

DEPARTMENT OF THE INTERIOR

BULLETIN

OF THE

UNITED STATES

GEOLOGICAL SURVEY

No. 155



WASHINGTON
GOVERNMENT PRINTING OFFICE
1898

QE 75

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nos. 155-159

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UNITED STATES GEOLOGICAL SURVEY

CHARLES D. WALCOTT, DIRECTOR

EARTHQUAKES IN CALIFORNIA

IN

1896 and 1897

BY

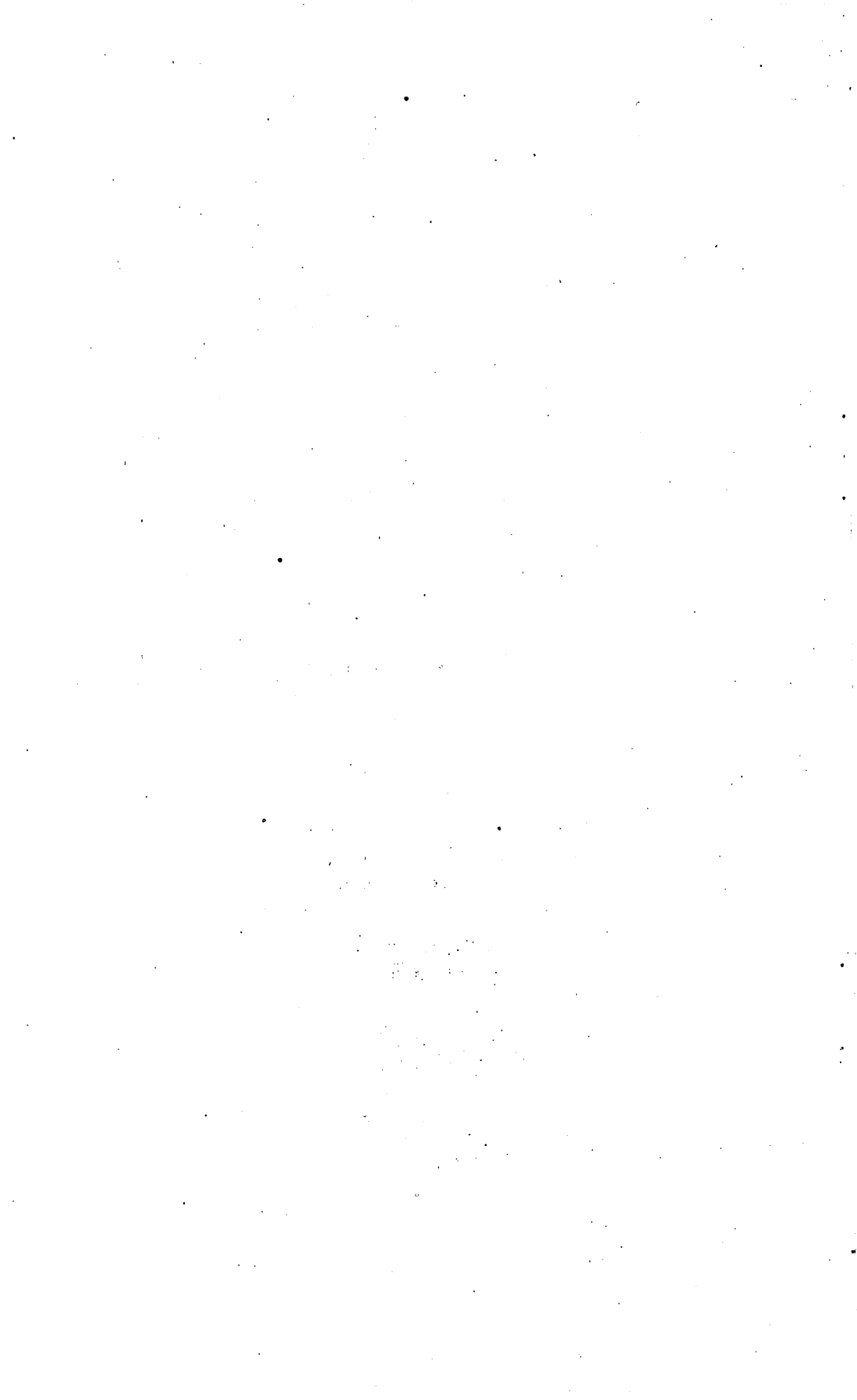
CHARLES D. PERRINE

ASSISTANT ASTRONOMER IN CHARGE OF EARTHQUAKE OBSERVATIONS
AT THE LICK OBSERVATORY



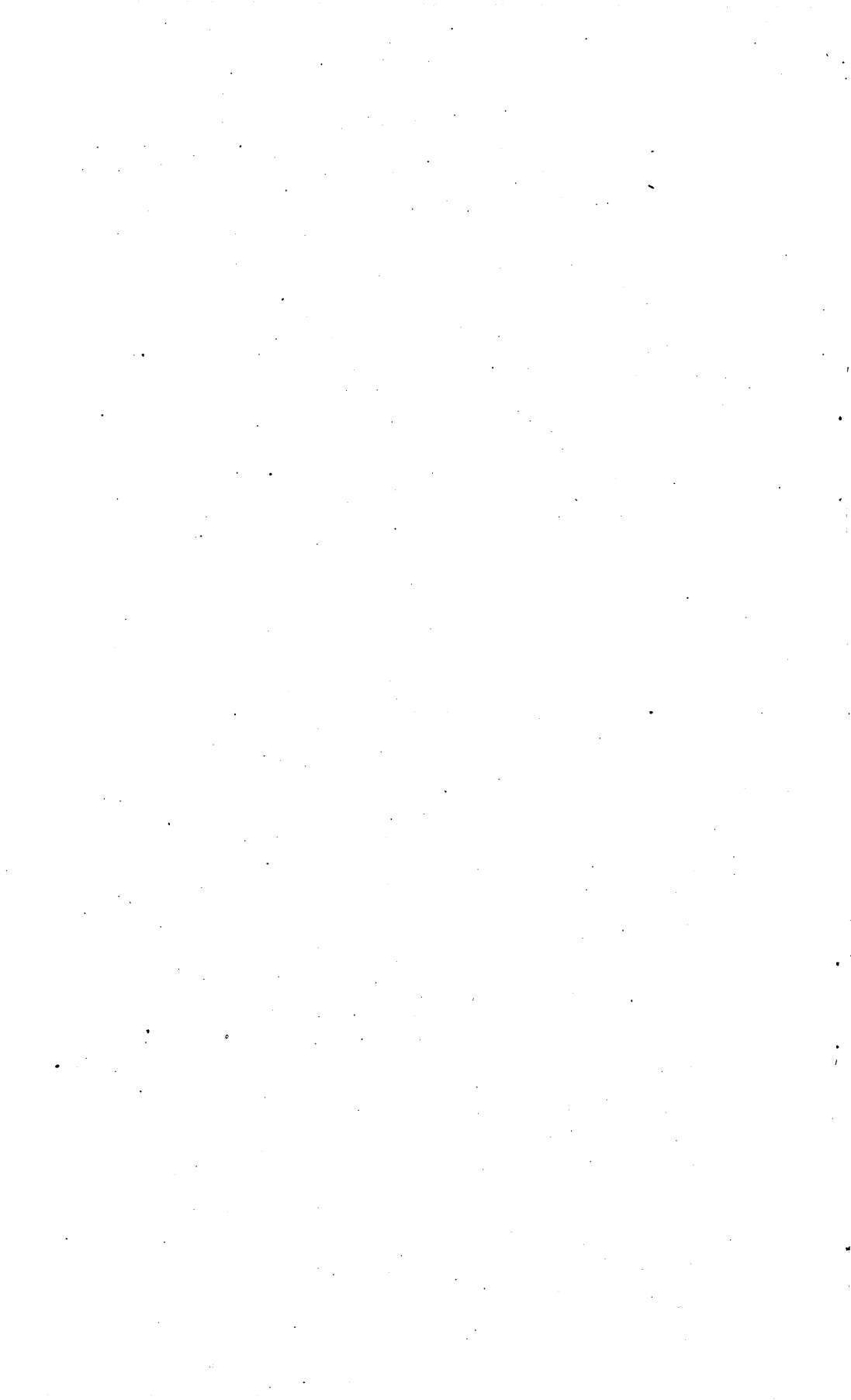
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LETTER OF TRANSMITTAL.

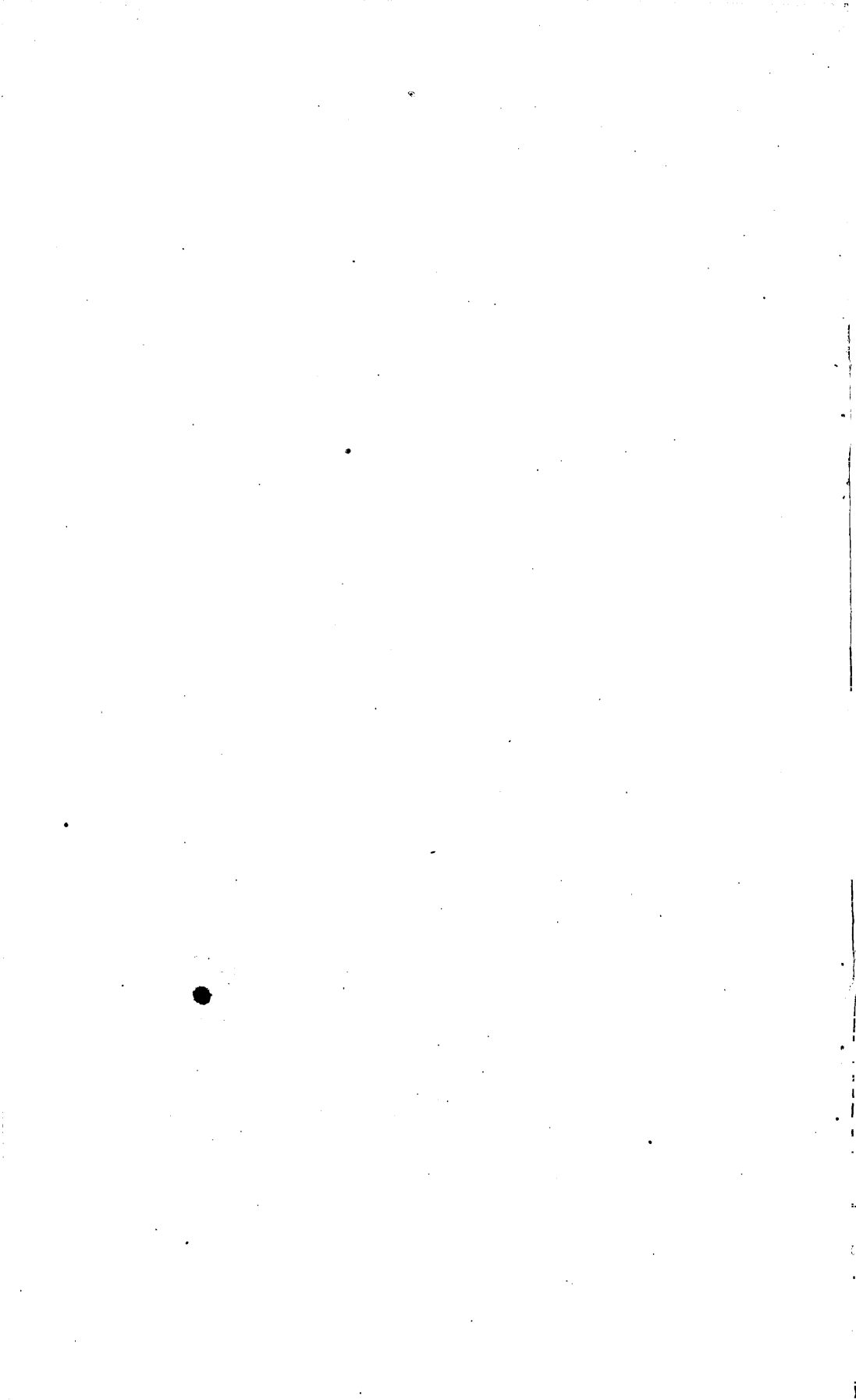
LICK OBSERVATORY,
UNIVERSITY OF CALIFORNIA,
Mount Hamilton, May 16, 1898.

