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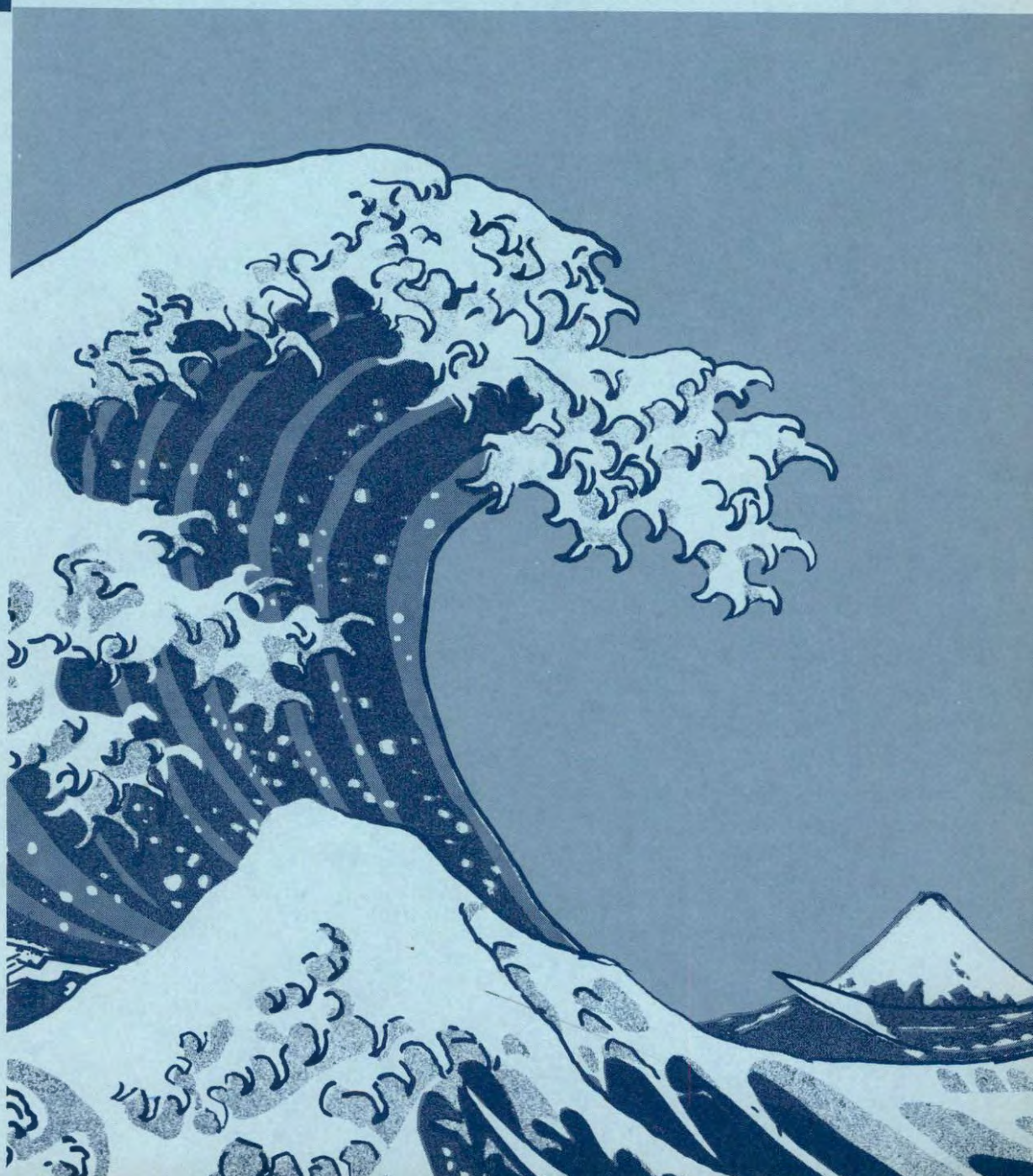
A UNITED STATES DEPARTMENT OF COMMERCE PUBLICATION

PUBLICATION 30-3, REVISED JUNE 1970

Wave Reporting Procedures for Tide Observers in the Tsunami Warning System



U.S. DEPARTMENT OF COMMERCE

Environmental Science Services Administration

Coast and Geodetic Survey

Wave Reporting Procedures for Tide Observers in the Tsunami Warning System

PUBLICATION 30-3
Revised June 1970

U.S. DEPARTMENT OF COMMERCE
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Original edition March 1953
Revised June 1964,
December 1966, and
June 1970

UNITED STATES
GOVERNMENT PRINTING OFFICE
WASHINGTON: 1970

For sale by the Superintendent of Documents, U.S. Government Printing Office
Washington, D.C. 20402 - Price 50 cents

Foreword

The Tsunami Warning System provides tsunami warning information to the civilian population and military personnel of the Pacific region. Although a cooperative effort of international scope, the responsibility for developing, administering, and operating the Warning System is assumed by the Coast and Geodetic Survey, Environmental Science Services Administration, whose Honolulu Observatory serves as the operational headquarters for the network of participating seismic and tide stations in the Pacific. Information from the network of stations is sent to Honolulu Observatory, where it is analyzed and relayed as tsunami watches and warnings to civil defense organizations, weather bureaus, military installations, and other local governmental offices that have been designated to receive the information by the participating countries, territories, and administrative areas throughout the Pacific. Effectiveness of the System results in a large measure from the prompt and accurate reports of the observers who staff the stations of the network.

The purpose of this publication is to provide general information and specific instructions to aid tide observers in reporting tsunamis. Both regular tide observers and alternate or substitute observers at participating tide stations should be familiar with the procedures outlined herein. These instructions supersede *Coast and Geodetic Survey Publication 30–3 (1966)* and all tsunami-reporting instructions issued pursuant thereto.

This publication was prepared by M. G. Spaeth, Office of Seismology and Geomagnetism, Coast and Geodetic Survey.

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Telephone numbers of local communication stations:

_____

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SUMMARY OF EMERGENCY INSTRUCTIONS

DURING TSUNAMI EMERGENCIES, THE TIDE OBSERVER SHOULD:

1. ACKNOWLEDGE RECEIPT OF HONOLULU OBSERVATORY MESSAGE IMMEDIATELY;
2. CHECK GAGE OPERATION;
3. REPORT BEGINNING OF TSUNAMI PROMPTLY;
4. REPORT AMPLITUDE AND DIRECTION OF FIRST RISE OR FALL; and
5. REPORT MAXIMUM WAVE HEIGHTS AT REGULAR INTERVALS.

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SECTION 1

General Information

1.1 Nature and description of tsunamis

Tsunamis (or seismic sea waves) are true gravity waves of extremely long length and period that travel in series across the ocean. At sea the waves are low, but in coastal areas, the wave heights are increased by shoaling of the sea floor, and vast expanses of lowland sometimes are inundated by sudden rises in sea level with the arrival of the larger waves. The waves are set in motion by underwater disturbances, usually associated with earthquakes in the underlying sea floor or along the bordering lands. Near the place of origin, the first wave may be the largest, but at greater distances, the largest wave of the group is generally one of the six following waves. Not all submarine earthquakes produce tsunamis, and not all tsunamis are large enough to cause damage; however, occasional large waves have caused great destruction and loss of life in coastal areas. At present, there is no way to determine if an earthquake has generated sea waves, except to note the occurrence and locate the geographic position of the earthquake and then to detect the arrival of the characteristic waves at a network of tide stations.

1.2 The Tsunami Warning System

The Tsunami Warning System is a cooperative undertaking directed by the Coast and Geodetic Survey of the Environmental Science Services Administration, U. S. Department of Commerce. The System, which was established to detect the giant waves in the Pacific and to warn civilian and military authorities in Hawaii of approaching waves, has been greatly expanded since its inception and now sends warning information to many countries and islands throughout the Pacific region. Seismograph and tide stations participating in the System are shown in figure 1. Objectives of the warning service are accomplished by (1) through a network of seismic stations, detecting and determining the location of earthquakes of tsunami-producing magnitude and (2) verifying the existence of newly generated tsunamis from observations of changing sea levels at tide stations, particularly tide stations located near the epicenter of any reported earthquake.

1.3 Communication Plan

The Coast and Geodetic Survey has made arrangements with the Department of Defense (DOD), the Federal Aviation Administration (FAA), the National Aeronautics and Space Administration (NASA), and other government agencies, both domestic and foreign, to handle the message traffic essential to the success of the Warning System. The arrangements provide for the transmission of the messages on a high priority basis, commensurate with the need for rapid communications and the regulations of the various communication agencies. The *Com-*

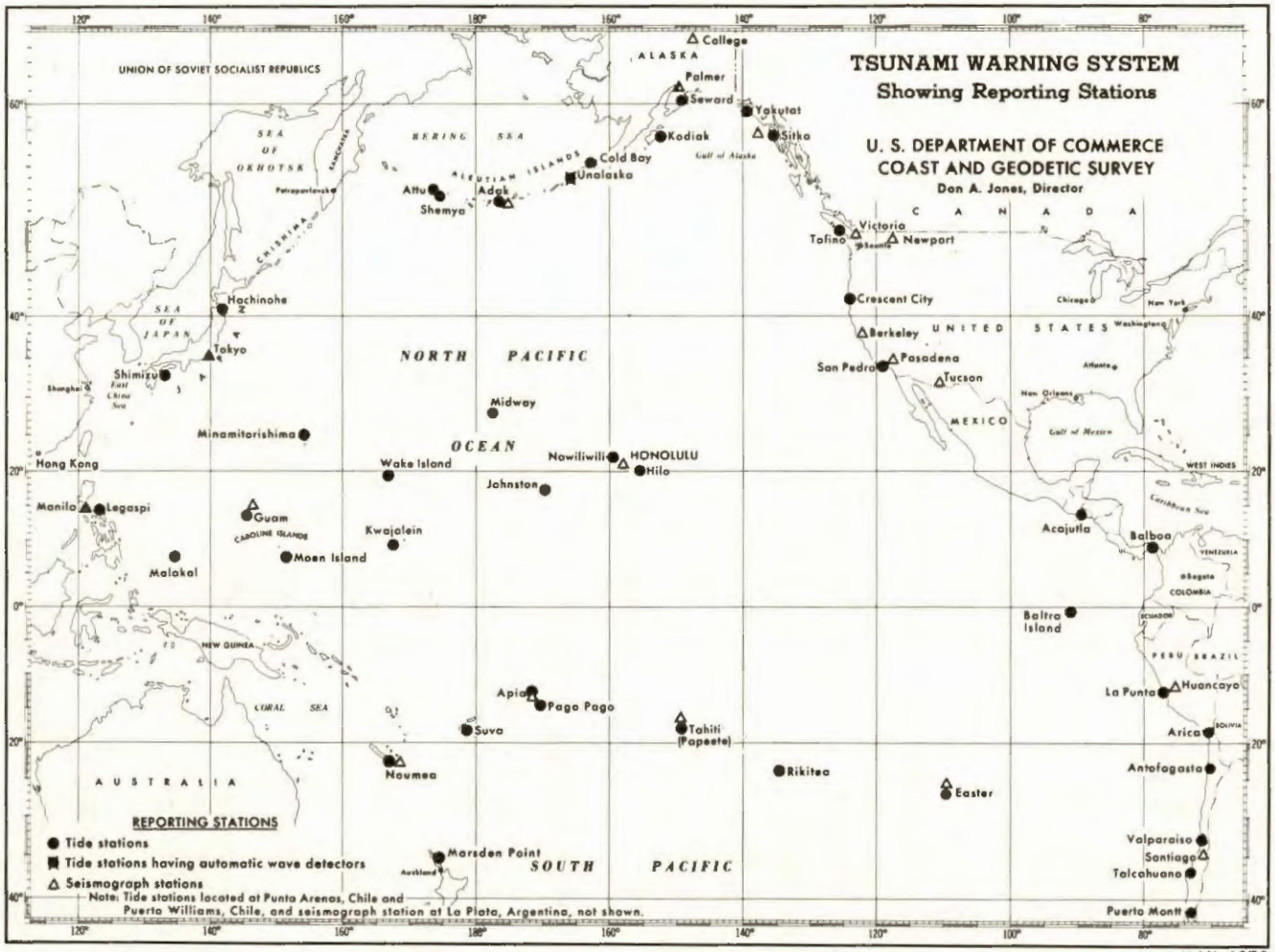


FIGURE 1.—Locations of tide and seismic stations cooperating in the Tsunami Warning System.

munication Plan for Tsunami Warning System outlines communication channels between Honolulu Observatory and each seismic station, tide station, and dissemination agency in the System. Every member of the System and all communication agencies handling Warning System messages should maintain an up-to-date copy of this Communication Plan. Some information in the Plan is repeated in Section 4, Warning System Messages. The information is correct for the date of this publication, but future changes in the Communication Plan may invalidate portions. In such a case, the latest instructions in the Communication Plan must be followed. The Plan also provides information on tsunamis, a history of the Warning System, and a description of the duties and responsibilities of System participants.

SECTION 2

Duties of Tide Observers

2.1 Responsibilities

It is essential that a capable tide observer be available at all hours to report the occurrence of tsunamis. Substitute observers should be designated as necessary, and each should be made thoroughly familiar with the recording instruments and the reporting procedures of the Tsunami Warning System.

2.2 Duties

2.2.1 Keep the tide gage in operation at all times (see Section 3).

2.2.2 Keep the tide transmitters and remote recorders (if available) functioning properly at all times (see Section 3).

2.2.3 Report immediately the occurrence of any tsunami to the Honolulu Observatory, even though the station has not been alerted by the Honolulu Observatory (see Section 6).

2.2.4 Watch the tide record for evidence of tsunamis when requested to do so by the Honolulu Observatory; report back to Honolulu Observatory in accordance with instructions in this publication; follow any special instructions in messages from Honolulu Observatory (see Section 6).

2.2.5 Reply promptly upon receipt of all test messages from the Honolulu Observatory (see Section 5).

2.2.6 At those tide stations where water heights are telemetered from the gage location to a remote recorder at another location, the individual on duty at the remote recorder is responsible for reporting to the Honolulu Observatory during a tsunami dummy or an actual tsunami emergency. During an emergency, the person responsible for checking the tide gage daily should first check the gage and then make himself available to the observer on duty at the remote recorder.

2.2.7 Report any change of the observer's address and telephone or teletype numbers to local communication stations through which messages are sent and received. The same information should be given in letter form to the Director, National Tsunami Warning Center, 91–270 Fort Weaver Road, Ewa Beach, Hawaii 96706.

2.2.8 Whenever the tide gage is out of operation, notify Honolulu Observatory of that fact. Include an estimate of when the gage will return to operation, if possible. Notify Honolulu Observatory when the gage does return to operation.

