 22	0.1
		N	e 16 34 24	e 16 40 34	16 44 20	16 48		17 04	0.1
13	June 18.....	E	8 28 04	8 37 52	8 55 29			9 30	0.1
		N	8 28 08	8 37 52				9 30	
14	July 12.....	E	e 5 41 31		5 42 04			5 52	0.1
15	July 12.....	E	e 13 43		6 14 17			6 22	0.1
16	July 23.....	E	e 7 32 13	7 33 12	7 33 34	7 33 51		7 55	3.5
		N	7 32 05	7 33 22	7 33 33	7 33 47	7 35	7 50	6.9
17	Aug. 23.....	E	23 17 00	23 19 00	23 19 18	23 19 39	23 27	24 22	32.0
		N	23 17 03	23 19 00	23 19 20	23 20 19	23 27	23 47	9.0
18	Sept. 1.....	E	3 11 22	3 22 01	e 3 34 35	3 50 20	3 51	6 05	5.5
		N	3 11 29	3 22 09	e 3 34 44	3 37 14		4 35	0.8
19	Sept. 2.....	E	e 3 02 55	3 09 53	3 28 49	3 32 00	3 36	4 32	0.7
20	Sept. 23.....	E	e 3 48 17		3 48 35	3 48 47		3 58	0.1
		N			e 3 49 34			3 50	
21	Sept. 30.....	E		e 1 30 00	1 48 46	1 54 50	1 59	2 32	5.0
		N	e 1 31 05	1 38 41	1 48 46	1 54 47	1 59	2 11	0.6
22	Sept. 30.....	E	18 28 14					18 33	0.1
		N	18 28 14					18 29	0.1
23	Oct. 7.....	E	e 4 02 58		4 22 43	4 28 32		4 56	0.2
24	Oct. 10.....	E	7 21 16	7 29 51	7 40 58	7 48 14		7 58	0.1
25	Nov. 1.....	E	e 9 10 45		9 13 09			9 24	0.1
26	Nov. 1.....	E	e 20 02 00			20 05 20		20 15	0.2
		N	e 20 02 35			20 06 53		20 09	0.1
27	Nov. 2.....	E	21 21 52	21 32 52	1 21 52 36	22 04 00		22 50	0.2
28	Nov. 4.....	E	e 0 22 04	e 0 29 45	e 0 48 57	0 53 20		1 18	0.3

## Register of earthquakes—Continued

No.	Date	Component	P			S			I <sub>1</sub>			M			C	F		A
			h.	m.	s.	h.	m.	s.	h.	m.	s.	h.	m.	s.	h.	m.	m/m.	
1923																		
29	Nov. 5	E	22	09	58			22	10	33	22	11	28		22	46	0.4	
		N	22	09	58			22	10	52					22	22		
30	Nov. 7	E	23	57	58			23	58	51	23	59	32		24	15	5.4	
		N	23	57	58			23	59	01	23	59	07		24	15	2.6	
31	Nov. 9	E						e 3	27	11	3	27	27		3	48	0.2	
		N						? 13	32	12	13	32	28		13	34	0.2	
32	Dec. 18	E	13	31	16			? 13	31	52					13	23	0.2	
		N						? 16	08	03					16	10	0.1	
33	Dec. 19	E	16	07	31			? 16	08	03			16	08	25		0.1	
		N													16	10	0.1	
34	Dec. 26	E						e 8	03	05	8	04	50		8	14	0.1	
		N																
1924																		
35	Jan. 14	E	21	03	00	21	13	16			21	32	32		21	34	0.1	
36	Jan. 25	E	e 6	09	23	e 6	13	45			6	15	59		6	33	0.2	
37	Mar. 4	E	10	14	29	10	19	56	10	24	31	10	29	07	11	15	2.0	
38	Mar. 4	E	e 11	51	06	11	55	59	11	01	13	11	05	01	11	20	0.1	
39	Mar. 11	E	e 10	58	25						11	02	05		11	13	0.1	
40	Mar. 30	E	0	14	02	0	18	41	0	22	58	0	23	58	0	42	0.2	
41	Apr. 14	E							17	19	06	17	14	38		18	19	0.4
42	Apr. 21	E	20	05	13	20	08	07	20	09	44	20	10	29	20	11	20	6.1
		N	20	05	09				20	09	20	20	10	10		20	16	6.5
43	May 1	E	20	00	18	e 20	06	05	e 20	09	13	20	10	34	20	24	2.0	
		N							e 20	09	51	20	22		20	28		
44	May 21	E	1	29	44				1	30	02	1	30	09		1	38	0.2
		N	1	29	31											1	31	
45	June 4	E	e 16	22	19						16	22	54		16	40	0.2	
46	June 18	E	e 17	31	13				17	31	52	17	32	20	17	35	0.4	
		N	e 17	31	33									17	34	17	44	
47	June 26	E							2	30	50	2	31	49	2	40	1.4	
		N							2	34	16			2	39			
48	June 30	E	15	56	17	16	05	23							17	00		
49	July 3	E	e 5	32	18				5	42	17	5	42	47	6	10	0.1	
50	July 6	E							14	44	12	14	44	45	15	00	0.1	
51	July 11	E							20	42	40	20	50	04	21	20	0.1	
52	Aug. 14	E				18	25	36	18	42	50	18	48	11	19	20	0.3	
53	Aug. 25	E	23	35	59	23	33	02	23	38	46	23	40	46	23	52	0.2	
54	Aug. 30	E	e 23	55	26				3	55	56				4	23	0.1	
55	Sept. 2	E	e 23	55	45				23	55	50	23	56	38	24	06	0.2	
		N	e 23	55	45													
56	Oct. 17	E	e 4	39	50				4	41	34	4	42	04	4	50	0.1	
57	Oct. 18	E							e 23	28	03				23	44	0.1	
58	Dec. 28	E				23	16	46	e 23	31	13	23	37	07	24	01	0.1	

