QB
275
.U35
no. 294
1953

U. S. DEPARTMENT OF COMMERCE
SINCLAIR WEEKS, Secretary
COAST AND GEODETIC SURVEY
ROBERT F. A. STUDDS, Director

Special Publication No. 294
March 1, 1953

WAVE REPORTING MANUAL
for Tide Observers in the Seismic Sea Wave Warning System

LIBRARY
AUG 28 1996
N.O.A.A.
U.S. DEPT. OF COMMERCE

UNITED STATES
GOVERNMENT PRINTING OFFICE
WASHINGTON : 1953

National Oceanic and Atmospheric Administration

ERRATA NOTICE

One or more conditions of the original document may affect the quality of the image, such as:

Discolored pages
Faded or light ink
Binding intrudes into the text

This has been a co-operative project between the NOAA Central Library and the Climate Database Modernization Program, National Climate Data Center (NCDC). To view the original document, please contact the NOAA Central Library in Silver Spring, MD at (301) 713-2607 x124 or www.reference@nodc.noaa.gov.

LASON
Imaging Contractor
12200 Kiln Court
Beltsville, MD 20704-1387
January 1, 2006

FOREWORD

The seismic sea wave warning system is a cooperative effort, involving seismograph stations, tide stations, communication services, and others, organized for the benefit of Pacific bases and communities. Since it operates only in emergencies, each participant must be prepared to do his part promptly.

The purpose of this manual is to provide tide stations in the Pacific with the general information and specific instructions needed for effectively performing their roles as wave reporting stations in the warning system. Not only the regular tide observer, but all alternates or substitutes who have been designated to act for him when he is not available, should become familiar with it. It supersedes the previous manual and instructions.

If additional copies are wanted, or if additional information is needed, write to The Director, U. S. Coast and Geodetic Survey, Washington 25, D. C. or to the District Office of the Coast and Geodetic Survey to which the records from the tide stations are sent.

This manual was prepared by W. B. Zerbe, Chief, Section of Oceanography, Division of Tides and Currents.

X-7140

MAR 24 1953

Contents

I. Seismic sea waves . . . . . Page 1
II. The warning system 3
III. Duties of wave reporting stations . . 6
IV. The tide gage 7
V. The seismic sea wave detector 9
VI. Messages 12
VII. Communication tests and rehearsals . 15
VIII. Procedure for reporting a wave when not alerted by HMO 16
IX. Procedure when alerted by HMO . . . 17
X. Illustrative examples 19

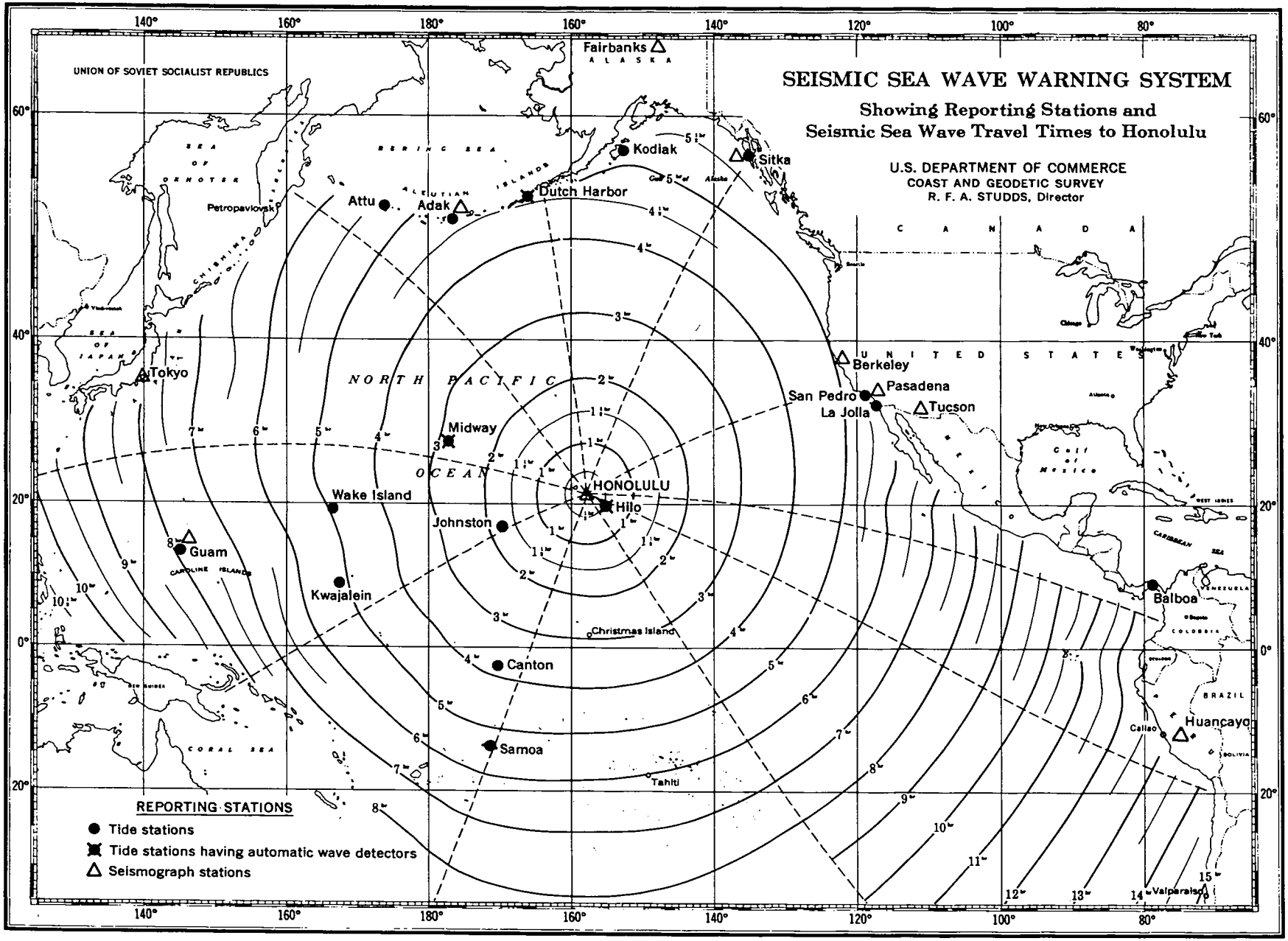


Figure 1. The Honolulu center (HMO) locates earthquakes from reports of seismograph stations, and when advisable, alerts selected tide stations to watch for resulting waves and to report back. Warnings are issued on the basis of these reports. The time curves show wave travel times to Honolulu from any earthquake epicenter in the Pacific; the dashed lines are great circle paths to Honolulu.

WAVE REPORTING MANUAL FOR TIDE OBSERVERS IN THE SEISMIC SEA WAVE WARNING SYSTEM.

I. Seismic Sea Waves

1. Cause. Seismic sea waves (also called "tsunamis" and "tidal waves") are waves set up in the water by an earthquake under the sea. There are many submarine earthquakes that do not produce sea waves and often the waves produced are small, but the occasional large ones have been costly of life and property. They can be very damaging both to property on shore and to ships in harbors. At sea they are low, long, and harmless; it is the underwater features near shore that cause them to build up to dangerous size. Except that small shocks can be eliminated as the cause of dangerous waves, there appears to be no way of determining whether a particular earthquake has generated a wave except by observation.

2. Frequency. Lists have been published of the larger seismic sea waves that have occurred throughout the world. There are often a number of years in succession without a serious wave, but in some years there have been several. In 1946, for instance, there were three earthquakes that produced very damaging waves -- earthquakes in the Aleutian Trench, near the Dominican Republic, and Japan. Probably not a year passes without several seismic sea waves in the Pacific basin, most of them small. A list for the Hawaiian Islands shows that, of the many waves that have reached the islands from 1868 to 1946, 11 have caused damage, making an average of one damaging wave each 7 years. The longest period between damaging waves was 23 years, yet in one year there were two severe waves.

3. Propagation. Though the waves travel outward in all directions from the earthquake epicenter, some areas are protected by the interference of topographic features. It has been suggested that in some instances the waves are directional, that is, the impulse may be stronger in one direction than in others. Their speed depends on depth. In the deep water of the open ocean their speed is of the order of 300 to 500 knots, their length may be as much as 100 miles, but their height is probably not more than a few feet. In the open sea they are harmless and will pass a ship unnoticed. Upon reaching shoaler water they decrease in velocity and length, and increase in height and they can become dangerous even at a great distance from their origin. In the warning system, even a small wave must be considered of sufficient importance to warrant reporting, for a wave that is small at one place may be large and destructive at another.

4. Observable features. Because of their great length and small height, the waves cannot be detected at sea either from a ship or from the air. During the 1946 wave, men on ships standing off the Hawaiian coasts could see the waves breaking on shore yet experienced nothing unusual themselves. On shore, sometimes the first noticeable part of the wave is the trough which causes a recession of the water, and people who have gone out to investigate the unusual exposure of the beach have been engulfed by the oncoming crest. Such an unexplained withdrawal of the sea should be considered as nature's warning of an approaching wave. Tide gage records of the waves of April 1, 1946 and of many others show that the recession is usually, though not always, preceded by a smaller but distinct rise of the water level. The waves are so long that they may not be visually recognizable as waves but only as a general rising and falling of the water surface. In favorable locations, the crest may overtake the trough some distance offshore so that the wave advances to the shore as a bore, or wave with a steep, churning front.

5. Destructive force. At some places the advancing turbulent wave front is the most destructive part of the wave. Where the rise is quiet, the outflow of water to the sea between crests may be rapid and destructive, carrying great rocks and buildings with it. For ships, the mere nearness of shore at such a time is dangerous. The destructive force of such waves should not be minimized. The wave from the earthquake of April 1, 1946 in the Aleutian Trench demolished Scotch Cap light station which was situated nearby on a 57-foot high promontory. In the Hawaiian Islands 2200 miles away it took 173 lives and caused property damage of $25,000,000. There the water rose to heights as great as 50 feet. At a point as distant as Iquique, Chile, several boats were destroyed, and a 30-foot wave was reported to have struck the Juan Fernandez Islands 600 miles off Valparaiso.

6. Period and duration. The seismic sea wave phenomenon is not just one wave but a series of waves. The time between crests is usually from 10 to 40 minutes, and oscillations of destructive proportions may continue for several hours. It may take several days for the sea surface to quiet down to its normal pattern. For graphic records of seismic sea waves, see Figs. 6 to 20.

II. The Warning System

7. Purpose. The seismic sea wave warning system is a cooperative undertaking whose purpose is to detect the great sea waves that are caused by submarine earthquakes so that warnings of their approach can be broadcast to the Hawaiian Islands and other areas in the Pacific in time to prevent the loss of life that has resulted from such waves in the past. It is designed to provide the center of the system at Honolulu promptly with the location of every earthquake that could possibly cause a wave in the Pacific and with prompt reports from observers at wave reporting stations who are alerted whenever an earthquake of wave-producing magnitude is located in their part of the ocean.

8. Participating groups. There are four principal activities or groups participating in the operation of the warning system: seismograph stations, wave reporting stations (tide stations), communication agencies, and the Honolulu Center. The military authorities and civil communities, have made their own arrangements for disseminating warnings when they are alerted by the Honolulu Center.

9. Seismograph stations. The fact that an earthquake has occurred and the seismological information required to locate its epicenter are provided by seismograph stations. U. S. Coast and Geodetic Survey stations are located at Fairbanks, Sitka, Tucson, and Honolulu (HMO). They have visual recording seismographs with an alarm that alerts the observer when there is a large earthquake. Other cooperating observatories that are often called upon for data are located at Berkeley, Pasadena, Huancayo, Adak, Guam, and Tokyo. Whenever there is a large earthquake, these stations send their seismograph readings to the Honolulu station (HMO) either on their own initiative or on request from Honolulu.

10. HMO, The Honolulu Center. The Honolulu Magnetic Observatory (HMO) of the Coast and Geodetic Survey, is the center of operation of the system. It receives and evaluates the reports from the other seismograph stations and determines the location of the earthquake epicenter. If the epicenter is on land or at a place where it could not cause a sea wave in the Pacific, nothing further is done. If the earthquake is in a location where it could cause a sea wave, HMO calls upon wave reporting stations nearest the epicenter to watch for evidence of a wave and to report back. Special charts like Fig. 1 show when a resulting wave should reach Honolulu and the wave reporting stations, so that HMO knows how much time can be used in obtaining

reports. If reports indicate that a potentially dangerous wave exists, HMO notifies certain designated military and civil agencies accordingly. If HMO believes that there is no wave or that it is too small to be dangerous, it cancels any stand-by alert that may have been issued.

11. Wave reporting stations. Evidence as to whether a wave has been generated by a particular earthquake is obtained and reported to Honolulu by tide stations which are distributed throughout the Pacific. Tide stations report on their own initiative or upon request from HMO. Since the automatic tide gage record is an excellent means of revealing the existence of a wave and of providing accurate information on times and heights as well as definite negative information, only tide stations have been formally organized into the system as wave reporting stations. Seismic sea wave detectors, developed in the Coast and Geodetic Survey, have been installed at several tide stations; they automatically set off an alarm in the observer's quarters when they are actuated by a wave of proper period. While the function of a tide station with respect to the warning system is to provide wave information on short notice, it may at times be the beneficiary of a sea wave warning.

