# RESMAC: THE NEW MEXICAN SEISMIC ARRAY

A Canadian viewpoint of progress,

with particular reference to the proposed

Canadian-Mexican cooperative aid

in the establishment of similar

networks in Central and South America

by

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SEISMOLOGICAL SERVICE OF CANADA

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Division of Seismology and Geothermal Studies

Earth Physics Branch

Department of Energy, Mines and Resources

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## Introduction

This report was written following the visit of the author to Mexico from 15 March 1977 to 16 April 1977.

From a Canadian point of view the purpose of the visit was to permit C.I.D.A. to be in a position to make a critical assessment of proposed cooperative aid projects in which Canada and Mexico would supply a comprehensive highly automated earthquake monitoring network to the Central American Republics and to other eligible countries in South America.

As a part of the assignment the author was asked by the Director of The Institute of Applied Mathematics and Systems (IIMAS) of the Autonomous University of Mexico (UNAM) to report his findings during the visit. Rather than repeat much of the same material, that report is attached to, and forms a part of the present report.

In addition a copy of the OAS resolution regarding a Seismological Network for Central America is attached to this report. It includes the terms of reference for the committee which is to make recommendations on the facilities that might satisfy the requirement.

## A review of my report of 14 April 1977

The numbers below refer to the attached report. In sections one and two the background of seismological study in Mexico is described and should be of general interest. In particular section 2.1 mentions some of the persons involved in the project.

Section three lists the objectives that were established for the system and recommends that the time is appropriate for a general review of the current work program which would probably lead to some adjustments in priorities. I should add that there exists considerable scope for interdisiplinary jurisdictional disputes with regard to seismological data collection and analysis.

Section four is a point by point review of the present project status and includes a technical discussion of problem areas, or areas where several options as to future development exist. Because of the technical detail in this section, most of it is not relevant to this report. However, I can summarize the more relevant points of this section in a few lines.

1. The detail of the overall system design requires more attention and effort.
2. The communications facilities should be recognized as a major part of the system, and as such require the attention of all levels of management in ensuring that facilities are made available as soon as possible and which, after installation, are adequately maintained.
3. That more attention be devoted to ensuring the timely order and delivery of sub-system components.
4. That the digital system design is receiving adequate attention and has few problems.
5. That more attention should be devoted to the sensor-analogue-digital interface.

Summarizing, I believe the project team has sufficient technical expertise in the academic sense, but it is lacking both experience in Seismological Instrumentation and in Project Management.

An examination of methods of supplying RESMAC technology to third countries

Notwithstanding the fact that RESMAC has not been demonstrated as an operational system, Dr. Cinna Lomnitz, the Project Coordinator, has been actively promoting the system in Central and South America. As a consequence of the P.A.I.T. meeting, Dr. Lomnitz saw Canada as a source of funding for future RESMAC systems in "tripartite" arrangements with a third country. In this scheme Mexico would supply the technology and the Outstation hardware. Canada would supply the E.D.P. equipment in the form of PDP11 minicomputers, valued at about $100K. Since these computers are manufactured by Digital Equipment Corporation and are perhaps only assembled in Canada, I am not sure to what extent this could be regarded as Canadian content (as opposed to U.S. content).

In considering the manufacture of Outstations it should be noted that the University does have a prototype printed circuit manufacturing facility, however, the examples I have seen of equipment made in this facility are not to accepted manufacturing standards of workmanship even though they do work. I should also point out that the University does not have available to it the services which are a part of any manufacturing operation such as sales, contract administration, assembly, test, technical literature and test procedures, operation manuals, spare parts and other after sales services. Perhaps this would be a role for Canadian or Mexican industry, in which case the concept of technology transfer is involved.

Recommendations regarding cooperative projects

Based on the present status and arguments in this report, I believe it is premature to seriously consider any cooperative projects involving RESMAC. Canada (and other countries) should wait until there is a minimum of six months demonstrated operational experience of RESMAC before making any kind of commitment. There is scope for further examination of the kind of cooperation that would be mutually acceptable to all the parties that would be involved.

A further comment on the RESMAC approach to the study of seismicity in underdeveloped contries

Seismologists in Canada and elsewhere have expressed doubts as to whether the RESMAC technology is the most appropriate solution to the problem of creating and maintaining a viable and reliable national seismograph network. RESMAC employs state of the art electronics technology with digital transmission of data to a central digital computer. It is thus a highly centralized high technology project. Other approaches using somewhat less sophisticated frequency division multiplex of analogue FM transmission have been successfully employed, notably in the Californian Regional Network. Certainly the conventional Mexican Photographic Seismograph Network has been a dismal failure. This has been attributed to the difficulty in maintaining a sufficient level of interest by seismograph station operators in a widely dispersed network and is aggravated by the principle of tenure and the lack of any native ability of operators to tinker in order to make things work.

By contrast the centralized system is deliberately made sophisticated, utilizing the theory that interest increases with sophistication and hence it becomes feasible to attract and keep motivated a team of technological specialists at a central location. I have discussed this concept with a noted seismologist of international reputation, James A. Brune, of the University of California, San Diego. He has had as much experience as any foreign seismologist of prevailing conditions in Mexico, and was originally in favour of simplicity in a seismograph network. However, simplicity by North American standards is sophistication at the village level in Mexico. He is now having "second thoughts" and having observed the high motivation in the RESMAC project team will concede that the high technology concept warrants testing. In Mexico the choice of an all digital system was made two years ago and is fait accompli. In any third country the FM analogue system could be considered a viable alternative. Several U.S. companies can supply most of the equipment required from their established product lines. To my knowledge, no company is offering off-the-shelf digital telemetry systems. Presumably the Mexican interest is in promoting Mexican technology which is digital. Would Canada promote FM systems utilizing U.S. technology and hardware?

The Earth Physics Branch has also developed and successfully used the digital technology similar to that being developed in Mexico. The Canadian stations have been operational since 1974 and present plans call for significant expansion during 1978. This technology could be transferred to a Canadian Company by a licensing agreement through CP&D.

<u>International contacts which have been made by Mexico</u>

The following are notes of a conversation between C. Lomnitz and the author.

Columbia

C. Lomnitz has had discussions with Jesus Emilio Ramirez, Director, Instituto Geofisico de los Andes and with Mr. Camil Coté, 2nd Secretary of the Canadian Embassy in Bogota. Apparently, Mr. Coté thought that a RESMAC system for Columbia would be a good opportunity to try out a "tripartite" approach in cooperative aid. A budget of the order of $250K-$500K was mentioned. Mexico would supply the technology, system design and assistance in training. Canada would provide the funding and the computer equipment. Columbia would assemble the hardware.

Central America

An O.A.S. resolution has been passed in favour of a Central American Seismograph Network and the O.A.S. has agreed to fund a feasibility study to be started in October 77. The team on the study would include Dr. Lomnitz, Gary Latham, University of Texas, E. Counsel from Chile, and R.B. Hayman of Canada (the author of this report).

The project would be controlled by Antonio Quesada, Earth Sciences Program, Science and Technology Branch, Department of Science and Technology, O.A.S.

ORGANIZATION OF AMERICAN STATES

INTER-AMERICAN COUNCIL FOR
EDUCATION, SCIENCE, AND CULTURE

CIECC

VIII REGULAR MEETING OF CIECC
February 3-11, 1977
Montevideo, Uruguay

OEA/Ser.J/II.19
CIECC/doc.14
28 December 1976
Original: Spanish

# SEISMOLOGICAL NETWORK FOR CENTRAL AMERICA AND PANAMA
AG/RES. 215 (VI-0/76)

Topic II.3 of the Draft Agenda

## EXPLANATORY NOTE

The General Assembly, at its Sixth Regular Session, in resolution AG/RES. 215 (VI-O/76), instructed the General Secretariat to coordinate, in consultation with the Governments of Central America and Panama, the preparation of a Seismological Plan or Program for the region and to provide that the plan thus prepared be presented for consideration to the next regular meeting of CIECC, which shall be responsible for adopting measures to finance it.

The present document includes a copy of AG/RES. 215; the agreement reached at the XIV Regular Meeting of CEPCIECC, regarding the need to carry out a prior study for the preparation of the plan, as recommended by the Inter-American Committee on Science and Technology at its XIX Regular Meeting; and the document, "Central American Seismological Network," (CICYT/doc.160) which is to be submitted to CIECC for consideration.

AG/RES. 215 (VI-O/76)

# SEISMOLOGICAL NETWORK FOR CENTRAL AMERICA AND PANAMA

(Resolution adopted at the second plenary session, held on June 16, 1976)

WHEREAS:

The Central American region is subject to frequent seismic phenomena whose disastrous consequences for human life and the economy of the countries have been evident in recent years in the cases of the Managua earthquake and the recent one in Guatemala;

Seismological studies based on the experimental analysis of seismic movements are very important as a basis for earthquake-resistant engineering, a science that makes it possible to construct or adapt civil engineering works (buildings, bridges, roads, dams, industrial installations, etc.), so that they have the greatest capability of resisting the effects of high-intensity seismic accelerations without appreciable damage;

It is equally important to educate and alert the population to follow an individual and collective pattern of behavior that facilitates the action of the authorities in restoring life to normal following an earthquake; and

The OAS, within its technical assistance activities in science and technology, has rendered services in these matters to the Central American countries and Panama,

THE GENERAL ASSEMBLY

RESOLVES:

1. To instruct the General Secretariat of the OAS to coordinate, in consultation with the governments of Central America and of Panama, the preparation of a plan or program designed to:

a. Strengthen existing seismic installations in that area and coordinate them, so that they may come to form a Central American Seismological Network;

b. Promote a studies and research program for training professional teams of seismologists, geologists, volcanologists, and engineers specializing in earthquake-resistant construction;

c. Render any technical assistance requested by the governments for preparing or updating codes or standards for earthquake-resistant construction;

d. Assist the governments in formulating and disseminating among their people information on the action that they should take, individually or as a group, in the event of an earthquake; and assist the governments, also, in organizing within the sphere of the public authorities, centers or teams that can act in cases of national emergency.

2. To provide that the plan thus prepared shall be presented for consideration to the next regular meeting of CIECC, which shall be responsible for adopting measures to finance it.

FINAL REPORT OF THE XIV REGULAR MEETING OF CEPCIECC
CEPCIECC/doc.365 rev. 1 corr. 1 page 49 (English version)

At its XIV Regular Meeting CEPCIECC decided:

Seismological Network for Central America and Panama - AG/RES. 215 (VI-0/76) - CICYT/doc.164

To approve the study proposed in document CICYT/doc.164 and to instruct the Secretariat to provide the funds necessary to implement it in the next budget, since it would benefit not only Central America but all the countries. That study could be conducted by three experts under the coordination of the General Secretariat. Those experts should have broad knowledge of the unique features of the region and could be hired for a period of two months each. The working plan would include a visit to each of the Central American countries and Panama, with an average stay of nine days per country. Existing earthquake-monitoring stations could be visited and the technical needs could be analyzed with local experts. The cost of this study is estimated at US$22,000, distributed as follows: fees, US$9,000; travel and per diem, US$13,000.

The group recommends that the Secretariat be instructed to secure, through the ONE's the participation of specialists whose services would be paid by their own institutions, leaving the expenses of per diem and travel for payment by the Secretariat.

In the design of the project, account will be taken of the activities and capacities of the centers of the special project "Evaluation of Seismic Risk," which has been in operation since the beginning of the 1976/77 period.

It likewise recommends that as a future action, a study be undertaken for a project that will eventually include all the Andean countries and the Caribbean countries as participants.

INTER-AMERICAN COUNCIL FOR
EDUCATION, SCIENCE, AND CULTURE
CIECC
*INTER-AMERICAN COMMITTEE ON SCIENCE AND TECHNOLOGY*

NINETEENTH MEETING OF CICYT
November 1 - 5, 1976
Washington, D.C.

OEA/Ser.J/XI
CICYT/doc.160
October 29, 1976
Original: Spanish

# CENTRAL AMERICAN SEISMOLOGICAL NETWORK

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## CENTRAL AMERICAN SEISMOLOGICAL NETWORK

BACKGROUND

The General Assembly of the OAS, at its session on June 16, 1976, adopted resolution AG/RES. 215 (VI-0/76) which states in its operative part:

"1. To instruct the General Secretariat of the OAS to coordinate, in consultation with the governments of Central America and of Panama, the preparation of a plan or program designed to:

a) Strengthen existing seismic installations in that area and coordinate them, so that they may come to form a Central American Seismological Network;

b) Promote a studies and research program for training professional teams of seismologists, geologists, volcanologists, and engineers specializing in earthquake-resistant construcstruction;

c) Render any technical assistance requested by the governments for preparing or updating codes or standards for earthquake-resistant construction;

d) Assist the governments in formulating and disseminating among their people information on the action that they should take, individually or as a group, in the event of an earthquake; and assist the governments, also, in organizing within the sphere of the public authorities, centers or teams that can act in cases of national emergency.

2. To provide that the plan thus prepared shall be presented for consideration to the next regular meeting of CIECC, which shall be responsible for adopting measures to finance it."

CICYT, at its Eighteenth Meeting, on June 28, 1976 studied the resolution of the General Assembly and pointed out the following (doc.158):

"1. For preparing this project, other agencies in the system, such as the Pan American Institute on Geography and History, and its Geophysics Committee, the Inter-American Geodesic Service, located in the Panama Canal Zone, as well as all the member countries and any other countries concerned should be asked to cooperate.

2. It is considered important for the project to be prepared by utilizing the experience of the Multinational Earth Sciences Project and the Multinational Engineering Project of the PRDCYT.

3. A topic on forecasting earthquakes should be included among the project topics.

4. The characteristics and multinational impact of the proposed network indicate that the project could be presented as a special project with the countries concerned.

At its regular meeting on July 26, 1976, CEPCIECC, in doc. 330, rev. 1, took the following decision:

"The Committee took note of the work that the General Secretariat must carry out, and also the recommendation contained in the final report of the XVII Meeting of CICYT and decided that, at its next meeting, it would study the plan to be presented."

## II. ANALYSIS OF THE PROBLEM

Due to its geological conditions, Central America is one of the areas of greatest seismicity in the American hemisphere.

In the period from 1900 to 1976, more than 2,820 earthquakes have been recorded in Central America with surface wave magnitudes above 5.5 Ms. on the Richter scale, of which 953 were destructive. Notable among these were the ones on April 28 and May 1, 1919, which caused the destruction of San Salvador; the one on November 5, 1928, which destroyed León; the one on December 23, 1972, which devastated Managua; and the one on February 4, 1976, which destroyed a wide area of Guatemala.

The seismic phenomenon taken in its most simplistic form, is the result of vibration and acceleration induced in a part of the crust of the earth, because of the tectonic movements of the continental plates, as a result of the constant evolution of the planet.

During a seism, buildings are subjected to these vibrations and accelerations, and in the majority of cases the probable behavior of the soil-structure system is unknown. For this reason, it is easy to make errors in calculation and design of buildings, which makes it highly likely they may collapse, thus causing the characteristic damage of an earthquake.

In order to provide effective protection for the cities and buildings of the region, it is necessary to collect as much seismic information as possible, to obtain a thorough knowledge of the geologically active and inactive areas, and the mechanics of the seismic phenomenon. This knowledge will allow the respective governments to establish standards, codes, and laws that will ensure to the inhabitants of the region effective protection against disasters of this kind.

## III. NEED FOR A SEISMOLOGICAL NETWORK AND IMPLICATIONS OF ITS INSTALLATION

The Central American region has a remarkable periodicity in the incidence of seismic phenomena, some of which are accompanied by volcanic eruptions. The frequency of these phenomena is unknown; also unknown are which areas are most active and the behavior of the soil and of the structures built on it under the action of seismic waves.

In order to be able to interpret these phenomena, it is necessary to record the seismic waves of various kinds, which is done by instruments, such as: seismographs, accelerometers, and seismoscopes, placed in permanent stations located in various geographic locations. The group of these actions form the so-called "Seismological Network."

The stations operate under a constant system, and the information that they obtain may be collected periodically by the staff, or transmitted immediately to a central office by telemetric systems. In both cases, it is in this central office that the information is analyzed and processed by a group of highly-trained professional workers, having master's or doctorate degress in the seismological and geological sciences.

The results of this research will be applicable immediately by engineers and planners in the establishment of codes, standards, and urban zoning, which will lead to greater protection of lives and property during an earthquake. It will also be a function of this group of seismologists to conduct research directed toward prediction at seismic and volcanic phenomena.

## IV. SEISMIC FACILITIES EXISTING IN CENTRAL AMERICA AND PANAMA

### i. Equipment

Several countries of the region now have seismological networks whose functions are confined to surveillance of volcanic activity, or to studies for protecting hydraulic works under way. Such is the case with the seismological network of Guatemala at Lake Atitlán and the Volcán de Fuego, or the Costa Rican network in the vicinity of the Arenal Volcano and the dam under construction.

Networks more national in nature, whose function it is to determine areas of greatest seismic risk in the country for purposes of urban and regional planning, are those of Nicaragua, operated by the Seismic Research Institute of Nicaragua, and that of Costa Rica, operated by the Central American School of Geology. Both networks are deficient in equipment and technical personnel.

EXISTING SEISMIC STATIONS IN CENTRAL AMERICA

| Country | No. of Stations | Instruments | Coverage | Location |
|---|---|---|---|---|
| Guatemala | 4 | 6 seismographs | local | - Lake Atitlán<br>- Volcán Fuego |
| El Salvador | 1 | 1 seismograph | local | Near Tejutla |
| Honduras | 1 | 1 seismograph | local | In Tegucigalpa |
| Nicaragua | 14 | 14 seismographs | national | In the seismically active region in the western part of the country |
| Costa Rica | 10 | 10 seismographs | partial | Vicinity of Arenal Volcano, in the central plateau, and in the city of San José |
| Panama | 1 | 1 seismograph | local | Canal Zone |

ii. Personnel

Central America has highly-skilled personnel in the fields of geology and civil engineering; in the field of seismology, only Costa Rica and Nicaragua have, in the last three years, started personnel training programs.

## V. STRUCTURE OF A SEISMOLOGICAL NETWORK

The basic components of a seismological network are the research personnel and the seismological stations.

### i. Seismological Stations

A group of more than three "seismological stations," each located at a different geographical point and having the possibility of seismic triangulation among them, constitutes a so-called "seismological network."

Each station should have a number of pieces of equipment able to detect the seismic waves of various kinds and to record them independently of the magnitude of such waves.

A typical station is composed of a seismometer of two or three components with the ability to record the horizontal and vertical seismic waves, an automatic system to measure time, and recording systems, which can be either graphic or telemetric.

This group of instruments should be installed permanently and protected against the atmospheric elements and at a distance from urban centers with a great deal of traffic, in order to avoid interference from them. This involves constructing a small building that constitutes the so-called "Seismological Station."