DEAR SIR: I transmit herewith the record of earthquakes in California in 1896 and 1897, by Mr. Perrine. I trust that you may be able to publish this as a bulletin, as previously. The list of earthquakes in 1896 has already been published in a list compiled by Professor Holden and printed as one of the Smithsonian Miscellaneous Collections, but as it occupies only a few pages, to complete the series published by the Survey, we have thought you would prefer to have it included.

Yours, very truly,

J. M. SCHAEBERLE,
Acting Director

Hon. CHARLES D. WALCOTT,
Director United States Geological Survey.



EARTHQUAKES IN CALIFORNIA IN 1896 AND 1897.

By CHARLES D. PERRINE.

INTRODUCTION.

The following paper is a continuation of similar records¹ furnished by officers of the Lick Observatory, and completes the list up to the end of 1897. It records all the shocks observed or felt on Mount Hamilton and all those reported to the Lick Observatory by letter, as well as newspaper reports of such earthquakes as occurred in the State during the year.

It also includes a number of shocks in various localities on the Pacific coast which it was thought might not have been recorded in other reports. No systematic examination of newspapers has been made, however, and some reports of earthquakes may have escaped notice.

INSTRUMENTS.

The instruments used for recording earthquakes on Mount Hamilton are described in Publications of the Lick Observatory, Vol. I, p. 82. The largest and most complete instrument records the north-and-south, east-and-west, and vertical components of the earth's motion separately on a smoked-glass plate, which is started by the preliminary tremors of the earthquake and rotates in about three minutes, the edge of the plate being graduated into seconds by the clock, which also serves to record the time of occurrence of the shock. This instrument has been called the Ewing seismograph in the notes. Another form consists of the heavy "duplex" pendulum adjusted to a long period of vibration, with a magnifying pointer or pen, which records on a smoked-glass plate both horizontal components of the motion. The vertical component and the time are not recorded. The motion of the earth is magnified 4.6 diameters in the duplex seismometers. The Observatory possesses other seismographs of various patterns, but they are not constantly in use.

¹List of recorded earthquakes in California, Lower California, Oregon, and Washington Territory, from 1769 to 1888, by Edward S. Holden, Sacramento, State Printing Office, 1887. Earthquakes in California in 1888, by Edward S. Holden: *Am. Jour. Sci.*, 3d series, vol. 37, May, 1889. Earthquakes in California in 1889, by James E. Keeler: *Bull. U. S. Geol. Survey* No. 68, 1890. Earthquakes in California in 1890 and 1891, by Edward S. Holden: *Bull. U. S. Geol. Survey* No. 95, 1892. Earthquakes in California in 1892, by Charles D. Perrine: *Bull. U. S. Geol. Survey* No. 112, 1893. Earthquakes in California in 1893, by Charles D. Perrine: *Bull. U. S. Geol. Survey* No. 114, 1894. Earthquakes in California in 1894, by Charles D. Perrine: *Bull. U. S. Geol. Survey* No. 129, 1895. Earthquakes in California in 1895, by Charles D. Perrine: *Bull. U. S. Geol. Survey* No. 147, 1896.

SCALE OF MEASUREMENTS.

In the record made by the Ewing seismograph both the horizontal components are magnified about 4 diameters (see p. 12), and the vertical component is magnified 1.8 diameters. The measures of the vibrations as given in the notes are taken directly from the tracings, and therefore represent the magnified motion, unless otherwise mentioned.

If both the period (T) and the amplitude (a) of an earthquake wave are given, the maximum acceleration due to the impulse, which may be taken as the measure of the intensity (I) or destructive effect of the shock, is given by the formula—

$$I = \frac{4 \pi^2 a}{T^2}$$

in which the motion is assumed to be harmonic.

DIFFERENCES OF INTENSITY.

Estimates of the intensity of shocks are given also (in Roman numerals inclosed in parentheses) according to the Rossi-Forel scale, which for convenience of reference is inserted below. Experience has suggested that for observations in California a few additions should be made to this scale, and these are printed here in italics. When these are in quotation marks also they are expressions actually used in newspapers, etc., in describing earthquake shocks whose intensity is otherwise known. The scale as amended is as accurate as anything of the kind can be.

I.

Microseismic shocks recorded by a single seismograph, or by seismographs of the same model, but not putting seismographs of different patterns in motion; reported by experienced observers only.

II.

Shocks recorded by several seismographs of different patterns; reported by a small number of persons at rest; "*a very light shock.*"

III.

Shock reported by a number of persons at rest; duration or direction noted: "*a shock;*" "*a light shock.*"

IV.

Shock reported by persons in motion; shaking of movable objects, doors, and windows, cracking of ceilings; "*moderate;*" "*strong;*" "*sharp;*" (sometimes) "*light.*"

V.

Shock felt generally by everyone; furniture shaken; some bells rung; *some clocks stopped; some sleepers waked;* "*smart;*" "*strong;*" "*heavy;*" "*severe;*" "*sharp;*" "*quite violent.*"

VI.

General awakening of sleepers; general ringing of bells; swinging of chandeliers; stopping of clocks; visible swaying of trees; some persons run out of buildings; *window glass broken*; "severe;" "very severe;" "violent."

VII.

Overturning of loose objects; falling of plaster; striking of church bells; general fright, without damage to buildings; *nausea felt*; "violent;" "very violent."

VIII.

Falling of chimneys; cracks in the walls of buildings.

IX.

Partial or total destruction of some buildings.

X.

Great disasters; overturning of rocks; fissures in the surface of the ground; mountain slides.

The relation between the intensity of a shock as determined by the formula already given and the numbers of the Rossi-Forel scale has been reduced from all available data up to 1888 by Professor Holden, and is given below in tabular form. It is, of course, a rough approximation only:

Intensity, Rossi-Forel scale.	Intensity, millimeters per second.	Difference.
I.....	20
II.....	40	20
III.....	60	20
IV.....	80	20
V.....	110	30
VI.....	150	40
VII.....	300	150
VIII.....	500	200
IX.....	1,200	700

One of the objects of the earthquake observations on Mount Hamilton is to obtain data for correcting this table, so that the intensity (I) of a shock, as defined mathematically by the formula

$$I = \frac{V^2}{a}$$

(where V is the maximum velocity of the vibrating particle), can be inferred from the ordinary description of its effects.

STATIONS.

A number of duplex-pendulum seismographs, quite similar to the one used at the Lick Observatory, are placed at different points on the Pacific coast, but they are not all in operation. The stations are:

Students' Observatory, Berkeley, in charge of Professor Leuschner.

Chabot Observatory, Oakland, in charge of Mr. Burckhalter.

Private observatory of Mr. Blinn, in East Oakland.

Observatory of the University of the Pacific, San Jose.

Observatory of Mills College, near Oakland, in charge of Professor Keep.

Office of State Weather Bureau, Carson, Nevada, in charge of Professor Friend.

Alameda, California, at the residence of Mr. P. Perrine.

Esquimault, British Columbia, at the Meteorological Station, Mr. E. Baynes Reed in charge.

Tacoma, Washington, at the residence of Mr. F. G. Plummer. (Mr. Plummer's seismograph is not a duplex.)

The reports of the United States Weather Bureau and of the United States Light-House Board should be consulted in this connection, as they record disturbances felt at their stations, which may not be included in this list.

MAGNIFYING RATIOS OF EWING SEISMOGRAPHS OF THREE COMPONENTS, AND OF THE DUPLEX-PENDULUM SEISMOGRAPHS.

In the following deductions the pen and plate are assumed to move with respect to the steady point, and the motions of each are considered separately. In the reduction of the recorded displacements given by the pens upon the smoked glass plate, to the actual displacement of the earth particle, there are several circumstances to be taken into account. In the case of the two horizontal components there are four considerations, viz:

A.—The ratio of the pens, i. e., the distance from the point of the pen to the steady point, divided by the distance from the steady point to the point of support.

B.—The angle which the meridian of the pens makes with the true meridian of the place. If they coincide, there is no factor to be introduced on that account.

C.—The angle which a radius of the circular plate drawn through the point of the pen makes with a line drawn through the point of the pen and the steady point. If this angle is 90 degrees, there is no factor to be introduced on this account.

D.—The effect on the record caused by the motion of the record plate itself, due to the earthquake.

Let a = the record of the N. and S. pen as it appears upon the plate.

b = the record of the E. and W. pen as it appears upon the plate.

Let d = distance from steady point to point of support of pendulum.

e = distance from steady point to point of pen.

$$r = \frac{e}{d}$$

x = angle which the meridian of the pendulums makes with the true meridian of the place.

y and y' = angle between the direction of the pen arm and a radius of the plate drawn through its point for the N. and S. and E. and W. pens, respectively.

z = angle which the radius of the plate drawn through the point of the pen makes with the true meridian of the place.

α = actual displacement of the earth N. and S.

β = actual displacement of the earth E. and W.

A.—The ratio of the pens is the ratio of the distances from the steady point to the point of the pen, and from the steady point to the point of support; in the instruments we are especially considering, the line joining the steel points which bear in the agate cups. Theoretically, the steady point, or rather line, is the vertical line through the cylindrical weight about which the force of gravity is symmetrical. Practically, there is a little uncertainty as to the exact location of the steady point, which, however, will be very near the axis of the cylindrical weight.

This ratio is given by the formula:

$$r = \frac{e}{d}$$

B.—The horizontal pendulums should be so adjusted that their meridian coincides with the true meridian of the place; i. e., that the plane (q) passing through the points of support and the steady point of the pendulum, in the case of the E. and W. pendulum, should coincide with the meridian. In the N. and S. pendulum this plane should lie E. and W.

If, however, there is no such coincidence and the meridian of the instruments makes an appreciable angle (x) with the true meridian, then the displacements of the pendulums in the true coordinates by the earthquake will vary with this angle. If the direction of the earth's motion which it is designed to register is not *normal* to the plane (q), then the recorded motion will be less than it should be in the ratio of $\cos x : 1$.

C.—If the horizontal pens are so situated that when at rest the radii of the plate passing through their points are tangent to the arcs described by them, then no factor is to be introduced on this account. Otherwise the displacement measured on such a radius will be too small in the proportion $\cos y : 1$.

D.—The plate upon which the record is made is, of course, carried about by the earth in its movements, which must be taken into account in deducing the actual motion of the earth from the records of the pens.

In horizontal pendulums where the angle (p) between the lines drawn from the steady point to the point of the pen and from the steady point to the point of support is greater than 90 degrees, it can be shown that the *motion of the plate* due to the earthquake will be *additive* to the *pen's motion*, thus *increasing* the *record* of the pen, the plate being carried under the pen in an opposite direction to that in which the pen is moving. On the other hand, if the angle (p) is less than 90 degrees the effect will be the *opposite*; i. e., to *decrease* the pen's record. This assumes that the pendulums are not *far* out of adjustment with respect to their meridians. In the Lick Observatory instruments the angle (p) is greater than 90 degrees; hence the effect is to *increase* the record. This is true for both coordinates.

The component motion of the *plate* N. and S. as projected on a radius depends upon the angle (z) which that particular radius makes with the meridian, and varies as the *cosine* of that angle.

The component motion of the *plate* E. and W. as projected on the radius passing through the point of the E. and W. pen will vary as the *sine* of the angle (z).

From the foregoing we deduce the following formulæ for the reduction of the observed records to the true displacements of the earth:

$$\frac{a}{a} = \frac{e \cos x \sin y}{d} \pm \cos z \quad (1)$$

$$\frac{b}{\beta} = \frac{e \cos x \sin y'}{d} \pm \sin z \quad (2)$$

Professor Schaeberle suggests that we may also consider the plate and supports of the pens as one rigid system, and the steady point to move with respect to this system.

Let f = distance from point of pen to point of support of pendulum, and, as before, d = distance from steady point to point of support of pendulum.