12. Need for rapid communication. Seismic sea waves travel with such great speed that the amount of time available for obtaining wave reports is very limited. The amount of usable time will depend upon the location of the earthquake. A wave from the Aleutians could reach Honolulu only 15 minutes after it arrived at Midway, and one from near Honshu might reach Attu only 30 minutes before it hit Midway, etc. The speed with which a tide observer's report gets to Honolulu will determine how many islands or areas can be warned on the basis of that report. Every minute is important and rapid communication is essential.

13. The communication plan. Communication officers of the military services and the Civil Aeronautics Administration (CAA) have made arrangements to handle (by use of existing military and CAA communication facilities) the message traffic essential to the successful operation of the warning system. The arrangements provide for transmission of the messages on a high priority basis commensurate with the need for rapid communication. The "Communication Plan for Seismic Sea Wave Warning System" designates primary and, wherever practicable, alternate channels between Honolulu and each seismograph station and between Honolulu and each tide station. Each tide station, seismograph station, and communication center has been supplied with a copy of the Communication Plan or with as much of it as applies to that station. Some of it is repeated herein under Section VI, Messages.

14. Alerts by HMO. The civil and military authorities in the Hawaiian Islands have designated certain central agencies to receive warnings from HMO, and they are alerted by HMO whenever it believes a warning is justified by wave reports. The further dissemination of warnings is the responsibility of these agencies, the military authorities, and the civil communities. A brief description of how they are organized for such an emergency is interesting and may be helpful to others.

15. Dissemination of warnings. When HMO reports that an alarm is justified, military authorities in Honolulu issue the warnings to all military bases that might be affected. Base commanders will put into effect any precautions deemed necessary. Elsewhere warnings will be broadcast by civilian authorities. Disaster committees have been set up on all the major islands of the Hawaiian group to alert the population and to assist in evacuation and rescue as needed. In Honolulu and Hilo, former air raid sirens now operated by the Police department will be used. As a special precaution at Hilo, a seismic sea wave detector has been installed at the tide station with its alarm in the police station. On Oahu and eventually on the other islands, Civil Air Patrol planes equipped with sirens will fly the shoreline and sound the alarm. On all the major islands police cars equipped with sirens will patrol the coastal areas. Local commercial broadcasting stations will interrupt all programs to give the latest information and instructions. Should a warning occur when a radio station is closed, it will come on the air immediately and remain on until the all clear is sounded. When there is a warning, waterfront areas should be vacated. People should seek high ground away from shore and ships should head for deep water of the open sea, though a ship in a harbor will have to base its procedure on the amount of time available.

241954 O - 53 - 2

III. Duties of Wave Reporting Stations

16. Observers. In order that a capable wave reporter will be available at all hours, the person in charge should, where necessary, designate substitutes for the regular tide observer and see that each is familiar with the instruments and understands his duties in the warning system.

17. List of duties. The duties of each tide station with respect to the seismic sea wave warning system may be listed briefly as follows:

(1) Keep the tide gage in operation at all times. (See Section IV).

(2) If the station has a seismic sea wave detector, keep it in continuous operation, (see Section V).

(3) Report promptly to HMO any seismic sea wave known to exist, even though the station has not been alerted by HMO. (See Section VIII).

(4) When requested by HMO, watch the tide record for evidence of a seismic sea wave and report back to HMO in accordance with the instructions in this manual. Follow any special instructions in the message from HMO. (See Section IX).

(5) Answer promptly all test messages from HMO. (See Section VII).

(6) Inform the local communication stations in the warning system immediately by telephone of any change in the address or telephone number that they use to reach the observer or observers. Supply the same information by letter to the U. S. Coast and Geodetic Survey, Washington 25, D. C.

The following sections provide the detail needed for carrying out these instructions.

18. Caution. Even though instructions specify that the observer shall examine the tide record for evidence of a seismic sea wave, it is not intended for the observer to assume needless risk to reach the tide gage when there is known to be a wave that would make this procedure dangerous. Under such circumstances, visual evidence of a wave should be reported to HMO without going to the gage.

IV. The Tide Gage

19. The standard automatic tide gage. Each tide station in the warning system is equipped with an automatic tide gage. The rise and fall of a float are recorded as a continuous curve by a pencil moving to and fro across a sheet of paper that is moved forward slowly by clockwork. The float rides on the water in a vertical well or pipe to which the sea is admitted by a hole that is small enough to damp out much of the short period waves due to wind. Except for these waves, the tide gage record shows all motions of the sea surface, including the tide, seiche, and seismic sea waves.

20. Care of gage. Instructions in the care and operation of the tide gage are given in Coast and Geodetic Survey Special Publication No. 196, "Manual of Tide Observations." In order that the station may be able to report wave data needed in every emergency, every effort should be made to keep the gage running satisfactorily and to correct operating difficulties promptly. All who are required to respond to alerts should understand the gage and its operation so that it can be started in an emergency if necessary. If special questions arise, write to the Coast and Geodetic Survey.

21. Accurate time. Accurate time is especially important at tide stations in the warning system. Before each daily visit to the gage, the observer should check his watch with the radio, the local communication station, or other reliable source so that the gage clock can be kept as accurate as possible.

22. Clear record. If the record is kept clear and distinct at all times, it will help the observer interpret the record in time of an emergency. It will also make it possible to obtain good photographs of the record later, and that is sometimes necessary. For this reason, the observer should attend the gage and make a comparative note once a day. It will then be unnecessary to make this note at the time of an alert.

23. Special scale. When reporting waves to HMO, report the actual motion of the water which can be determined by scaling the times and heights from the record. A special scale furnished by the Coast and Geodetic Survey should be kept near the gage so that it will always be available. Additional scales can be obtained upon request. (This scale is for reading waves only, and must never be used to obtain the height of the tide given in the daily comparative note; this height must be obtained from the tide staff.)

24. Wave heights. When reading heights, remember that UP IS TOWARD THE CLOCK, that is, when the water rises the pencil moves toward the clock. The special scale will give heights directly in feet and tenths. If an ordinary ruler is used to measure heights, the height scale of the gage must be known. It differs for different gages. A scale of 1:6 means that the pencil moves 1 inch while recording a 6-inch motion of the water, or 2 inches to the foot. The scales and their equivalents are:

1:6	or 2	inches	to the foot,
1:9	or 1 1/3	inches	to the foot,
1:12	or 1	inch	to the foot,
1:16	or 3/4	inch	to the foot,
1:24	or 1/2	inch	to the foot,
1:32	or 3/8	inch	to the foot.

25. Wave times. The recording pencil makes a short horizontal mark each hour on the hour. The time of any point on the curve is obtained by measuring the distance of the point from the beginning of an hour mark. The special scale will give this distance in minutes, but a ruler can be used. Since the paper moves forward one inch an hour, $\frac{1}{2}$ inch on the record is 30 minutes, $\frac{1}{4}$ inch is 15 minutes, 1/8 inch is $7\frac{1}{2}$ minutes, 1/10 inch is 6 minutes, etc. When using the scale or ruler to estimate time, hold it near the hour marks and parallel to the edge of the paper, not parallel to the tide curve. The clocks of most gages are set to local standard time, which should be converted to Greenwich time when reporting to HMO (see Paragraph 37).

V. The Seismic Sea Wave Detector

26. The detector. Several of the tide stations are equipped with seismic sea wave detectors which can be described briefly as follows. (See Figure 2). A length of 6-inch pipe, closed at one end, is fixed vertically in the sea, open end down. As the sea surface rises and falls, air pressure in the pipe increases and decreases. The change in pressure actuates mercury in a U-tube, and when it is changed by a wave of sufficient magnitude, the mercury reaches an electric contact setting off an alarm. By placing the pipe in a well similar to a tide gage float well with a small access hole,

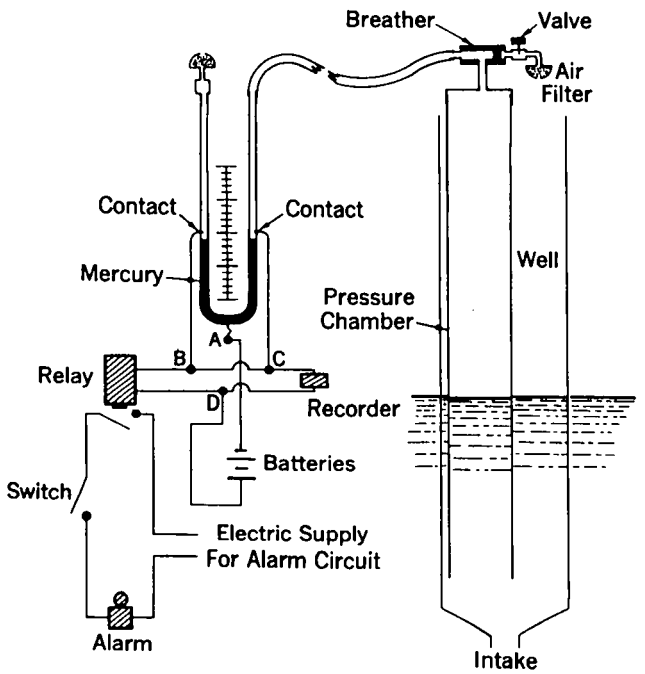


Figure 2. Seismic sea wave detector

the short period waves due to wind are eliminated. A tiny hole in a breather in the top part of the pipe permits the chamber to breathe without changing pressure during the slow rise and fall of the tide (it can be used only where the tidal range is relatively small). More rapid risings and fallings of the water, such as occur with seiches and seismic sea waves, move the mercury column, but the distance from mercury to contact points is large enough so that contact will not be made by seiches normally occurring at a station. This leaves seismic sea waves as the only agency likely to set off the alarm.

27. The recorder. A magnetically operated pencil recorder is mounted on the tide gage and connected electrically to the alarm circuit of the seismic sea wave detector. It makes a continuous straight line except when the seismic sea wave detector actuates the electric circuits. It then makes a jog in the line, thus providing a record of the time at which the seismic sea wave detector signalled an alarm.

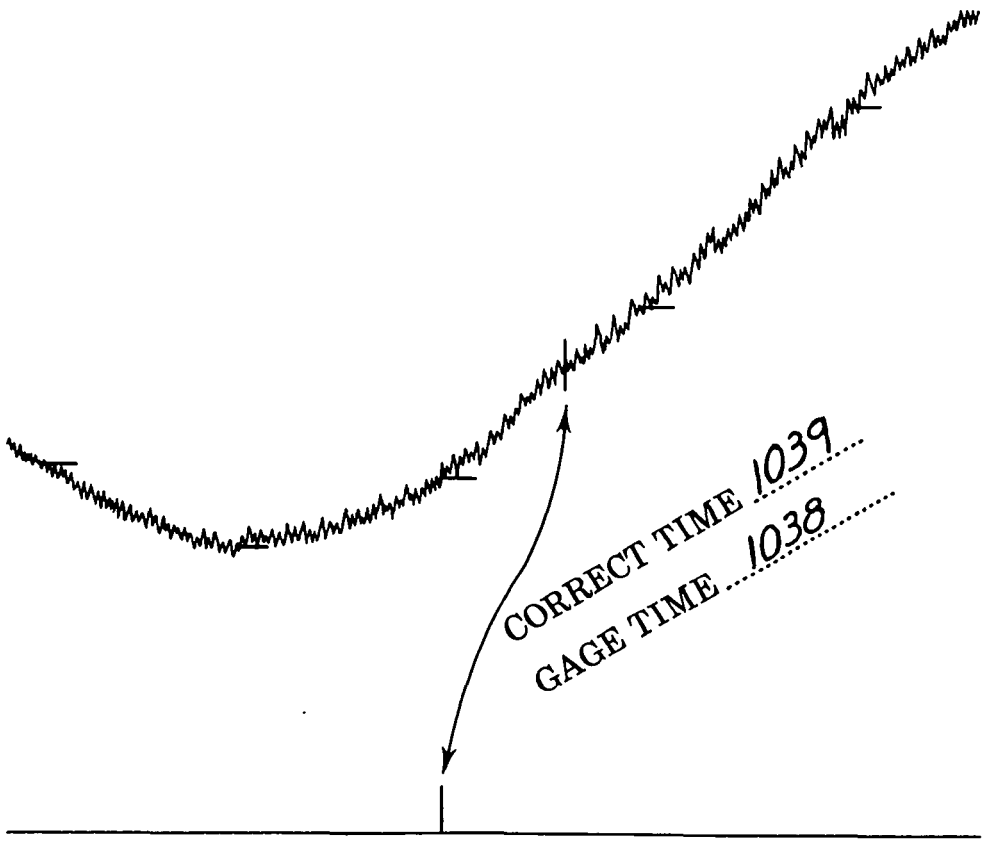


Figure 3. Note on tide record showing relation between wave detector recording pencil and tide recording pencil.

