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INTERGOVERNMENTAL OCEANOGRAPHIC COMMISSION

International Co-ordination Group for the Tsunami Warning System in the Pacific

(Third Session, Tokyo, Japan, 8-12 May 1972)

SUMMARY REPORT

This document is being given a wide initial distribution to all official correspondents of the Commission. Recipients are requested to retain this copy for use at future meetings

NB. Please note that the former document code CG-4 for the International Co-ordination Group for the Tsunami Warning System in the Pacific has been replaced by ITSU.

SC-72/CONF.76/3

ITEM 1: Opening of the Meeting:

Dr. G.L. Pickard, Vice-Chairman of the Group, opened the meeting, welcomed the participants, and made special mention of the addition of Peru and Thailand to the Group. He reported that as Mr. Klaasse, the Chairman of I.C.G., had retired because of ill health he had acted as Chairman in preparation for this meeting. He acknowledged the assistance of Mr. Klaasse's associates in the U.S.A. in preparing the Chairman's report for this meeting.

It was agreed that Professor Pickard should act as Chairman for the present meeting.

On behalf of the host country, welcoming speeches were made by Dr. K. Takahashi, Director-General of the Japan Meteorological Agency, and Dr. K. Nishida, Director-General of the Japan National Committee for Unesco. They underlined the importance of the work of the Group and wished it every success in its work during the coming week. On behalf of the IOC, Mr. Tolkachev welcomed the participants and expressed appreciation to the host country and the Japan Meteorological Agency for the warm hospitality and excellent arrangements made for this meeting. Mr. Tolkachev agreed to become rapporteur. (List of participants: Annex I).

ITEM 2: Adoption of the Agenda

The agenda was adopted by the Group without any changes, and the Chairman opened the discussion on its items (Annex II).

ITEM 3: Report on recommendations from the Second ICG Session in Vancouver, Canada, May 1970

The Chairman reviewed the report of the actions taken on the Recommendations of the Second ICG Meeting (Annex III). During the discussion, the representative of the Philippines made a request for one more tide gauge, and the Canadian delegate agreed that this would be sent if approval was given by both Unesco and ITIC. The delegate from the United States stated that they have equipment available, including a number of seismographs and tide gauges, and any request from member countries would be welcomed. Such requests should be transmitted through ITIC and Unesco.

The Group welcomed the addition of Peru and Thailand.

The representative of the IOC Secretariat indicated that invitations to Member States to join the Group will be reissued, in accordance with Resolution VII-24 of IOC.

It was agreed that actions taken on the other Recommendations will be considered under further items of the agenda.

When reviewing the actions made on Recommendation 5(2) - Telecommunications, the Group agreed with the opinion of the Chairman that, until more detailed requirements are expressed, these frequencies will be adequate for regional transmission of seismic or sea level data pertinent to tsunami warnings.

ITEM 4: National reports related to the Tsunami Warning System

The delegates of Canada, Chile, Japan, Peru, United States, the Philippines, and Union of Soviet Socialist Republics presented reviews of their reports on the national activities of their countries. The full texts of these reports appear in Annex V.

The representative of Canada, Mr. Dohler, presented his report describing instrument developments and applications as well as current research on tsunami problems. In reply to a question from Dr. Soloviev he stated that information on microbarograph observations in the vicinity of gauging stations is available from the Atmospheric Environment Service.

The delegate of France reiterated the statement made by the representative of France at the previous meeting of the Group (Report of the Second Meeting of ICG, Item 8).

The delegate of the USSR expressed his appreciation of the effective work of the Group, and in particular the ITIC in further developing the Tsunami Warning System in the Pacific, and noted that the USSR had been actively participating in this work since 1965 in close collaboration with other countries of the Pacific. In this connexion, special attention in his report was given to the tsunami dummy transmissions conducted in 1970 and 1971 between Honolulu, Tokyo and Khabarovsk. In these dummy tests the USSR had used the regulations on the exchange of urgent information between USSR, Japan and the United States set up in December 1964. He mentioned that in the USSR they had been designing new instruments for measuring sea level, and some improvements had been made at the observation stations of the Kurile Islands and Kamchatka. The meeting was also informed of the research work the USSR is doing on improved methods of tsunami forecasting.

In presenting the national report of Chile, Mr. Garcia-Huidobro noted that his country has a complete programme for improving the communication network, but they have some financial difficulties in its implementation. The Group reviewed the recommendations made by the Chilean delegate in his report and came to the conclusion that certain action had already been taken by the Group on the questions raised in the recommendations. In this connexion, references were made to Recommendation 3 of the First Meeting of ICG and Recommendation 8 of the Second Meeting, as well as to Resolution VII-28, "Tsunami Warning Systems", of the Seventh Session of IOC. Regarding the assistance Chile requires for installation and maintenance of equipment, it was recommended that the detailed request be sent to the Chairman of the Group for further submission to Unesco for consideration.

In reviewing the report of Japan, Dr. Suyehiro proposed to discuss the setting up of an international formating system so that all tsunami messages can be handled by computers used by Japan for this purpose and to provide rapid relay of information to other countries. (Annex VI) Dr. Suyehiro stated that in recent years the transcommunication system around Tokyo had been greatly improved. The Group noted with satisfaction the completion of the plan, introduced during the first meeting of the Group, for the creation of a network of telemetering seismic stations for tsunami warning in Japan. Five Tsunami Warning Centres had been set up in Japan to provide warnings on tsunamis generated by local earthquakes. In answer to a question by Dr. Soloviev, Dr. Suyehiro explained that they planned to set up ocean bottom stations equipped with seismic and hydraulic pressure gauges.

In presenting the U.S. national report, Mr. L.M. Murphy cited the addition of several stations to the Tsunami Warning System during the past two years (as listed in the report). By installation of the tide station at Manzanillo, Mexico, it was mentioned the gap between California and Central America will be practically closed. Mr. Murphy described briefly the new Communication System in Hawaii for providing immediate communication between the various islands in Hawaii. He also described the Palmer, Alaska system for detection of earthquakes in the Alaskan area. Mr. Eppley informed the meeting that next year several communication channels of a geostationary satellite, to be positioned at 0° lat. 100° long., would be available to the Tsunami Warning System for the relay of seismic and sea level data. Dr. Miller summarized the tsunami research as related to source mechanism, propagation and run up, model studies and instrumentation.

The Peruvian delegate in his report, noted that Peru, in co-operation with other Central American countries (Colombia, Ecuador, Peru, Trinidad/Tobago, and Venezuela) could undertake studies on tsunamis, in accordance with a programme to be developed in the period 1974 to 1978 under the CERESIS project. He also made some comments on the ITIC proposal on the expansion of the seismic and tidal networks in the TWS, as related to the tide stations in Peru, and expressed the hope that Unesco would provide support for the establishment of a Peruvian National Service on tsunami warning.

ITEM 5: ITIC Developments

Dr. G. Miller, Director of ITIC, explained the many organizational changes within ITIC, the relocation of the seismologists, and the moving of the Director's office to the University of Hawaii. He requested those present at the meeting to contribute information which might be appropriate for inclusion in "The International Tsunami Information Centre Newsletter." He expressed the desire to have good continuity from now on, and said that he would be sending our inquiries to members of the Group because he is still unfamiliar with many operational aspects. He added that the National Weather Service will ultimately be operating the Tsunami Warning System, after approximately one year. Dr. Miller said that two scientists, one from Japan and one from the USSR, had worked at the Centre and he expressed the hope that others would also visit the Centre in the future. Dr. Soloviev pointed out that there was great need for the existence of such a Centre and that the Group must underline the necessity to take other steps to secure the activities of the Centre, the regular preparation of the Newsletter, and the programme to enable scientists from different countries to work at the Centre, which had proved to be of great help. A recommendation was adopted on this subject (Annex IV).

ITEM 6: Problems and improvements in communications

In taking up this item. Dr. Suyehiro of Japan introduced the proposals of Japan on improvement in communication (Annex VI), and the Group set up a sub-committee to consider this subject and prepare a recommendation. A recommendation was adopted on this subject (Annex IV).

The meeting was informed about the work of the Joint WMO/IOC Group of Experts on Telecommunication, and recognizing the importance of further close contact with that Group, decided that the Group should be represented at the 4th Meeting of ITEL, to be held 12 to 19 December 1972. It was agreed that the Chairman of the Group would designate a representative of ICG to participate in the above meeting.

ITEM 7: Proposal for an expansion of the Tsunami Warning System

Dr. Miller, Director of ITIC, distributed suggestions for the expansion of the Tsunami Warning System (Annex VIII). He quoted Recommendation No. 3 from the Vancouver meeting of the Group, i.e., "Considering the locations of seismic and tidal stations in the Pacific Ocean area, it is recommended that a list of key stations be compiled for use in designing a network to protect life and property in those countries:

(a) belonging to the Tsunami Warning System in the Pacific, and

(b) which may join in the future.

In selecting the stations, consideration should be given to the tsunami origin, either close to or distant from the coasts. It is further recommended that ICG should accept the offer of the ITIC to compile a draft list which will be distributed to the Member States for review and finalization."

The stations in the draft lists were selected on the basis of the following considerations:

(a) Existing seismograph and tide stations were chosen, where possible, in order to provide more complete geographic coverage.

(b) The density of tide stations in the major tsunamigenic areas will permit tsunami detection within at most one half hour.

Several delegates commented on the proposed tide and seismograph stations to be included in the Pacific Tsunami Warning System. Recognizing the importance of the proposed system, however, the Group felt that further study of different aspects of this proposal would be necessary by each member country, and, in connexion with this an appropriate recommendation was adopted on this subject (Annex IV).

ITEM 8: Summary report on IUGG Tsunami Committee Meeting in Moscow, August 1971

Dr. Soloviev, Chairman of the IUGG Tsunami Committee, gave a report on the International Symposium on Tsunami held in Moscow in August 1971, (Annex VIII). The Group was informed that reports made at the Symposium would be made available in Russian, and that there are tentative plans to publish the papers in English.

Dr. Soloviev outlined proposals of the IUGG Tsunami Committee made in response to Recommendation No. 8, Unesco/IOC Meeting of Tsunami Warning System, which are related to the activities of the ICG. They read as follows:

"I - that installation of multiple-site recording systems, using open ocean marigraphs recording on shore be strongly recommended to all warning systems involved with near-shore sources of tsunami, in view of the usefulness of the method in the protection of populated areas;

II - that all stations of warning systems be encouraged to utilize microbarographs for the airwave detection of remote tsunami;

III. - deduction of bottom displacements from seismic data and elaboration for this purpose of methods of reliable and quick determination of focal depth, mechanism and moment of an earthquake;

IV - automation of epicentre and magnitude determination of earthquakes;

V - research on tsunami propagation in near-shore areas and of determination of local responses to tsunami propagation in view of the applicability of the results in such uses as preparation of inundation or damage-risk maps."

Referring to the above proposals, Dr. Soloviev emphasized once again that all countries should try to install the equipment recommended in Proposal 1, and use it effectively.

ITEM 9: Date and place of next meeting, and arrangements for co-ordination of ICG activities during the interim period

It was agreed that the next meeting should be in two years time, i.e. in early 1974. In the meantime, ICG activities will be co-ordinated through the Chairman's office. The Chairman stated that, to date, no offers had been received to host the next meeting and the Group suggested that the IOC Secretariat contact the Member States on this subject.

ITEM 10: Other business

The representative of IOC brought Resolution VII-28, "Tsunami Warning System" (Annex IX), to the attention of the Group, and in particular the item concerning the preparation of educational material designed to arouse public awareness of the dangers of tsunamis and also the protective action that should be taken upon receipt of a tsunami warning. After a short discussion the Group adopted the recommendation on that subject.

On the afternoon of Wednesday, 10 May, the Group visited the Japan Meteorological Agency and were shown the various aspects of the mechanisms for receiving and transmitting tsunami information and, in particular, the Tsunami Warning System Centre. At the conclusion of the visit two films were shown. These were produced in the USSR and the U.S.A. to inform the public on the dangers of tsunami and on the Tsunami Warning System to mitigate such dangers.

ITEM 11: Adoption of report

The draft report of the meeting and the recommendations proposed were discussed and agreed upon.

ITEM 12: Election of Chairman and Vice-Chairman

Dr. S. Suyehiro was elected Chairman and Professor G.L. Pickard was re-elected Vice-Chairman of the Group, to take office at the conclusion of this meeting.

ITEM 13: Closure of the meeting

Mr. L.M. Murphy expressed the sincere appreciation of the Group to the host country, the organizations and the individuals concerned for the excellent arrangements for the meetings, for the pleasant social occasions and for the visit to the J.M.A. during the meeting, and for the study tour of coastal areas planned for after the meeting.

The Acting Chairman closed this Third Meeting of the ICG on Thursday afternoon, 11 May 1972.

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ANNEX/ANNEXE/ANEXO/ПРИЛОЖЕНИЕ I

LIST OF PARTICIPANTS/LISTE DES PARTICIPANTS/ LISTA DE PARTICIPANTS/СПИСОК УЧАСТНИКОВ

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ANNEX II

PROVISIONAL AGENDA

1. Opening of the session.
2. Adoption of the agenda.
3. Report on recommendations from the Second ICG session in Vancouver, May 1970.
4. National reports on current tsunami research and instrumental developments.
5. ITIC developments.
6. Problems and improvements in communications.
7. Proposal for an expansion of the Tsunami Warning System.
8. Summary report on IUGG Tsunami Committee meeting in Moscow, August 1971.
9. Date and place of next meeting and arrangements for co-ordination of ICG activities during the interim period.
10. Other business.
11. Adoption of report of meeting.
12. Election of chairman.
13. Closure of meeting.

ANNEX III

REPORT OF THE CHAIRMAN ON ACTIONS TAKEN ON THE RECOMMENDATIONS OF THE SECOND MEETING

Recommendation No.1 - Equipment for the Pacific TWS

IOC Circular Letter No. 303 dated June 22, 1970, solicited information from Members of the ICG as to the availability of seismic and sea level recording equipment to other participating countries for use in the Tsunami Warning System.

Canada responded to this letter by offering ten Foxboro pressure-type tide gauges to any participating countries which expressed an interest in operating such gauges. The ITIC was assigned responsibility for the final disposition of the instruments.

Subsequently, the Philippines requested and received one of the tide gauges. Chile and Korea have expressed interest in the gauges but no further action has been reported.

Since the last ICG meeting, the United States has provided, on indefinite loan, additional remote recording tide gauge equipment and visual recording seismograph systems to several countries. The tide gauge instruments were installed in Peru and Chile while the seismic systems were installed in Hong Kong, the Philippines, Western Samoa, Fiji, and New Zealand.

Recommendation No. 2 - ICG Participation

On September 14, 1970, the Acting Secretary of the IOC distributed a circular letter to all Member States of the Pacific Region who were not members of the ICG inviting them to participate in the work of the Group. The circular letters were sent to Australia, Colombia, Indonesia, Malaysia, Mexico, Panama, Peru, Singapore, and Thailand.

As a result of the invitations, Peru and Thailand accepted membership in the ICG. Colombia and Panama have indicated some interest in joining the Group while Mexico declined the invitation.

Following are the other members of the ICG : Canada, Chile, China, Ecuador, France, Guatemala, Japan, Korea, New Zealand, Philippines, U.S.A., and U.S.S.R.

Recommendation No. 3 - Network of Seismic and Tide Stations

This recommendation proposed that the ITIC compile a list of seismic and tide stations which would form an expanded network designed to offer greater protection to Member States from tsunamis generated either close or distant from their coasts.

Such a list will soon be distributed by the ITIC to each Member State so they will have the opportunity to study the proposed locations and make appropriate recommendations at the 1972 ICG Meeting. Those countries who do not expect to have representatives at this meeting are encouraged to send their comments to the Chairman, ICG.

Recommendation No. 4 - Tsunami Data Reporting

The recommended procedures to be used by tide observers in reporting tsunami data were made available to all participating stations in December 1970 when the United States distributed a revised version of the publication, "Wave Reporting Procedures for Tide Observers in the Tsunami Warning System."

Since then there have been only a few small tsunamis reported to the Warning Center. In reviewing these reports, it was noted that all stations did report wave heights in metric units. However several stations failed to follow the recommended format of reporting the initial amplitude and subsequent maximum wave heights at regular intervals.

Continuing efforts should be made by each member country to provide full instructions to their tide station personnel on emergency reporting of tsunami data.

Recommendation No. 5 - Telecommunications

In July 1970, the Chairman sent letters to all National Coordinators requesting information on each Nation's telecommunication requirements and plans. The information was requested so that the Chairman could respond to certain questions raised at the 3rd Meeting of the Joint WMO/IOC Group of Experts on Telecommunications in May 1970.

The replies submitted by the Group members indicated that they were not yet in a position to supply details on the use of telecommunications for the Pacific TWS.

In viewing the situation with regard to telecommunication requirements in the TWS, it should be noted that the Joint Group of Experts has approved certain frequencies for tsunami warning purposes as quoted below from the report of their second meeting :

> "The Group felt that it should make interim arrangements for the collection of initial data for warning purposes (e.g., tsunami, hazardous weather phenomena, etc.). Since these data will have to be transmitted on a non-scheduled basis, it was felt that the lowest assignable frequency in each of the six allocated bands* should be reserved for the collection of these data exclusively. The occupied band widths for these transmissions should be as small as possible and preferably should not exceed 100 hz."

The Chairman believes that, until more detailed requirements are expressed, these frequencies will be adequate for regional transmission of seismic or sea level data pertinent to tsunami warnings.

For long range transmission of data and warnings in the Pacific TWS, the United States expects to launch a communications satellite in 1973 which will have the capability of relaying telemetered data to the Warning Center from distances of about 8,000 kilometers. About 100 channels will be available for emergency use in the 401.850 MHZ to 402.00 MHZ range.

Recommendation No. 6 - Communication Tests

In accordance with Recommendation Number 6, arrangements were made through the ITIC for a test transmission from Khabarovsk to Honolulu and Tokyo. The test was conducted on September 16, 1970, using direct radioteletype. Khabarovsk used three transmitters in the test. From 0200 GMT to 0205 GMT, Kharbarovsk transmitted on the following frequencies : 4516.7 khz, 9230 khz, and 14737 khz. After a 10 minute intermission, Khabarovsk broadcast from 0215 GMT to 0220 GMT on the following frequencies : 6830 khz, 12253 khz, and 19275 khz. Honolulu reported good reception at only the two highest frequencies. No signals were received at the two lowest frequencies and reception was poor for the two intermediate frequencies. Tokyo had good reception on 6830 khz and did not monitor the other frequencies.

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* Allocated frequency bands :

4162.5 - 4166.0 KHZ
6244.5 - 6248.0 KHZ
8328.0 - 8331.5 KHZ
12479.5 - 12483.0 KHZ
16636.5 - 16640.0 KHZ
22160.5 - 22164.0 KHZ

commendation No. 7 - Communication Tests

In accordance with Recommendation Number 7, communication tests were carried out between Honolulu, Tokyo, and Khabarovsk, testing both direct broadcast and point-to-point transmission over existing teletype circuits operated for meteorological or other purposes.

There were two direct broadcasts made from Khabarovsk in addition to the one on September 16, 1970.

The first one, on March 15, 1971, was transmitted on the following frequencies : 3995 khz, 5885 khz, 8130 khz, 12295 khz, 16080 khz, and 21750 khz. Honolulu reported no signal received on the first three frequencies, fair reception on the next, and good reception on the last two. The report from Tokyo did not mention the first two frequencies and reported good reception on the last four.

The second Khabarovsk test was run on September 15, 1971, and used the same frequencies except that 16080 khz was replaced by 16010 khz. No signal was received by Honolulu on the first two frequencies, the reception on the next three was fair to good with voice and CW interference, and reception was good on the last frequency. Tokyo did not report results of this test to the ITIC.

Three test broadcasts were also made from Honolulu. All three used the same six frequencies : 4163 khz, 6245 khz, 8328.5 khz, 12480 khz, 16637 khz, nd 22161 khz. These are the frequencies recommended by the Joint WMO/IOC Group f Experts on Telecommunications for use in tsunami transmissions.

In the first test, on December 15, 1970, Tokyo reported no signal on the first three frequencies, fair to good reception on the fourth, very good reception on the fifth, and good reception on the sixth. The broadcast was reported to have been received in Khabarovsk, but no details on frequency reception were made available to the ITIC. In a test on June 17, 1971, Honolulu missed the scheduled broadcast time for the first, third, and fifth frequencies. No report was received from Tokyo or Khabarovsk on whether the other three frequencies were received. In another test, on December 15, 1971, Tokyo reported no signal on the first three frequencies, fair reception on the fourth, good reception on the fifth, and very good reception on the sixth frequency. No report was received from Khabarovsk.

All broadcast tests were conducted between the hours of 0200 and 0220 GMT.

Four tests were initiated by the ITIC utilizing existing teletype circuits between Honolulu Observatory and Japan Meteorological Agency, and between JMA and the Hydrometeorological Service in Khabarovsk. Khabarovsk responded to all four tests and round trip times were as follows : June 16, 1970, 1 hr. 10 min.; December 4, 1970, 2hr. 25 min.; March 16, 1971, 6hr. 12 min.; and June 22, 1971, 1 hr. 16 min.

Since the Khabarovsk filing time was reported to the ITIC only on the December 4 test, this is the only test in which the actual communication time can e separated from the in-station delays. On this occasion, the actual two-way transmission time was 43 minutes.

ANNEX IV

RECOMMENDATIONS

1. Recognizing the importance of the existence of the International Tsunami Information Center (ITIC) and its work in the development of the Tsunami Warning System in the Pacific, the ICG recommends that its activities should not be diminished in any way by internal organizational changes and that the attention of the ITIC should be devoted primarily to the collection and dissemination of information on research and technical developments on tsunamis as well as promoting the exchange of scientific and technical personnel among participating countries. It further recommends that the Member Countries provide all possible support to the ITIC.

2. The Group recommends that the Director of ITIC prepare a description of the functions and main activities of the ITIC and include it in the next issue of the Tsunami Information Center Newsletter.

3. Considering the proposal of ITIC on expansion of the Tsunami Warning System made in accordance with Recommendation 3 of the Second Meeting of ICG, it is recommended that all member countries consider which of the proposed tide and seismograph stations suggested for the Pacific Tsunami Warning System should receive priority, bearing in mind technical and telecommunication aspects, and submit before the end of 1972 their proposals to the ITIC for presentation to the next ICG meeting.

4. Recognizing the recent improvement in the telecommunication system in the Pacific Area, the International Coordination Group urges the countries concerned, mainly Japan, the United States of America, and the Soviet Union, to study the Japanese proposal on the format of tsunami messages as a basic material, and give to the Japan Meteorological Agency their suggestions on the agreement to process and relay these messages automatically by ADESS (Automatic Data Editing and Switching System).

5. Noting the importance of standardization in providing exchange of urgent information among Pacific countries, the Group recommends that member countries participating in the operational exchange of this information should review the procedures in use with a view to obtaining complete standardization among member countries and should report the results to the 4th meeting of ICG.

6. Bearing in mind the positive results achieved during the conduct of tsunami dummy tests, and with the view to keeping the existing telecommunication systems active, the International Coordination Group recommends the continuation of dummy tests and exchange of actual tsunami warnings between Honolulu, Tokyo and Khabarovsk. The details for the tests will be agreed by letter.

7. Bearing in mind Resolution No. VII-24 of IOC, in particular the item on the necessity of preparing educational material designed to arouse public awareness of the danger of tsunamis and also the protective action that should be taken upon receipt of a tsunami warning, and recognizing the importance of this material for creation of Tsunami Warning Systems in the developing countries, ICG requests all member countries to prvide to ITIC copies of their educational material so that bibliographies and examples can be prepared by ITIC for distribution, through the IOC Secretariat, to other countries.

CANADIAN NATIONAL REPORT

PREPARED

FOR THE 3RD MEETING

OF

THE INTERNATIONAL COORDINATION GROUP
FOR THE TSUNAMI WARNING SYSTEM IN THE PACIFIC

TOKYO, JAPAN MAY 8-12, 1972

Instrument Developments

In accordance with a request made by the Intergovernmental Oceanographic Commission, the Canadian Government authorized a gift of ten surplus tide gauges to be allocated through the International Tsunami Information Centre (ITIC) to countries participating in the Tsunami Warning System in the Pacific. At the end of April 1972, only one instrument was requested by ITIC for use by the Philippine Coast and Geodetic Survey at Manila. The instrument was shipped from Canada early in 1971.

The Tsunami Warning stations at Tofino and Victoria have been working satisfactorily throughout the last two years. Honolulu was advised about three times during that period on equipment failures or the relocation of stations and equipment. Revised instruction procedures for the Honolulu Tsunami Warning Centre Personnel were requested and supplied for the interrogation of the Canadian gauges. In addition, hourly tide predictions were prepared for the same centre covering the years 1971, 1972 and 1973.

It was reported during the second meeting that a fully operational Telemetry system between Langara Island and Prince Rupert Airport would be available by the end of 1970. Breakdown of the submersible transducer and the difficult access to Langara Island caused many delays. Procedures on how to obtain data from Honolulu for Langara via Prince Rupert radio will be prepared after the system has been operational for at least two months.

For the last year, the interrogation of gauging equipment has been tested at several locations, utilizing telex facilities. After receiving the data at a central location, computation and storage is done with the aid of a time sharing computer. So far the results are encouraging. It seems, however, that the mechanical devices employed to record and transmit the data are prone to failure.

For those interested in the operation of the telex system employed, a short description is attached.

Investigations are now under way to utilize the telephone system in connection with metal oxide semiconductors (MOS) and complementary - symmetry metal oxide semiconductors (COSMOS) elements to perform various logic and memory functions for direct access to the digital data recorded.
For warning purposes, data recorded six hours prior to a Tsunami occurrence, and at frequencies of one minute or less thereafter, should be accessible in almost real time.

The data will be available in the four digit metric system with proper time and even identification to the interrogator. During the period of the call, recording of the water level changes should continue without interruption of the selected cycles.

One of the recommendations made by the I.U.G.G. Tsunami Committee at the Moscow meeting in August 1971 was that countries supply tide gauge data obtained during major earthquakes. For some Canadian west coast stations data covering 19 major earthquakes during 1970 have been sent to ITIC. We did not find anything particularly significant, but will send annually selected tide gauge data, collected during major earthquakes, to Honolulu.

Current Tsunami Research

Since the West Coast of Canada has a highly irregular coastline indented with many complex inlets (some having as many as thirty branches), analytical studies are unlikely to be successful. For this reason we have concentrated on numerical methods to model the topography as realistically as possible. The resonance phenomenon has been identified as the primary source of tsunami amplification in the West Coast inlet systems and for this reason our research effort has been concentrated upon understanding, in as much detail as possible, the resonance characteristics of the important inlets.