Then, on the above assumption, it can be shown that

$$\frac{a}{\alpha} = \frac{b}{\beta} = \frac{f}{d} \quad (3)$$

so long as the instrumental meridian coincides with the true meridian of the station, and the radius of the plate passing through the points of the pens is normal to the lines passing through the points of the pens and their points of support. If, however, the instrument is not in adjustment in these two particulars, due allowance must be made for such variations.

THE VERTICAL COMPONENT.

In the mechanism for recording the earth's vertical motion, the pen proper is jointed to a vertical arm, which in turn is fastened rigidly to the counterpoised pendulum. The lifting by the earth causes the joint between the pen arm and the vertical arm to be displaced in the arc of

a circle whose center is the steady point of the pendulum. This displacement is resolved into a *horizontal* component (s), which leads to the magnified record on the plate, and a *vertical* component (t).

Let h = distance from steady point to point where pen arm is hinged to vertical arm.

i = distance from point of support to hinge of pen arm.

j = distance from steady point to point of support of pendulum.

m = angular displacement of the hinge of pen arm from the steady point as a center.

n = angle included between the lines drawn from pen arm hinge to steady point, and from pen arm hinge to point of support of pendulum.

s = horizontal component of the displacement of pen-arm hinge.

t = vertical component of the displacement of pen-arm hinge.

γ = vertical displacement of the earth.

c = the record of the vertical pen as it appears upon the plate.

m and n are found from

$$\sin m = \frac{\gamma}{j} \quad (4)$$

$$\tan n = \frac{j}{i} \quad (5)$$

and we find s and t from

$$s = \frac{h \sin m}{\cos \frac{1}{2} m} \cos \left(\frac{1}{2} m + n \right) \quad (6)$$

$$t = \frac{h \sin m}{\cos \frac{1}{2} m} \sin \left(\frac{1}{2} m + n \right) \quad (7)$$

For ordinary displacements of the earth (m being always small) we may write (6) and (7) in the following forms:

$$s = h \sin m \cos n \quad (8)$$

$$t = h \sin m \sin n \quad (9)$$

It will be seen that the pen-arm hinge is lifted a little *higher* by the earth's motion than the plate itself. This causes the pen's record on the plate to be *shortened* slightly.

In a seismograph of the usual form the dimensions are such that so long as the pen arm makes but a small angle with the plane of the plate this factor will be small.

To compute the amount of this shortening, we have the following quantities in a right triangle:

a' = distance from point of pen to hinge of pen arm = hypotenuse.

b' = perpendicular let fall from hinge of pen arm to plate.

c' = distance from pen's point to foot of perpendicular = base of triangle.

A' , B' , C' = angles opposite given sides respectively, A' being the right angle.

We find B' from

$$\sin B' = \frac{b'}{a'} \quad (10)$$

and we have (approximately)

$$\Delta c' = - \frac{\cos C' \Delta b'}{\cos B'} \quad (11)$$

in which $\Delta c'$ is the decrease in the *record* due to the increase ($\Delta b'$) in the distance from pen-arm hinge to plate as a result of the lifting of the instrument by the shock.

For the Lick Observatory instrument we have:

$$a' = 5^{\text{in.}}.75$$

$$b' = 1^{\text{in.}}.75$$

Using this data, I have computed the shortening of the *record* due to this cause, and find it to be only $0^{\text{in.}}.014$ for a vertical motion of the earth of $0^{\text{in.}}.50$. Hence it will be seen that for shocks likely to be observed with these instruments this effect may be ignored without sensible error.

If in equation (8) we substitute for $h \cos n$ its equivalent i , and for $\sin m$ its equivalent $\frac{j}{\gamma}$ we find (approximately),

$$\frac{s}{\gamma} = \frac{i}{j}$$

It can be shown that the same result follows from considering the motion to be about the support of the pendulum as the axis.

Finally we have for the magnifying ratio of the vertical pen,

$$\frac{c}{\gamma} = \frac{s}{\gamma} + \Delta c' \quad (12)$$

in which $\Delta c'$ may be neglected, as shown, or with sufficient accuracy,

$$\frac{c}{\gamma} = \frac{i}{j} \quad (13)$$

For the Lick Observatory instruments we have the following data:

$$d = 3.75 \text{ inches,}$$

$$e = 13.0 \text{ inches,}$$

$$x = 6^{\circ},$$

$$y = 105^{\circ},$$

$$y' = 76^{\circ},$$

$$z = 38^{\circ}.5,$$

$$h = 10.3 \text{ inches,}$$

$$i = 9.0 \text{ inches,}$$

$$j = 5.0 \text{ inches,}$$

from which we derive the following ratios:

$$\frac{a}{\alpha} = 4.11 \quad (\text{N. and S.})$$

$$\frac{b}{\beta} = 3.97 \quad (\text{E. and W.})$$

$$\frac{c}{\gamma} = 1.8 \quad (\text{vertical}).$$

The data given above and the constants deduced from them are suitable for the reduction of observations from April, 1893, to date.

MAGNIFYING RATIO OF THE DUPLEX SEISMOGRAPH.

In the ordinary form of this instrument there are two circumstances to be considered as affecting the magnification of the earth's motion, viz:

First. The magnifying ratio of the vertical arm, which is given by

$$\frac{a''}{b''}$$

in which

a'' = distance from lower end of vertical arm to level of glass plate;

b'' = distance from lower end of vertical arm to gimbal joint of bracket.

Second. The motion of the plate itself during the shock. It can be shown that the motion of the plate itself tends to decrease the *record* by the amount of the earth's motion. Hence we have the following formula for the magnification:

$$\frac{a'' - b''}{b''} \quad (14)$$

In the Lick Observatory instrument of this class we have,

$$a'' = 13^m.10$$

$$b'' = 2.35$$

and consequently the magnifying ratio = 4.6.

Owing to uncertainties, such as the friction of the pen upon the plate, the friction of the pendulums at the point of support, the probable motion of the steady point itself after a few seconds, and other minor causes, it is not necessary to take into account all the lesser factors affecting the magnification of the record. All that is here attempted is to include those which have a practical effect. I have not been able to find the formulæ for these reductions in any publication on the subject here.

CHRONOLOGICAL RECORD, 1896.¹

1896. January 3; Esquimault, British Columbia; 10h. 9m. p. m., P. s. t.²
A distinct shock of earthquake.—Reported by E. Baynes Reed.
1896. January 3; Victoria, British Columbia; 10h. 20m. p. m.
A severe shock of earthquake was felt here to-night at 10.20 o'clock. Many citizens in the public offices, believing the shock to be produced by the falling in of some large roof, or like cause, hurried to the streets.—Newspaper report.
1896. January 3; Port Angeles, Washington; 10h. 30m. p. m.
At 10.30 o'clock last night two distinct shocks of earthquake were felt in this city. They were severe enough to shake chimneys off lamps and dishes off shelves (VII Rossi-Forel scale).—Newspaper report dated January 4, 1896.
1896. January 5; Cocopah Mountains, via Indio, January 5.
Prospectors report seeing immense quantities of smoke and steam rising off the desert toward the volcanoes below the Cocopah Mountains during the day and a bright light at night, showing that the volcanoes in that vicinity are again in active operation.—San Francisco Chronicle.
1896. January 8; Turn Point Light House, Washington; 9h. 56m. p. m.
A shock.—MS. kindly communicated by the United States Light-House Board.
1896. January 8; Lake Chapala, Mexico, via San Diego, California, January 12.
Prof. E. H. Coffey, of this city, has just received a letter from a correspondent living near Lake Chapala, State of Jalisco, Mexico, which describes some startling phenomena occurring there. Lake Chapala is a sheet of water 50 miles long and 10 miles wide. The formation of the country around it is purely volcanic. On the forenoon of January 8 the residents of one of the small settlements near the western end of the lake were terrified to see a gigantic whirlpool raging far out on the waters. The water rose in great serpentine movements and from all directions rushed toward a common center, where a vast cavity seemed to exist. At the same time a heavy rumbling, apparently in the bowels of the earth, took place. The whirlpool was caused by the sudden sinking of a large portion of the lake's bottom. The disturbance continued for twenty minutes, and before it subsided several pleasure boats were drawn into the whirlpool and disappeared with their occupants. It is estimated that a score of lives were lost.—San Francisco Examiner, January 13.

¹ Included in this list are one or two reports the correctness of which may be doubted. These were derived from newspapers entirely and are of such a nature that they should be confirmed before acceptance. Each of these doubtful reports has been indicated by some note.

² Pacific slope time.

1896. January 25, 27; Carson, Nevada.

Prof. C. W. Friend reports: We have had quite a number of earthquake shocks on January 25 and 27, 1896; they were rather peculiar. On the 25th the first noticeable one occurred, at 4.45 a. m., and was the heaviest that day. I also noticed one at 4.46 a. m. and 5.02 a. m., both light. The motion, west to east, was hardly perceptible.

We had quite a number of shocks on the 27th, viz: 7.59 a. m. S. to N. (II Rossi-Forel scale); 8.34 a. m. W. to E. (III); 11.04 a. m. SW. to NE. (III); 11.19 a. m. SW. to NE. (I); 1.01 p. m. SW. to NE. (IV); 6.32 p. m. SW. to NE. (II); and quite a number of very light tremors between, which I noticed, being quiet in the building. The seismographs did not record a spot larger than one-tenth inch on the plate for all of these, although some of the shocks were quite severe, so much so that a great many people were scared. On the 25th I hung up a 1-ounce plumb bob on a fine thread 3 feet long in a glass case fastened to a stone wall, and it was all I could do to determine the motion by it; all the shocks, including those of the 25th, were vertical and produced a very strange feeling.

1896. January 27; Carson, Nevada.

The first heavy shock was about 8.30 o'clock in the morning, and it was quick and lively. It rattled the glass and china in everybody's cupboard, made the windows shake, and got several lazy people out of bed (R.-F. V?). The next was about 11 o'clock and was also quite sharp. At 1 o'clock came the heaviest of all, and it shook every building in the city. The capitol building was particularly well shaken, and inside of a minute there was a rush to the basement of the building to see the record of the seismograph. It had been deflected about an eighth of an inch by each shock, and had also recorded small shocks all through the day.

The Signal Service records showed a very unsettled barometer. Rapid changes occurred, and their suddenness was unequaled by anything recorded since last July. These shocks were all graded as No. III, Rossi-Forel scale. There were two others during the day that graded I and II, respectively. The first was north and south, the second east and west, and the last three southwest and northeast. They were principally vertical.

The jar at 1 o'clock made a large crack in the side of the Government building, and shook some of the plaster from the ceiling of the county building (VII).—San Francisco Call.

1896. February; Tauquiz Peak, via Los Angeles, February 4.

A special to the Times from San Jacinto says: There is considerable excitement here over what appears to be an eruption of part of the San Jacinto Mountains called Tauquiz Peak, 20 miles from here. The streets of San Jacinto have been crowded with people looking through telescopes at the ominous clouds of smoke which have

1896. February; Tauquiz Peak, via Los Angeles, February 4—Continued.
hung over Tauquiz all day. When first noticed at 9 o'clock the vicinity of the peak was hazy with smoke. Within the next hour this cleared away and glasses leveled at the extinct volcano were able to detect a straight line of smoke ascending. Soon this disappeared, and then, puff, puff, came more black smoke, like that which pours out of the smokestack of a locomotive.

The smoke has continued to pour out of Tauquiz all day, and everybody is much excited, fearing an eruption. This peak has been pronounced by scientists an extinct volcano.—San Francisco Chronicle, February 5, 1896.

This report has not been confirmed.—C. D. P.

1896. February 5; Tauquiz Mountain, via San Bernardino, February 5.

Parties who have returned from the San Jacinto Mountain report that Mount Tauquiz gives out mysterious rumblings and that smoke is plainly visible. To-day smoke was seen from this city.—San Francisco Chronicle.