28. Calibration of recorder. To serve its purpose, the position of this pencil with relation to the tide recording pencil (the one that makes the hour marks) must be known. Therefore when the paper is first put on the gage each month, and also on each visit to the gage, move this pencil and at the same time make a mark with the tide recording pencil. Then draw a line pointing to each mark (without touching them), and near it write the correct time and gage time. For example, see Figure 3.

29. Pencil adjustment. It requires a rather delicate adjustment to obtain the right pressure of the pencil against the paper. If the pressure is too great, the magnet can not move the pencil. If the pressure is too light, the pencil will not write. Each day, examine the recorder to see that the pencil is making a legible mark. A fine adjustment can be made merely by screwing the pencil lead in or out. The record will be improved by lightly rubbing fine sand paper or emery paper over the lead of the pencil.

30. The weekly test. For the detector to be in proper operating condition, the intake to the well must be open and clean, the pressure chamber must be airtight except for the breather which must be open and clear, and the batteries, relays, and electric circuits must be functioning so that the recorder and alarms will operate when the mercury touches a contact in either leg of the U-tube. A weekly test provides data that should reveal deterioration and operating difficulties. Instructions for making the test and space for recording the results are given on Form 802, "Report of Weekly Test." The completed form should be forwarded promptly each week to the Coast and Geodetic Survey.

31. Procedure when the detector signals an alarm. When the detector signals an alarm follow the procedure in Section VIII. Do not alert HMO for an obviously false alarm.

32. False alarms and other disorders. Any faulty operation should be corrected as soon as possible. If trouble develops that cannot be cleared up after reading available instructions, request further instructions at once from the Coast and Geodetic Survey. In any event, all false alarms and other operating difficulties, whether remedied or not, should be reported on the Weekly Test Form 802.

VI. Messages

33. Compliance with instructions in Communication Plan. Instructions in the COMMUNICATION PLAN FOR SEISMIC SEA WAVE WARNING SYSTEM shall be followed. Some of the principal points to be remembered are the following.

34. The parts of the message. Each message shall contain, in the order given, (1) a precedence designation or priority indicator, (2) a date-time group, (3) station designators for both the originator of the message and the addressee, (4) the group count, (5) the identifying words SEISMO or SEISMO DUMMY, and (6) the text of the message.

35. Precedence or priority. The term "precedence designation" as used by the military services is essentially equivalent to the term "priority indicator" which is used by the CAA. They provide the relative order in which messages are handled or processed. Precedence designations and priority indicators are assigned by the originator of the message, that is, by the tide observer.

a. "Live" messages. Live messages include seismograph reports, alert messages to tide stations, replies by tide stations to alerts, "tide reports and other messages containing factual reports of unusual natural phenomena which may cause or have caused a condition of disaster." Live messages should be assigned EMERGENCY precedence for transmission via military channels or SVH priority for transmission via CAA channels.

b. Test messages. Test messages (see Paragraphs 48, 49, and 50) will be assigned OPERATIONAL IMMEDIATE precedence for transmission over military channels and SVH priority for transmission over CAA channels.

c. Routine messages. If occasion requires contact with HMO for routine purposes, such as reports of instrument failure or deficiency, routine requests for instrument data, etc., such messages will be assigned ROUTINE precedence for transmission via military channels and OPERATIONAL (OPN) priority for transmission via CAA channels.

36. Date-time group. The observer will enter a date-time group following the precedence designation or priority indicator to show the exact time at which he finishes writing the message. It consists of six figures. The first two, from 01 to 31 denote the date, the next two show the hour and the last two the minute. Thus, 8:21 Greenwich Civil Time on 3 April would be 030821Z. The date-time group serves to identify the messages and helps in evaluating the contents since it establishes the exact time of origin.

37. Greenwich time. Greenwich Civil Time shall be used in all messages to and from the tide stations. Greenwich time is identified by placing the letter "Z" after the time. To convert standard time used at tide stations in the Pacific to Greenwich time:-

add	4	hours	to	60°W.	meridian	time	(zone	Q or + 4)
"	5	"	"	75°W.	"	"	("	R or + 5)
"	6	"	"	90°W.	"	"	("	S or + 6)
"	7	"	"	105°W.	"	"	("	T or + 7)
"	8	"	"	120°W.	"	"	("	U or + 8)
"	9	"	"	135°W.	"	"	("	V or + 9)
"	10	"	"	150°W.	"	"	("	W or + 10)
"	11	"	"	165°W.	"	"	("	X or + 11)
"	12	"	"	180°W.	"	"	("	Y or + 12)

subtract	12	hours	from	180°E.	meridian	time	(zone	M or -12)
"	11	"	"	165°E.	"	"	("	L or -11)
"	10	"	"	150°E.	"	"	("	K or -10)
"	9	"	"	135°E.	"	"	("	I or - 9)
"	8	"	"	120°E.	"	"	("	H or - 8)

If the application of these differences throws the time into the following or preceding day, the date must be changed accordingly when giving the time as Greenwich time. For example, if it is 1830 on April 18 in 165°W. time, it will be 0530 April 19 in Greenwich time, and this time would be given in a date-time group as 190530Z. To change the Greenwich time given in a message to the standard time as given by the tide gage, reverse the process.

38. Station designators. Each seismograph station and tide station has been assigned a station designator which identifies the station to communication operating personnel. It eliminates the need for giving a cumbersome name and address. The appropriate station designators shall be used in all messages in accordance with instructions in the Communication Plan for Seismic Sea Wave Warning System.

a. Station designator for HMO. The station designator for HMO is HONOLULU MAGNETIC.

b. Station designators for tide stations. The station designator for each tide station (except Sitka) is the name of the station followed by the word "observer", thus:

ATTU OBSERVER	SAMOA OBSERVER
ADAK OBSERVER	CANTON OBSERVER
DUTCH HARBOR OBSERVER	HILO OBSERVER
KODIAK OBSERVER	JOHNSTON OBSERVER
SITKA MAGNETIC	MIDWAY OBSERVER
SAN DIEGO OBSERVER	WAKE OBSERVER
LA JOLLA OBSERVER	KWAJALEIN OBSERVER
BALBOA OBSERVER	GUAM OBSERVER

39. Group count. The group count is the number of words or groups of figures in the text. On each message it will be entered as GROUP followed by the figure showing the actual count of words and/or groups.

40. Message identification. All live messages shall contain the word SEISMO as the first word of the text. The text of all test messages shall begin with the words SEISMO DUMMY. Such an entry permits ready identification of the message by communication operating personnel.

41. Sample message. The following is an example of the form in which a message should be given to the communication station by the observer. It shows the order in which the various items described above are to be given,

EMERGENCY 030821Z
FROM DUTCH HARBOR OBSERVER
TO HONOLULU MAGNETIC
GROUP 19
SEISMO WAVE BEGAN 0813Z WATER FELL ONE POINT
FIVE FEET IN FIVE MINUTES STILL FALLING 0818Z
WILL REPORT FURTHER.

VII. Communication Tests and Rehearsals

42. Purpose and procedure. It is of extreme importance that the system function efficiently in time of emergency. Since genuine emergencies are infrequent, test messages are sent to observers periodically, but at unannounced times, in order to provide rehearsal, to maintain contact between observers and communication officers, and to check the speed of operation of the system. Both HMO and the tide observers will assign OPERATIONAL IMMEDIATE precedence to test messages for transmission via military channels and SVH priority if sent via CAA. For purpose of identification, test messages must contain the words SEISMO DUMMY preceding the text of the message. Unless the observer is specifically requested to go to the tide station, he should not do so, but should reply to the message at once giving merely the time of its receipt.

43. Test message from HMO. The following is a sample test message as it would be prepared at HMO.

OPERATIONAL IMMEDIATE 041024Z
FROM HONOLULU MAGNETIC
TO BALBOA OBSERVER
GROUP 6
SEISMO DUMMY ADVISE TIME OF RECEIPT

44. Reply by observer. The observer should reply at once, and it can often be done immediately while the communication officer is still on the phone. The following sample can be used as a standard form of reply.

OPERATIONAL IMMEDIATE 041036Z
FROM BALBOA OBSERVER
TO HONOLULU MAGNETIC
GROUP 6
SEISMO DUMMY YOUR 041024Z RECEIVED 041035Z

VIII. Procedure for Reporting a Wave When Not Alerted by HMO

45. Procedure. If the observer believes that seismic sea wave exists at his station or in his part of the Pacific Ocean because of information obtained from

(a) visual evidence,
(b) apparently reliable report, or
(c) seismic sea wave detector alarm,

he should proceed as follows (see Paragraph 41, Sample Message; Paragraph 18, Caution; and Paragraph 37, Greenwich Time):

(1) Send a message to HMO telling as much as is known about the wave, its time of arrival and size, and give the basis of the information. It is preferable first to confirm (b) and (c) from the tide record if that procedure will not materially delay the first message. Do not report an obviously false alarm.

(2) Go to the tide gage to determine the existence of wave at the station, and for more definite information on time of arrival and size. (See Paragraphs 23-25 and Section X, Illustrative Examples). Send this information to HMO as soon as possible.

(3) Watch the tide record and send any additional messages that are needed to give HMO more definite information on the existence of the wave or on its character.

46. Precedence of messages. Assign "live" message precedence to all of the above messages (see Paragraph 35a). Once HMO has been alerted, all subsequent messages pertaining to the alert -- even a message stating that the alarm was false -- should carry the same high precedence.

IX. Procedure When Alerted by HMO

47. The alert by HMO. When HMO locates a large earthquake in the Pacific, it will alert those tide stations that would be the first to experience a resulting wave. By means of travel time charts, HMO can determine roughly when a wave (if there is one) should reach the tide station. It must allow some leeway because the travel times are sometimes based upon inadequately surveyed ocean areas and because the earthquake cannot always be located with precision in the short time available. The message to the tide station will therefore usually instruct the observer to examine the tide record for an unusual disturbance during a period of one to three hours.

48. Procedure. When the observer is requested to examine the tide record for an unusual disturbance either during a period that has just passed or during a period that extends into the immediate future, he should proceed as follows (see Paragraph 41, Sample Message; Paragraph 37, Greenwich Time; and Paragraph 18, Caution):

(1) Acknowledge the alert promptly. The following illustrates a satisfactory text of an acknowledgement message: SEISMO YOUR 041024Z RECEIVED 041032Z WILL COMPLY.

(2) Go to gage; see that gage is operating.

(3) Watch record as requested, examining past record as necessary, to determine existence of wave and report to Honolulu in one or more messages following instructions in the message and in Paragraphs 49 and 50 (see also Paragraphs 23-25). Remember that it is important to get preliminary information to Honolulu promptly, using a second or third message to provide added detail.

49. Reporting an unusual disturbance. If the gage has already recorded an unusual disturbance, details of time and size should be sent at once to HMO. If an unusual disturbance is being recorded while the observer is watching the gage, he should wait just long enough to satisfy himself that it is something unusual and report at once to HMO, stating when it started, whether the water first rose or fell and how far it rose or fell up to the time the observer left the gage. If the observer is not sure that a disturbance is unusual enough to report, he should report and describe what he sees. Do not wait for full details, but send this first report as soon as possible. Then return to the gage for further details and report them to HMO in a second message. (See Section X, Illustrative Examples).

50. Reporting no unusual disturbance. If the gage has not recorded an unusual disturbance during the period specified in HMO's message (which may have been, for example, 1500Z to 1700Z), the observer should inform HMO immediately at the end of the period. The following text is adequate for such a message: SEISMO NO UNUSUAL DISTURBANCE 1500Z TO 1700Z.

51. Precedence of messages. Assign "live" messages precedence to all of the above messages (see Paragraph 35a). All messages replying to an alert by HMO, including the acknowledgment message and messages giving positive or negative information should carry "live" message precedence.

X. Illustrative Examples

52. Source of the examples. The following examples are given to assist the observer in interpreting the tide record and to illustrate the action required in various situations. Few seismic sea waves have occurred since the formation of the warning system and, therefore, to provide the desired variety of illustrative examples, many of the records shown antedate the warning system or are from stations not in the system. Consequently, though the figures are reproductions of actual tide records, the messages have been invented for the purpose of illustration.

53. Explanation. Figures 4 and 5 show tide records at times when there were no seismic sea waves. All of the others are records of actual waves. The times shown on the figures are Greenwich.

Figure 4 shows three normal tide records.

Figure 5 shows tide records with seiche and tells how to distinguish seismic sea waves from seiche.

Figures 6 - 8 show records of seismic sea waves together with queries that might have been received from HMO and suggested replies by observers sent at the times marked by letter on the curves. Since the portions of the curves to the right of these points would not have been recorded at the time the observer sent his message, the reader can put himself in the observer's place by covering the part to the right of these marks. Only the texts of messages are given here; for a sample of a complete message, see Paragraph 41.

Figures 9 - 20 are additional samples of seismic sea waves, but without messages.