For long and narrow inlets one-dimensional models have been used and we are starting to look into the resonance problems in wide bays which require a two-dimensional formulation. Using some new techniques developed recently in hydrodynamics the normal modes of a given water body will be computed once and for all, using solely the hydrographic data. Then the response of the system to any forcing, whether it be a tsunami or a storm, can be determined by a suitable combination of the normal modes. Using this technique we hope to look at the response of the Dixon Entrance, Hecate Strait, Queen Charlotte Sound system to incoming tsunamis.

Since after entering an inlet, a tsunami might be transformed somewhat into a bore, we are looking at the general problem of propagation of bores. We have also been working on the question of correct modelling of open boundaries in tsunami problems. One of the very difficult problems in numerical modelling is the treatment of open boundaries and a very clear distinction has to be made between excitation by travelling waves in contradistinction to excitation by standing waves. Finally, we hope to look at the tsunami proneness of our inlet systems in great detail using detailed hydrographic information.

CANADIAN MEMBERS

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Ottawa, April 1972

REAL TIME WATER LEVEL INTERROGATION

For the last few months, Tides and Water Levels at Ottawa has been testing the interrogation of gauging equipment, utilizing telex facilities. Satisfactory results have been obtained and a data file at Dataline's Computer Centre in Toronto is being created.

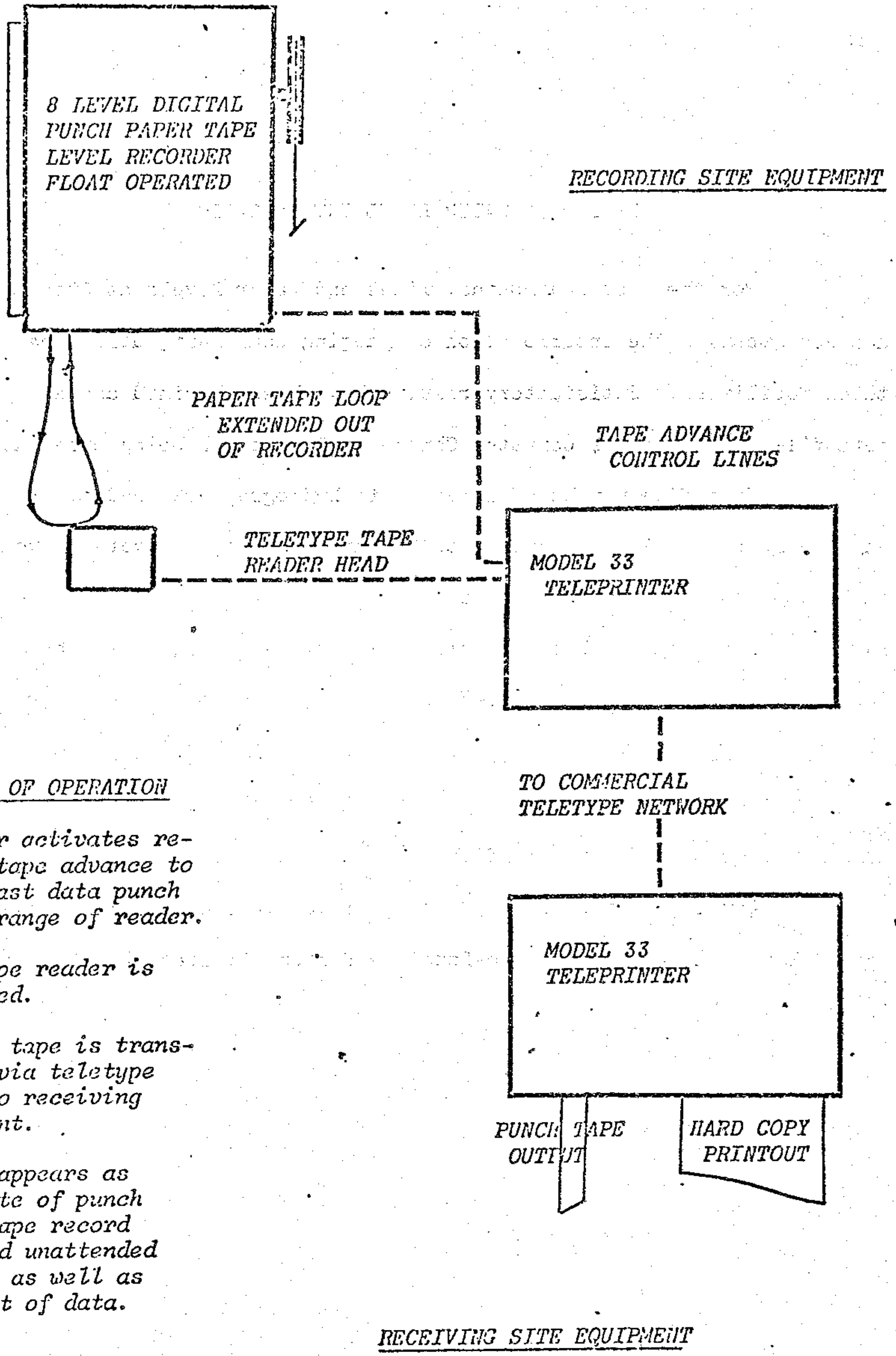
This file may be of interest to hydrographers, hydraulic engineers, power plant operators or scientists to obtain water level data on an almost real time basis.

The attached block diagram illustrates the recording and interrogation system and the computer instructions to obtain water level data from the present Tide and Water Levels file at Toronto.

We could provide more detailed information or give a demonstration here in Ottawa if the system is of interest.

Any information on the rental or services of the required terminal should be addressed to Dataline Systems Limited, 40 St. Claire Street West, Toronto.

Ottawa, November 1971.



METHOD OF OPERATION

1) Operator activates recorder tape advance to bring last data punch within range of reader.

2) Then tape reader is activated.

3) Data on tape is transmitted via teletype lines to receiving equipment.

4) Output appears as duplicate of punch paper tape record gathered unattended on site as well as printout of data.

SAMPLE TELEX LISTING

```
71110508

11860 GODFPICH
0204 0203 0203 0201 0200 0200 0197 0199 0198 0197 0196
0194 0196 0194 0193 0190 0192 0187 0188 $

13030 PTWELLER
0086 0083 0085 0086
0087 0085 0084 0084 0087 0086 0085 0087 0089 0086 0088 0087
0089 0091 0089 0090 0088 0090 0092 0092 $

13320 TOFONTO
0089 0087 0089 0089
0088 0086 0085 0085 0088 0086 0085 0087 0089 0089 0090 0090
0092 0094 0094 0095 0095 0094 0095 0094 $

13590 COBOURG
0088 0088 0088 0088
0088 0088 0088 0087 0086 0085 0087 0088 0087 0087 0088 0088
0088 0089 0089 0090 0099 0090 0089 0090 $

@
13988 KINGSTON
0090 0092 0090 0091
0090 0092 0094 0094 0096 0090 0088 0090 0088 0086 0088 0086
0086 0084 0083 0085 0085 0085 0087 0084 $END
```

SAMPLE COMPUTER OUTPUT

DAILY MEANS

57927 57914 57925 0 0 0 0

MONTHLY MEAN 57940

HIGH EXTREME 7 930 58012 LOW EXTREME 3 8 57871

HOURLY HEIGHTS FOR STATION 13030 STARTING 29 10 71

291071	1312	1312	1308	1308	1312	1308	1312	1308	1312	1315	1315	1315
	1312	1322	1315	1312	1308	1302	1312	1308	1318	1315	1315	1318
301071	1318	1312	1312	1312	1302	1305	1305	1308	1305	1308	1308	1312
	1312	1312	1312	1308	1308	1312	1312	1315	1312	1318	1322	1322
311071	1325	1318	1322	1318	1312	1308	1308	1312	1308	1305	1305	1305
	1312	1308	1302	1302	1302	1299	1299	1295	1299	1289	1295	1302
11171	1305	1305	1299	1302	1302	1312	1305	1299	1299	1302	1308	1308
	1305	1305	1305	1308	1305	1302	1302	1302	1299	1302	1302	1315
21171	1318	1325	1318	1322	1322	1308	1305	1299	1305	1302	1295	1279
	1282	1292	1312	1312	1302	1285	1285	1292	1299	1295	1289	1292
31171	1295	1299	1302	1299	1299	1295	1295	1295	1295	1295	1299	1299
	1295	1295	1295	1295	1285	1282	1279	1282	1282	1292	1295	1289
41171	1285	1299	1299	1292	1285	1285	1285	1282	1282	1272	1279	1282
	1285	1279	1276	1276	1285	1282	1279	1285	1292	1282	1289	1285

DAILY MEANS

24412 24411 24406 0 0 0 0

MONTHLY MEAN 24402

HIGH EXTREME 5 200 24425 LOW EXTREME 7 1005 24372

HOURLY HEIGHTS FOR STATION 13320 STARTING 29 10 71

291071	1318	1318	1315	1312	1305	1305	1315	1318	1318	1322	1322	1318
	1315	1318	1315	1315	1312	1318	1318	1315	1315	1318	1328	1315
301071	1308	1308	1315	1312	1312	1315	1312	1318	1318	1315	1308	1315
	1325	1318	1315	1308	1315	1318	1315	1315	1322	1328	1328	1325
311071	1331	1331	1331	1318	1312	1315	1318	1318	1312	1315	1315	1318
	1322	1322	1318	1312	1308	1305	1308	1308	1295	1302	1302	1295
11171	1299	1302	1302	1299	1305	1305	1302	1299	1305	1305	1308	1308
	1305	1308	1308	1312	1312	1308	1315	1312	1308	1308	1315	1315
21171	1322	1325	1331	1335	1328	1318	1308	1305	1302	1299	1295	1292
	1295	1308	1318	1315	1302	1289	1292	1299	1312	1299	1299	1299
31171	1308	1312	1308	1305	1308	1305	1299	1305	1305	1308	1315	1308
	1308	1308	1305	1295	1292	1289	1282	1285	1295	1305	1302	1299
41171	1295	1305	1302	1302	1299	1295	1292	1292	1292	1285	1292	1292
	1289	1282	1279	1279	1289	1282	1279	1285	1292	1292	1295	1295

TIDES AND WATER LEVELS DATA FILE

This report concerns data stored on DECtape at DATALINE'S computer centre in Toronto. The tape contains hourly heights and daily means from the first of the month up to date. Data for the previous month is retained for a few days after the beginning of the month and then deleted.

The stations for which data is stored are:

03130	Riviere-du-Loup, Que.
03170	St. Jean Port Joli, Que.
11860	Goderich, Ont.
13030	Port Weller, Ont.
13320	Toronto, Ont.
13590	Cobourg, Ont.
13988	Kingston (Portsmouth) Ont.
15520	Montreal, Jetty No. 1, Que.

The following instructions describe how to obtain a terminal listing, printer listing, and/or punched cards containing data from this tape.

The underlined parts of the instructions are not typed by the user, but are responses from the computer.

The ↑C is obtained by holding down the CTRL key and typing C.

The ↙ is not typed. It is used here to designate when the user should depress the RETURN key.

1. Connect terminal to computer by telephone

2. Log into the system, mount DECtape D268, and transfer program PUB to user disk area:

```
↑C
.LOG↲                                                   log into system
JOBi    DATALINE VERS DSLiii
NOTICE.TXT LAST CHANGED time    data
# account number↲
PASSWORD: password↲
time        date        TTYi                            mount DECtape

.R MOUNT↲
*M D268↲
REQUEST ACCEPTED                                        n will be a
*D268 MOUNTED ON DTAn                                   digit from 0
*↑C                                                     to 7

.AS DTAn 13↲                                            assign DECtape
DTAn ASSIGNED                                           unit (in place
                                                        of n use digit
                                                        assigned above)

.R PIP↲
*DSK:/X←13:PUB.REL↲                                     transfer program
*↑C                                                     to user disk area
```

3. Run program PUB

```
.EX PUB↲
LOADING

LOADER 14K CORE
EXECUTION

ENTER STATION NUMBER FOLLOWED BY A CARRIAGE RETURN
NO STATION NUMBER WILL CAUSE ALL STATIONS TO BE PROCESSED
3130↲                                                   (1)

ENTER STATION NUMBER FOLLOWED BY A CARRIAGE RETURN
13030↲

ENTER STATION NUMBER FOLLOWED BY A CARRIAGE RETURN
↲                                                       (2)

ENTER STARTING DATE (YMD) - NO STARTING DATE WILL CAUSE
FIRST DAY OF THE MONTH TO BE ASSUMED                    (3)
↲

ENTER ENDING DATE (YMD) - NO ENDING DATE WILL CAUSE
LAST DAY OF THE MONTH TO BE ASSUMED
711115↲

ANSWER THE FOLLOWING WITH A Y FOR YES OR AN N FOR NO
FOLLOWED BY A CARRIAGE RETURN
```

HOURLY HEIGHTS? (4)

Y↙

TERMINAL OUTPUT?

Y↙

HOURLY HEIGHTS (TYPE II) OR SMALLER INTERVAL (TYPE I) OR BOTH (TYPE B)?
FOLLOW LETTER WITH A CARRIAGE RETURN (5)

H↙

PRINTER OUTPUT?

N↙

CARD OUTPUT?

N↙

PLOTTER OUTPUT? (6)

N↙

DAILY MEANS? (7)

Y↙

TERMINAL OUTPUT?

Y↙

PRINTER OUTPUT?

N↙

CARD OUTPUT?

N↙

PLOTTER OUTPUT?

N↙

any terminal output

EXIT

Note: (1) If no station number is entered here (i.e. (just a ↙), all stations will be processed. It is not advisable to do this at this time.

(2) By entering just a ↙ here the user tells the program he has entered all the stations he wishes data for.

(3) By entering just a ↙ here the user tells the program that the data he wants begins at the first day of the month.

(4) If N↙ is entered here, no hourly heights are desired and all questions up to DAILY MEANS? will be omitted.

(5) If N↙ were entered in response to TERMINAL OUTPUT? this question is omitted.

(6) No plotter output is available at present.

(7) If N↙ is entered here, no daily means are desired and the remaining questions are omitted.

4. Dismount the DECtape

```
.R MOUNT
*F↙
DTAn DISMOUNT REQUESTED
*D268 DISMOUNT
*↑C
```

5. If printer or card output was requested, it can be obtained as follows: Otherwise, proceed to 6.

```
.R PRINT↙
*HHLIS.DAT/F/D↙          Hourly height listing
*DMLIS.DAT/F/D↙          Daily mean listing
*↑C
```

```
.R PUNCH↙
*HHCDS.DAT/D↙            Hourly height cards
*DMCDS.DAT/D↙            Daily mean cards
```

6. Log off the system

```
.KJOB↙
CONFIRM:K↙
```

log out information

IOC/ITSU-III/3
Annex V (b)

JAPANESE NATIONAL REPORT

TSUNAMI WARNING SERVICE AND ITS SYSTEM IN JAPAN

Prepared for

Third Session of
the International Coordination Group
for the Tsunami Warning System in the Pacific

Tokyo, Japan
8-12 May, 1972

the Japan Meteorological Agency
Ote-machi, Chiyoda-ku, Tokyo

TSUNAMI WARNING SERVICE AND ITS SYSTEM IN JAPAN

The tsunami warning service in Japan started on April 1, 1952. It took about two years for preparation after the authorization by the Cabinet Council on Dec. 2, 1949. The service gained the first success for the tsunami caused by the Tokachi-oki earthquake of 1952. Since then the service had been operating principally against the tsunamis occurring near the Japan Islands until the Chilean Tsunami of 1960 which brought Japan extensive damage. The service was, therefore, reinforced and improved from the international point of view.

1. System in the JMA

The Tsunami Warning Service in Japan consists of three parts: 1) tsunami forecast system, 2) dissemination system to transmit forecast messages to coasts, 3) terminal system to evacuate the people rapidly on receiving warnings. The first part is operated exclusively by the Japan Meteorological Agency (JMA), the second by a number of civil and public organizations and the third, by local autonomies.

The system for tsunami warning in the JMA is composed of seismic monitoring stations, tidal monitoring stations and analysis centers. The communication between seismic or tidal stations and centers are maintained through the JMA exclusive lines and public telephone lines. If the landline is broken, wireless communication system will be ready to operate.

The JMA system is operated by special regulations.

1.1 Tsunami analysis centers and divisions of coasts

The entire coast of Japan is devided into 17 divisions, for which five Regional Tsunami Centers are assigned them as shown in Fig. 1.

When a tsunami originates in a distant ocean farther than 600 km from the Japanese coasts, the Headquaters of JMA (Tokyo) is responsible for its analysis as the National Center. Whereas near tsunamis are analysed by the Regional Centers. The Regional Centers are in District Meteorological Observatories (DMO) under the JMA except for Tokyo DMO, in place of which JMA Headquater (JMAH) performs the work.

For the tsunami work, two persons are always on duty in the office of the seismological section in JMAH and at least one in the observation section in each DMO.

Consolidated training for Tsunami Warning System is made once or twice a year in each DMO.

1.2 Seismic Monitoring stations

Seismic observation is made in 106 weather stations under the JMA. Four stations of Okinawa will join JMA netwark on May 15, 1972. Sixty nine stations of them are specifically designed to make additional observation necessary for the warning against tsunamis from near earthquakes. They are called "seismic-stations for tsunami warning". Similar additional observation for distant earthquakes is also made by 13 selected stations among them. They are called "teleseismic-stations for tsunami

warning". All the stations (106) are devided into five groups belonging to each tsunami center.

Exact locations of these stations are given in Table 1 together with the list of seismographs. Their standard response curves are shown in Fig. 2.

Whenever an earthquake is felt, a seismic station interprets prompty the record of seismograph and dispaches the results by telegram to its Center. This telegram is called "seismo-telegram".

Seismic-stations for tsunami warning should dispaches the special seismo-telegram, 1) when the staff of the station feels earthquake stronger than IV in the JMA Intensity Scale (see Table 2) or 2) when the record of strong motion seismograph ($V=1$, $T_H=6$ sec, $T_V=5$ sec) exceeds 5 mm in double amplitude. This telegraphic report is called "seismo-telegram for tsunami warning" and consists of two parts. First report should be sent within five minutes after the shock reporting intensity and P-time, and second one within ten minutes reporting all available informations. The telegram is sent with the top priority.

The station designated for distant earthquakes must send the reading data to JMAH by telegram when an earthquake occurred farther than 60 sec in S-P time and the trace amplitude by a special seismograph of 10 sec period exceeds a certain level. This kind of telegram is called "seismo-telegram for distant tsunami warning".

The distribution of these stations is shown in Fig. 3, classified by several different kinds of seismograph. The principal seismograph of the system is the Strong Motion Seismograph (notation S in Table 1) which is installed in all stations and used for measuring amplitudes necessary for determining the magnitude of large shocks.

In order to report P- and S-times necessary to locate epicenters, seismographs with a magnification of about 100 are used. The principal seismograph is of electromagnetic type (notation VI or VI' in Table 1). All seismographs used for warning service employ visual recordings of ink-writing or smoked papers. Urgent reading is made without removing the records from the recorder.

Telemetered seismic observation system with magnetic tape recording has been developed in order to locate earthquakes in and near Japan as quickly as possible for the purpose of tsunami warning. These stations are shown in Fig. 4, which includes the installation plan. Data from 4 stations are telemetered to each Tsunami Regional Center for the immediate location of regional earthquakes. The monitor recorder and alarm bell start in addition to the tape recorder when the vectorically composed horizontal amplitude exceeds a pre-set triggering level, 10 to 30 microns, depending on each station.

By the telemetering system, a visible recorder (visigraph) at the Tsunami Regional Center writes simultaneously the same signals which appear on the monitor recorder at each station. Accordingly, in each Tsunami Regional Center, the analog seismic signals sent from 4 subordinate stations can be seen. In each station, the non-linearly compressed "velocity" is written on the monitor for easier identification of P-time. However, in the Tsunami Regional Center, the identification of S-time is also important for an immediate location work, and the horizontal components are restored back to linear quantity and integrated to obtain "displacement". The recording is made dually through high sensitivity ($\times 100$) and low sensitivity ($\times 10$) channels to ensure a large dynamic range. The vertical component, however, is written only as non-linearly compressed quantity for easier identification of P-time.

In the case of large earthquakes an immediate estimation of the epicental region can be made simply from these monitor recorders.

1.3 Code for seismo-telegram

We have two kinds of codes each being in use for reports by the seismic-station for tsunami warning and the teleseismic-station for tsunami warning.

ヒゼウ
iiiY'Y' $X_1h_eh_em_em_e$ $s_es_e(t_1t_1t_1)$ $(4X_2bbX_3)$ $(A_1A_1A_1$ ミリ)」 O'_bO_b'
ジシン
iiiY'Y' $X_1h_eh_em_em_e$ $s_es_et_1t_1t_1$ $4X_2bbX_3$ $A_2A_2A_2A_2A_2$」 エンチ」 $O_b'O_b'$

where parentheses are omitted in the first report,

ヒゼウ : Emergency (datum code, in Japanese)
ジシン : Earthquake (datum code, in Japanese)
iii : International station number
X_1 : The JMA Intensity Scale of Earthquake (see Table 2)
$Y'Y'h_eh_em_em_es_es_e$: Day, hour, minute and second of commencement time of P-phase
$t_1t_1t_1$: S-P time in second
X_2bb : Sense and direction of the initial motion (see remarks)
$A_1A_1A_1$ ミリ : Double amplitude of maximum ground motion in mm (ミリ; in Japanese) multiplied by the station factor
$A_2A_2A_2A_2A_2$: Double amplitude of maximum ground motion in micron with station factor
エンチ : Distant earthquake (in Japanese)
$O_b'O_b'$: Abbreviation of seismic-station
X_3 : Remarks

Remarks

X_2	3	8	/
Vertical motion	(+)	(−)	unknown

bb	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16
Azimuth	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NWN	N

X_3	Remarks
0	No remark
1	iP, iS
2	iP, eS
3	eP, eS
4	eP, iS
5	Local earthquake type
6	Spindle shape type
7	Deep earthquake type
8	ScS is recorded.
9	Period of maximum amplitude being longer than 1/3 minutes by eye-measurement

1.4 Tidal monitoring stations

Under the JMA, 53 tide-gauge stations are operating. They are distributed in Fig. 5. Most of them are equipped with Fuess type recorders, and some of them, with pressure type recorders.

Because of the distance between the weather station and the tide-gauge site and also of the danger which threatens an observer at the time of tsunami, 11 tide-gauge stations along the Pacific coast of Japan are equipped with telemetering device which enable them to watch the behaviour of the sea surface at their own stations. The staff members read the record of the height of peaks or troughs of the wave from the datum level and telegraph the coded data to the Regional and National Centers. The state of the sea surface in every moment is very important also to cancell an already issued tsunami warning, when it becomes unnecessary any longer.

The code used by the tsunami stations for the report of tsunami observation is as follows:

i) In case of commencement of tsunami,

ヒゼツ

iiiY'Y'G'G'g'g'vv$H_TH_TH_T$」ツナミカンソク」$O_b'O_b'$

where

Y'Y'G'G'g'g' : Day, hour and minute of arrival time of tsunami

vv : Peak or trough

$H_TH_TH_T$; Height of water level from the datum line in cm.
One thousand is added if $H_TH_TH_T$ has minus sign.

ツナミカンソク : Tsunami observation (in Japanese)

Other symbols have the same meaning as those of the seismo-telegrams.

ii) In case of peak and trough of tsunami,

サイスモツナミカンソク

iiiY'Y'G'G'g'g'vv$H_TH_TH_T$」記事」NN」$O_b'O_b'$

サイスモツナミカンソク : Seismo-tsunami observation (datum code, in Japanese)

記事 : Remarks (in Japanese)

NN : Number in series

Other symbols have the same meaning as those of the seismo-telegrams.

2. Function of the tsunami center

When the alarm bell starts or the Regional Center receives a seismo-telegram, the Regional Center immediately begins its activity. The process of analysis is as follows: 1) location of epicenter, 2) determination of grade magnitude of tsunami and 3) determination of warning message. These works in the Regional Center including the delivery of warning message to the dissemination centers should be completed within 20 minutes after the occurrence of an earthquake.

2.1 Location of epicenter

The data indispensable to locate the epicenter of earthquakes are the P-times and S-P times. A nomogram for obtaining epicentral distance from S-P time is provided, which is based upon Wadati-Masuda travel time table. First some focal depth is assumed to the shock, say 40 km, and, making use of the nomogram, circles as many as the number of messages from the reporting stations are drawn on a blank map with centers at their locations. The epicenter is located at the point where these circles intersect each other most densely. When the intersection points of these circle are not dense enough, the same process is repeated assuming another depth until satisfactory results are obtained. The epicenter and depth can, in this way, be estimated simultaneously. The epicenter thus obtained is checked by the iso-P lines which are drawn from P times. The directions of initial motions are also useful for the check of the result obtained by other methods. Especially, in the case of large earthquakes, S-P data often lose their value or location of epicenter, owing to falses S reading, and iso-P lines and directions of initial motion must inevitably be used.

2.2 Determination of the grade magnitude of tsunami

The grade magnitude of tsunami, for the practical use of warning, is devided into three grades: 1) major tsunami, 2) minor tsunami and 3) no tsunami.

On the tsunami forecasting chart, the amplitudes reported in "seismo-telegram" are entered against their respective epicentral distance obtained during the process of 2.1 (see Fig. 6). From the

pattern of the distribution of observed points, an estimation of the magnitude of the shock can be made. If the magnitude of the shock falls between 7.0 and 7.8 in Richter scale, then a tsunami of small scale is assumed to occur and if it is greater than 7.8, a tsunami of large scale is assumed to occur.

It is of course desirable to take into consideration the effect of focal depth and earthquake mechanism of the shock. No time, however, can be spared to distinguished a little difference in depths less than 20 km or to pay attention to its mechanism, as far as the analysis work is manually done. It is necessary for us to automate the process of the present analysis in order to improve the Tsunami Warning Service both in rapidity and accuracy.

2.3 Determination of warning message

In determining the message of tsunami warning to be publicly announced, the following method is employed.

When a major tsunami is expected as a result of analysis on the forecasting chart, "a major tsunami" is issued to the coastal division nearest the epicenter and "a minor tsunami", to its adjacent divisions. When "a minor tsunami" is issued to the nearest coast of the epicenter, "no tsunami" is issued to the adjacent divisions.