In addition to the network, the installation of recording apparatus that provides additional information on the behavior of certain types of construction and of the soils supporting them during violent seismic movements should be planned. For this, it is necessary to install simpler instruments, such as accelerographs and seismoscopes, in the construction whose behavior it is wished to learn.

The number of stations depends on the area to be covered and the degree of detail of information required. For this reason it is necessary to carry out a preliminary study on the installation of each station to determine its desirability and feasibility.

The information produced by each station is collected by the attendant personnel or transmitted by a telemetric system to a central station; in the latter case the stations have telemetric equipment and remote control and are hooked up to each other. This allows a national seismological network to be connected to another network in a neighboring nation through the use of existing microwave channels, which gives both networks a regional opening for studies on prediction.

Because all this equipment is electronic and highly sophisticated, it is absolutely necessary to have facilities for their maintenance and calibration. Past experience has shown that due to lack of adequate maintenance, only 10% of existing instruments in a country have been operable when an earthquake occurred.

Given the characteristics of the Central American region, it is estimated that about 80 stations are needed to organize national networks in the six countries, and on that basis the networks would constitute the "Central American Network."

ii. Staff

For the operation of, and the analysis of the information produced by each one of the national networks of national coverage, a group of highly trained professionals is required, to deal with the following:

(a) Location of foci and epicenters, (b) Determination of active seismic zones (faults), (c) Determination of the anomalies in the upper part of the mantle, (d) Preparation of maps of seismicity (isoseismic and exoseismic), (e) Microzoning of important cities, (f) Studies on seismic and volcanic prediction.

Geologists with a Master's degree, whose function would be to collaborate with the seismologists to improve the existing geological maps and to aid them in preparing seismicity and microzoning maps.

Electronic technicians with experience in the maintenance of seismological equipment. Their function would be to provide necessary maintenance of the equipment.

The composition of the team will depend on the level and volume of activities and should take into account the necessary infrastructure (premises, transportation, secretarial staff, and area) for its proper functioning.

## VI. DEVELOPMENT OF A PLAN

In order to form a Central American seismological network it is necessary to:

i. Conduct studies to determine the number of stations required by the countries, their location, and the institutions responsible for their operation.

ii. Decide which of the two systems will be used in the gathering of information from the stations: (a) graphic, (b) telemetry.

The graphic system involves periodic collection, daily or weekly, of the information produced by each station. The telemetric system involves more sophisticated electronic equipment for automatic transmission of the information.

The development of these two points may require about 6 man-months of work in visits to the countries and to other networks already established.

The setting up of the seismological network can be accomplished through one of the following methods:

a. Acquisition of all the necessary equipment. Installation and functioning of that equipment basically by contracted personnel while the national staff is being trained abroad. This alternative would require a period of approximately two years for setting up the network and a larger initial investment.

b. The other alternative is to define successive stages in which, initially, staff is trained and a limited number of stations are equipped. The investments in equipment are carried out gradually and progressively over six or seven years.

## VII. COLLABORATION WITH OTHER ORGANS OF THE SYSTEM

In developing the plan, consideration could be given to the participation of other agencies of the system or international agencies, as long as the activities to be carried out by each one are defined, and there is coordination to prevent the dilution of the project.

## VIII. BENEFITS OF A SEISMOLOGICAL NETWORK

### Short-term Direct Benefits

a. Production of more precise geological maps, which would promote greater confidence in large investments such as hydroelectric, geothermal, and other projects it is desired to develop in the region.

b. Determination of the areas of greatest seismicity that could affect present or future urban areas.

c. Microzoning of the cities of the region that would permit designing of better building codes and establish urban zoning laws suited to the real geological situation.

### Long-term Benefits

A unified network would permit the gathering of the statistical data needed to initiate systems for predicting earthquakes and volcanic eruptions, a goal not too far off in the development plans of some nations, and one that would avoid repetition of the recent catastrophes caused by the earthquakes in Nicaragua and Guatemala.

# RESMAC: The New Mexican Seismic Array

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Ottawa, 14 April 1977

## Introduction

This report outlines the topics covered during the visit of Mr. R.B. Hayman to IIMAS between 15 March 1977 and 16 April 1977. During the three weeks many aspects of the RESMAC system were discussed and compared with experience gained in the design and operation of the two Canadian telemetered seismic networks, ECTN and WCTN, which have been in operation since 1974. The Mexican RESMAC system will be similar to the Canadian systems in several respects. For example, each system includes:

1. data transmission by the national microwave telephone network
2. wide dynamic range digital data format
3. unattended outstations
4. on-line data processing and event triggering by PDP11 minicomputer
5. automatic remote calibration of outstations

A description of the RESMAC system has been published by Lomnitz and Gil. A copy of this paper is shown in appendix 1.

## 2. Background

### 2.1 Seismology in Mexico

The National centre for both seismology and Earthquake Engineering is located in the Autonomous University of Mexico in Mexico City (UNAM). Dr. Cinna Lomnitz is head of the Department of Seismology and Physics of the Earth's Interior, which is a part of the Instituto de Geofisica, where he is responsible for the Mexican Seismograph Network.

In addition, a cooperative venture with J.N. Brune et al (U. of C., San Diego), has established a separate network in the Baha California.

The Instituto de Ingeneria has responsibility for the strong motion network and studies in Engineering Seismology. A significant project in this area has been the establishment of a telemetered strong motion network in Mexico City.

The Instituto de Investigaciones Matematicas Aplicadas y en Sistemas (IIMAS) is developing the RESMAC system as a special project in Systems Engineering. The Instituto de Geofisica is funding the capital purchases with Dr. Lomnitz as the project coordinator. The senior staff associated with the RESMAC project in IIMAS are: the Director, Dr. Tomas Garza; the head of the Digital Systems Design group, Jorge Gil, and Software Design group leader and Institute secretary, Dr. Alberto Tubilla.

Further details of the staff and activities of these three Institutes are given in appendices 2, 3, and 4.

Some idea of the seismicity of Mexico can be obtained by referring to table 1 and fig. 1 after Lomnitz[2].

Examples of the bulletins published by both the Institutes of Engineering and of Geophysics are shown in appendices 7 and 8 respectively.

## 2.2 The original Mexican seismograph network

The first stations of the Mexican seismograph network were established in 1905. Additional stations were added from time to time, and the network reached its present configuration in 1950. The location of the stations are sketched in the map of figure 2. The operation of these stations has presented many problems due to the lack of technical expertise in the remote areas where many of the stations are located. The station time corrections for many stations have been unreliable and frequently useless. Often there is insufficient expertise on site to correct the smallest malfunction. All servicing has had to be done by staff from Mexico City with the inherent expense of travel to the stations.

Presently, I understand that seven of the nineteen stations are operating fairly reliably. This excludes stations in the Baha California network which are considered in section 2.3.

## 2.3 The Baha California network

Three stations were established in 1969 in the Baha region as a result of an agreement between scientists of the Universidad Nacional Autonoma de Mexico (UNAM) and the California Institute of Technology, coupled with the active cooperation of the Comision Federal de Electricidad (CFE), Lomnitz et al[3]. Subsequently, the network was expanded by the addition of five more stations. Presently, seven stations are operating.

Most stations in this network include: a baby Benioff seismometer and two special horizontal long period seismometers, a local photographic recorder, a WWVB time receiver and a crystal clock system. Power is obtained from a solar panel and battery. Although simple, the network has been expensive to operate, with even the simplest maintenance having to to be done by field travel from a central location.

Stations of this network are marked with an asterisk in table 2.

## 2.4 SISMEX: The Mexico City strong motion network

In 1972, with assistance from UNESCO, the Institute of Engineering, UNAM, established a multicomponent seismograph and strong motion network which has been described by Prince[4]. The system utilizes a mix of vertical seismometers and triaxial accelerometers. Data is telemetered to the Institute of Engineering using FM on FM radio telemetry operating in the 150MHz band. Four radio links are employed, some of which have two repeaters. Up to ten analogue channels are multiplexed on to one radio carrier. For example, one channel may include three gain levels of three components of acceleration plus one seismometer channel for a total of ten channels. At the central facility data are recorded on a seven (fourteen?) channel direct tape recorder in the multiplex format. One channel of the tape is allocated to a locally generated IRIG (VELA) time code and one to standard time radio transmissions.

Data are demodulated only on playback and are digitized and processed by an on-site minicomputer system.

All channels but the Puebla link are presently operational. The network layout has been sketched in figure 3.

## 3. RESMAC: A review of the project objectives

The principle uses for RESMAC have been described by Lomnitz and Gil. I quote,

> "The immediate objective of RESMAC will be to provide a full coverage of the national territory for uniform and reliable earthquake information to be used in zoning, microzoning, and other methods of estimating earthquake risk on a regional or local scale."

This is no minor undertaking, since it would make Mexico one of the first countries to have such an extensive centralized, fully computerized seismological network. Because of this, I believe the available R and D resource at the UNAM should be concentrated on this established, immediate objective, which is a systems engineering problem.

I think it useful at this point to list the 'routine functions' which the system must perform so that I can later consider the implications of some of these requirements:

1. To acquire raw data from outstations.
2. To trigger on events.
3. To sort events into categories: local, regional, and teleseismic.
4. To identify and list seismic phase arrival times.
5. To determine epicenter and magnitude according to the category of event.
6. To publish an earthquake bulletin.
7. To create and maintain a library of digital event tapes and provide for dissemination of data either as edited digital event tapes or as a visual record.
8. To maintain the system with adequate calibration of amplitude and phase and with reliable absolute timing.

## 4. Project status and some recommendations

### 4.1 System design

This is the area in the project which requires the most attention. Potential users of the system should be consulted in order to determine their needs more carefully. This should be followed by a further review of the objectives with modification as appropriate. These objectives could then be used to define a number of work elements or sub-projects to be distributed amongst the available manpower. I believe that this type of approach would allow a number of parallel work paths to be established and allow the project as a whole to progress even when one element is temporarily blocked. (eg. no lines!)

### 4.2 Communication network

This item must be recognized as the key to the success of the project as a whole. A sustained effort will be required in this area at all levels of management to ensure that lines are made available as promised and that an adequate priority and quality of maintenance is applied to the lines after the initial installation. Experience in Canada with ECTN and WCTN has shown that phone line failure is a major cause of down time. Dean[5] has reported similar experience for LASA, with line failure and CPU failure each accounting for 1.7% down time. At IIMAS, two conventional lines are about to be installed (April 1977) whilst communication technicians have recently conducted propagation tests as a preliminary step in the establishment of a 24 channel direct microwave link from IIMAS to the Mexico City central communications facility. I estimate that a minimum of six months will elapse before this link becomes fully operational. Table 3 lists the locations of repeater sites of the Mexican microwave communication network which are available for use by RESMAC.

## 4.3 Central processor hardware and configuration

Twin Digital PDP11'40 central processors were installed in 1976 in the configuration described by Lomnitz and Gil and are fully operational. The original cabinet, unibus and box layouts were as shown in figs 5, 6, and 7, and the system block diagram is as shown in the paper by Lomnitz and Gil (reproduced in appendix 1). The present scheme has been modified somewhat since the original proposal and now has the DH11 multiplexer, 16K of memory, the twin tape drives and twin disc drives on the shared bus. This system has the disadvantage of having one of the magnetic tape drives and the tape controller tied to the on-line task, making tape to tape transfers a difficult proposition. In addition, a severe disadvantage of magnetic tape systems is that operator action is required to place a unit back on-line following a power failure.

Experience in Canada and elsewhere[5] points to the desirability of keeping the on-line system as simple as possible, changing to a batch type of operation as soon as feasible in the signal flow.

Discussions with Alberto Tubilla led to the development of a new system block diagram, as shown in fig. 8, which also includes provision for a system clock and the display plotter sub-system.

A brief evaluation of the new proposal is given below:

Advantages

1. Simpler on-line system.
2. High redundancy of key elements eg. discs.
3. No on-line magnetic tape drives.
4. Direct access to tentative event files since they would be stored on disc.
5. All 1/0 peripherals are accessible to the user of the off-line processor all the time.

6. Off-line user has access to two magnetic tape drives and can thus do direct tape to tape transfers.

Disadvantages

1. Data storage problem when off-line system is down.
2. Less on-line storage capacity.
3. High buss loading of off-line system.
4. No automatic transfer of disc capacity.
5. Requires fast I/O channel between CPU's for event transfer.

Calculations on the time to transfer an event from CPU1 to CPU2 using the existing DL11 interface yield cumbersome times. Therefore the new configuration would need a faster transfer channel such as a DA11B. The DL11 units thus released could be utilized for the link to the display processor.

In Canada unnecessary downtime is incurred on ECTN and WCTN as a result of there being no operator to reinitialize the system following certain classes of fatal error (eg. Trap to 4). These errors often occur following a power bump which can apparently fool the CPU power fail autorestart circuitry. A scheme to automatically reboot the system and reinitialize the programs would largely eliminate this form of downtime. The RSX11 software provides most of the software required to do this.

4.4 System chronometer

A Systron Donner model 8110 Digital Clock has been ordered for use as the System Chronometer. The clock should include provision for synchronization to WWV, should have a precision 60 HZ reference output, and should include a non-interruptible power supply so that system time can be maintained through a power interruption.

The clock could be conveniently interfaced to the PDP11 using one of the DECkit 11 general purpose interfaces. The interface should permit the operating system time to be synchronized with real time. Use of the precision 60HZ for the line clock interrupts to the PDP11 will ensure continued synchronism of the programs after the system time has been set. A flag bit on the clock which is set by the clock hardware when an operator changes the time would be a convenient method of notifying the processor that re-synchronization is necessary. The clock should, of course, be interfaced to the shared unibus so that the on-line processor can always access it.

### 4.5 Central processor software

The central processor utilizes the Digital RSX11M real time operating system. This is an event driven multi-programming system which permits priorities to be attached to each program and permits controlled interaction between concurrently running programs.

Before the development of application software could commence at IIMAS, some special system software had to be developed to augment the operating system as delivered. This was a consequence of the particular twin processor configuration which had been installed.

Subsequently a driver program was written to interface the DH11 phone line multiplexer to the event detector program. This is operational. An event detector program has been written which compares the broadband short term rectified running average with a long term average to generate event triggers. Presently the program does not use disc circulation of immediate past data; rather a core buffer of several seconds only is used. The program has been tested with a single local outstation with the event being played back as an X-Y plot on a typewriter terminal.

Currently, three new programs are under development. Software is being developed for the interprocessor link which currently employs the DL11 interface. Note that the recommendation of section 4.3 is that this link should be upgraded to a DA11-B. A modular approach should be used in the interprocessor link software in order to permit an easy change over to the faster hardware at a later date.

Another software package is being developed to permit the Tektronix storage terminal to be used to display events. This is an interim measure since these duties will eventually be taken over by a modified DEC GT44 display processor, however, a more effective way of displaying data is needed urgently.

In addition, a Fast Fourier Transform package is also being finalized, and is being used to analyze calibration pulses.

Following a review of the system objectives as discussed in section 3.3, I believe that some kind of overall system flow chart should be developed similar to that shown in fig. 9 and described by Bungum[6] (1974). Crampin[7,8,9] (1974) has described a system for the automatic analysis of tape-recordings from seismic networks. Although this was not a real time system the techniques are very relevant to the RESMAC system.

I think it appropriate at this stage of development not to attempt automatic phase identification as described by Crampin. For the immediate future more rapid overall progress would be achieved by including an operator in the system flowchart who would determine phase arrival times for subsequent epicentre determination.

Discussions with Alberto Tubilla led to the development of a tentative system flow chart fig. 10. This might be used as a basis for further discussion.

4.6 Type TT station (SPZ)

Specifications and some block diagrams of the TT Station are shown in Appendix 5. In concept this station is very similar to the Outstations of ECTN/WCTN in Canada.

Three prototype stations have been built and are ready for field trials. The design will be finalized after the evaluation of data from the field trials. The lack of telephone lines has impeded progress in this area, but this should be resolved shortly.

The digital end of the package, including the modem, apparently presents no problems. However, I believe some further work can be justified on the analogue front end, although this should not be allowed to impede the progress of field trials.

The present scheme of filtering, using parallel matched filters for each of the four gain levels, is cumbersome to build and maintain. On the highest gain channel there is a danger of limiting taking place by signals out of the band of interest. I also feel that a more satisfactory design would include differential amplification of the seismometer signals. I understand that an alternative filter design with a much lower noise level is being developed.

A low noise filter design would permit a more efficient arrangement of the block diagram of the gain ranging stage which would avoid out of band limiting, contain fewer components and avoid the requirement for carefully matched components. Careful placement of the filter section would also remove the need for a three second delay when the system is gain ranging to lower signal levels and thus avoid the decision as to the optimum delay time. Considerations of dynamic range and gain separation are given separately in section 4.9. All three types of Outstations presently operate from 115V mains supply which can be unreliable. The

The possibility of utilizing the non-interruptible power system which is used in all microwave repeater systems might be investigated. This approach would require a dc-dc converter in place of the present power supply.

4.7 Type T station (SPZ + LPZ + LPN + LPE)

The electronics of this station are essentially the same as in the type TT station and so many of the same remarks apply. However, in my discussions, it became apparent that no one had really appreciated the higher level of care that is needed for the successful operation of the long period seismometers. These instruments can have a mass position temperature constant as high as 2.7 mm/$^{o}$C (Geotech model SL210). Since the instrument is designed to measure fractions of a micron, care must be taken to reduce temperature variations and air convection to a minimum. Furthermore, whereas with SP measurements the ground noise velocity decreases with increasing frequency, with LP measurements there is a sharp peak in microseismic ground noise at about 6 seconds period (fig. 11) so that the noise level increases with frequency. Buoyancy effects from atmospheric disturbances will also introduce noise into the system.

Consideration might also be given to the option of recording the LP, data in a broadband format as discussed by Marshall et al[10] (1972) and others.

Note that a remote Long Period seismometer must include electronics to automatically measure the position of, and centre the coil in the magnetic field.

It is also worth noting the input noise characteristics of a typical commercial long period amplifier such as the Geotech model AS620:-

0.1 V p-p (0.01 to 0.1HZ)

0.075 V p-p (0.005 to 0.036HZ)

measured with a total source impedance of 2K at 25$^{o}$C. The reason for this noise level can be seen by reference to fig. 12.

4.8 Type I station (SPZ + LPZ + LPN + LPE + μP)

A block diagram of this station is given in appendix 5. The electronics of this station are essentially the station T with the addition of an Intel 8080 microprocessor. Testing of the prototype microprocessor circuit boards is underway and a program has been written which will permit the Outstation to operate in an event triggered mode and send data on request to the central processor. The microprocessor end of this station is well under control, but the same remarks as for stations T and TT apply to the sensor end. It should be noted that the inclusion of the microprocessor certainly gives some flexibility in the organization of the Outstation.

Further thought is required on the best method of utilizing this type of station. One good idea, which merits further thought is the use of this kind of station in a multidrop communication network. Careful on-site editing of data could make this type of station competitive in terms of data handling capacity with conventional analogue FM transmission. However, to be effective these stations may need more on-site memory in order to buffer the data effectively when several stations on the same line are triggered simultaneously, as will often be the case.