2.3 Safety measures

Although tide records must be examined for evidence of tsunamis, the observer is not expected to take needless risks to reach the tide gage when dan-

gerous waves are approaching. At such times, visual sightings of tsunamis should be reported to the Honolulu Observatory without visiting the gage. Since requests for wave reports are usually made only when there is a good chance that a tsunami has been generated, persons in charge of tide stations should take every precaution to avoid endangering personnel at the station.

SECTION 3

The Tide Gage

3.1 Types of gages

Two types of tide gages are generally used at tide stations of the Tsunami Warning System—the standard automatic tide gage and the gas-purging pressure tide gage (bubbler gage).

3.2 Standard automatic tide gage

The standard automatic tide gage is used at most stations throughout the Warning System network. This gage is operated by a float that moves up and down with the rise and fall of water level in a stilling well. The movement of the float and attached line turns a worm screw on the gage, and this in turn moves a pencil back and forth across a strip of paper that is moved forward by a motor clock. The stilling well eliminates the effect of horizontal water movement on the float and, by the size of its intake opening, greatly reduces the effect of rapid changes in water level produced by wind waves. With the exception of the short-period wind waves, the tide-gage record reflects all vertical motions of the sea surface, including the rise and fall of the tide, vertical oscillations caused by seiches, and tsunamis generated by earthquake disturbances.

3.3 Gas-purging pressure tide gage

This type of gage, also known as a bubbler gage, is used at some tide stations in the Warning System where installation of a float-operated tide gage is not practical. The strip-chart recorder unit is connected to a submerged orifice (sensor) by small-diameter plastic tubing through which a regulated volume of compressed gas (dry nitrogen) is dispensed. By keeping the tubing and orifice full of gas, changes in water level are sensed by a temperature-compensated bellows, or transducer. The transducer measures the changing pressure of the hydraulic head above the fixed orifice chamber from which gas bubbles escape. A mechanical linkage assembly connects the bellows to a recording pen. The marigram is drawn on a 5-inch strip chart.

3.4 Remote recorders

Remote recorders can be used with the standard automatic tide gage and the gas-purging pressure tide gage. Both systems consist of a transmitter at the site of the tide gage, a receiver (or recorder) at the remote recording site (fig. 2), and a two-conductor (private) line connection or its equivalent between the transmitting and receiving instruments. An alternating-current power source is required at both sites. The systems differ only in the input mechanism used for

each type of gage—a chain and sprocket drive linkage to the drum shaft is used with the float-operated gage, and a pressure-sensing unit, connected by a T-fitting to the orifice line, is used with the gas-operated gage (fig. 3). The transmitter can also be float-operated (fig. 4). Remote recorders are in use at many tide stations in the Warning System network. Their use eliminates the necessity of visiting gage sites to visually inspect the tide record, or marigram. This reduces the hazard to station personnel and the time required to respond to requests for wave reports. Remote recording systems also provide readily available wave information of use in determining the time to safely sound the "all clear" following

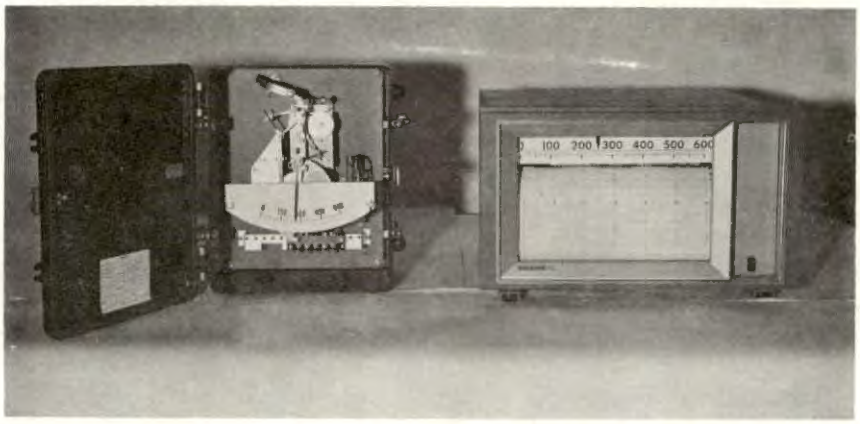


FIGURE 2.—Shaft input transmitter and receiver, or recorder, units of remote recording system.

tsunami warnings or the passage of tsunamis. It also is possible to telemeter wave information—from the gage site—over long distances by using radio (microwave) frequencies, instead of "hard wire."

3.5 Care of gage

Every effort should be made to keep the tide gage performing satisfactorily and to correct operating difficulties promptly. All tide station personnel with responsibility for answering requests for tsunami data should understand the operation of the tide gage sufficiently to make emergency repairs. Instruction in the care and operation of tide gages is given in the *Manual of Tide Observations*, Coast and Geodetic Survey Publication 30–1, 1965, a revision of Special Publication No. 196.

3.6 Accurate time

It is especially important that accurate time be kept at tide stations participating in the Warning System network. Before each daily visit to the tide gage, the observer should check the time of his watch with that of the radio, the local communication station, or any other reliable source, so that the time of the gage clock can be kept as accurate as possible. At stations having a remote recorder, the time should be checked daily and the record adjusted as necessary.

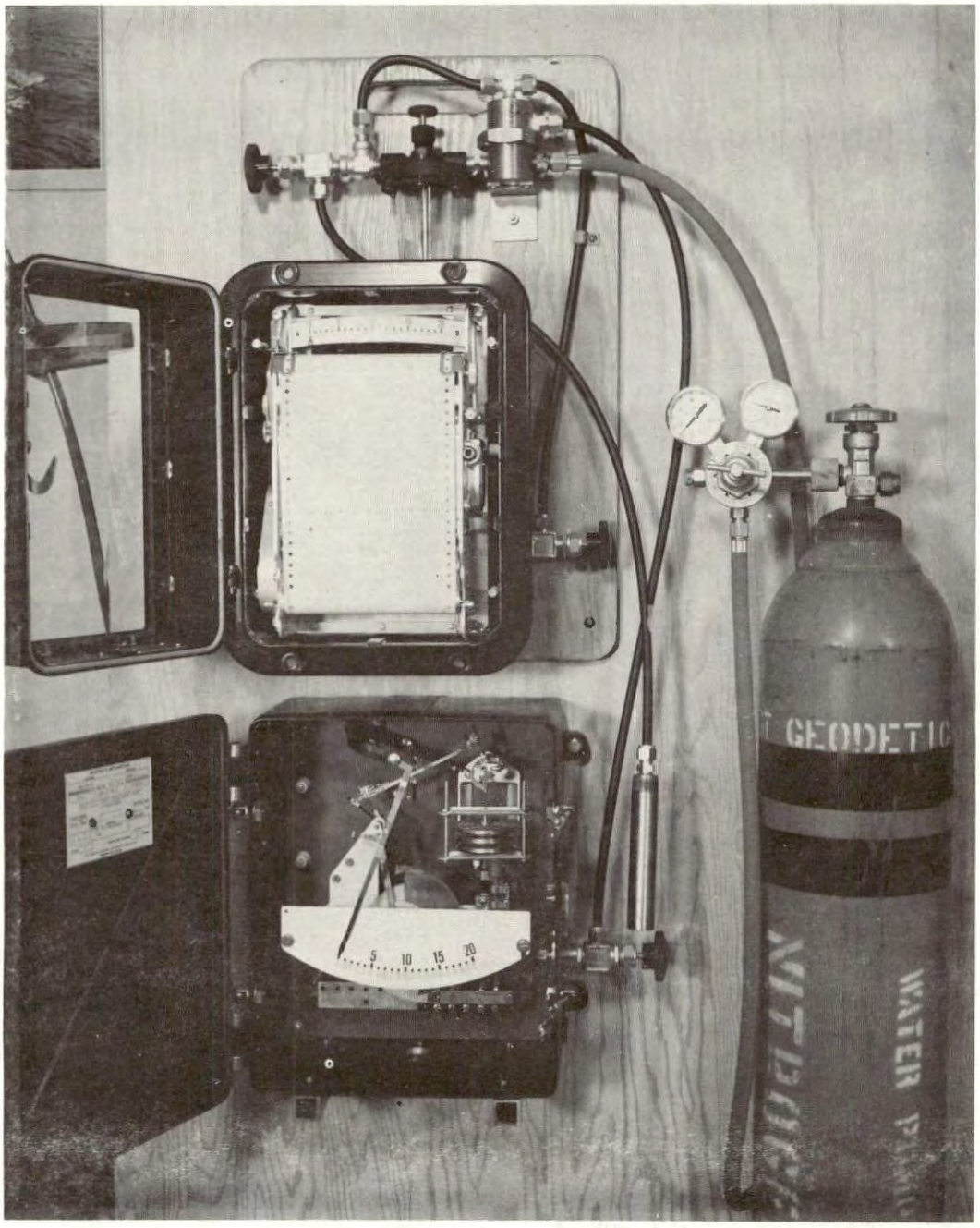


FIGURE 3.—Strip-chart recorder of gas-purging pressure tide gage and pressure-sensing transmitter unit of remote recording system.

3.7 Legibility of record

The graphic record should be kept clear and distinct at all times. This will facilitate interpretation of the record in time of emergency. This also is important in providing good photographs of the record. The observer should visit the gage and make a comparative note once a day. If this is done daily, the procedure can be omitted at the time of a tsunami alert.

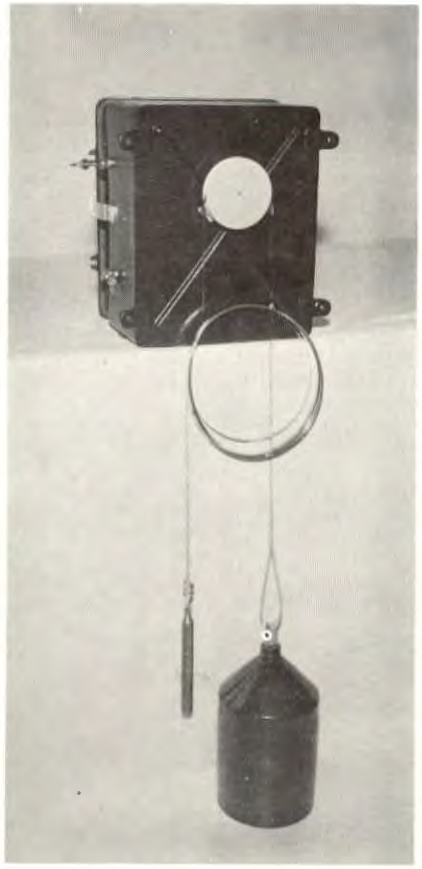


FIGURE 4.—Shaft input transmitter with float, counterweight, and tape.

3.8 Special scale

A special scale, graduated in units corresponding to the height scale of the tide gage, is furnished for measuring times and heights of water-level change (fig. 5). Only the actual motion of the water, the amount of fluctuation in water level, is reported to the Honolulu Observatory. The scale should be kept near the gage so that it is always available. Additional scales can be obtained upon request. *Caution:* Scaled heights should never be substituted for actual tide staff readings (for example, to obtain the height of the tide) in the daily comparative note.

3.9 Wave heights

When scaling wave heights on the standard tide gage record (fig. 6, Section 5), remember that the recording pencil moves toward the clock unit of the gage as the water rises. Wave heights can be read directly in centimeters by using the special scale for the particular gage, or indirectly by using an ordinary ruler. If a ruler is used, the scale of the gage must be considered. For example, a gage scale of 1:6 means that the recording pencil moves 1 centimeter in recording a 6-centimeter change of water level. The following tabulation gives the various gage scales and respective pencil movements compared to water-level change.

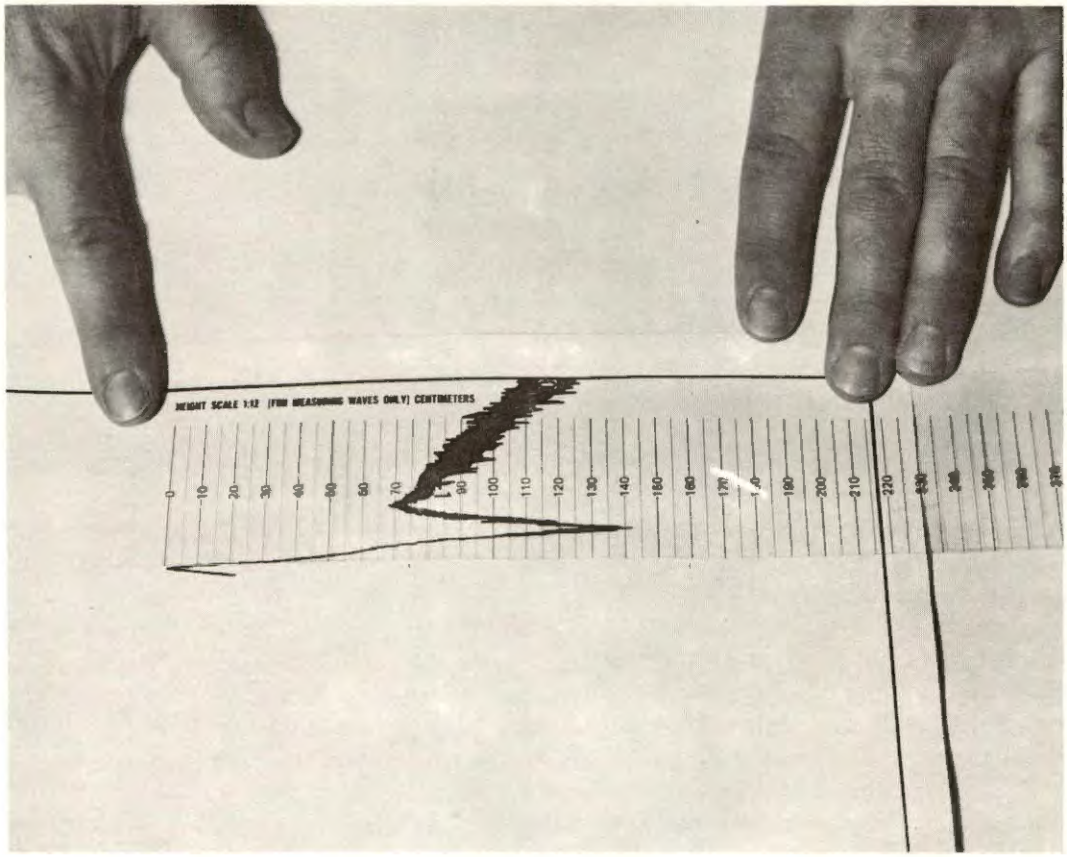


FIGURE 5.—Special scale for measuring time and amount of water-level change.