Five degrees of messages for tsunami forecast, including those already mentioned above, are employed as shown in the following. The height of tsunami means the maximum height of peak measured from the usual tide level.

1 No tsunami — None or almost imperceptible.

2 Fear of tsunami — Tsunami is predicted but its magnitude is uncertain.

3 Minor tsunami — No damage or slight damage. Height of tsunami is generally us to several tens centimeters (up to 2 meters in the worst places).

4 Major tsunami — More serious than the above. Height of tsunami is generally up to 1 meter (up to 3 meters in the worst places).

5 Cancellation of warning — No more danger.

The code by which a message of tsunami forecast is sent to the dissimination centers are as follows:

a) When it is sent by telegram,
"Forecast message, number of the coastal division, number of coastal division, ——".

b) When it is sent by telephone,
"Number of coastal division, number of coastal division, ——, forecast message."

c) When a warning announcement is made by radio or television,
the epicentral region and numerically coded message are given to broadcasting stations to avoid misinterpretation.

When the maximum seismic intensities observed at the coastal stations do not exceed II and no tsunami is obvious, the announcement of "no tsunami" will not be given.

While the warning is effective, the Regional Center makes regular announcements of information on the earthquake, tsunami and damage until the cancellation of warning is issued.

3. Dissemination of warnings

The code of tsunami forecast prepared at the Regional Center is sent to the dissemination centers either by telephone or telegram and relayed to the coasts. The names of dissemination centers are as follows:

a) The NHK (Japan Broadcasting Corporation) Broadcasting Station

b) The Nippon Telegraph and Telephone Public Corporation

c) The Japan National Railways

d) The Maritime Safety Agency

e) The National Poice Agency and Prefectual Police.

Whenever a Regional Center issues a tsunami forecast, the contents of forecast must be informed to the following organizations:

a) The weather stations under the control of the center

b) The Japan Meteorological Agency

c) The other organizations designated by the director of the Center.

On receiving the tsunami warning code from one or more Regional Centers, the JMA transmits the contents to the following organizations:

a) The Ministry of Transportation

b) The Central Disaster Prevention Committee

c) Other organizations designated by the Director-General of JMA.

The offices of villages, towns or cities along the coast which have received tsunami warning message by telephone, telegraph, radio or television etc., should inform the people of it by fire bells or sirens.

Cancellation message is transmitted through the same route as in the case of warning to each coastal division.

It is generally seen that autonomies of coastal regions, where tsunami was frequently attacked in the past, perform regularly the training of evacuation of people against future tsunamis on a memorial day of past large tsunami.

4. Warning service for distant tsunami

As stated before, the warning for the tsunami which originates farther than 600 km the coast of Japan, is handled by the National Center. When a large shock occurs somewhere at a great distance and the seismo-telegram for distant tsunami warning comes to the Center from the teleseismic-stations, the National Center starts locating epicenter and estimating magnitude. On the other hand, the Center immediately establishes connection with the Tsunami Warning Center at Honolulu Observatory by sending seismic data of Matsushiro Observatory and requests data of their side.

Against distant tsunamis such as from Kamchatka, Aleutian or Chile, our Tsunami Warning System depends largely on the information from the stations around the Pacific coasts mostly coming through the Honolulu Observatory, the NOAA-NOS, the Tsunami Warning Center in the Pacific. (Fig. 7)

When the tsunami is observed in Japan, mareographic data of at least Hachinohe and Tosa-shimizu are to be sent to the Tsunami Warning Center at Honolulu Observatory.

USSR started the broadcast of tsunami warning in English from Khabarovsk since October in 1963. Messages from Khabarovsk via MRS (Meteorological Regional Circuit) is relayed automatically to Honolulu and Palmer by the ADESS since April of 1972, and all messages headed by TSUNAMI are relayed automatically to Khabarovsk, tentatively. These data are vitally important for warning against tsunamis originating in the northern Pacific.

Present status of international tsunami warning service at the JMA is as follows.

4.1 Determination of the epicenter of distant earthquake

a) For areas covering the Kurile Islands, Kamchatka Peninsula and the Aleutian Islands, the

epicenter has been located satisfactorily by the S-P circle method using the data from Japanese stations as well as those from College, Palmer, Sitka, Honolulu, etc. and the stereo-chart projected from the globe of 20 cm diameter. Iso-P difference lines among Matsushiro, College and Honolulu drawn on the globe of 45 cm diameter or on the stereo-chart have been also in use. (Fig. 8)

b) For areas covering the southern seas of Japan, the epicenter is usually located by the S-P circle method centering Guam, Hong Kong and other stations in Japan on the stereo-charts or iso-P difference lines among Matsushiro, Hong Kong and Shillong.

4.2 Criteria for the issuance of tsunami warnings

When it is clear that the earthquake has occurred under the ocean and its magnitude is more than 8 in Richter scale, the "Fear of tsunami" is issued. The message goes through the same route as in the case of near tsunami. Besides, the NHK nation-wide broadcast is used for dissemination.

After a warning is issued, information on the tsunami is announced regularly through radio and television. Distant tsunamis allow a plenty of time before the arrival unlike near tsunamis, and the broadcast of information becomes an important part of the warning service. The contents of the information are, a) forecast of arrival time of tsunami, b) estimation of wave height, c) the actual state observed at coasts of foreign countries reported from the Tsunami Warning Center at Honolulu Observatory, d) the actual state at the Japanese coasts, e) the countermeasure to be taken against the coming tsunami.

Several kinds of refraction diagrams (Fig. 9) are used to estimate arrival time of tsunami at places of the northern, middle and southern parts of the Pacific coasts of Japan. The information is sure to include an estimation of time delay of the occurrence of maximum wave from the first arrival of tsunami.

If there is no report of tsunami with wave height of more than 50 cm after 2-3 hours from the arrival of first tsunami, the warning is usually cancelled. However, it is cautioned that the oscillation of the sea water may continue two or three days, and the people interested in sea shore industry should watch the motion of sea surface even after the cancellation.

4.3 Issuance and dissemination of tsunami warnings

Any tsunami warning issued to the coasts of Japan and seismograph reports collected from Japanese stations are sent to Honolulu and Palmer together with the information of epicenter and tsunami, if observed. If it is likely to affect as far as Hong Kong, the warning will be sent there.

Table 1. List of JMA stations and their seismographs

Station	λ	φ	Height	Seismographs
			m	
●Abashiri	E144°17.0′	N44°01.0′	38	S, VI, OP
●Aikawa	138 14.5	38 01.2	34	S, VI, EMT
Ajiro	139 05.8	35 02.6	59	S, VI, EMT′
●Akita	140 06.1	39 43.1	9	S, VI, EMT′
Anabuki	134 10.2	34 02.5	57	S, P
⊙●Aomori	140 47.0	40 49.0	4	S, EMT
●Asahikawa	142 22.4	43 46.2	111	S, VI, EMT′
●Ashizuri	133 01.0	32 43.0	30	S, VI
Asosan	131 04.5	32 52.7	1143	S, P
Chichibu	139 04.9	35 59.5	218	S, P
●Choshi	140 50.6	35 43.5	27	S, EMT′
●Fukue	128 50.0	32 42.0	26	S, VI
●Fukui	136 13.6	36 03.2	9	S, VI
⊙●Fukuoka	130 22.8	33 34.8	2	S, VI, VD
●Fukushima	140 28.5	37 45.4	67	S, VI, OP
Gifu	136 45.9	35 23.9	13	S, W, EMT
⊙●Hachijojima	139 47.3	33 06.1	80	S, VI
●Hachinohe	141 31.6	40 31.5	27	S, VI, EMT
●Hakodate	140 45.5	41 48.8	35	S, VI, OP
●Hamada	132 04.4	34 53.6	18	S, VI, OP
●Hamamatsu	137 43.4	34 42.5	32	S, VI, EMT
Hikone	136 14.8	35 16.4	87	S, EMT
Himeji	134 42.1	34 50.2	37	S, P
Hiroo	143 19.0	42 17.0	32	S, P
⊙●Hiroshima	132 26.2	34 21.8	29	S, W
●Iida	137 50.1	35 30.6	482	S, VI, EMT
Irozaki	138 50.8	34 36.0	55	S
Ishinomaki	141 18.2	38 25.5	43	S, VI, EMT
●Izuhara	129 17.7	34 12.2	21	S, P
⊙●Kagoshima	130 33.2	31 34.4	4	S, VI
Kakioka	140 11.6	36 13.9	27	S, W
●Kanazawa	136 38.9	36 32.8	27	S, VI, EMT
Karuizawa	138 33.1	36 20.4	999	S, P
Kawaguchiko	138 45.8	35 29.9	860	S, P
Kobe	135 10.8	34 41.3	58	S, P
●Kochi	133 32.0	33 33.0	40	S, P
●Kofu	138 33.5	35 39.9	272	S, VI
Kumagaya	139 23.1	36 08.8	30	S, VI, EMT
●Kumamoto	130 42.6	32 48.6	38	S, EMT′
⊙●Kushiro	144 23.7	42 58.7	33	S, VI, EMT
●Kyoto	135 44.1	35 00.7	41	S, VI, OP
●Maebashi	139 03.9	36 24.1	112	S, EMT′
●Maizuru	135 23.2	35 28.3	31	S, EMT′
Matsue	133 04.3	35 27.3	17	S, P
Matsumoto	137 58.4	36 14.6	610	S, P
⊙ Matsushiro	138 12.5	36 32.3	440	AW, B, L, WW, V
●Matsuyama	132 46.8	33 50.4	32	S, W
Mishima	138 55.8	35 06.7	20	S, W
●Mito	140 28.3	36 22.7	30	S, VI, EMT′
●Miyako	141 58.1	39 38.7	46	S, EMT, VD
●Miyazaki	131 25.6	31 55.0	7	S, VI, EMT
●Morioka	141 10.0	39 41.8	155	S, VI, EMT′
Muroran	140 59.0	42 19.0	43	S, P
●Murotomisaki	134 10.7	33 14.9	185	S, VI, OP
●Nagano	138 11.8	36 39.6	418	S, VI
⊙●Nagasaki	129 52.2	32 43.9	27	S, VD, EMT′
●Nagoya	136 58.1	35 09.9	52	S, VI, OP
Nara	135 50.0	34 41.0	105	S, EMT′
⊙●Nemuro	145 35.2	43 19.7	26	S, VI, VD, OP
●Niigata	139 03.1	37 54.6	2	S, VI, EMT
Nobeoka	131 41.0	32 35.0	19	S, EMT′
●Obihiro	143 13.3	42 55.2	39	S, EMT′
●Ofunato	141 43.1	39 03.7	38	S, VI, EMT′
●Oita	131 37.4	33 14.0	5	S, EMT′
●Okayama	133 54.9	34 40.9	4	S, VI, EMT′
Omaezaki	138 12.8	34 36.2	45	S, P
●Onahama	140 54.4	36 56.7	3	S, VI, EMT
⊙●Osaka	135 31.3	34 40.7	13	S, VI

Station	λ	φ	Height	Seismographs
			m	
●Oshima	E 139°22.7′	N34°45.7′	191	S, W
●Owase	136 11.7	34 04.0	14	S, VI, EMT
●Rumoi	141 38.0	43 57.0	22	S, P
Saga	130 18.3	33 14.7	4	S, P
●Saigo	133 20.0	36 12.3	26	S, VI, OP
●Sakata	139 50.8	38 54.4	3	S, EMT
⊙●Sapporo	141 19.5	43 03.5	17	S, VI, EMT
⊙●Sendai	140 54.0	38 15.6	38	S, VI, S*
●Shimonoseki	130 56.5	33 57.2	46	S, VI, EMT
●Shionomisaki	135 45.8	33 26.9	74	S, W, EMT
Shirakawa	140 13.5	37 07.1	354	S, EMT
●Shizuoka	138 24.4	34 58.4	14	S, VI, EMT
Sumoto	134 54.5	34 20.1	109	S, EMT
●Suttsu	140 14.4	42 47.4	16	S, EMT′
Takada	138 15.0	37 06.3	13	S, VI
●Takamatsu	134 03.5	34 19.0	10	S, W
Takayasuyama	135 39.6	34 36.7	472	VD′
Takayama	137 15.3	36 09.1	561	S, EMT
●Tanegashima	131 00.0	30 44.0	17	S, VI
●Tateyama	139 52.1	34 59.0	6	S, VI, EMT
●Tokushima	134 34.6	34 03.9	2	S, P
⊙●Tokyo	139 45.5	35 41.2	21	S, VI′, VD′, I′, J′
●Tottori	134 10.7	35 30.7	17	S, EMT′
●Toyama	137 12.5	36 42.4	9	S, VI
Toyooka	134 49.5	35 32.0	4	S, W
Tsu	136 31.1	34 42.1	3	S, P
Tsuruga	136 03.9	35 39.0	1	S, P
Unzendake	130 15.2	32 44.1	849	S
●Urakawa	142 46.8	42 09.5	30	S, VI, EMT′
●Utsunomiya	139 52.3	36 32.6	120	S, EMT
Uwajima	132 33.5	33 13.5	43	S, P
●Wajima	136 53.9	37 23.4	6	S, VI, EMT
●Wakayama	135 10.0	34 13.6	14	S, VI
●Wakkanai	141 40.4	45 25.0	90	S, VI, OP
Yamagata	140 21.0	33 15.2	151	S, EMT′
Yokohama	139 39.3	35 26.2	38	S, EMT
●Yonago	133 20.6	35 26.0	7	S, P
Ishigakijima	124 10	24 20	6	S, VI
Naha	127 41	26 13	11	S, VI
Miyakojima	125 17	24 47	40	S, VI
Yonagunjima	123 01	24 28	32	P
(Mori	140 34.5	42 06.3	12	S)
(Tomakomai	141 35	42 38	8	P)

Notations:—

λ	:	Longitude
φ	:	Latitude
S	:	Strong motion seismograph (magnification; 1)
S*	:	do (magnification; 0.4)
P	:	Portable seismograph
W	:	Wiechert type seismograph
VI	:	JMA 59-type electromagnetic seismograph with visible recorder
VD	:	JMA 61-type electromagnetic seismograph with visible recorder
OP	:	JMA 59-type electromagnetic seismograph with optical recorder
EMT	:	Electromagnetic seismograph with magnetic tape recorder
EMT′	:	Electromagnetic seismograph with magnetic tape recorder and transmitting unit
VI′, VD′, I′, J′	:	JMA 63-type seismograph
AW	:	Anderson-Wood seismograph
B	:	Benioff seismograph L: Long period, S: Short period
L	:	Long period seismograph with magnetic tape recorder H: High gain, L: Low gain
V	:	Short period vertical seismograph
WW	:	World-wide standard seismograph L: Long period, S: Short period
( )	:	Stations which send data only by request from the Center.
●	:	Seismic-stations for the tsunami warning
⊙	:	Teleseismic-stations for the tsunami warning

Table 2. The JMA Intensity Scale of Earthquake

Rating Number	Adiectival Description	Descriptive Remarks
0	No Feeling	Shocks too weak to cause human feelings and registered only by seismographs.
I	Slight	Extremely feeble shocks only felt by persons at rest or by those who are observant to earthquakes.
II	Weak	Shocks felt by most persons, slight shaking of doors and Japanese latticed sliding doors (Shoji).
III	Rather Strong	Slight shaking of houses and buildings, rattling of doors and Japanese latticed sliding doors (Shoji), swinging of hanging objects like electric lamps, moving of liquids in vessels.
IV	Strong	Strong shaking of houses and buildings, overturning of unstable objects, spilling of liquids out of vessels.
V	Very Strong	Cracks in walls, overturning of gravestones, stone lanterns, etc., damage to chimneys and mud-and-plaster warehouses.
VI	Disastrous	Demolition of houses by less than 30% in total number, land-slips, fissures in the ground etc.
VII	Very Disastrous	Demolition of houses by more than 30%, intense landslips, large fissures in the ground, faults.

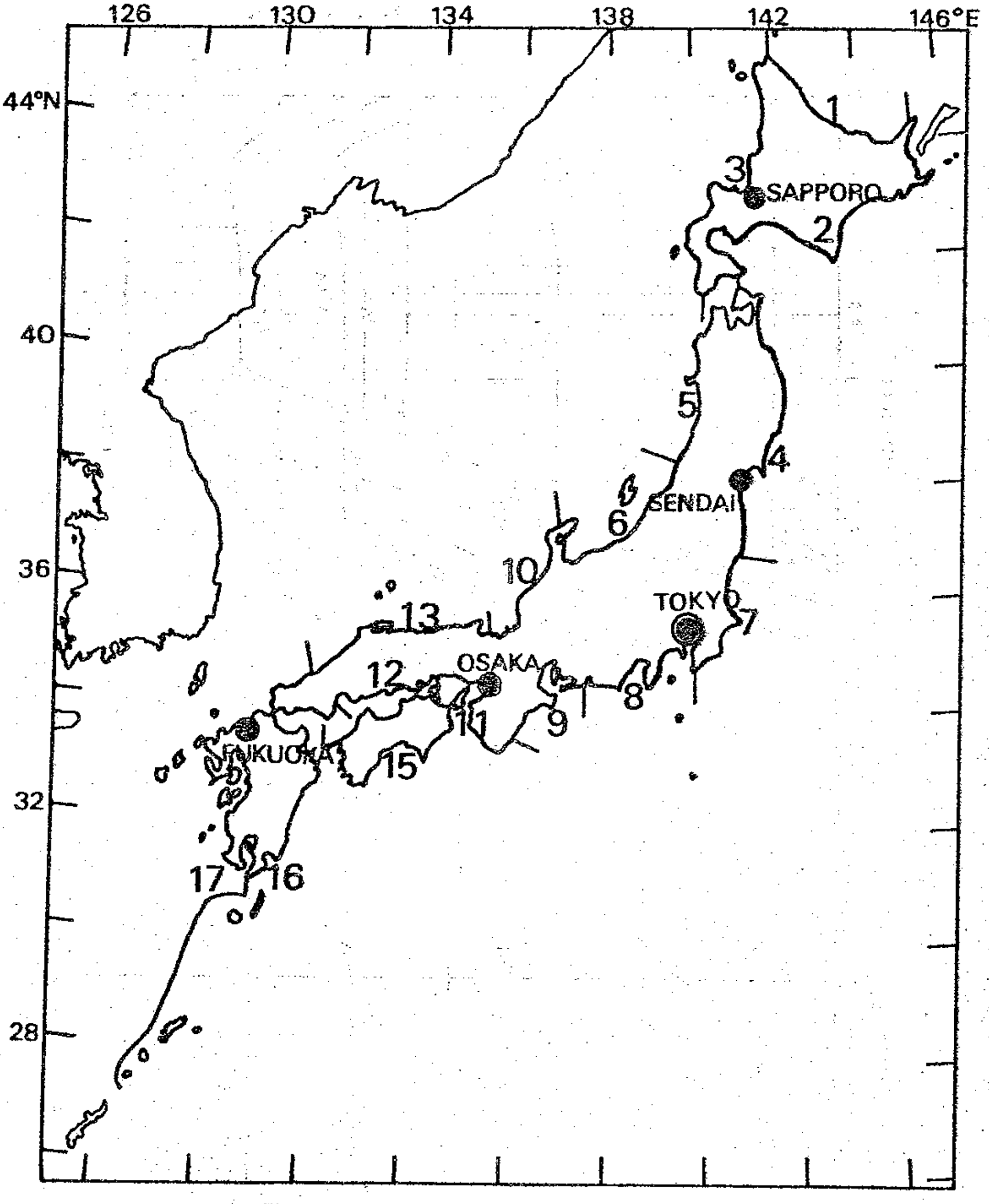


Fig. 1 Network for Tsunami Forecast of the JMA.

Numbers in the follows show the divisions of coasts assigned to respective Tsunami Centers.

center	coast
SAPPORO	1, 2, 3
SENDAI	4, 5
TOKYO	6, 7, 8, 9, 10
OSAKA	11, 12, 13, 14, 15
FUKOUKA	16, 17

Closed circles show the Regional Tsunami Centers and a double circle shows the National Tsunami Center,

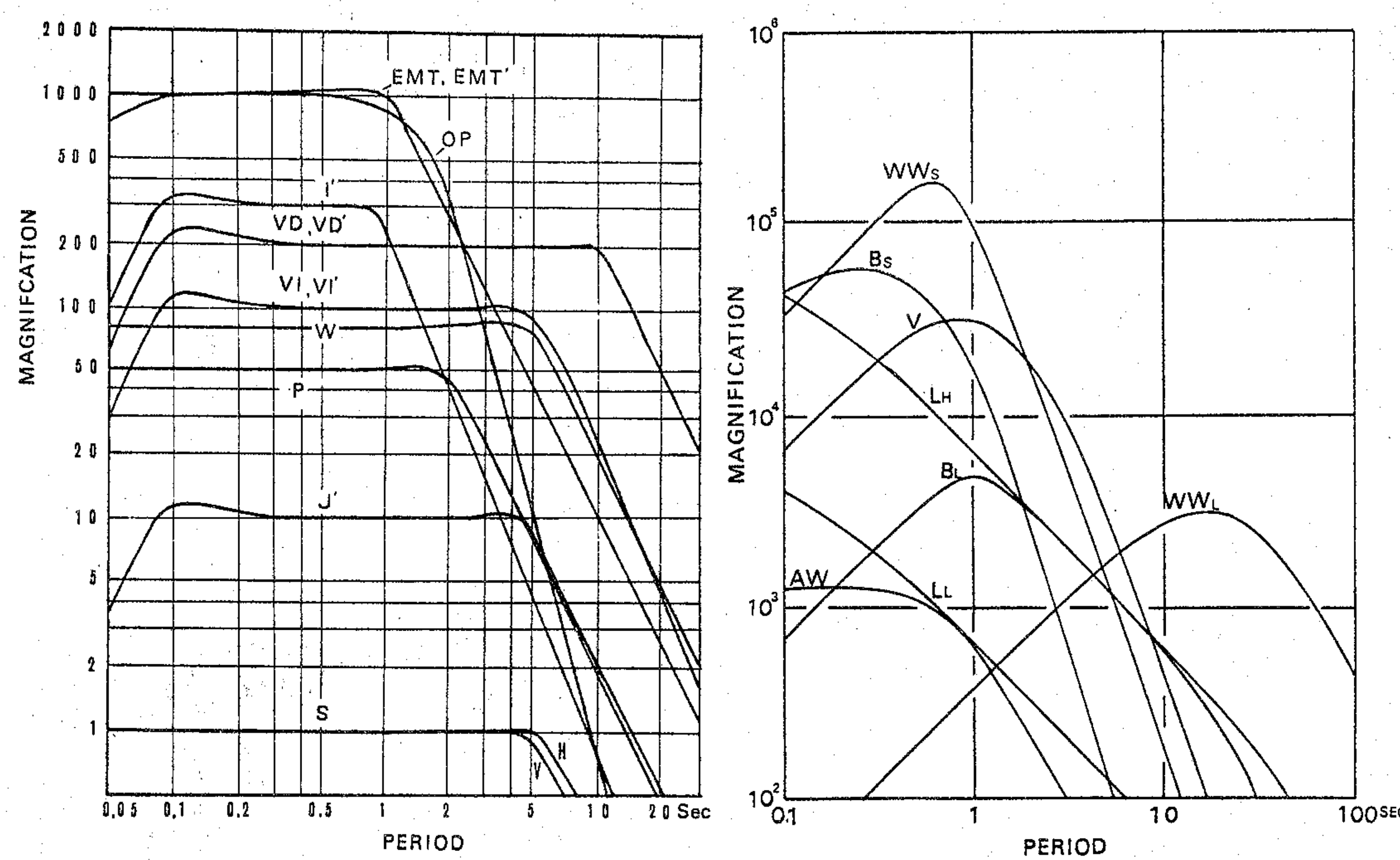


Fig. 2 Standard Response Curve of Seismographs shown in ~~Fig.~~ 1.