Consideration might also be given to integrating the station types T and I so that a microprocessor would be available for control of the LP seismometer.

4.9 A discussion of digitization parameters

The choice of one to ten hertz bandpass for a system designed for regional seismicity studies is in keeping with accepted practice. (One to ten hertz is the standard response in Canadian Reginal Stations).

Local events certainly may have some energy at frequencies above 10HZ, but I do not believe there is any useful phase information at these high frequencies. To my knowledge, the only studies that utilize the energy beyond 10HZ are those that determine source parameters from the natural event corner frequencies. Smaller events would require an instrument response extending well beyond ten hertz in order to be able to accurately measure the high-cut asymtote. If these data were a requirement, I believe that it may well be feasible and economic to transmit only the spectrum information of the higher frequencies rather than the broadband time series.

The choice of 36 samples/second and hence on 18HZ folding frequency in conjunction with 10HZ second order filters will give adequate protection against aliasing. It remains now to discuss the system dynamic range and resolution.

Fig. 12 is an attempt to present an overview of the ground motion spectrum. Recognizing that a seismometer is a velocity transducer, the vertical axis is plotted as velocity. Thus lines of constant acceleration will have a slope of minus one, whereas lines of constant ground displacement will have a slope of plus one. The ground noise spectrum is derived from fig. 11 but is plotted for a constant octave band width. This is more representative of the noise that might be observed and measured on a seismogram. Average and maximum levels of noise are shown. The upper bounds of ground velocity and ground acceleration are theoretical values taken from Brune and Lomnitz[11] which have been substantiated by field measurements but are not yet fully accepted by seismologists. The three heavy outlines indicate the normal areas of operation of typical long and short period seismographs and of accelerometers. At the top of the figure a triangular shaded area indicates the ground velocity required to produce 1cm displacement of a seismometer coil. This is the limit of linear motion for the Geotech S13. A second lower triangular outline corresponds to 1mm of coil displacement. Most seismometers should operate in linear manner up to coil displacements of 1-10mm.

Since the bandwidth has been defined, we can now shade in the possible area of operation of a SP wide dynamic range seismograph. The lower limit has been set at the average noise level of 10mm/sec. This is also the lower level of the Canadian ECTN/WCTN and has been found to be just satisfactory. The upper level is determined by restricting the coil displacement to 1mm corresponding to a velocity of 1cm/sec. This level just overlaps the trigger level of an accelerometer. Thus the desired dynamic range is $10^6$.

In the left margin the voltage output of an L4 seismometer is shown for reference. In addition, two gain ranging schemes are shown. Both have the same starting resolution (10nm/s). The right hand column corresponding to four amplifiers with a gain separation of 4 shows that this scheme cannot cover the required range since the top limit is at $1.3 \times 10^6$nm/s. The left hand column shows a scheme with a gain separation of eight which has the required $10^6$ range.

Both of the schemes have an identical digital format, that is, a 12 bit mantissa and two bits of gain information. However, there is a trade off between an order of magnitude of dynamic range and one bit of resolution. The $8^3$ system has a minimum resolution of 1:256 whilst the $4^3$ system has 1:512. The Canadian system has been operating without resolution problems (so far!) at a resolution of 1:256. A further consideration favouring a lower resolution is that the noise spectrum is flat within the bandpass. This would not be the case if a broadband system were contemplated since an additional two decades of resolution would be required to handle the microseismic noise peak at 0.2HZ without the loss of low level signal fidelity.

Brune has said (discussion with RBH) that his experience has been that seismometers become useless at high ground velocities, perhaps because of spurious responses. I have been in contact with Geotech to try to get more information on this point but have not received any at the time of writing.

I recommend that the $8^3$ system be chosen as the most useful until such time as a definite problem is identified. Furthermore, I believe there is considerable sense in adopting a uniform scheme for all stations. Experience has shown that despite the best intentions, there will be uncertainty in the parameters of a system in which the dynamic range/resolution is individually optimized according to the noise level at each site. Since there is sufficient dynamic range the gain can be defined for the quietest site and that value used throughout the network.

### 4.10 Helicorder monitors

Further consideration should be given to the number of helicorders that should be connected to the computer through appropriate DA convertors in order to provide a conventional visual monitor of activity within the network. Four to six units might be appropriate.

## 5. Conclusions

The RESMAC project is progressing well. A prototype Outstation is operational. The central computer is fully operational and a trigger algorithm is working. Graphics routines are being developed to display the data. The telephone lines, however, have been disappointingly slow in materializing. The achievement is significant since it represents a leap frog in the technology of seismic data acquisition in Mexico. A contributing factor in the progress to date has been the high level of motivation of the team at work on the project at IIMAS. There are a few areas which I think warrant closer attention:

1. Who is going to operate the system? And who will be the user of the processed output? These questions become particularly significant when long term funding of the operational system is considered.
2. The communications network will always be a key part of the system. A long term commitment to quality service is required.
3. There is a tendency for both hardware and software designers to move on to more sophisticated systems before the simpler approaches have been made fully operational. A review of the project objectives followed by a redefinition of priorities might help here.
4. More time needs to be devoted to understanding the seismometer end of the Outstation package, particularly where LP instruments are to be used.

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TABLE 14.5

Earthquakes of Mexico–Guatemala (Region 5)

| *Date* | *Epicenter* | *M* | *Comments* |
|---|---|---|---|
| 1538 | Mexico | | |
| 1542 Mar. 17 | Mexico | | |
| 1568 Dec. 27 | Cocula, Jalisco | | |
| 1573 | Colima | | |
| 1575 | Puebla | | |
| 1582 | Mexico | | |
| 1586 | Guatemala | | |
| 1603 | Oaxaca | | |
| 1604 March | Oaxaca | | |
| 1608 Jan. 8 | Oaxaca | | |
| 1611 Aug. 25 | Mexico | | very large |
| 1619 Jan. 13 | Oaxaca | | |
| 1622 May 6 | Zacatecas | | |
| 1626 | Puebla | | |
| 1655 Nov. 25 | Oaxaca | | |
| 1662 Jun. 7 | Oaxaca | | |
| 1667 Jul. 30 | Puebla | | |
| 1697 Feb. 25 | Acapulco, Guerrero | | |
| 1701 Dec. 21 | Oaxaca | | destructive |
| 1711 Aug. 16 | Mexico, Colima, Guadalajara | | several dead |
| 1727 Mar. 10 | Oaxaca | | |
| 1739 Jul. 14 | Colima | | |
| 1749 | Mexico | | |
| 1750 | Mexico | | |
| 1754 Sep. 1 | Acapulco, Guerrero | | tsunami |
| 1773 Jul. 29 | Guatemala | | 100 dead; capital city moved to present site |
| 1784 Mar. 28 | Acapulco | | tsunami (12 ft), several dead |
| 1801 Oct. 5 | Oaxaca | | 7 dead |
| 1806 Mar. 25 | Jalisco | | many dead |
| 1818 May 31 | Mexico, Colima | | |
| 1820 May 9 | Acapulco | | tsunami |
| 1830 Apr. 1 | Guatemala | | |
| 1838 | Veracruz | | tsunami |
| 1845 Apr. 7 | Acapulco | about 7 | tsunami |
| 1852 May 17 | Amatitlan, Guatemala | | |
| 1854 Apr. 15 | Guatemala | | |
| 1858 Jun. 19 | Michoacán | about 7 | |
| 1862 Dec. 19 | Antigua, Guatemala | | |
| 1864 Oct. 3 | Puebla | | |
| 1870 May 11 | Oaxaca | about 7 | |
| 1872 Mar. 27 | Oaxaca | | |
| 1874 Sep. 18 | Guatemala | | |
| 1875 Feb. 11 | Zapopan, Jalisco | 7.5 | |
| 1882 Jul. 19 | Puebla | | |
| 1897 Jun. 5 | Oaxaca | 7 | |

TABLE 1



TABLE 14.5 (co

| *Date* |
|---|
| 1899 Jan. 29 |
| 1900 Jan. 19 |
| 1902 Jan. 16 |
| 1902 Apr. 19 |
| 1902 Sep. 23 |
| 1903 Jan. 14 |
| 1907 Apr. 15 |
| 1908 Mar. 26 |
| 1909 Jul. 31 |
| 1909 Sep. 5 |
| 1909 Oct. 31 |
| 1910 May 31 |
| 1911 Feb. 3 |
| 1911 Jun. 7 |
| 1911 Aug. 27 |
| 1911 Dec. 16 |
| 1912 Nov. 14 |
| 1918 Jan. 3 |
| 1919 Apr. 17 |
| 1920 Jan. 3 |
| 1920 Apr. 19 |
| 1928 Feb. 9 |
| 1928 Mar. 21 |
| 1928 Apr.16 |
| 1928 Jun. 17 |
| 1931 Jan. 15 |
| 1932 Jun. 18 |
| 1932 Jun. 22 |
| 1936 Dec. 14 |
| 1941 Apr. 15 |
| 1942 Aug. 6 |
| 1943 Feb. 20 |
| 1943 Feb. 22 |
| 1948 Dec. 4 |
| 1954 Feb. 5 |
| 1956 Nov. 9 |
| 1957 Jul. 28 |
| 1959 May 24 |
| 1959 Aug. 26 |
| 1962 May 11 |
| 1962 May 19 |
| 1962 Nov. 30 |
| 1964 Jul. 6 |
| 1965 Dec. 9 |
| 1967 Mar. 11 |
| 1968 Aug. 2 |
| 1968 Sep. 25 |
| 1970 Apr. 29 |
| 1973 Jan. 30 |
| 1973 Aug. 28 |

TABLE 14.5 (continued)

| *Date* | *Epicenter* | *M* | *Comments* |
|---|---|---|---|
| 1899 Jan. 29 | Oaxaca | 8.9 | |
| 1900 Jan. 19 | Jalisco | | |
| 1902 Jan. 16 | Guerrero | 7 | |
| 1902 Apr. 19 | Quetzaltenango, Guatemala | 8.3 | many dead |
| 1902 Sep. 23 | Chiapas | 7.8 | |
| 1903 Jan. 14 | Oaxaca | 8.3 | |
| 1907 Apr. 15 | Acapulco | 8.3 | |
| 1908 Mar. 26 | Guerrero | 7.5 | |
| 1909 Jul. 31 | Guerrero | 7¾, 7 | |
| 1909 Sep. 5 | Guerrero | 6.6 | |
| 1909 Oct. 31 | Guerrero | 7 | |
| 1910 May 31 | Guerrero | 6.5 | |
| 1911 Feb. 3 | Oaxaca | 7.25 | |
| 1911 Jun. 7 | Jalisco | 8 | 45 dead, damage in Mexico City |
| 1911 Aug. 27 | Oaxaca | 6.7 | |
| 1911 Dec. 16 | off Guerrero | 7 | |
| 1912 Nov. 14 | Acambay, Jal. | 7 | |
| 1918 Jan. 3 | Guatemala | | destructive in Guatemala City; several dead |
| 1919 Apr. 17 | Guatemala | 7.0 | |
| 1920 Jan. 3 | Oxochoacán, Puebla | | |
| 1920 Apr. 19 | Jalapa, Veracruz | about 6 | |
| 1928 Feb. 9 | Oaxaca | 7.7 | |
| 1928 Mar. 21 | Oaxaca | 7.5 | |
| 1928 Apr.16 | Oaxaca | 7.7 | |
| 1928 Jun. 17 | Oaxaca | 7.9 | |
| 1931 Jan. 15 | Oaxaca | 7.9 | |
| 1932 Jun. 18 | Jalisco | 7.9 | tsunami |
| 1932 Jun. 22 | Colima | 7.9 | tsunami |
| 1936 Dec. 14 | Tuxtla Gutiérrez Chiapas | | |
| 1941 Apr. 15 | Guerrero | 7.0 | |
| 1942 Aug. 6 | Guatemala | 7.9 | |
| 1943 Feb. 20 | Paricutín, Mich. | | volcanic eruption |
| 1943 Feb. 22 | Guerrero | 7.5 | damaging in Mexico City |
| 1948 Dec. 4 | Islas Marias | 7¼ | |
| 1954 Feb. 5 | Chiapas | 6¼ | |
| 1956 Nov. 9 | Tehuantepec | | |
| 1957 Jul. 28 | Guerrero | 7½ | several dead, damage in Mexico City |
| 1959 May 24 | Oaxaca | 6.8 | |
| 1959 Aug. 26 | Veracruz | 6.5 | |
| 1962 May 11 | Acapulco | 6.7 | |
| 1962 May 19 | Acapulco | 6.5 | |
| 1962 Nov. 30 | Guerrero | 5.5 | local damage |
| 1964 Jul. 6 | Guerrero | 6.5 | |
| 1965 Dec. 9 | off Guerrero | 6.8 | |
| 1967 Mar. 11 | Veracruz | 5.5 | damage |
| 1968 Aug. 2 | Oaxaca | 6.5 | damage |
| 1968 Sep. 25 | Chiapas | 6 | |
| 1970 Apr. 29 | Chiapas | 6.3 | |
| 1973 Jan. 30 | Michoacán-Colima | 7.7 | 56 dead |
| 1973 Aug. 28 | Puebla-Veracruz | 7.1 | 100 km depth; 600 dead |

TABLE 1 (contd)

MEXICO

BAJA CALIFORNIA
- EGM EL GOLFO DE SANTA CLARA
- LAY BAHIA DE LOS ANGELES
- RHM RIO HARDY
- SFP SAN FELIPE

CHIAPAS
- COM COMITAN
- PMM PRESA MALPASO

CHIHUAHUA
- CHH CHIHUAHUA

COLIMA
- MNZ MANZANILLO

GUANAJUATO
- LCG LEON CERRO GORDO
- LNM LEON

JALISCO
- GUM GUADALAJARA

MEXICO
- OXM OXTOTITLAN
- PPM POPOCATEPETL

MEXICO F.D.
- IXT C IXTAPALAPA
- TAC TACUBAYA
- UNM NAT UNIVERSITY OF MEXICO (WWNSS)

MICHOACAN
- PIM C PRESA INFIERNILLO

MORELOS
- TPM TEPOZTLAN

NUEVO LEON
- TMM TECHNOLOGICO DE MONTERREY

OAXACA
- OAX OAXACA
- PBJ PRESA BENITO JUAREZ
- VHM VISTA HERMOSA

PUEBLA
- PUE C PUEBLA

SINALOA
- CUL C CULIACAN
- MAZ MAZATLAN

SONORA
- CBS CABORCA
- GYM GUAYMAS

TERR. DE BAJA CALIFORNIA SUR
- LAP LA PAZ
- SRL C SANTA ROSALIA

TLAXCALA
- VGM C VILLA GRAJALES

VERACRUZ
- VCM VERACRUZ

YUCATAN
- MER MERIDA

Table 2
A list of seismograph stations in Mexico
( USGS, Seismograph station abbreviations and coordinates, March 1974. )

RESMAC

RED NACIONAL DE MICROONDAS S.C.T.

LISTA DE ESTACIONES CONMUTADORAS.

| | |
|---|---|
| Acapulco, Gro. | Guadalajara, Jal. |
| Acayucan, Ver. | Guaymas, Son |
| Aguascalientes, Ags. | Ixtepec, Oax. |
| Campana, Son. | Jaltipan, Ver. |
| Campeche, Camp. | Jiménez, Chih. |
| Campo Nuevo, Ver. | Juchitán, Oax. |
| Cd. Guzmán, Jal. | La Memoria, Sin. |
| Cd. Obregón, Son. | La Mina, Chis |
| Cd. Victoria, Tamps. | La Virgen, Zac. |
| Cerro Culiacán, Gto. | Las Lajas, Ver. |
| Chetumal, Q.R. | León, Gto. |
| Chihuahua, Chih. | Loma Batea, Nay. |
| Coatzacoalcos, Ver | Loma Larga, Oax. |
| Colima, Col. | Lomas de Nogales, Son. |
| Comitan, Chis. | Los Lirios, Gro. |
| Córdoba, Ver. | Malinche, Tlax. |
| Crestón, Oax. | Manzanillo, Col. |
| Culiacán, Sin. | Matamoros, Tamps. |
| Donají, Oax | Martías Romero, Oax. |
| Durango, Dgo. | Medias Aguas, Ver. |
| El Tormento, Camp. | Mérida, Yuc. |
| Ensenada, B.C. | Mexicali, B.C. |

TABLE 3

Minatitlán, Ver.

Monclova, Coah.

Monterrey, N. L.

Morelia, Mich.

Nevería, Sin.

Nuevo Laredo, Tamps.

Palma Sola, Oax.

Piedras Negras, Coah.

Poza Rica, Ver.

Puebla, Pue.

Reynosa, Tamps.

San Pedro, D. F.

Sabinas, Coah.

Salina Cruz, Oax.

Saltillo, Coah.

Tampico, Tamps

Tapachula, Chis.

Texixco, D. F.

Tijuana, B. C.

Torreón, Coah.

Tulancingo, Hgo.

Tuxtla Gutíerrez, Chis.

Uruapan, Mich.

Vega, Coah.

Veracruz, Ver.

Villahermosa, Tab.

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TOTAL 70 ESTACIONES CONMUTADORAS.