Scale		*Pencil Movement*		*Water-Level Change*
1:6	*or*	1 centimeter	=	6 centimeters
1:9	*or*	1 centimeter	=	9 centimeters
1:12	*or*	1 centimeter	=	12 centimeters
1:16	*or*	1 centimeter	=	16 centimeters
1:24	*or*	1 centimeter	=	24 centimeters
1:32	*or*	1 centimeter	=	32 centimeters

On the gas-purging pressure tide gage (bubbler gage) the scale is printed on the record paper. Scales of 10, 20, 30, 40, and 50 feet and 300 centimeters per width of record paper are used. Special scales are provided for measuring the heights of water-level changes in centimeters. On the charts on which the lines correspond to feet and portions of feet, care must be taken to report heights measured with the special scale.

On the remote recorders, the scale is printed on the record paper (fig. 7, Section 5). Scales of 300, 600, and 900 centimeters per width of record paper are used. Heavy and light lines on the record paper make it possible to scale the tide wave in meters and centimeters as follows:

12-inch Recorder

	Centimeters		
Scale indicated on record paper	300	600	900
Scale units between heavy lines	10	25	25
Scale units between light lines	2	5	5

4-inch Recorder

	Centimeters	
Scale indicated on record paper	300	600
Scale units between heavy lines	25	50
Scale units between light lines	5	10

3.10 Wave times

The recording pencil of the standard automatic tide gage makes a short horizontal mark each hour, on the hour, on the tide record. The time of any point on the tide curve is obtained by measuring the distance between the point and the beginning of the horizontal hour mark. The special scale can be used to measure this distance in minutes. A ruler also can be used. Since the paper is moved forward by the clock motor at a rate of 1 inch per hour, ½ inch on the record is 30 minutes; ¼ inch is 15 minutes; ⅛ inch is 7½ minutes; and $1/10$ inch is 6 minutes. When estimating time, the edge of the special scale or ruler should be placed near the hour mark and parallel to the edge of the paper. Local standard time is used at most tide stations. This time should be converted to Greenwich mean time in reporting to the Honolulu Observatory (see Section 4.5, Greenwich mean time). On the bubbler gage record, vertical lines spaced ½ inch apart indicate half-hour intervals. Time lines on the Bristol 670 remote recorder are spaced 15 minutes apart. Time lines on other Bristol recorders are spaced at 30-minute intervals. For convenience in reporting, Greenwich mean time is printed on the Bristol recorder paper.

3.11 The tsunami detector

Tsunami detectors, installed at some tide stations to set off an alarm automatically when a tsunami passes, are gradually being phased out of the Warning System. The detector operates by mechanically filtering out water-level changes induced by the tides and wind waves, and closing an alarm circuit when a disturbance having a period in the range characteristic of tsunamis is registered. The position of the pencil recorder connected with the detector alarm circuit does not necessarily correspond with the position of the tide recording pencil. Therefore, each time the observer visits the gage, he should make simultaneous marks on the record with both pencils and label them with the correct time and the gage time. The detector should be tested weekly and the results reported to the Coast and Geodetic Survey on Form 802A, *Seismic Sea Wave Detector Report* (Report of Weekly Test).

SECTION 4

Warning System Messages

4.1 The Communication Plan

Instructions for all those handling Warning System messages are given in the *Communication Plan for Tsunami Warning System.* The instructions repeated in this section are in compliance with the Communication Plan, as revised to September 1970, but in the event of future conflict due to revision of the Communication Plan, the instructions in the Plan are to be followed.

4.2 Parts of the message

Each message contains the following parts:

(1) Precedence designation or priority indicator;
(2) date-time group;
(3) station designators of originator and addressee;
(4) security classification;
(5) the identifying words TSUNAMI or TSUNAMI DUMMY; and
(6) text of the message.

4.3 Precedence or priority

A precedence designation as used by the Department of Defense (DOD) or the National Aeronautics and Space Administration (NASA) is essentially equivalent to a priority indicator as used by the Federal Aviation Administration (FAA). Both indicate the relative order in which a message is to be handled or processed with respect to other messages. Precedence designations and priority indicators are assigned to the message by the originator. They indicate: To the originator—the required or desired speed of delivering the message; to communication personnel—the relative order of processing, transmitting, and delivering the message; and, to the addressee—the relative order of importance or significance assigned to the message. Messages of the Tsunami Warning System will not usually be assigned a DOD precedence higher than *Immediate,* a NASA precedence higher than *Urgent,* or an FAA priority higher than *SS.*

4.3.1 Precedence of live messages. Live messages contain factual information about the occurrence of natural phenomena that have caused, or that might cause, a disaster. Messages in this group include requests to tide stations for information, replies by tide stations providing requested information, and tide reports. Live messages normally are assigned *Immediate* precedence when transmitted by DOD communication channels, *Urgent* precedence when transmitted by NASA channels, and *SS* priority when transmitted by FAA channels.

4.3.2 Precedence of test messages. Test or dummy messages contain the

words TSUNAMI DUMMY (see Section 5, Communication Tests). Precedence assigned to test messages is as follows: *Immediate* when transmitted over DOD channels; *Urgent* when transmitted over NASA channels; and *SS* priority when transmitted over FAA channels.

4.3.3. Precedence of routine messages. Message requests for instrument data, reports of instrument failure or malfunction, and general information and instructions normally are assigned *Routine* precedence when transmitted by DOD and NASA channels and *FF* priority when transmitted by FAA channels.

4.4 Date-time group

When the message is complete, the day of the month and the hour and minute of the day are entered, in Greenwich mean time, after the precedence designation. In this six-digit group, the first two figures indicate the day (01–31), the third and fourth figures indicate the hour (00–23), and the fifth and sixth figures indicate the minute (00–59). The letter identifying the time zone follows. Thus, 2:42 p.m. on March 5, Greenwich mean time, reads 051442Z. The date-time group identifies the message and establishes the time of its origin.

4.5 Greenwich mean time

Greenwich mean time, identified by the letter Z in the date-time group of the messages, is used for all messages to and from the tide stations. To convert standard time at Pacific tide stations to Greenwich time, use the accompanying conversion table. Enter the table on the line designating the standard time zone for the station. Standard time zones are designated by their central meridian in column 1 and by letter designator in column 2. To the station's standard time, add or subtract (as indicated) the number of hours in column 3 of the table. This is the Greenwich time. Be careful to change the date when the difference changes the Greenwich time to the following or preceding day. To change the Greenwich time

Conversion Table for Greenwich Mean Time

Standard time zone of tide station		Greenwich mean time (Z)	
Central meridian	Letter designator	To convert local time to Z	To convert Z to local time
		(*hours*)	(*hours*)
60°W.	Q	+ 4	− 4
75°W.	R	+ 5	− 5
90°W.	S	+ 6	− 6
105°W.	T	+ 7	− 7
120°W.	U	+ 8	− 8
135°W.	V	+ 9	− 9
150°W.	W	+10	−10
165°W.	X	+11	−11
180° W.[1]	Y	+12	−12
180° E.[2]	M	−12	+12
165° E.	L	−11	+11
150° E.	K	−10	+10
135° E.	I	− 9	+ 9
120° E.	H	− 8	+ 8

[1] 180° to 172°30′ W.
[2] 180° to 172°30′ E.

of a message to the standard time of the tide station, enter the table on the line designating the standard time zone of the station and add or subtract (as indicated) the number of hours in column 4 of the table. *Special Note:* The 12th zone of the standard time system is divided by the 180th meridian. The half in west longitude (180° to 172°30′ W.) is designated zone Y and is numbered plus 12; the half in east longitude (180° to 172°30′ E.) is designated zone M and is numbered minus 12.

4.6 Station designator

Each participant in the Warning System network—seismic station, tide station, and dissemination agency—is assigned a station designator that is listed in the Communication Plan. These designators shall be used in all messages in accordance with instructions contained in the Communication Plan.

4.7 Security classification

All Tsunami Warning System messages are transmitted as unclassified material. This is indicated by the designation UNCLAS at the beginning of the text when messages are sent by DOD and NASA channels. The security classification is not required for messages sent by FAA channels.

4.8 Message identification

The first word of the text identifies the message as a live message or test message. Live messages begin with the word TSUNAMI. Test messages begin with the words TSUNAMI DUMMY.

4.9 Sample messages

Examples follow showing the form and order of items for messages as they should be given to the communication station by the tide observer.

4.9.1 Message prepared for DOD communication channels.

Example:

IMMEDIATE 150935Z
FROM ATTU TIDE OBSERVER
TO HONOLULU OBSERVATORY
UNCLAS
TSUNAMI. WAVE BEGAN 0920Z. TIDE RECORD SHOWS WATER ROSE 0060 CM IN 7 MINUTES AND FELL 0108 CM IN 5 MINUTES. STILL FALLING 0932Z. WILL REPORT FURTHER.

4.9.2 Message prepared for NASA communication channels.

Example:

URGENT 030804Z
FROM VALPARAISO TIDE OBSERVER
TO HONOLULU OBSERVATORY
UNCLAS
TSUNAMI. NO UNUSUAL ACTIVITY BETWEEN 0600Z AND 0800Z.

4.9.3 Message prepared for FAA communication channels.

Example:

SS 172104Z
FROM CRESCENT CITY TIDE OBSERVER
TO HONOLULU OBSERVATORY
TSUNAMI. WAVE BEGAN 2050Z. TIDE RECORD SHOWS WATER ROSE 1202 CM IN 9 MINUTES. NOW FALLING. WILL REPORT FURTHER.

SECTION 5

Communication Tests

5.1 Test messages

It is important that the Warning System function efficiently in time of emergency. Therefore, test messages are sent to observers each month at unannounced times to determine the transmission times of messages, to keep communication personnel familiar with procedures for handling Warning System messages, and to help maintain contact between tide observers and personnel at local communication stations. Test messages are identified by the words TSUNAMI DUMMY at the beginning of the text and are assigned precedence, or priority, as follows: *Immediate* precedence when transmitted by DOD channels; *Urgent* precedence when transmitted by NASA channels; and *SS* priority when transmitted by FAA channels. The observer should follow any special instructions in the test message.

5.2 Test message from Honolulu Observatory

IMMEDIATE 051600Z
FROM HONOLULU OBSERVATORY
TO ADAK TIDE OBSERVER
UNCLAS
TSUNAMI DUMMY. REPORT TIME OF RECEIPT OF THIS MESSAGE. MARK TIDE RECORD AND REPORT HEIGHT AND TIME OF MARK.

5.3 Test procedure at tide station

During test messages, observers at tide stations follow the procedures outlined below.

5.3.1 Standard gage. Rotate the float drum to make a vertical line on the tide record, as is done during the normal daily inspection of the gage. Use the plastic tsunami wave scale to measure the height of the vertical line. Label the line on the tide record to indicate: Tsunami dummy test, correct Greenwich time, and scaled height of the line as shown in figure 6.

5.3.2 Gas-purging pressure tide gage. On the strip-chart recorder of the gas-purging pressure tide gage (bubbler gage), move the recording pen to the right a small amount. Label the line made by this movement as in 5.3.1 above—Tsunami dummy test, Greenwich time, and height of water-level rise represented by the line. *Caution:* Do not move pen to the left, as this can damage the recording mechanism.

5.3.3 Remote recorder. Draw an arrow to the tide curve to indicate position of recording pen at time message is received (fig. 7). Label the arrow tsunami

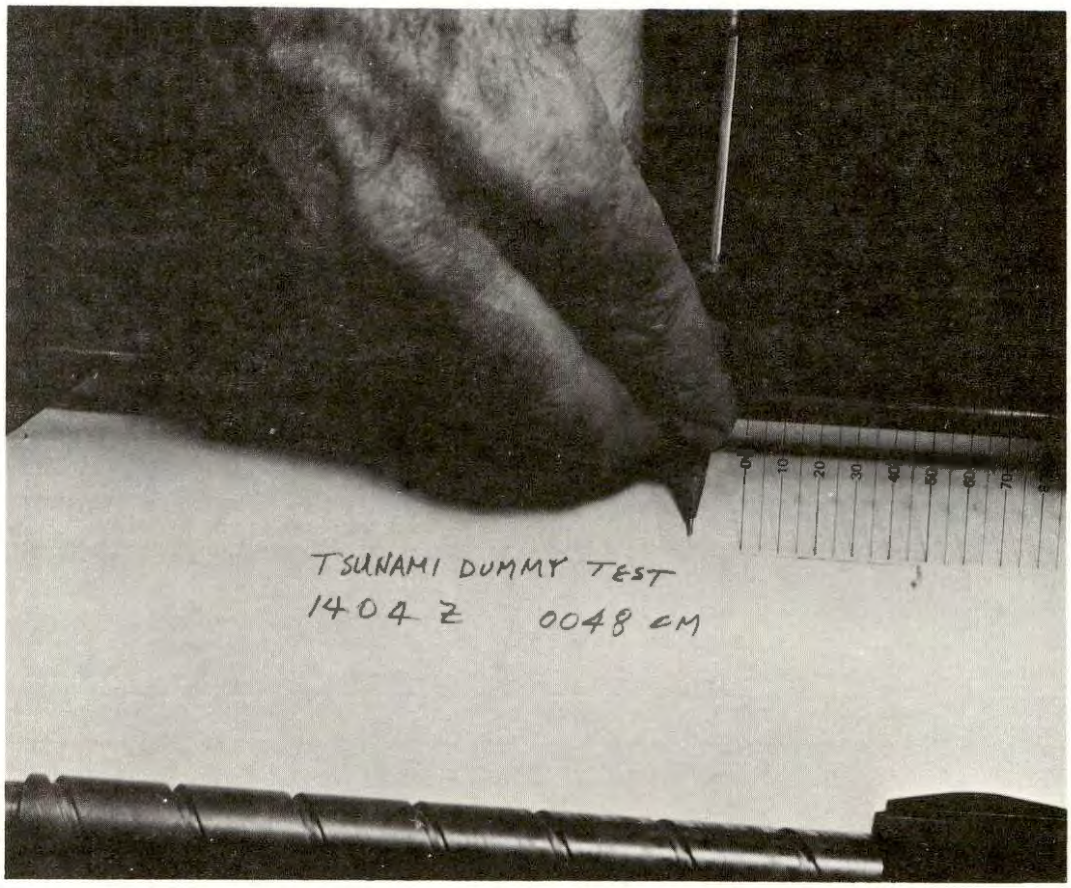


FIGURE 6.—Tsunami dummy test note on standard gage tide record.

dummy test, give Greenwich time, and indicate height of tide record at marked point. DO NOT MOVE THE PEN.