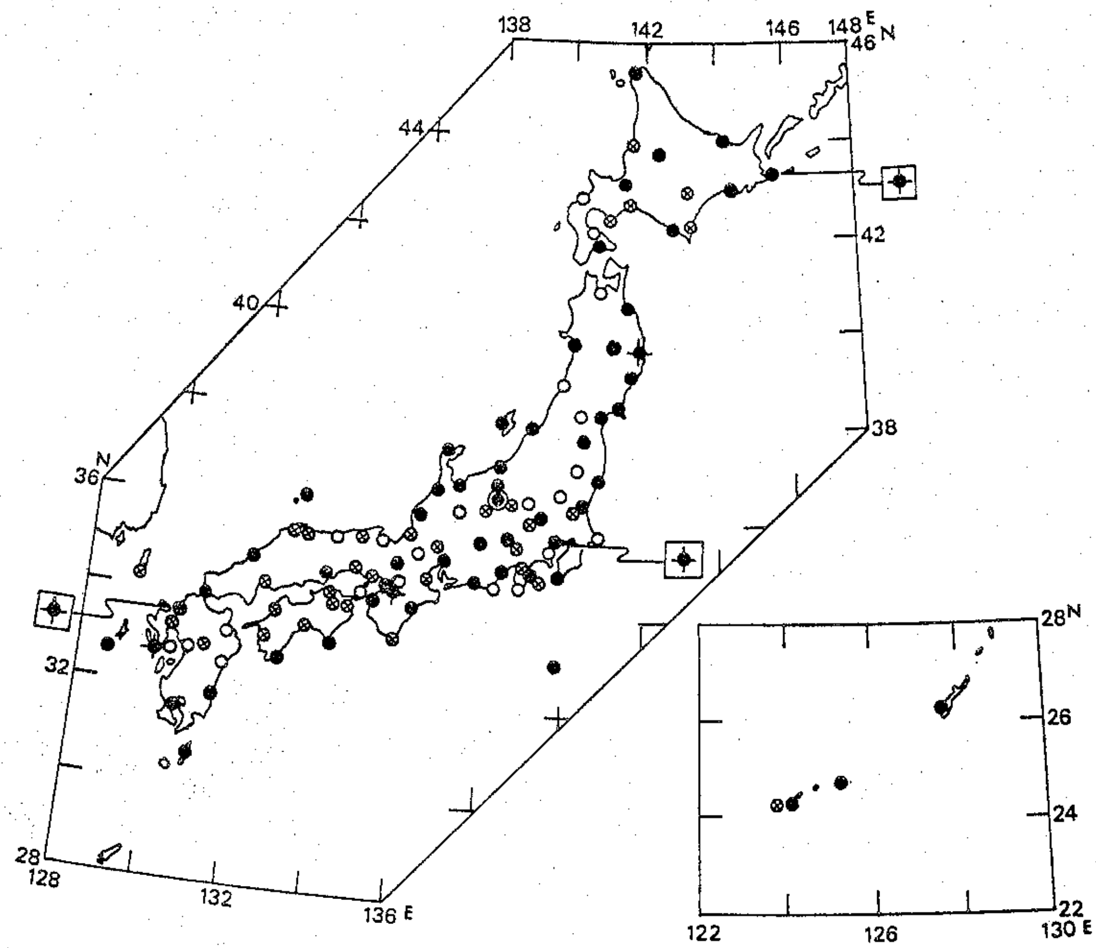
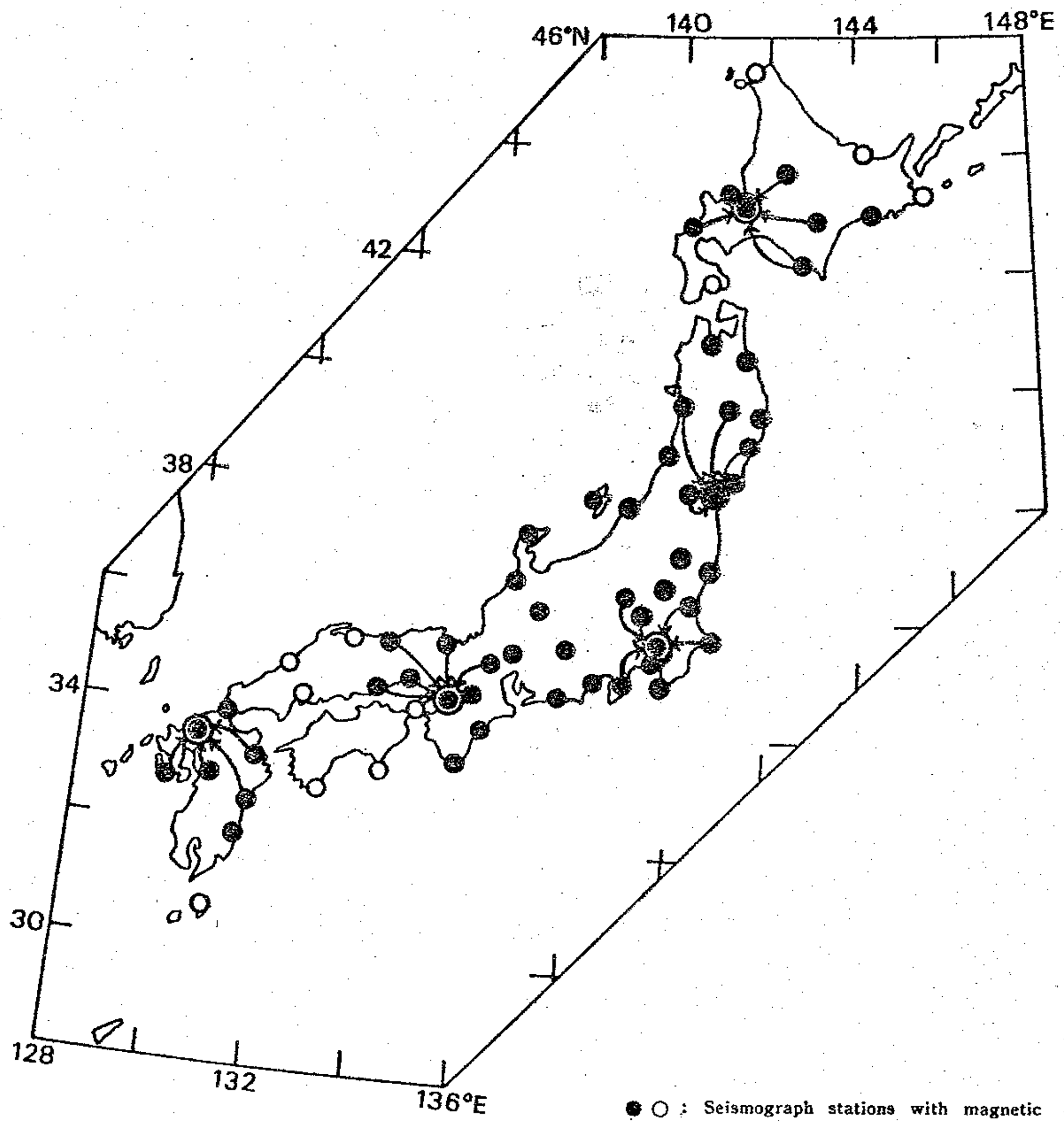


Fig. 3 Seismic Monitoring Station.

● : Stations with JMA-59 type electromagnetic seismograph (T_0=5 sec)
◆ : Stations with JMA-61 type electromagnetic seismograph (T_0=10 sec)
⊗ : Stations with Wiechert type and portable seismograph
○ : Stations with other seismograph



● ○ : Seismograph stations with magnetic tape recording

⊙ : Regional Tsunami Centers

●→⊙: Telemetering stations with magnetic tape recording

DEPLOYMENT PLAN

●→⊙ ●: Completed by March, 1972

○ : Scheduled to complete by March, 1973

Fig. 4 Installation Plan of Telemetered and Non-telemetered Seismic Observation System with Magnetic Tape Recording at the JMA.

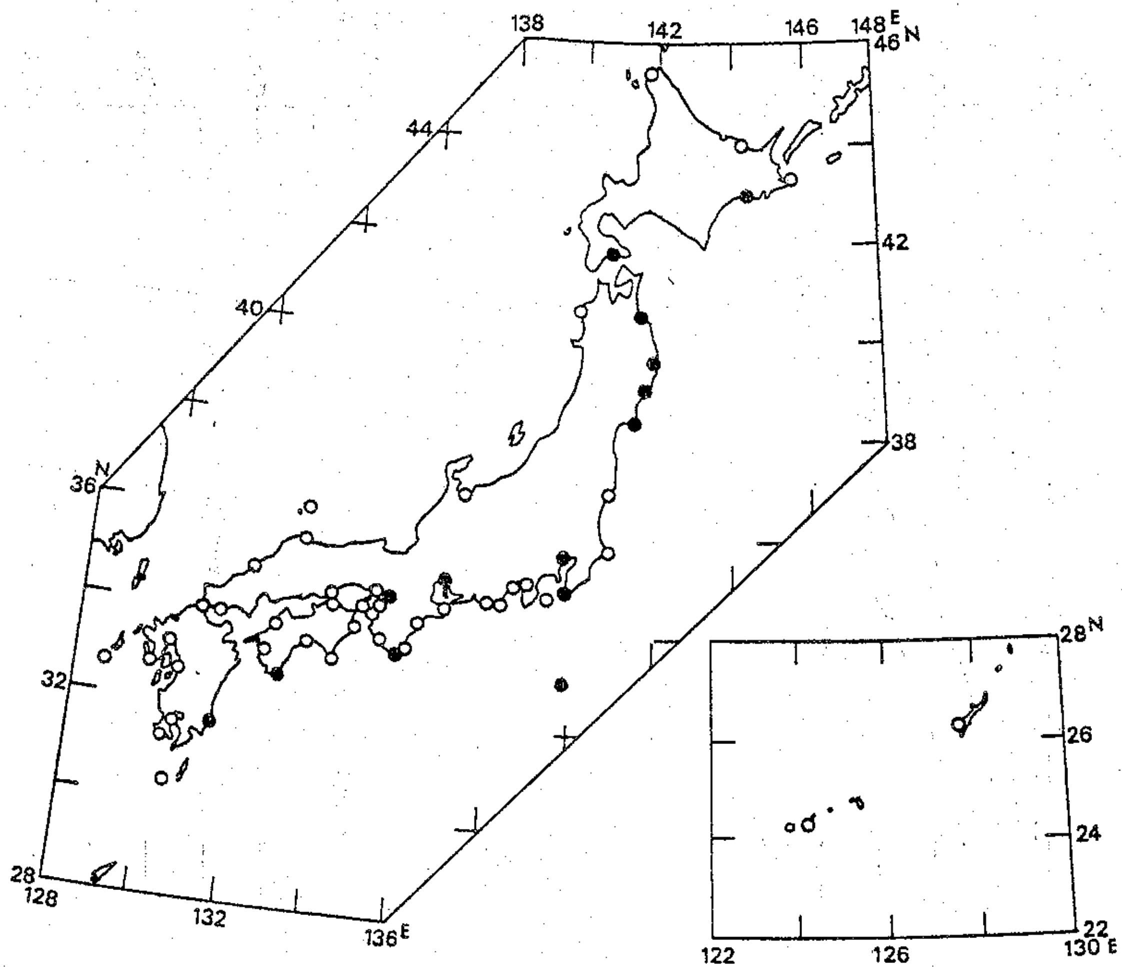


Fig. 5 JMA Tide-gauge Stations.

Closed circles show tide-gauge stations with telemetering system and open circles ones without it.

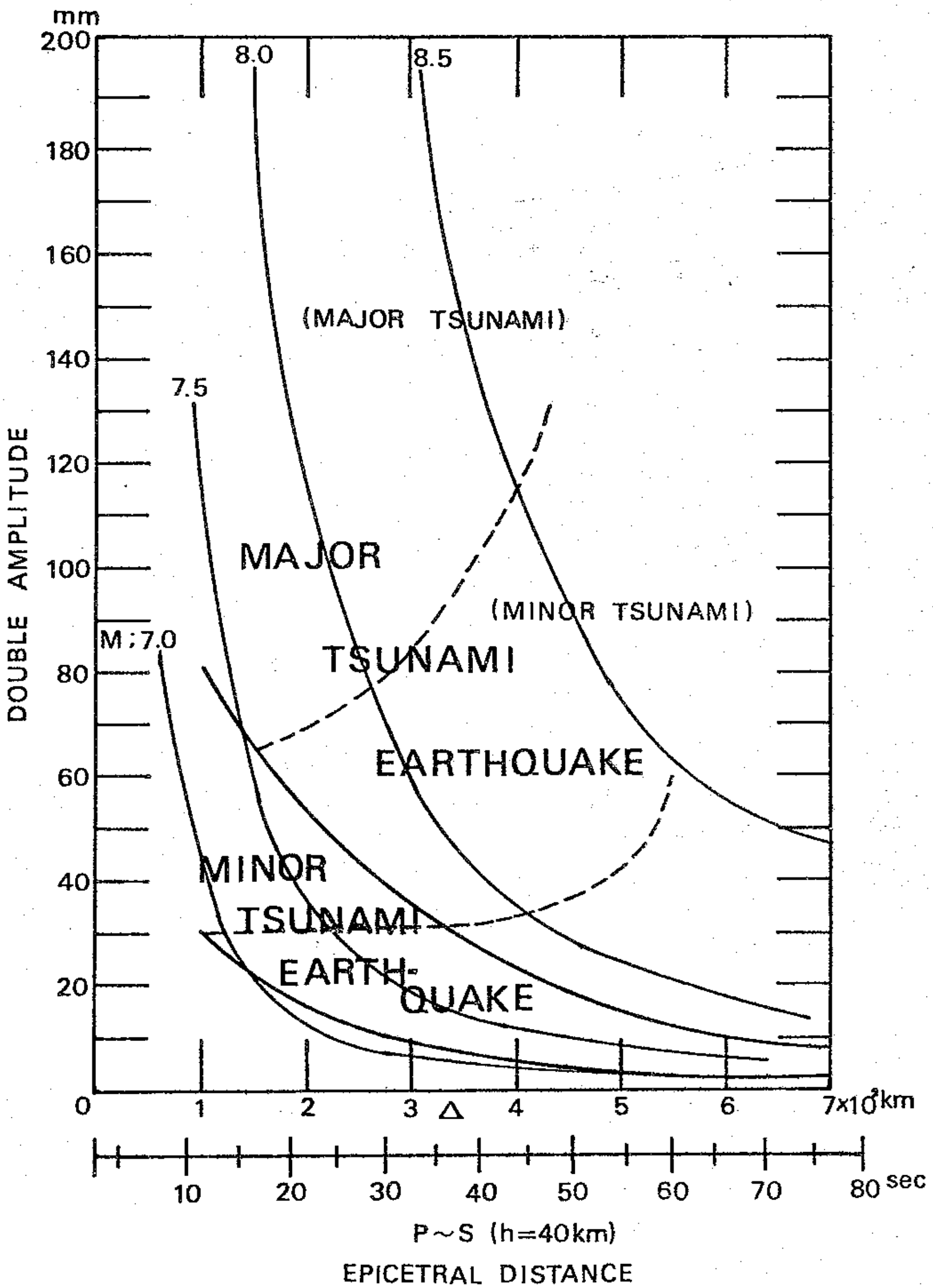


Fig. 6 Tsunami Forcasting Chart of JMA.

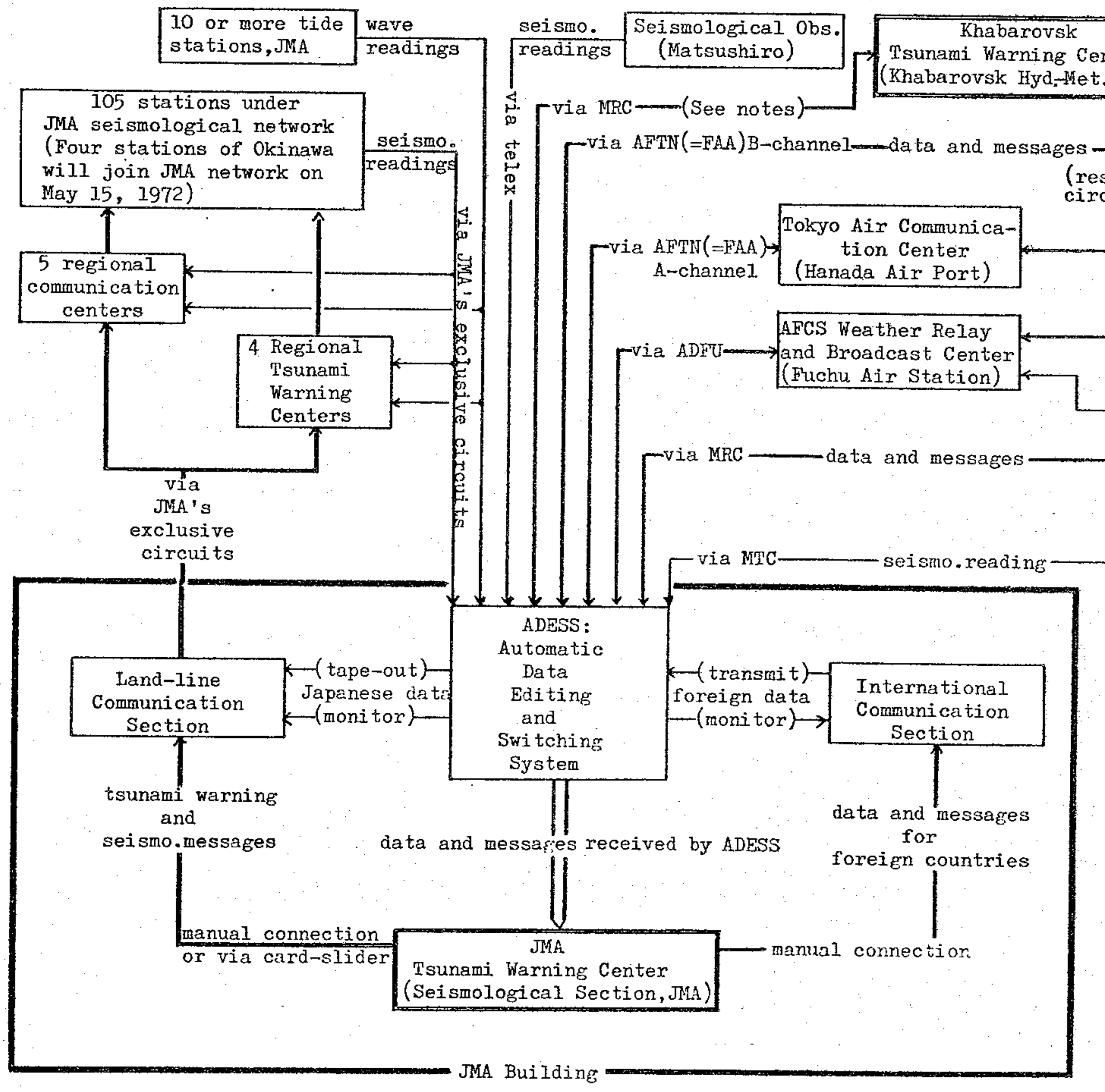
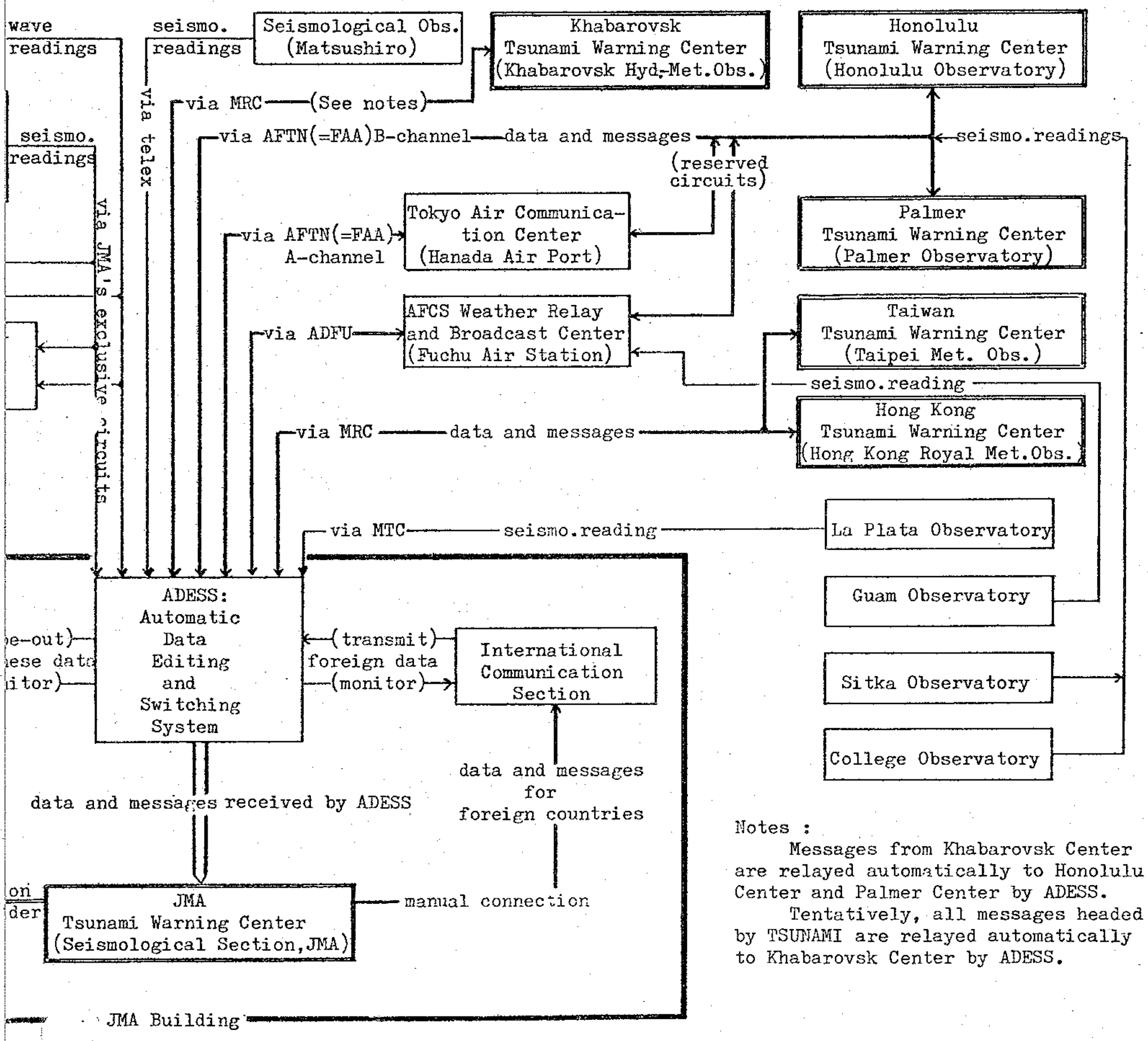


Fig. 7 Block Diagram of JMA Communication Circuits for Tsunami Warning System



Notes :

Messages from Khabarovsk Center are relayed automatically to Honolulu Center and Palmer Center by ADESS.

Tentatively, all messages headed by TSUNAMI are relayed automatically to Khabarovsk Center by ADESS.

Fig. 7 Block Diagram of JMA Communication Circuits for Tsunami Warning System.

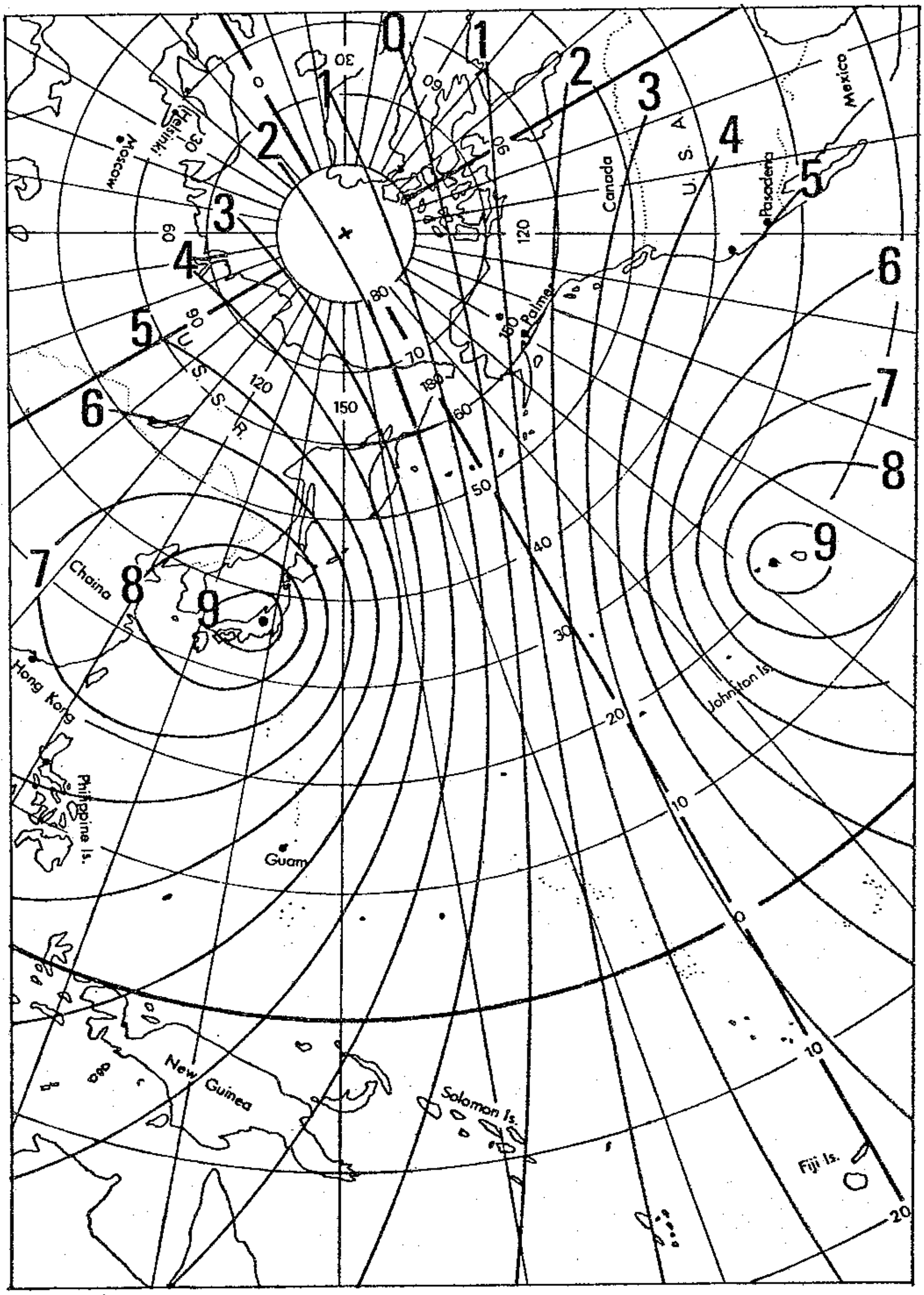


Fig. 8 ISO-P Time Difference Curve between Matsushiro and Honolulu.
Numbers show minutes.

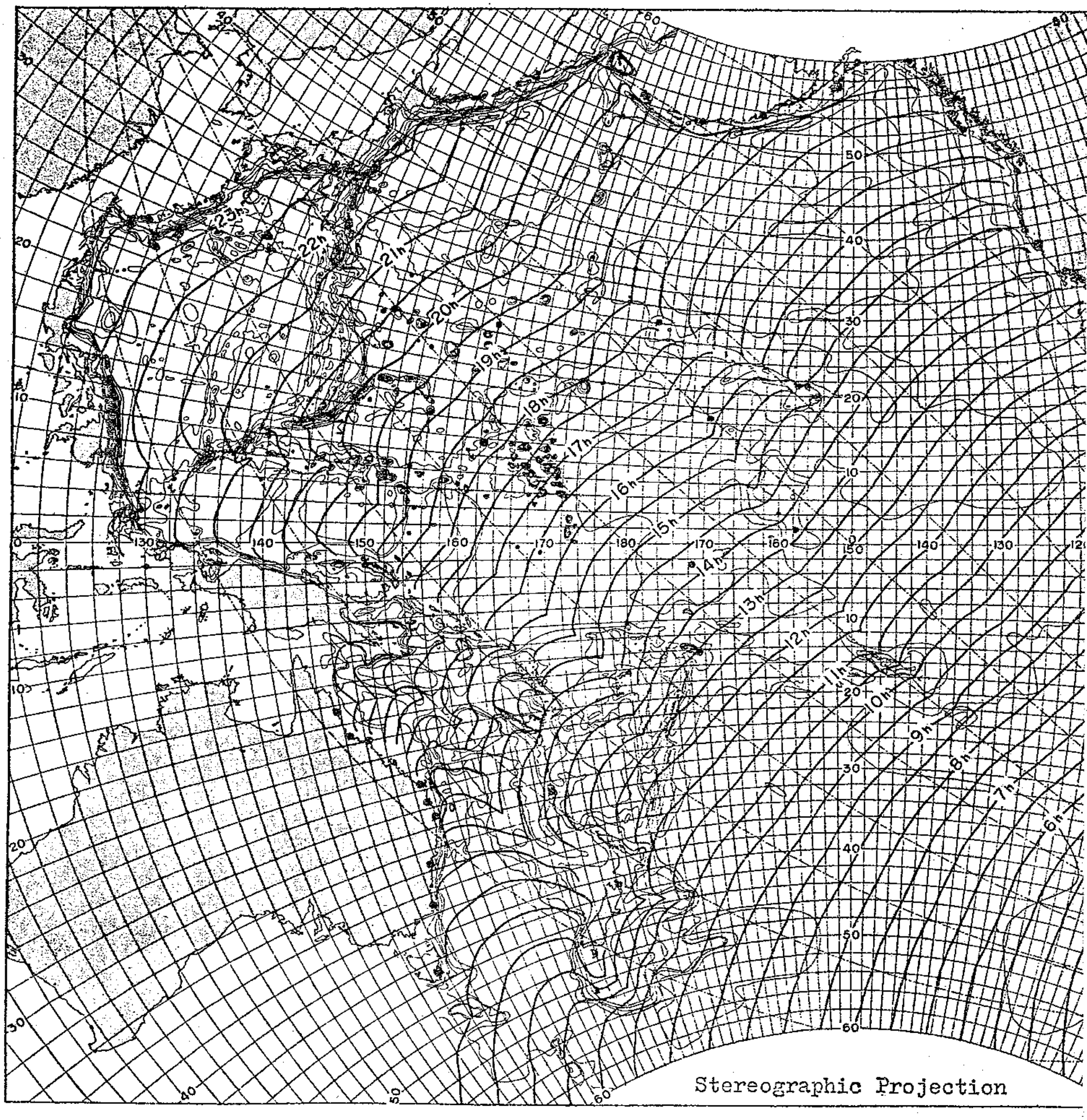


Fig. 9 The Refraction Diagram of the Chilean Tsunami of May 22, 1960.

