PREFACE

The Volcano Letter was an informal publication issued at irregular intervals by the Hawaiian Volcano Observatory (HVO) during the years 1925 to 1955. Individual issues contain information on volcanic activity, volcano research, and volcano monitoring in Hawaii. Information on volcanic activity at other locations is also occasionally included.

To increase accessibility of this resource, previously only available in print format, this compilation was scanned from the highest quality Volcano Letter originals in the HVO archives. Optical Character Recognition (OCR) was run on the entire file. In addition, the file size was reduced by making it compatible with only Adobe Reader v. 8 and later. The scanning was done by Jim Kauahikaua and the quality control and posting was done by Katie Mulliken, both current staff at the Hawaiian Volcano Observatory.

Originals of the first three Volcano Letters could not be found so copies plus the Title Page and Index for 1925 have been extracted from an excellent scan of Volcano Letters for 1925 to 1929 available in Books.Google.com

The Volcano Letter was published by HVO through multiple changes in administration, including the Hawaiian Volcano Research Association (1925-1932), the U.S. Geological Survey (1932-1935), the Department of the Interior (1935-1938), and the University of Hawaiʻi (1938-1955). Issues 1–262 were published weekly from January 1, 1925, to January 2, 1930, and consisted of a single page of text. Issues 263–384, also published weekly, from January 9, 1930–May 5, 1932, were generally longer—four-pages—and provided more detail on volcanic activity, including photographs, maps, and plots. Weekly issues 385–387, published May 12–26, 1932, were a single page of text due to budget reductions brought on by the Great Depression. Budget restrictions reduced the publishing frequency to monthly for issues 388–428, covering the period of June 1932 to October 1935; these issues were generally shorter, 1–2 pages, and sometimes featured figures. From November 1935 to July 1938, issues 429–461 remained monthly but increased in length (generally eight pages) and featured figures frequently. Issues 462–530, published over the period of August 1938–December 1955, varied in length from 2–15 pages, but were published quarterly, rather than monthly.

Six of the letters are misnumbered:
Jan. 21, 1926 number is 55 though it should 56
July 29, 1926 number is 82 though it should be 83
Feb. 16, 1928 number is 161 though it should be 164
May 31, 1928 number is 197 though it should be 179
Nov. 29, 1928 number is 204 though it should be 205

For background information on the Hawaiian Volcano Observatory: https://pubs.usgs.gov/gip/135/

The Volcano Letter publications are also available in print:

Fiske, R.S., Simkin, T., and Nielsen, E.A., eds.,1987, The Volcano Letter, No. 1-530. See https://www.si.edu/object/siris_sil_328087

April 2023

THE VOLCANO LETTER

No. 483 **Department of Interior** **National Park Service** **January-March 1944**

PUBLISHED BY THE UNIVERSITY OF HAWAII

HAWAII NATIONAL PARK: Edward G. Wingate, Superintendent; R. H. Finch, Volcanologist

UNIVERSITY OF HAWAII: T. A. Jaggar, Geophysicist

HARMONIC TREMOR

By R. H. FINCH

Shortly after the seismographs were installed at the Hawaiian Volcano Observatory in 1912 it was noticed that they were recording small tremors continuously.[1] Omori had noticed similar tremors near some of the Japanese volcanoes. From their obvious connection with volcanic activity H. O. Wood called them volcanic vibrations. It was soon noticed, however, that there was no obvious connection between the outbreaks of the periodic fountain, "Old Faithful," in Halemaumau and the tremors as recorded at the Observatory 2.1 miles away. In general the tremors were most conspicuous during times of violent fountaining. The idea that such tremors are due to volcanic activity was confirmed when the seismographs that were installed in Hilo, 22 miles away, failed to record such tremors. When magmatic action totally ceased at Kilauea in 1924 the volcanic vibrations, as was to be expected, disappeared from the seismograms.

After seismograph drums with higher speed were installed at the Observatory in 1918, it was found that there were two types of tremors, one with a quite uniform period and amplitude and the other with a greater range in period and amplitude. To distinguish between the two, Dr. T. A. Jaggar in November, 1918[2] called the more rhythmic vibration "harmonic microtremor." This term was later shortened to "harmonic tremor." The less regular vibrations which often resemble miniature earthquakes were named "spasmodic tremor."[3] Austin E. Jones[4] divides spasmodic tremors into two classes and illustrates the two by idealized sketches. Mixed continuous tremor is recorded at the Observatory during Mauna Loa eruptions even though the source may be 22 miles away.

Harmonic tremor that was recorded under different conditions of the lava column at Halemaumau is shown in figure 1. In most cases the portion reproduced is typical of the tremor as recorded for days preceding and following the sample selected. *A* of figure 1 was taken when the lava lake was high and a flow was pouring on to the southwest floor of Kilauea through a tunnel the intake of which was a small distance below the Halemaumau rim. It is not likely that any of the tremors recorded were due to lava surging in this tunnel. *B* is from the record when lava was flowing at Makaopuhi and Napau craters along the Puna rift. Considering the small scale of these outbreaks and the indicated distance—over 7 miles—it seems probable that the tremors were due to lava surging in conduits under Halemaumau rather than from the seat of the outbreak. *C* shows a portion of the record in 1924 just preceding the explosive eruption of that year and at a time when no molten lava was visible. Numerous earthquakes along the Puna rift, the sinking of the lava column at Halemaumau, and harmonic tremor at this time indicated lava drainage through this rift. *D* is a portion of the record during the short-lived activity at Halemaumau starting on September 6, 1934. The especially large tremors were recorded during some of the most violent fountaining ever observed at Kilauea. Each spell of violent fountaining was usually followed by a rather quiet interval of about 30 minutes as shown by the two comparatively straight lines just below the lower large harmonic tremor. In this case there was a direct correlation between fountaining action in Halemaumau and harmonic tremor. This was due as Dr. T. A. Jaggar has explained[5] to a rather high viscosity of the lava and the inception of the fountains at the bottom of a shaft.

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[1] H. O. Wood, "The Hawaiian Volcano Observatory," *Bulletin Seismological Society of America,* Vol. III, No. 1 (1913), p. 17.

[2] T. A. Jaggar, *Bulletin Hawaiian Volcano Observatory,* Vol. VI, No. 11 (Nov., 1918), p. 131.

[3] T. A. Jaggar, "Seismometric Investigations of the Hawaiian Lava Column," *Bulletin Seismological Society of America,* Vol. X, No. 4 (Dec., 1920), p. 264.

[4] Austin E. Jones, "Empirical Studies of Seismic Phenomena of Hawaii," *Bulletin Seismological Society of America,* Vol. XXVIII, No. 4 (Oct., 1938), p. 316.

[5] T. A. Jaggar, *Volcano Letter,* No. 415 (Sept., 1934).