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January 23,
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int one was
fairly severe

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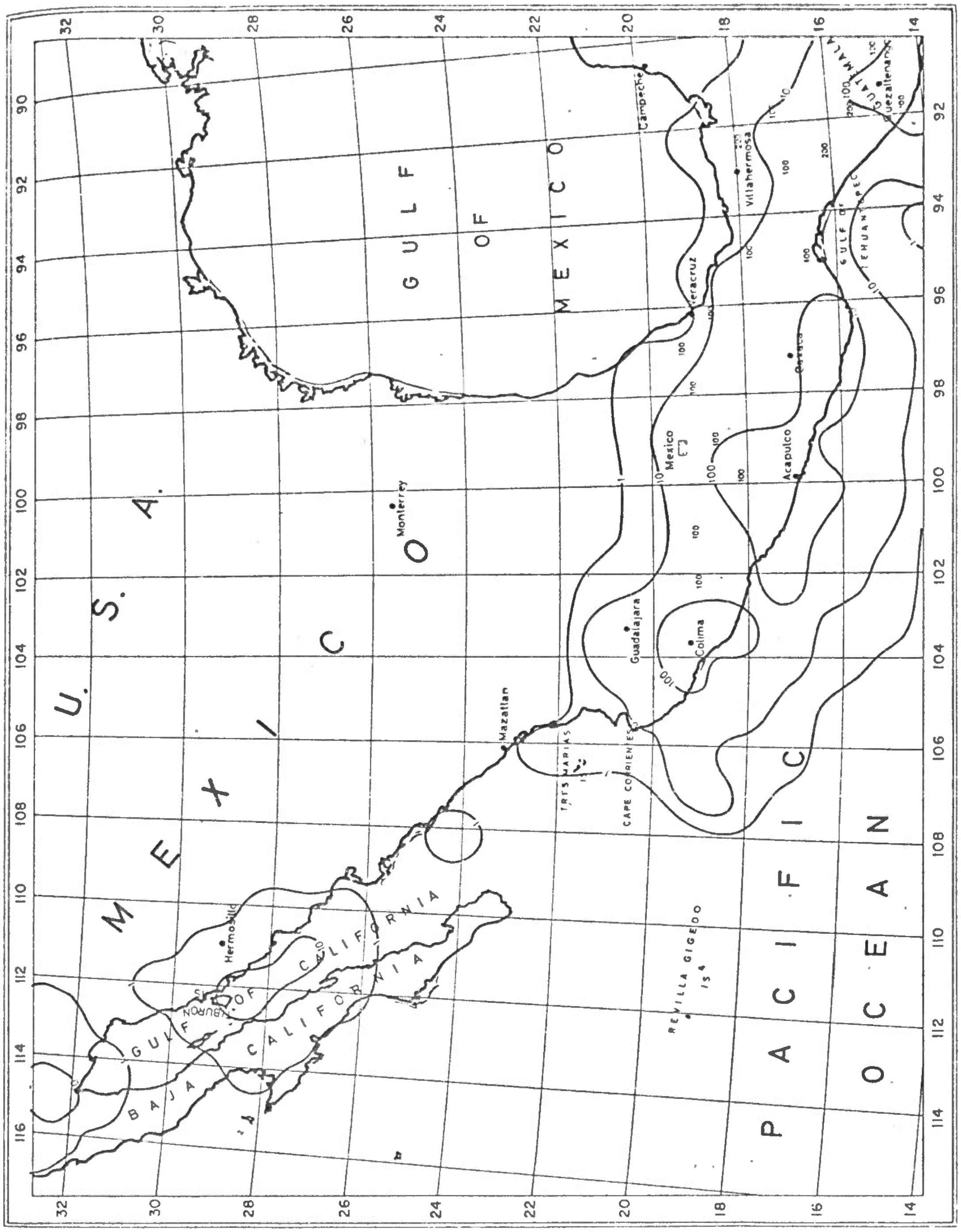
parallels the
is quite dif-
north by the
n of eastern

g the major
allow-focus
Michoacán,
between the
dre del Sur.
ic Belt and

s. North of
nto Sonora,
t. This is a
the Rocky
California




Map 8. Seismicity of Mexico: Regions 4–5. Seismicity contours are numbered in $10^{15}$ ergs $km^{-2}$ $year^{-1}$.)

fig 1


FIG. 2.

THE MEXICAN SEISMOGRAPH NETWORK

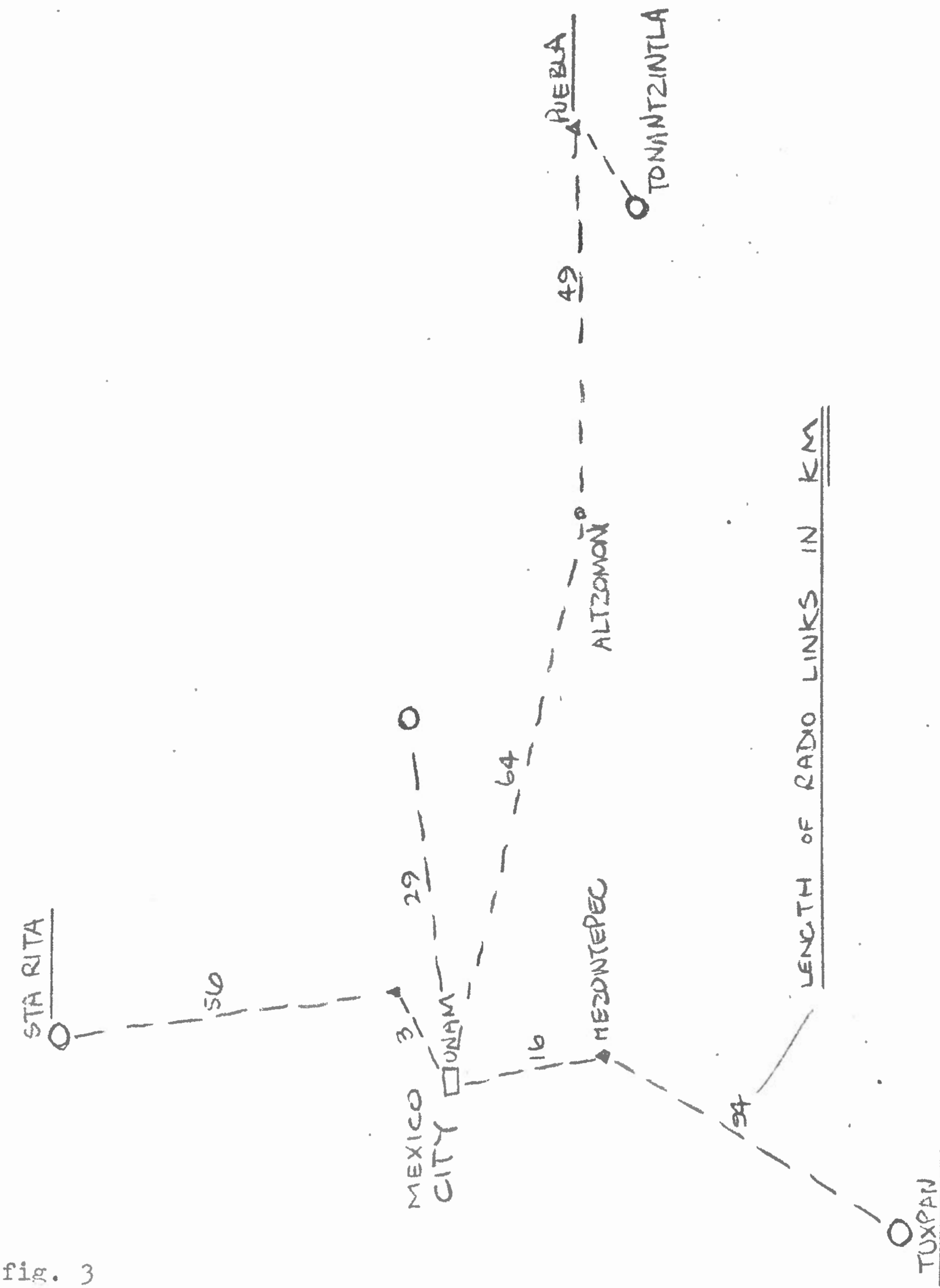



fig. 3
Seismograph stations of SISMEX
( Proc. of VWCEE, Rome, June, 1073.

fig. 4
The Baha California Network

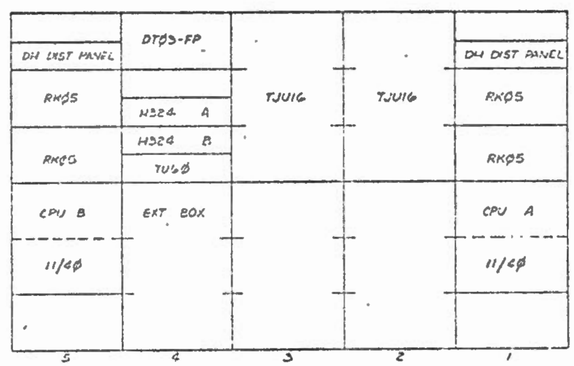



fig 5

CABINET LAYOUT

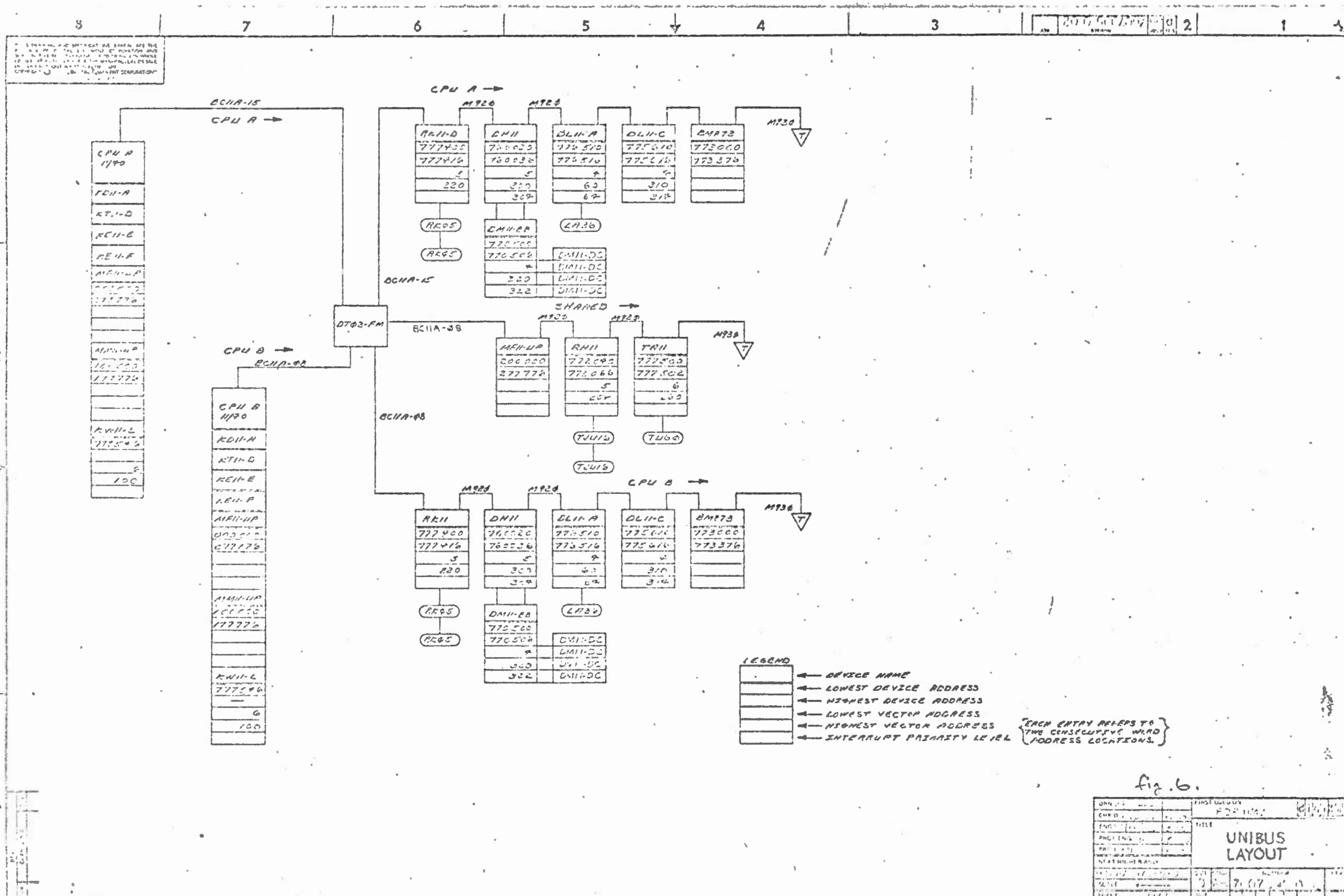



fig. 6.

UNIBUS LAYOUT

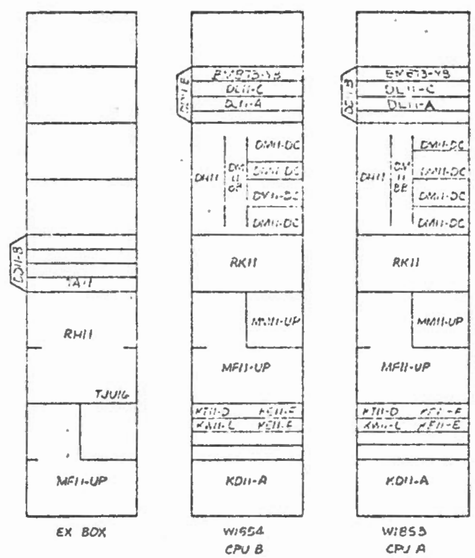



fig 7.

| FIRST USED ON OPTION MODEL | QTY | DESCRIPTION | PART NO. |
|---|---|---|---|
| PDP11/47 | | | |

UNLESS OTHERWISE SPECIFIED DIMENSIONS IN INCHES

TOLERANCES

MATERIAL

FINISH

digital EQUIPMENT CORPORATION

TITLE: BOX LAYOUT

SIZE: D

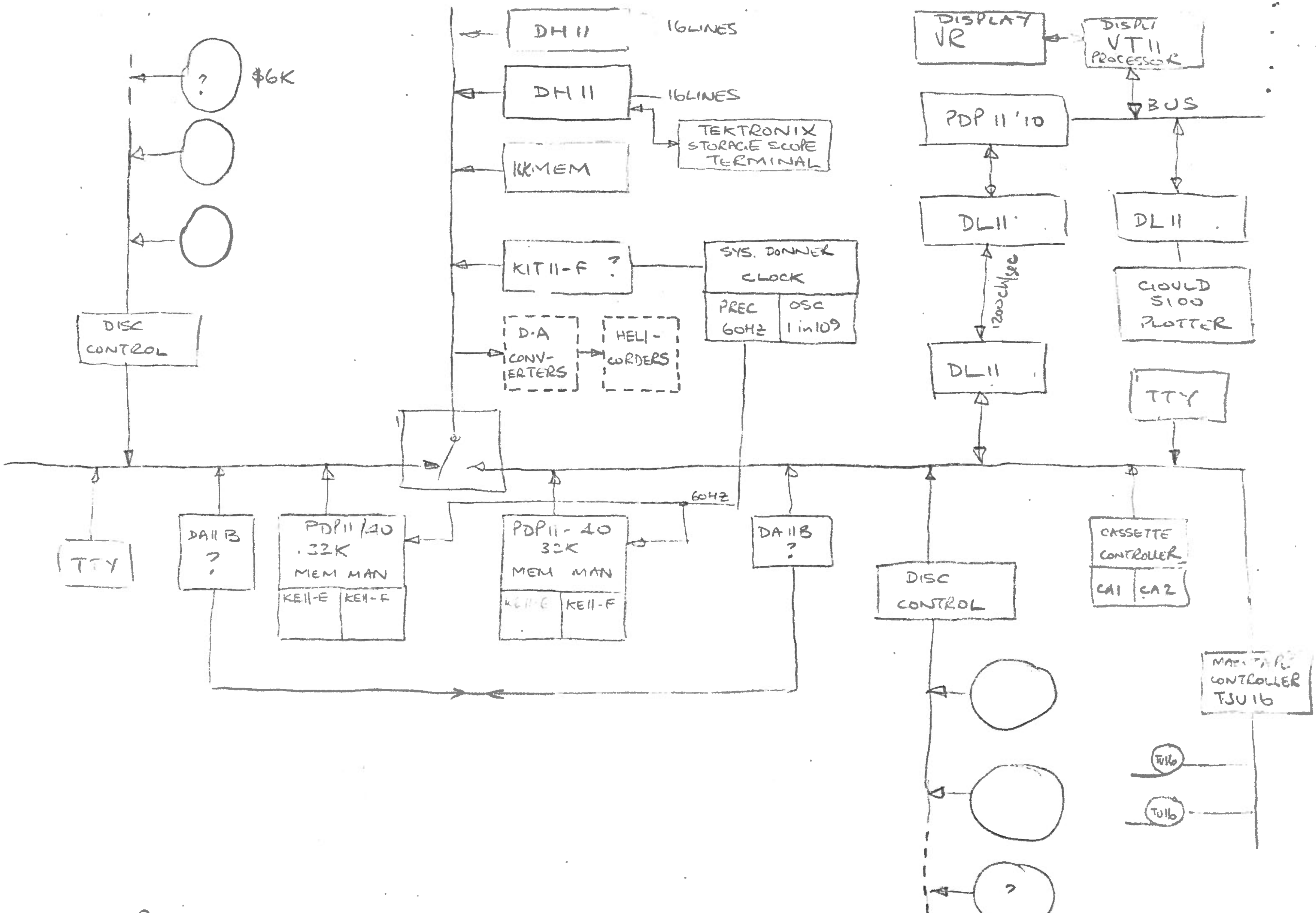



Fig. 8. Proposed new CPU configuration

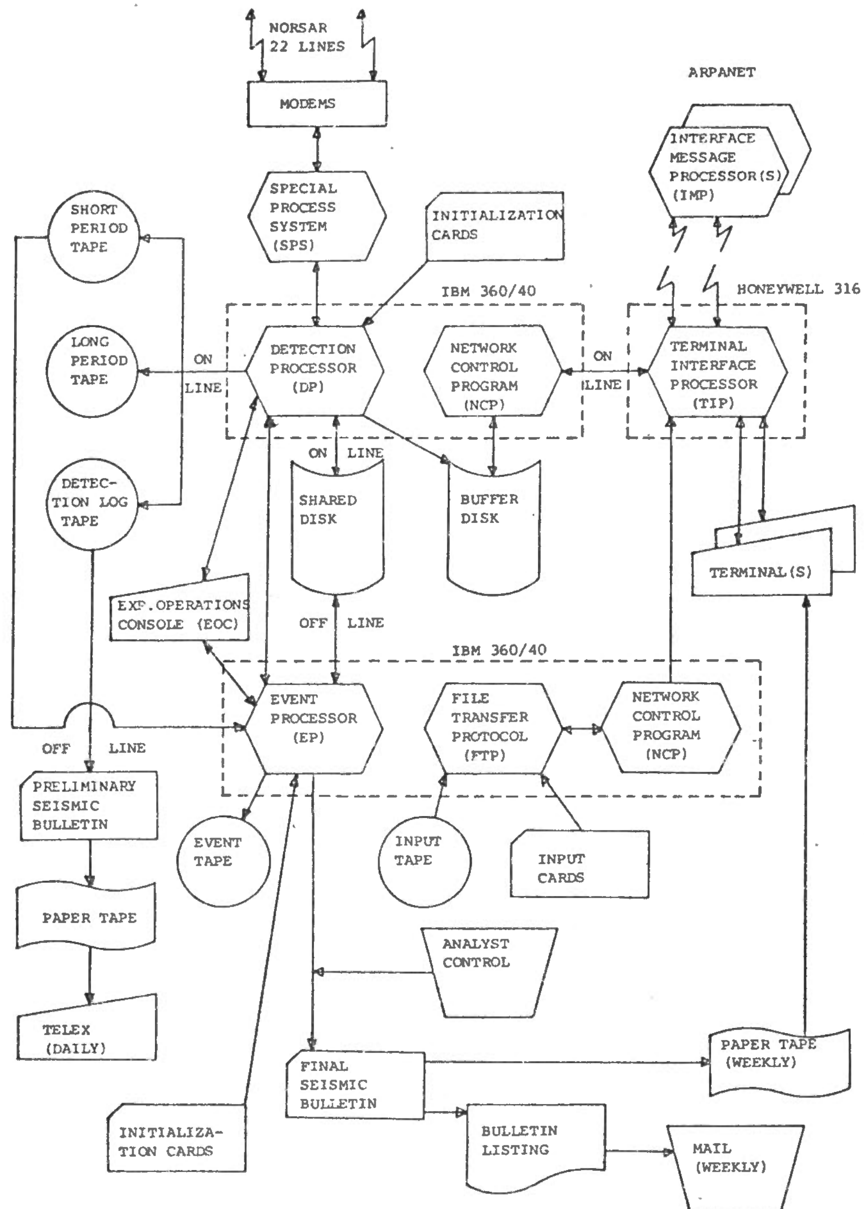



Figure 9. Physical and logical structure of the data processing system at NORSAR. For simplicity, most of the physical peripheral equipment has been left out, and emphasis is put on data flow. At the present date (May 74), the TIP is connected only to two