1896. February 5; Tauquiz Mountain, via San Bernardino, February 7.

Mount Tauquiz, a spur of the San Jacinto Mountains, and well known to be an extinct volcano, situated about 12 miles from the town of San Jacinto, is again reported to be giving forth smoke. Two men from San Jacinto say a column of vapor can be plainly seen rising from the highest point and that it looks nearly as white as snow. Reports of this mountain being in a state of active eruption have been numerous for several days, and to-morrow a party of newspaper reporters will leave the city on an expedition to Tauquiz. The last 4 miles of the trip will have to be made through banks of snow several feet in depth, the mountain being covered with snow this season of the year and being 10,000 feet in height.—San Francisco Examiner, February 8, 1896.

1896. February 5; Tauquiz Mountain, via San Bernardino, February 9.

It is reported to-day that people in and about Mount Tauquiz are getting ready to leave the vicinity, as the action of the mountain is, to say the least, very threatening.

The first that was noticeable in its strange demeanor was a whistling sound—not shrill, but hoarse and guttural-like. This was followed by a deep roar like distant thunder, followed by peal on peal.

This continued for several days, when one morning the Indians in camp were startled by a shock like that of a heavy earthquake, and immediately smoke was seen issuing from the mountain's peak, at first in thin white layers, followed immediately by puffs like those from the smokestack of an engine. This has kept up almost incessantly up to date.

It has been handed down in Indian history in that neighborhood that Mount Tauquiz once belched forth volumes of fire.—San Francisco Call, February 10, 1896.

1896. February 6; East Clallam, Washington; 9h. 55m. p. m.

Quite a well-defined shock. The direction of the temblor was from west to east. It lasted about a minute. Every house in the town, large and small, was shaken to its very foundations, but as far as can be learned no damage was done.

The Indians on Neah Bay Reservation all felt the shock. The same shock was also experienced on Tatoosh Island about the same time. The captain of the bark *Edinburghshire*, lying at anchor in the bay, says the shock was felt by every person aboard his vessel. Some of the sailors became so scared that they wanted to take to the ship's boats.—San Francisco Chronicle.

1896. February 13; Redding.

A slight earthquake shock was felt in this city about 10 o'clock this forenoon. The shock was more perceptible in the western part of the city and on the hill upon which the county court-house stands.

1896. February 13; Weaverville; 9h. 55m. p. m.

Three successive shocks of earthquake were felt very perceptibly here at 9.55 o'clock. They were of short duration, with a vibration from south to north. Buildings of more than one story received a hard shaking.

1896. February 13; Eureka; 9h. 55m. p. m.

At 9.55 o'clock this morning a sharp shock of earthquake, vibrating from north to south, was felt in Humboldt County.—San Francisco Examiner, February 14, 1896.

1896. February 15; Los Angeles; 2h. 52m. p. m.

A distinct shock of earthquake was felt here at 2.52 p. m. The temblor lasted several seconds. Large buildings of substantial structure were considerably shaken. In the court-house the shock was distinctly felt by the county officials and their deputies, and they were frightened.

1896. February 15; Pasadena; 2h. 57m. p. m.

Pasadena was visited by a slight earthquake shock at 2.57 o'clock this afternoon, lasting about fifteen seconds. The wave seemed to pass from northwest to southeast.—San Francisco Call.

1896. February 15; Los Angeles; 2h. 45m. p. m.

A slight shock, lasting about two seconds, was felt in this vicinity at 2.45 o'clock this afternoon.—San Francisco Chronicle.

1896. March 15; Burrard Mountains, British Columbia, via Vancouver, British Columbia, March 16.

One of the Burrard Mountains, directly opposite Vancouver and 10 miles distant, is believed to have been in a state of eruption last night. Numbers of persons vouch for the accuracy of the statement. C. Harris, a reputable lawyer, declares that dense smoke and flames poured from the mountain for several minutes. No one has scaled the mountain, so that its geological formation is not known. In view of the fact that several shocks of earthquake occurred here in the past year, the story is believed by many.—Newspaper report.

This report has not been confirmed.—C. D. P.

1896. March 19; Carson, Nevada; 4h. 1m. a. m.
Light.—C. W. F.
1896. March 20; Carson, Nevada; 11h. 25m. p. m.
Light.—C. W. F.
1896. April 2; Portland, Oregon; 3h. 20m. \pm p. m.
About 3.20 a. m. a single shock of brief duration was felt here. The shock was felt as far south as Salem.
1896. April 2; McMinnville, Oregon; 3h. 17m. a. m.
The inhabitants were awakened at 3.17 this morning by an earthquake (R.-F. VI). Two or three distinct shocks followed in quick succession, with a loud rumbling noise coming from the west. The earth appeared to tip toward the east.—San Francisco Chronicle.
1896. April 28; San Francisco; 2h. 57m. p. m.
A slight shock, lasting a very short time. It was observed by none of the Weather Bureau officials on the tenth floor of the Mills Building.
"We were in the office of the Alaska Commercial Company, at 310 Sansome street, when the shock occurred," said Professor Davidson. "All who felt the shock agreed that the movement was from east to west. The shock was very light and of short duration, lasting not more than a second, if that long. My son took the time, which was 2.57 p. m."—San Francisco Chronicle, April 29, 1896.
1896. April 28; Alameda.
A disturbance was registered by Mr. Perrine's instrument, the principal motion being north and south.
1896. June 5; 10h. 20m. p. m.; Cape Blanco Lighthouse, Oregon.
Tower vibrated considerably for about thirty seconds. I could not say positively that it was caused by an earthquake.—MSS. kindly communicated by the United States Light-House Board.
1896. June—; Big River, California, via Ukiah, June 23.
Considerable excitement was created on the coast of Mendocino "a few days ago" by an immense tidal wave. The swell was 7 feet higher than ordinary and rushed up Big River with great force. The great wall of water is attributed to the Japanese earthquake.—San Francisco Chronicle, June 24, 1896.
1896. July 3; San Diego; 9h. 27m. p. m.
A severe shock of earthquake. It lasted for several seconds. The oscillation was from north to south and was quite pronounced.—Newspaper report.
1896. July 13; Berkeley.
Slight record.—Professor Soulé.
1896. July 23; Vallejo; 1h. 50m. a. m.
A sharp shock. The vibrations were from southeast to northwest.—San Francisco Chronicle.
1896. July 25; Berkeley.
Slight record N. and S. [?].—Professor Soulé.

1896. July 26; Berkeley.

Same as July 25 [?].

1896. August 11; Mount Hamilton; 8h. 58m. 7s. \pm p. m., P. s. t.

Rossi-Forel II.—E. S. Holden.

No record of the above on either of the seismographs.

1896. August 11; Alameda.

Mr. Perrine's seismograph shows quite a complicated tracing, the principal disturbance being east and west.

1896. August 17; Merced.

At 3.40 o'clock this morning Merced was visited by an earthquake which lasted about three seconds. The roll was from north to south and shook things up quite lively for the time. Many clocks stopped as a result (VI).

1896. August 17; Visalia; 3h. 29. \pm a. m.

A slight earthquake shock was felt here early this morning; a very slight temblor, followed in about five seconds by three distinct wave-like motions in quick succession. The direction the waves traveled seemed to be a little north of west. The time, as fixed by different observers, was from 3.29 to 3.30 o'clock.—San Francisco Chronicle.

At 3.26 o'clock this morning Visalia was shaken by an earthquake. There were two distinct shocks. Many persons were awakened and alarmed (VI).—San Jose Mercury, August 18, 1896.

1896. August 18; Mount Hamilton.

11h. 0m. 24s. \pm p. m., P. s. t. Rossi-Forel III.—E. S. Holden.

11h. 0m. 13s., P. s. t.—A. L. Colton.

1896. August 18; Napa.

A slight shock was felt here this afternoon.—San Francisco Chronicle.

1896. August 18; Evergreen, Santa Clara Co.; 11h. 0m. 15s. p. m., P. s. t.

I was awakened by a slight earthquake, running, apparently, from north to south.—William Wehner.

1896. August 19; Alameda.

A slight disturbance was recorded by Mr. Perrine's seismograph. The direction of motion could not be determined.

1896. August 26; Mount Hood, Oregon.

Newspaper dispatches report the narrow escape of a party of tourists on Mount Hood on the afternoon of August 26 from an avalanche. The dispatches convey the impression of a volcanic eruption, but it seems entirely possible to explain the occurrence without any such assumption. A slight earthquake may have accompanied or even caused the avalanche. No reports have been received of any disturbances elsewhere on that day.

1896. September 1; Pinole, Contra Costa County.

[At 1 o'clock p. m. the works of the California Powder Company exploded. There were three separate explosions, the heaviest one being the mixing house with its 15,000 pounds of dynamite. This explosion was not noticed at Mount Hamilton, nor did the seismographs or barometers record any tremors.]

1896. September 10; Santa Rosa; 3h. 45m. a. m.

A sharp shock. The vibration was north and south.—San Francisco Chronicle.

1896. September 24; Mount Hamilton; 5h. 25m. p. m.

5h. 25m. 30s. \pm p. m., P. s. t. R.-F. III.—E. S. Holden.

5h. 25m. 45s. p. m., P. s. t. R.-F. I. L. O. main building creaked, but did not notice any particular motion. There was a slight mark on the plate of the duplex seismograph.—C. D. P.

1896. September 30; Descanso.

California State Weather Service Bulletin.

1896. October 19; Santa Rosa; about 6 a. m.

Quite a severe earthquake shock. The vibrations were from north to south, lasting about three seconds. No damage.—San Francisco Chronicle.

1896. November 3; Mount Hamilton; 10h. 58m. 44s. \pm 1s. a. m.

In my office rattled stove, lamp shade, etc. Three or four short, sharp shocks, all within one and one-half seconds.—W. W. Campbell.

1896. November 11; Cahto.

Two shocks of more than ordinary note were felt here at 2 o'clock this morning. They shook crockery from shelving, stopped clocks, etc., doing no material damage. The vibrations were from east to west and the duration was about four seconds (R.-F. VI).—San Francisco Chronicle.

1896. November 29; Mount Hamilton; 11h. 3m. 37s. a. m., P. s. t.

An irregular, slight shaking, lasting five or six seconds. Not exactly like the vibrations of an earthquake, but could find no other explanation (R.-F. I). I was in the 12-inch dome at the time. No record on the seismographs.—C. D. P.

1896. December 8; Mexico.

A heavy earthquake occurred to-day at the various Pacific ports of this Republic, the first shock coming at 9.30 a. m. and the second, an up-and-down and very alarming one, at 1.30 p. m., and at 5 p. m. the third shock occurred. No casualties are reported.—San Francisco Chronicle, December 9, 1896.

1896. December 17; Santa Barbara.

A tidal wave, the largest in the history of Santa Barbara, washed over the boulevard at 8 o'clock this morning, carrying back with it a large section of that beautiful and expensive driveway. The boulevard was built some five years ago and bulkheaded so securely that it was thought to be impervious to the action of the waves, but the bounding billows carried off in its receding grasp a portion of asphaltum and solid masonry, heavy framework and iron, nearly 50 feet square and 8 feet deep. A large sand hill between the boulevard and ordinary high tide was carried completely out to sea.—San Jose Mercury, December 18, 1896.

1896. December 22; Mount Hamilton.

1h. 52m. 41s., P. s. t. (R.-F. V).—E. S. H.

1h. 52m. 43s., P. s. t. (middle of shock). Three seconds duration. Did not rattle dishes.—W. W. C.

1h. 52m. 44s., P. s. t. (end of shock).—W. J. H.

1h. 52m. 44s., P. s. t. (end of shock), duration estimated at two seconds.—A. L. C.

1h. 52m. 37s. \pm 1s., P. s. t. Time noted at cottage.—R. G. A.

1h. 52m. 40s. p. m., P. s. t. (beginning). Second floor brick house. Lasted two to three seconds. Light tremors increasing to two well-marked vibrations, then dies out suddenly. Building creaks. Direction seemed to be N. and S.—C. D. P.

The duplex seismograph recorded a small disturbance, about NW. and SE.—1.5 mm. \times 1 mm. NE. and SW. The clock only of the Ewing instrument was started.