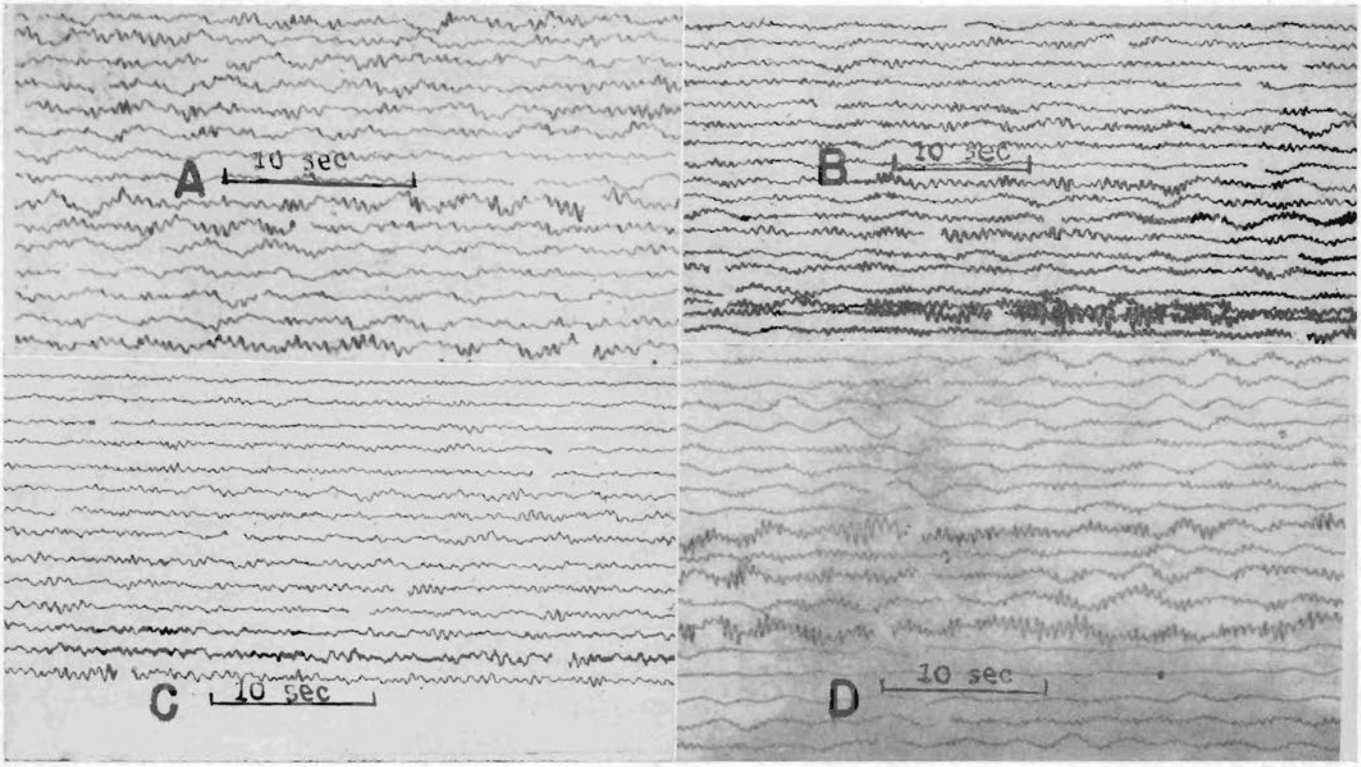

Fig. 1.—Harmonic tremor as recorded on the Bosch-Omori seismograph at Hawaiian Volcano Observatory, 2.1 miles northeast of Halemaumau. Travel from right to left. E-W component.

A. March 26, 1921—lava was high in Halemaumau and flowing in southwest part of Kilauea Crater. ×2½.

B. May 29, 1922—lava was flowing from the Puna rift. No lava was visible in Halemaumau. ×2⅓. Local earthquake is shown in second line from bottom.

C. May 8, 1924—no lava was visible in Halemaumau. Underground movement of lava in the Puna rift was suspected. ×2⅓.

D. September 30, 1934—was taken during lava activity lasting one month in 1934. The especially large tremors accompanied intermittent strong explosive fountaining. ×2½ (magnification of the seismogram, itself magnifying the earth motion about 100 times).

The absence of harmonic tremor at the time of the "False Eruption" on January 11, 1928, strengthens the belief that the small amount of lava which appeared on this date owed its appearance to being squeezed from a crusted pool of 1927 lava by a heavy landslide.

Harmonic tremor at Kilauea appears to be due to underground surging in feeding conduits below Halemaumau. If the surging is induced by the movement of very large gas bubbles in magma, then with a nearly stationary lava lake the bubbles moving through lake magma cannot set up harmonic tremor large enough to be recorded by the Observatory seismographs. When the surging takes place in a conduit of more or less restricted dimensions the solid walls of the conduit may be induced to vibrate with sufficient amplitude to be recorded. In general the tremor is larger when the magma column is falling than when rising.

Harmonic tremor affords good evidence of underground surging of lava whether magma is visible in the pit or not.

Hawaiian Volcano Observatory Report for January-March 1944

VOLCANOLOGY

January

The year opened with both Mauna Loa and Kilauea inactive. The number of Mauna Loa shakes exceeded those from Kilauea; records showed 43 and 39, respectively. The northeast rift of Mauna Loa was more active than the southwest one. The strongest shake during the month, which originated near Puu Ulaula on the NE rift of Mauna Loa on January 23, was generally felt over the southern part of the island of Hawaii.

At 2:00 p.m. on January 15, while on the road between Mauna Loa and Mauna Kea, A. L. Jess observed a distinct fume cloud with a faint yellow tinge over Mokuaweoweo.

Two landslides from the walls of Halemaumau were observed during the afternoon of January 19. Some more slides were observed during the latter part of the same week.

February

Despite the fact that the 4 perceptible earthquakes that occurred during February were of Kilauea origin, more seismic disturbances were recorded at Mauna Loa than at Kilauea; they were 41 and 33, respectively.

Clouds, lacking the characteristics of ordinary cumulus formation that frequently develops over isolated mountain peaks, were observed over Mokuaweoweo during the late afternoon of

February 7. On February 23, a white vapor cloud was visible above the radiation fog which capped Mauna Loa from 8:05 to 8:30 a.m. At other places humps in the fog marked the sites of hot spots in the crater floor.

March

While flying over Mauna Loa on March 30, Ranger Frank Hjort observed blue fume arising from Mokuaweoweo.

A total of 7 seismic disturbances was recorded in about 3 hours during the evening of March 29. Three of the shakes were strong enough to be felt locally. The series of shakes began with the strongest which dismantled the Bosch-Omori seismographs near Park Headquarters. The origin of the shakes was quite deep under the southern end of Kilauea Crater. Forty-four seismic disturbances were recorded at Kilauea and 59 at Mauna Loa.

The strong southerly wind of March 4 raised conspicuous dust clouds over the Kau Desert and adjacent cultivated fields of the Kapapala Ranch. Such winds—opposite in direction from those commonly observed transporting ash in the Kau Desert—though rare, may have been an appreciable factor in developing some soil over portions of the NE slope of Mauna Loa.

R.H.F.

SEISMOLOGY

Earthquake Data, January-March 1944

Week Ended		Minutes of Tremor	Very Feeble	Feeble	Slight	Local Seismicity*	Teleseisms
January	2	4	0	0	0	1.00	0
	9	12	2	0	2	8.00	0
	16	8	2	0	0	3.00	0
	23	3	3	1	1	5.25	0
	30	3	1	0	0	1.25	0
February	6	0	7	0	3	9.50	0
	13	1	1	0	0	0.75	0
	20	7	0	0	0	1.75	0
	27	11	1	1	0	4.25	0
March	5	6	1	0	2	6.00	0
	12	4	1	0	0	1.50	0
	19	8	0	0	0	2.00	0
	26	8	3	0	0	4.50	0

* For definition of local seismicity, see Volcano Letter No. 371.

The data of the following local disturbances were determined from seismograph stations operated on the island of Hawaii by the Hawaiian Volcano Observatory of the Hawaii National Park. Time is Hawaiian Standard, 10 hours and 30 minutes slower than Greenwich. The number preceding each earthquake date is the serial number of the quake for the current year.

1. January 4, 02:48, slight, northern end of Kilauea Crater.
2. January 5, 00:05, very feeble, Kilauea shake.
3. January 5, 04:47, very feeble, Kilauea shake.
4. January 7, 09:42, slight. Felt as a sharp jolt, NE end of Kilauea Crater.
5. January 10, 23:25, very feeble, SW part of Mauna Loa.
6. January 12, 20:04, very feeble, shallow focus NE rift of Mauna Loa, 12 miles SW of Hilo.
7. January 17, 01:00, very feeble, SW part of Mauna Loa.
8. January 22, 02:38, very feeble.
9. January 23, 14:40, slight, E-W dismantled, Mauna Loa instrument dismantled. Felt locally and Pahala, near Puu Ulaula.
10. January 23, 15:28, very feeble, probably same origin as No. 9.
11. January 23, 23:42, feeble, NE rift of Mauna Loa.
12. January 28, 17:23, very feeble, Mauna Loa instrument dismantled, NE rift of Mauna Loa.
13. February 1, 11:31, very feeble.
14. February 2, 19:18, very feeble, NE rift of Mauna Loa.
15. February 3, 01:02, slight, near SW end of Kilauea Crater.
16. February 3, 01:16, slight, under Kilauea Crater.
17. February 3, 01:19, very feeble, Kilauea shake.
18. February 3, 01:27, very feeble.
19. February 3, 01:28, slight, Kilauea Crater.
20. February 3, 03:37, very feeble, NE rift of Mauna Loa.
21. February 5, 21:49, very feeble, near Mokuaweoweo.
22. February 5, 23:32, very feeble.
23. February 8, 02:41, very feeble, SW rift of Mauna Loa.
24. February 22, 09:47, very feeble, near Mokuaweoweo.
25. February 27, 04:49, feeble, under Kilauea Crater.
26. February 29, 04:53, slight, E-W dismantled, underneath observatory.
27. March 3, 12:37, very feeble, E flank of Mauna Loa.
28. March 5, 09:39, slight, felt locally, NE rift of Mauna Loa.
29. March 8, 04:47, very feeble.
30. March 23, 10:36, very feeble, NE rift of Mauna Loa.
31. March 25, 10:45, very feeble.
32. March 25, 20:18, very feeble.
33. March 29, 19:54, slight, dismantled instruments, under southern end of Kilauea Crater.
34. March 29, 20:38, very feeble, same origin as No. 33.
35. March 29, 22:20, slight, probably same origin as No. 33, though initial wave was compressional in No. 35 and dilatational in No. 33.
36. March 29, 22:41, slight, similar to No. 35.
37. March 30, 00:55, very feeble.