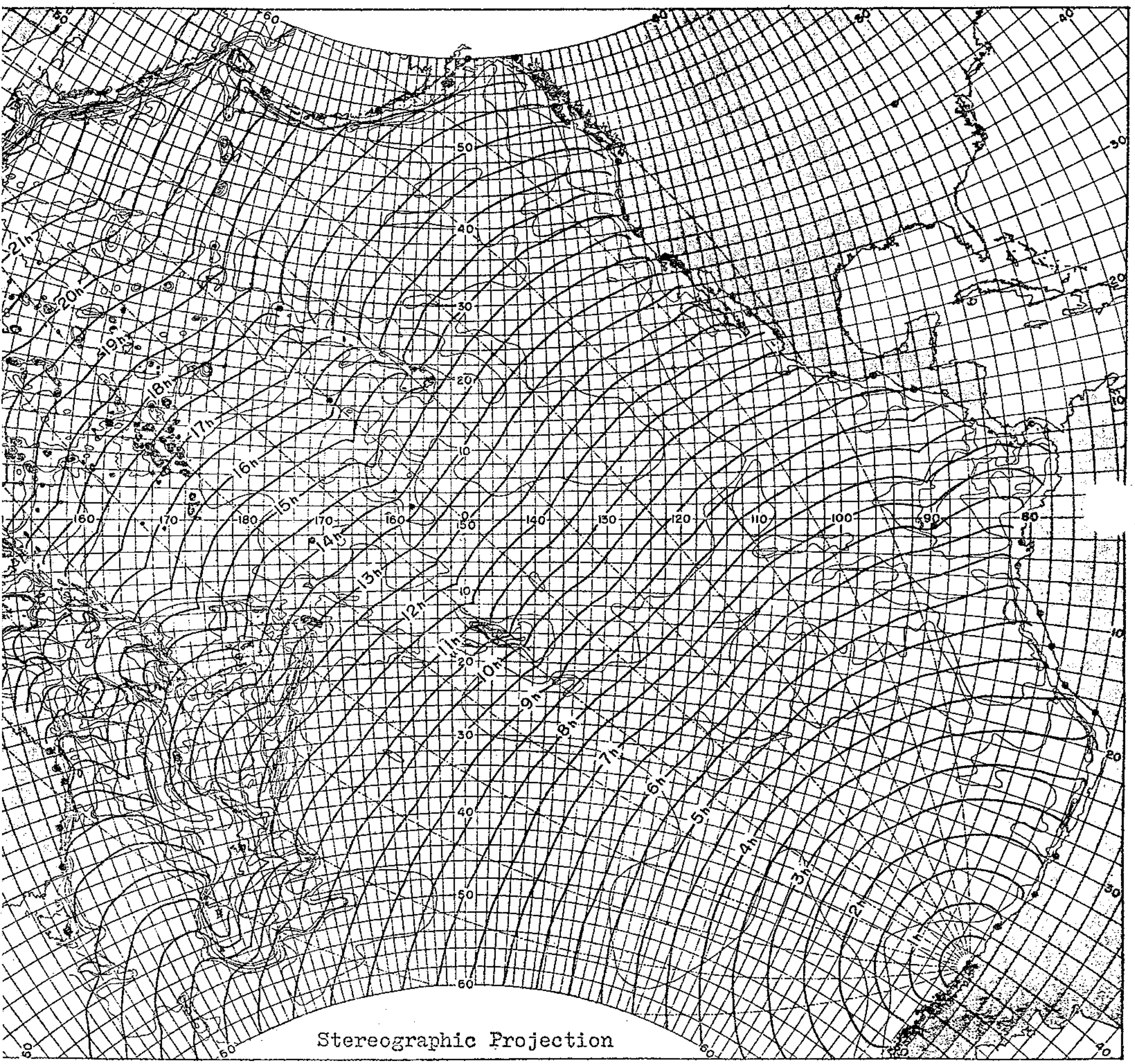


Fig. 9 The Refraction Diagram of the Chilean Tsunami of May 22, 1960.

UNITED STATES NATIONAL REPORT

TSUNAMI WARNING SYSTEM

Prepared for the

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Acknowledgement is also made of contributions from other national and state agencies.

UNITED STATES NATIONAL REPORT
TSUNAMI WARNING SYSTEM

I. REVIEW OF PROGRESS RELATED TO MAY 1970 ICG RECOMMENDATIONS

A. Recommendation on Equipment

IOC Circular Letter No. 303 dated June 22, 1970, solicited information from Members of the ICG as to the availability of seismic and sea level recording equipment to other participating countries for use in the Tsunami Warning System.

Canada responded to this letter by offering ten Foxboro pressure-type tide gauges to any participating countries which expressed an interest in operating such gauges. The ITIC was assigned responsibility for the final disposition of the instruments.

Since the last ICG meeting, the United States has provided, on indefinite loan, additional remote recording tide gauge equipment and visual recording seismograph systems to several countries. The tide gauge instruments were installed in Peru and Chile while the seismic systems were installed in Hong Kong, the Philippines, Western Samoa, Fiji, and New Zealand.

B. Recommendation on ICG Participation

On September 14, 1970, the Acting Secretary of the IOC distributed a circular letter to all Member States of the Pacific Region who were not members of the ICG inviting them to participate in the work of the Group. The circular letters were sent to Australia, Colombia, Indonesia, Malaysia, Mexico, Panama, Peru, Singapore, and Thailand.

As a result of the invitations, Peru and Thailand accepted membership in the ICG. Colombia and Panama have indicated some interest in joining the Group while Mexico declined the invitation.

Following are the other members of the ICG : Canada, Chile, China, Ecuador, France, Guatemala, Japan, Korea, New Zealand, Philippines, U.S.A., and U.S.S.R.

C. Recommendation on Seismic and Tide Station Network

This recommendation proposed that the ITIC compile a list of seismic and tide stations which would form an expanded network designed to offer greater protection to Member States from tsunamis generated either close or distant from their coasts.

Such a list has been distributed by the ITIC to each Member State so they will have the opportunity to study the proposed locations and make appropriate recommendations at the 1972 ICG Meeting. Those countries which do not expect to have representatives at this meeting were encouraged to send their comments to the Chairman, ICG.

D. Recommendation on Tsunami Data Reporting

The recommended procedures to be used by tide observers in reporting tsunami data were made available to all participating stations in December 1970 when the United States distributed a revised version of the publication, "Wave Reporting Procedures for Tide Observers in the Tsunami Warning System."

Since then there have been only a few small tsunamis reported to the Warning Center. In reviewing these reports, it was noted that all stations did report wave heights in metric units. However several stations failed to follow the recommended format of reporting the initial amplitude and subsequent maximum wave heights at regular intervals.

E. Recommendation on Telecommunications

In July 1970, the Chairman sent letters to all National Coordinators requesting information on each Nation's telecommunication requirements and plans. The information was requested so that the Chairman could respond to certain questions raised at the 3rd Meeting of the Joint WMO/IOC Group of Experts on Telecommunications in May 1970.

The replies submitted by the Group members indicated that they were not yet in a position to supply details on the use of telecommunications for the Pacific TWS.

In viewing the situation with regard to telecommunication requirements in the TWS, it should be noted that the Joint Group of Experts has approved certain frequencies for tsunami warning purposes as quoted below from the report of their second meeting :

> "The Group felt that it should make interim arrangements for the collection of initial data for warning purposes (e.g., tsunami, hazardous weather phenomena, etc.). Since these data will have to be transmitted on a non-scheduled basis, it was felt that the lowest assignable frequency in each of the six allocated bands should be reserved for the collection of these data exclusively. The occupied band widths for these transmissions should be as small as possible and preferably should not exceed 100 hz."

The Chairman believes that, until more detailed requirements are expressed, these frequencies will be adequate for regional transmission of seismic or sea level data pertinent to tsunami warnings.

For long range transmission of data and warnings in the Pacific TWS, the United States expects to launch a communications satellite in 1973 which will have the capability of relaying telemetered data to the Warning Center from distances of about 8,000 kilometers. About 100 channels will be available for emergency use in the 401.850 MHZ to 402.00 MHZ range.

F. Recommendation on Communication Tests

In accordance with Recommendation Number 6, arrangements were made through the ITIC for a test transmission from Khabarovsk to Honolulu and Tokyo. The test was conducted on September 16, 1970, using direct radioteletype. Khabarovsk used three transmitters in the test. From 0200 GMT to 0205 GMT, Kharbarovsk transmitted on the following frequencies : 4516.7 khz, 9230 khz, and 1437 khz. After a 10 minute intermission, Khabarovsk broadcast from 0215 GMT to 0200 GMT on the following frequencies : 6830 khz, 12253 khz, and 19275 khz. Honolulu reported

good reception at only the two highest frequencies. No signals were received at the two lowest frequencies and reception was poor for the two intermediate frequencies. Tokyo had good reception on 6830 khz and did not monitor the other frequencies.

G. Recommendation on Communication Tests

In accordance with Recommendation Number 7, communication tests were carried out between Honolulu, Tokyo, and Khabarovsk, testing both direct broadcast and point-to-point transmission over existing teletype circuits operated for meteorological or other purposes.

There were two direct broadcasts made from Khabarovsk in addition to the one on September 16, 1970.

The first one, on March 15, 1971, was transmitted on the following frequencies : 3995 khz, 5885 khz, 8130 khz, 12295 khz, 16080 khz, and 21750 khz. Honolulu reported no signal received on the first three frequencies, fair reception on the next, and good reception on the last two. The report from Tokyo did not mention the first two frequencies and reported good reception on the last four.

The second Khabarovsk test was run on September 15, 1971, and used the same frequencies except that 16080 khz was replaced by 16010 khz. No signal was received by Honolulu on the first two frequencies, the reception on the next three was fair to good with voice and CW interference, and reception was good on the last frequency. Tokyo did not report results of this test to the ITIC.

Three test broadcasts were also made from Honolulu. All three used the same six frequencies: 4163 khz, 6245 khz, 8328.5 khz, 12480 khz, 16637 khz, and 22161 khz. These are the frequencies recommended by the Joint WMO/IOC Group of Experts on Telecommunications for use in tsunami transmissions.

In the first test, on December 15, 1970, Tokyo reported no signal on the first three frequencies, fair to good reception on the fourth, very good reception

on the fifth, and good reception on the sixth. The broadcast was reported to have been received in Khabarovsk, but no details on frequency reception were made available to the ITIC. In a test on June 17, 1971, Honolulu missed the scheduled broadcast time for the first, third, and fifth frequencies. No report was received from Tokyo or Khabarovsk on whether the other three frequencies were received. In another test, on December 15, 1971, Tokyo reported no signal on the first three frequencies, fair reception the fourth, good reception on the fifth, and very good reception on the sixth frequency. No report was received from Khavarovsk.

All broadcast tests were conducted between the hours of 0200 and 0220 GMT.

Four tests were initiated by the ITIC utilizing existing teletype circuits between Honolulu Observatory and Japan Meteorological Agency, and between JMA and the Hydrometeorological Service in Khabarovsk. Khabarovsk responded to all four tests and round trip times were as follows : June 16, 1970, 1 hr. 10 min.; December 4, 1970, 2 hr. 25 min.; March 16, 1971, 6 hr. 12 min.; and June 22, 1971, 1 hr. 16 min.

Since the Khabarovsk filing time was reported to the ITIC only on the December 4 test, this is the only test in which the actual communication time can be separated from the in-station delays. On this occasion, the actual two-way transmission time was 43 minutes.

II. NATIONAL TSUNAMI WARNING CENTER

A. Watch and Warning Actions 1970-1972

Although no major tsunami activity has occurred in the Pacific Ocean during the past two years, the NTWC has issued several Tsunami Watch Bulletins for earthquakes that could have generated destructive waves. Following is a tabulation of these events :

Date	Epicentral Region	Earthquake Magnitude	NTWC Action
5/31/70	Peru	7.8	Watch
6/24/70	Queen Charlotte Is.	7.0	Watch (Palmer)
1/10/71	West New Guinea	8.1	Watch
5/2/71	Aleutian Is.	7.1	Watch
7/14/71	New Ireland Region	7.9	Watch
7/26/71	New Ireland Region	7.9	Watch
12/15/71	Kamchatka	7.8	Watch

The NTWC now issues Watch and Warning information to 34 U.S. civilian and military agencies. In addition, through the mechanism of the International Tsunami Information Center, dissemination is made to 13 Pacific countries and territories.

B. Improvements at the National Tsunami Warning Center

The new instrument console at the NTWC designed to meet the requirements of both the Hawaiian Regional Tsunami Warning System and International System has been in operation approximately two years. This console includes improved amplifiers and recorders for seismic and tidal data. All experimentation, adjustments and operational developments have been completed on the long period seismograph system and on the short period quadripartite seismograph system based on the island of Oahu. A regional warning system being developed by the University of Hawaii which involves radio telemetry of short period seismic and tide data from the other islands in Hawaii is not complete although the recording equipment, as noted above, is ready.

The long period seismograph system peaks at 20 second period and records on helicorders at three magnification levels - 1000, 100 and 10. Magnitude calculations are readily made for Ms, using appropriate surface wave peak to peak scalings and tables corresponding to the three calibrated gains.

The Oahu quadripartite network provides approximate azimuths from real time arrivals on helicorders or from the combined film presentation on the develocorder. This system also provides coverage of local earthquakes.

The Tsunami Warning System and all Geophysical Observatories of NOAA were placed under the direction of the Environmental Research Laboratories headquartered in Boulder, Colorado, effective July 1971. Administrative changes included the assignment of the duties of Director, National Tsunami Warning Center to the Chief of the Honolulu Observatory, a position which is not subject to a scheduled rotation. This will increase overall efficiency as all functions of this former position were carried out from data collected at the Observatory.

C. New Stations in the Pacific TWS

Since May 1970, the Pacific Tsunami Warning System has continued to expand the number of participating seismograph and tide stations as shown in the following listing:

Seismograph Station	Date Joined TWS
Easter Island	June 1970
Wellington, N.Z.	March 1971
Nandi, Fiji	August 1971

Tide Station	Date Joined TWS
Marsden Port, N.Z.	June 1970
Baltra Island, Galapagos Is.	June 1970
Manzanillo, Mexico	Jaunuary 1971

Yap Island	January 1971
White Beach, Okinawa	March 1971

These additional stations have provided directional control for earthquake epicenter determinations and the possibility of earlier tsunami dectection and reporting. Communications for several of the stations are not satisfactory; however, efforts are continuing to reduce delays in transmission times. Regular tests of communication circuits are conducted to identify and eliminate sources of breakdown or message mishandling. Alternate circuits are also explored.

D. Hawaii Warning System (HAWAS)

HAWAS (Hawaii Warning System) is a new emergency communication system linking key elements of State, County and Federal Government for more rapid dissemination of attack warning and other emergency conditions including the transmission of tsunami watches and warnings, severe weather conditions, and reports on downed aircraft. HAWAS operates in accordance with the - "STATE OF HAWAII PLAN FOR EMERGENCY PREPAREDNESS".

The system is a full-period, four wire, private-line, voice circuit, authorized and funded by the Federal Government, and installed and maintained by Hawaiian Telephone Company.

The following locations are interconnected to provide simultaneous - 'voice-loudspeaker-intercom' - dissemination to all points critical to warning and emergency relay of information to subordinate government agencies, key officials and the public.

1. 362 Air Division, Oahu.

2. State Civil Defense Emergency Operating Center, Birkhimer Tunnel.

3. State Civil Defense, Fort Ruger.

4. State Warning Point, Honolulu Police Department.

5. Kauai Civil Defense, Lihue, Kauai.

6. Kauai County Warning Point, Kauai County Police Department.

7. Maui County Warning Point, Maui County Police Department, Wailuku, Maui.

8. Hawaii County Civil Defense, Hilo.

9. Hawaii County Warning Point, Hawaii County Police Department.

10. National Tsunami Warning Center, Honolulu Observatory, Ewa Beach, Oahu.

The system was accepted as fully operational, 6 January 1972. HAWAS will be tested by a roll call three times daily at an unscheduled time.

III. REGIONAL WARNING SYSTEMS

A. Alaska Tsunami Warning System

As the result of the great earthquake which occurred in the Price William Sound area of Alaska in March 1964, the Alaska Tsunami Warning System was established and became operational in September 1967.

The Palmer Seismological Observatory, now under the Earth Sciences Laboratories of the Environmental Research Laboratories, is headquarters for the Alaska Tsunami Warning System. The National Oceanic and Atmospheric Administration is the parent agency for ERL.

The primary function of the warning system is to detect and locate earthquakes in those areas of the North Pacific where tsunami generation would pose an immediate threat to Alaska and the west coasts of Canada and the U.S. Immediate Warnings are issued to coastal residents of Alaska and Watch messages are disseminated to Canada, Washington, Oregon, and California. Vital immediate earthquake information is furnished to the National Earthquake Information Center in Rockville, the Internation Tsunami Information Center in Honolulu, and the Japan Meteorological Agency in Tokyo.

The basic systems developed at the Palmer Observatory have served well, but many additions and modifications in instrumention, procedures, and communications have been made to increase the capability and efficiency of the Alaska Tsunami Warning System. There has been a continuing process of improvements directed toward increased accuracy and a lower response time. At first the requirement to actually issue a warning within fifteen minutes of occurrence of an Alaskan earthquake was quite a challenge for the staff. Now only very serious weather conditions or major equipment failure concurrent with a severe earthquake could cause any real delay beyond this time limit.

Several satellite seismic stations and one tide gage have been added since the system became operational. The multi-component seismograph systems at

Palmer, thirteen remote seismic stations and eight tide gage stations (Figure 1) provide 69 channels of real time tidal and seismic data at Palmer. The collection and dissemination of these data requires over 4500 miles of telemetry circuits involving 14 voice circuits, 4 teletype circuits and 2 radio systems. The tidal and seismic information is continuously recorded on 14 helicorders, 8 Bristol recorders, a twenty-channel Develocorder, and a magnetic tape system with 2 eight-channel dynograph recorder play-back systems. The number of racks containing most of the recording and electronic control equipment has increased from a console of eight racks to two consoles of seventeen racks.

Telemetry line amplifiers to handle large carrier level changes; isolation units to eliminate DC component and drift from incoming telemetry data; driver amplifiers to offer extended gain ranges without changing field attenuators; and variable filters to select desirable pass bands for particular stations are a few of several other important pieces of equipment which have been added to improve the quality and reliability of the data recorded at Palmer (Figure 2). The long and short period seismograph systems at the observatory have been converted from the standard phototube to solid state amplifier systems. Besides the small space requirement for these rack mounted units compared to the phototube amplifier systems there are many other advantages. The new systems have lower power consumption; are less expensive; require simpler installation, trouble-shooting, and maintenance; maintain better magnification stability; and produce a wider dynamic range. The new remote field stations also utilize the new solid state package with an FM output.

The dynamic range of the instrumentation is very important at the Palmer Observatory since it is necessary to operate a wide range of magnifications so that key phases will not be lost by "clipping" or "whiting-out". This enables the staff to compute magnitudes for all local or teleseismic earthquakes. All tsunami warnings are based on the surface wave magnitude. The multigain solid state long period

horizontal systems make it possible to work up surface wave magnitudes on the closer events since they eliminate the galvanometer motion.

The sophisticated collection and analysis of data at the Palmer Observatory has little value unless it can be disseminated. The addition of the Alaska Civil Defense Phone and another military Autovon drop to the original communications system makes the observatory's telecommunication capabilities among the most extensive in Alaska (Figure 3). Palmer transmits simultaneously over both the National and State full period phones reaching directly eighteen first and second order warning points. The Federal Aviation Agency teletype and the Autovon circuits are the other two most important primary methods in dissemination of information.

Primary dissemination points have increased from six to fifteen. Because of its rapid epicenter determination and direct communication capabilities, the West Coast of the United States and Canada have been added to Palmer's area of responsibility. General procedures have been established for each situation and location to provide the urgently needed timely information to the affected or threatened area.

During the early years of operation, tsunami warnings were based on Ms magnitude 6.5 for Alaskan Coastal earthquakes. The procedure is now to issue a watch for Ms magnitude 6 3/4 to 7 and a warning for Ms 7 or larger. The area of warning depends on the size of the earthquake. For Canada, California, Washington, and Oregon coastal earthquakes, a watch is issued for Ms 7 1/2 or larger. The observatory staff disseminates an immediate tsunami watch for the Western Aleutians when an event of Ms 7 1/2 or greater occurs off the Coast of Kamchatka or in the Komandorsky area.

B. Experimental Hawaii Regional Tsunami Warning System

Development of an experimental tsunami warning system for locally generated tsunamis in Hawaii began several years ago. The design of the system included several seismographs on the islands of Hawaii and Maui to provide data for rapid epicenter determinations, a

number of sea level sensors on the island of Hawaii that would give early indications of tsunami generation and magnitude, and a telemetry system using VHF links that would transmit these data in real time to the warning center at Honolulu Observatory (Figure 4). More detailed information can be found in the U.S. National Report proposal for the International Meeting of the ICG/TWS, May 12-14, 1970.

All equipment has been installed and a number of test transmissions have been made. However, various problems with the communications gear have prevented continuous data recording at the warning center. It is anticipated that further effort will be made this year to make the system operational and thus provide a basis for evaluating its potential value.

IV. TSUNAMI DATA REPORTING

A. Recommended Procedures for Reporting Tsunami Data

In order to avoid confusion at the Tsunami Warning Center when tide reports are interpreted, tide stations have been instructed to report tsunami data in metric units. Tsunami heights are to be reported in centimeters in four digits. For example, a wave height of 55 centimeters is to be reported as 0055 cm.

To further standardize the reporting of tsunami data, the U.S. distributed the publication "Wave Reporting Procedures for Tide Observers in the Tsunami Warning System" to all participating tide stations. All member countries of the TWS should provide full instructions to their tide station personnel on emergency reporting of tsunami data.

V. TSUNAMI RESEARCH

Basic research in tsunamis is conducted in many universities and by governmental agencies throughout the United States. Some of the principal universities conducting research related to long wave hydrodynamics are: Harvard; the Courant Institute; Texas A & M; Scripps Institution of Oceanography; and of a more applied nature, the Engineering Department of the University of California at Berkeley and the Ocean Engineering Department of the University of Hawaii. Basic and applied research is carried out at the University of Hawaii in the Joint Tsunami Research Effort which is a University of Hawaii/National Oceanic and Atmospheric Administration (NOAA) cooperative group. Work mainly concerned with numerical solutions of hydrodynamic equations is conducted at Stanford and at Los Alamos Scientific Laboratory.

Geophysical and plate tectonics studies are conducted at most universities which have geophysics departments. These studies are more or less directly related to tsunamigenesis.

A. Source Mechanism

The NOAA Geophysics Research Group has nearly completed development of computer programs which will produce focal mechanism solutions and plot the confidence limits. These computer programs will be used to study the relationship between tsunami generation and earthquake focal mechanisms. The techniques were described in the paper "Focal Mechanism Determinations Using P- and S-Wave Data" by S. T. Harding, W. H. Dillinger, and A. J. Pope which was presented at the April 1969 Annual Meeting of the Seismological Society of America. Implementation of the data gathering system required for real-time focal mechanism solutions is currently underway. Identification of focal mechanisms and their relationship to tsunami generation provides one method for early identification of tsunami-generating earthquakes.

B. Propagation and Run-up

With the exception of a very limited amount of research being conducted on a statistical and theoretical

basis of forward scattering, propagation studies are receiving little attention. A notable exception is the development of a numerical approach based on the non-linear long wave equations which has been developed by Hwang and Divoky (1970). This numerical time-stepping technique is suitable for any geometry of source and bottom topography. It has been successfully applied to the 1964 Alaska earthquake. It should, to a large extent, replace ray tracing as a method for deriving relative energies remote from the generating area. An article "Tsunamis" by Hwang and Divoky is included as an appendix to this report.

Run-up studies continue to receive a large amount of attention. At Stanford, Dr. John Williams and Dr. Webster are studying the interaction of long waves with cone-shaped, elliptical islands. New wave forms utilizing the Carrier and Greenspan technique have had solutions derived by Dr. Lester Spielvogel of JTRE. In these studies, the non-linear behavior of waves with the largest run-up factors yet predicted has been examined.

A continuing research program at Texas A & M University is concerned with a numerical approach to the hydrodynamics of gravity waves. Professors R. O. Reid and A. C. Vastano and various graduate students have conducted numerical studies of the propagation of gravity waves in simplified topography. Analytical solutions are computed as checks on the numerical results. The spectral response of long waves has been studied in order that near-shore recordings can be used to extrapolate the frequency distribution of tsunami energy in deep water. These studies may, in time, lead to reasonably accurate numerical forecasts of tsunami run-up.