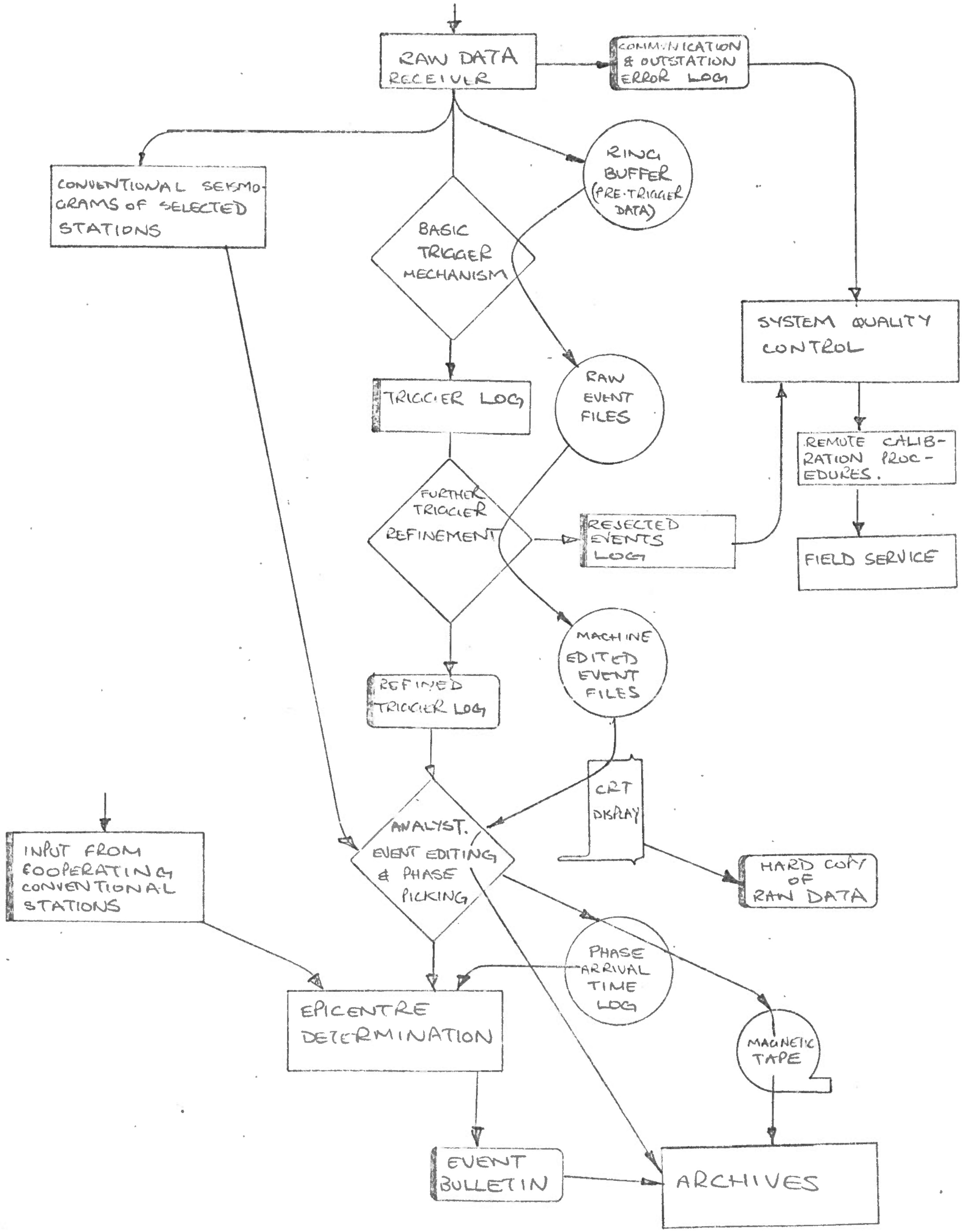



fig 10 RESMAC: A tentative System flow chart.

-pe-' ' seismo-

60, 1735, 1970.

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..: How and why
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72.

seismological data
array.
a Seismology And
Earth's Interior".

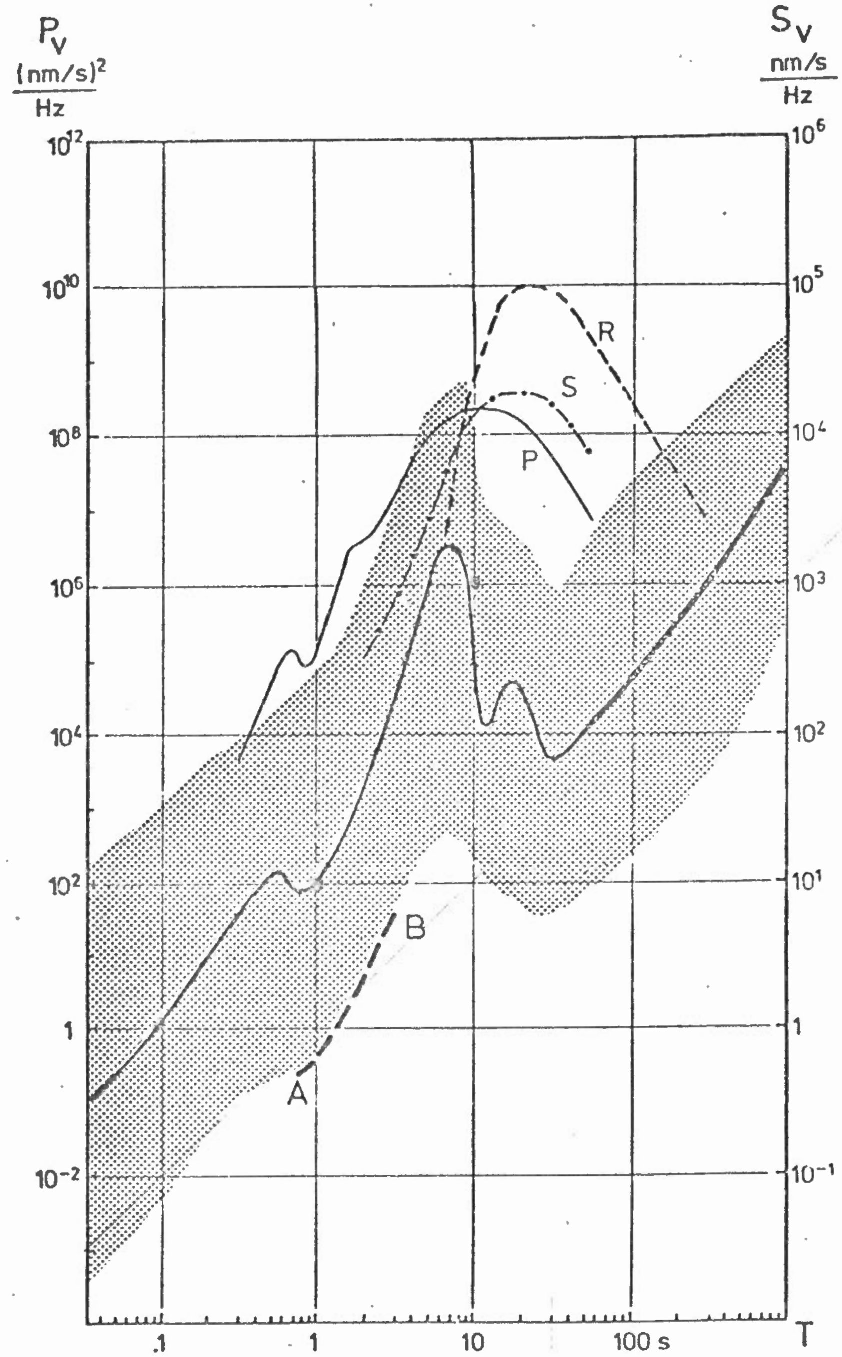



Fig.11 Seismic Noise - And Signal - Power - Spectrum

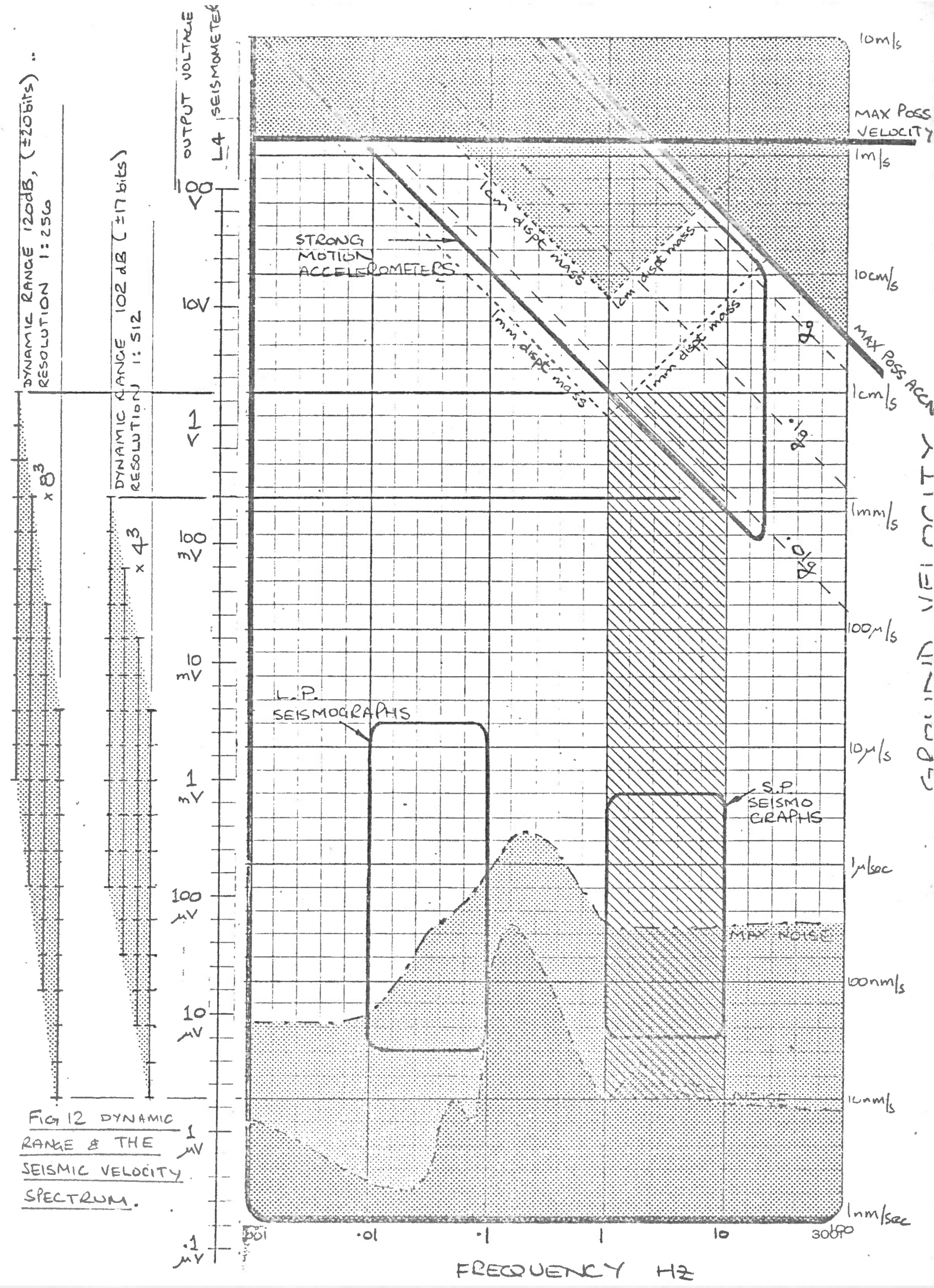



FIG 12 DYNAMIC RANGE & THE SEISMIC VELOCITY SPECTRUM.

Reprinted from
EØS
Vol. 57, No. 2, February 1976


# Resmac: The New Mexican Seismic Array

C. Lomnitz
and J. Gil

A new seismic array is currently being installed throughout Mexico. Resmac, which stands for Red Sismica Mexicana de Apertura Continental, or Mexican continental aperture seismic array, will use a nationwide microwave communication network as a vital element in a modern, all-digital, integrated system of seismic data acquisition and processing.

The Mexican microwave network spans the country from Tijuana to Cozumel and from coast to coast: hence it is called a 'continental aperture array.' Eventual cooperative projects now under the consideration of the Central American nations make a southward extension to Panama a possibility. At present, however, the Resmac project is sponsored exclusively by five agencies of the Mexican federal government, there being no financial or technical contribution from outside sources. The executive agency is the National University of Mexico, which is in close cooperation with the Department of Communications and Transportation of the federal government.

## The Resmac System

The system is accessible through any of 320 microwave transmission towers in the 30 states of Mexico. Most of these towers are located at remote mountain sites where conditions for seismic recording are close to optimal. The sensors will be buried in shallow wells within 250 m of the transmission towers. Three types of stations are currently being built at the CIMAS (Centro de Investigación en Matemáticas Aplicadas y en Sistemas) Digital Design Laboratory of the University of Mexico: (1) passive single station, type TT; (2) multicomponent station, type T; and (3) type I station.

The type TT station digitizes the output from a single vertical seismometer and feeds the data via Modem to a voice grade channel (Figure 1). Timing and calibration are also provided. The type T station may include up to six different sensors, digitized at different sampling rates: short- and long-period seismometers, tide gages, strainometers, and so on. The type I station includes a microcomputer unit; it may detect and store seismic information and transmit such information either continuously or in the batch mode. This type of station may be interrogated from the data center, and it may also be tuned by remote control.

## The Data Center

The microwave terminal building of the Mexican national communications system is located some 8 km from the data center on the University of Mexico campus. A

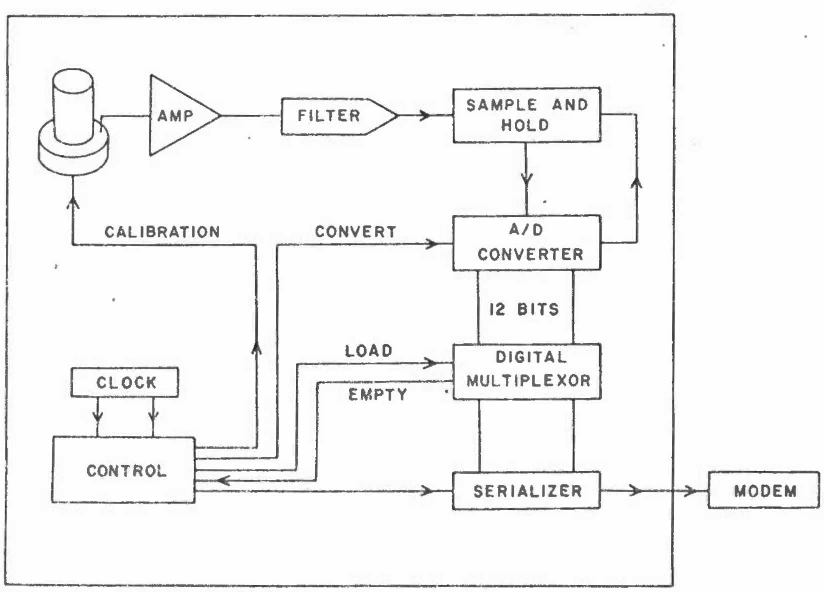



Figure 1. Station TT.

microwave link will be set up to bypass the telephone switching systems. The data processing facilities feature a duplex computer, including two identical central processor units (CPU) which are accessible through a common switching unit (Figure 2). One of the CPU's handles up to 100 channels of incoming digital data in real time, while the second CPU is held in standby for periods of maintenance or malfunction. The standby unit is also used for off-line processing. Each unit has independent core, disk, and tape storage; in addition, the off-line unit has an interactive screen terminal, which will be used for data editing and for a wide range of research activities.

Most routine functions, such as epicenter and magnitude determinations, bulletin compilations, and emergency messages for official use, will be executed automatically. Some research functions may also be programed for automatic execution, e.g., steering the array to focus on a specific region after a large earthquake has just occurred in that region. Surveillance of specific regions to detect premonitory changes in seismic transmission characteristics may also be programed as it is required.

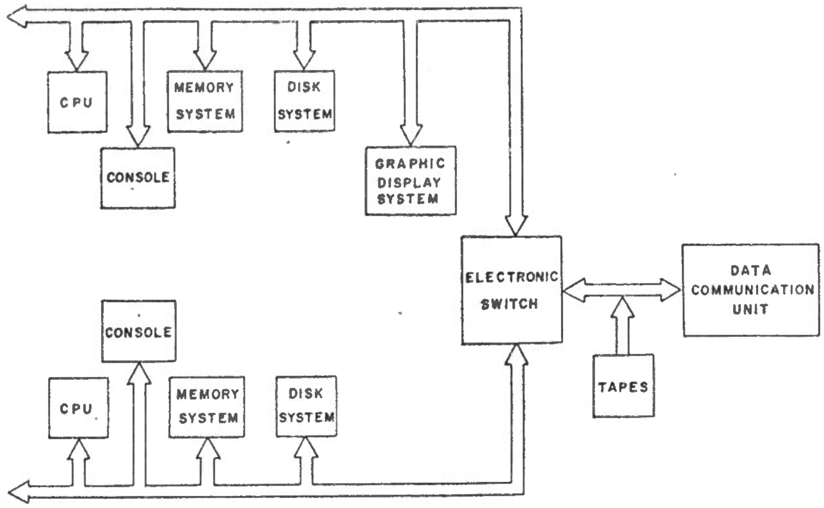


Figure 2. Processing facility.

## An Instrument for Earthquake Risk Studies

Resmac will be a powerful tool for seismological research. At present, however, because of budget limitations, only those seismic events detected by the system itself and deemed to be of interest to geophysicists will be stored on tape. The algorithm which detects these events may be set at a conventional threshold; except for special research purposes the emphasis will be on domestic earthquakes.

Mexico is situated at the intersection of four major lithospheric plates. Its territory contains an important sector of the east Pacific rise, with active spreading in the Gulf of California; a major active oceanic trench; at least two triple junctions off the Pacific Coast; and one of the greatest chains of active volcanos in the world.