5.4 Reply by tide observer

The tide observer should reply to test messages as soon as he can provide the requested information. An example of the reply to the test message from Honolulu Observatory in paragraph 5.2 follows:

IMMEDIATE 051618Z
FROM ADAK TIDE OBSERVER
TO HONOLULU OBSERVATORY
UNCLAS
TSUNAMI DUMMY. YOUR 051600Z RECEIVED 051612Z. MARK HEIGHT 0075 CM AT 051615Z.

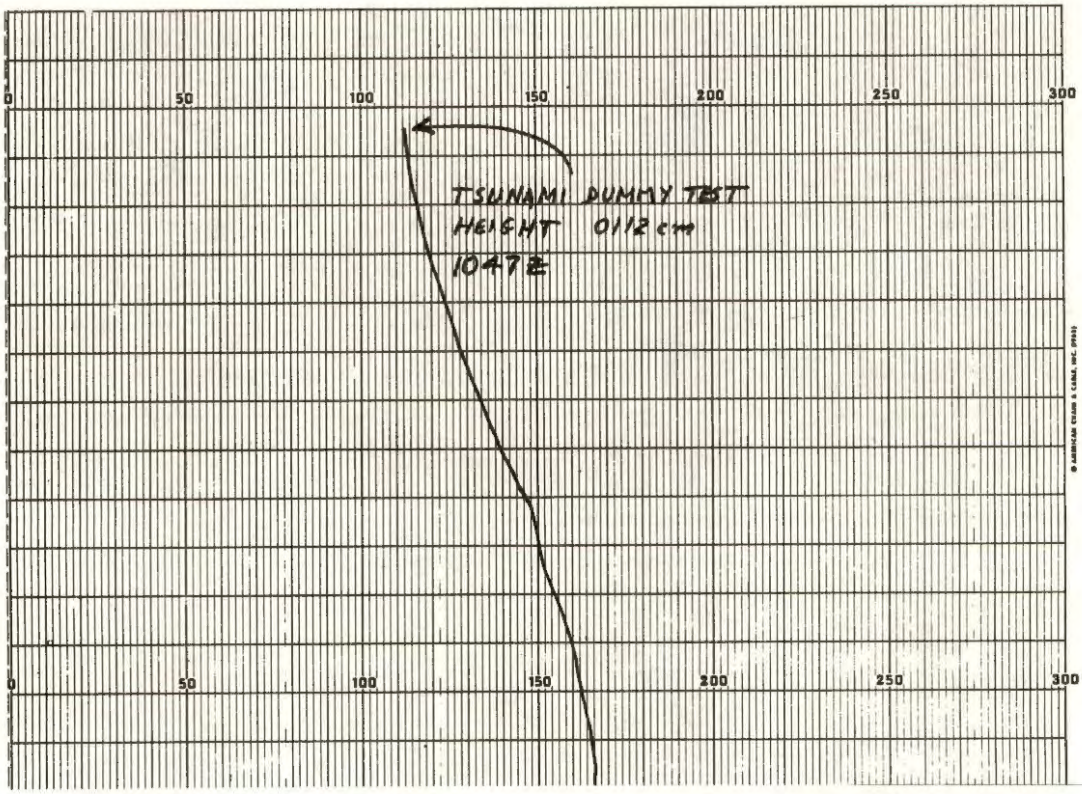


FIGURE 7.—Tsunami dummy test note on remote recorder tide record.

SECTION 6

Reporting Waves to Honolulu Observatory

6.1 Reporting when not alerted

Whenever an observer believes a tsunami exists at his station or in his area of responsibility, he should send a message to the Honolulu Observatory. Evidence of a tsunami may be based on visual observations, apparently reliable reports, or alarm signals of the tsunami detector.

6.1.1 Procedure when not alerted. The message to Honolulu Observatory should tell as much as is known about the wave—its time of arrival and its size; the source or basis of the information. When possible, confirm reports and alarm signals before sending the message. This procedure, however, should not unduly delay sending of the message. Alarms that are obviously false should not be reported. If the tide gage cannot be visited prior to sending the message, send the message and then go immediately to the gage to verify existence of the tsunami and to obtain information about it. Send this information to Honolulu Observatory as soon as possible. Continue to watch the tide record and send any additional information to the Honolulu Observatory.

6.1.2 Precedence of message when not alerted. The precedence for live messages (see paragraph 4.3.1) is assigned to all reported occurrences of tsunamis. After alerting the Honolulu Observatory, all subsequent messages pertaining to the alert, including any notification of a false alarm, are assigned the same high precedence.

6.2 Reporting when alerted

The Honolulu Observatory, after determining the location of a large earthquake in the Pacific, alerts those tide stations which are likely to experience tsunamis. Personnel at the Observatory, by means of traveltime charts constructed for each tide station, can determine approximately when the waves of any generated tsunami will reach a given tide station. In predicting the arrival time of tsunamis, allowance is made for uncertainties about the rate of wave travel across inadequately surveyed areas of the ocean, and for uncertainties about the precise location of the earthquake. Consequently, messages to tide stations usually instruct tide observers to examine the tide record for any unusual disturbance during a period of 1 to 2 hours.

6.2.1 Procedure when alerted. When the observer is requested to watch the tide record for unusual disturbances during an alert period, he should proceed as follows. First, acknowledge the alert promptly. An example of the acknowledgment message text follows:

TSUNAMI. YOUR 280850Z RECEIVED 280900Z. WILL COMPLY.

Next, examine the tide record and instrumentation. Continue to watch the record as requested. Examine the past tide record to determine the existence and character of any tsunamis. It is important to transmit preliminary data to Honolulu Observatory promptly. Provide additional detail in later messages.

6.2.2. Precedence for messages when alerted. All messages pertaining to a tsunami alert are assigned live message precedence, or priority, as specified in paragraph 4.3.1.

6.3 Reporting an unusual disturbance

If an unusual disturbance begins while the observer is checking the record, he should report the time at which the disturbance begins and the change (rise or fall) in water level up to the time the observer makes his report. For example (fig. 10), if an observer arrived at his gage at 0915Z and was watching as a tsunami began at 0918Z, he would send a message such as the following at 0925Z:

> TSUNAMI. WAVE BEGAN AT 0918Z AND ROSE 0015 CM IN 7 MINUTES. STILL RISING AT 0925Z.

The amplitude of the first rise or fall and its beginning and ending times should be included in the first message sent after it is completed.

If the record shows that a tsunami has already begun when the observer reaches his gage, the observer should immediately report to Honolulu Observatory the beginning and the ending times, the amplitude of the first rise or fall if it has been completed, and the maximum wave height, trough to peak or peak to trough, that has been recorded by the time the gage is checked. For example (fig. 11), if the observer arrived at his gage at 0958Z and found that a tsunami had begun recording at 0918Z, he would immediately send a message such as the following:

> TSUNAMI. WAVE BEGAN AT 0918Z. ROSE 0074 CM BY 0935Z. MAXIMUM WAVE HEIGHT OBSERVED BY 0958Z IS 0142 CM.

If the observer is not sure that the disturbance he sees on his record is a tsunami, he should report immediately, giving a description of the observed phenomenon. For example (fig. 9, Station F), suppose that a tide observer was requested to observe his gage for a tsunami whose estimated arrival time was 1520Z. If his station was experiencing severe weather conditions, he might send the following message:

> TSUNAMI. TSUNAMI DISTURBANCE VERY INDISTINCT DUE TO HEAVY SURF AND SEICHE ACTION. 0025 CM SEICHE ACTIVE FOR PAST 4 HOURS. POSSIBLE SLIGHT DISTURBANCE DUE TO TSUNAMI ABOUT 1535Z.

Once the initial report of an unusual disturbance has been submitted, additional messages should be filed at regular intervals for at least the first 2 hours of the tsunami. The intervals usually should not exceed 30 minutes; however, reports may be delayed for a few minutes if necessary to record complete waves. Data to be given in these messages include the maximum height, measured from trough to crest or crest to trough, recorded since the previous message and the beginning and ending times of the reporting interval. For example (fig. 12), the observer who sent the first message above might submit the following message at 0958Z.

> TSUNAMI. REPORTING PERIOD 0918Z TO 0958Z. WAVE BEGAN AT 0198Z. ROSE 0074 CM BY 0935Z. MAXIMUM WAVE HEIGHT OBSERVED IS 0142 CM. MINOR FLOODING IS OCCURRING.

All measurements should be made with the special scales provided, and all wave heights should be reported in *centimeters* to Honolulu Observatory. To reduce transmission errors, all heights should be reported in four figures. For example, a height of 5 centimeters would be reported as 0005 cm; one of 46 centimeters would be reported at 0046 cm; one of 293 centimeters would be reported as 0293 cm; etc.

If damaging waves are still occurring after 2 hours, or if the wave size is still increasing, the tide observer must continue reporting to Honolulu Observatory at regular intervals, until such time as the damaging waves cease or the size begins decreasing. When the observer sends his last message, he should tell Honolulu Observatory that he will not report again.

If the size of the waves begins to increase significantly after the observer has stopped reporting, he should resume reporting, giving the maximum wave height recorded since his previous message. The observer should continue reporting at regular intervals until the height of waves again decreases.

6.4 Reporting when disturbance does not occur

If an unusual disturbance does not occur during an alert period as specified in the Honolulu Observatory message, the observer should so inform Honolulu Observatory at the end of the period. Example:

TSUNAMI. NO UNUSUAL DISTURBANCE 1500Z TO 1700Z.

SECTION 7

Illustrative Examples

To aid observers in interpreting tide records and to provide guidelines in preparing messages, samples of tide records and of messages relating thereto are presented in this section. The tide records are selected from Coast and Geodetic Survey files to illustrate various wave conditions, without regard to date and source. The sample messages simulate those which might be sent during the sequence of events depicted by the tide records.

Figures 8 and 9 show normal tide records with varying wave action produced by winds. Figure 9 also shows seiche oscillations. Figures 10 through 17 show simulated messages relating to the observed conditions that might have been sent to Honolulu Observatory by a tide observer during the course of a tsunami. Only the texts of the messages are given in the examples. For samples of complete messages, including precedence or priority indicator, date-time group, station designators, security classification, and type-of-message identification, see paragraph 4.9. In figures 18 through 24, additional samples of tsunamis are shown without messages.

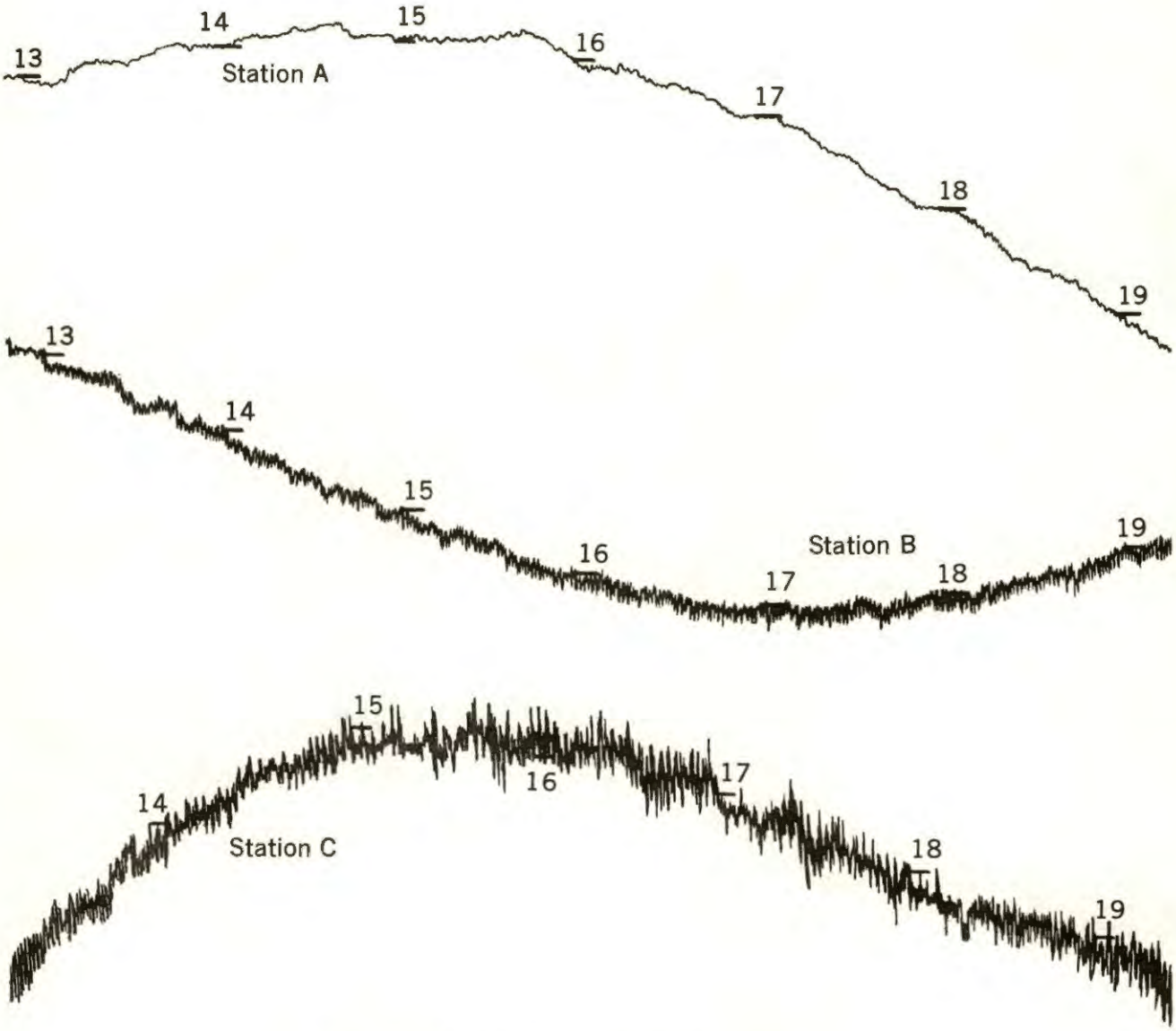


FIGURE 8.—Normal tide records showing wind waves.

Tide records for the three stations show varying amounts of pencil motion caused by differences in gage exposures and in size of intake openings in stilling wells.

Stations A, B, and C might have received the following message from Honolulu Observatory:

> TSUNAMI. EARTHQUAKE OCCURRED . . . .Z. LAT . . . . LONG. . . . . OBSERVE TIDE RECORD 1600Z TO 1800Z. REPORT ANY UNUSUAL ACTIVITY IMMEDIATELY OR REPLY NEGATIVE AT 1800Z. ACKNOWLEDGE RECEIPT OF THIS MESSAGE IMMEDIATELY.

Each station, after acknowledging the message immediately, might reply as follows at 1800Z:

> TSUNAMI. NO UNUSUAL ACTIVITY BETWEEN 1600Z AND 1800Z.