1896. December 31.

The following notes are from MSS. kindly communicated by the United States Light-House Board. The reporters are the light-house keepers:

Coquille River (near Bandon), Oregon: The station went into operation February 29, 1896. No earthquakes during the year.

Cape Arago, Oregon: No record of earthquakes from January 4, 1891. No previous record.

Umpqua River, Oregon: Station went into operation January 1, 1895. No record of any earthquakes.

Haceta Head, Oregon: Station went into operation April 1, 1895. No record of any earthquakes.

Cape Meares, Oregon: Station went into operation January 1, 1890. No record of any earthquakes.

Tillamook Rock, Oregon; also Point Adams, Oregon: No record of any earthquakes.

Cape Disappointment, Washington; also Willapa Bay, Ediz Hook, New Dungeness, West Point (all in Washington) have no records of any shocks on their books. Narrowstone Point, Washington, went into operation April 7, 1896. No earthquakes recorded.

Patos Island, Washington, went into operation December 1, 1893. No earthquakes recorded.

CHRONOLOGICAL RECORD, 1897.

1897. January 1; Berkeley; 1h. 10m. p. m.

Distinct shock; duration, five seconds. Recorded by the duplex seismograph. Reported by the Students' observatory.

1897. January 11; Oaxaca, Mexico; 4h. 25m. p. m.

CITY OF MEXICO, *January 11*.—At 4.25 this afternoon an earthquake was felt in Oaxaca, the first shock being general. The second was very sharp and caused consternation, but no harm was done of any consequence. There is much seismic activity in the State of Oaxaca, and at one point on the Pacific coast earthquakes have kept fishermen in continual alarm.—San Francisco Chronicle.

1897. January 16; Mount Hamilton.

3h. 58m. 41s. ± 5s. a. m. R.-F. II.—W. W. Campbell.

3h. 58m. 35s. ± 5s. a. m. R.-F. I. Third story of brick dwelling.

Two rather long, slow waves lasting one and one-half or two seconds. Scarcely any trace on duplex seismograph. Did not start Ewing instrument.—C. D. P.

1897. January 17; San Francisco; 1h. 9m. p. m.

The following facts are taken from an article in the San Francisco Call of January 18:

A sharp earthquake shock was felt in all parts of this city a fraction of a minute after 1.09 o'clock yesterday afternoon. There were two well-defined counter vibrations of considerable force, according to the description by Weather Observer McAdie, who carefully noted the time, and subsequently compared notes with one of his coworkers in the weather forecast office in the Mills Building. He reports it as one of the shortest shocks he had ever felt, and was not certain that it was not due to an explosion rather than an earthquake, as he was at lunch and failed to notice any disturbance of the surfaces of liquids.

Prof. George Davidson felt two slight shocks about four seconds apart. He thinks the motion was wholly vertical.

The seismographic record at the Chabot Observatory showed that the disturbance was a heavy one, and that the vibrations were mainly from east to west.

1897. January 17; Alameda; 1h. 11m. p. m.

A complicated record was made by the duplex seismograph, the disturbance being principally east and west. The magnified record is 6 mm. long in this direction and 2 mm. north and south.—Reported by P. Perrine.

1897. January 17; Oakland; lh. 11m. 11s. p. m., P. s. t.

Two sharp shocks were observed about one second apart. The time given is for the second shock and is believed to be correct within a second. The first shock seemed heavier than the second, and both suggested an explosion rather than an earthquake. An examination of the country in the direction of the powder mills was made immediately from the housetop, with a glass, but no evidences of an explosion were visible.

A heavy rumbling was noticed just preceding the shocks, and the house creaked. The windows on the north side of the house seemed to rattle before, and louder than those on the opposite side. The chandelier shook, and as it came to rest the vibrations appeared to be north and south approximately.—Reported by A. H. Babcock.

1897. January 17; Oakland; lh. 10m. 55s. ±2s. p. m., P. s. t.

The shock was accompanied by a distinct report.—Reported by G. R. Lukens.

1897. January 17; Mills College; lh. 11m. p. m., P. s. t.

The shock was short, but quite sharp and distinct. Some say they heard a distinct noise before the shake.—Reported by Josiah Keep. The blue print of the record made by a duplex seismograph, which accompanied the above report, shows an area of 7 mm. north and south and 4 mm. east and west, containing a great number of individual vibrations impossible to unravel. There are also one double wave and one or two single ones extending to the west (?) of the main disturbances.—C. D. P.

1897. January 26; Newport, Alsa Bay, Oregon; 2h. 45 m. p. m.

NEWPORT, OREGON, *January 27*.—This section was visited by an earthquake shock yesterday at 2.45 p. m. The shock was about three seconds in duration. Houses were shaken until dishes on the shelves rattled. The vibration appeared to come from a northerly direction, and was accompanied by a slight rumbling noise like thunder. Reports from Alsa Bay state that the shock was felt plainly there about the same time.—San Francisco Chronicle.

1897. February 2; Tomales.

SAN RAFAEL, *February 2*.—The town of Tomales, situated on Tomales Bay, Marin County, is greatly excited over two sharp explosions that were heard shortly before 11 o'clock this morning. The reports, which seemed to come from the direction of the ocean, were followed by a vibration of the earth's surface similar to that felt during earthquakes. The shaking sensation, though slight, was distinctly felt in Tomales and the adjoining country. Among those who felt the shock are John Arthur and M. O'Neal, dairyman, and D. Thrasher, a blacksmith. It was at first supposed that the explosions were the reports of a gun aboard some ship in distress, but that theory was soon dismissed when it was learned that many of the citizens distinctly felt the earth tremble immediately

1897. February 2; Tomales—Continued.

after the reports. Edward Collins and Mrs. Keyes claim to have seen a meteor burst in a field near Tomales, but a thorough search failed to reveal any trace of a heavenly visitor. The citizens have come to the conclusion that Tomales was visited by a slight earthquake, but they are unable to explain the cause of the explosions.—San Francisco Examiner, February 3.

1897. February 5; Orizaba Volcano, Mexico.

CITY OF MEXICO, *February 6.*—Orizaba Volcano last night was somewhat active, throwing a red light against the sky and emitting large volumes of smoke. The inhabitants are alarmed, and fear that an earthquake will occur.—San Francisco Examiner, February 7.

1897. February 13; Colima, Tepic, Mexico.

COLIMA, MEXICO, *February 18.*—The people of this vicinity were treated to a shaking up last Saturday which for a time set almost the entire population to praying. An earthquake, which lasted ten seconds, was followed at intervals of two or three minutes by others of shorter duration for more than an hour. The cathedral tower perceptibly rocked, and it seemed for a time as if a disaster was certain. The streets were filled with people on their knees, while the priests did their utmost to console and pacify them.

The shocks were very distinct, and seemed to run from north to south. During the past three months there have been but six days when shocks have not been felt, and recently they have been increasing in intensity.

TEPIC, MEXICO, *February 18.*—The seismic disturbances which have been felt for the last three months along the coast have been much more pronounced during the past week, and on Saturday the old volcano of Ceboruco began an active eruption. This was one of the smaller volcanoes, and has never, in the memory of man, done much damage. The fires have never died out, and there have always been smoke and noxious gases arising from the crater, and numerous blowholes.

The first indication of renewed activity came Saturday at 2 o'clock in the afternoon, when a sharp earthquake shock startled the people of Tepic. Almost immediately afterward clouds of smoke and ashes spouted from the crater and continued during the rest of the day. Saturday night the display was very beautiful from the reflection of internal fires, but by Sunday night the disturbance had again died down, and only a thin cloud of bluish-gray smoke ascended from the crater.—San Francisco Chronicle.

1897. February 18; Mount Hamilton.

8h. 3m. 40s. \pm p. m., P. s. t. R.-F. I. 8h. 4m. 30s. \pm p. m., P. s. t. R. F. II.—E. S. Holden.

8h. 3m. 52s. \pm 5s. p. m., P. s. t. R.-F. I. Heard a blast of wind immediately after—which might have caused it?—C. D. P.

1897. February —; Cacaluta, Mexico.

GUADALAJARA, MEXICO, *February 28.*—James Watson, an American who is interested in mining property near the coast of Colima, arrived from Cacaluta this morning, having left there just after the recent volcanic and seismic disturbance. He says that the shock was very marked at Cacaluta and along the shore, which is faced by an immense cliff of black rocks known as Roca Negro. Off this cliff the ocean is very deep, and it has been customary for vessels to skirt close to the shore. Immediately after the disturbance it was discovered that the water had shoaled to such an extent that boats were compelled to keep almost a mile offshore, and in many places, at low tide, rocks projected above the water. As the water had been from 15 to 20 fathoms deep 100 yards from the Roca Negro, it is thought that the bottom of the ocean for miles along here has been elevated.—San Francisco Chronicle.

1897. February —; Great Salt Lake, Utah.

SALT LAKE, UTAH, *March 1.*—What appears to be a genuine volcano has burst forth in the Great Salt Lake, a short distance south of Promontory Station, on the Central Pacific Railway. The phenomenon recently appeared in the shape of a small cloud hovering over the water about a mile and a quarter from the shore. It gradually increased in dimensions and shot up so high in the air that it is now visible for a great distance, and the water in the immediate vicinity boils and seethes and the spray is thrown high in the air for hundreds of feet. The volcano is situated in the big arm of the lake on the west side of a long range of mountains, and is distinctly visible from Brigham City. The phenomenon is accounted for by the fact that for the last six months there have been felt several slight shocks of earthquake in these regions.

A number of people have witnessed the phenomenon, which has caused considerable alarm in the vicinity.—San Francisco Bulletin. This has not been verified.—U. D. P.

1897. March 6; Acapulco, Vera Cruz, Oaxaca, Orizaba, Cordoba (Mexico); 7h. 30m. p. m.

CITY OF MEXICO, *March 7.*—The Government Meteorological Bureau has advices that the earthquakes which were felt yesterday were also felt in Acapulco, Vera Cruz, Oaxaca, Orizaba, and Cordoba at 7.30 o'clock in the evening. The weather is unusually warm, which is believed to be a sign of more shocks.—San Francisco Chronicle.

1897. March 13; Mount Baker, Washington.

The San Francisco Chronicle of March 16 contains a dispatch from Tacoma to the effect that Deputy United States Marshal Emory McGinnis saw what he took to be smoke issuing from the crest of Mount Baker on Saturday, March 13. Using a glass, his belief was strengthened.

1897. March 13; Mount Baker, Washington—Continued.

NOTE.—It has been rumored before that smoke was issuing from this mountain, but the facts were that clouds and dry snow carried about by the winds were the cause of the appearances ascribed to volcanic action.—C. D. P.

1897. March 15; Ukiah; 11h. p. m.

UKIAH, *March 16.*—A severe shock of earthquake was felt in this city at 11 o'clock last night. The vibrations were from north to south and lasted about ten seconds.—San Francisco Chronicle.

1897. March 15; Highland Springs, Pinta, Lakeport; 10h. 51m. p. m.

On Monday (*March 15*) at 10.51 p. m. a heavy shock of earthquake, lasting fully ten seconds. It was the most severe I have felt in twenty-two years in California. Others say there was one about twenty minutes earlier, but I did not feel it.

It was strong enough to throw a bottle off a shelf in Mr. Joseph Craig's house. I instantly noticed the time by my watch, which is with the railroad time of the San Francisco and North Pacific Railway. It was also severe at Pinta and Lakeport. The railroad time, I understand, is furnished by the observatory.—Reported by William B. Collier, under date of March 17.

1897. April 10; Mexico.

OAXACO, MEXICO, *April 10.*—The country south of here is experiencing another series of severe earthquakes. In the mountainous districts considerable damage has been done. There are no volcanic eruptions indicated.—San Jose Mercury, April 11.

1897. May 14; Moro Bay.

SAN LUIS OBISPO, *May 19.*—About 7.30 o'clock this evening residents of the country adjacent to Moro Bay were startled by a report, which began like the low rumble of thunder and ended with a somewhat louder blast. About a week ago a similar report was heard, and a mud geyser appeared in the small arm of Moro Bay, just opposite the town site of El Moro. This geyser has formed a small island, which for a week past has been the wonder of the people of the county, and has been visited by a great many.