TELESEISMS

With the exception of what appeared to be feeble long waves of two teleseisms recorded in the midst of large microseisms on March 6, no teleseisms were recorded during the quarter.

MICROSEISMS

Microseisms were strong on February 12, and March 4, moderate on February 20, March 4, and 5. Throughout the rest of the quarter microseisms were present though slight.

Tilting of the Ground

Normal southwesterly tilt started early in January and continued throughout the quarter. The direction of tilt was really south-southwest as westerly tilt was less than normal and southerly tilt above the average. In fact southerly tilt for the first three months of 1944 exceeded that for similar periods of every year since 1937. If, as seems probable, easterly tilt correlates with increase in internal pressure under Mauna Loa the less than normal westerly tilt indicates a sustained high pressure under that mountain. There were some fluctuations in the direction of tilt at the stations near the rim of Halemaumau.

Table of Tilt at Observatory on NE Rim of Kilauea

Week Ended		Amount of Tilt	Direction of Tilt
January	2	1.14″	N 58° E
	9	0.60″	N
	16	2.30″	S 25° W
	23	0.65″	S 22° W
	30	1.45″	S
February	6	0.33″	S 45° W
	13	0.53″	S 68° E
	20	1.09″	S 27° E
	27	1.74″	S 33° W
March	5	1.27″	S 17° E
	12	3.60″	S 39° W
	19	0.44″	S 34° W
	26	1.46″	S 5° W

Crack Measurements

There was a slight opening of 5 of the cracks around Halemaumau though most of those measured showed no movement. No movement was detected in the cracks at the Devil's Throat and along the Chain of Craters Road. R.H.F.

THE VOLCANO LETTER

No. 484 Department of Interior National Park Service April-June 1944

PUBLISHED BY THE UNIVERSITY OF HAWAII

HAWAII NATIONAL PARK: Edward G. Wingate, Superintendent; R. H. Finch, Volcanologist

UNIVERSITY OF HAWAII: T. A. Jaggar, Geophysicist

RADIO TRANSMISSION OF EARTHQUAKE RECORDS

By ROBERT J. STRATTON[1]
Federal Communications Commission
Radio Intelligence Division

Time control for several of the seismographs operated by the Volcano Observatory of the Hawaii National Park is obtained by a phantom circuit on Park telephone lines.[2] The location of outlying seismographs is determined by existing roads and telephone lines. This leaves a vast expanse of Mauna Loa where it is impractical to locate ordinary seismographs. If all the instruments could be made to register at one central point continuously, much travel could be avoided.

The use of radio at once suggests itself as a possible solution. The radio seismographs could be made to record on one shaft and the problem of synchronizing would be solved. Also in the case of a disturbance, records would be immediately available at the Observatory.

Radio links for the remote recording of seismographs were utilized in 1931 by Seizo Haeno.[3] He developed a short-distance, short-time scale instrument based upon the principle of frequency modulation for use in geophysical prospecting. His transmitter was a simple self-excited oscillator in which the capacity in the tank circuit was varied by the displacement of the seismograph mass. His receiver was an equally simple Tuned Radio Frequency receiver tuned off resonance and using galvanometer recording. This system was sufficiently stable for geophysical work since the recording run is normally only for a few minutes. It would not be stable, however, for continuous recording because of frequency drift.

Frequency stability could be gained by using crystal controlled transmitters. Moreover, the frequency of a crystal oscillator may be varied within limits by the use of a variable capacity across the crystal. It is proposed, therefore, that each element of the outlying Hawaiian Volcano Observatory seismographs should be equipped with a low-powered, battery-operated, crystal-controlled transmitter as shown in figure 1. Each transmitter would be far enough separated from the others in frequency so that mutual interference would be avoided. The variable "seismograph" condenser shown in figure 1 would have its rotor plates attached to the movable arm of the seismograph, while the stator plates would be attached to the seismograph frame. Any movement of the arm, however slight, would cause a corresponding change in the frequency of the oscillator. This is, of course, nothing more than frequency modulation of the rest-position carrier.

Several of the Hawaiian Volcano Observatory seismograph stations are within reach of A.C. power lines. The radio transmitters at these stations could be supplied from A.C. power in conventional ways. Some of the Hawaiian Volcano Observatory seismograph stations, both present and proposed, are in remote areas and would necessarily be battery operated. With the proper choice of frequency, tubes, and oscillator design, the use of number 6 dry cells for filament supply and 45 volt B-batteries for plate supply would be economically possible.

The continuously emitted signal would be received with a well-designed Tuned Radio Frequency receiver as shown in figure 2. As shown in the diagram, the amplified radio frequency output of this receiver is fed into a Wheatstone bridge which is

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[1] The author is indebted to Mr. Guy Omer for finishing this manuscript and drawings.—R.H.F.

[2] Waesche, H. H. "Time Controls for Seismographs Operated by the Hawaiian Volcano Observatory." *Volcano Letter* No. 464 (April-June 1939).

[3] Haeno, Seizo. "The Radio-Seismograph," *Japanese Journal of Astronomy and Geophysics*. Vol. VIII, (1931), pp. 39-50.

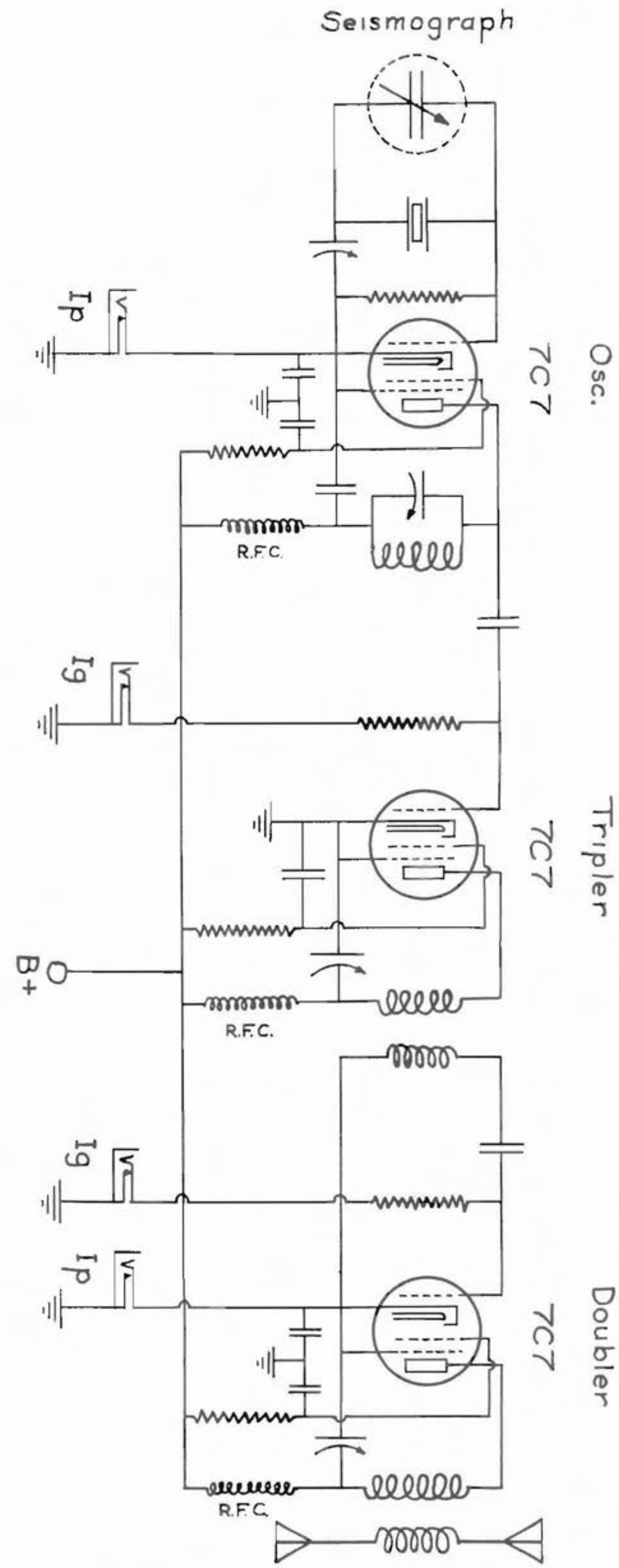

Fig. 1—Transmitter for radio seismograph.