Some theoretical work is being done on the response of harbors to long period waves and some of this work has been correlated with actual observation. Dr. C. L. Su of SUNY Buffalo has modified and extended the work of Professors Carrier and Shaw on the derivation of a solution for narrow mouthed harbors in which the location of the node at the boundary is no longer assumed known. The "narrow mouth" restriction for a circular harbor is valid almost to a 60° opening. Dr. Rudolph Preisendorfer of JTRE has applied transmission line theory to waves in channels and canals of varying cross-section and having arbitrary interconnections.

Various governmental agencies are concerned with the practical aspects of tsunami run-up. John Ritter of the U.S. Geological Survey is working on the prediction of tsunami inundation in San Francisco Bay. The state of California Division of Mines and Geology is attempting to delineate tsunami hazards in California. O. T. Magoon and N. L. Arno of the U.S. Army Corps of Engineers are undertaking studies with a view toward prediction of long term tsunami inundation and also to the design of protective structures to reduce tsunami damage. Professor R. T. Wiegel under a contract with the Corps of Engineers, is attempting to compute the probability of the extreme water level produced by a combination of astronomical tide and a particular tsunami.

C. Model Studies

The use of models in tsunami research has always encountered the problem of vertical-to-horizontal scale. Most model studies are conducted using distorted models in which the vertical scale is enlarged by a factor of three or more. A model of Haleiwa Harbor has been constructed on an undistorted 1:75 scale at the University of Hawaii. Dr. T. Lee is studying response as a function of excitation both in the model and in the prototype. Dr. H. Loomis is running a numerical model of the physical model.

In another model study, Professor Williams of the University of Hawaii completed the process of making a physical model with a straight sloping beach and a stationary wave form as an initial condition. The particular wave forms used are those of James Butler (Hawaii Institute of Geophysics Report No. 67-16); this is a form for which the non-linear analytic solution is known. In this model work the wave height and the beach slope are relatively large, but the theory is valid for smaller wave heights and any beach slope. The correspondence between model and theory has been established; one can now go on making models for which an analytic solution is difficult or impossible.

There are, of course, many model studies that are designed to study harbors. While these harbor surge studies are not primarily conducted for the purpose of harbor response to tsunamis, many are quite useful in determining what the water motion might be if there were a tsunami.

D. Instrumentation

It has long been recognized that one of the major difficulties in conducting research either on run-up or on source mechanisms is that to date there has not been a measurement of a tsunami in the open ocean. In other words, there is no input for run-up studies nor is there verification of any source mechanism theory which might be developed.

Various groups in the United States have been working on open ocean tsunami and tide gages. However, there have not been any tsunamis at the time that these gages happened to have been recording.

Drs. Vitousek and Miller of JTRE have developed a free-fall tsunami recording system which is capable of transmitting wave data to the surface acoustically in real time. Nine successful deployments of these instruments have been made in the southern Aleutian Islands. In one case, a 3 cm amplitude 150 sec period wave train appears to have been generated locally by a submarine landslide induced by a subterranean explosion.

A second subsystem of this instrumentation has been built and tested but not yet installed. This particular piece of equipment can be installed on the ocean bottom under any ocean station ship or any permanent reporting buoy. It transmits wave data to the surface acoustically upon command from the surface. A buoy system is being developed which would serve in place of the surface ship if a suitable communication system to the buoy were available. The GOES satellite when in orbit should provide communications of low power requirement between these buoys and the shore station.

Several new tsunami gages have been installed recently. Gages with a pressure resolution of less than 1 mm of water level change have been installed at Minamitorishima, Wake Island, and Oahu (north and south shore). Installation of a similar gage in the Gulf of Alaska is underway.

E. Tsunami Forecasting

Currently the Tsunami Warning System does not make a forecast of actual wave height, rather the TWS indicates that a potentially dangerous wave has been generated.

Until such time as open ocean wave heights are available to the warning center in real time, it is doubtful that an actual forecast of nearshore wave heights could be made. However, when methods are developed for the rapid determination of source mechanism of an earthquake, it may be possible to estimate more accurately the probability of tsunami generation.

The problem of tsunami forecasting will require considerable study, and it is hoped that the International Coordinating Group can stimulate the needed research.

VI. FUTURE PLANS

A. Expansion of the Pacific Tsunami Warning System

The number of participants in the Pacific Tsunami Warning System has been increasing since the System was organized 24 years ago. At the present time, 23 seismograph stations (and an additional 9 unmanned satellite stations in the Alaskan Regional System) and 47 tide stations are members of the Warning System, furnishing data to the Warning Center at Honolulu. In order to extend the coverage of the TWS and to provide earlier warnings to the nations bordering the Pacific, it has been estimated that about 30 seismograph stations and about 110 tide stations will be required. A number of the tide stations should be of the ocean bottom type. A list of proposed new stations has been distributed to the Member States of the ICG for study and recommendation.

During the past two years, seismic observatories at Easter Island; Wellington, New Zealand; and Nandi, Fiji, have joined the TWS. Tide station coverage has also increased since 1970 with the addition of Baltra Island, Galapagos Islands; Marsden Point, New Zealand; Manzanillo, Mexico; Yap Island; and White Beach, Okinawa, to the System.

B. Automation of the Pacific TWS

The proposed expansion in the number of seismic and tide stations are the beginning of what we intend to be a completely automated warning system. Data telemetry has become feasible with the use of the geostationary satellite as a communication relay station. This type of satellite maintains a fixed position 22,300 miles above the equator on any selected meridian.

The eventual volume of data and the need for rapid analysis dictates the eventual need for computer analysis of incoming data. An on-line computer at the Warning Center will be programmed to identify the seismic signals by mathematical analysis, extract the arrival times, compute the hypocenters, calculate origin times, and determine the estimated times of arrival of the tsunami, if generated, at all points. Once ETA's have been obtained,

a watch will be issued and the computer will program a series of queries to selected tide stations based on the progress of the tsunami.

In early 1973 the Geostationary Operational Environmental Satellite (GOES) will be placed in synchronous orbit at 100°W. The GOES will be used by NOAA to relay data from ground stations to central recording facilities. The initial area of coverage will include most of the western hemisphere and Hawaii. Coverage will be extended in subsequent years by additional satellites. Some of the GOES data channels will be allocated to the Tsunami program, probably on a pre-emptive rather than fulltime basis. As presently planned, one of these channels will be used to relay tide data to the Tsunami Warning Center in Honolulu and the others will be used to relay seismic data. Tide stations equipped with the special radio sets needed to communicate with the satellite, when interrogated, will sample water height and transmit this information back to the Warning Center. A single communication channel will be able to handle a large number of tide stations. Existing tide gages can be modified for use in this program but ultimately it is planned to use tsunami sensors now under development.

Because of the limited number of channels and the limited bandwidth of each channel, it is planned to transmit processed rather than raw seismic data. Initially, satellite communication will be used to shorten the time required for manned seismograph stations to report phase arrivals to the Tsunami Warning Center. Subsequently, these reporting observatories will be augmented by unmanned seismographs. The unmanned seismic sensors are being developed to detect and store P arrival times and will transmit these arrival times to the Warning Center when interrogated.

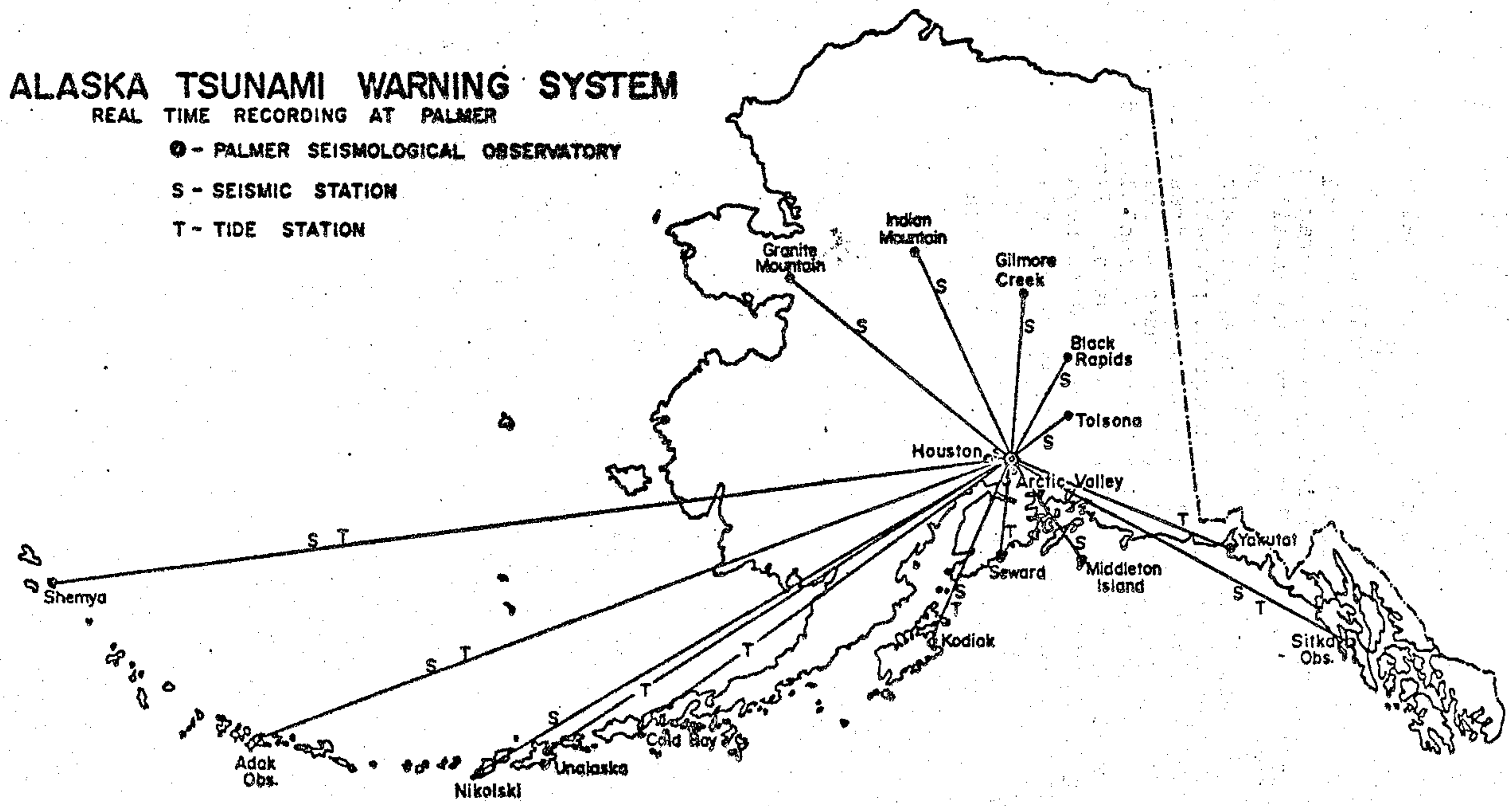

ALASKA TSUNAMI WARNING SYSTEM
REAL TIME RECORDING AT PALMER
⊙ - PALMER SEISMOLOGICAL OBSERVATORY
S - SEISMIC STATION
T - TIDE STATION
Granite Mountain
Indian Mountain
Gilmore Creek
Black Rapids
Tolsona
Houston
Arctic Valley
Yakutat
Seward
Middleton Island
Kodiak
Sitka Obs.
Shemya
Adak Obs.
Nikolski
Unalaska
Cold Bay

Fig. 1

PALMER OBSERVATORY

AS-330 REMOTE SHORT-PERIOD SEISMOGRAPH SYSTEM

TYPICAL DATA CHANNEL

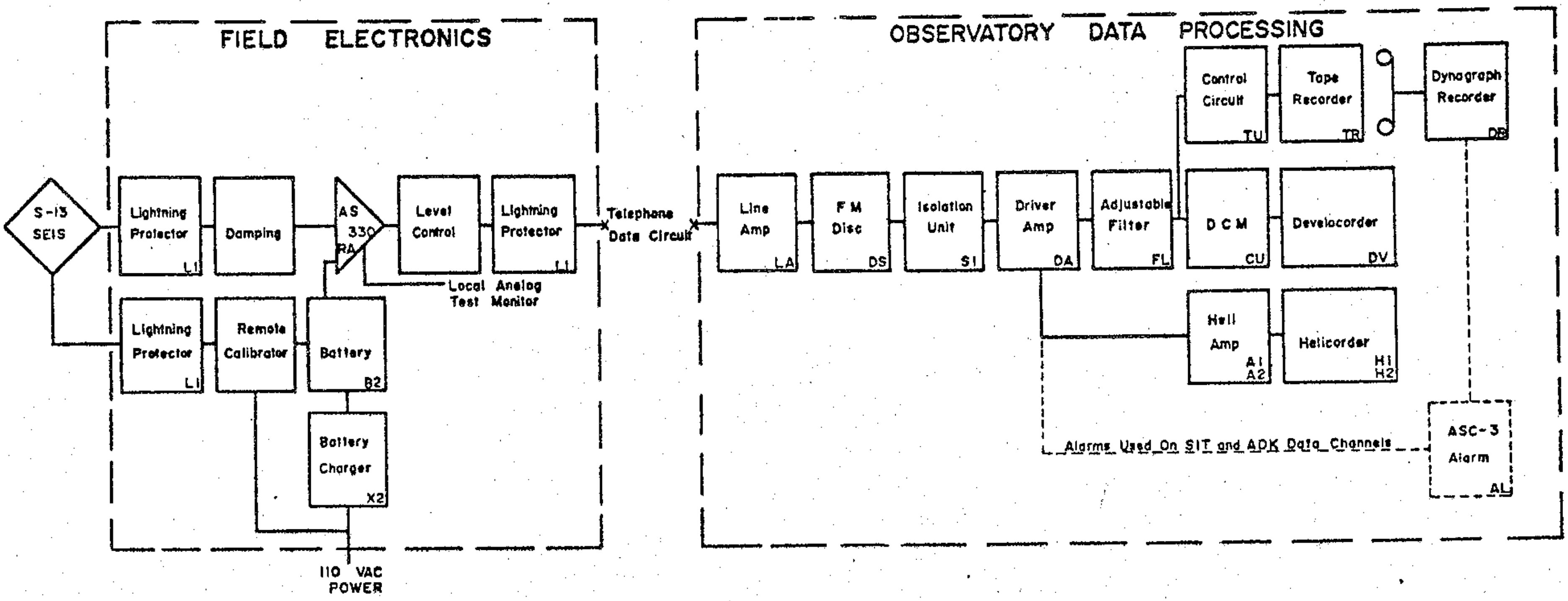
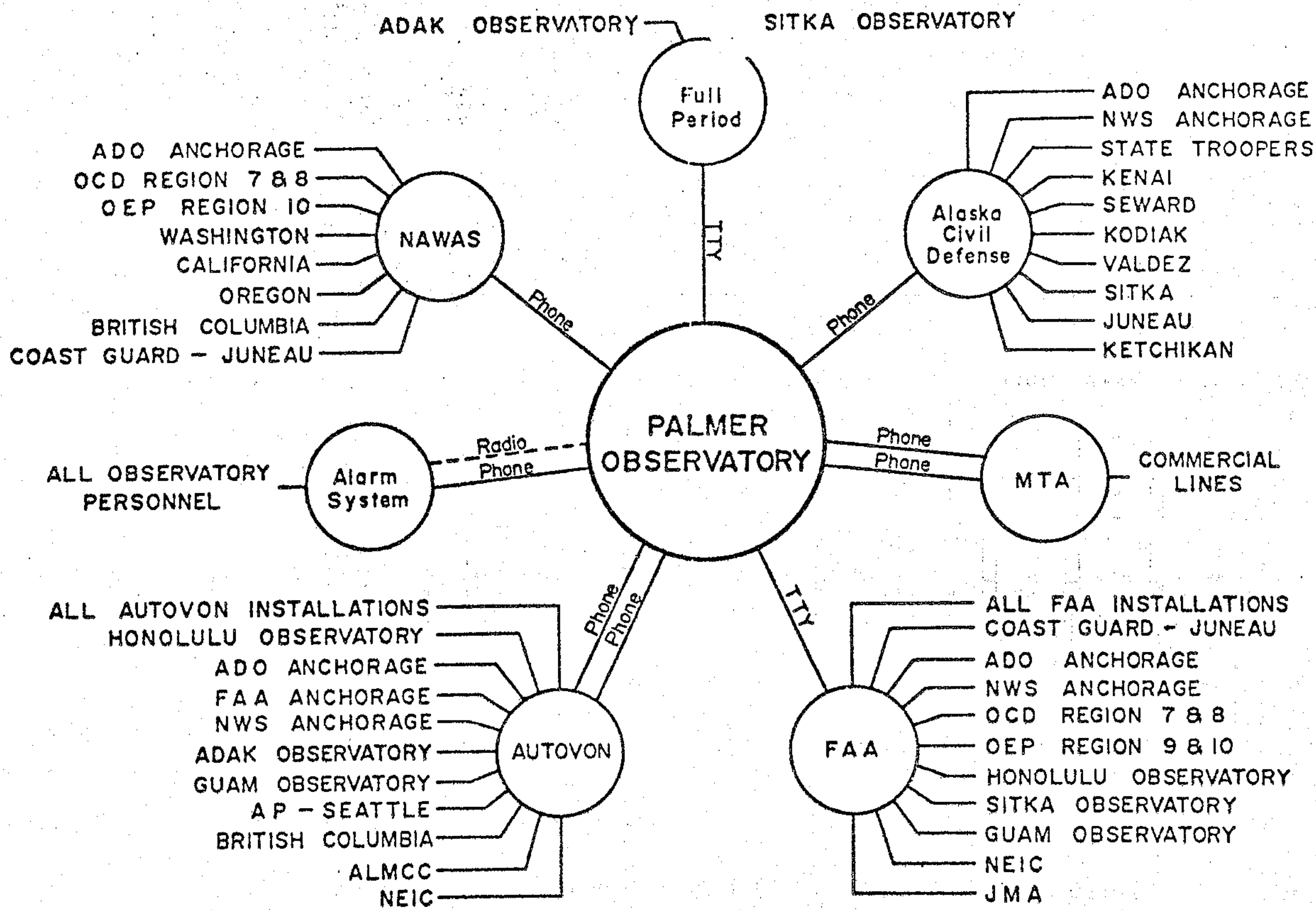
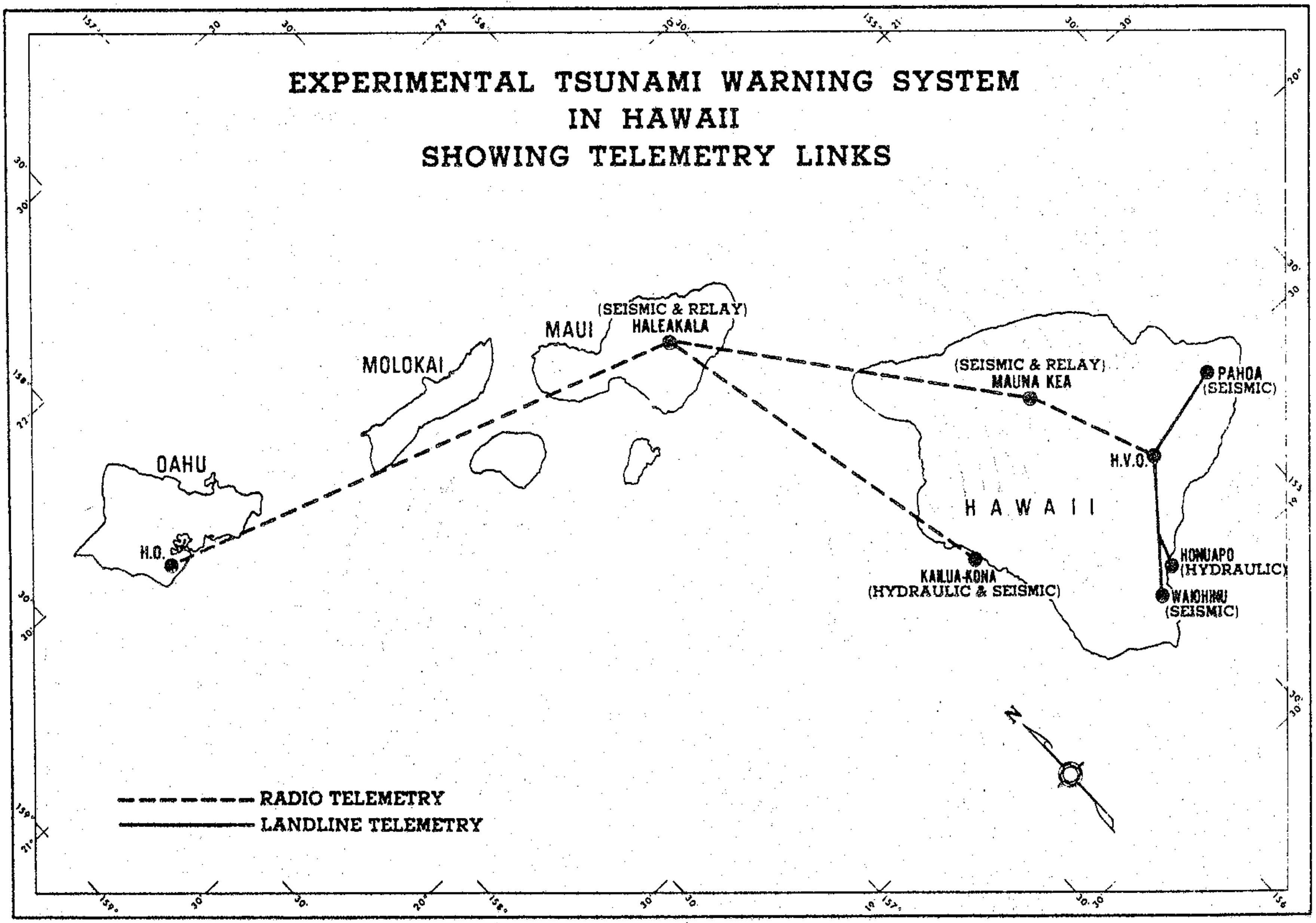


Fig. 2



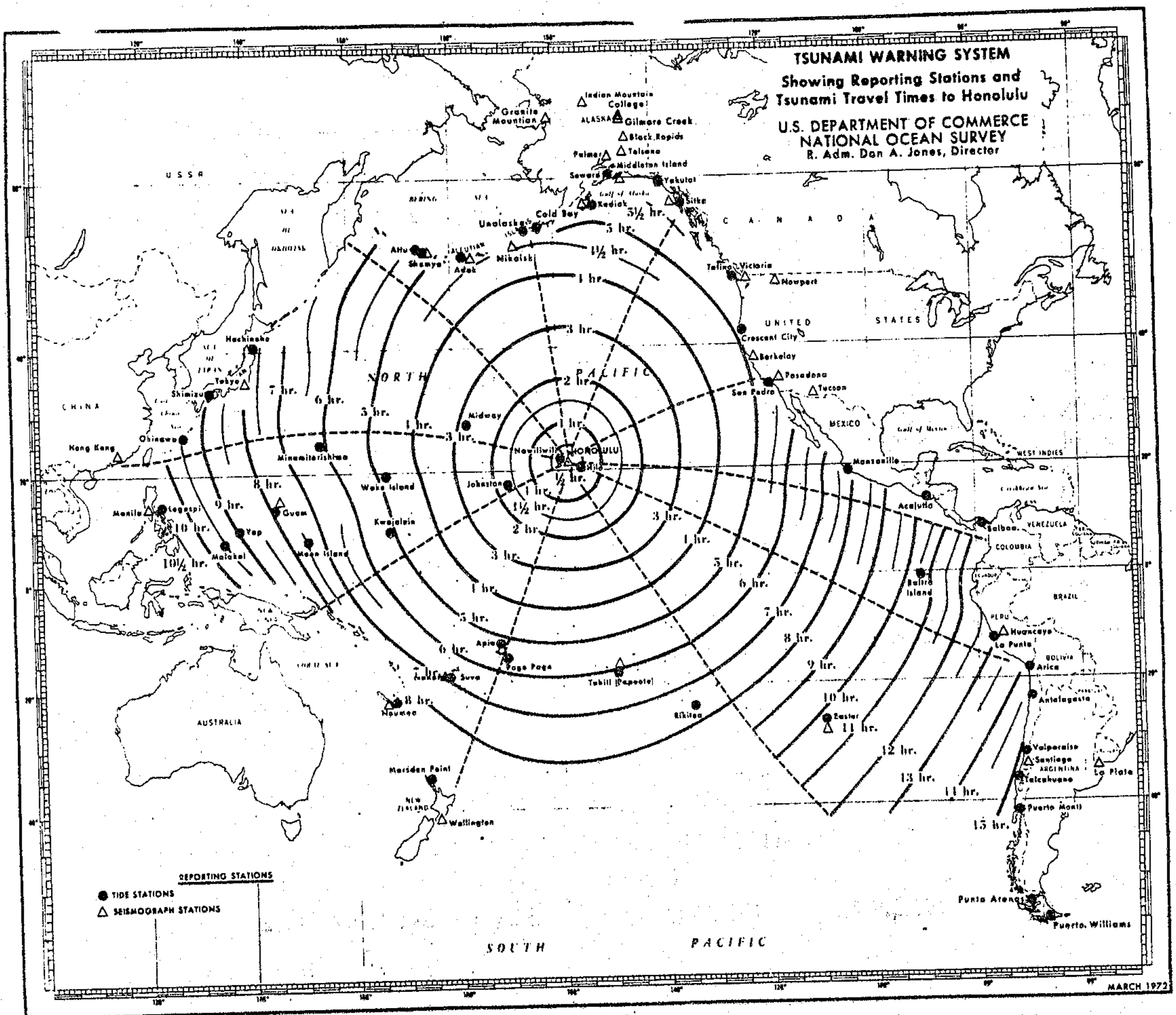
PALMER OBSERVATORY COMMUNICATION SYSTEM

Fig. 3



Annex V (c) - par. 27

Fig. 4


TSUNAMI WARNING SYSTEM
Showing Reporting Stations and Tsunami Travel Times to Honolulu
U.S. DEPARTMENT OF COMMERCE
NATIONAL OCEAN SURVEY
R. Adm. Don A. Jones, Director
REPORTING STATIONS
TIDE STATIONS
SEISMOGRAPH STATIONS
NORTH PACIFIC
SOUTH PACIFIC
HONOLULU
MARCH 1972

NATIONAL REPORT - CHILE

1. REFERENCES

a) Intergovernmental Oceanographic Commission 1965 Paris.

b) First Meeting of the International Coordinating Group on the Tsunami Warning System in the Pacific 1968 Honolulu, Hawaii.

c) Second Meeting of the I.C.G. 1970 Vancouver.

d) Meeting of the I.O.C. 1971 Paris.