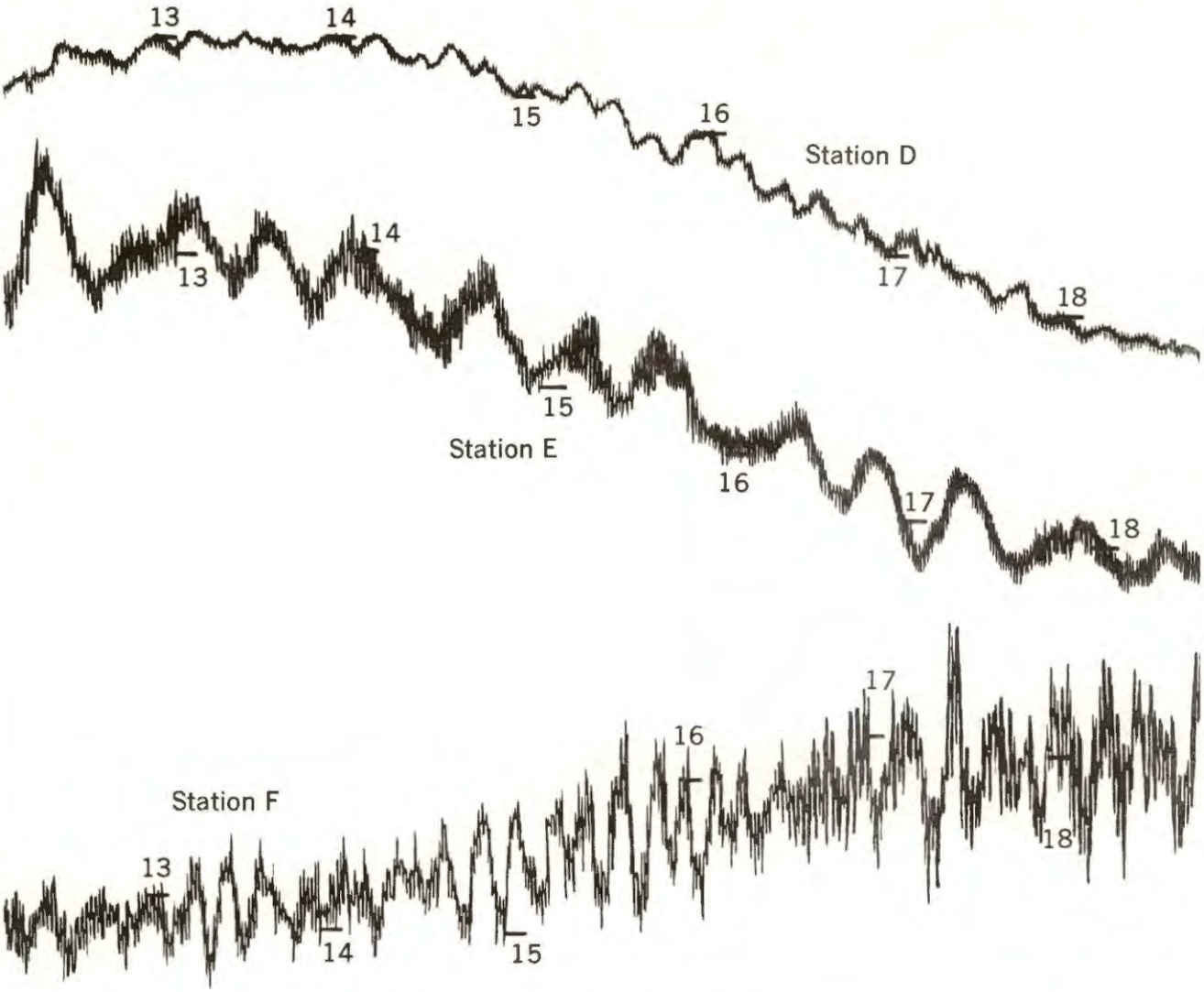


FIGURE 9.—Tide records showing wind waves and seiche oscillations.

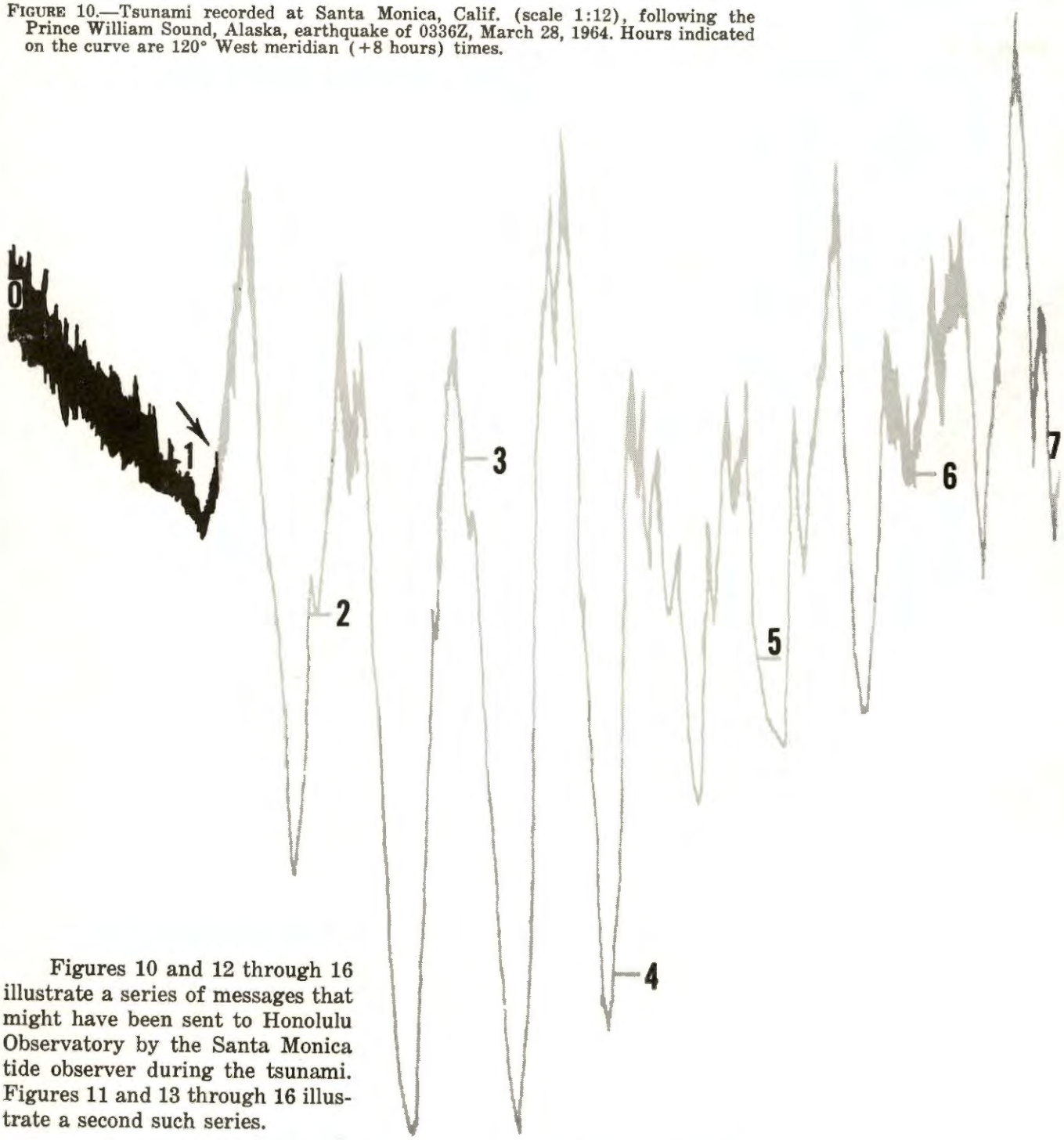
It is difficult sometimes to distinguish seiche (pronounced saysh) oscillations from small tsunamis. Both types of waves can have the same period—the time between successive crests at a given point. At Stations D and F, the seiche oscillations have a period of about 12 to 15 minutes; at Station E, the period is about 30 minutes. Seiche action usually is caused by meteorological conditions and is intensified by the resonance characteristics of the harbor.

An identifying feature of seiches is their gradual growth in size over a period of hours, whereas the onset of a tsunami is identified by a sudden change in wave pattern on the tide record. In figures 20 and 24, seiche oscillations precede the tsunamis.

Any query relative to unusual activity on the tide records for Stations D, E, and F, between 1600Z and 1800Z, might have been answered as follows:

TSUNAMI. NO UNUSUAL ACTIVITY BETWEEN 1600Z AND 1800Z. SEICHE OF . . .
CM HAS BEEN ACTIVE FOR . . . HOURS OR MORE.

FIGURE 10.—Tsunami recorded at Santa Monica, Calif. (scale 1:12), following the Prince William Sound, Alaska, earthquake of 0336Z, March 28, 1964. Hours indicated on the curve are 120° West meridian (+8 hours) times.



Figures 10 and 12 through 16 illustrate a series of messages that might have been sent to Honolulu Observatory by the Santa Monica tide observer during the tsunami. Figures 11 and 13 through 16 illustrate a second such series.

After watching the start of the tsunami at 0118 local time (0918Z), the observer would send a message such as the following at 0925Z:

TSUNAMI. WAVE BEGAN AT 0918Z AND ROSE 0015 CM IN 7 MINUTES. STILL RISING AT 0925Z.

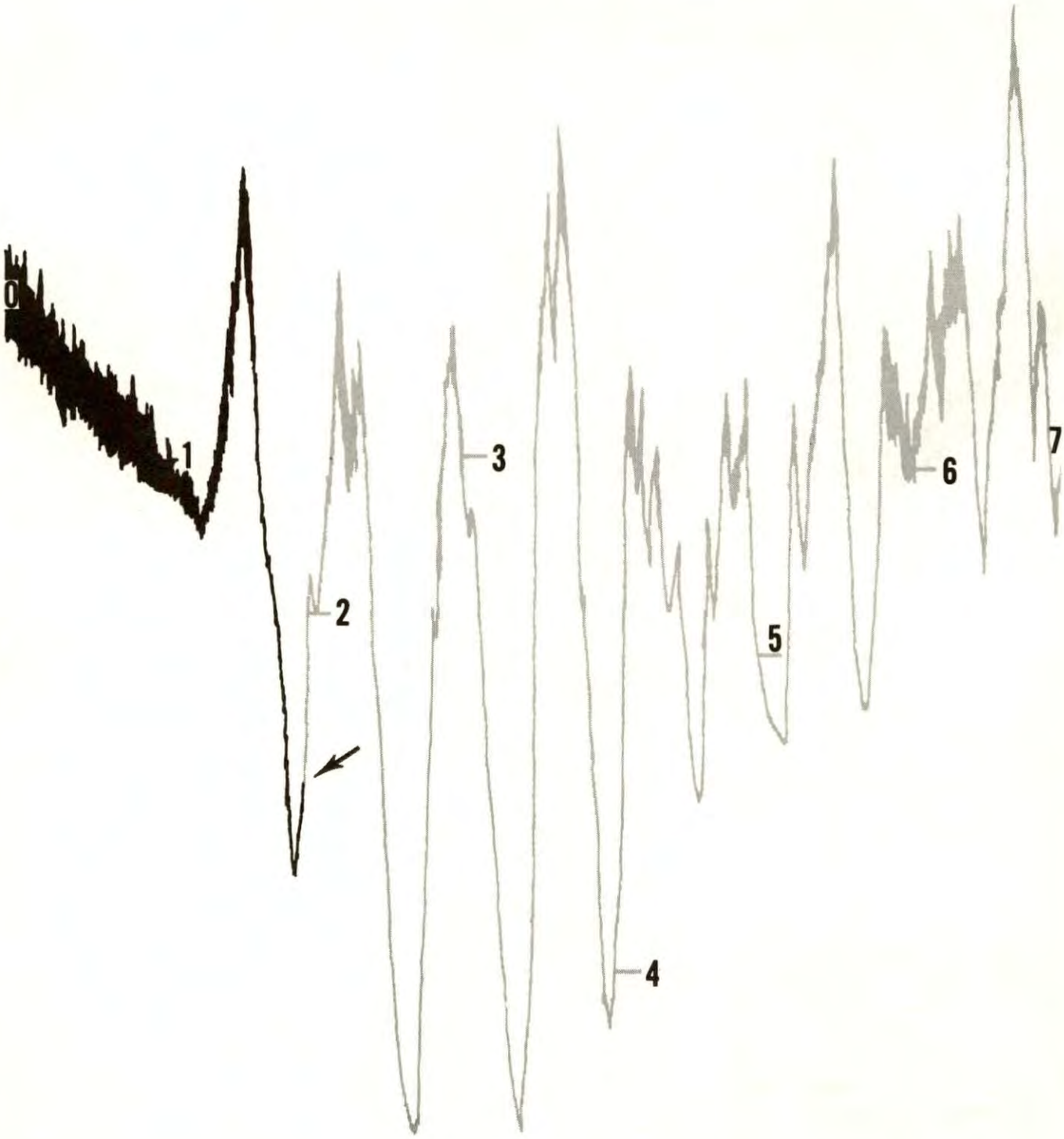


FIGURE 11.—If the Santa Monica observer arrived at his gage at 0158 local time (0958Z) and found the tsunami recording shown above, he would send a message similar to the following to Honolulu:

TSUNAMI. WAVE BEGAN AT 0918Z. ROSE 0074 CM BY 0935Z. MAXIMUM WAVE HEIGHT OBSERVED BY 0958Z IS 0142 CM.