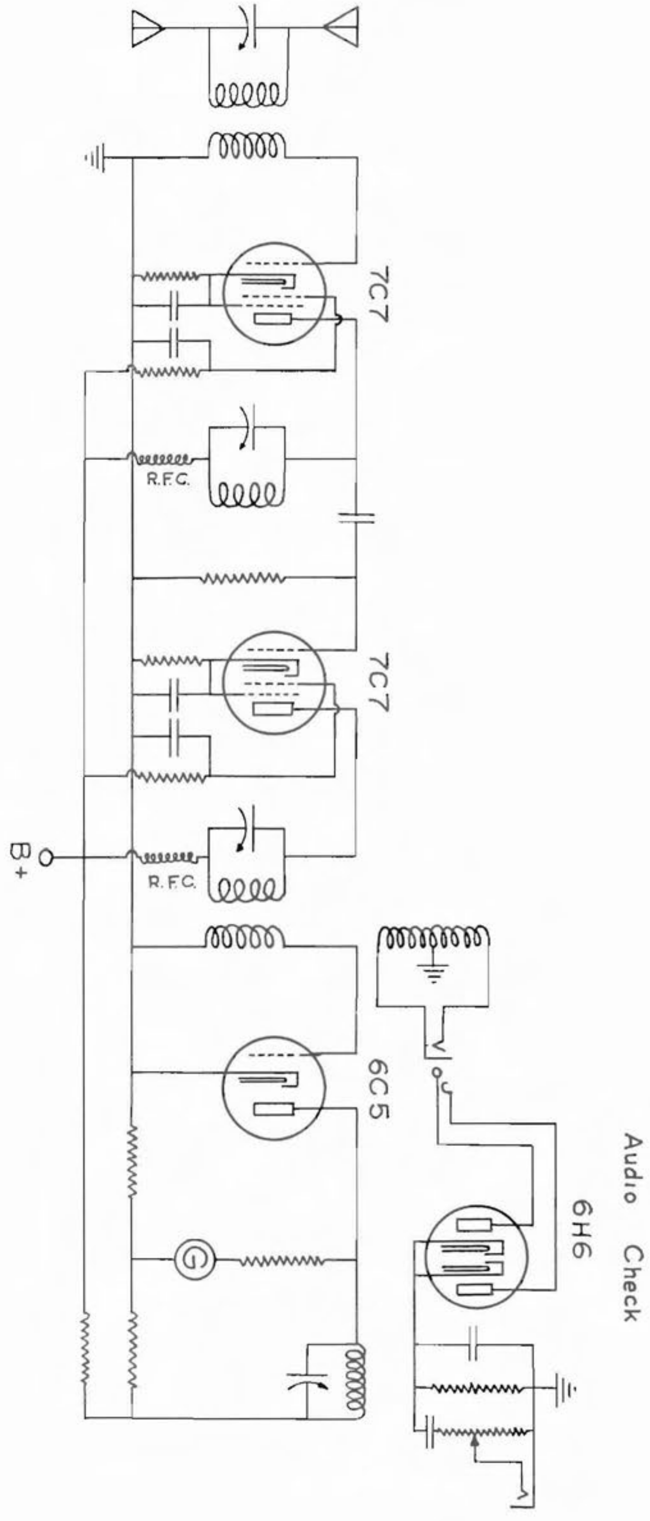

Fig. 2—Receiver for radio seismograph.

balanced at the rest-position carrier frequency. When the seismograph arm is displaced, the frequency changes, the bridge is then unbalanced, and the galvanometer is deflected. For proper operation, of course, the parallel tuned circuit in the bridge must be tuned far enough away from the rest-position frequency so that it presents a linear rising impedance over the modulation range. The actual production of the seismograph record would be by optical recording by a pin-point beam of light, reflected from the galvanometer mirror onto a continuously moving photographic film.

This system, of course, requires a separate receiver and recording chain for each transmitter. All of the receiving and recording equipment at the Observatory would be A.C. operated.

The recording of tilt is much simpler. The proposed plan for this also makes use of the principle of varying the frequency of an oscillator but with a different application. Since the change in tilt is very slight over a considerable period of time, no rapidly variable indicating instrument is necessary. For this purpose, it is proposed to use two crystal oscillators with a difference of frequency of 440 cycles per second. Only one of these oscillators will be equipped with a variable capacity as described in figure 1. The other oscillator remains constant. It then is apparent that, with the arm of the tilt instrument at center position, the two oscillators will beat against each other producing a resultant audio tone of 440 cycles. Any change in the position of the movable arm on the tilt instrument will vary the resultant tone. If the tilt is in one direction, the tone will be raised. If in the other, the tone will be lowered. The Bureau of Standards Station WWV can always be heard in this area on a frequency of either 15 mc., 10 mc., or 5 mc. depending on the time of day. This station transmits a tone standard of 440 cycles which is accurate to 0.000001 cycles per second. With this as a standard any change in the pitch of the beat of the tilt oscillators can be determined as can the direction of the tilt.

The selection of frequencies for all of these transmitters is quite important, both from the point of possible outside interference and of propagation characteristics. The latter point offers no particular difficulty for this location since all of the seismograph locations are within "line of sight" of the Observatory. Therefore, in order to avoid possible interference from extraneous signals, the use of frequencies around 50 to 60 mc. is indicated. Theoretically, no difficulty should be encountered in the use of this band of frequencies, although experiment may prove otherwise. Higher frequencies require the use of more tubes with the corresponding higher battery drain.

Owing to conditions incident to the war, it has not been possible to test the above ideas experimentally.

Hawaiian Volcano Observatory Report for April-June 1944

VOLCANOLOGY

April

Blue fume was observed over Mokuaweoweo on March 30 and again on April 1. The only other surface activity observed at Kilauea and Mauna Loa was the usual steaming. The number of steam vents as well as the amount of steam escaping at Kilauea and Mauna Loa is essentially the same as at the commencement of continuous observations in 1912.

No earthquake strong enough to be felt locally was experienced in April. Eighteen small seismic disturbances were recorded at Kilauea and 44 at Mauna Loa.

There were several small landslides from the walls of Halemaumau.

May

A conspicuous steam cloud that was observed over the lower part of the 1942 lava flow from Mauna Loa shows that the lava was still hot 2 years after it was erupted.

May continued the seismic quiet of the last several months. The Mauna Loa seismograph registered 48 seismic disturbances while the number recorded at Kilauea was 28.

June

The seismic lull that was especially noticeable in April and May continued through June. No perceptible earthquakes were recorded at the Observatory. Twenty-three seismic disturbances were recorded at Kilauea and 44 at Mauna Loa. A majority of the shakes distinct enough to show phases originated on the northeast slope of Mauna Loa at shallow depths. R.H.F.

SEISMOLOGY

Earthquake Data, April-June 1944

Week Ended		Minutes of Tremor	Very Feeble	Feeble	Slight	Local Seismicity*	Teleseisms
April	2	8	2	0	3	10.00	0
	9	4	0	0	0	1.00	0
	16	5	0	0	0	1.25	0
	23	3	3	0	0	2.25	1
	30	2	1	0	0	1.00	0
May	7	8	0	0	0	2.00	0
	14	7	0	1	0	2.75	0
	21	1	0	0	0	0.25	0
	28	2	2	0	0	1.50	2
June	4	6	3	1	0	4.00	0
	11	6	1	0	0	2.00	0
	18	6	1	0	0	2.00	0
	25	4	1	0	0	2.00	0

* For definition of local seismicity, see Volcano Letter No. 371.

The data of the following local disturbances were determined from seismograph stations operated on the island of Hawaii by the Hawaiian Volcano Observatory of the Hawaii National Park. Time is Hawaiian Standard, 10 hours and 30 minutes slower than Greenwich. The number preceding each earthquake date is the serial number of the quake for the current year.

38. April 19, 17:43, very feeble. 40 miles SE.
39. April 20, 06:03, very feeble. NE rift of Mauna Loa.
40. April 22, 08:15, very feeble. NE rift of Mauna Loa.
41. April 26, 08:23, very feeble.
42. May 12, 17:27, feeble. Deep under the northeastern rim of Kilauea crater.
43. May 23, 21:07, very feeble. SW flank of Mauna Loa.
44. May 28, 20:40, very feeble. Felt at Naalehu and Pahala. SW rift of Mauna Loa.
45. May 29, 04:21, feeble. Felt locally and at Pahala. East flank of Mauna Loa.
46. May 29, 04:27, very feeble. High up NE rift of Mauna Loa.
47. May 31, 14:12, very feeble.
48. June 1, 11:09, very feeble.
49. June 9, 12:01, very feeble.
50. June 16, 01:09, very feeble.
51. June 21, 17:34, very feeble. Near Puu Ulaula on NE rift of Mauna Loa.
52. June 23, 00:13, very feeble. NE rift of Mauna Loa.