## REMARKS

- Local tremors.
- O at 9:04:18, distance 1,550 km.; L<sub>2</sub> and L<sub>3</sub> on E at 9:11:43 and 9:12:46, respectively; L<sub>2</sub> on N at 9:11:36; recorded on magnetograph.
- Recorded on the magnetograph.
- O at 5:08:07, distance 6,920 km.; L<sub>2</sub> on E at 5:43:46.
- O at 16:01:41, distance 7,320 km.; P<sub>2</sub> on both at 16:12:47; P<sub>3</sub> on N at 16:21:42; I<sub>1</sub> on N at 16:22:51; e on E at 16:24:31 and on N at 16:25:44; e on E at 16:27:58; SR<sub>2</sub> on E at 16:30:01 and on N at 16:39:49; M<sub>2</sub> off paper at 16:39:26; recorded on magnetograph.
- L<sub>2</sub> on N at 0:43:23; recorded on magnetograph.
- Local tremors.
- SR on N at 7:58:35; L<sub>2</sub> on E at 8:10:51 and on N at 8:14:27.
- Local.
- e on E at 6:03:42; local.
- Local; recorded on magnetograph.
- O at 16:28:47, distance 4,210 km.; L<sub>2</sub> on E at 16:45:01 and on N at 16:46:56.
- O at 8:16:14, distance 8,550 km.; e on E at 8:28:39, 8:38:12, and 8:41:18; records very faint.
15. Local tremors.
- O at 7:30:40, distance 640 km.; recorded on magnetograph.
- O at 23:14:35, distance 1,120 km.
- O at 2:58:42, distance 9,600 km.; e on E at 3:45:26; N not in good adjustment.
- O at 2:46:23, distance 9,675 km. from L<sub>2</sub>-S<sub>2</sub>; e on E at 3:22:47; N not in good adjustment; only slight evidence of waves.
- Local shock.
- O at 1:20:49, distance 6,400 km. from L<sub>2</sub>-S<sub>2</sub>; ePR<sub>1</sub> on E at 1:33:18; SR<sub>1</sub> on E at 1:44:09.
- Local shock.
- L<sub>2</sub> on E at 4:27:32; N out of order.
- O at 7:10:42, distance 7,110 km.; L<sub>2</sub> and L<sub>3</sub> on E at 7:43:21 and 7:48:05, respectively; P and S barely perceptible.
- O at 21:08:48, distance 10,040 km.; PR<sub>1</sub> on E at 21:25:40; SR<sub>2</sub> on E at 21:44:12; L<sub>2</sub> and L<sub>3</sub> on E at 21:59:09 and 22:01:45, respectively; N component not operating satisfactorily.
- e on E at 22:20:11; M<sub>2</sub> on E at 22:22:09; recorded on magnetograph; e<sub>2</sub> apparently another earthquake.
- I on E at 23:59:31; recorded on magnetograph; tremors superimposed on L<sub>2</sub>.
- 34, 35, 36. No record on N.
- O at 10:07:38, distance 3,660 km.; ePR at 10:16:46; e at 10:20:21; SR at 10:22:14; L<sub>2</sub> at 10:28:15; N not operating during March.
- Interpretation based on report of Porto Rico observatory.
- O at 18:20:15, distance 12,100 km.; PR<sub>2</sub> at 18:42:17; e at 18:45:45; P<sub>2</sub> and S<sub>2</sub> at 16:49:40; SR<sub>1</sub> and SR<sub>2</sub> at 16:55:15 and 16:59:42, respectively; e at 17:10:57; origin based on PR<sub>2</sub> and SR<sub>2</sub>; N not operating satisfactorily.
- O at 20:01:29, distance 1,720 km.; recorded on magnetograph; observed in magnetometer while making declination observations.
- M<sub>2</sub> on E at 20:21:48; record of N defective; phases not well defined.
- e on E at 1:29:09; this may not be seismic.
- N not in good adjustment.
- ePR on E at 1:57:22; P<sub>2</sub> on E at 2:07:16 and on N at 2:07:30; SR on E at 2:14:16; L<sub>2</sub> on E at 2:33:28.
- O at 15:45:05, distance 7,820 km.; no definite long waves.
- 49, 50, 51. N out of order during July.
- e on E at 18:38:35; N not operating satisfactorily during August.
- P and S extremely weak.
- N out of order during October.
- eL<sub>2</sub> at 23:38:02.
- N out of order.