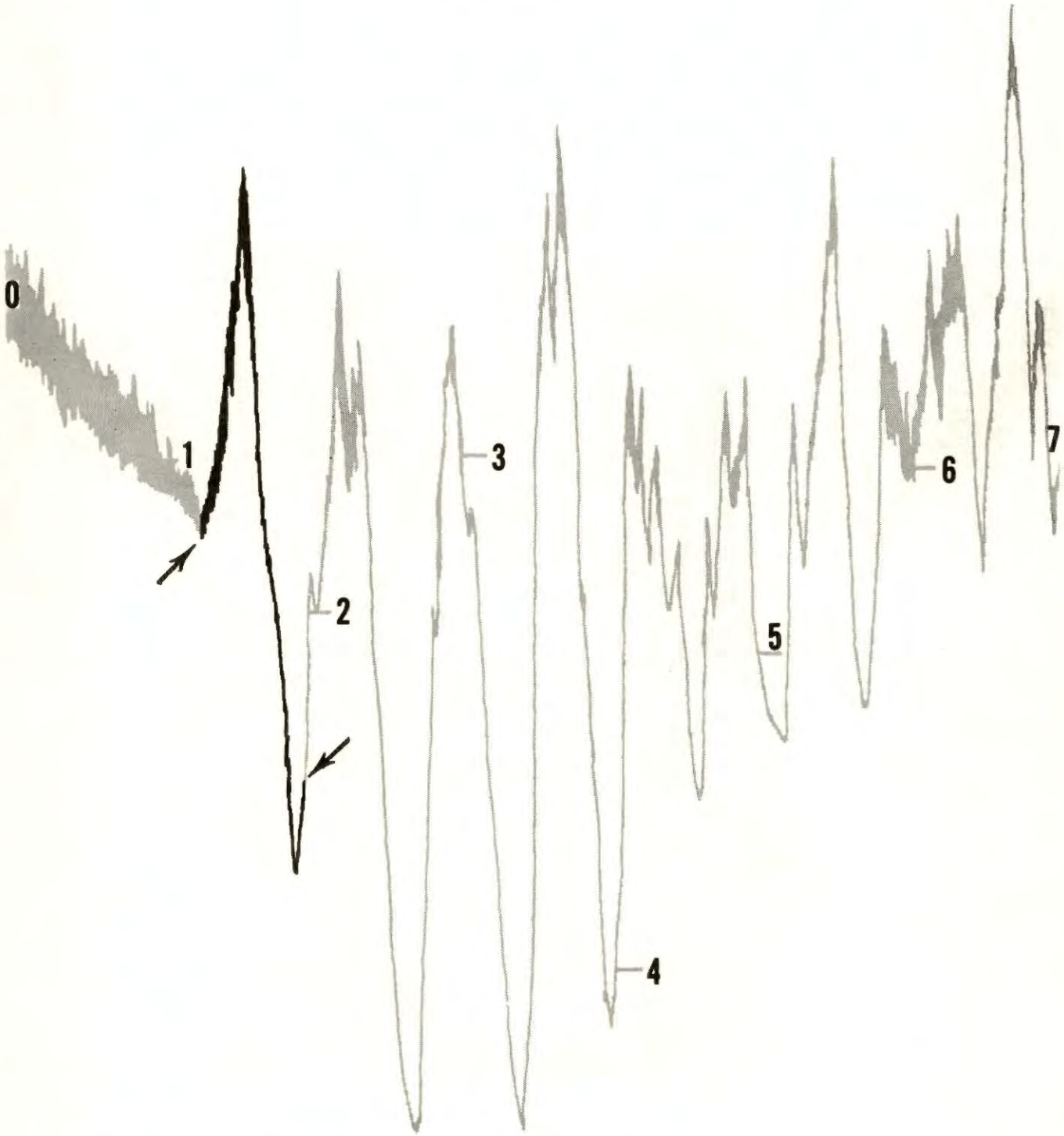


FIGURE 12.—At 0158 local time (0958Z), the Santa Monica tide observer, who sent the message in figure 10, would send the following message:

TSUNAMI. REPORTING PERIOD 0918Z TO 0958Z. MAXIMUM WAVE HEIGHT OBSERVED IS 0142 CM. MINOR FLOODING IS OCCURRING.

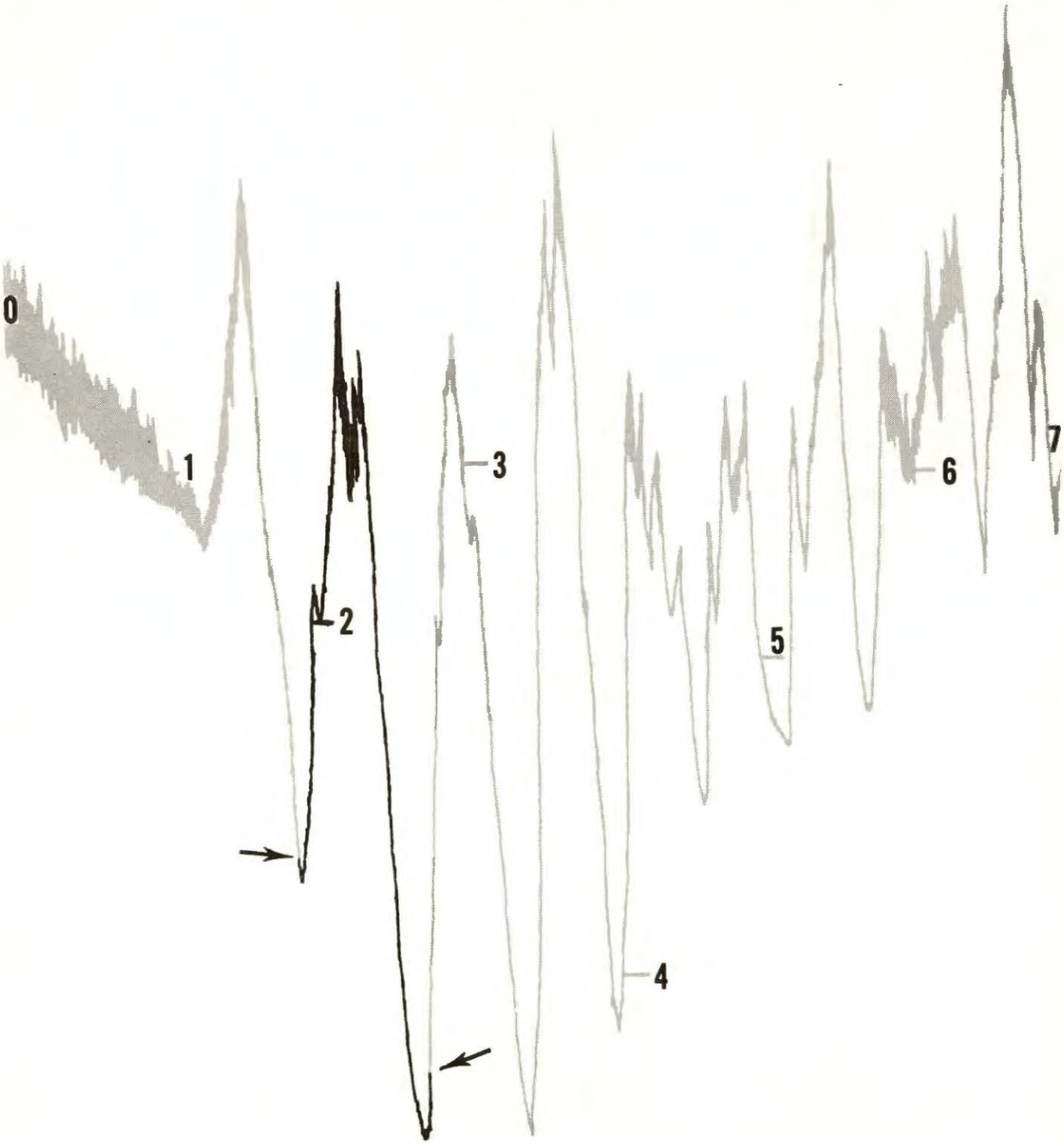


FIGURE 13.—At 0242 local time (1042Z), the Santa Monica observer would send a message such as the following:

TSUNAMI. REPORTING PERIOD 0953Z TO 1042Z. MAXIMUM WAVE HEIGHT 0173 CM.

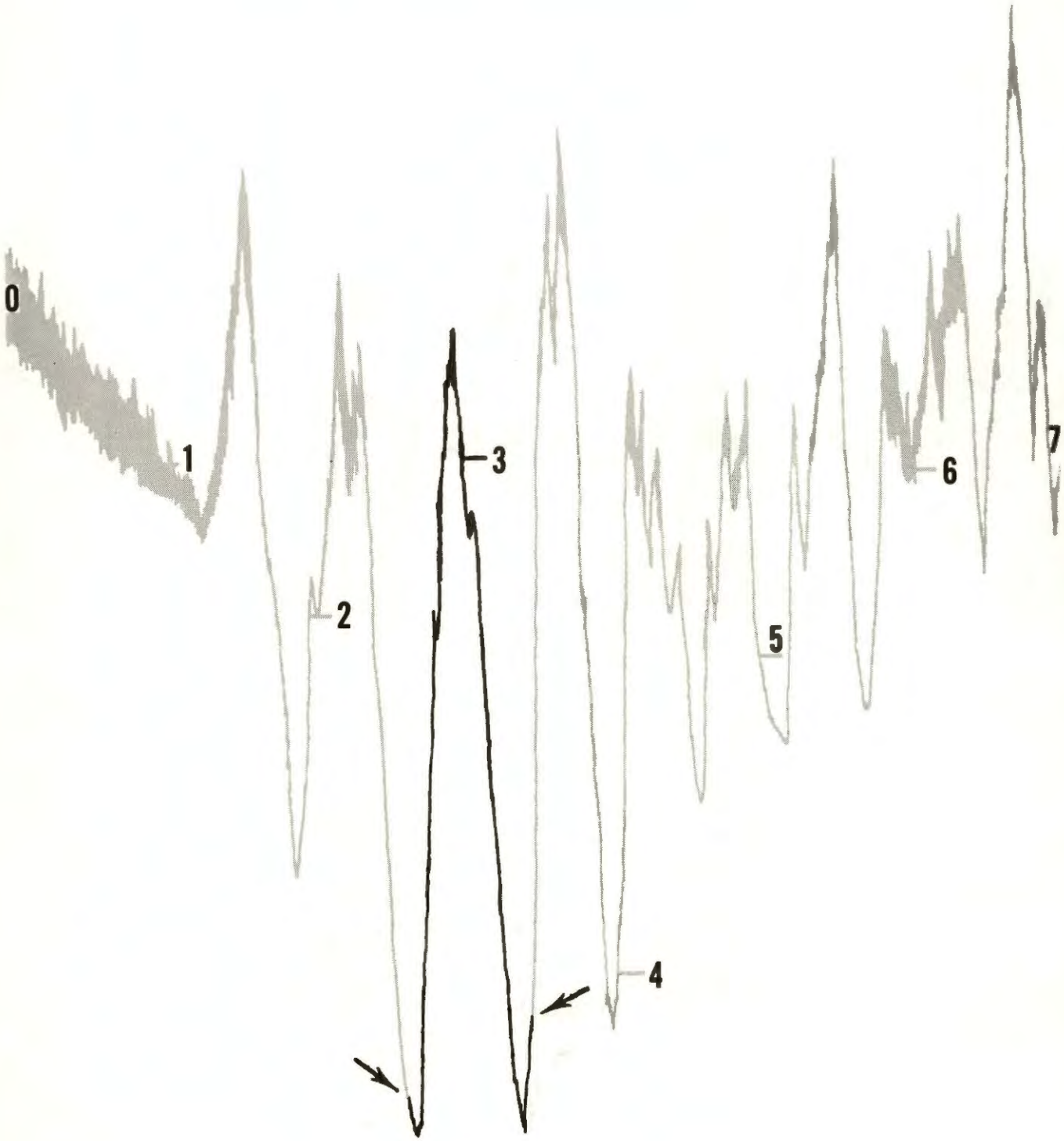


FIGURE 14.—At 0325 local time (1125Z), the Santa Monica observer would send a message such as the following:

TSUNAMI. REPORTING PERIOD 1036Z TO 1125Z. MAXIMUM WAVE HEIGHT 0162 CM.

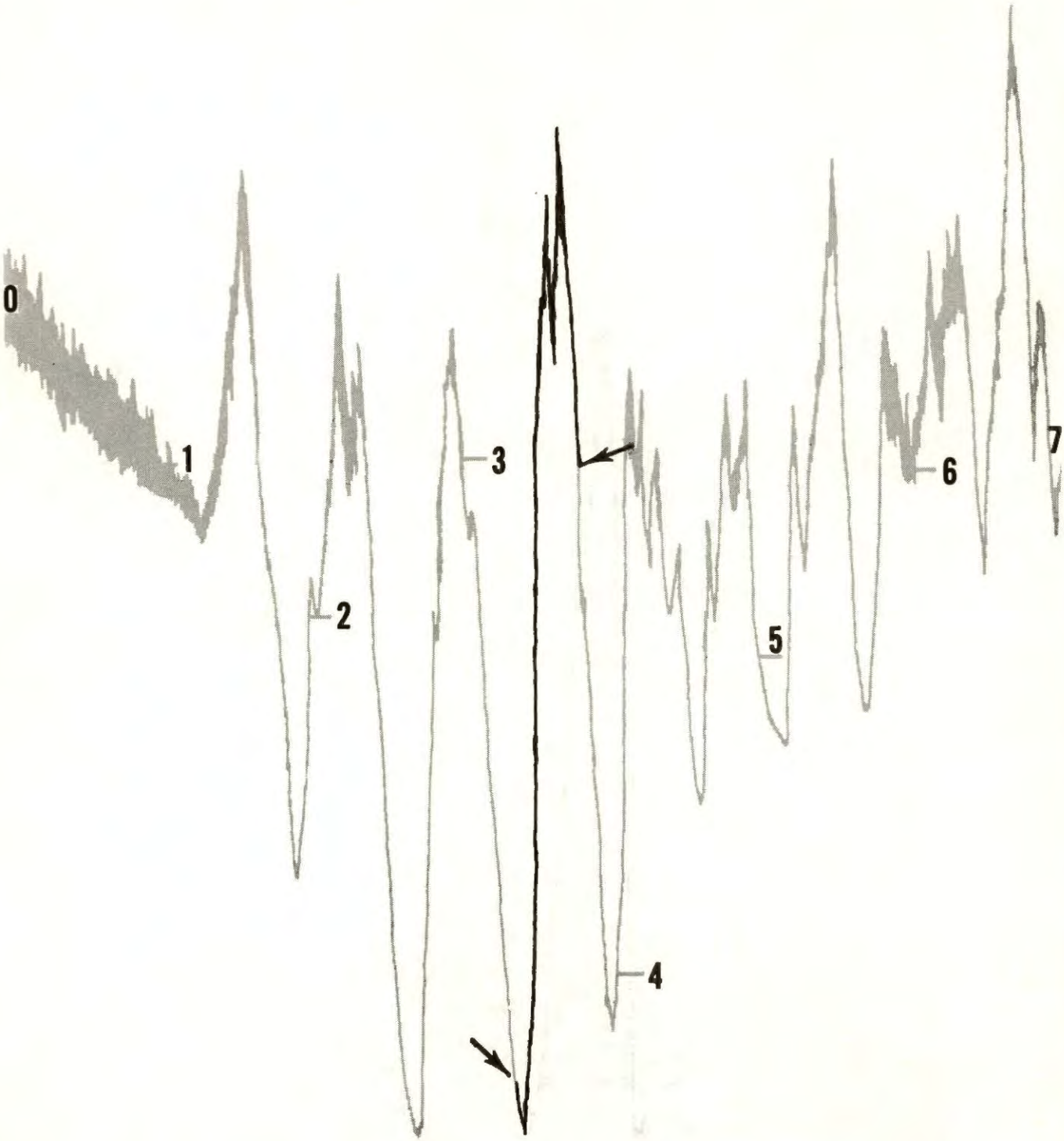


FIGURE 15.—At 0347 local time (1147Z), the Santa Monica tide observer would send a message such as the following:

TSUNAMI. REPORTING PERIOD 1120Z TO 1147Z. MAXIMUM WAVE HEIGHT 0202 CM.