TELESEISMS

May 23, 04:30, slight.
May 25, 02:38, moderate. 6600 km. New Ireland.
June 16, 11:42, slight.
June 27, 21:56, slight.

MICROSEISMS

Microseismic motion was quite uniformly slight throughout the quarter.

TILTING OF THE GROUND

Southerly tilt was more pronounced during the first three months of 1944 than for the corresponding period in the last several years. The total, however, was not unusual as northerly tilt set in on April 1, or over a month earlier than common.

Table of Tilt at Observatory on NE Rim of Kilauea

Week Ended		Amount of Tilt	Direction of Tilt
April	2	0.75″	S 56° W
	9	0.12″	E
	16	0.44″	N 56° W
	23	1.77″	N 16° E
	30	1.31″	S 67° W
May	7	1.36″	N 80° W
	14	0.74″	N 70° E
	21	0.74″	N 70° W
	28	0.24″	N
June	4	0.44″	N 34° W
	11	0.98″	S 30° W
	18	0.17″	N 45° W
	25	0.55″	N 64° E

CRACK MEASUREMENTS

There was but little movement of the cracks at the Devil's Throat and along the Chain of Craters Road. The cracks near Halemaumau opened slightly in April and June and were stationary during May. R.H.F.

HAWAIIAN VOLCANO RESEARCH ASSOCIATION
in cooperation with UNIVERSITY OF HAWAII

The **Hawaiian Volcano Research Association** was founded in 1911 for record of volcanoes in the Hawaiian Islands and around the Pacific Ocean. Its equipment at Kilauea Volcano, Hawaii Island, has been transferred to the United States Government, Department of the Interior, National Park Service.

The **University of Hawaii** cooperates in maintaining a research laboratory at Hawaii National Park. The **Association** and the **University** supplement the work of the government with research associates, instrumental plants and special investigation. Dr. T. A. Jaggar is their geophysicist resident in the National Park.

The **Volcano Letter**, a quarterly record of Hawaiian volcano laboratories and published by the University of Hawaii, is issued by authority of the Department of the Interior and supplied to a restricted membership and exchange list of the above establishments.

THE VOLCANO LETTER

No. 485 **Department of Interior** **National Park Service** **July-September 1944**

PUBLISHED BY THE UNIVERSITY OF HAWAII

HAWAII NATIONAL PARK: Edward G. Wingate, Superintendent; R. H. Finch, Volcanologist

UNIVERSITY OF HAWAII: T. A. Jaggar, Geophysicist

OUTPUT CHANGES IN KILAUEA STEAM VENTS

By GUNNAR O. FAGERLUND

Naturalist and Chief Ranger

Hawaii National Park

There is some evidence that the volume of steam from vents at the northern end of Kilauea Caldera has decreased in the last 100 years.

In 1823 Ellis[1] reported pools of water there adjacent to and on the lee side of steaming chasms. These condensation pools could exist only with much greater steam volume than there is at present. The pools subsisted during rainless periods. However, the 1790 explosion may have provided an impervious ash layer that helped in pool formation for many years.

Accompanying Kilauea activity in 1886, the steaming at Sulphur Bank fluctuated for a short period. First the steam temperature increased, then the steaming almost ceased, and finally normal temperature and volume resumed.[2] Normally the volume and temperature of the steam change little if any to correlate with Halemaumau activity.

Gordon A. Macdonald[3] states: "The distribution of altered rock and deposits of sulfur and salts, indicates that solfataric activity was once more extensive than now. Some migration of the active vents occurs."

Photographic stations have recently been established for photographing the steaming vents. Photographs taken at ten-year or greater intervals under nearly identical conditions of humidity, air temperature, and wind velocity should show whether or not the steam volume is changing.

The visibility of the vapor varies with different conditions of air temperature, humidity, and wind velocity. Actually the amount of water vapor escaping from any one vent is nearly constant. Figures 1 and 2 show visibility difference under somewhat different air conditions, but by no means do they show the maximum visibility contrast. On warm, sunny days with comparatively low humidity, some vents produce no visible vapor, while on cold damp days the same vents produce conspicuous vapor clouds. Even during a single clear day a marked contrast may be seen between early morning or evening and noon visibility of the vapor. On cold days the vapor density of the steam increases and its increased condensation forms conspicuous fog clouds. An increase in the number of hygroscopic nuclei also causes greater condensation. This fact can be demonstrated by directing tobacco smoke into steam vents where no vapor is visible. This causes a visible cloud to appear instantly. It is by this effect of nuclei that air humidity influences vapor visibility. Wind also affects visibility by dispersing and evaporating the fog.

Though air conditions affect the vapor visibility most markedly, a difference exists too when vapor is viewed in transmitted and in reflected light; this is most manifest when the sun is low. The greater visibility is in transmitted light. There is also a color difference—the vapor appearing bluish in reflected light and trending toward the red end of the spectrum in transmitted light.

The making of reliable photographic records of the vapor volume output from the steaming vents must take into account all the conditions that affect the visibility, or more precisely the photoactinicity, of the vapor. Pictures taken at intervals to show change, if any, in the actual steam volume output must

[1] ELLIS, WILLIAM. THE JOURNAL OF WILLIAM ELLIS. P. 179. Hawaiian Gazette Co., Ltd., Honolulu. 1917.

[2] BRIGHAM, WILLIAM T. THE VOLCANOES OF KILAUEA AND MAUNA LOA. Bernice P. Bishop Museum Memoirs. 2(4):162. 1909.

[3] MACDONALD, GORDON A. SOLFATARIC ALTERATION OF ROCKS AT KILAUEA VOLCANO. Am. Jour. Sc. 242(9):497. 1944.

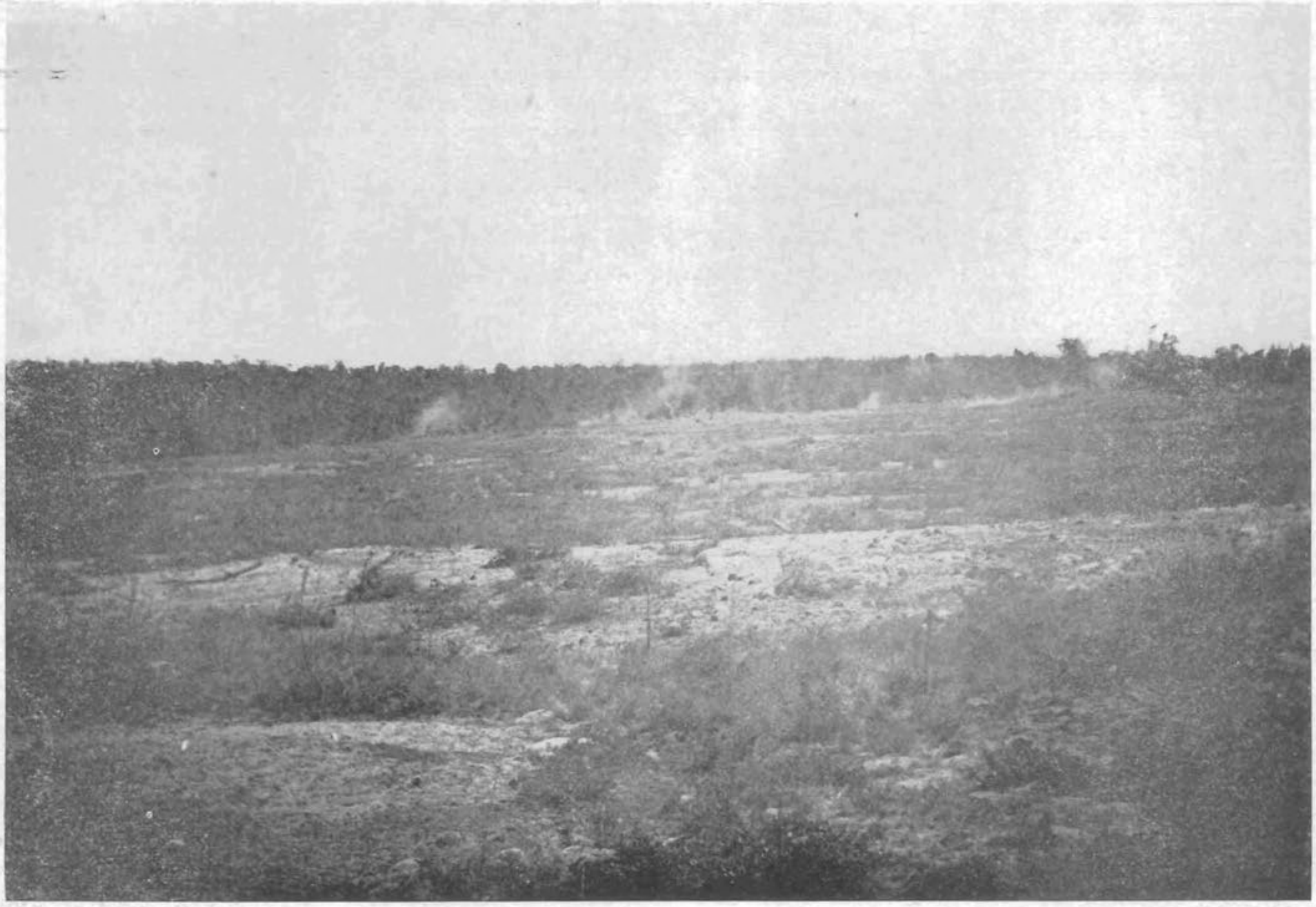

Figure 1.—Vapor issuing from vents west of Sulphur Bank. Photographed on November 19, 1944, with air temperature 62° F., humidity 68%, wind velocity 8 to 10 m.p.h. (Photographic station located on steaming flat 80 feet north of road, on line 12°49′ left from Uwekahuna to Observatory bench marks.)

be taken under nearly identical air and light conditions, with similar color sensitive film, and printed on similar paper. It would be advisable to use similar processing methods.