Earthquake hazard has become a controlling factor in industrial expansion and economic development. In many states the incidence of earthquakes is very poorly known. Quite recently, the engineering design factors of two large new power projects (one hydroelectric and one nuclear) had to be raised substantially to allow for incomplete information on local seismicity. Hence the immediate objective of Resmac will be to provide a full coverage of the national territory for uniform and reliable earthquake information to be used in zoning, microzoning, and other methods of estimating earthquake risk on a regional or local scale.

The research facilities at the Resmac data center will be made available to Mexican and foreign scientists on a demand-quota basis. Limited operation of the system is scheduled to begin in about one year. Research in hardware and software design at the National University of Mexico is being carried out under a contract awarded by CONACYT, the Mexican National Research Council, which also acts as the coordinating agency on behalf of the Mexican federal government.


Cinna Lomnitz received his M.S. in 1950 from Harvard University and his Ph.D. in 1955 from the California Institute of Technology, where he remained as a research fellow in seismology until 1957. He has since been associated with Latin American seismology, first as the Director of the Institute of Geophysics at the University of Chile and currently as head of the Seismology Department of the Institute of Geophysics at the University of Mexico and as Earth Science Coordinator of the Mexican National Research Council. He is also currently 'debugging' a new program for epicenter location called Resmac 3.

Jorge Gil is head of the Digital Design Laboratory at the CIMAS Center for Applied Mathematics and Systems at the University of Mexico. He graduated in 1960 from the Instituto Politécnico Nacional in Mexico and has since worked at the Mexican Atomic Energy Commission, the Instituto Politécnico Nacional, and the University of Mexico. In addition to his teaching and research work on digital circuits, Jorge Gil is interested in the mathematical structure of musical compositions.

# INSTITUTO DE GEOFISICA

## OBJETIVO

Realizar investigaciones para conocer y resolver problemas del mundo en que vivimos, sus océanos, atmósfera y el espacio que lo rodea. Estudiar los fenómenos que directamente afectan al hombre, tales como el estado del tiempo y las mareas. Tratar de preveer fenómenos catastróficos como sismos y erupciones. Desarrollar las técnicas que permitan un mejor conocimiento de los recursos minerales y energéticos con que se cuenta y en resumen todos los estudios teóricos y prácticos del medio ambiente en que vivimos

## EVOLUCION

1945 Se crea el Instituto de Geofísica, a partir de un Departamento del Instituto de Geología. Empieza a funcionar en 1949

1954 Se le destinan los pisos 3, 4 y 5 de la Torre de Ciencias, en Ciudad Universitaria

1976 Se traslada el Instituto al nuevo edificio en el Conjunto de Instalaciones del Circuito Exterior

## DIRECTOR

(Dr Julián Adem)

(5 de marzo de 1971-5 de marzo de 1977)

## SECRETARIO

## MIEMBROS DEL CONSEJO INTERNO

| | |
|---|---|
| Dr | Julián Adem (Presidente) |
| M en C | Humberto Bravo |
| M en C | Luis Del Castillo |
| M en C | Ruth Gall |
| Dr | Cinna Lomnitz |
| Ing | Pedro Mosiño |

## MIEMBROS DE LA COMISION DICTAMINADORA

| | |
|---|---|
| Dr | Ismael Herrera |
| Ing | Alberto J Flores |
| Dr | Santiago López de Medrano |
| Dr | Juan Manuel Lozano |

**SUPERFICIE CONSTRUIDA** 5,443 m2

**PRESUPUESTO 1976** $29,434,438.00

**INVERSION EN EQUIPO CIENTIFICO** $20,000,000.00

## PUBLICACIONES

Geofísica Internacional (4 números al año)

Anales del Instituto de Geofísica

Tablas de Predicción de Mareas. Puertos del Golfo de México

Tablas de Predicción de Mareas. Puertos del Océano Pacífico

Observatorio Magnético de Teoloyucan, Méx. Valores Magnéticos

Noticiario

Datos Geofísicos

## ORGANIZACION ACADEMICA

### Departamentos

- Ciencias Atmosféricas
- Contaminación Ambiental
- Espacio Exterior
- Exploración Geofísica
- Geodesia y Gravimetría
- Geomagnetismo
- Sismología y Física del Interior de la Tierra



APPENDIX 2

**Secciones**

Oceanografía Física
Servicio Mareográfico Nacional
Pronóstico de Mareas

**Laboratorios**

Geohidrología y Contaminación de Aguas
Propiedades Eléctricas de Rocas
Paleomagnetismo y Geofísica Nuclear

**Estaciones Experimentales fuera de la Ciudad Universitaria**

| | |
|---|---|
| 21 | estaciones sismológicas distribuidas en la República Mexicana |
| 20 | estaciones mareográficas (13 en la Costa del Pacífico y 7 en la Costa del Golfo de México) |
| 3 | estaciones de Radiación Solar (incluyendo la de CU) |
| 1 | Observatorio Magnético en Teoloyucan |
| 70 | estaciones magnéticas de repetición, ubicadas en diversos puntos de la República Mexicana |

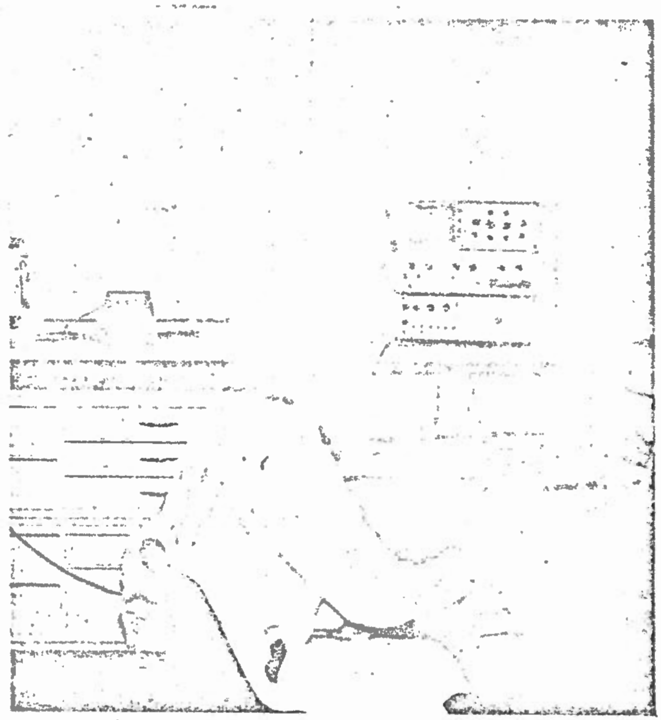
## PERSONAL ACADEMICO*

**Departamento de Ciencias Atmosféricas**

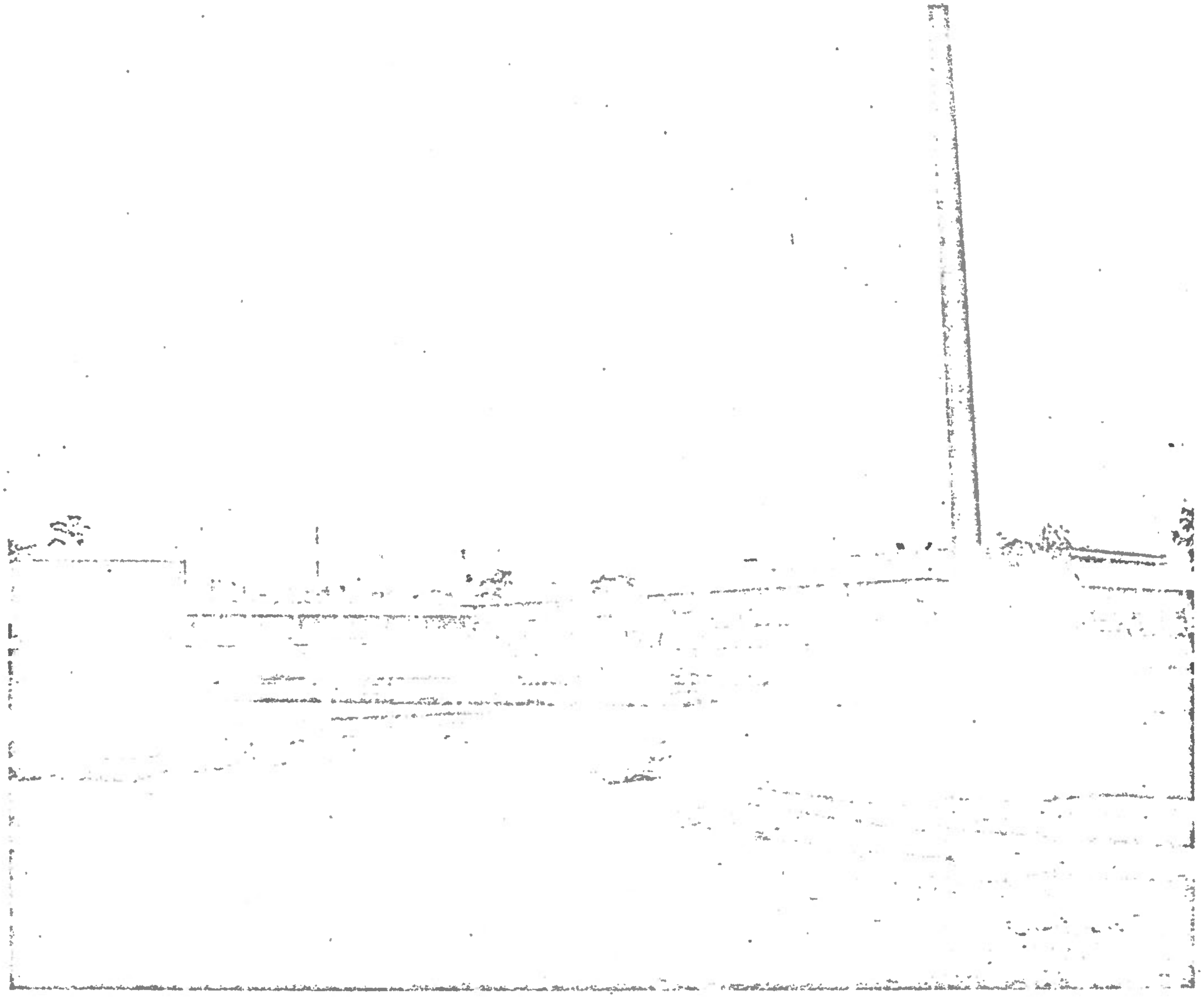
**Jefe de Departamento** Dr Julián Adem

| | |
|---|---|
| Sr | Angel Alvarez |
| Met | José Arroyo G |
| Sr | Sergio Arzac |
| Sr | Ricardo Berlanga Z |
| Fís | José Luis Bravo |
| M en C | Enrique Buendía |
| Fís | Liborio Cruz |
| Fís | Alfonso Estrada Betancourt |
| Dr | Ignacio Galindo |
| Sr | Luis Galindo L |
| Fís | Sergio Guzmán |
| Fís | Gabriel Haro |
| Mat | Juan Carlos Iracheta |
| M en C | Luis Le Moyne |
| M en C | Amando Leyva |
| Sr | Elio Loza Llanos |
| Ing | Jesús Martínez Guerrero |
| Sr | Gilberto Martínez Mares |
| Ing | Pedro Mosiño |
| Fís | Agustín Muhlia |
| Sr | Heriberto Ornelas |
| Srita | Guadalupe Patiño |
| Srita | Inés Ramírez Pioquintos |
| Fís | Rodolfo Revilla |
| Sr | Gil Rodríguez Rivera |
| M en C | Sergio Serra Castelán |
| Sr | Vidal Valderrama |

* Al 30 de agosto de 1976



**Electrónica del Sistema de Espectrometría de rayos gamma. Muestra la salida de los datos del Analizador Multicanal al Teletipo**



Instalaciones del Instituto de Geofísica en el Circuito Exterior, inauguradas el 29 de noviembre de 1976

## Departamento de Contaminación Ambiental

**Jefe de Departamento** Dr Humberto Bravo

| | |
|---|---|
| Ing | Salvador Ayanegui |
| M en C | Humberto Bravo |
| Quím | Noelia García Peña |
| Fís | Raúl Magaña |
| Quím | Sonia Salazar |

## Departamento de Espacio Exterior

**Jefe de Departamento** M en C Ruth Gall

| | |
|---|---|
| Fís | Silvia Bravo |
| Dr | Javier Otaola |
| Fís | Adolfo Orozco |
| M en C | Román Pérez |
| Dr | Héctor Pérez de Tejada |
| Sr | Alejandro Salas |
| Fís | Oscar Troncoso |
| Sr | José Francisco Valdés |
| Sr | Gerardo Zenteno |

## Departamento de Exploración Geofísica

**Jefe de Departamento** M en C Luis Del Castillo

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| M en C | Alberto Domínguez |
| Ing | Roberto Domínguez Burguete |
| M en C | Tomás González Morán |
| Mat | Lázaro Mendive Abreu |
| Sr | Marcelo Rivas Torres |
| M en C | José Héctor Sandoval Ochoa |
| Dr | Shri Krishna Singh |
| Ing | Jaime Urrutia F |

## Sección de Geodesia y Gravimetría

**Jefe de Sección** Ing Julio Monges Caldera

| | |
|---|---|
| Ing | Macario Martínez |
| Sr | Manuel Mena Jara |
| Sr | Eduardo Salyano J |

## Sección de Geomagnetismo

**Jefe de Sección** Mat Anselmo Chargoy

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|---|---|
| Ing | Carlos Cañón Amaro |
| Mat | Lucía Chargoy |
| Mat | Manuela Garín de Alvarez |

## Departamento de Sismología y Física del Interior de la Tierra

**Jefe de Departamento** Dr Cinna Lomnitz

| | |
|---|---|
| Ing | José Luis Acosta Cussi |
| M en C | Servando de la Cruz |
| M en C | Sergio Ferráes |
| Ing | Jesús Figueroa |
| Sr | Zenón Jiménez |
| Ing | Federico Mooser |
| Dr | José Merino y Coronado |
| Dr | Lautaro Ponce M |
| Sr | Bernardino Rubí |
| Fís | Jerónimo Rubí |
| Dr | Federico Sabina |

## Sección de Física del Océano

**Jefe de Sección** M en C Raúl Ocampo

| | |
|---|---|
| Fís | Miguel Angel Alatorre |
| M en C | José Barberán |
| Dr | Ingvar Emilsson |
| Fís | Agustín Fernández |
| Dr | Nicolás Grijalva |
| Fís | Francisco Ruiz Rentería |

## Servicio Mareográfico Nacional

**Jefe de Sección** Ing Herminio Cepeda

| | |
|---|---|
| Arq | Ma de la Luz Bernal |
| Sr | José Trinidad Guzmán |
| Sr | José Quintana Esquivel |
| Sra | Martha Rojas de Silva |
| Ing | Ruffo Arce |
| Sra | Alicia Estevez de Castillo |
| Ing | Francisco Grivel Piña |

**Laboratorio de Geohidrología y Contaminación de Aguas**

**Jefe de Laboratorio** M en C Armando Báez

| | |
|---|---|
| Sr | Raúl Belmont |
| M en C | Diana García |
| Quím | Eréndira Gómez Barredo |
| Quím | Ofelia Guzmán de González |
| Fís | José Antonio López Cruz |
| Quím | Irma Rosas |
| Quím | Felipe Solorio |

**Laboratorio de Propiedades Eléctricas de Rocas**

**Jefe de Laboratorio** Dr Román Alvarez B

| | |
|---|---|
| Sr | Michael Andrade |
| Sr | León del Río |

**Laboratorio de Paleomagnetismo y Geofísica Nuclear**

**Jefe de Laboratorio** Dr Surendra Pal

| | |
|---|---|
| Fís | Roberto Carrillo |
| Ing | Ermilio Herrero |
| Fís | David Terrell |

**Coordinación Académica**
**Encargada**

| | |
|---|---|
| Fís | Consuelo Gómez de Medina |

**Sección Editorial**

**Jefe de Sección** Dra Martha Adem

| | |
|---|---|
| Pas | Guadalupe Aceves |
| Sra | Thelma Gutiérrez |

**PROYECTOS DE INVESTIGACION EN PROCESO (31)**

Aplicación del Modelo Termodinámico del Clima al Mar Caribe y al Golfo de México

Aplicación del Modelo Termodinámico para explicar la sequedad de los desiertos

Modelos de predicción a corto plazo

Preparación de una Carta de Radiación Solar para la República Mexicana

Climatología de la turbidez atmosférica en la Ciudad de México

Predicción de temperatura de placas y eficiencias de calentadores solares de agua, en base a los datos meteorológicos

Parametrización de los componentes radioactivos de la atmósfera

Posible relación de las anomalías mensuales de la temperatura superficial de los océanos y la frecuencia de los huracanes en el mismo periodo

Programa que pronostica la posición de los huracanes en el Pacífico Nororiental (EPANALOG)

Efecto de corrosión de la contaminación atmosférica en la Ciudad de México, sobre metales

La calidad de aire en cuatro ciudades mexicanas, usando una estación móvil

Primera parte del modelo matemático para el manejo de residuos sólidos en zonas urbanas marítimas mexicanas

Segunda parte de la "Aplicación de modelo matemático para manejo de residuos sólidos en Veracruz, a la ciudad de Santiago, República Dominicana"

Estudio del transporte y difusión de un contaminante no reactivo en la Cuenca del Valle de México

Segunda fase del estudio —Aeropuerto— Medición de partículas y gases de emisión por turbinas de aeronaves

Estudio para tratamiento de efluentes líquidos de ingenios azucareros

Estudio preliminar del tamaño y número de partículas 3 micras desde la superficie a 9,000 pies de altura en la Cuenca del Valle de México

Estudio de funciones de núcleo a partir de ecuaciones íntegro-diferenciales y difero-diferenciales con posibles aplicaciones en sistemas no-lineales, así como con partículas lineales

Observaciones gravimétricas para la elaboración del Plano de Anomalías Gravimétricas de la República Mexicana

Observaciones geomagnéticas en la República Mexicana, Panamá y Costa Rica (para elaborar la Carta Magnética de México y Centroamérica para la época 1975.0)

Mecanismos de conducción eléctrica en el regolito lunar

Estudio de propiedades eléctricas de muestras de carbón de la región de Sabinas, Coah

Estudios aeromagnéticos en la zona de Alchichica, Pue.

Programa de percepción remota de minerales

Conductividad a alta temperatura (hasta 1,200°C)

Estudio sobre los efectos de la contaminación industrial en el estuario del río Pánuco

Estudio sobre la contaminación y transporte de metales pesados residuales en el Gran Canal del Desagüe y la zona de influencia en el distrito de riego de Tula, Hgo.