Following the report this evening, a second geyser sprang into existence about 200 yards distant from the first and a little farther inland. This last geyser is an exact counterpart of the one formed last Friday night. Like the eruption of last Friday night, the surface of the second island bears evidence of having a small-sized crater, from which large quantities of the blackest mud are slowly arising.

The body of water in which these eruptions occurred is a small, narrow arm of Moro Bay, extending inland about a mile. It branches off from the main portion of the bay at the head of Moro Rock. The arm is not over a quarter of a mile in width at any point, and is almost uniform in width from its mouth to its end. The eruptions occurred within a short distance of the extreme

1897. May 14; Moro Bay—Continued.

end of the arm. The long stretch of land which forms the bar dividing the arm from the bay is only a few hundred yards in width and is supposed to be a long "rib" extending out from the granite formation of Moro Rock.

The island formed by the geyser to-night does not extend as far above the surface of the water as the one formed last Friday night by several feet, but is much broader, and the report was considerably louder.—San Francisco Chronicle, May 20.

1897. May 14; Reno, Nevada.

RENO, NEV., *May 14.*—Quite a severe shock of earthquake was felt here this evening about 6 o'clock, lasting several seconds. The vibration was from north to south.—San Francisco Chronicle.

1897. May 15; San Diego.

SAN DIEGO, CAL., *May 15.*—A slight earthquake shock was felt here at 4 o'clock this morning.—San Francisco Call.

1897. May 15; Carson, Nevada; 11h. 4m. a. m.

CARSON, NEV., *May 15.*—A severe earthquake shock was experienced this morning at 11.04, lasting two seconds. The seismograph registered the vibration from northeast to southwest. Plaster was broken in many buildings. The weather is sultry.—San Francisco Chronicle.

1897. May 22; San Diego; 6h. 58m. a. m.

SAN DIEGO, *May 22.*—There was a sharp shock of earthquake at 6.58 o'clock this morning, lasting two seconds.—San Jose Mercury, May 23.

1897. June 20; Mount Hamilton; 12h. 13m. p. m.

It was not more severe than R.-F. V at Mount Hamilton. The duration was twenty seconds in the third story of the brick dwelling. The shock of January 2, 1891, was R.-F. VII at Mount Hamilton.—E. S. Holden.

12h. 12m. 55s. to 13m. 5s.; direction northeast and southwest; "heavy," "rocked pictures on wall;" "very perceptible."—W. W. Campbell.

A heavy earthquake shock was felt to-day at 12h. 12m. 56s. (noon). The shock lasted fully twenty seconds, and the direction of motion seemed to be nearly east and west.—R. G. Aitken.

12h. 12m. 56s.—H. D. Curtis.

12h. 13m. (second not noted).—J. Macdonald.

Both the Ewing and duplex seismographs recorded the shock.

The record of the duplex instrument is not complete, the pen coming in contact with some obstruction in its excursions to the west. The record is 16 mm. in length in a north and south direction, and 9 mm. east and west. The Ewing instrument was started and gave a complete record of the shock. The duration indicated by this instrument, in all three components, is slightly over thirty seconds. The vibrations of the pens continue for a much longer time, but after this are due probably to residual motion of the pendulums.

1897. June 20; Mount Hamilton—Continued.

The waves are generally of considerable amplitude and slow, the greatest motion being east and west. The heaviest wave seems to have occurred one second after the commencement of the shock, the amplitude (magnified) being 16.3 mm., or an earth motion of 4.1 mm., east and west. There is also a north-and-south component of this wave of 6.3 mm. (magnified), corresponding to an earth movement of 1.5 mm. Hence the greatest double amplitude of this wave is 4.4 mm., with a period of 1.5 seconds, which gives an intensity of 39 mm. per one second, or II on the Rossi-Forel scale. The next move recorded by the east and west pen is probably the one of greatest *intensity*, although of small magnitude,

$$a = 0.25 \text{ mm.}$$

$$T = 0.37 \text{ s.}$$

from which $I = 74$ or R. F. IV.

The greatest vertical disturbance occurred toward the middle of the shock, when the record shows four waves of 4 mm. double amplitude (magnified), with an average period of about two seconds. For the first four seconds of the shock there were but slight irregular vibrations.

The whole shock exhibits marked irregularities; none of the waves are smooth, but all have lesser vibrations superposed upon the larger.

On June 27 the finding clocks in the Large Dome and Meridian Circle House were found stopped at 6h. 2m. Mount Hamilton sidereal time, and wound up. They had been wound at noon on the day of the earthquake, and the time at which they stopped agrees within their probable limits of error of the sidereal time of the shock. The pendulum of the clock in the Large Dome swings east and west and that in the Meridian Circle House north and south.

1897. June 20; College Park.

The seismograph at the University of the Pacific registered the shock.

The tracing is very complicated and is three times the size of the tracing by a similar instrument at the Lick Observatory. The axis of greatest disturbance was northwest and southeast, the record measuring 50 mm. in this direction. At right angles to this the record measures 28 mm. Allowing for a magnification of 4.0 diameters, this makes the greatest actual motion of the earth about 12 mm.

1897. June 20; Mills College; 12h. 13m. p. m.

The shock was quite severe, set chairs to rocking, etc., but did no serious damage. It seemed to be double, the latter part being the heavier.—Reported by Josiah Keep.

The print of the tracing accompanying the report shows a compact mass of vibrations, covering an area some 8 mm. in diameter, from which there extends on all sides several larger excursions of the

1897. June 20; Mills College—Continued.

pen and on the northeast, southeast, and southwest one or two double excursions of the pen to considerable distances. The total length of the record northeast and southwest is 30 mm., and at right angles to this 18 mm.

1897. June 20; Cantau Creek, Fresno County; 12h. 13m. p. m.

On Sunday, June 20, at 12.13 p. m., I felt a slight shock of earthquake; location NW. $\frac{1}{4}$ section 32, township 17 S., range 14 E., M., B. & M., on Cantua Creek, Fresno County. Duration about fifteen seconds; ninth shock; undulation and whirling motion.—S. C. Lillis.

1897. June 20; San Jose, 12h. 13m. p. m., P. s. t.

So far as reported, only one building was injured. The plastering on the walls of the South Methodist Church, northeast corner of Second and San Fernando streets, was cracked. A number of clocks were stopped.—San Jose Mercury, June 21.

1897. June 20; San Jose.

SAN JOSE, June 20.—San Jose was visited to-day by the longest continued earthquake on record, and at the same time one of much severity. It was just a little past the noon hour when the earth began to tremble, and there was a violent movement from east to west. At some of the churches services were still in session and the quake was so severe that there was a stop to the proceedings. Some persons left, but there was no panic.

The shake was so pronounced and continued so long it was noticed even by those walking on the street. Occupants of the lodging houses in the center of town came trooping out, in many instances in a state of great alarm. There have been rumors afloat this afternoon of damage to walls and plate glass, but they seem to be only of imagination.

Almost every clock in town was stopped, and there was a decided feeling of alarm while the tremor continued. Dishes were rattled, mirrors shaken, and rockers moved.—San Francisco Chronicle, June 21.

1897. June 20; Gilroy; 12h. 15m. p. m.

GILROY, June 20.—The most severe earthquake ever experienced in Gilroy occurred here to-day at 12.15 p. m. The oscillation was from northwest to southeast and it lasted for several seconds. People rushed from the churches and houses into the street and were terror-stricken for several minutes. Much damage was done to brick buildings, and chimneys all over town were cracked or demolished and plastering fell to the floor. The Southern Pacific Hotel had all the front windows shattered. Nearly every clock in town stopped at exactly the hour of the disturbance.

A report comes from Sargents Station, 6 miles from Gilroy, of the demolition of an adobe building, and also from San Juan much damage is reported.

1897. June 20; Gilroy—Continued.

A rain storm followed the earthquake. Several lighter shocks have been felt during the afternoon, and people are afraid to remain indoors.—San Jose Mercury, June 21.

GILROY, *June 20.*—The heaviest earthquake shock ever felt here took place at 12.11 p. m. to-day, lasting only a few seconds, but doing a great deal of damage.—San Francisco Chronicle, June 21.

1897. June 20; Hollister; 12h. 15m. p. m.

HOLLISTER, *June 20.*—At 12.15 p. m. to-day one of the severest earthquakes ever felt since 1868 took place. The vibrations lasted about fifteen seconds and seemed to be from north to south. Several thousand dollars worth of damage was done to buildings, fixtures, and goods. No casualties occurred, though several narrow escapes are recorded.

There is scarcely a brick building in the town that has not suffered, and it is reported that the court-house has been badly damaged in the way of cracked walls and plastering. The top of the north fire wall of the McMahon House fell upon adjoining buildings. Much window glass was broken and cracked. In several instances entire window sashes were thrown into the street from the second story of buildings.—San Francisco Chronicle, June 21.

1897. June 20; Salinas; 12h. 13m. p. m.

SALINAS, *June 20.*—Salinas was visited by the heaviest shock of earthquake experienced in its history to-day. The shock was felt about 12.13 p. m., the vibrations being from east to west and lasting probably fifteen seconds. The people were panic-stricken and rushed into the streets. Chimneys tumbled down and the plate glass in many business blocks was cracked. In many buildings in course of construction the fire walls toppled in and the walls were rent.—San Jose Mercury, June 21.

SALINAS, *June 20.*—The severest earthquake shock ever experienced in this section was at 12.15 p. m. to-day. The motion was from west to east and lasted nearly thirty seconds. A number of brick buildings were cracked, plate-glass windows smashed, and chimneys toppled over. The atmosphere has been very close all day, but has now become cooler and the clouds are dispersing.—San Francisco Chronicle, June 21.

1897. June 20; Los Gatos; 12h. 15m. p. m.

LOS GATOS, *June 21.*—The earthquake yesterday at 12.15 was the heaviest shock experienced in the place for many years. The oscillation was from north to south and lasted ten seconds. None of the buildings were injured, but the people on Glen Ridge ran into the streets, being afraid to remain indoors. Nearly every clock on Glen Ridge was stopped at exactly the hour of the disturbance.—San Jose Mercury, June 22.

1897. June 20; Santa Cruz.

SANTA CRUZ, *June 20.*—The earthquake shock shortly after noon to-day was distinctly felt in all parts of the city. Plastering was knocked from the walls in many buildings, and the terror-stricken people rushed out into the streets, fearing that the structures would fall upon and crush them. The vibration appeared to be from east to west. Only cases of minor damage have been reported.—San Jose Mercury, June 21.

SANTA CRUZ, *June 20.*—The heaviest earthquake shock in years was felt here at 12.20 to-day. A slighter shock occurred an hour later. The vibrations were from east to west. No damage resulted.—San Francisco Chronicle, June 21.

SANTA CRUZ, *June 20.*—Two heavy earthquakes were felt here this noon. The first shock was unusually heavy and long and passed from north to south, at 12.03 p. m. It gave the people great fright but no damage resulted. The second shock was not so noticeable and occurred shortly afterwards.—San Francisco Examiner, June 21.

1897. June 20; Templeton; 12.15 p. m.

TEMPLETON, *June 20.*—There was a lively earthquake to-day at 12.15 p. m. The shock lasted ten seconds, but no damage resulted.—San Francisco Chronicle, June 21.

1897. June 20; Monterey.

MONTEREY, *June 20.*—A heavy earthquake shock was felt at noon to-day. It caused a panic in the congregation of the San Carlos Mission Church. A portion of the adobe wall was thrown down among the frightened worshipers and several fainted. Other damage resulted to historic adobe buildings. Many people were completely terrified. At Del Monte three distinct shocks were felt, preceded by a rumbling noise. The hotel creaked and swayed and guests rushed from their rooms. Pictures and glassware were thrown down.—San Francisco Chronicle, June 21.

1897. June 20; Pacific Grove; 12.15 p. m.

PACIFIC GROVE, *June 20.*—A decided earthquake shock was felt here at 12.15 p. m. The shock continued several minutes, preceded by a deep rumbling noise. A panic was threatened among the congregation of the Methodist Church, but was averted by the minister's presence of mind. Persons in all parts of town were terrified.—San Francisco Chronicle, June 21.