A factor that will affect the reliability of photographic records, and therefore should be given attention, is the pulsating manner in which the steam issues from the vents. The photographs herein were exposed as near to the instant of maximum output for the existing conditions as could be determined. The effect of the pulsating action becomes less as the distance between the vent and the camera increases. The volume of vapor recorded on a photograph encompassing considerable horizontal and vertical distances, as in the illustrations herein, would be little if at all affected by the pulsating action, except in high wind velocity.

Hawaiian Volcano Observatory Report for July-September 1944

VOLCANOLOGY

July

The seismic quiet of the last several months continued through July. No earthquakes strong enough to be perceptible at the Hawaiian Volcano Observatory were recorded though some shakes were felt at Kapapala 17 miles to the southwest. Thirty-two seismic disturbances were recorded at Kilauea and 58 at Mauna Loa.

August

A conspicuous fume cloud was observed over Mokuaweoweo from Puu Ulaula on August 12. A similar cloud was observed from the rim of Mokuaweoweo during the afternoon and evening of August 14. No glow was detected. By morning of August 15, however, nothing but the usual steaming was noted. On August 31, another conspicuous cloud was observed from the rim of Mokuaweoweo. During the fuming spell of August 12 to 14, two sharp earthquakes were felt at Puu Ulaula. The seismograph indicated that these shakes, like many that have been recorded here during the past year, occurred at very shallow foci along the upper northeast rift of Mauna Loa. Fourteen seismic disturbances were recorded at Kilauea and 56 at Mauna Loa.

September

Unusually heavy steam clouds were observed over Mokuaweoweo during the afternoons of September 11, 12, and 16. Three of the 19 earthquakes recorded at Kilauea were strong

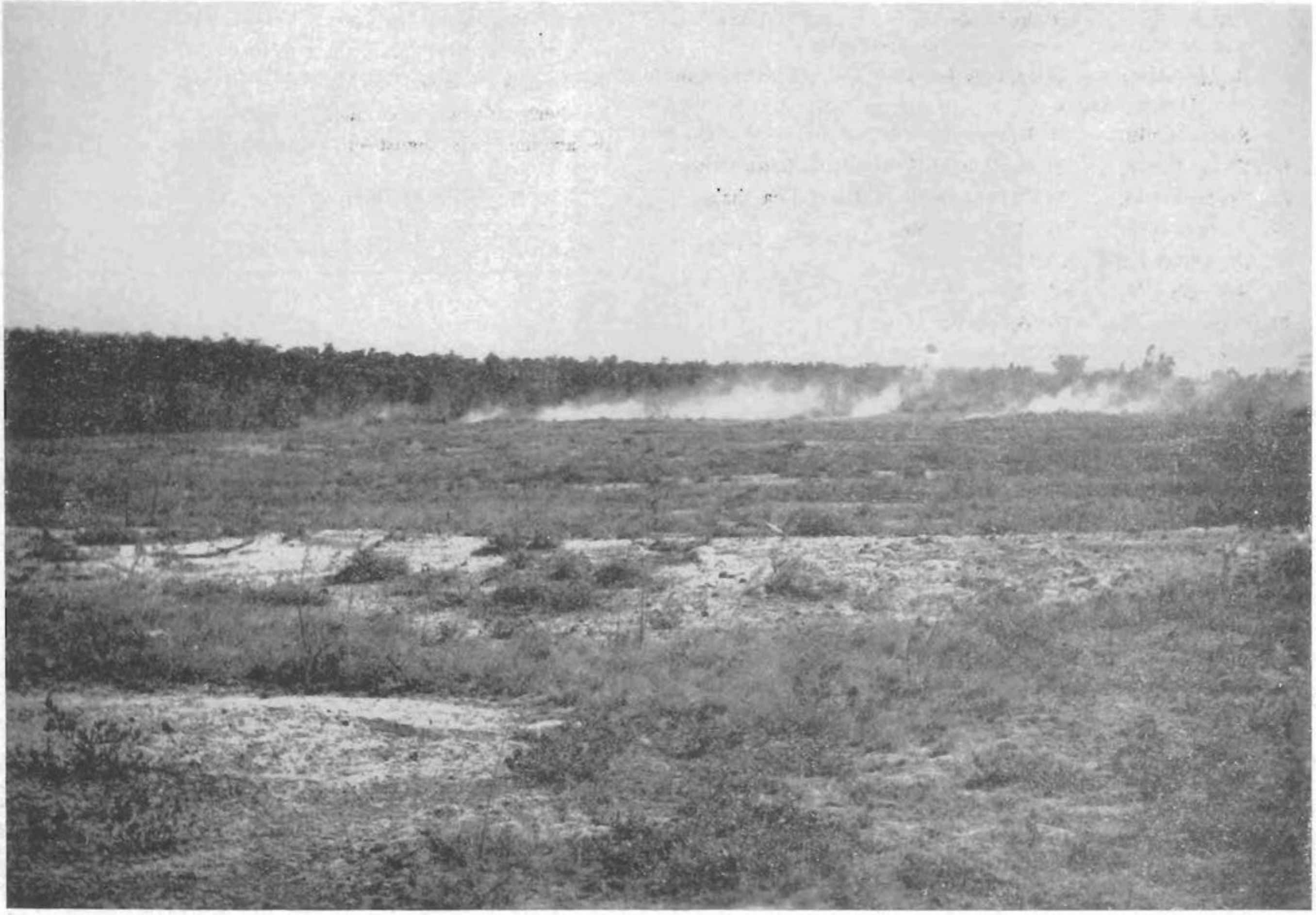

Figure 2.—Vapor issuing from same vents as in Figure 1, showing the higher visibility associated with somewhat lower temperature and higher humidity. Photographed on December 18, 1944, with air temperature 54° F., humidity 81%, wind velocity 10 to 15 m.p.h. (Photographic station the same as for Fig. 1.)

enough to be felt locally. They appear to have originated under the northern end of Kilauea crater. A majority of the 48 shakes recorded at Mauna Loa originated along the northeast rift. R.H.F.

SEISMOLOGY

Earthquake Data, July-September, 1944

Week Ended		Minutes of Tremor	Very Feeble	Feeble	Slight	Local Seismicity*	Teleseisms
July	2	5	0	2	0	3.25	1
	9	4	1	0	0	1.50	0
	16	2	3	0	0	2.00	0
	23	5	4	0	0	3.25	2
	30	3	0	0	0	0.75	1
August	6	3	2	1	0	2.75	0
	13	0	0	1	0	1.00	1
	20	4	0	0	0	1.00	1
	27	1	2	0	0	1.25	0
September	3	1	1	0	0	0.75	1
	10	1	2	1	1	4.25	0
	17	1	0	0	0	0.25	0
	24	5	4	0	1	5.25	1

* For definition of local seismicity, see Volcano Letter No. 371.

The data of the following local disturbances were determined from seismograph stations operated on the island of Hawaii by the Hawaiian Volcano Observatory of the Hawaii National Park. Time is Hawaiian Standard, 10 hours and 30 minutes slower than Greenwich. The number preceding each earthquake is the serial number of the quake for the current year.