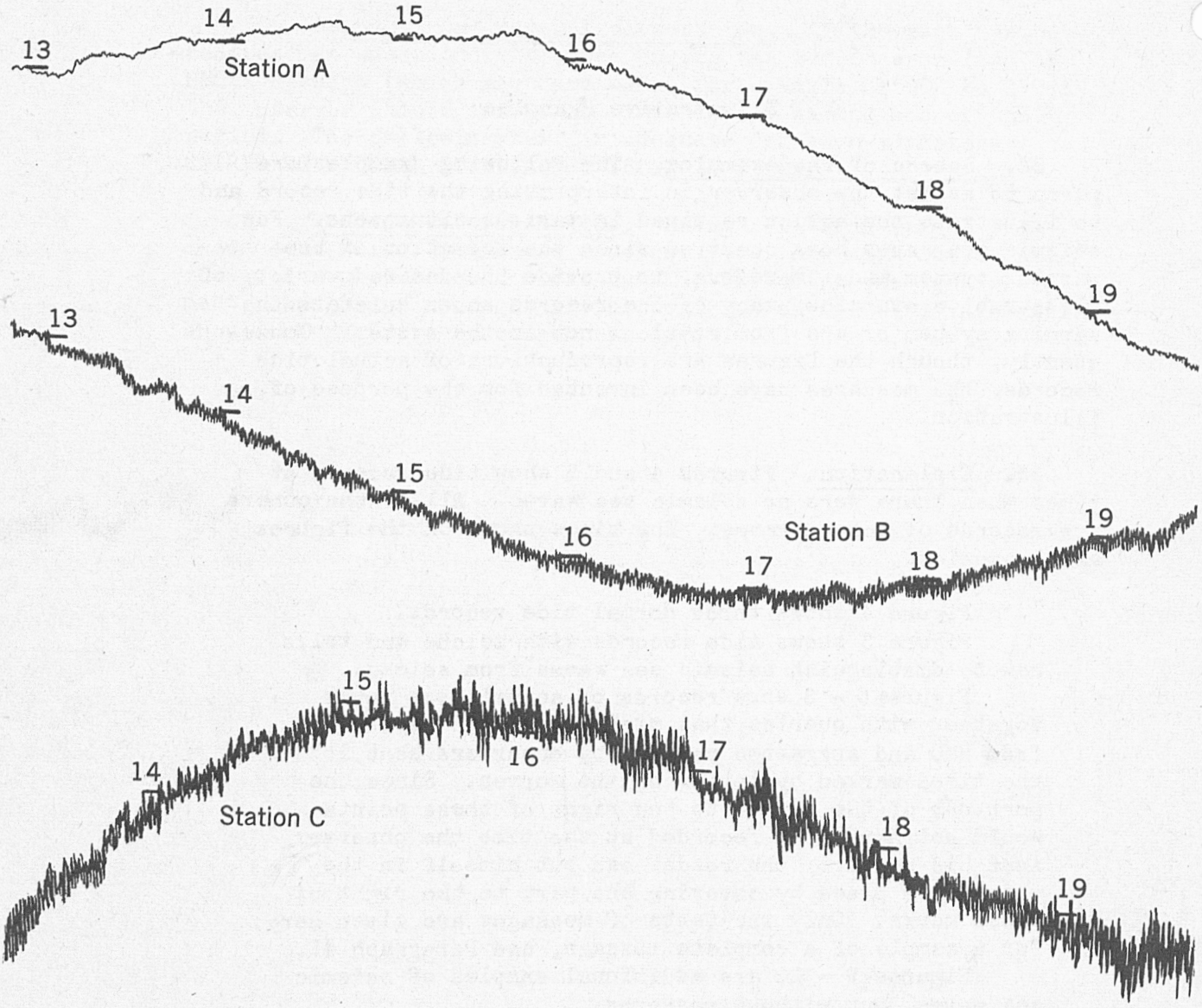


Figure 4. Here are three normal tide records showing different amounts of pencil motion, due to wind waves, resulting either from different size intakes in the float wells or from a difference in the exposure of the stations to waves.

Had these stations received the following message from HMO:

SEISMO OBSERVE TIDE RECORD BETWEEN 1600Z AND 1800Z. REPORT ANY UNUSUAL ACTIVITY IMMEDIATELY OR REPLY NEGATIVE AT 1800Z. ACKNOWLEDGE.

each station would have acknowledged it immediately, and then at about 1802Z each would have sent the following reply (text only is shown here):

SEISMO NO UNUSUAL ACTIVITY BETWEEN 1600Z AND 1800Z.

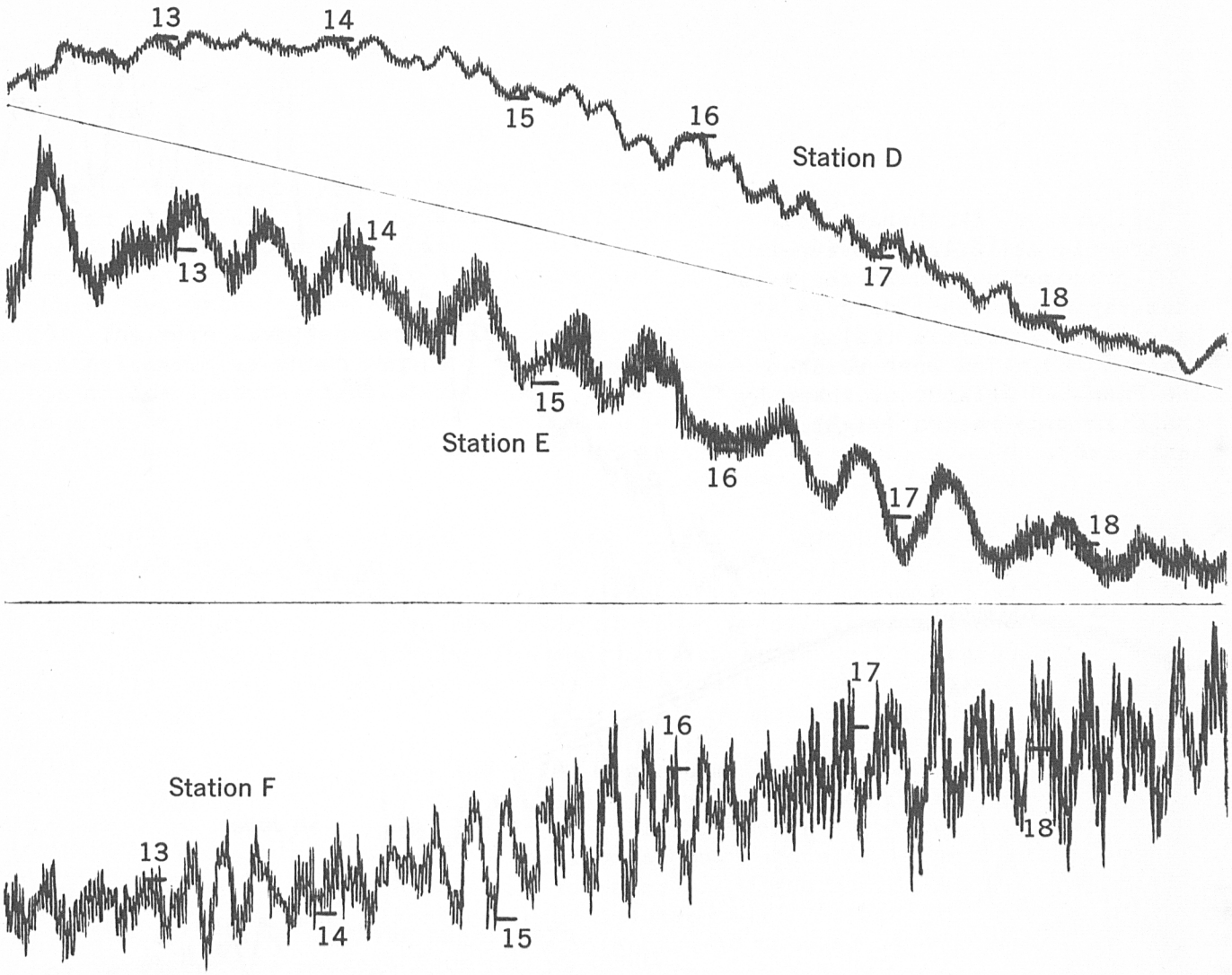


Figure 5. These three tide records show oscillations called "seiche" (pronounced saysh) which may sometimes be difficult to distinguish from small seismic sea waves. Seismic sea waves often have the same period (time from crest to crest) as these seiches. At stations D and F, the period is about the same: 12 to 15 minutes; at E it is somewhat more or less than half an hour. Seiche action is usually due to meteorological conditions, sometimes far at sea, and some harbors tend to magnify the oscillations.

Seiche can usually be distinguished from small seismic sea waves by remembering that seiche generally starts gradually, growing in size over a period of hours, whereas an identifying feature of a seismic sea wave is the sudden change in the pattern of the record, as indicated in the following figures. (Note particularly Figures 9, 11, 15, and 17 which illustrate seiche prior to the arrival of seismic sea waves.)

To a query relative to unusual activity on tide record between 1600Z and 1800Z, the observer might have replied:

SEISMO. NO UNUSUAL ACTIVITY BETWEEN 1600Z AND 1800Z. SEICHE OF ____ FOOT HAS BEEN ACTIVE FOR 8 HOURS OR MORE.

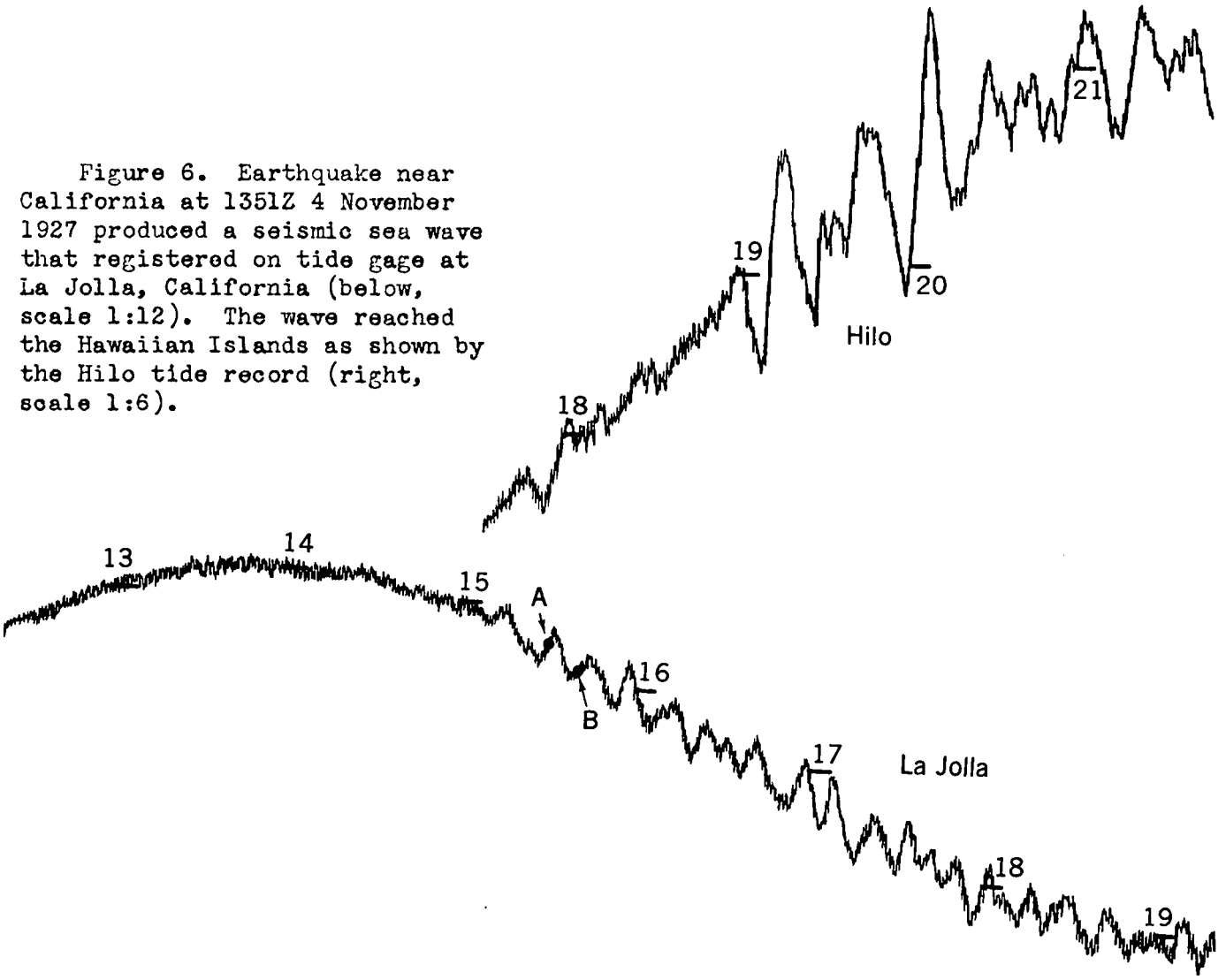


Figure 6. Earthquake near California at 1351Z 4 November 1927 produced a seismic sea wave that registered on tide gage at La Jolla, California (below, scale 1:12). The wave reached the Hawaiian Islands as shown by the Hilo tide record (right, scale 1:6).