1897. June 20; Stockton; 12.14 p. m.

STOCKTON, *June 20.*—A sharp shock of earthquake was felt here at 12.14 o'clock to-day, which seemed to be from northeast to southwest in movement. It was felt in all parts of the city, and caused people to exchange notes of the disturbance over the telephone system. Some declare they heard a rumbling sound just before the vibration.—San Francisco Chronicle, June 21.

1897. June 20; Modesto, Newman.

MODESTO, *June 20.*—A sharp shock of earthquake was felt here shortly after noon to-day. Many people in the upper stories of brick buildings ran into the streets in alarm. At Newman, in this county, a brick building of one story was cracked slightly.—San Francisco Chronicle, June 21.

1897. June 20; Merced; 12.13 p. m.

MERCED, *June 20.*—An earthquake shock from southeast to northwest visited Merced at 12.13 o'clock this afternoon, which shook things up for a few seconds. There were two shocks, three or four seconds apart, the last one being the most distinct. It was the worst shock ever experienced at this place, and several people were so frightened that they ran out of their houses. A few clocks were stopped.—San Francisco Chronicle, June 21.

1897. June 20; Visalia; 12.10 p. m.

VISALIA, *June 20.*—Two severe earthquake shocks were felt here to-day at 12.10 o'clock. The vibrations were from west to east. Suspended lamps vibrated for fifteen seconds, houses were shaken, and some people ran out doors. The shock was the most severe felt here in years.—San Francisco Chronicle, June 21.

1897. June 20; Milton; 12.15 p. m.

MILTON, *June 20.*—A distinct shock of earthquake was experienced at this place at 12.15 o'clock to-day. The vibrations were from south to north.—San Francisco Chronicle, June 21.

1897. June 20; Santa Rosa.

SANTA ROSA, *June 20.*—Shortly after noon to-day quite a sharp earthquake was felt here, but no damage was done. People were much frightened by the rattling of doors and windows.—San Francisco Chronicle, June 21.

SANTA ROSA, *June 20.*—A slight shock of earthquake was felt here to-day about noon. The oscillations were from east to west and were very light.—San Jose Mercury, June 21.

1897. June 20; Haywards; 12h. 15m. p. m.

HAYWARDS, *June 20.*—Two well-defined shocks of earthquake occurred here to-day at 12.15 p. m. The vibrations were from southwest to northeast; duration, about three seconds; no damage.—San Francisco Chronicle, June 21.

1897. June 20; Decoto; 12.13, 12.55 p. m.

DECOTO, *June 20.*—Two heavy shocks of earthquake were felt in this section at 12.13 to-day. The vibrations seemed to be from the north to the south. One or two old barns in the neighborhood fell to the ground. There was another shock at 12.55 p. m., lighter than the first two.—San Francisco Chronicle, June 21.

1897. June 20; Sacramento; 12.12 p. m.

SACRAMENTO, *June 20.*—At 12.12 o'clock this noon a very light shock of earthquake was felt in this city. It was from north to south and sufficiently strong to cause some clocks to stop.—San Francisco Chronicle, June 21.

1897. June 20; Watsonville.

WATSONVILLE, *June 20*.—The earthquake shock shortly after noon to-day did some damage to buildings in Watsonville and badly frightened the people of the town. The walls of Peck's Block, in which the Pajaro Valley Bank is located, were so badly cracked that they will probably have to be rebuilt. Windows in all parts of the city rattled during the shock and many panes of glass were broken. The earthquake lasted about ten seconds.—San Jose Mercury, June 21.

WATSONVILLE, *June 20*.—The heaviest earthquake that has visited this place since 1881 was felt to-day. The vibrations were from east to west. Clocks were stopped and a couple of chimneys toppled over, but no great damage was done.—San Francisco Examiner, June 21.

1897. June 20; Hanford.

HANFORD, *June 20*.—An earthquake shock was felt here about 11.15 [12.15?] this morning. The direction was from north west to south-east. No damage was done.—San Jose Mercury, June 21.

1897. June 20; Not felt at Bakersfield.

BAKERSFIELD, *June 20*.—Nothing whatever was felt of the earthquake which is reported to have been experienced in other parts of the State this afternoon.—San Jose Mercury, June 21.

1897. June 20; San Francisco; 12h. 14m. \pm p. m.

One of the most severe earthquakes that has served to disturb the coast of late years visited San Francisco a few minutes after 12 o'clock yesterday afternoon. There were two distinct shocks, the second following close in the wake of the first, and both lasting for a period that is variously stated at from ten to thirty seconds. The earthquake was particularly noticeable at the city hall. The "temblor" caused all the clocks in the city hall to stop. One of them was left standing for the purpose of recording the exact time at which the convulsion shook the building. The standing clock in the chief's office says the earthquake passed that part of the city at exactly 12.13 o'clock.

As to the exact minute that the earthquake struck the city there is some dispute. Many clocks that were stopped by the shock record the event as happening at 12.14 p. m. and others a minute earlier. At the harbor police station the clock stopped at exactly 12.13.

In many of the churches the big quake created a panicky feeling and interrupted the morning services.

The big shock at 12.14 o'clock yesterday afternoon was not the only shock during the day. It was followed by another and almost imperceptible tremor a minute before 1 o'clock, and Frank W. Edmonds, of the United States Coast and Geodetic Survey, declares that there was a slight shock at 6.37 o'clock yesterday morning.—San Francisco Chronicle, June 21.

1897. June 20; San Francisco—Continued.

SAN FRANCISCO, *June 20.*—A severe earthquake shock shortly after noon to-day caused a mild scare in many of the churches and big buildings throughout the city. There were two distinct shocks less than an hour apart, one about 12.15 and the other a few minutes past 1 p. m.

At the weather bureau, on the tenth floor, two clocks were stopped, one keeping local time, at 12.14, and the other running on Washington time at 3.14. As there is no seismograph or seismoscope in the building, or in fact in the city, no accurate record of the local course of the earthquake was obtainable.

A piece of mortar and stone, weighing 10 or 15 pounds, fell from a corner of the second story of the Schilling Building, on Market street, and struck the sidewalk less than 4 feet from where Tom Williams, of the Examiner, was standing, giving him quite a scare.—San Jose Mercury, June 21.

Frank Edmonds, of the United States Coast and Geodetic Survey, said there was a slight shock at 6.37 a. m., followed by a similar vibration about 12.15 p. m., immediately after which two distinct and very severe shocks were felt. A fifth trembling of the earth brought the temblor's programme to a close at 12.48 p. m.—San Francisco Examiner, June 21.

1897. June 20; Oakland; 12h. 13m. p. m.

A prolonged shock of earthquake was observed here to-day, commencing at 12h. 13m. 9s. p. m., P. s. t., and continuing for at least twenty-five seconds. It was noticed first as a sharp settling of the floor; then came a rumbling sound, followed by a slow, swaying motion, which gradually increased in strength and frequency for about ten seconds, when the maximum was reached. At this time the vibrations were decidedly marked: the house creaked, the windows rattled, and the pictures bumped against the walls. The swing of the chandeliers was in an approximately north and south line. The vibration gradually diminished, until 12h. 13m. 34s., when they could no longer be observed. In a jeweler's shop, about two blocks away, a pendulum clock, which was fastened on a wall running in an east and west direction, had stopped at 12h. 13m. 27s. This clock is usually kept very close to standard time.

The intensity of the shock at its maximum may be estimated at IV, or possibly V, on the Rossi-Forel scale. Two persons report a very faint shock about fifteen minutes later, but it was not observed by me.—Reported by A. H. Babcock.

1897. June 20; Oakland; 12h. 13m. 35s. p. m.

OAKLAND, *June 20.*—The big clocks of the city were stopped at thirteen minutes after the hour of noon to-day by as violent an earthquake as ever visited Oakland. There was no forewarning, and the first anyone knew of the visitation was an undulating

1897. June 20; Oakland—Continued.

motion that swayed tall buildings and played havoc with things of smaller size. The shock probably lasted seven seconds, although it seemed much longer. It was followed by another decided tremor, which, however, was no circumstance to the first. The excitement for a time was great. People ran out of their houses and into the middle of the streets. In all the big churches of the city the congregations were attentively listening to sermons, and the shock abruptly ended several of these services. As far as can be learned there were no windows broken or other actual damage done, although many are complaining that valuable china and glass ware was knocked off of tables and shelves and ruined.

The seismograph at the Chabot Observatory shows that there were three distinct tremors. The direction of the first was from northwest to southeast, while the others were from northeast to southwest. The successive tremors lasted a fraction over eight seconds, and the time recorded at the observatory is 12h. 13m. 35s. The quake was distinctly felt in Berkeley, Alameda, and other towns in the vicinity.—San Francisco Chronicle, June 21.

1897. June 20; Gonzales.

GONZALES, *June 20.*—The heaviest earthquake ever felt in this locality occurred here to-day. The vibrations were from north to south, and lasted for a full quarter of a minute. Clocks were stopped, horses frightened, and a few window panes were broken. For several hours after the quake the water in the Salinas River was quite muddy; an unusual thing at this time of the year.—San Francisco Examiner, June 21.

1897. June 20; Fresno.

FRESNO, *June 20.*—A sharp shock of earthquake passed through this county to-day. The duration is variously estimated at three to ten seconds. In this city the effects were principally felt in the two and three story brick buildings, some of which were shaken in a manner to cause their occupants to rush out into the street. The Hughes Block and the Temple Bar Building were among the structures shaken. No damage is reported, but a general feeling of alarm prevailed. At the residence of T. C. White a vase was thrown to the ground and broken.—San Francisco Examiner, June 21.

1897. June 20; Redwood City.

REDWOOD CITY, *June 20.*—This city was shaken by the earthquake. The shock rang the bell in the dome of the new high-school building and cracked the plaster in a few of the old pioneer buildings.—San Francisco Examiner, June 21.

1897. June 20; San Rafael, 12.14, 12.56 p. m.

SAN RAFAEL, *June 20.*—Two slight earthquake shocks were felt in this city at noon to-day. The first shock, which was a trifle more

1897. June 20; San Rafael—Continued.

severe than the second, was felt about 12.14 noon. The second, which was barely perceptible, was at 12.56. The shocks were felt at Sausalito, Mill Valley, and other Marin County towns.—San Francisco Examiner, June 21.

1897. June 20; Oaxaca, Mexico.

OAXACA, MEXICO, *June 20.*—Continued earthquake shocks and heavy rains have seriously interrupted telegraphic communications with the Isthmus of Tehuantepec during the past three days.

Advices were received here to-day that the official commissioners sent to the city of Tehuantepec by President Diaz to investigate the reported formation of a volcano and the extent of damages have arrived at their destination, and found the condition of affairs much worse than they had expected. The town of Tehuantepec contained about 7,000 inhabitants, and is completely destroyed as far as houses and buildings are concerned, not one remaining standing. There were a number of substantial and costly buildings in the town. The people are living in tents and in the open air on the outskirts of the place. Earthquake shocks continue to be felt at frequent intervals, and people are terrified. Heavy smoke and other indications of an active volcano to the west of Tehuantepec are no longer visible.—San Francisco Chronicle, June 2.

1897. June 21; Gilroy; 5h. 15m. a. m.

GILROY, *June 21.*—There was another slight shock of earthquake felt here at 5.15 a. m. to-day.—San Jose Mercury, June 22.

1897. June 21; Salinas.

SALINAS, *June 21.*—A slight shock of earthquake was reported here just after midnight, but there was no damage done. By yesterday's shock the walls of the court room in the court-house and of the county jail were spread nearly an inch. The old Salinas hotel, adjoining the new building, has several wide fissures extending its entire length. The rear of the armory, occupied by Troop C, is badly cracked and the plastering is well shaken off.—San Francisco Examiner, June 22.