2. DESCRIPTION

The recommendations and resolutions approved in the Meetings mentioned in the above references, have been implemented in Chile in the following way:

Recommendation No. 2 of the First Meeting No. 1 and 8 of the Second Meeting.

To improve the detection of Tsunami generation the Hydrographic Institute of the Navy completed a network of sea level recording station in the following locations of the Chilean coast:

a. Sea level recording Network

Arica	Latitud 18 28 S	Longitud 70 20 W
Antofagasta	Latitud 23 39 S	Longitud 70 25 W
Caldera	Latitud 27 04 S	Longitud 70 50 W
Isla de Pascua	" 27 09 S	Longitud 109 27 W
Valparaiso	Latitud 33 02 S	Longitud 71 38 W
Isla Juan Fernandez	Latitud 33 37 S	Longitud 78 50 W
Talcahuano	Latitud 36 41 S	Longitud 73 06 W
Puerto Montt	Latitud 41 29 S	Longitud 72 58 W
Bahia Covadonga	" 63 19 S	Longitud 57 54 W

- The Bahia Covadonga station was established with the purpose of studying tsunami effects in Antartic Region.

- The stations in Arica and Valparaiso were equipped with Remote Recorders (Telemetry and direct interrogation system)

- Antofagasta and Talcahuano Stations will be equipped with Remote Recorders during the course of this year.

- The station in Puerto Montt probably will have Remote Recorders during 1973, as a part of a more extensive plan which includes a change in the location of the station, the installation of a Nitrogen Gas Bristol Sea level recorder and other improvements.

b. Seismic Station Network

- With the purpose of improving the detection of Tsunami generation the Geophysical and Seismological Institute of the University of Chile has seismographers installed in the following locations:

Antofagasta	Latitud 23 39 S	Longitud 70 25 W
Santiago	Latitud 33 30 S	Longitud 70 20 W

- The University of Chile informs directly of its progress to the National Oceanic and Atmospheric Administration (U.S.A.)

c. Telecommunication Network

1) Internal

- Due to the lack of economic resources, for the development of internal telecommunications the National Alarm System has been using old equipment; which, because it belongs to other Telecommunication Network, presents difficulties for easy and prompt connection in an emergency situation.

- The average time between a seismic phenomenon and the receipt of the warning was 30 minutes in the simulations made.

- This points to the fact that the National Alarm System is completely ineffective for us in those cases where Tsunamis are generated by earthquakes near the Chilean Coast.

2) External

In the international aspects, communications with the Honolulu Station have worked normally, through the use of the NASA Station in Santiago.

- Recommendation No. 8 of the Second Meeting

Budgetary limitations have made it impossible to develop scientific investigation of the generations of Tsunami.

- Recommendation No. 3 of the First Meeting

Chile has not made use of the opportunity opened through this recommendation due to the lack of information on the availability of funds and the programs to be studied.

- Recommendations No. 4 and 5 of the First Meeting and No. 2 and 3 of the Second Meeting

Are supported by Chile.

- Recommendations No. 6 and 7 of the Second Meeting

Are supported by Chile.

- Recommendations No. 1 of the First Meeting and No. 5 of the Second Meeting

During the course of the present year authorization for the use of specific frequencies will be given by the corresponding Government Agency.

3. CONCLUSIONS

a. The interest that Chile has in participating in the Tsunami Warning System is evidenced by the efforts and advances made in this respect, which make the Chilean System useful to the rest of the member countries for the detection of Tsunamis generated near our coasts. Unfortunately, due to the lack of economic resources reflected in the inadequacy of the equipment being used, the local system is inefficient for us in those cases where Tsunamis are generated by earthquakes near our coast.

b. The equipment necessary for Telemetry and Direct Interrogations System via satelites, which make the National System more suitable for International cooperation in the detection of Tsunamis generated in front of the Chilean coast, have been provided by member countries of the Tsunami Warning System. The installation and the operation of the equipment has been entrusted to Chile.

Nevertheless, optimum benefits have not yet been achieved due to the lack of economic resources necessary for efficient installation and operation of the equipment.

c. The same budgetary limitations have made it impossible for Chile to engage in scientific research on the Tsunami phenomenom.

d. The absence of information has kept Chile out of participation in programs for studies in other member countries.

4. RECOMMENDATIONS

a. With the purpose of fulfilling Recommendation Number 3 of the First Meeting, we hereby request that the pertinent information regarding financing terms and programs available be sent to Chile.

b. With the purpose of fulfilling Recommendation Number 8 of the Second Meeting, we request that a recommendation that technical and financial assistance be given to Chile be made.

c. With the purpose of improving the Communication System, both on the local as well as the international scenes, and to complete the installation of adequate seismographers, we request that a recommendation be extended to UNESCO for it to give special attention to requests for assistance made by underdeveloped countries.

d. With the purpose of improving the sea level recording station already existing in Chile, we hereby request to the Chairman Director of the International Tsunami Information Center to entertain the request made by Chile in its letter to him dated October 21, 1970 relating to the furnishing by Canada of Foxboro automatic sea level recorders.

e. With the purpose of improving the seismometric network, we request that the necessary equipment, which has been selected by the Institute of Hydrography of the Navy in accordance with recommendations made by the corresponding center of the University of Chile, be furnished to the Chilean Navy.

f. Once more, we wish to state categorically the interest of Chile in cooperating with this International effort directed at minimizing the disastrous effects of Tsunamis, which we have painfully experienced in the past.

At the same time, we are trying to point out the problems that nations such as ours, with scarce resources, face in the implementation of the necessary measures, and which reduce the effectiveness of our efforts.

Therefore, we would very much appreciate that a realistic approach to the solution of these problems be undertaken by all the member countries, especially those with a greater availability of resources, and that integral programs for economical and technical assistance be established which may consider every aspect of the problems of obtaining, installing and operating the equipment necessary for the existence of the System.

Francisco Garcia-Huidobro G.
Delegado de Chile

Tokyo, 9 May 1972

TEMA A TRATAR EN LA TERCERA REUNION DEL GRUPO INTERNACIONAL DE COORDINACION DEL SISTEMA DE ALERTA CONTRA LOS TSUNAMIS EN EL PACIFICO - MAYO 1972 - TOKIO - JAPON

INFORME DEL PERU

Señor Presidente, señores delegados, señores observadores:

En respuesta a la Carta Circular de la COI del 14 de Setiembre de 1970, el Perú oficializó su participación como miembro del Grupo Internacional de Coordinación del Sistema de Alerta Contra los Tsunamis en el Pacífico, recayendo la representación a la Dirección de Hidrografía y Faros del Ministerio de Marina del Perú. En nombre de mi país y de la Institución a la cual represento, hago llegar a Ud. el saludo peruano y los votos para que en esta reunión, el entendimiento, la razón y la buena voluntad de sus miembros, orienten las decisiones y recomendaciones en beneficio, no solo de los países participantes sino también de la humanidad en general.

PROGRAMA DE INVESTIGACION

El Centro Regional de Sismología para América del Sur (CERESIS) ha presentado un ante-proyecto para el Estudio de la Sismicidad de los Andes Septentrionales, con la asistencia del programa de las Naciones Unídas para el Desarrollo. Dicho programa de estudio, está programado para desarrollarse en el período 1974-78, en el cual, se considera el estudio de los Tsunamis en cuanto a frecuencia y características de los mismos y la influencia de la topografía costera y batimétrica en su comportamiento.

Para el Perú y para los países que entran a formar parte en este estudio, sería de gran provecho la aceptación de este programa por parte de la UNESCO, por lo que me permito pedir una recomendación de apoyo al ante proyecto del CERESIS mencionado anteriormente.

Equipo para el Sistema de Alerta contra los Tsunamis

Con relación a la recomendación No. 1 de la Segunda Reunión, los Estados Unídos de Norte América enviaron al Perú, en calidad de préstamo de duración indefinida, un mareógrafo tele-registrador para ser instalado en la Estación Mareográfica de La Punta. Al respecto informaré que dicho equipo llegó en el mes de Enero de 1971, y que al ser instalado sufrió una avería, que según el Técnico se debía a la diferencia de ciclaje entre el diseño del equipo y la corriente eléctrica alimentadora. Este equipo fué devuelto a los Estados Unídos.

Posteriormente enviaron otro equipo, por el mes de Noviembre de 1971, este último equipo hasta la fecha no ha sido instalado y se encuentra en prueba donde los representantes de la Bristol Co. en el Perú.
Sería conveniente que la escala del registrador visual de dicho instrumento sea modificada en el sentido de colocar el "0" (Cero) en la mitad de la escala, ya que este se encuentra en el extremo derecho del mismo, con esta modificación las lecturas serían equivalentes al nivel de referencia del maréógrafo automático ya instalado.

Red de Estaciones Mareométricas:

Respecto a la Carta del Centro Internacional de Información de los Tsunamis, de fecha 1°de Abril 1972, sobre la ampliación de la red de estaciones mareométricas en el Perú, comunicaré lo siguiente:

Actualmente, existen cinco estaciones mareográficas a lo largo del litoral peruano, siendo estas:

LA PUNTA - desde 1941
MATARANI - desde 1941
TALARA - desde 1942
CHIMBOTE - desde 1954
SAN JUAN - desde 1957

La propuesta de ampliación del Centro Internacional de Información de los Tsunamis, considera el establecimiento de nuevas estaciones mareométricas en:

Pimentel
Paramonga
Pisco
Chala

Al respecto recomendamos que la propuesta de Paramonga pase al puerto de Supe y la de Pisco al puerto San Martín en Punta Pejerrey, distante unas de otras 9 y 6.5 millas náuticas respectivamente. Esta sugerencia obedece al mejor cuidado, mantenimiento y sistema de comunicación existentes o por establecer en dichos puertos.

La propuesta de Pimentel quedaría en el mismo puerto, sin embargo, la de Chala, consideramos que se encuentra cercana al mareógrafo de San Juan, por lo cual pensamos dejarla sin efecto.

Resumiendo las estaciones existentes y las propuestas con los cambios antedichos, la red mareográfica del Perú quedaría formada de la siguiente manera:

Talara
Pimentel
Chimbote
Supe
La Punta - Callao
Pto. San Martín
San Juan
Matarani

Para el equipamiento de estas nuevas estaciones mareográficas, nos acogemos a la recomendación No. 1 de la Segunda Reunión del Grupo de Coordinación, esperando la buena voluntad de los miembros del Grupo. La atención de los mismos quedaría a cargo de la Dirección de Hidrografía y Faros del Ministerio de Marina del Perú.

Comunicaciones de Datos sobre los Tsunamis:

Teniendo en cuenta que las alturas de las olas deben transmitirse en el sistema decimal, la Dirección de Hidrografía y Faros, ha confeccionado reglas graduadas en centímetros para ser instaladas en las cinco estaciones mareográficas que tiene a su cargo, posiblemente para el mes de Junio queden instaladas. Asimismo, se encuentra en preparación un manual de instrucciones para distribuirlos a los observadores de las mareas.

Telecomunicaciones:

La recepción y envío de mensajes de Tsunamis con la Central de HO se sigue manteniendo a través de la CORPAC, según lo indicado en el Plan de Comunicaciones del Sistema de Alerta Contra los Tsunamis.

Sin embargo, nuestro sistema nacional de alerta no cuenta con servicios adecuados, por lo que solicitamos a la UNESCO y al Fondo de las Naciones Unídas para el Desarrollo, se sirvan acoger nuestra petición sobre el establecimiento de un Servicio Nacional Peruano de comunicaciones de alerta, en atención a la Resolución 7.16 aprobada en la 7ma. Reunión de la Comisión Oceanográfica Intergubernamental.

En la misma Resolución de la COI, se alude al material educativo destinado a señalar la atención del público sobre los peligros y medidas de protección que se han de tomar cuando se reciba una alerta contra Tsunamis, este punto lo consideramos de gran importancia por los beneficios que se obtienen en salvaguardar la vida humana.

Recientemente en el Perú se ha creado el Sistema de Defensa Civil, que contempla dentro de sus objetivos la prevención de daños ocasionados por procesos naturales. Siendo los Tsunamis un proceso natural de consecuencias funestas para la vida y bienes humanos, el adoctrinamiento y la enseñanza son de vital importancia.

En este sentido recurro a todos aquellos participantes del Grupo que cuenten con un Sistema de Movilización Nacional contra los Tsunamis, para solicitarles su colaboración sobre la organización, difusión, etc. de este tipo de defensa.

National Report - Philippines

Although the Philippines has a long coastline facing the Pacific, no research in Tsunami has yet been initiated as at present as we are still in the process of instrumental development and data gathering. There is only one tide gauge fronting the Pacific Coast and that is in Legaspi, Albay, while a few are in inland areas.

There are three agencies in the Philippines involved in Tsunami Warning. They are:

1) The Philippines Coast & Geodetic Survey - that takes care of the reporting of tide gauge readings;

2) The Manila Observatory, operated by Jesuit Fathers - whose main responsibility is the reporting of major earthquakes to the International Tsunami Warning Center in Honolulu, Hawaii; and

3) The Philippine Weather Bureau - that takes care of the communications network, both for international and local purposes. The Weather Bureau is responsible for collation of Tsunami warnings and advisories for use in the local warning system.

It might be worth mentioning and we are thankful for it, that the Manila Observatory and the Philippine Coast and Geodetic Survey, are now operating the seismograph and tide gauge respectively, donated to the Philippines as a result of the 2nd Session of the Tsunami Warning System held in the Pacific in Vancouver, Canada. It is recommended, however, that more tide gauges be made available for installation in places fronting the Pacific Ocean.

With regards to communications, the main artery, which is the network of the Civil Aeronautics Administration and the Weather Bureau, located at the Manila International Airport, was burned recently. Temporary communication links have been installed at the local airport, but it is not so efficient because messages have to be telephoned from the CAA to the W.B. communicator. This oftentimes is the cause of delay due to the volume of weather messages being handled. Direct teletype connections, however, between the W.B. and the CAA are in the process of installation.

Lastly, there is also the local problem of disseminating tsunami warnings and advisories to the coastal areas fast enough. Present facilities are not very capable. Community preparedness is a project that has to be attented to as soon as possible and the problem here is the adamant attitude of the public and local authorities due to the fact that the Philippines, at least during this generation, has not yet been hit by a devastating tsunami.

It is hoped that this International Coordination Group may in some way or another be able to help improve tsunami observations and dissemination of warnings in the Philippines.

ANNEX VI

INTERNATIONAL SYMPOSIUM ON TSUNAMI

(Moscow, 10-12 August)

by

S. L. Soloviev, Chairman, Tsunami Committee, IUGG

An international symposium on tsunami problems was held in Moscow on 10 August through 12 as part of the IUGG XV General Assembly proceedings. It consisted of three seminars (convened by):

1. tsunami magnitude (K. Iida, Japan),

2. short-period prediction of tsunami (G. Miller, U.S.A.),

3. long-period prediction of tsunami (S.S. Vogt, USSR).

The general guidance of the symposium was performed by B. Zetler, U.S.A. and S. L. Soloviev, USSR. 30 papers by scientists from seven Pacific countries were presented.

The first seminar dedicated to a comparatively narrow problem of tsunami classification by magnitude discussed six communications, of which three, made by Japanese seismologists, treated the tsunami magnitude scale.

In particular, K. Iida reviewed tsunami classification methods mentioning the Zeiberg-Ambraseys descriptive scale, the tsunami magnitude scale and its various modifications made by K. Iida, S. L. Soloviev's intensity scale etc. In his second communication K. Iida suggested that by analogy with earthquake magnitude tsunami magnitude be understood as a logarithm of a wave amplitude at 100 km from the centre of a tsunami source reckoned from some conventional level.

Two modifications were proposed based on measurements of the amplitudes of the first and the maximum level oscillations, respectively. Formal calibration curves representing decrease in tsunami amplitudes with distance along the Pacific coast were plotted for the practical determination of magnitudes. Transitional lineary correlations have been established between the new scales and the old Imamura-Iida scale.

The communication by T. Hatori had much in common with K. Iida's papers. The author has found empirical relationships of the attenuation of the maximum wave height with distance along the Pacific coast from the earthquake epicenter. The author believes that by means of these relationships the tsunami magnitude can be estimated from records of a single station within the accuracy of about 10.5.

Using three small Black Sea tsunami as an example, Z. K. Grigorash and I. A. Korneva, USSR, developed convenient practical techniques to take account of ray tube distortions in calculations of tsunami energy. Based on the equation of energy balance, L. N. Ikonnikvs, USSR, estimated the energy loss of tsunami in their propagation from the source to the coast due to friction of water particles against the bottom and wave deformation when the numerical values of the coefficients of friction and deformation are variable.

A brief communication by C. Lomnitz, Mexico, presented basic actual data on small tsunamis that were connected with the disastrous earthquakes in Peru in 1968 and 1970. In particular, attention was drawn to the existence of high velocity waves that forerun the main tsunami waves and are to be explained.

No recommendations for international use of particular tsunami scales were adopted at the seminar. The problem of the best tsunami classification methods is to be further considered. In particular, reliable practical methods of tsunami energy determination are to be developed.

Out of the papers presented at the seminar on short-period tsunami prediction, in other words, on improving the methods and means of prompt tsunami warning service it might be well to point out the communications by V.M. Jaque, USSR, G. Miller, T. Sokolovsky, L. Spilfogel, and M. Vitousek, U.S.A., on results of application of open-sea mareographs for remote observation of tsunami.

The bottom instrument of the Sakhalin Complex Scientific Research Institute installed on the shelf at 20 km from the Shikotan Island used vibrotron and piezoceramic sensors of the hydrostatic pressure, and temperature and horizontal current velocity sensors; telluric currents were recorded for a short time.

About a hundred very small (1 to 10 cm) tsunami-type waves excited in most cases by aftershocks of the 1969 Shikotani earthquake were recorded during two years of operation of the instrument.

A similar instrument with cable communication with the shore was installed at 30 km from Amchitka Island (an American underground nuclear weapon test field) by the University of Hawaii Joint Tsunami Research headed by G. Miller. Also two bottom instruments equipped with vibrotrons and installed 5 km offshore are still in operation in the Hawaii Islands. One of these provided good records of a small tsunami from the earthquake in the Solomon Islands, while conventional mareographs installed in the Central Pacific missed this tsunami.

Two bottom autonomous mareographs are under test. One of these is installed on the Pacific Ocean bottom at approximately 100 km north of the Hawaii Islands in the stopping place of weather vessels. The information accumulated is transmitted to the surface by an acoustic channel. Endurance of the instrument is three years including three months of continuous transmission of information by the acoustic channel. The other similar instrument is planned to be used together with a radiobuoy, the information being transmitted to the shore via a communication satellite; however, means to provide the necessary power for the signal have not been found so far.

Finally, two deep-water piezoceramic sensors of level are installed at the Torishima and Wake Islands. As to the seismic instruments, there was information to the effect that the accuracy of determination of the azimuth and the epicentral distance of an earthquake has been essentially improved by means of a four-point seismic aggregate installed at Oahu Island. Distance is determined by the angle of the P wave egress.

In his paper, J. Larsen, the University of Hawaii Joint Tsunami Research Effort, demonstrated the basic possibility of separating the disturbances of electromagnetic fields associated with propagation of long tsunami-type waves in the ocean.

Three Soviet papers recapitulated below presented empirical data generation results that make it possible to refine the conditions of excitation of tsunami waves by earthquakes and are of direct interest for tsunami warning services.

L. M. Ealakina compared focal mechanisms of 24 tsunamigenic and 97 non-tsunamigenic earthquakes that occurred in the North-Western Pacific. It was found that upthrust movements in a focus along steep planes that are orientated along island area and dip under the ocean are characteristic for tsunamigenic earthquakes. Non-tsunamigenic earthquakes are characterized by either gentle dipping of nodal planes or large components of fault displacements of the wings or a great focal depth and a small magnitude.

S. L. Soloviev compiled and generalized all the actual data on earthquakes and tsunamis in the Pacific Ocean, considered their recurrence in different zones and plotted diagrams of earthquake and tsunami recurrence. The author found that the probability of excitation of tsunami by an earthquake depends on the peculiarities of the seismic zone, being higher within shelf zones with vertical motions of crustal blocks and lower within island area zones. Threshold values of magnitudes of sounding tsunami alarm from seismic data depending on the location of the earthquake epicenters were calculated.

Several problems were treated in the paper by A.I. Ivashohenko, A.A. Poplavsky, and I.N. Tikhonov. Firstly, tsunamigeneity and focal depth were compared for earthquakes in the North-Western Pacific. The conclusions obtained on the threshold magnitude values of tsunamigeneous earthquakes are in good agreement with the results obtained by Balakina and Soloviev. Secondly, for the same part of the Pacific Ocean, a tendency of tsunamigenic earthquakes to be grouped in time was found, and a possibility of new strong tsunami in 1975 was predicted. Thirdly, it was shown that there is a possibility of automatically determining arrival time of the S wave and hence epicentral distance of an earthquake by means of special treatment of records in a computer (the sharp change in the polarization of seismic oscillations is used).

The communication by R. M. Garipev, USSR, joined the above group of papers. This communication suggested seeking for and selecting indications of tsunamigeneity of earthquakes by means of the recognition theory using analytical solutions to the problem of excitation of tsunemi waves by earthquakes obtained for simplified models of environment and processes.

P. Mechler, France, spoke on a successful experiment on tsunami prediction in Tahiti and other islands of French Polynesia by means of the T waves. The shapes of the submerged basements of some of the islands where short-period (10.2 sec.) seismographs with a very large (- 100,000) amplification are installed are favourable for conversion of hydroacoustic energy into seismic energy. According to the accumulated experience, all the recent Pacific tsunamigenic earthquakes produced intensive waves in the records observed at these stations.

H. Watanabe, Japan, generalized empirical data on times of maximum level oscillations for four disastrous tsunamic of 1952, 1957, 1960, and 1964. Three types of the form of level oscillations near the shore, A,B,C, were distinguished. A are individual-type waves; these are tsunami waves coming directly from the source and are best observed at Central Pacific Islands. B are edge waves, i.e. dispersive oscillations of the interference nature that propagate along the shelf and are often observed by stations on the continents and marginal island arcs. C is a combination of the A and B types. Different types of oscillations are comparatively regularly observed at different stations depending on the location of a tsunami source. This circumstance can be used in the tsunami warning service for estimating the expected time of the maximum water elevation.

As a whole, the seminar on short-period tsunami prediction showed that a considerable progress has been made in improving the tsunami warning methods even for the last two years since the Honolulu Tsunami Symposium in October 1969.

A number of papers presented at the seminar on long period tsunami prediction dealt with the development of the general theory of tsunami generation and propagation. A very detailed review of theoretical studies on tsunami waves carried out for about the last 10 years was made by R. Preisenderfer, U.S.A. Mathematical methods of solving such problems as generation of tsunami, propagation of waves in the open ocean, diffraction of waves and in particular their propagation round isolated islands, shealing, the affect of the shore, resonance phenomena in bays and on the shelves, propagation of tsunami over dry beaches were considered by the author. Especially detailed consideration was given to studies made in the Western United States the most interesting unsolved problems according to the author's belief were enumerated.

R. Braddock, Australia, showed that, unlike the case of homogeneous distortion of the bottom, the amplitude of the head wave is smaller than these of the following dispersive train of oscillations when the impulse distortion of the bottom is in homogeneous in area.

S. S. Voit and B.I. Sabekin, USSR, obtained a curtailment-type expression for tsunami waves from sources of different types located on the bottom of the ocean, its free surface and within the water thickness. Reflection of tsunami from rectilinear coast and a depth jump were studied and it was found that Kelvin type long-period waves propagate along these boundaries in a rotating basin.

K. Kajiura, Japan, derived the ratio between the energy of the first tsunami wave and that of the edge wave that runs along the shelf and is formed in the case when the tsunami source is on the shelf or near it. It was found that

the portion of the energy entrapped by the shelf increases as the longitudinal axis of the source (oriented along the coastline) decreases and the source approaches the coast. A train of oscillations with a gradually decreasing amplitude runs into deep water.

The paper by K. Knowles and R. Reid, U.S.A., described numerical methods of calculating the shape of a plane tsunami wave in the open ocean from a mareogram obtained at an isolated island. Transmissive functions of islands of a complicated profile were obtained from numerical models.

The paper by L. V. Cherkesov, V.V. Knish, I.P. Iuking, V.S. Fedosenko, KRSS, dealt with the study of the change in the tsunami profile as the wave approaches the coast, and on continuous change in water depth due to such effects as non-linearity of the processes, near-bottom friction, stratification of water etc. The effect of the underwater relief on internal waves which can be produced in the process of tsunami generation and propagation was also analysed.

The paper by A.V. Nekrasov, V.A. Makarov, R.V. Pleskovsky and V.G. Bukhteev, USSR, was directed to numerical solution of the tsunami propagation equations by means of finite-difference and electroanalogic methods. The numerical methods were developed for cases of one-dimentional and two-dimentional propagations of the wave. Scattered and concentrated reflexion of a tsunami from the shelf and its boundaries was studied in detail. The shape of the initial distortion in the 1964 Niigata tsunami source was recreated and its energy was estimated.

Two papers by T. Murty and R. Henry, Canada, described numerical analysis of travelling tsunami waves along the Canadian Pacific shelf and their entrance into the multi-branched inlet system characteristic of that coast. Edge waves that are formed on the shelf were considered. Possibilities of calculating free and induced oscillations of water in multi-branch and complex inlets were compared by means of different methods (successive approximations, numerical integration, etc.) The so-called impulse-response method is given preference.

In their paper L.A. Ostrovsky and En. N. Pelinovsky, USSR, considered the following problems; the effect of non-linearity, depression and heterogeneity of the environment on propation of cnoidal waves in a near-coastal zone; travelling of an individual wave for cases of uneven and gentle variation of water depth; dependence of the wave breaking point on the dipping of the bottom; dissipation of waves described by nonlinear equations.

G. Loomis, U.S.A., presented results of numerical calculation of the behaviour of tsunami waves in Hilo Bay, Hawaii, for different angles of arrival and parameters of the wave in the open ocean and for different locations of the breakwater that is designed to be constructed for the protection of Hilo against tsunamis. Calculations were made by linearized equations with a quadratic member that takes account of friction on a grid of 82 x 54 grid points. For some conditions water elevation between the breakwater and the shore was maximum over the aquatorium; in other cases there was a great level difference near the breakwater, which would be in danger of collapse.

The paper by Vasiliov and V.G. Sudobicher, USSR, presented a review of possible methods for calculating tsunami run-up. The authors used the difference scheme based on a movable grid with isolation of the breaking place. Examples of such problems as rolling of an individual wave onto a sloping beach and entrance of a tsunami into a river mouth were given.