The tide observer might have received this query at 1430Z from HMO:

SEISMO OBSERVE TIDE RECORD 1400Z TO 1600Z. REPORT ANY UNUSUAL ACTIVITY IMMEDIATELY OR REPLY NEGATIVE AT 1600Z. ACKNOWLEDGE.

The observer would have acknowledged the message immediately, as follows:

SEISMO. YOUR 041422Z RECEIVED 041430Z. WILL COMPLY.

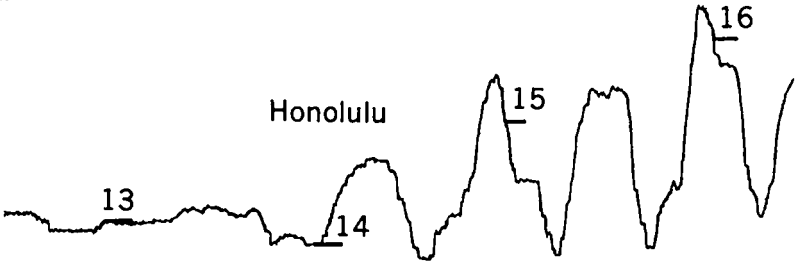
At 1530Z (time A), the observer could have sent this message:

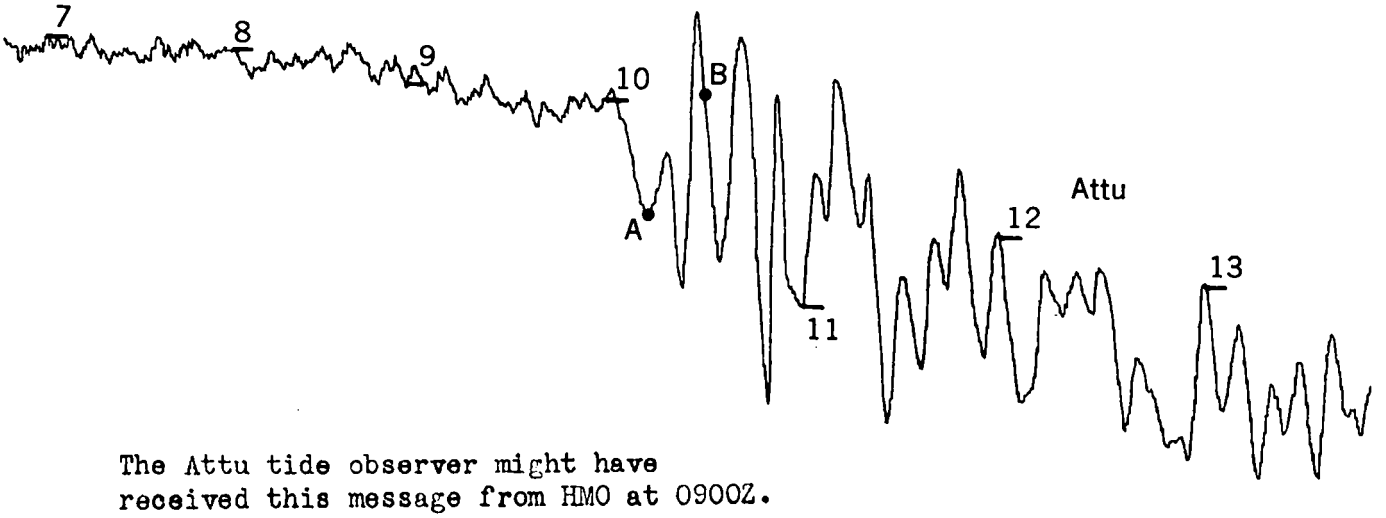
SEISMO SMALL POSSIBLE DISTURBANCE TO TIDE RECORD BEGAN ABOUT 1510Z. WATER ROSE 0.1 FOOT IN 5 MINUTES. FELL 0.3 FOOT IN 10 MINUTES. WILL REPORT FURTHER.

At 1540 (time B), the observer could have sent this second message:

SEISMO. DISTURBANCE TO TIDE RECORD 1510Z IS DEFINITE BUT WAVE IS VERY SMALL. WATER ROSE 0.2 FOOT BETWEEN 1527Z AND 1532Z.. FELL 0.3 FOOT BY 1538Z. WILL NOT REPORT AGAIN UNLESS WAVE GETS LARGER.

Figure 7. Earthquake off Honshu I., Japan at 0436Z 7 December 1944 produced a seismic sea wave that registered on the tide gage at Massacre Bay, Attu (below, scale 1:12). The wave also reached the Hawaiian Islands as shown by the Honolulu tide record (right, scale 1:6).





The Attu tide observer might have received this message from HMO at 0900Z.

SEISMO. OBSERVE TIDE RECORD 0900Z TO 1100Z.
REPORT ANY UNUSUAL DISTURBANCE IMMEDIATELY
OR REPLY NEGATIVE AT 1100Z. ACKNOWLEDGE.

The observer would have acknowledged this message immediately, as follows:

SEISMO. YOUR 070822Z RECEIVED 070900Z. WILL COMPLY.

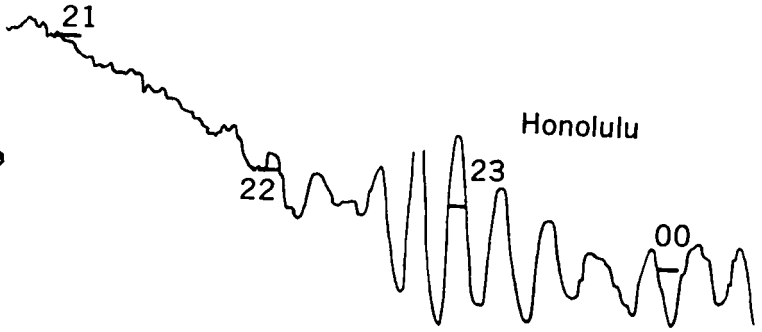
At 1015Z (time A), the observer could have sent this message:

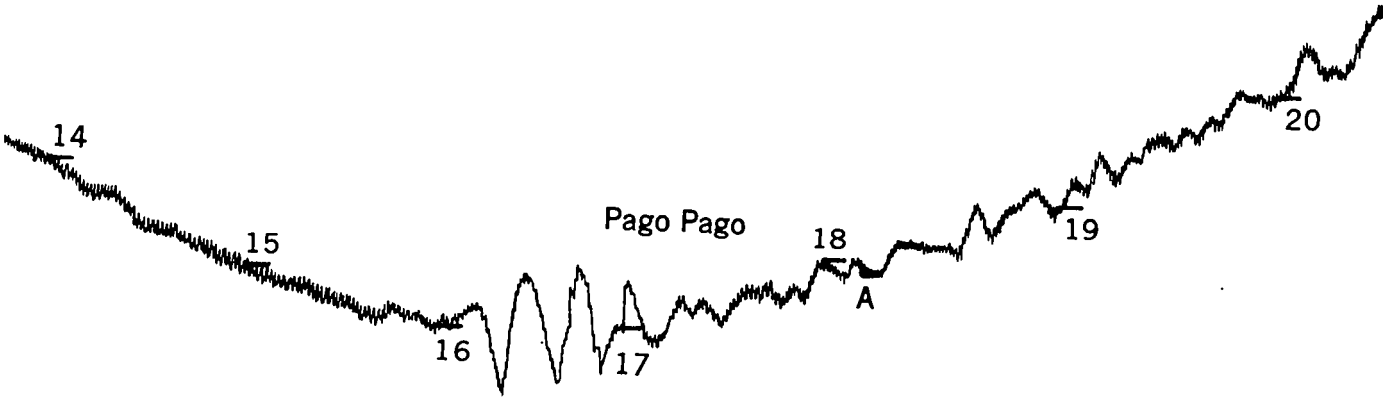
SEISMO. UNUSUAL DISTURBANCE BEGAN 1003Z. WATER FELL
0.6 FOOT IN 10 MINUTES. STILL FALLING.

At 1032Z (time B), the observer could have sent this second message:

SEISMO. WATER BEGAN FALLING 1003Z. FELL 0.7 FOOT BY 1015Z.
THEN ROSE 0.4 FOOT IN 5 MINUTES, FELL 0.7 FOOT IN 5 MINUTES,
ROSE 1.5 FEET IN 5 MINUTES. NOW FALLING. SHIPS HAVING
TROUBLE HOLDING MOORINGS. NO DAMAGE ON SHORE. WILL NOT
REPORT AGAIN UNLESS WAVE BECOMES LARGER.

Figure 8. Earthquake near the Tonga Islands at 1509Z on 8 September 1948 produced a small seismic sea wave that registered on the tide gage at Pago Pago, Samoa (below, scale 1:12). The wave reached the Hawaiian Islands as shown by the Honolulu tide record (right, scale 1:6).





At about 1802Z the tide observer at Pago Pago might have received this message from HMO:

SEISMO. EXAMINE TIDE RECORD FOR UNUSUAL ACTIVITY BETWEEN 1600Z AND 1800Z. REPORT IMMEDIATELY.

After acknowledging the message the observer would have gone immediately to the gage. At 1812Z (time A), he might have sent this message:

SEISMO. SEISMIC SEA WAVES SHOW DISTINCTLY. AFTER SLIGHT RISE WATER BEGAN TO DROP SUDDENLY AT 1615Z. THERE WERE THREE WAVES OF HALF FOOT HEIGHT BY 1705Z. WAVES THEN QUIETED DOWN.

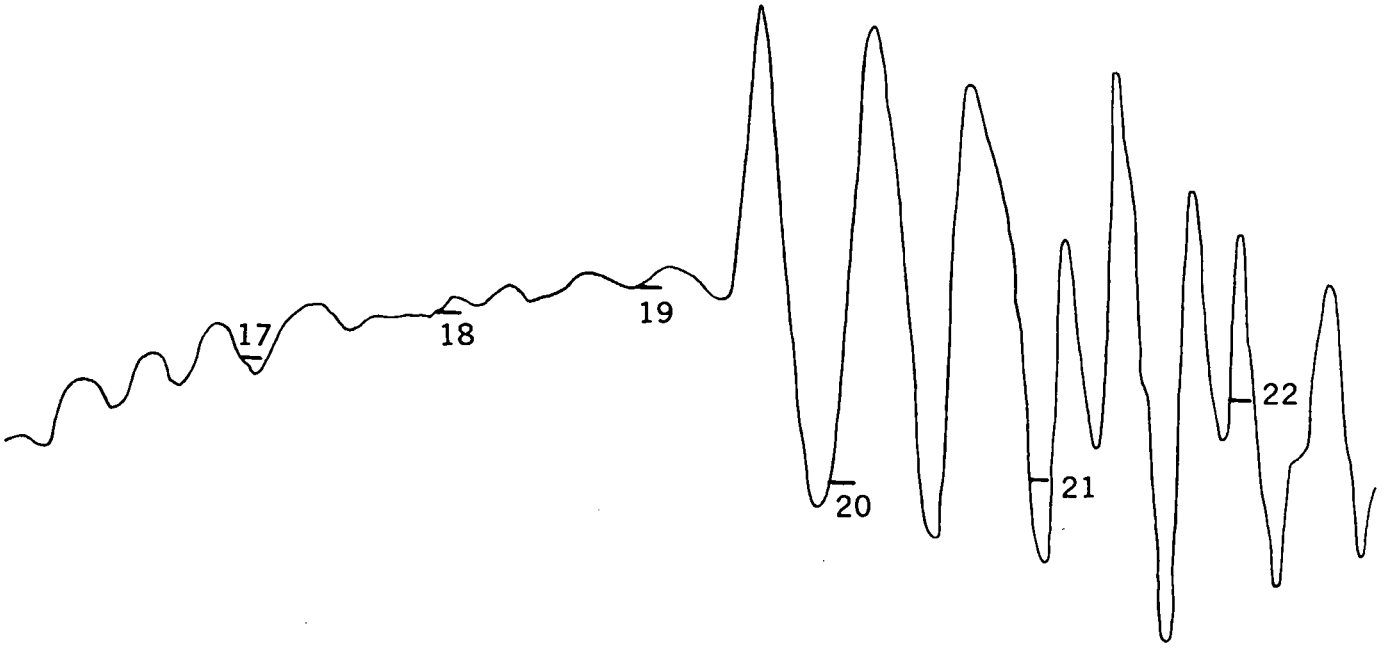


Figure 9. Honolulu tide record (scale 1:6) showing seismic sea wave from earthquake off the coast of Chile at 0432Z 11 November 1952. Wave arrived about 1928; prior oscillations are seiche.