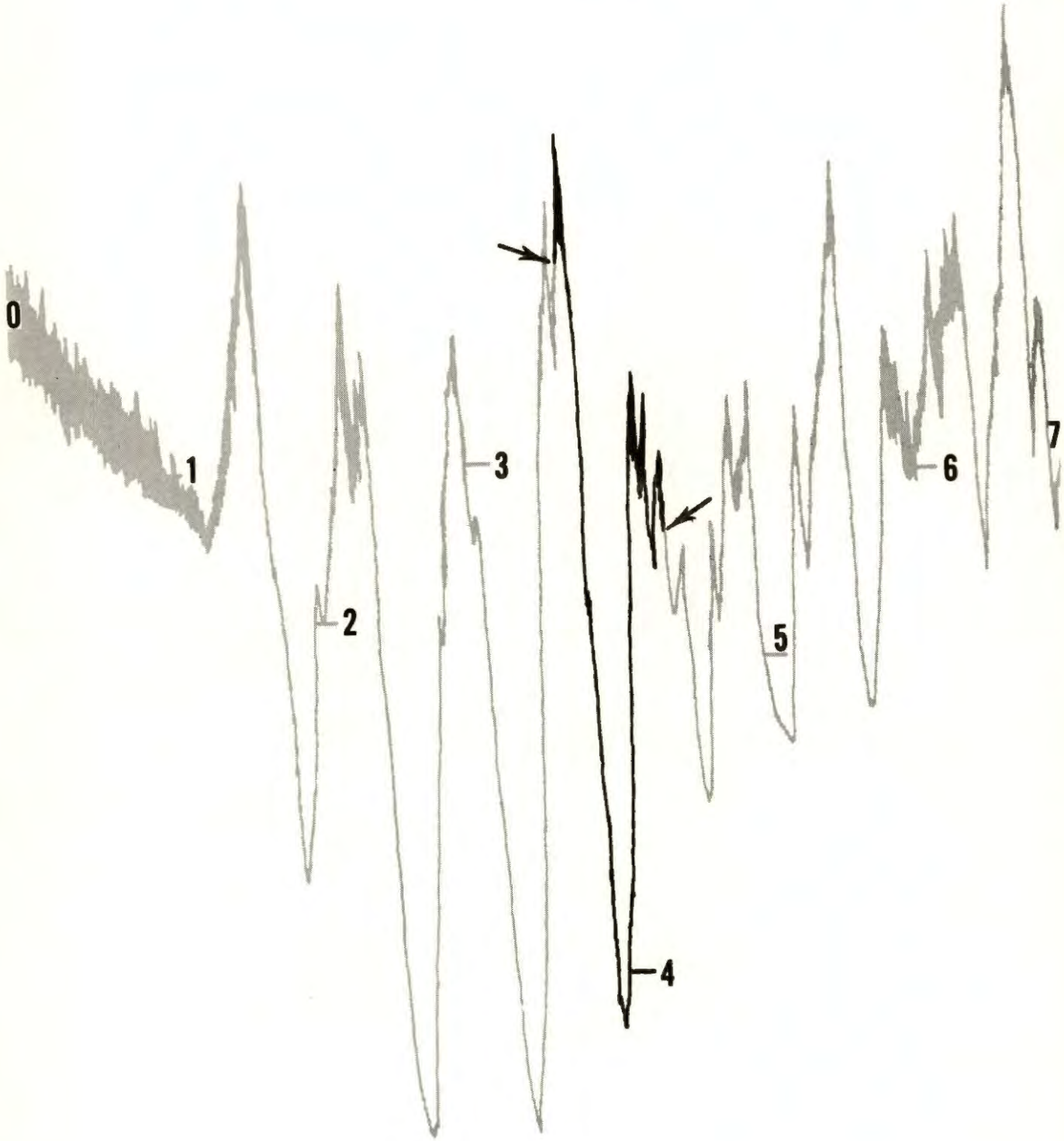


FIGURE 16.—At 0422 local time (1222Z), the Santa Monica tide observer would send a message such as the following:

TSUNAMI. REPORTING PERIOD 1139Z TO 1222Z. MAXIMUM WAVE HEIGHT 0180 CM. WAVES DIMINISHING. WILL NOT REPORT AGAIN UNLESS WAVES INCREASE SIGNIFICANTLY.

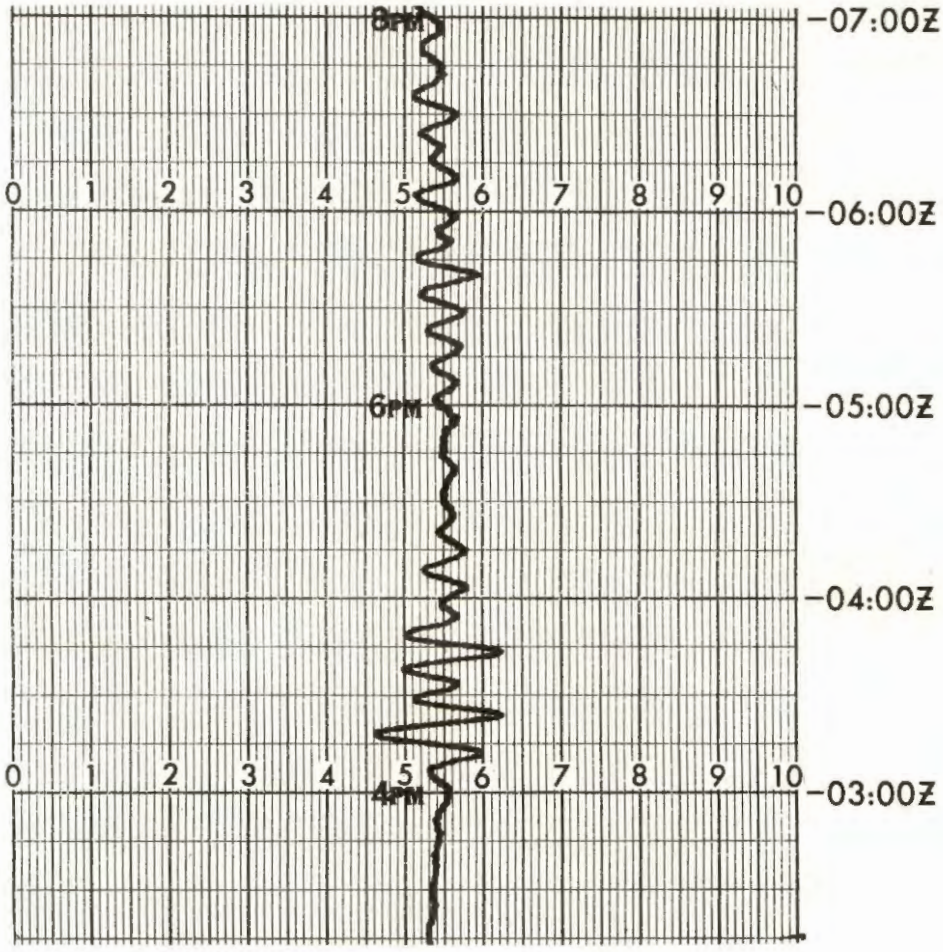
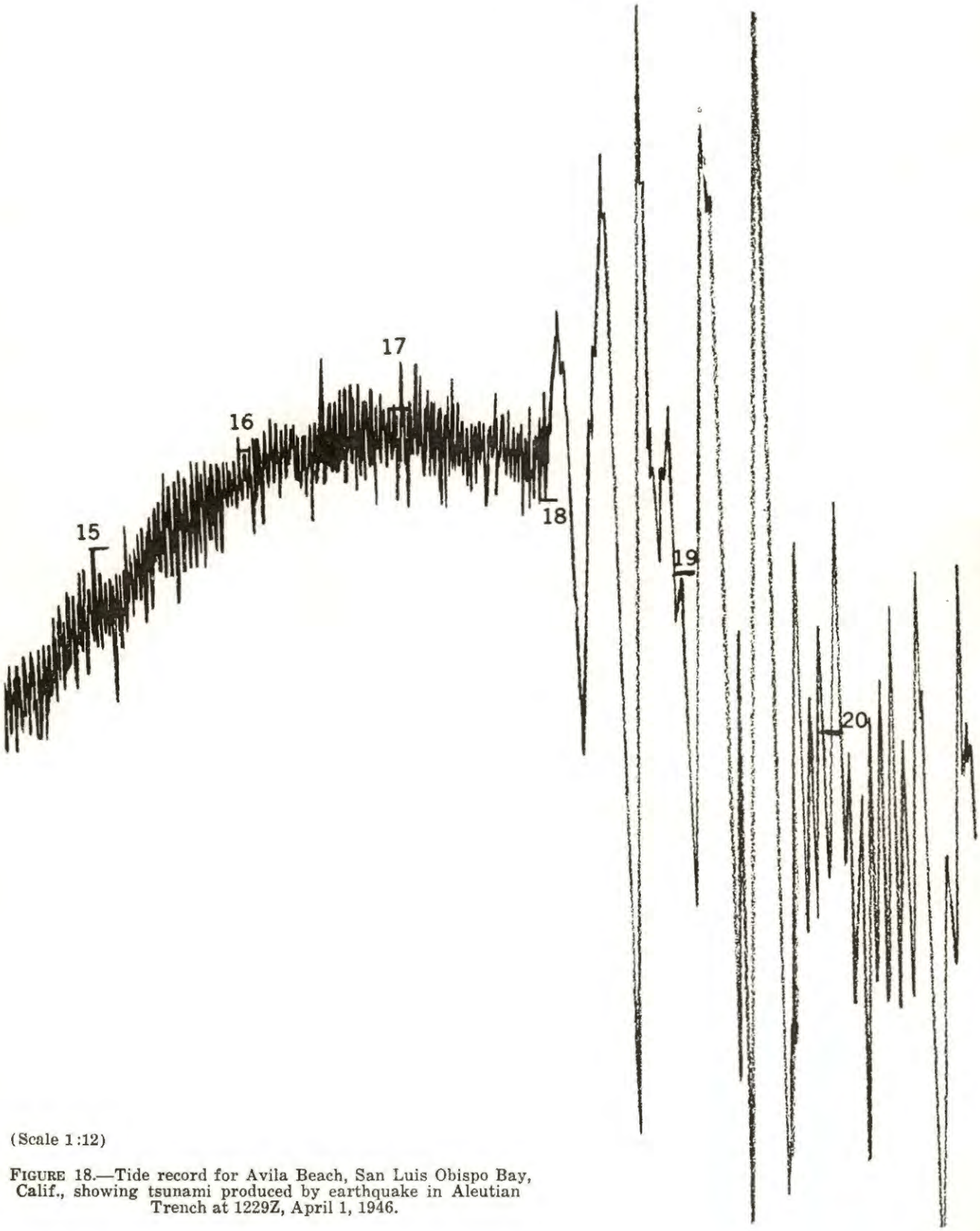
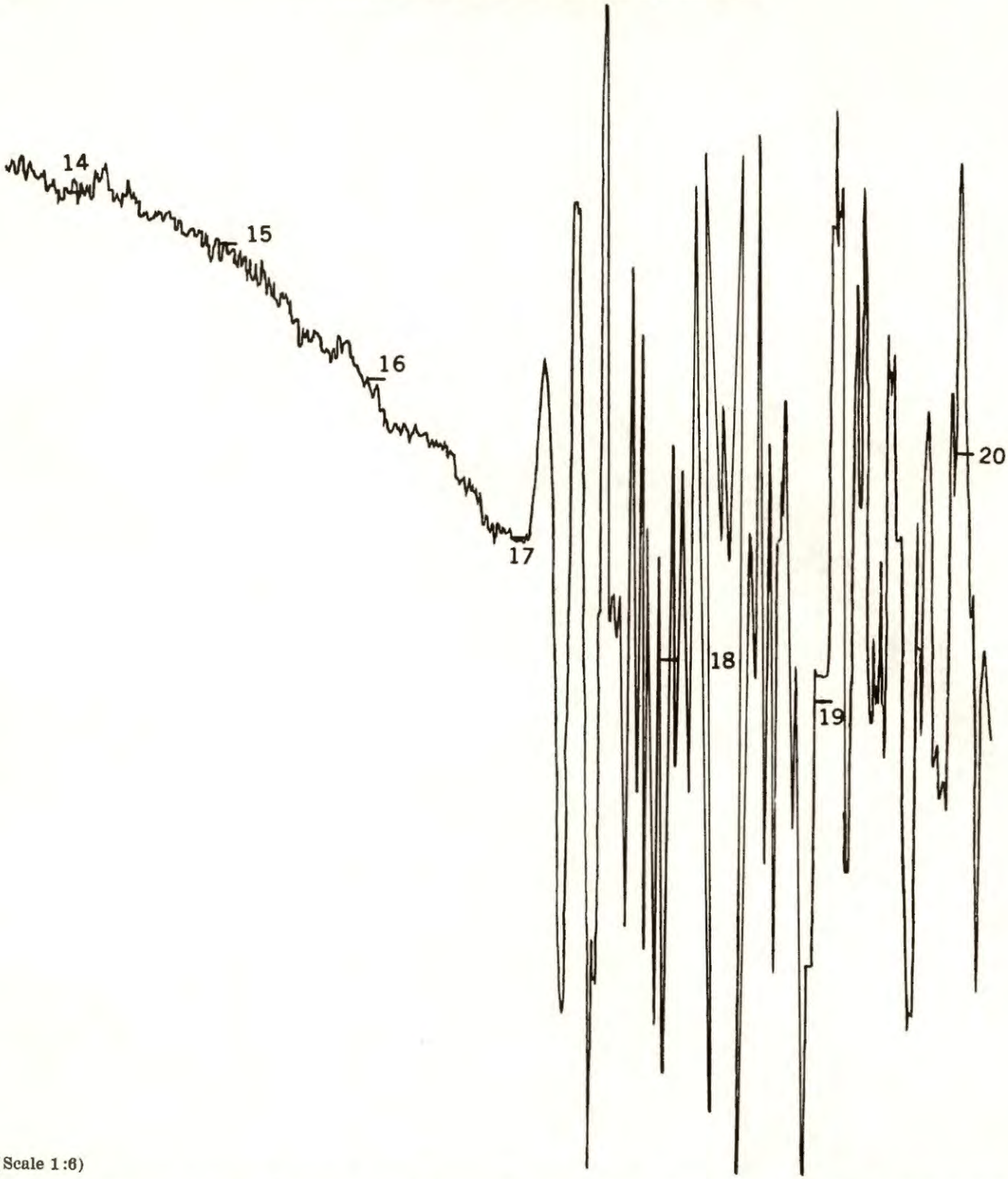


FIGURE 17.—Midway Island remote record showing the tsunami produced by the Kuril Islands earthquake of 2128Z, August 11, 1969.