1897. June 24; Santa Barbara; 6h. 10m. a. m.

SANTA BARBARA, *June 24.*—A slight earthquake shock was felt here at 6.10 o'clock. The shock was strong enough to rattle the doors and windows.—San Jose Mercury, June 25.

SANTA BARBARA, *June 24.*—The citizen of this place were aroused from their slumbers this morning by a slight earthquake. It lasted about three seconds, and caused windows and doors to rattle.—San Francisco Chronicle, June 25.

1897. June 26; Mexico.

OAXACA, MEXICO, *June 26.*—Severe earthquake shocks have continued at intervals of a few hours during the past three days at

1897. June 26; Mexico—Continued.

Tehuantepec, and as far east as San Cristobal. No further damage is reported, but the inhabitants are in a state of terror. The Indians of the Isthmus of Tehuantepec are fleeing into the valleys.—San Jose Mercury, June 27.

1897. June —; Sawmill Peak, Butte County.

CHICO, *June 30.*—Interest in the results of the remarkable earthquake which swept away a large portion of Sawmill Peak continues. The excitement along the ridge has received fresh impetus from facts developed by recent investigations. It was a formidable undertaking to determine the extent of the landslide, as the peak on the side rent by the earthquake was almost inaccessible. It rises nearly perpendicularly from the west branch. The shifting lava beds, toppling rocks, and loosened trees render exploration hazardous, but a party of mining men, led by Floyd Taber, of Oroville, have been at the scene and made an examination of the ground. The party found a newly made chasm on the south side of the mountain, 60 feet deep and 300 feet square. The mountain is of volcanic formation. It is conjectured that Sunday's rumblings were but the forerunner of volcanic disturbances which may occur at any moment.

The descent into the chasm, owing to the insecure lava masses, the steep incline from the summit, and the danger from loose rocks, could not be accomplished by the exploring party. A. J. Lawrence, one of the explorers was not to be turned back, however. He fastened a rope around his waist and was lowered by his companions into the hole. There he found great masses of lava and rocks.—San Francisco Examiner, July 1.

This report has not been verified.—C. D. P.

1897. June —; Douglas Island, Alaska.

TACOMA, WASH., *July 4.*—Alaska papers of June 26 received to-day state that the volcano on Douglas Island, opposite Juneau, is in a state of eruption. The event caused considerable excitement, and the entire town of Juneau was watching with interest the immense clouds emitted from the crater. This volcano has no name, but is one of the highest peaks on Douglas Island and is situated a little north of the Treadwell mines.—San Francisco Chronicle.

1897. July 19; Santa Barbara; 11h. 45m. p. m.

SANTA BARBARA, *July 20.*—This city experienced two strong shocks of earthquake last night about 11.45 o'clock. The first shock lasted about four seconds and was undulating in character. The second was much stronger, but of shorter duration. The oscillations caused the old town clock bell to strike. No damage was done.—San Francisco Chronicle.

SANTA BARBARA, *July 20.*—Two shocks of earthquake were felt here last night about midnight. There was an interval of twelve minutes between the first and second shock. The first was wavy

1897. July 19; Santa Barbara—Continued.

in character, while the second had an up-and-down motion. Both shocks appeared to have had a southwesterly direction. No damage was done. Those who have lived here for many years state that it was the strongest earthquake they ever experienced in Santa Barbara.—San Francisco Call.

1897. July 26; Mount Hamilton; 5h. 40m. 50s. p. m., P. s. t.

R. F. III.—E. S. Holden.

The duplex seismograph shows a small mark, which, however, resembles "creeping" of the pen more than an earthquake.

1897. July 26; San Francisco; 5h. 40m. 35s. p. m., P. s. t.

At 530 California street, on Monday at 5h. 40m. 35s. P. s. t., we felt the earthquake. It lasted about two and a half seconds. Tom and I were leaning on the drafting table, and I can not tell direction of shock—probably east and west.—Reported by George Davidson.

1897. July 26; Alameda.

Mr. Perrine's seismograph gives a record of this shock which, however, was very light, only one or two irregular, short waves.

1897. July 26; San Francisco.

There was a sharp, short, and heavy shock of earthquake at 5.40 o'clock last evening, preceded by a low, rumbling sound, that caused many people to think that there had been an explosion in one of the powder mills across the bay. The shock alarmed the nervous ones, and they sought safety by going into the streets. Although the heaviest and strongest buildings in the city trembled, no damage was reported. The rumbling noise that heralded the earthquake was particularly noticeable in the resident portions of the city. In the commercial center and along the principal thoroughfares, the noise was drowned by the clanging of car bells and the rattling of heavy teams over the pavement. Although people in the business quarter did not hear the noise, they all experienced the shock. The atmosphere was close and the sky partly obscured by fog when the shock occurred.

"The earthquake," said Local Forecast Official McAdie, of the Weather Bureau, "was due to the surface of the earth drying up and cracking like the skin on an apple. There was no atmospheric disturbance, either before or after it. The clock in the Weather Bureau office registered the time at forty minutes and thirty-five seconds past 5 o'clock when the earth began to rock. I was on the roof of the Mills Building at the time and distinctly felt the shock. It lasted about two seconds. The building moved up and down. I at first thought that one of the powder magazines at Pinole had blown up, and looked in that direction, half expecting to see a cloud of smoke. The building moved as if some heavy weight had been dropped on the floors. It was a quick, jerky motion, but the shock was not as heavy as that on June 20 last, when considerable damage was done in the interior of the State."—San Francisco Examiner, July 27.

1897. July 26; Berkeley; 5.42 p. m.

BERKELEY, *July 26*.—A slight earthquake shock was felt here at 5.42 this afternoon. The vibrations were east and west. No damage was done.—San Francisco Call.

1897. July 26; Oakland.

OAKLAND, *July 26*.—There was very little shock felt here of the earthquake this afternoon. At the Chabot Observatory the instruments showed only a slight mark on the plate, and nothing of any consequence was recorded.—San Francisco Call.

1897. September 27; Olympia, Washington; 1h. 30m. a. m.

OLYMPIA, WASHINGTON, *September 27*.—A slight shock of earthquake was felt here this morning at 1.30 o'clock. The vibrations were of sufficient force to awaken sound sleepers. No damage reported.—San Jose Mercury, September 28.

1897. October 2; College Park; 8h. 41m. 57.3s. a. m., P. s. t.

Earthquake shock preceded by rumble. Shock was quite marked, especially on upper floors of buildings.—Reported by H. D. Curtis.

1897. October 2; San Francisco; 8h. 42m. a. m.

At eighteen minutes before 9 o'clock yesterday morning a moderately sharp shock of earthquake was felt in this city by residents of the western addition, although it did not seem to make much of an impression on the down-town buildings. Mr. William M. Pierson, who is a Fellow of the Royal Astronomical Society of London and past president of the Astronomical Society of the Pacific, is authority for the exact time. At his residence on Van Ness avenue Mr. Pierson felt the shock, and with the instinct of a trained observer noted the exact time. To him, as to others in the residence quarter, the direction seemed to be about north and south. Chandeliers were vibrated in that general direction, and the force would be about II on the Rossi-Forel scale.—San Francisco Examiner, October 3.

1897. October 2; Alma; 8h. 45m. a. m.

ALMA, *October 2*.—A strong shock of earthquake was felt here at 8.45 this morning. It lasted ten seconds. There was no damage.—San Francisco Examiner, October 3.

1897. October 2; Santa Cruz; 8h. 45m. a. m.

SANTA CRUZ, *October 2*.—An earthquake shock was felt at 8.45 this morning. Vibrations were east and west.—San Francisco Examiner, October 3.

1897. October 5; Stockton; 7h. 44m. p. m.

STOCKTON, *October 5*.—This city had a slight shock of earthquake this evening at 7.44. Many people felt the shock, and in some places chandeliers shook perceptibly.—San Jose Mercury, October 6.

1897. October 17; Mount Hamilton; 3h. 30m. 26-21s. p. m., P. s. t.

Three irregular jolts nearly north and south, lasting five seconds. Loose windows rattled. R.-F. III.—C. D. P.

1897. October 17; Mount Hamilton—Continued.

The shock was recorded by the duplex seismograph as almost entirely northeast and southwest, the magnified record in this direction being 2.3 mm.; at right angles to this the record is 1 mm.

1897. October 17; San Jose; 3h. 30m. p. m.

SAN JOSE, *October 17.*—A slight shock of earthquake was felt here at 3.30 o'clock this afternoon. There were irregular vibrations lasting some seconds, the motion being from northeast to southwest. No damage was done.—San Francisco Examiner, October 18.

1897. November 21; Randsburg; 11.30 a. m., 12.30 p. m.

RANDBURG, *November 21.*—Two very distinct earthquakes have been felt here to-day, the first at 11.20 o'clock and the next an hour later. The vibrations were from north to south. Buildings shook perceptibly, but no damage was done.—San Jose Mercury, November 22.

1897. December 6; Forest Grove, Oregon; 8.30 p. m.

Slight shock.—Monthly Weather Review, December, 1897.

1897. December 10; Mount Hamilton.

Slight shock felt by several persons between midnight and daylight. Time not taken. Barely a trace on the duplex seismograph. Did not start the Ewing instrument.

1897. December 15; Waterville, Washington.

Duration, four to six seconds; direction, northwest to southeast.

1897. December 15; Lakeside, Washington.

A severe shock.—Monthly Weather Review, December, 1897.

1897. December 16, 17, 20; Lakeside, Washington.

Light shocks, all occurring at 6 a. m., vibrating from west to east.—Monthly Weather Review, December, 1897.

1897. December 23; Mills College; 5h. 15m. a. m.

Distinct shock of earthquake.—Reported by Josiah Keep.

1897. December 26; Centerville; 7.06 a. m.

Duration, five seconds; direction, north to south.—Monthly Weather Review, December, 1897.

In 1897 there were twenty-five shocks of earthquake recorded in California, as against sixteen for the year 1896.

The shock of June 20 was accurately timed both at Mount Hamilton and Oakland, and as we know approximately the center from which the disturbance radiated, we can obtain the velocity over this part of its path. At Mount Hamilton the beginning was noted at 12h. 12m. 56s., P. s. t., by several observers, and Mr. Babcock obtained 12h. 13m. 9s., P. s. t., as the time of the same phase in Oakland, an interval of thirteen seconds.

Assuming the epicentrum to have been between San Juan and Salinas, we find Mount Hamilton to be 40 miles from this point, while Oakland is 80 miles. As both points lie nearly in the same direction

from the origin of the disturbance (differing only 20'), we may assume that the disturbance moved toward both stations with the same velocity. From this data we find the velocity between Mount Hamilton and Oakland to be 3.1 miles per second.

This is an unusually high velocity, and in this connection it will be interesting to note the intervals in the cases of other shocks which have been timed with sufficient accuracy.

	Seconds.
1889. July 31; Lick Observatory; East Oakland	+ 11
July 31; Lick Observatory; San Francisco.....	+ 7
1890. April 24; San Francisco; San Jose (U. P.).....	- 40
May 11; San Francisco; East Oakland	± 0
1891. January 2; Lick Observatory; San Francisco	- 22
January 2; Lick Observatory; San Jose	- 12
June 28; Lick Observatory; San Francisco.....	- 10
October 11; San Francisco; Oakland	- 17
1892. April 19; Lick Observatory; Carson, Nev.....	- 70 ±
April 21; San Francisco; Reno, Nev.....	- 107
1896. July 26; Lick Observatory; San Francisco.....	+ 15

The April, 1892, shocks had their origin in the great Central Valley of California, and we may safely take a point near Vacaville as the epicentrum of both disturbances. Assuming that the velocity was the same at equal distances from this point, we find for the shock of April 19, an average velocity of 0.8 mile per second for a distance of 56 miles from Carson, Nev., measured toward the center of disturbance. The interval of time of seventy seconds is somewhat uncertain, perhaps ten or fifteen seconds. For the shock of April 21 we deduce an average velocity of 0.8 mile between Reno and a point 90 miles distant toward the center of disturbance. There are no accurate times available at or near the epicentrum of these two shocks. The centers of disturbance for the other cases are entirely too uncertain to base any velocities upon.



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