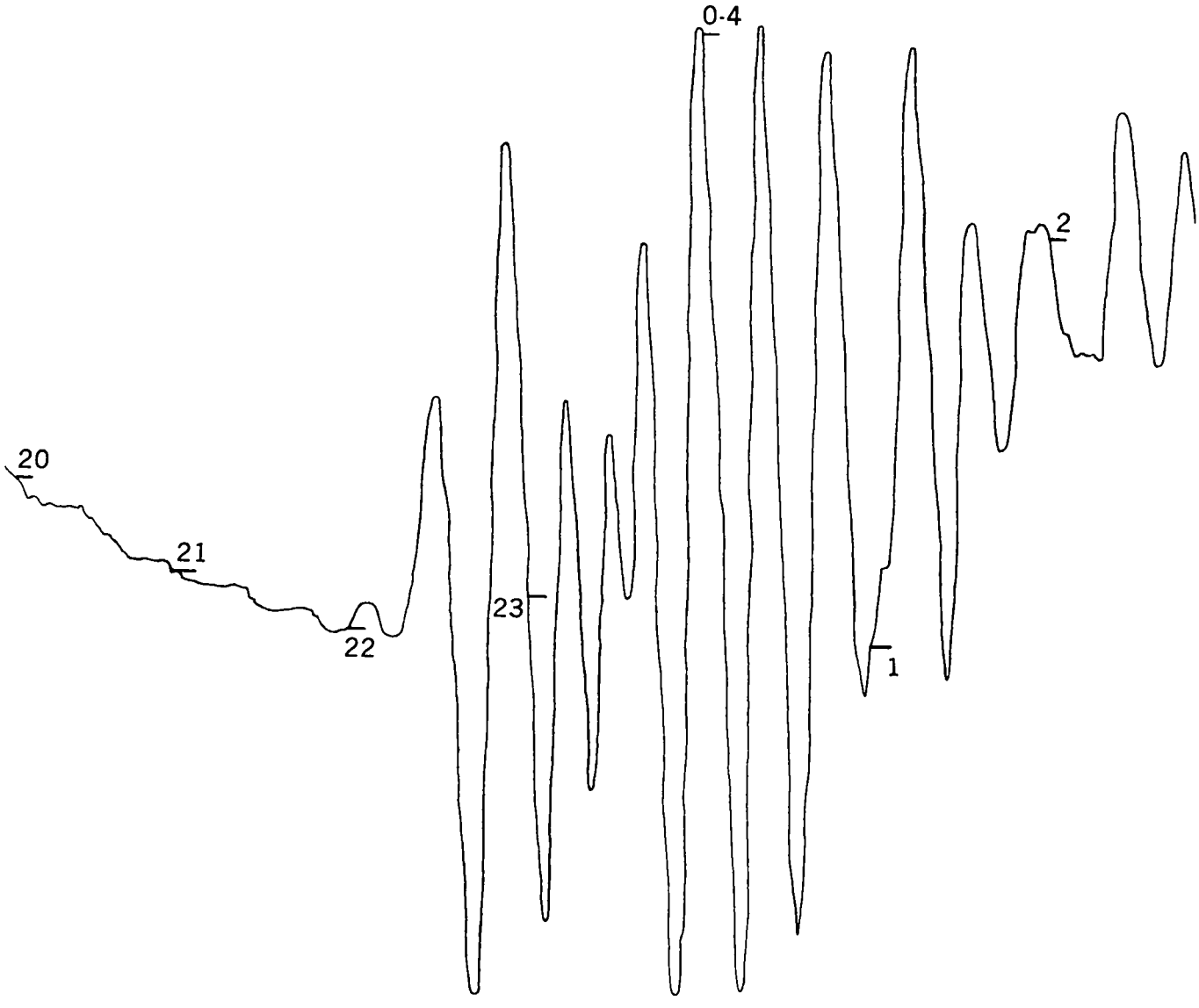


Figure 10. Honolulu tide record (scale 1:6) showing seismic sea wave from earthquake near Kamchatka at 1602Z 3 February 1923. This wave caused damage in the Hawaiian Islands.

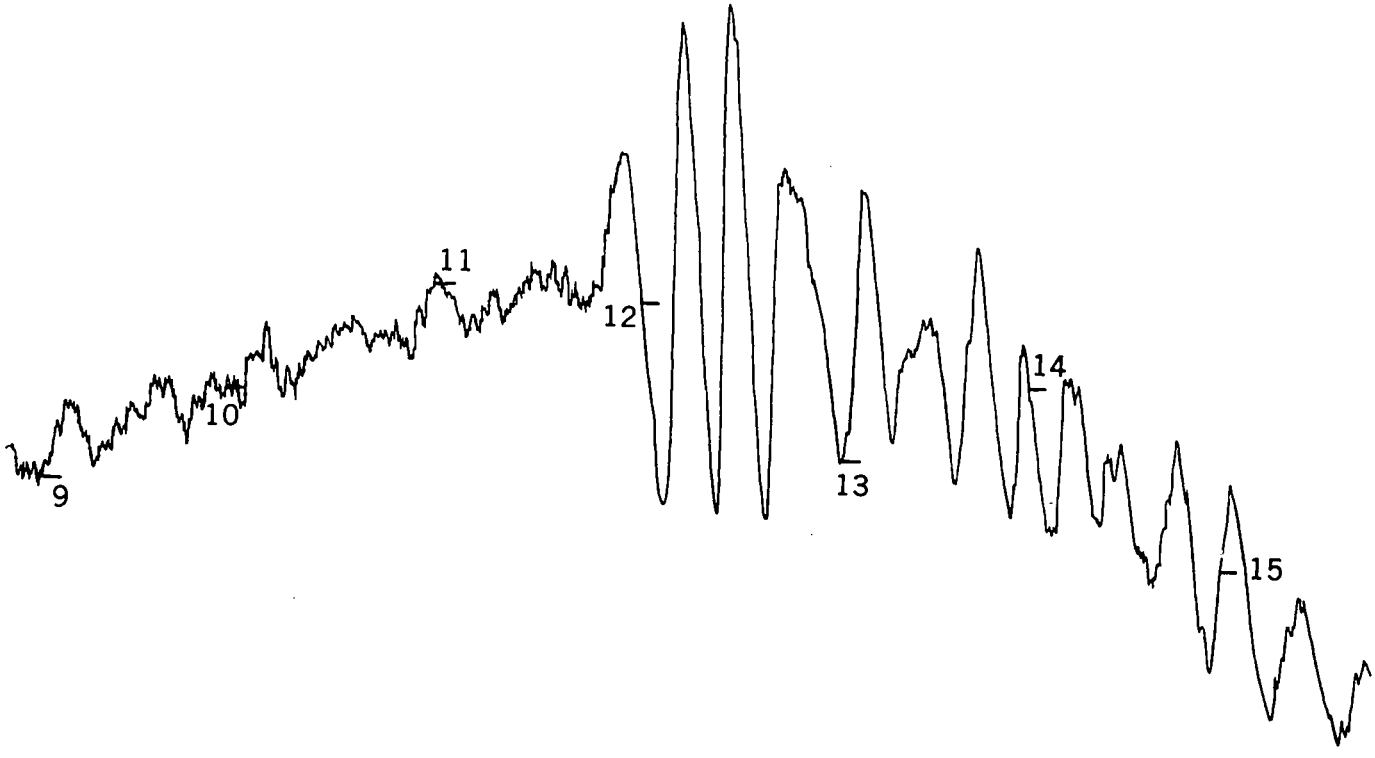


Figure 11. Hilo tide record (scale 1:6) showing seismic sea wave from an earthquake off the coast of Mexico at 0319Z 17 June 1928. Wave arrived about 1145; prior oscillations are seiche.

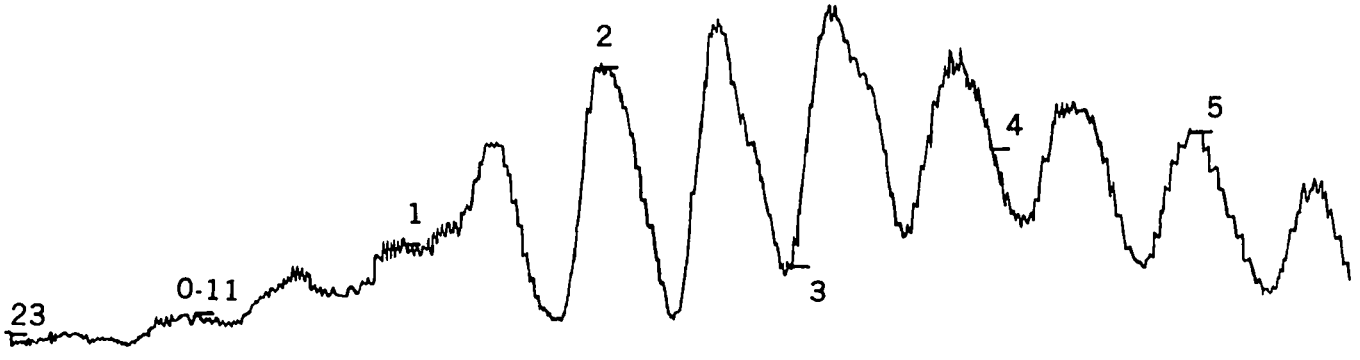


Figure 12. Honolulu tide record (scale 1:6) showing seismic sea wave from an earthquake near the Alaska Peninsula at 2019Z 10 November 1938. The wave period of 35 minutes is rather long and unusually constant.

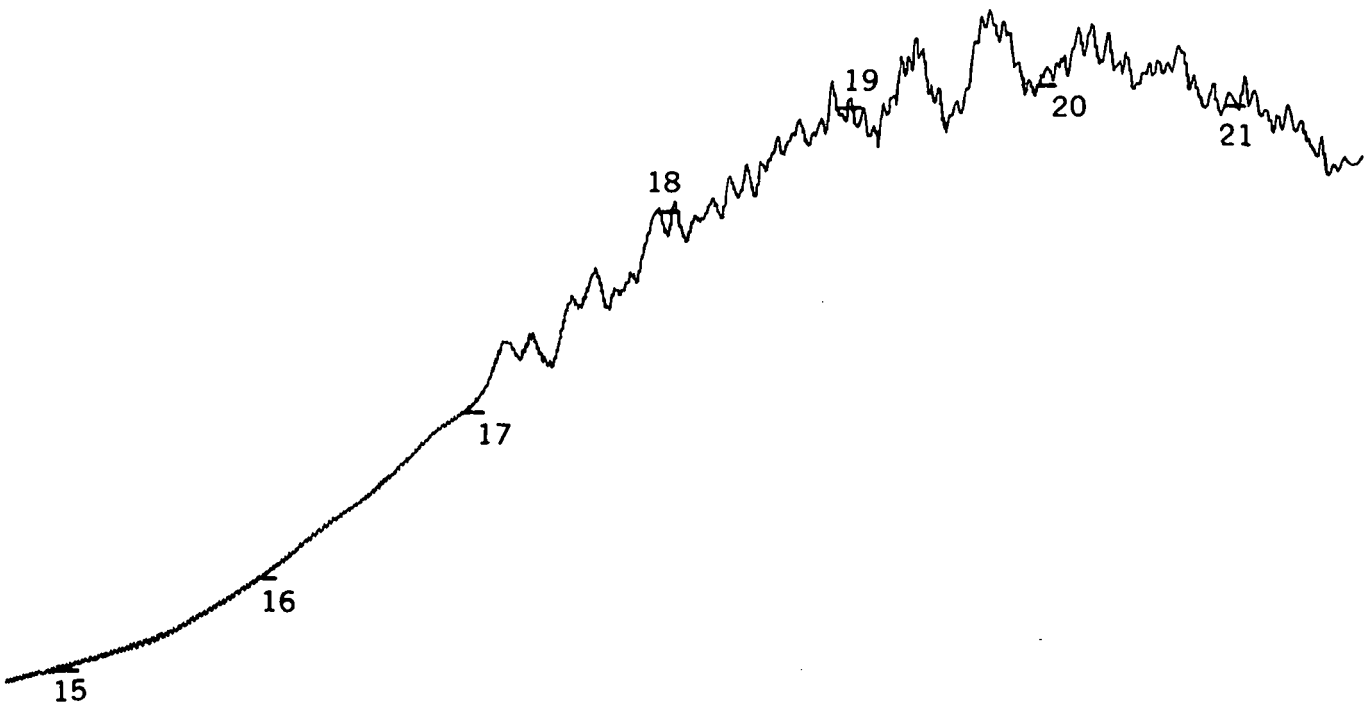


Figure 13. Tide record (scale 1:24) for Neah Bay (near Cape Flattery), Washington showing seismic sea wave from the earthquake in the Aleutian Trench at 1229Z 1 April 1946. This was the wave that was so destructive in the Hawaiian Islands. The wave was much larger a little farther south on the California Coast (Figure 14). This shows that even small waves should be reported, for a wave that is small at one place may be large and destructive at another.