53. July 1, 16:00, feeble. In hour mark.
54. July 2, 20:48, feeble. In NW Hawaii.
55. July 6, 22:23, very feeble.
56. July 14, 10:47, very feeble.
57. July 16, 01:01, very feeble.
58. July 16, 16:01, very feeble.
59. July 18, 01:01, very feeble. NE rift Mauna Loa.
60. July 20, 07:53, very feeble. Eastern slope of Mauna Loa.
61. July 22, 08:30, very feeble. NE rift of Mauna Loa.
62. July 22, 21:52, very feeble. In NW Hawaii.
63. July 31, 22:33, very feeble.
64. August 2, 00:04, very feeble. NE rift of Mauna Loa.
65. August 5, 18:53, feeble. SW slope of Mauna Loa.
66. August 7, 10:53, feeble. NE rift of Mauna Loa.
67. August 22, 06:15, very feeble. Lower NW slope of Mauna Kea.
68. August 23, 01:32, very feeble.
69. August 30, 08:47, very feeble.
70. September 4, 16:18, slight. Felt locally. Northern end of Kilauea crater.

71. September 7, 16:36, feeble. Felt locally. Northern rim of Kilauea. Accompanied by a rumble.
72. September 9, 09:14, very feeble. Near northern end of Mokuaweoweo.
73. September 10, 21:37, very feeble.
74. September 18, 00:06, slight. Felt locally. Kilauea crater.
75. September 18, 10:01, very feeble. Mauna Loa shake.
76. September 18, 19:33, very feeble.
77. September 19, 22:45, very feeble.
78. September 23, 02:52, very feeble.
79. September 29, 09:05, feeble.
80. September 29, 09:20, very feeble.
81. September 30, 18:34, very feeble.

TELESEISMS

July 19,	00:36, slight.	Off Japan.
July 20,	02:12, slight.	
July 26,	13:41, slight.	Off Aleutians.
August 9,	15:40, slight.	Off British Columbia.
August 18,	00:13, slight.	Japan.
September 3,	09:04, slight.	
September 23,	01:52, slight.	5400 km.

MICROSEISMS

Microseisms were present though slight throughout the quarter.

TILTING OF THE GROUND

Very slight westerly tilt prevailed during July and until August 20, when normal easterly tilt set in and continued through the rest of the quarter. The time of change from west to east tilt in 1944 corresponds to that of 1941, 1942, and 1943 though it is more usual for the change to occur during the spring. Northerly tilt was continuous throughout the quarter though the amount from August 4 to September 30 was less than normal.

Table of Tilt at Observatory on NE Rim of Kilauea

Week Ended		Amount of Tilt	Direction of Tilt
July	2	0.51″	N 15° E
	9	0.62″	N 79° W
	16	0.62″	N 11° E
	23	0.37″	N 45° E
	30	0.86″	N 45° W
August	6	0.74″	N 10° E
	13	0.85″	N
	20	0.65″	S 68° W
	27	0.87″	N 74° E
September	3	0.54″	N 27° E
	10	0.39″	S 71° E
	17	0.48″	W
	24	1.60″	S 81° E

CRACK MEASUREMENTS

There was practically no movement at any of the cracks measured during July and August. A majority of the cracks around Halemaumau opened slightly during September, and at the Devil's Throat and along the Chain of Craters Road a few showed a slight opening. R.H.F.

HAWAIIAN VOLCANO RESEARCH ASSOCIATION
in cooperation with UNIVERSITY OF HAWAII

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The **Volcano Letter**, a quarterly record of Hawaiian volcano laboratories and published by the University of Hawaii, is issued by authority of the Department of the Interior and supplied to a restricted membership and exchange list of the above establishments.

THE VOLCANO LETTER

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HAWAII NATIONAL PARK: Edward G. Wingate, Superintendent; R. H. Finch, Volcanologist

UNIVERSITY OF HAWAII: T. A. Jaggar, Geophysicist

THE NOVEMBER-DECEMBER 1944 CRISIS AT KILAUEA

By R. H. FINCH

For over a year and a half the seismographs and tilt records have indicated a fairly high pressure under the Kilauea-Mauna Loa volcano system. In November, 1943, Mauna Loa produced several rather conspicuous fume clouds.[1] In August, 1944, fuming greater than the normal from Mokuaweoweo was observed.

It was not surprising then to find Kilauea showing definite signs of uneasiness starting with an earthquake on November 12 that originated 8 to 10 miles below the southwest rim of Halemaumau. The history of Kilauea indicates that some form of activity might be expected at any time now. In a press release dated September 13, 1943, the following statement was made: "If the present period of volcanic activity is to parallel the probable sequence following the 1790 explosive eruption, lava activity at Kilauea or Mauna Loa, or both, may be expected about the middle of this decade."

It has been over ten years since molten lava was present in Halemaumau. This is the longest period of inactivity in the recorded history of Kilauea. This is not overlooking the thirteen more or less quiet years from 1894 to 1907. During this thirteen-year period molten lava was visible for short intervals on several occasions, and considerable fume was always present. The longest period of total inactivity was the three years from July, 1924, to July, 1927. The interval between the last activity which started on September 6, 1934, and the next previous outbreak was two years and eight months or well above the average of such intervals since molten lava disappeared from Halemaumau in 1924. It is interesting to note that the 1934 outbreak was the most gaseous and lasted the longest of any of the short-lived outbreaks that have occurred since 1924. It might be expected then that a return of activity to Halemaumau will be marked by high pumice producing fountains.

On November 15, 1944, there was another earthquake with about the same epicenter as the one on November 12, but with a much more shallow focus. From November 15 until December 6 there were a few scattered Kilauea shakes with indications of a more or less progressive decrease in depth of foci. Two earthquakes on November 29 that were felt as sharp jolts at Halemaumau and recorded as feeble or slight shakes only at the Observatory twenty-two miles away were obviously of very shallow foci. The fact that the earthquakes occurred as separate shakes, often several days apart, rather than in swarms is what might be expected if molten lava were rising in the feeding conduits under Halemaumau.

At the Observatory, on the northeast rim of Kilauea, the northeast tilt was but little more than normal for this season of the year though rather definitely indicating a pressure increase under Kilauea. Beginning about the 12th of November, however, tilt instruments near Halemaumau showed a pronounced tilt; this indicated that the crater floor was doming appreciably with the maximum rise in the vicinity of the southern edge of Halemaumau. The amount of tilt during the last week in November at the Halemaumau tilt cellars is not known since the index of each instrument went completely off the scale and was stopped by horizontal braces.

[1] FINCH, R. H. ACTIVITY AT MAUNA LOA IN NOVEMBER 1943. Volcano Letter No. 482. October-December, 1943.

The focus of application of the force producing this final spurt of tilting must have been rather high to produce such marked effects near Halemaumau and so comparatively little effect at the Observatory.

The retreat of the lava column also indicates that a high level of the molten magma was reached. By the morning of December 7, both Halemaumau tilt instruments had gone completely off their scales and were resting against their frames. In this case the direction was the opposite of that during November; this indicated a sinking of the crater floor. The rapid sinking of the crater floor occurred on December 6 and 7, but a sharp southerly tilt did not start in at the Observatory until December 21. This southerly tilt continued until December 30 and amounted to 3.6 seconds of arc.

The earthquake pattern accompanying this minor 1944 crisis is rather typical. First one or two rather strong shakes of appreciable depth occurs marking the introduction of lava to the conduits under Halemaumau. (The earthquake of November 12 appears to have been of this type.) Then follow scattered lighter shakes of decreasing depth of foci accompanying the upsurge of molten lava. The spreading apart of walls of fissures and introduction of hot lava and gases reduce the tendency of seismic grating. At times of rapid recession of the lava column and appreciable subsidence of the crater floor, earthquakes are numerous. Twenty-nine earthquakes occurring between 08:30 December 6 and 13:50 December 7 accompanied the suspected 1944 recession.

The uneasiness manifested at Kilauea in the autumn of 1944 was the most conspicuous indication of fairly high internal activity that has been observed since the 1934 outbreak. It should be borne in mind that lava pressure in a volcano conduit can vary through a large range without any lava appearing at the surface. Whether molten magma reaches the surface or not depends upon, among other things, the duration of high pressure and the amount of lava involved in any particular upsurge.

Hawaiian Volcano Observatory Report for October-December 1944

VOLCANOLOGY

October

Mauna Loa and Kilauea were both quiet throughout October, Forty-eight seismic disturbances were recorded at Mauna Loa and 26 at Kilauea. Four shakes were felt at the Observatory and six were felt at Hilo. The number of distinctly Mauna Loa shakes was the smallest for the last several months.