(Scale 1:12)

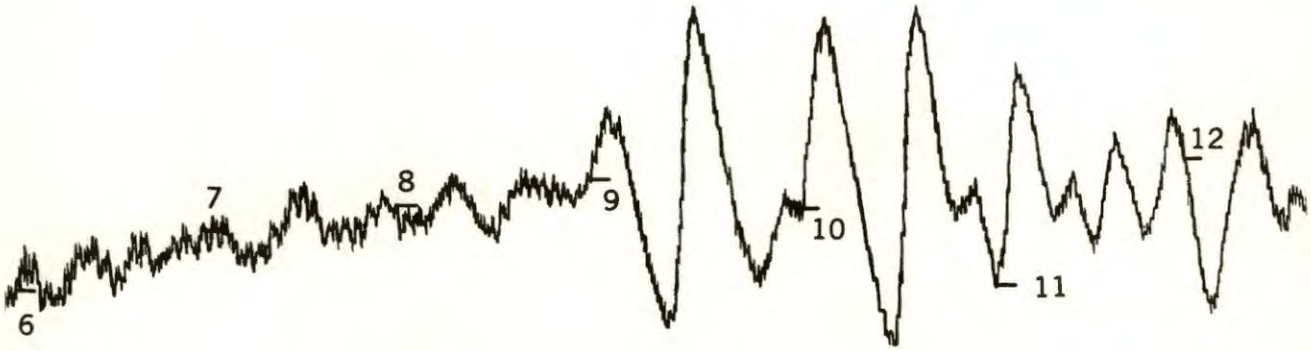
FIGURE 18.—Tide record for Avila Beach, San Luis Obispo Bay, Calif., showing tsunami produced by earthquake in Aleutian Trench at 1229Z, April 1, 1946.



(Scale 1:6)

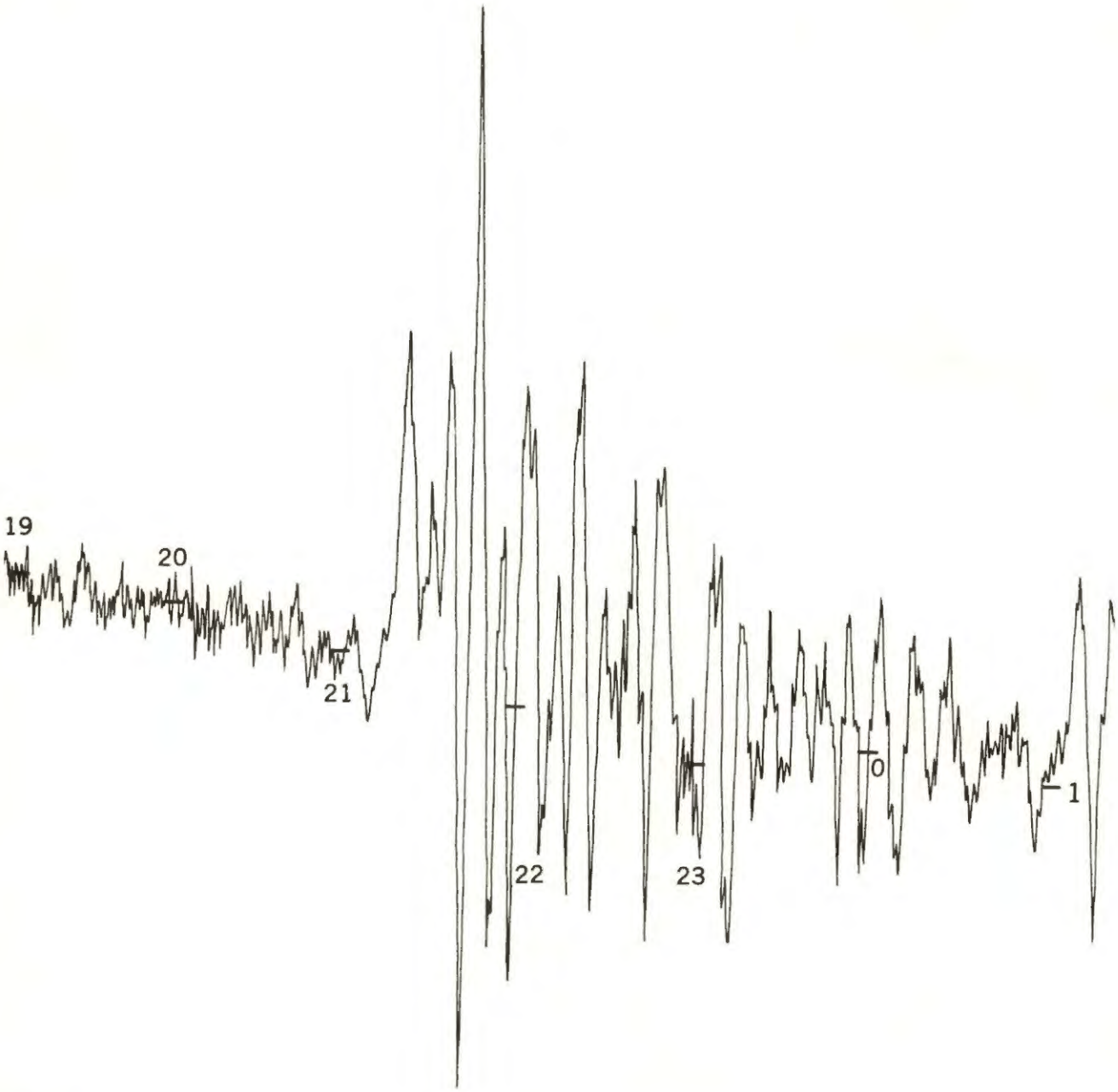
FIGURE 19.—Honolulu tide record showing tsunami produced by earthquake in Aleutian Trench at 1229Z, April 1, 1946.

This tsunami caused 173 deaths and property damage amounting to $25,000,000 in Hawaii.



(Scale 1:12)

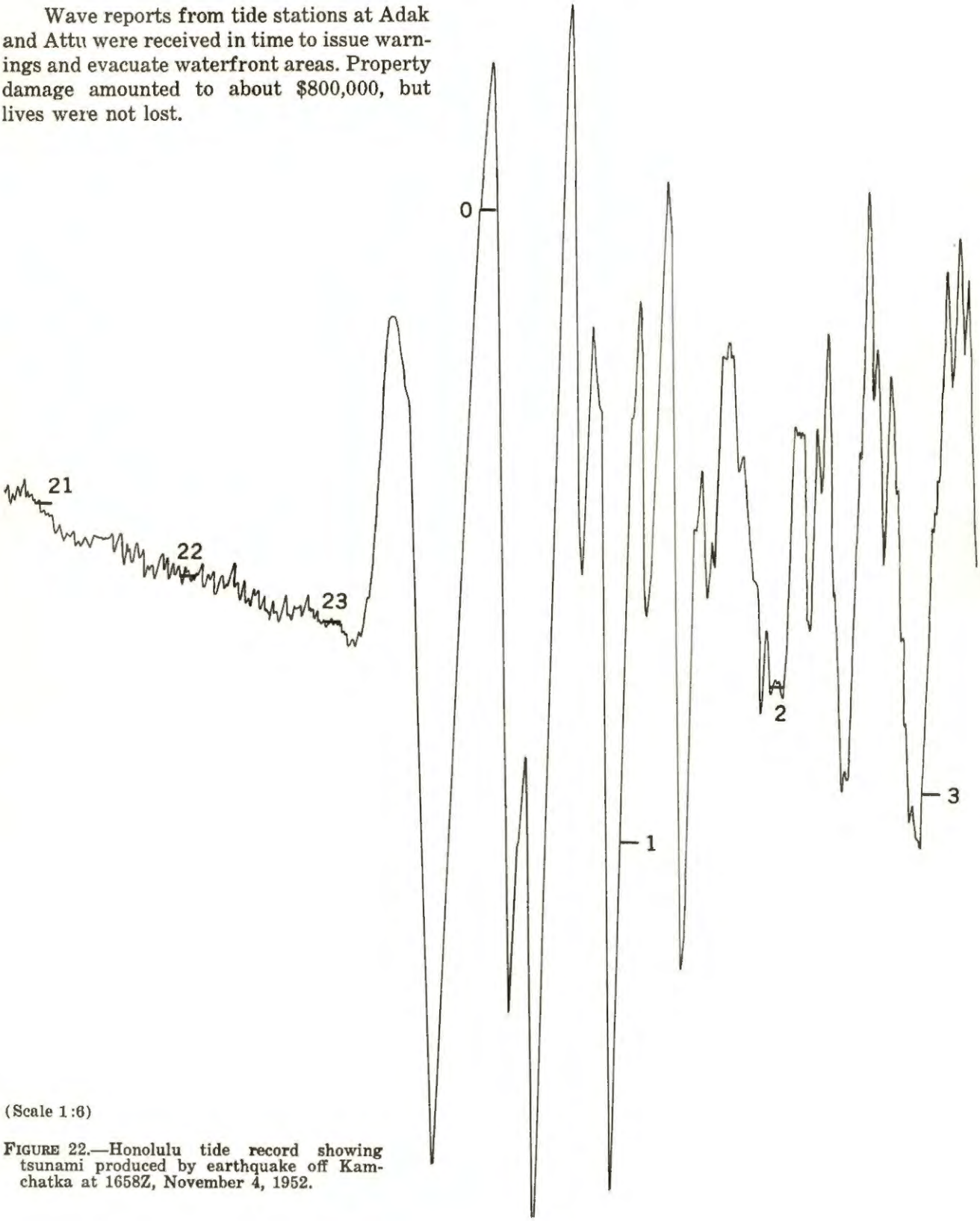
FIGURE 20.—Tide record for Kahului, Maui, Hawaii, showing tsunami produced by earthquake off Hokkaido, Japan, at 0123Z, March 4, 1952.



(Scale 1:12)

FIGURE 21.—Midway tide record showing tsunami produced by earthquake off Kamchatka at 1658Z, November 4, 1952.

Wave reports from tide stations at Adak and Attu were received in time to issue warnings and evacuate waterfront areas. Property damage amounted to about $800,000, but lives were not lost.



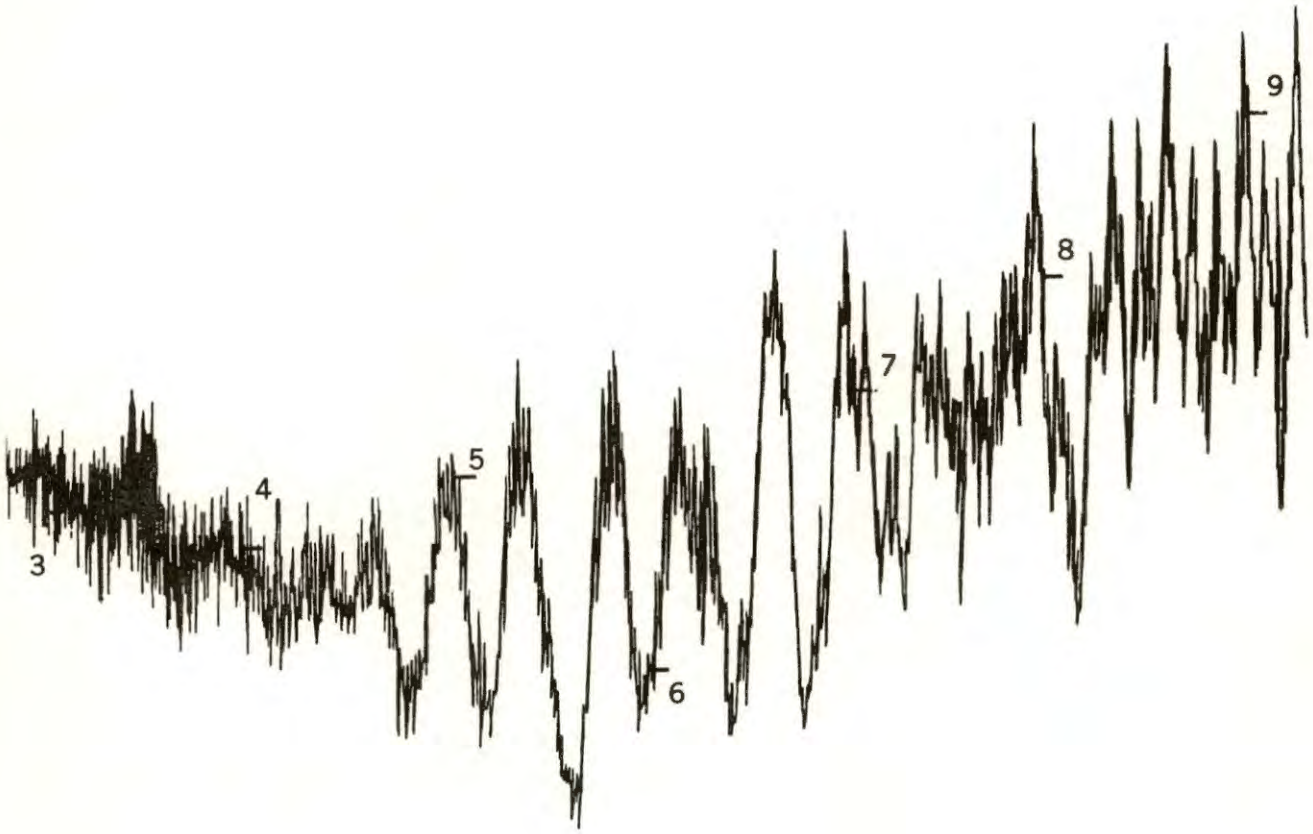
(Scale 1:6)

FIGURE 22.—Honolulu tide record showing tsunami produced by earthquake off Kamchatka at 1658Z, November 4, 1952.

(Scale 1:24)

FIGURE 23.—Tide record for Neah Bay, near Cape Flattery, Wash., showing tsunami produced by earthquake in Aleutian Trench at 1229Z, April 1, 1946.

This was the tsunami that was so destructive in the Hawaiian Islands (fig. 19). The wave was much larger along the California (fig. 18) and Peru (fig. 24) coasts. Hence, even small waves should be reported, for a wave that is small at one place can be large and destructive at another location.



(Scale 1:12)

FIGURE 24.—Callao, Peru, tide record showing tsunami produced by earthquake in Aleutian Trench at 1229Z, April 1, 1946.

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