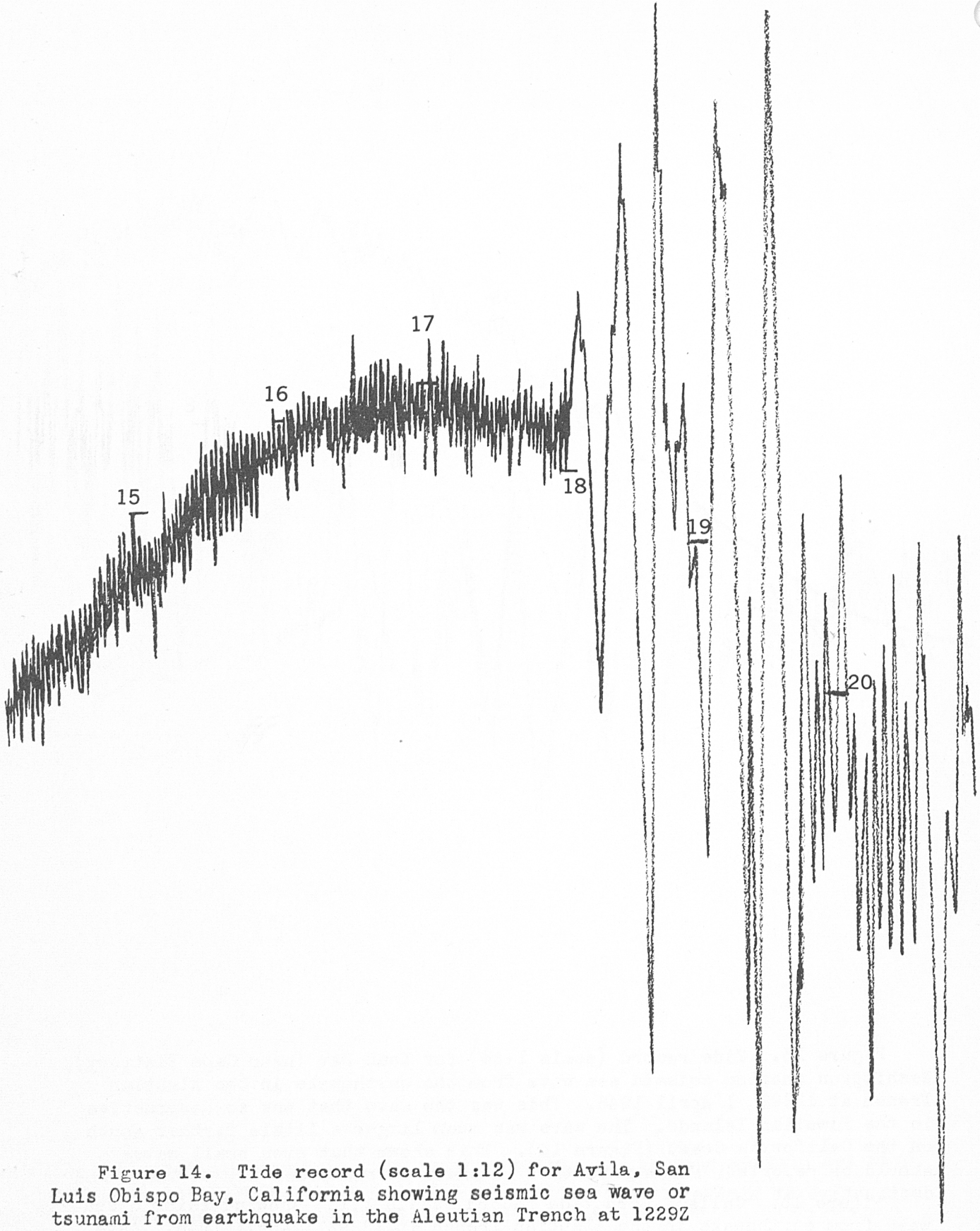


Figure 14. Tide record (scale 1:12) for Avila, San Luis Obispo Bay, California showing seismic sea wave or tsunami from earthquake in the Aleutian Trench at 1229Z 1 April 1946.

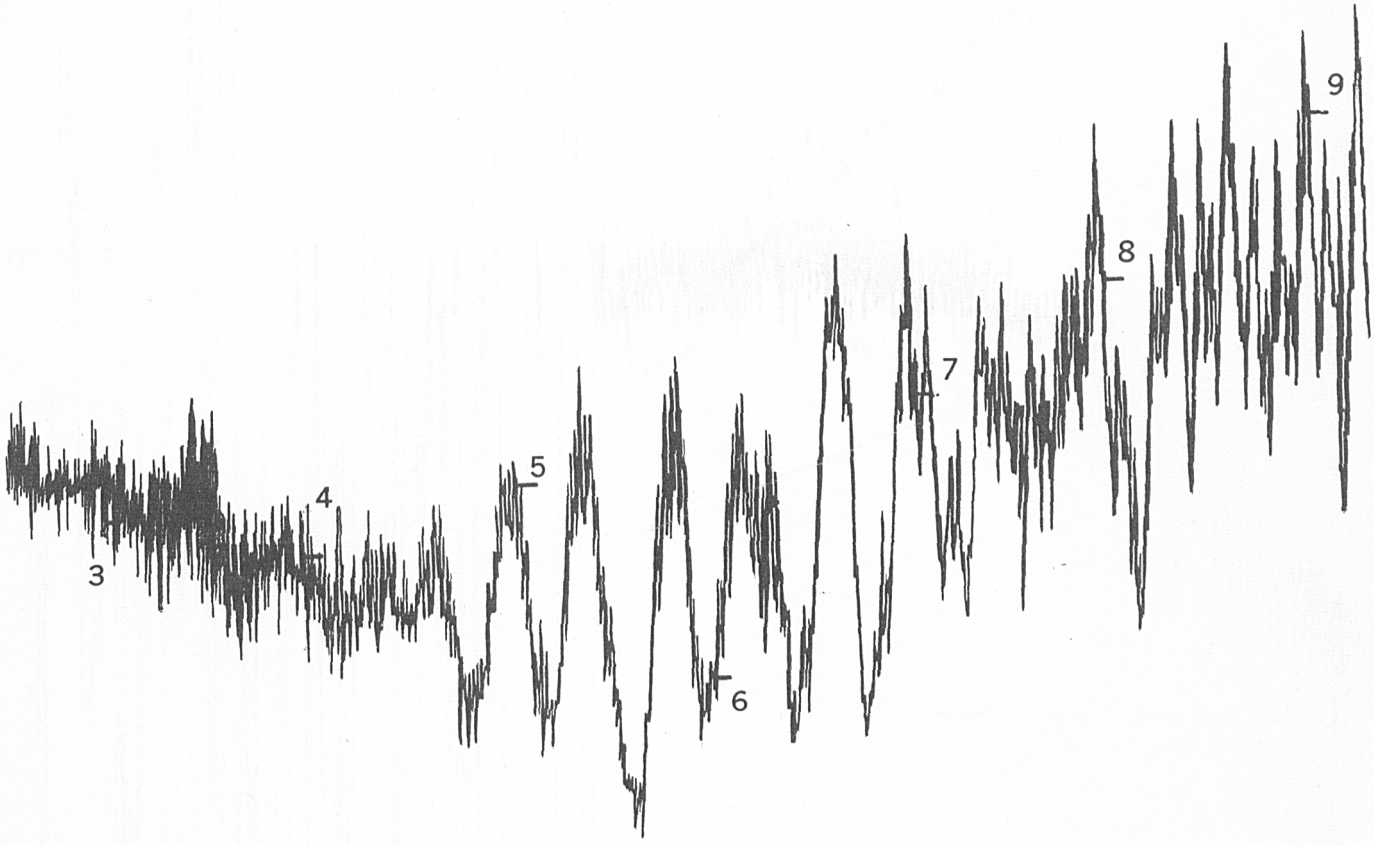


Figure 15. Callao, Peru tide record (scale 1:12) showing seismic sea wave from earthquake in the Aleutian Trench at 1229Z 1 April 1946. Wave arrived about 0435; prior oscillations are seiche and wind waves.

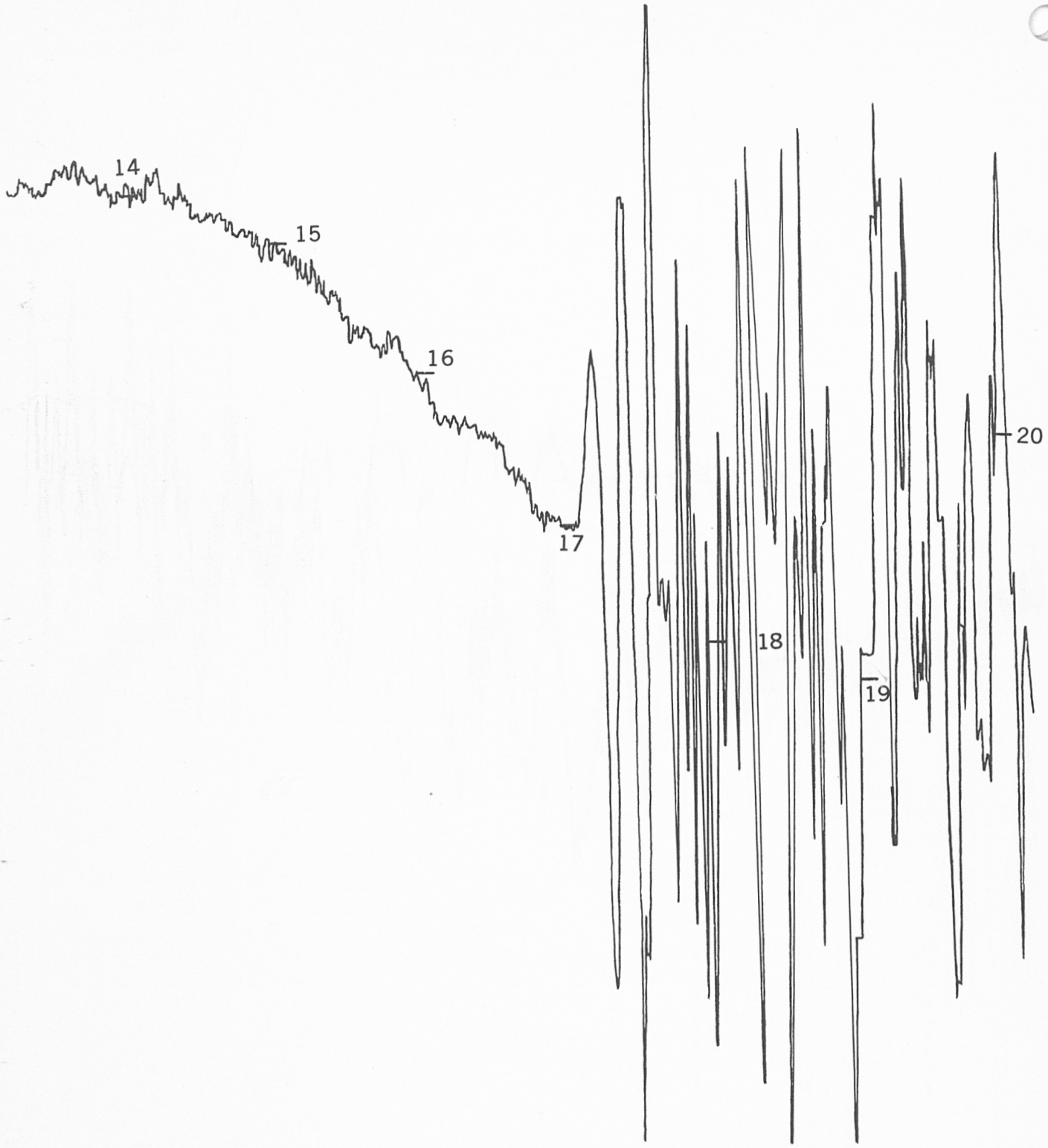


Figure 16. Honolulu tide record (scale 1:6) showing the tsunami or seismic sea wave from earthquake in the Aleutian Trench at 1229Z 1 April 1946. This wave caused 173 deaths and $25,000,000 property damage in the Hawaiian Islands.

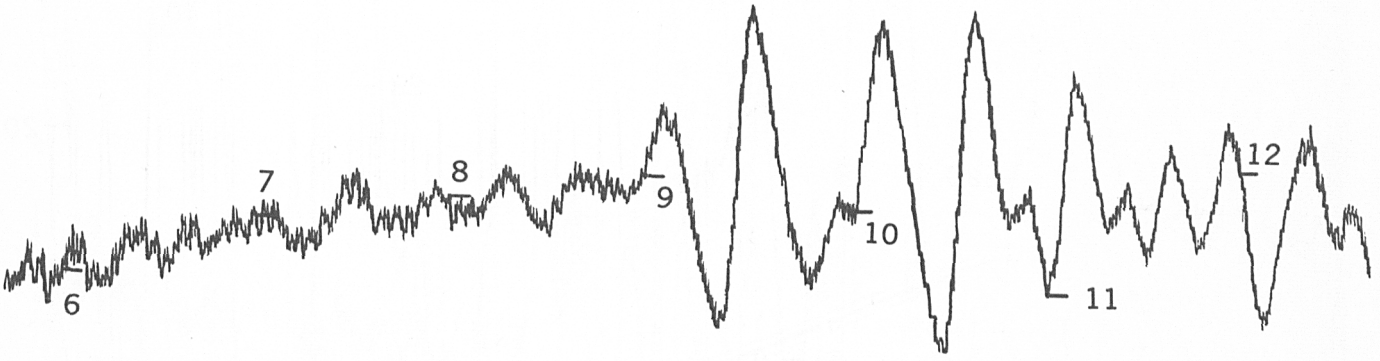


Figure 17. Tide record (scale 1:12) for Kahului, Maui, Hawaiian Islands for 4 March 1952 showing seismic sea wave from earthquake off Hokkaido, Japan at 0123Z 4 March. Wave arrived about 0855; prior oscillations are seiche and small wind waves.