**Proyectos Especiales**

Red Sismológica Mexicana de Apertura Continental (RESMAC)

Proyecto de Estimulación de la lluvia en el Valle de México

Tabla de valores para la red mundial de estaciones de rayos cósmicos solares

Evolución inicial de la naturaleza del sismo ocurrido en Guatemala el 4 de febrero de 1976

## TRABAJOS DE INVESTIGACION PUBLICADOS (1975-1976) 115

# INSTITUTO DE INGENIERIA

## OBJETIVO

Realizar investigación aplicada y fundamental para estimular el avance de la ingeniería y contribuir al desarrollo tecnológico del país

## EVOLUCION

1956 Comienzan las actividades del Instituto de Ingeniería A. C. como asociación no lucrativa, ocupando prestado el sótano del Instituto de Geología

1957 Se incorpora a la Universidad como División de Investigaciones de la Escuela Nacional de Ingenieros, manteniendo el nombre de Instituto de Ingeniería

1976 Se crea oficialmente el Instituto de Ingeniería

## DIRECTOR

Dr Daniel Reséndiz Núñez (6 de junio de 1974- 6 de septiembre de 1982)

## SUBDIRECTORES

Ing Gabriel Auvinet Guichard
Ing Antonio Capella Vizcaíno
Ing Jorge Elizondo Alarcón
Dr Luis Esteva Maraboto

## MIEMBROS DEL CONSEJO INTERNO

Ing Oscar De Buen López de Heredia
Ing Neftalí Rodríguez Cuevas
Dr Emilio Rosenblueth

## MIEMBROS DE LA COMISION DICTAMINADORA

Ing José Luis Sánchez Bribiesca
Ing Odón De Buen Lozano
Ing Daniel Ruiz Fernández
M en I Jesús Alberro Arámburu
Dr Octavio Rascón
Dr Gabriel Echávez Aldape

**SUPERFICIE CONSTRUIDA** 6,600 m2

**PRESUPUESTO 1976** $60,000,000.00

**INVERSION EN EQUIPO CIENTIFICO** $15,000,000.00

## PUBLICACIONES

Informe de actividades (anual)

Boletín (4 veces por año)

Serie técnica en español (aperiódica)

Serie técnica en lenguas extranjeras (aperiódica)

## ORGANIZACION ACADEMICA

Automatización y Electrónica
Dinámica
Estructuras
Hidráulica
Ingeniería de Sistemas
Ingeniería de Tránsito
Ingeniería Mecánica
Ingeniería Sanitaria
Ingeniería Sísmica
Ingeniería Térmica
Mecánica de Suelos
Pavimentos
Planeación
Vías Terrestres

## PERSONAL ACADEMICO*

Sr Eduardo Acosta Lara
M en I Manuel Aguirre Gándara

* Al 30 de septiembre de 1976



APPENDIX 3

| | |
|---|---|
| Ing | Jesús Alberro Arámburu |
| M en C | Rafael Almanza Salgado |
| Dr | Antonio Alonso Concheiro |
| Ing | Luis Alonso Coria |
| Ing | Gustavo Rafael Aranda Hernández |
| Ing | Alfonso Arenas Díaz |
| Ing | Arturo Arias Suárez |
| M en I | Gabriel Auvinet Guichard |
| Dr | Gustavo Amado Ayala Milian |
| Dr | Renato Barrera Rivera |
| Ing | Moisés Berezowsky Verduzco |
| Dr | Jacobo Bielak Radoshicka |
| Ing | Agustín Breña Puyol |
| Ing | Alberto Camacho Sánchez |
| Ing | Jaime Camargo Hernández |
| Dr | Roberto Canales Ruíz |
| M en I | Antonio Capella Vizcaíno |
| Ing | Carlos Gastón Carvajal Nava |
| Sr | Eugenio Domingo Cobo Pérez |
| Dr | Leonel Corona Treviño |
| Ing | Santiago Corro Caballero |
| Ing | Carlos Cortés Ruíz |
| M en I | Carlos Cruickshank Villanueva |
| Ing | Euler Chargoy del Valle |
| Dr | Enrique Chicurel Uziel |
| Dr | Ricardo Chicurel Uziel |
| M en I | Andrew Dawson Wayne |
| Sr | Pablo Delgadillo Reynoso |
| Ing | Oscar De Buen López de Heredia |
| Ing | Enrique De la Serna Ramírez |
| Ing | Carlos Díaz Mora |
| Ing | Enrique Díaz Mora |
| M en I | Jorge Abraham Díaz Rodríguez |
| Ing | Ramón Domínguez Mora |
| M en I | Juan N. Dyer de León |
| Dr | Gabriel Echávez Aldape |
| Biól | Beatriz Eugenia Elías López |
| Ing | Jorge Elizondo Alarcón |
| Ing | Juan Manuel Espinosa Aranda |
| M en C | Leopoldo Espinosa Graham |
| Ing | Raúl Espinosa Islas |
| M en C | Raúl F. Esquivel Díaz |
| Dr | Luis Esteva Maraboto |
| Dr | Ezio Faccioli Mistrorigo |
| Ing | Francisco Flores Herrera |
| Biól | Francisco José Flores Tena |
| Sr | Víctor Franco |
| Ing | Bernardo Fróntana de la Cruz |
| Ing | Armando Fuentes de la Rosa |
| Ing | Oscar Arturo Fuentes Mariles |
| Ing | Manuel García Flores |
| Ing | Sergio Gerard Bertrand |
| Ing | Javier Eugenio González |
| Ing | Jesús Gracia Sánchez |
| Srita | Lucía Guaida Escontria |
| Ing | Osbaldo Rubén Guerra Jiménez |
| Ing | Servio Tulio Guillén Burguette |
| M en I | Oscar Hernández Basilio |
| Dr | Gerardo Hiriart Le Bert |
| Ing | Rosario Iturbe Arguelles |
| Ing | Alberto Jaime Paredes |
| Ing | Luis Jiménez Escobar |
| Dr | Eulalio Juárez Badillo |
| Dr | Felipe Lara Rosano |
| M en C | Gerardo Legaria Martínez |
| Ing | José Luis León Torres |
| Dr | Enzo Levi Lattes |
| Ing | Santiago Loera Pizarro |
| M en C | Anastasio López Zavala |
| Sr | Antonio Lozada Bautista |
| Ing | Julio Lozoya Corrales |
| Ing | Miguel Madinaveitia Jurgenson |
| Ing | Miguel Madinaveitia Villanueva |
| M en I | Roberto Magallanes Negrete |
| Sr | Samuel Maldonado Caballero |
| Dr | Raúl Jaime Marsal Córdoba |
| Sr | José Luis Martínez Palacios |
| M en I | Belsay Martínez Romero |
| M en I | José Antonio Maza Alvarez |
| Ing | Marcos Mazari Menzer |
| M en L | Carmen Meda Vidal |
| Sr | Eduardo Medina Hernández |
| Dr | Roberto Meli Piralla |
| Ing | Víctor Manuel Mena Ferrer |
| Ing | Enrique Mena Sandoval |
| Ing | Carlos Javier Mendoza Escobedo |
| Ing | Gastón Mendoza Gámez |

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|---|---|
| Ing | Manuel Jesús Mendoza López |
| M en I | Enrique Mendoza Otero |
| Ing | José Luis Montaño Angeles |
| Ing | Ignacio Mora González |
| Ing | Víctor Morales Najar |
| Ing | Juan Morcos Salmán |
| Ing | Felipe Muñoz Gutiérrez |
| Ing | Fidel Nader Delgado |
| Srita | Irene Isabel Navarro González |
| Ing | Gonzalo Negroe Pérez |
| Ing | Juan Luis Neuman Vélez |
| Ing | Alfredo Olivares Ponce |
| Sr | Marciano Padilla Muñoz |
| Ing | Víctor José Palencia Gómez |
| Ing | Rodolfo Peters Lammel |
| Ing | Guillermo Prado Olivervides |
| M en C | Jorge Prince Alfaro |
| Ing | Roberto Federico Quaas Weppen |
| Ing | Luis Ramírez de Arellano Alvarez |
| M en I | Jorge Ramírez Flores |
| Ing | Carlos Ramírez Valenzuela |
| Ing | Armando Rangel Ordoñez |
| Dr | Octavio Rascón Chávez |
| Dr | Daniel Reséndiz Núñez |
| Ing | Alejandro Reyes González |
| Ing | Francisco H. Rodríguez y Cayeros |
| Ing | Edgardo Rodríguez Conrado |
| M en I | Neftalí Rodríguez Cuevas |
| Dr | Emilio Rosenblueth Deutsch |
| Sr | Julio Alberto Ruiz Barrón |
| Ing | Daniel Ruiz Fernández |
| Dr | Eduardo Rukos Manzur |
| Sr | Marcos Iván Saavedra Brofman |
| M en I | José Luis Sánchez Bribiesca |
| M en I | Francisco José Sánchez Sesma |
| Ing | Horacio Sandoval Rodríguez |
| M en I | Enrique Santoyo Villa |
| M en I | Carlos Silva Echartea |
| Arq | José Ramón Sordo Cedeño |
| Ing | Francisco Suzan Colombres |
| Ing | Víctor Talavera Rodarte |
| M en I | Francisco Téllez Granados |
| M en I | José Luis Trigos Suárez |
| Dr | Mirna Urquidi Fernández |
| Sr | Ramón Enrique Vera Salvo |
| M en I | Augusto Villarreal Aranda |
| Sr | Oscar Weckman Muñoz |
| Biól | Jorge Zamacona Evenes |
| Ing | Jorge Zárate Cruz |

**Asesores**

| | |
|---|---|
| Dr | Cinna Lomnitz |
| Dr | Singh Shri Krishna |

**PROYECTOS DE INVESTIGACION EN PROCESO (183)**

**Automatización**

Traducción del lenguaje oral al de máquina (3a. Etapa)

Procesamiento de imágenes

Simulación dinámica y desarrollo de algoritmos para el control en tiempo real de la red nacional de potencia

Diseño de un registro automático de vehículos

Desarrollo de una terminal de video de 7 colores

Programación de un monitor de tiempo real para computadoras redundantes

Uso actual y racionalización de energéticos

Estudio de problemas extremos

**Dinámica**

Respuesta sísmica de estructuras

Optimización del diseño estructural

Licuación de arenas, 2a. parte

Vibración forzada de bases apoyadas sobre medios elásticos

Estudio espectral de sismos

Análisis dinámico tridimensional de estructuras térreas

Parámetros de la fuente sísmica del temblor de Oaxaca

Procedimiento de formación de grandes especímenes de arena

Análisis crítico de los usos de la energía del viento

Interacción dinámica no lineal suelo-estructura

Regionalización eólica de la República Mexicana

Identificación del sistema estructural para fines de diseño sísmico

Mantenimiento de la red de anemógrafos y banco de datos sobre viento

Efectos locales sobre la evaluación probabilística del riesgo sísmico

Duques de Alba: Estructuras de protección, 2a. parte

Respuesta dinámica de estructuras apoyadas sobre pilotes de fricción

Análisis de interacción dinámica suelo-estructura como problema de difracción

**Estructuras y Materiales**

Libro sobre estructuras metálicas

Ménsulas en extremos de vigas, 2a

Propiedades de mampostería pretensada

Control de calidad de los concretos en grandes obras

Características físicas del agregado ligero "Gravamil 700" y su comportamiento en concretos estructurales

Revisiones y adiciones al Reglamento del Distrito Federal

Pruebas de carga. Criterios de evaluación con bases probabilísticas

Diseño sísmico de estructuras con muros de concreto. 1a. parte. Acondicionamiento de equipo y ensayes preliminares

Libro de diseño de estructuras de madera

Ensaye a flexión en rejillas metálicas

Manual para diseño y construcción de estructuras de concreto reforzado

Pruebas físicas en especímenes de concreto y tabique tratados con un producto impermeabilizante

Paneles de ferrocemento para vivienda económica

Procedimiento de reparación de viviendas de adobe en Chiapa de Corzo, Chis.

Revestimiento de canales con ferrocemento

Ensayes dinámicos de estructuras reforzadas en Chiapa de Corzo, Chis.

Materiales sílico-calcáreos de bajo costo (3a. etapa)

Muros de adobe mejorados

Vivienda rural en zona sísmica

Unidad hidro-sanitaria para vivienda rural

Estudio de las dimensiones y separación de los durmientes en la línea "A", Coatzacoalcos-Mérida, de Ferrocarriles Unidos del Sureste.

Estudio analítico de las propiedades carga-deformación lateral de muros de mampostería

Análisis sísmico de vivienda rural

**Ingeniería Hidráulica**

Seminario sobre Drenaje

Diseño hidráulico del vertedero de la presa Chicoasén. Chis.

Efectos de flujos de alta velocidad en ductos de concreto.

Instrumentación hidrológica de la cuenca Chicoasén, Chis (1a. Etapa)

Diseño hidráulico del vertedor de la presa El Caracol

Obras de protección y encauzamiento del río Verde, Oax.

Optimización de sistema de riego

Azolvamiento de embalses. Primera parte

Manejo del agua en el delta del río Balsas

Previsión de la erosión en Tlaxcala (2a. Parte)

Estudio geohidrológico preliminar en San Hilario, B.C.

Asesoría sobre métodos de análisis de drenaje urbano

Drenaje del Valle de México

Velocidades máximas permisibles en tuberías de drenaje urbano

Efectos Hidrológicos de la urbanización (2a. Parte)

Hidrología sistemática (2a. parte)

Aplicación de los sistemas de informática a la previsión de hidrogramas

Estudio de la red de alimentación y la red primaria de distribución de agua potable en el Valle de México

Participación en el Proyecto Hidrológico Internacional de la UNESCO

Modelo físico para el tránsito de avenidas en colectores

**Ingeniería Mecánica, Fluídos y Térmica**

Implementación de un laboratorio para pruebas de alta velocidad

Instrumentación y medición en canales vertedores de La Angostura

Sellado hidráulico de bombas centrífugas

Estriaciones longitudinales y procesos de transición en capas de pared

Modificaciones al transporte económico para el campo

Desarrollo de un motor rotatorio de vapor

Turbulencia en tanques amortiguadores

Bomba solar de agua

Calentadores domésticos híbridos

Sistemas de enfriamiento de las termoeléctricas Progreso, Manzanillo, Punta Prieta, Campeche Mazatlán y Guaymas

Uso de polímeros para reducir arrastre friccional

Prospectiva de la hidráulica en México

Aplicación del proyecto sobre comportamiento de recubrimiento de concreto

Dispositivo para absorción de energía

## Ingenieria Sanitaria

Impacto de los detergentes en el recurso hidráulico (4a. etapa)

Distribución de contaminantes en el río Santiago

Distribución vertical de la producción neta de oxígeno por fotosíntesis

Efecto de viento y lluvias en el coeficiente de aireación superficial en lagos

Evaluación de las alternativas factibles para la operación de la laguna evaporadora de Cerro Prieto, B.C.

Micrometeorología y difusión de contaminantes

Reuso del agua en la Ciudad de México

Contaminación de acuíferos por líquido percolado de un relleno sanitario

## Ingeniería Sísmica

Instrumentación Sísmica en el Edificio de la Lotería Nacional

Telemetría hidrológica en Chicoasén, Chis.

Colaboración con la Asociación Internacional de Ingeniería Sísmica

Diseño de un fechador para acelerogramas

Información para el Boletín sismológico del Instituto de Ingeniería

Instalación de cinco acelerógrafos en la Siderúrgica Lázaro Cárdenas. Las Truchas, S.A.

Mantenimiento de acelerógrafos

Diseño y construcción de canales acelerométricos de muy alta ganancia para la red SISMEX

Reconstrucción de la estación Tuxpan de la red SISMEX

Mantenimiento de la red SISMEX

Diseño y construcción de un sistema de graficación

Mantenimiento del sistema de procesamiento de datos de la mesa vibradora y entrenamiento del personal

Diseño y Construcción de un transmitor de VHF

Detección de errores en el sistema de digitización

Diseño y construcción de frecuencímetros digitales

Segunda fase de construcción de la red de telemetría sísmica de Chicoasén, Chis.

Desarrollo de un radio receptor de VHF

Participación en el Comité consultivo de normalización básica del CONACYT

Segunda fase de construcción de la red hidrológica de Chicoasén, Chis.

Construcción y Prueba del equipo para las estaciones de la red telemétrica hidrológica de Chicoasén, Chis.

Estudio de mecanismos focales en el noroeste de la República.

**Ingeniería de Sistemas**

Control de avance de obras en la Refinería de Tula, Hgo.

Evaluación económica del tractor agrícola UNAM

Selección de tecnologías y sus efectos en la distribución del ingreso

Transferencias de tecnologías en México

Toma de decisiones con objetivos múltiples

Organización matricial de una empresa

Definición de la red nacional de transporte

Análisis de formas mixtas de transporte

Costos de servicios en las ciudades según su tamaño

Calidad de la vida según el tamaño de las ciudades

Localización óptima de estaciones maestras de conteo de vehículos

**Instrumentación**

Equipo de medición eléctrica de dos hilos

Registro automático en campo con grabadora de audio

Transductor para medir aceleración

Amplificadores modulares para pruebas de campo

Prototipo de una central de adquisición de datos

**Mecánica Aplicada**

Evaluación de proyectos, sistemas constructivos y materiales

Respuesta sísmica de muros de retención

Sistemas de piso a base de losas reticulares

Algunos problemas en el análisis sísmico estático de edificios

Efectos de esbeltez con relación con los reglamentos de diseño estructural

Recomendaciones para diseño sísmico de tanques

Métodos aproximados para el análisis y diseño de marcos rígidos de dos dimensiones, utilizando subconjuntos (1a. parte)

Modelo constitutivo dinámico de arenas saturadas

Determinación de parámetros para diseño sísmico en la planta termoeléctrica de Manzanillo, Col.

Desarrollo y evaluación de sistemas para limitar las acciones sísmicas sobre edificios. Etapa II

Análisis plástico de entrepisos de marcos de acero

Diseño óptimo de armaduras y marcos planos

Análisis estático y dinámico de túneles y canales

Influencia de factores locales en los movimientos sísmicos

**Mecánica de Suelos**

Propiedades mecánicas de materiales de la Presa Necaxa

Subsuelo de 17 ciudades

Comportamiento de presas construidas en México

Colaboración con la Comisión de Zonas Minadas del D.F.

Estudios de amplificación sísmica en el Valle de México

Ensayes triaxiales con trayectoria de esfuerzos efectivos controlados

Estudio del comportamiento de arenas en condiciones de corte simple cíclico

Criterios de diseño para cimentaciones sobre suelos expansivos

Agrietamiento de terraplenes (4a. Etapa)

Ecuaciones constitutivas de arcillas

Estudio geotécnico, línea A, Ferrocarriles Unidos del Sureste (2a. Etapa)

Ensaye de los materiales de construcción de la cortina de la Presa Chicoasén

Comportamiento de pedraplenes (1a. etapa)

Programa para computadora para la solución de problemas de estabilidad de taludes (Léase II)

Análisis de respuesta dinámica de presas

Asesoría A SICARTSA, mina abierta de Ferrotepec

Asesoría a SICARTSA, estudios geotécnicos

Instrumentación estática Presa Andrés Figueroa, Gro.

Análisis de estabilidad de laderas rocosas

Definición y reconocimiento de las areas afectadas por licuación, sismo de Chiapa de Corzo, Chis.

Vocabulario Técnico en español de mecánica de suelos

Criterios de diseño sísmico de la Presa Chicoasén, Chis.