Results of hydraulic simulation of tsunami run-up on a steep coast were given in the paper by G.E. Kononkova and A.E. Reichrudel, USSR. The inclination angle of the slope, wave height, roughness of the bottom, water depth near the wave producer were varied. Dependence of rolling length and velocity on these parameters was obtained.

The paper by S. Nakamura, Japan, presented results of hydraulic simulation of entrance of tsunami into estuaries and formation of a bore. In the case of tsunami, the bore must have an oscillating profile. The results of the experiment are in satisfactory agreement with both observations and theory.

O. T. Nagoon and N.L. Arno, U.S.A. said that an aggregate of methods was used for long-period estimation of tsunami inundation risk in Crescent City, California. Historical data on tsunami were compiled, near-coastal underwater relief was studied in detail,refraction of the remote pacific tsunamis approaching the city was calculated, tsunami run-up was simulated in a chute. A conclusion was made that a small coastal rampart would be useful.

A practical scheme of calculating the probability of inundation of different elevations in a given point on the coast was proposed in the paper by Ch.N.G., V.A. Barnstein and A.A. Poplaveky, USSR It was noted that an artificial increase in roughness and mobility of the bottom near the water edge (by means of quarry-stone, for instance) decreases water elevation on the shore.

The seminar demonstrated, in particular, rapid progress in development and application of numerical methods for studying tsunami. Some speakers emphasized that the numerical simulation of tsunami is cheaper than the hydraulic one, the results being comparable.

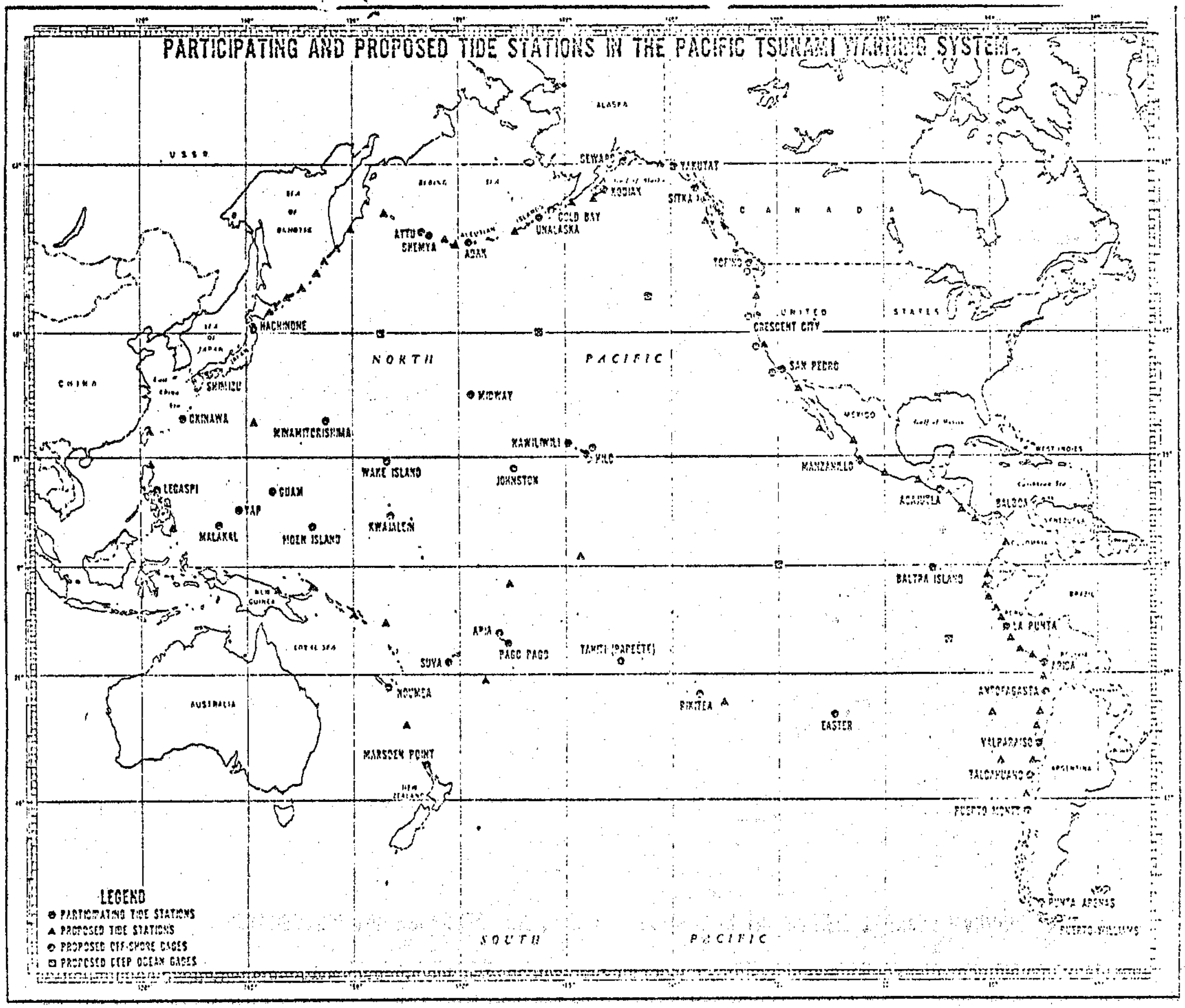
A film on the Soviet tsunami warning service operation produced by the TSENTRNAUCHFILM studio was shown at the symposium.

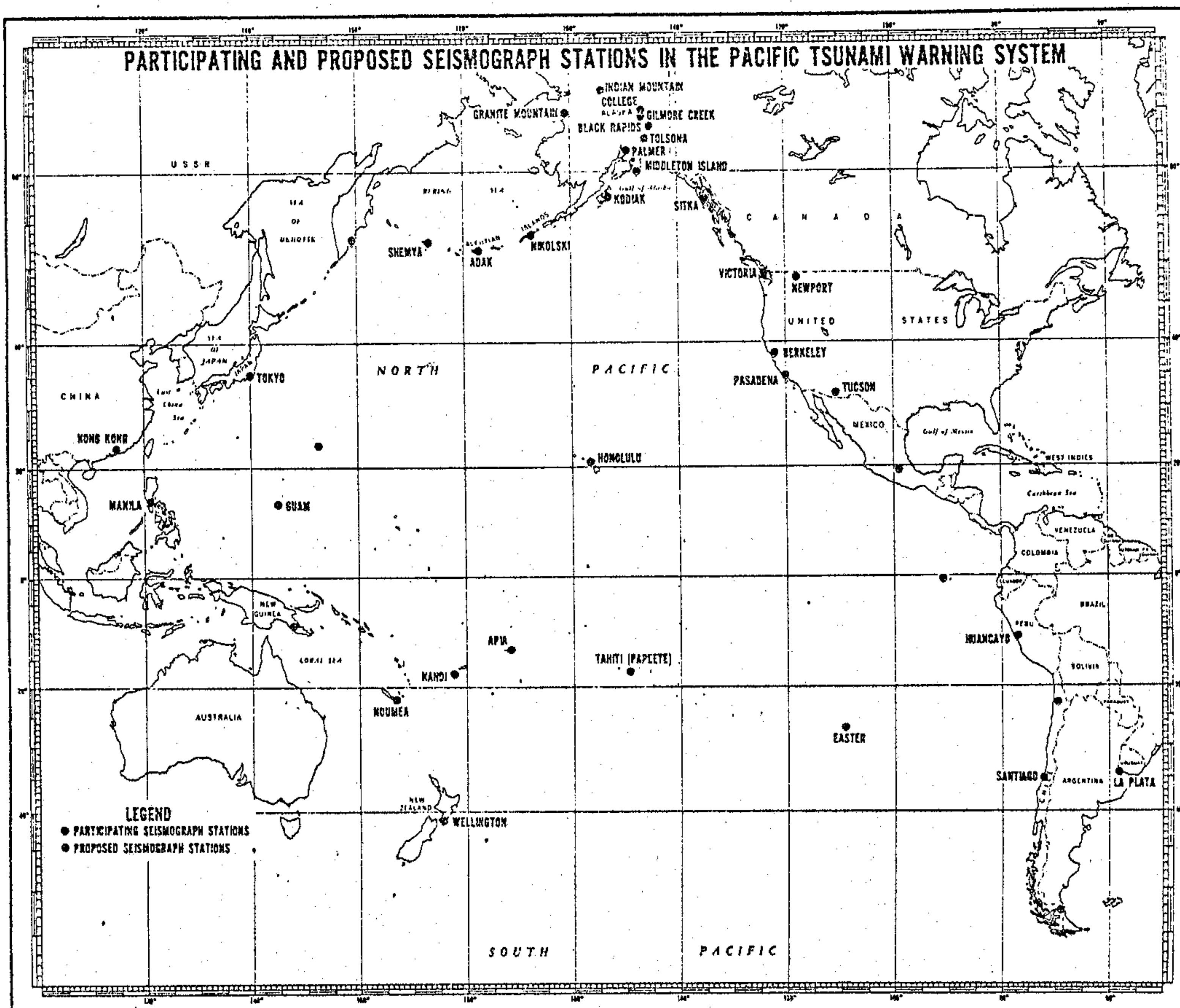
Two meetings of the IUGG Tsunami Committee were held. New officers were elected. Chairman: S.L. Soloviev, USSR, Vice-Chairman; K. Iida, Japan; Secretary; L. Murphy, U.S.A. Members of the Committee are: W.M. Adams, U.S.A.; N.N. Ambraseys, U.K.; R.D. Braddock, Australia; J.W. Brodie, New Zealand; K. Kajiira, Japan; C. Lownitz, Mexico, G.D. Miller, U.S.A.; V.S. Mereiza, Portugal; T.S. Murty, Canada; G.L. Piekard, Canada; R.O. Reid, U.S.A., IAPSO representative; E.E. Savurensky, USSR, LASPEI representative; E. Silgado, Peru; S.S. Volt, USSR; B.D. Zettler, U.S.A.

The Committee proposed amendments to section XII b TSUNAMIS of the guide to International Data Exchange through the World Data Centers, formulated proposals to the Unesco-IOC International Co-ordination Group for the Tsunami Warning System in the Pacific regarding practical measures and research work that improve

the service; recommended that greater emphasis be placed on tsunami research especially in developing countries of the Pacific Ocean and on training of scientists at various international centres such as the International Institute of Seismology and Earthquake Engineering in Tokyo and The International Tsunami Information Center in Honolulu; emphasized the necessity of compilation of an Atlas of tsunamis in the Pacific Ocean. According to the recommendation of the New Zealand representative, it was decided to convene the next international symposium on tsunami in Wellington in February, 1974.

ANNEX VII


PARTICIPATING AND PROPOSED TIDE STATIONS IN THE PACIFIC TSUNAMI WARNING SYSTEM
ALASKA
U S S R
SEWARD
YAKUTAT
KODIAK
SITKA
COLD BAY
UNALASKA
ATTU
SHEMYA
ADAK
C A N A D A
TOFINO
UNITED STATES
CRESCENT CITY
SAN PEDRO
HACHINONE
NORTH
PACIFIC
CHINA
SHIMIZU
OKINAWA
MIDWAY
MINAMITORISHIMA
KAWILIWILI
HILO
WAKE ISLAND
JOHNSTON
LEGASPI
GUAM
YAP
MALAKAL
MOEN ISLAND
KWAJALEIN
MANZANILLO
ACAJUTLA
BALBOA
BALTRA ISLAND
LA PUNTA
ARICA
ANTOFAGASTA
VALPARAISO
TALCAHUANO
PUERTO MONTT
PUNTA ARENAS
PUERTO WILLIAMS
APIA
PAGO PAGO
SUVA
TAHITI (PAPEETE)
RIKITEA
EASTER
NOUMEA
AUSTRALIA
MARSDEN POINT
NEW ZEALAND
NEW GUINEA
CORAL SEA
MEXICO
SOUTH
PACIFIC
LEGEND
PARTICIPATING TIDE STATIONS
PROPOSED TIDE STATIONS
PROPOSED OFF-SHORE GAGES
PROPOSED DEEP OCEAN GAGES


PARTICIPATING AND PROPOSED SEISMOGRAPH STATIONS IN THE PACIFIC TSUNAMI WARNING SYSTEM
INDIAN MOUNTAIN
COLLEGE
GILMORE CREEK
GRANITE MOUNTAIN
BLACK RAPIDS
TOLSONA
PALMER
MIDDLETON ISLAND
KODIAK
SITKA
U S S R
SHEMYA
ADAK
NIKOLSKI
C A N A D A
VICTORIA
NEWPORT
U N I T E D
S T A T E S
BERKELEY
PASADENA
TUCSON
MEXICO
C H I N A
TOKYO
N O R T H
P A C I F I C
KONG KONG
HONOLULU
WEST INDIES
MANILA
GUAM
VENEZUELA
COLOMBIA
PERU
BRAZIL
HUANCAYO
APIA
TAHITI (PAPEETE)
NANDI
BOLIVIA
AUSTRALIA
NOUMEA
EASTER
SANTIAGO
ARGENTINA
LA PLATA
LEGEND
PARTICIPATING SEISMOGRAPH STATIONS
PROPOSED SEISMOGRAPH STATIONS
WELLINGTON
S O U T H
P A C I F I C

Proposed Tide Stations in the Pacific Tsunami Warning System

	Country or Territory	IOC Member	Proposed Tide Stations
1.	U.S.	Yes	Newport, Ore. San Francisco, Calif. Amchitka, Alaska Perryville, Alaska Kiska I., Alaska Yunaska I., Alaska Trinity I., Alaska Yakataga, Alaska
2.	Canada	Yes	Langara I.
3.	Mexico	No	Rosario, Baja Calif. Puerto Magdalena, B.C. Mazatlan Acapulco Salina Cruz
4.	Costa Rica	No	Puntarenas
5.	Panama	No	Puerto Armuellas
6.	Colombia	No	Buenaventura
7.	Ecuador	Yes	La Libertad
8.	Peru	Yes	Talara Chimbote Matarani Pimintel Paramonga Pisco Chala
9.	Chile	Yes	La Serena Corral Puerto Aisen Caleta Lobos Chanaral Constitucion Juan Fernandez I. San Felix I.
10.	Australia	No	Norfolk I.
11.	Philippines	Yes	Davao Aparri
12.	China (Taiwan)	Yes	Hualien
13.	Japan	Yes	Kushiro
14.	USSR	Yes	Iturup, Kuril Is. Onekotan, Kuril Is. Urup, Kuril Is. Sarychevo, Kuril Is. Petropavlovsk, Kam Lopatka, Kam Komandorski Is.
15.	Tonga	No	Nukualofa
16.	Bonin & Volcano Is.	No	Iwo Jima
17.	British Solomon Is.	No	Honiara
18.	Central & Southern Line Is.	No	Christmas I.
19.	Phoenix Is.	No	Canton I.
20.	New Guinea	No	Rabaul Madang
21.	New Hebrides Is.	No	Santa Cruz Is.
22.	Pitcairn	No	Pitcairn

* Note: All Japanese tide stations participating in the Tsunami Warning System are not shown on the accompanying map. The stations indicated on the map are those for which Pacific tsunami travel time charts are available.

Proposed Seismograph Stations in the Pacific Tsunami Warning System

	Country or Territory	IOC Member	Proposed Seismograph Stations
1.	Mexico	No	Tacubaya
2.	Ecuador	Yes	Galapagos
3.	Chile	Yes	Sombrero Antofagasta
4.	USSR	Yes	Petropavlovsk
5.	Bonin & Volcano Is.	No	Minamitorishima
6.	Papua	No	Port Moresby

ANNEX VIII

Provisional Agenda 6. Problem and improvement in communication (Proposed by Japan)

1 Introduction

1.1 This item was discussed at the second meeting in Vacouver, Canada, on 12 - 14 May 1970.

The result of discussion appears in the final report of its second session, Annex VI - Improved telecommunication means for the exchange of tsunami messages (tsunami warning and information, tsunami and seismic data) between Japan, the United States of America and USSR.

1.2 In accordance with the plans of WWW/GTS and regional telecommunication network in RA-II, the Tokyo-Khabarovsk circuit for simultaneous 50 bps data and facsimile transmission were started on 2 March 1972. This is of the first phase of the plan agreed upon between Japan and USSR. The circuit for the time shared 1200 bps data and facsimile transmission, and 50 bps channel solely for the urgent tsunami information will be set up by March 1974 as the second phase.

1.3 Tokyo - Honolulu AFTN/MET channel is in operation at 75 bps by HF/ISB. Since HF band is often disturbed by the air condition, it will be replaced, in cooperation with USA, by the satellite communication channel on 10 May this year.

1.4 The circumstances between Japan and Thailand, which recently became a member of IGC, are as follows:

Tokyo - Bangkok met. circuit was established on June 1970 by means of cable via Hongkong in accordance with the plans WWW/GTS and RA-II, and reliable and steady transmission is now achieved.

1.5 All available circuits are accommodated into the ADESS (Automatic Data Editing and Switching System), by which automatical relay and switching of messages are made.

1.6 The met. telecommunication system has thus been highly improved since the time of the second meeting at Vancouver.
In order to facilitate the shortening of relay time through ADESS, the standardization of telecommunication procedures and formats of message is necessary. The proposal for such procedures and formats is described in para 3.

2 Present configuration of the international circuits around the RTH Tokyo (Regional Telecommunication Hub).

2.1 The function of the RTH Tokyo in accordance with WWW/GTS was completed in March 1972.
Some of these circiuts will necessary be graded up to speed up the transmission in future.
Present circuit situations are given in Fig. 1.

2.2 All of these circuits (cable and satellite circuits) are very stable. Neverthless, the provision of back-up routing is considered necessary for each circuit.

3. Japanese proposals for telecommunication procedures and formats.

3.1 In order to minimize the time-delay in the data transmission, it is necessary to strictly define the telecommunication procedures.

The following mandatory clauses will be taken into our consideration:

(1) An urgent priority should be given to the transmission of Tsunami messages,

(2) Procedures and format should in principle follow the WMO standard (Chapter 1 Volume C No. 9 TP 4 WMO Publication). Each circuit, however, has various kinds of character istics of itself, and an interim procedure should be decided in this session as a temporary step. The final procedure will desirably be examined by CBS/WG of WMO, which is resposible for the operation procedure on the GTS.

(3) Exchange and relay of Tsunami messages will be made by the Automatic Message Switching System, therefore, the necessary message identification for it should be agreed upon in this session.

(4) Used code should follow International Telegraph Alphabet No. 2 (CCITT No. 2 Code).

3.2 Message format

Message format comprises the following four phases:

A starting line
An abbreviate heading
A text
End of message or transmission

(all four phases together: Tsunami message.)

3.2.1 Format of starting line (Interim Procedures)

≪ ≡ ↓ZCZC→SSRR (or SRN)↑ nnn→JJJJJ SSSSS

nnn = transmission sequence number

SSRR = Indentification of circuit

Tokyo – Khabarovsk : TKHA

Khabarovsk – Tokyo : HATK

Tokyo – Bangkok : TKHB

Bangkok – Tokyo : HBTK

SS : Sending station

RR : Receiving station

SRN = Identification of circuit

Honolulu – Tokyo : HTB

Tokyo – Honolulu : THB

S : Transmitting terminal letter

R : Receiving terminal letter

N : Channel identification letter

JJJJJ SSSSS = Bell sinal

3.2.2 Format of abbreviated heading

≪≡↓ TSUNAMI CCCC $YYGG_{gg}$

TSUNAMI : Identification of urgent priority

CCCC : Location indicator of the station originating

$YYGG_{gg}$: Date and Time group

3.2.3 Text

TSUNAMI WAVE BEGAN AT 0920Z AND ..... (Ref. Vancouver Meeting Report Annex III TSUNAMI Data Reporting)

3.2.4 End of Message

↓ ≪ ≡≡≡≡≡≡≡≡ NNNN ↓↓↓↓↓↓↓↓↓↓↓↓

(≡ × 8) (↓ × 12)

4. Distribution of TSUNAMI messages (Interim Procedures)

The most effective method to ensure a rapid, reliable and automatic transmission of TSUNAMI messages is to indicate the addressee.

In order to facilitate this, the following table should be prepared beforehand.

ADDRESSEE / ORIGINATING	HONOLULU	TOKYO	KHABAROVSK	BANGKOK	HONG KONG
HONOLULU		X	X		X
TOKYO	X		X	X	X
KHABAROVSK	X	X			
BANGKOK	X	X	X		X
HONG KONG	X	X	X	X	

5. Requirements for stand-by circuit

Regular route is as shown in Fig. 1.

In order to ensure the at most reliability, it is necessary to make preliminary circuit for back-up purposes.

5.1 Tokyo - Honolulu portion

AFTN (Aeronoutical Fixed Telecommunication Network) circuit will be serviceable.

5.2 Tokyo - Khabarovsk portion

Exsisting aeronoutical telecommunication circuit or the means by some appropriate meteorological radio broadcasting services will be considered.

As for the details, fufther study should be made on it between the countries concerned.

6. Telecommunication test

It is necessary to carry out these telecommunication tests on the GTS (ref. Fig. 1) as soon as possible.

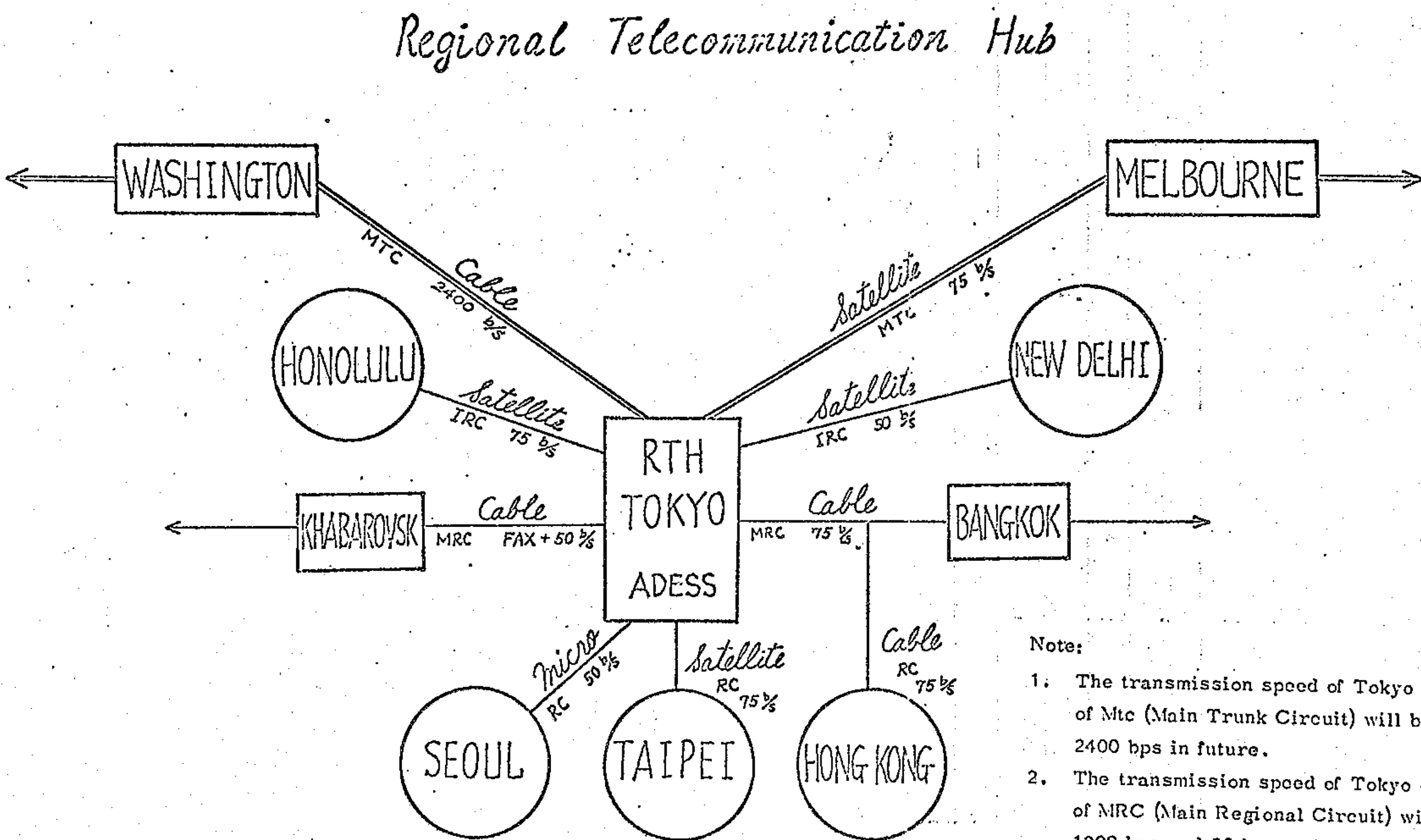


Fig. 1 Present configuration of the international circuits around the RTH Tokyo

Note:

1. The transmission speed of Tokyo - Melbourne portion of Mtc (Main Trunk Circuit) will be graded up to 2400 bps in future.
2. The transmission speed of Tokyo - Khabarovsk portion of MRC (Main Regional Circuit) will be graded up to 1200 bps and 50 bps on March 1974.
3. IRC: Inter-Regional Circuit
   RC: Regional Circuit

ANNEX IX

Resolution VII-28 - TSUNAMI WARNING SYSTEM

The Intergovernmental Oceanographic Commission,

Taking into account Recommendations 1, 2 and 5 of the Second Session of the International Co-ordination Group for the Tsunami Warning System in the Pacific (doc. SC/IOC-VII/26),

Requests Unesco and the UNDP to give favourable consideration to requests by Member States of the Group, particularly developing countries with long coastlines or subject to danger from tsunamis, for the establishment of adequate communications facilities for international alert stations, when necessary, and national warning systems,

Instructs the Secretary to investigate the availability of educational material designed to provide public awareness of the dangers and protective actions that should be taken upon receipt of a tsunami warning, and to report concerning his findings to the next meeting of the International Co-ordination Group on Tsunamis for its further consideration,

Further instructs the Secretary to reissue invitations to Member States to join the Group, and to invite other countries of the area which are members of any organization of the United Nations System and interested regional international organizations to be represented by observers at future meetings of the International Co-ordination Group,

Requests the Secretary to take appropriate steps to resolve with the Chairman of the ICG and the Chairman of the Joint IOC/WMO Group of Experts on Telecommunication, the questions concerning requirements for use of the HF radio frequency bands allocated by WARC, 1967,

Approves the summary report of the second session of the International Co-ordination Group for the Tsunami Warning System in the Pacific.