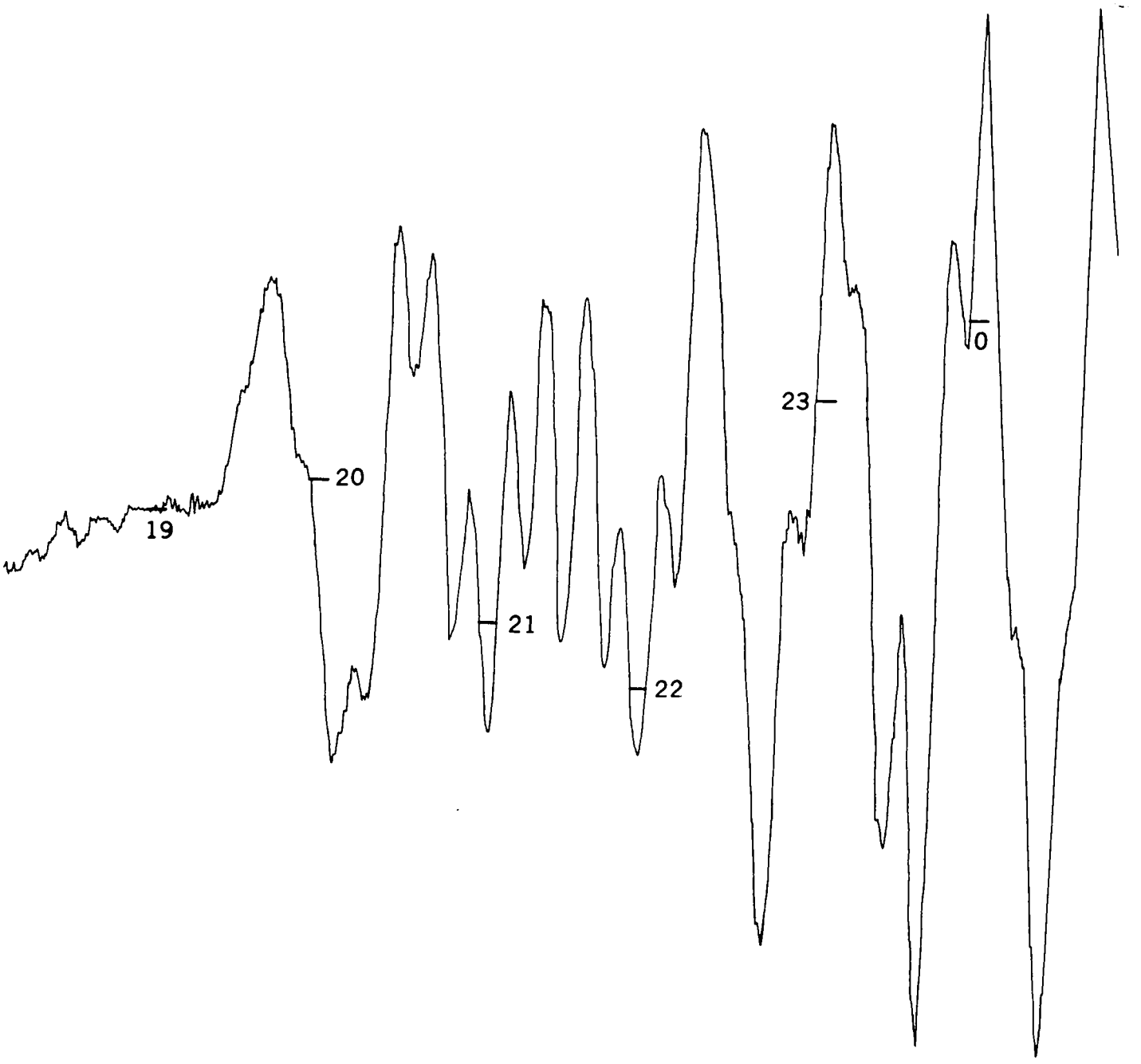


Figure 18. Adak tide record (scale 1:12) showing seismic sea wave from earthquake off Kamchatka at 1658Z 4 November 1952. Reports of this wave by the Adak and Attu observers reached HMO in time for warning other areas.

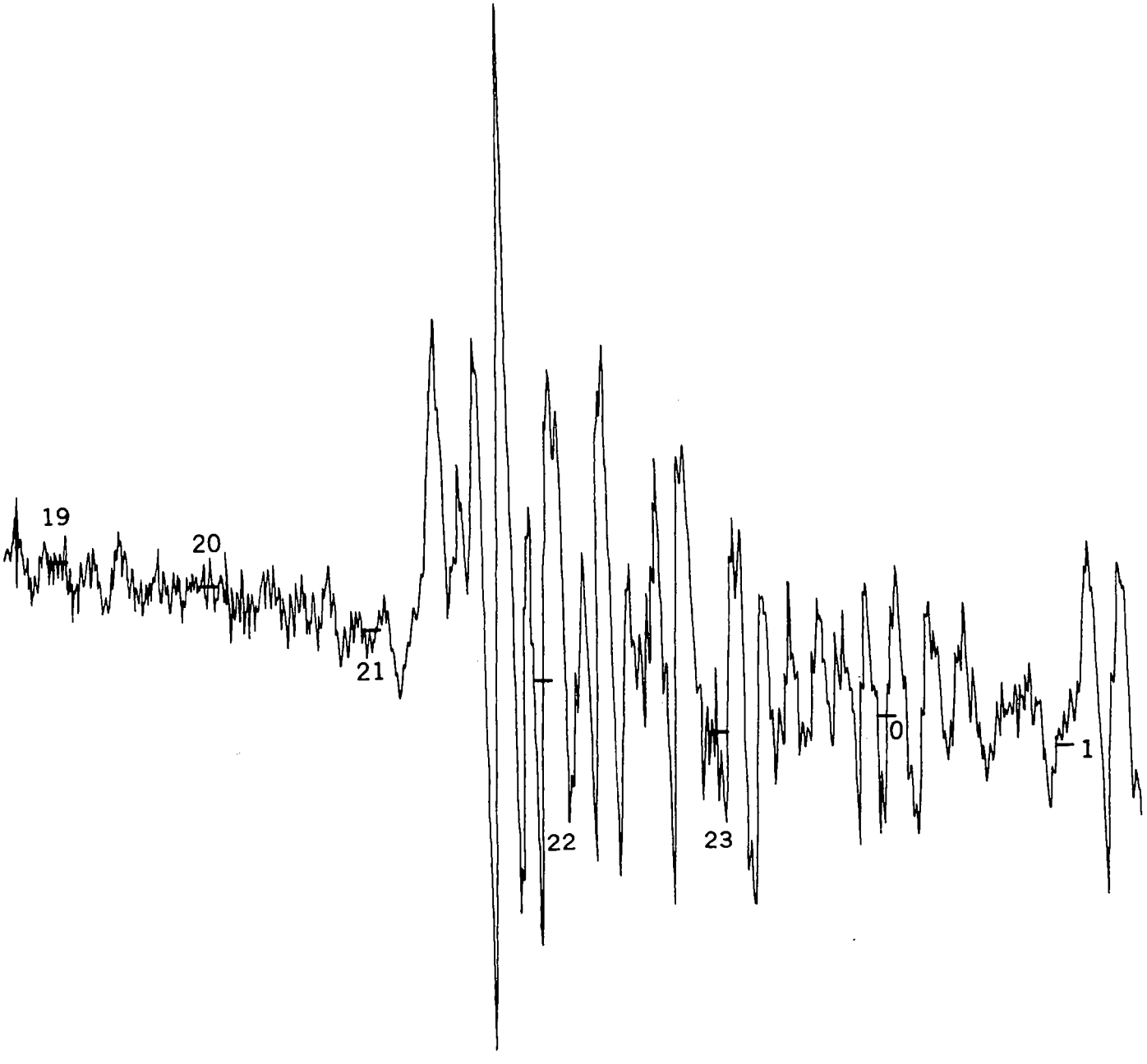


Figure 19. Midway tide record (scale 1:12) showing seismic sea wave from earthquake off Kamchatka at 1658Z 4 November 1952. Midway supplied valuable data on this wave. Crests of waves covered wharf at the gage.

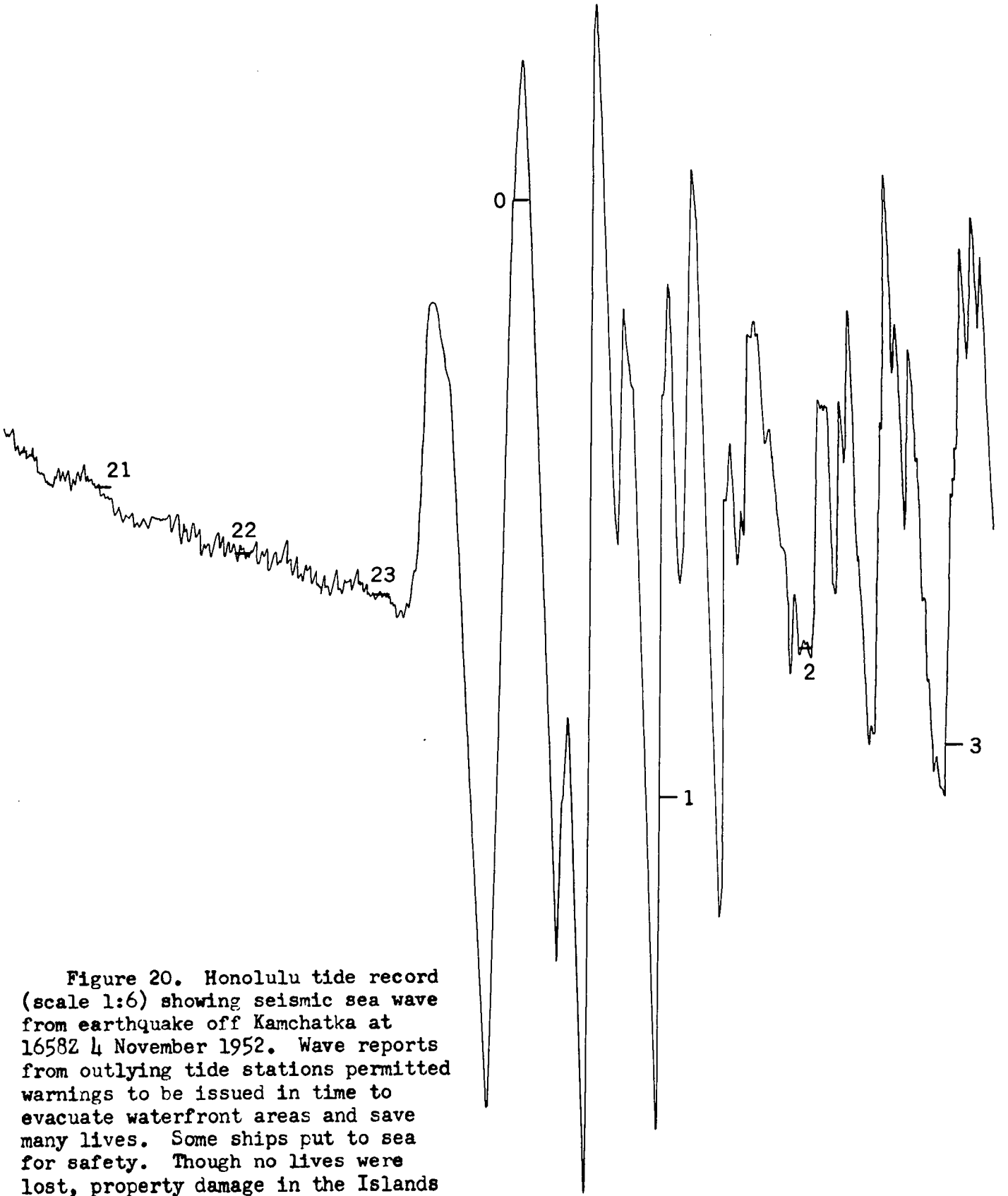


Figure 20. Honolulu tide record (scale 1:6) showing seismic sea wave from earthquake off Kamchatka at 1658Z 4 November 1952. Wave reports from outlying tide stations permitted warnings to be issued in time to evacuate waterfront areas and save many lives. Some ships put to sea for safety. Though no lives were lost, property damage in the Islands amounted to about $800,000.

U. S. GOVERNMENT PRINTING OFFICE : O—1953