November

For the first time in several months more earthquakes of Kilauea than of Mauna Loa origin were registered. The fact that 36 seismic disturbances were recorded at Mauna Loa and 35 at Kilauea does not show the true relative seismicity because most of the Kilauea shakes were recorded at Mauna Loa and several of the Mauna Loa shakes did not register at Kilauea. Starting with an earthquake on November 12 that was widely felt on the island of Hawaii, Kilauea showed distinct signs of uneasiness. The origin of the shake was 8 to 10 miles below the surface to the southwest of Halemaumau. On November 15, there was another Kilauea shake with about the same epicenter but with more shallow focus. A progressive decrease in depth of foci of earthquake continued until the end of the month. The tilt instruments on the crater floor indicated a distinct doming of the crater floor with the maximum rise in the vicinity of the southwest rim of Halemaumau.

December

The uneasiness of Kilauea continued until December 6. A series of earthquakes that started on this day and tilt indications of subsidence of the crater floor in the vicinity of Halemaumau clearly showed that a return of lava to the fire pit of Kilauea could not be expected.

A strong earthquake on December 27 caused Mauna Loa again to be the main center of interest. This quake as well as four others that followed within 3 days originated about 15 miles below the eastern rim of Mokuaweoweo. There was a slight migration of epicenters in a northeasterly direction in this series of shakes as though they followed along a fault block connecting southwest and northeast branches of the fundamental Hawaiian rift.

The strong earthquake of December 27 started many landslides at Halemaumau. The largest produced a roar that was audible 3 miles away, which was reminiscent of the explosions in 1924. R.H.F.

SEISMOLOGY

Earthquake Data, October-December 1944

Week Ended		Minutes of Tremor	Very Feeble	Feeble	Slight	Moderate	Strong	Local Seismicity*	Teleseisms
October	1	0	2	1	0	0	0	02.00	0
	8	3	3	1	1	0	0	05.25	1
	15	2	0	2	0	0	0	02.50	0
	22	3	1	1	0	0	0	02.25	0
	29	3	0	1	0	0	0	01.75	0
November	5	4	2	2	0	0	0	04.00	0
	12	4	3	0	0	1	0	05.50	0
	19	6	0	1	0	1	0	05.50	1
	26	3	2	2	1	0	0	05.75	1
December	3	8	0	3	1	0	0	07.00	0
	10	15	13	2	2	0	0	18.25	1
	17	6	4	0	0	0	0	03.50	0
	24	1	2	0	0	0	0	01.25	0
	31	12	6	0	1	2	1	18.00	3

* For definition of local seismicity, see Volcano Letter No. 371.

The data of the following local disturbances were determined from seismograph stations operated on the island of Hawaii by the Hawaiian Volcano Observatory of the Hawaii National Park. Time is Hawaiian Standard, 10 hours and 30 minutes slower than Greenwich. The number preceding each earthquake is the serial number of the quake for the current year.

82. October 2, 17 : 27, slight. Deep focus, near Ookala.
83. October 4, 15 : 22, very feeble.
84. October 6, 14 : 30, feeble.
85. October 6, 14 : 40, very feeble. Probably same origin as No. 84.
86. October 7, 14 : 41, very feeble.
87. October 11, 21 : 11, feeble. Felt locally, under Mokuaweoweo.
88. October 11, 21 : 12, feeble. Felt locally. Probably same origin as No. 87.
89. October 17, 13 : 54, feeble. Felt in Hilo, Mauna Kea.
90. October 17, 14 : 52, very feeble.
91. October 29, 17 : 17, feeble. Felt locally and in Hilo, Mauna Kea.
92. October 31, 04 : 26, feeble. Felt in Hilo.
93. October 31, 04 : 28, feeble. Felt in Hilo.
94. October 31, 04 : 32, very feeble.
95. November 5, 01 : 46, very feeble. Kilauea shake.
96. November 8, 02 : 16, very feeble.
97. November 8, 02 : 18, very feeble.
98. November 9, 08 : 25, very feeble.
99. November 12, 04 : 56, moderate. Widely felt in southern half island of Hawaii. Eight to 10 miles deep to the SW of Halemaumau. Dismantled seismograph at Hilo and Kona as well as at the Observatory.
100. November 15, 18 : 19, moderate. Felt locally. About same epicenter as No. 99 but with shallower focus.
101. November 15, 19 : 33, feeble. Felt locally. Origin at NE rim of Kilauea.
102. November 22, 22 : 53, slight. Under Kilauea.
103. November 23, 13 : 43, feeble. SW of Halemaumau.
104. November 23, 21 : 16, very feeble.
105. November 26, 00 : 48, very feeble.
106. November 26, 13 : 02, feeble.
107. November 28, 00 : 43, feeble.
108. November 29, 09 : 34, feeble. Felt as a sharp jolt at Halemaumau.
109. November 29, 09 : 36, slight. Felt as a sharp jolt at Halemaumau.
110. December 2, 00 : 17, feeble. Under Kilauea.
111. December 6, 07 : 38, very feeble. Under Kilauea.
112. December 6, 08 : 08, very feeble. Same as No. 111.
113. December 6, 09 : 47, feeble. Same as No. 112.
114. December 6, 11 : 51, very feeble.
115. December 6, 11 : 54, very feeble.
116. December 6, 19 : 29, very feeble. Under Kilauea.
117. December 6, 22 : 07, very feeble. Same as No. 116.
118. December 7, 00 : 58, very feeble. Same as No. 116.
119. December 7, 02 : 51, very feeble. Same as No. 116.
120. December 7, 05 : 15, very feeble.
121. December 7, 07 : 17, slight. Felt locally. Under Kilauea.
122. December 7, 08 : 46, very feeble. Accompanied by rumble audible at Halemaumau rim.
123. December 7, 11 : 18, very feeble.
124. December 7, 11 : 22, very feeble. Under Kilauea.
125. December 7, 11 : 39, feeble. Same as No. 124.
126. December 7, 12 : 50, slight. Same as No. 124.
127. December 9, 12 : 40, very feeble. Under Kilauea.
128. December 11, 22 : 01, very feeble.
129. December 15, 16 : 17, very feeble.
130. December 16, 15 : 08, very feeble. Kilauea shake.
131. December 16, 23 : 45, very feeble.
132. December 18, 10 : 38, very feeble. Kilauea shake.
133. December 21, 00 : 36, very feeble.
134. December 26, 09 : 35, very feeble. Probably Mauna Loa origin.
135. December 27, 03 : 42, strong. Dismantled all seismographs on island of Hawaii. Plainly felt on Oahu. Some objects toppled from shelves at places as widespread as Pepeekeo and Naalehu, stone fences were thrown down in vicinity of Hilea. Origin about 15 miles below eastern edge of Mokuaweoweo.
136. December 27, 04 : 21, very feeble. Same as No. 135.
137. December 27, 04 : 27, very feeble.
138. December 27, 05 : 46, slight. E-W instruments dismantled the same as by No. 135.
139. December 30, 09 : 21, moderate. Instruments dismantled the same as by No. 135.
140. December 31, 11 : 10, moderate. Instruments dismantled near Wood Valley. Twelve to 14 miles deep.
141. December 31, 19 : 53, very feeble.

TELESEISMS

October 5, 07 : 07, very slight. 4790 km.
November 16, 02 : 13, near Solomon Islands.
November 23, 16 : 26, slight.
December 6, 18 : 16, moderate. 3700 miles, Japan.
December 29, 12 : 50, slight.
December 29, 13 : 39, slight.
December 30, 11 : 47, slight.

MICROSEISMS

Microseismic motion was strong on October 12 and 13, moderate from October 14 to 20, 27 to 30, and on November 23. Throughout the rest of the quarter microseisms were present though slight.

TILTING OF THE GROUND

Northerly tilt was normal to the north in October, above the normal during the first three weeks in November, and about normal to the north until December 21, when a pronounced southerly tilt set in that continued until the end of the month. Easterly tilt was about normal in October and November. From December 6 to 26 there was a slight westerly tilt. A distinct east tilt accompanied the strong Mauna Loa earthquake of December 27, then the seasonal westerly tilt started.

Table of Tilt at Observatory on NE Rim of Kilauea

Week Ended		Amount	Direction
October	1	1.50″	N 14° E
	8	1.11″	N 40° E
	15	1.03″	S 45° E
	22	1.23″	N 11° E
	29	0.34″	N 45° E
November	5	1.75″	N 34° E
	12	0.72″	N
	19	1.45″	N 55° E
	26	0.44″	S 34° E
December	3	0.64″	N 22° W
	10	0.44″	N 34° W
	17	0.76″	N 18° W
	24	0.61″	S 11° E
	31	3.02″	S 37° E

CRACK MEASUREMENTS

During October there was no movement of consequence at any of the cracks around Halemaumau nor along the Chain of Craters Road. In November a majority of the cracks around Halemaumau showed an opening accompanying a rather rapid doming of the crater floor, though a few showed a distinct closing as is to be expected during times of such movements. There was considerable movement, both opening and closing, accompanying the rapid subsidence of the crater floor in December.

R.H.F.

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