Aparato de corte por torsión para suelos compactados

Mineralogía de las arcillas en las Presas Necaxa, Santa Ana y Laguna

Asesoría sobre diseño y construcción del proyecto Chicoasén, Chis.

Sistema para medición piezométrica en rocas.

Análisis sísmico tridimensional de la presa Chicoasén Chis.

Propiedades mecánicas de arcillas de presas

Evaluación del procedimiento constructivo del Lago Texcoco Sur

Fricción negativa en pilotes (2a. Etapa)

Cámara triaxial T-30-75. Etapa Final

Especificaciones para pruebas de laboratorio de mecánica de suelos (1a. Etapa)

Cámara triaxial T-30-75, Etapa Final

Especificaciones para pruebas de laboratorio de mecánica de suelos (1a. Etapa)

Alternativas posibles para el desarrollo de las obras del Lago de Texcoco

Vías Terrestres

Pavimentos rígidos para aeropistas de Zumpango, Méx.

Desarrollo de un clasificador de tránsito

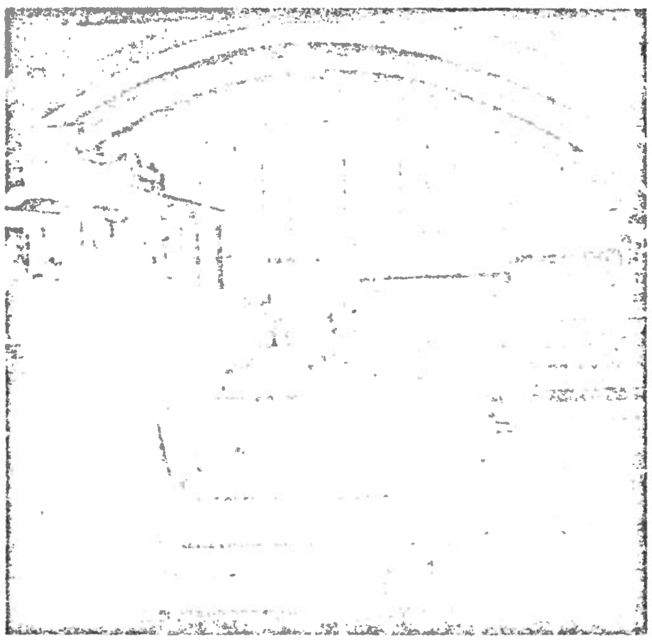
Evaluación de pavimentos en la red nacional y tramos de pruebas, Etapa B

Efectos de las heladas en el comportamiento de pavimentos flexibles

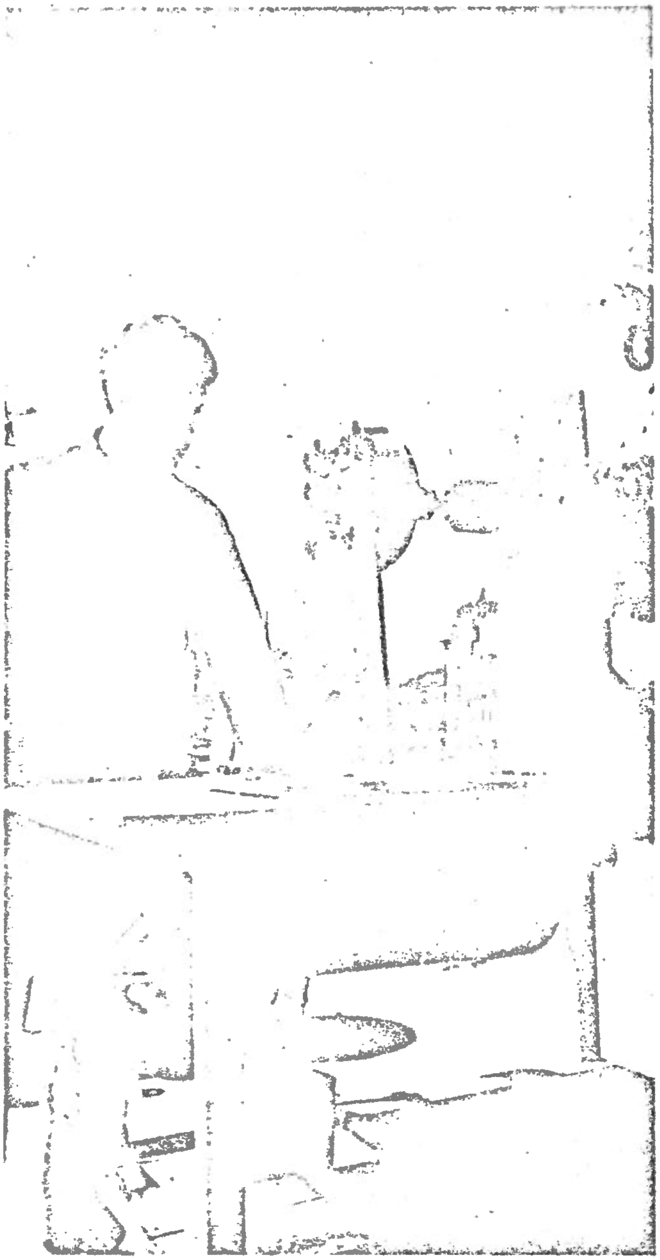
Adaptación del programa de computadora PDILB

Comportamiento de bases arcillosas

TRABAJOS DE INVESTIGACION PUBLICADOS (1975-1976) 136



**Talleres experimentales y maquinaria**



**Espejo parabólico para energía solar**

# INSTITUTO DE INVESTIGACIONES MATEMATICAS APLICADAS Y EN SISTEMAS

## OBJETIVO

Realizar investigaciones sobre diversos aspectos de las matemáticas aplicadas, principalmente en el análisis funcional, las ecuaciones diferenciales, las ciencias de la computación, el análisis numérico, la probabilidad, la estadística y la investigación de operaciones. Colaborar, además, en la solución de problemas concretos relacionados con estas especialidades, con otras dependencias universitarias o con organismos externos. Participar activamente en la enseñanza de las áreas mencionadas, en los niveles profesional y de postgrado .

## EVOLUCION

1955 Se crea el Departamento de Máquinas

1957 Se cambia de denominación por el de Oficina Central de Máquinas

1958 Se crea el Centro de Cálculo Electrónico

1959 Se convierte en Departamento Central de Máquinas

1964 Se funda el Departamento de Procesamiento de Datos; después cambia este nombre por el de Departamento de Sistemas

1966 Se fusionan el Departamento Central de Máquinas y el de Sistemas para crear la Unidad de Sistematización de Datos

1968 Se transforma en Dirección General de Unidad de Sistematización de Datos

1970 Se establece el Centro de Investigación en Matemáticas Aplicadas, Sistemas y Servicios (CIMASS)

1973 Se reorganiza el CIMASS y da lugar a dos centros: el de Investigación en Matemáticas Aplicadas y en Sistemas (CIMAS) y el Centro de Servicios de Cómputo (CSC)

1976 Se crea el Instituto de Investigaciones en Matemáticas Aplicadas y en Sistemas (IIMAS)

## DIRECTOR

Dr Tomás Garza Hernández
(19 de Abril de 1976-19 de Abril de 1982)

## SECRETARIO

Dr Alberto Tubilla Estefan

## MIEMBROS DEL CONSEJO INTERNO

— Dr Tomás Garza Hernández (Presidente)
— Ing Jorge Gil Mendieta
Dr Adolfo Guzmán Arenas
Dr Jean Pierre Hennart Boudet
Dr Ismael Herrera Revilla
Dr Jorge Ize Lamache
Dr Alejandro López Yáñez
Dra Cristina Loyo Varela
Dr Ignacio Méndez Ramírez
Dr Federico O'Reilly Togno
— Dr Alberto Tubilla Estefan

## MIEMBROS DE LA COMISION DICTAMINADORA

Dr Juan A. Careaga
Dr Ismael Herrera Revilla
— Dr Cinna Lomnitz Aronsfrau
Dr Juan Manuel Lozano
Dr Alberto Ruiz Moncayo
Dr Guillermo Torres

**SUPERFICIE CONSTRUIDA** 1,560 m2

**PRESUPUESTO** $18,191,837.00

**INVERSION EN EQUIPO CIENTIFICO** $1,500,000.00

## ORGANIZACION ACADEMICA

Departamento de Análisis Numérico
Departamento de Ciencias de la Computación
Departamento de Diseño de Sistemas Digitales



APPENDIX 4

Departamento de Matemáticas y Mecánica
Departamento de Probabilidad, Estadística e Investigación de Operaciones
Grupo Especial de Antropología y Taxonomía
Gupo Especial de Mecánica de Medios Continuos

## PERSONAL ACADEMICO*

### Departamento de Análisis Numérico

**Jefe de Departamento** Dr Jean Pierre Hennart Boudet

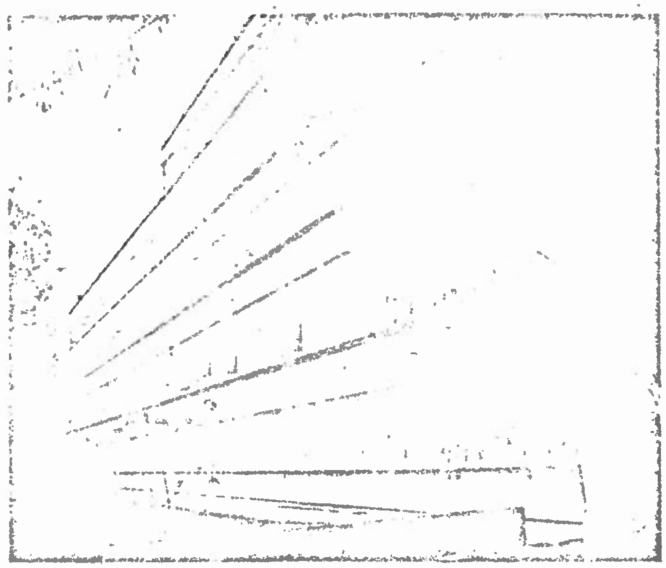
| | |
|---|---|
| Dr | Pablo Barrera Sánchez |
| M en C | Catherine García de Vargas |
| Dr | Víctor Guerra Ortiz |
| Dr | Alejandro Velasco Levy |

### Departamento de Ciencias de la Computación

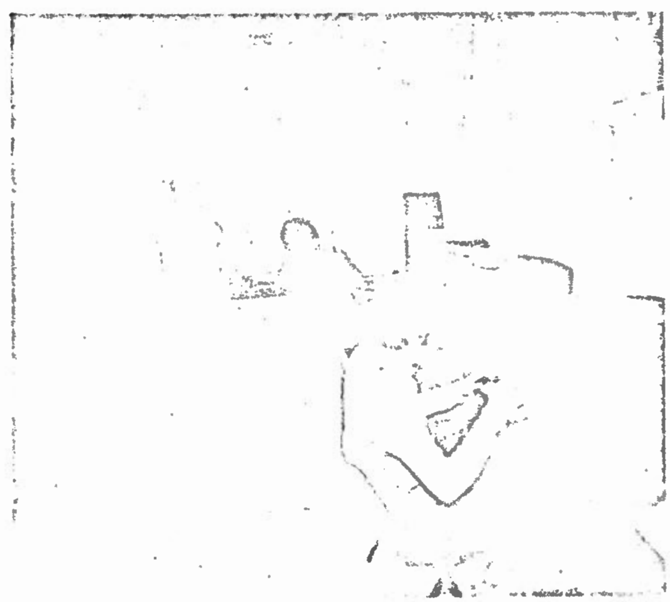
**Jefe de Departamento** Dr Adolfo Guzmán Arenas

| | |
|---|---|
| Lic Mat | Lorenzo Aguilar Cabello |
| Lic | Jennie Becerra de Barquet |
| Lic | Maximiliano Díaz De la Peña |
| Dr | Enrique Grapa Markuschamer |
| Lic | Dora Luz Gómez Sotomayor |
| Dr | Renato Iturriaga De la Fuente |
| M en C | Francisco Javier Izquierdo Sánchez |
| Lic | Armando Jinich Ripstein |
| Dr | Christian Lemaitre León |
| Dra | Cristina Loyo Varela |
| Lic | Juan Ludlow Saldívar |
| M en C | Raúl Medina Mora |
| Lic | Concepción Pérez de Celis Herrero |
| M en C | Héctor Fabio Pinzón Tofiño |
| Lic | Rosa María Seco de García |
| M en C | Raymundo Segovia Navarro |
| Dr | Alberto Tubilla Estefan |
| Lic | Carlos Velarde Velázquez |
| Lic | Héctor Villanueva Núñez |

* Al 1o. de octubre de 1976



**Edificio remodelado del Instituto de Investigaciones en Matemáticas Aplicadas y en Sistemas, y el Centro de Servicios de Cómputo**



**Terminales de computadoras**

**Departamento de Diseño de Sistemas Digitales**

**Jefe de Departamento** Ing Jorge Gil Mendieta

| | |
|---|---|
| Ing | Mónica Ardisson Pérez |
| Ing | José Antonio Banderas Gómez |
| Ing | Julio César Cano Damián |
| Ing | Fernando Casas Moyron |
| Ing | Juan Manuel Fernández Peña |
| Ing | Humberto Gómez Naranjo |
| Ing | Luis Arturo González Hermosillo Melgarejo |
| Ing | Héctor Haro Guzmán |
| Ing | Luis Arturo Haro Ruíz |
| Ing | Jaime Hernández Rubi |
| M en C | Angel Kuri Morales |
| Ing | Manuel Padilla Noriega |
| Ing | Enrique Felipe Pérez García |
| Ing | Mario Rodríguez Manzanera |
| M en C | José Ruiz Ascencio |
| Ing | Carlos Ruíz de Velasco Gutiérrez |

**Departamento de Matemáticas y Mecánica**

**Jefe de Departamento** Dr Alejandro López Yáñez

| | |
|---|---|
| Dr | José Luis Abreu León |
| Dr | Charles Boyer Place |
| Lic | Felipe Bracho Carpizo |
| Dr | José Angel Canavati Ayub |
| Dr | Miguel Angel García Alvarez |
| Dr | Jorge Ize Lamache |
| Lic | Luis Montejano Peimbert |
| Dr | Antonmaria Minzoni |
| Dr | Kurt Bernardo Wolf Bogner |

**Departamento de Probabilidad, Estadística e Investigación de Operaciones**

**Jefe de Departamento** Dr Ignacio Méndez Ramírez

| | |
|---|---|
| Lic | Pedro Alcántara Aguilar |
| Dr | Raúl Carvajal Moreno |
| Lic | Sigfrido Chaim Sánchez |
| M en C | Joaquín Díaz Saez |
| Lic | Guillermo Dueñas Villaseñor |
| Dr | Tomás Garza Hernández |
| Dr | Raúl Hudlet |
| Lic | Jaime Jiménez Guzmán |
| M en C | Francisco Martínez Palomo |
| Dr | Federico O'Reilly Togno |
| M en C | Santiago Rincón Gallardo |

**Grupo Especial de Antropología y Taxonomía**

**Jefe de Grupo** Dra Larissa Ader de Lomnitz

| | |
|---|---|
| M en C | Guillermo Espinosa Velasco |
| Lic | Jacqueline Fortes de Leff |
| Dr | Enrique Leff Zimmerman |
| Lic | José Arturo López Pérez |
| Lic | Enrique Molina León |

**Grupo Especial de Mecánica de Medios Continuos**

**Jefe de Grupo** Dr Ismael Herrera Revilla

| | |
|---|---|
| Dr | Federico J. Sabina |
| Dr | Arturo Vargas Guadarrama |

**PROYECTO DE INVESTIGACION EN PROCESO (53)**

Percepción Remota

Interconexión de Computadoras (Software)

Red Sismológica Mexicana de Apertura Continental (RESMAC) (Software)

Diálogos en Español por Computadora

Graficación por Computadora

Simulación de Transporte de Plasma

Elaboración de Código de Dinámica y Estática de Reactores

Solución Numérica de las Ecuaciones Navier-Stokes

Desarrollo de Métodos Numéricos para Ecuaciones Diferenciales Stiff

Diseño de Muestra para Estimar la Cosecha Nacional de Café

Curso de Formación de Profesores en Estadística

Pruebas de Hipótesis en Modelos Lineales con Restricciones

Métodos Eficientes para la Comparación de Tratamientos Agronómicos

Definición de Objetivos Operacionales y Sistemas de Trabajo de CONACYT

Revaluación de la Cruz Roja Mexicana

Estructura Organizacional de CONASUPO

Diseño Idealizado del Sistema Nacional de Información

Consideraciones sobre Posibles Acciones Futuras de "TEMA" en la Comisión Oceanográfica Intergubernamental de la UNESCO

Estudio de Técnicas de Simulación Dinámica Aplicada

Ecuaciones Constitutivas de Arcillas

Ecuaciones Constitutivas de Enrocamiento

Difracción de Ondas Elásticas

Acuíferos Semiconfinados

Aproximación de Longitud de Onda Larga para Difraçcion de Ondas Elásticas

Análisis de las ofrendas de los entierros de Tlatilco vía la Taxonomía Numérica

Revisión Bibliográfica sobre desarrollo Rural y Urbano

Estudio de Frecuencia de Olas

Métodos Topológicos en Ecuaciones en Derivadas Parciales

Teoría Probabilística del Potencial

Teoría Ergódica y Análisis de Fourier Generalizado

Transformaciones Canónicas y Grupos de Lie en la Mecánica Cuántica

Red Sismológica Mexicana de Apertura Continental (RESMAC) (Hardware)

Proyecto Microprocesadores

Microprogramación y Diseño de Contadores

Interconexión de Computadoras (Hardware)

Aplicaciones de la Teoría de Grupos al Diseño Digital

Diseño de Circuito y Timer para Encendido al Toque

Microprocesador para pruebas de Flybacks

Proyecto Modems

Diseño y Construcción de un Modem Inalámbrico

Diseño y Construcción de un Casette para Microprocesadores

Dispositivo para Control de Llamadas de Larga Distancia rros de Tla-

llo Rural y

en Deriva-

er Generali-

os de Lie en

tura Conti-

adores

dware)

Diseño

cendi... al

acks

Inalámbrico

para Micro-

s de Larga

Terminales para Computadoras

Diseño de Instrumental Vario

Sistema de Información para el Control de Componentes

Diseño de Relojes Digitales

Aplicaciones de la Teoría de Colas al Diseño de Monitores

Algoritmos para la Determinación de Epicentros

Algoritmos para Detección Automática de Señales Sísmicas

Estudios sobre Riesgo Sísmico

Estudio de Métodos de Optimización

Algoritmos para la Estimación de Parámetros No Lineales

Algoritmos para la Solución de Ecuaciones Integrales de la Primera Clase

## PROYECTOS DOCENTES

El IIMAS tiene a su cargo la organización académica de dos proyectos colegiados de docencia: La Maestría en Ciencias de la Computación y la Maestría en Estadística e Investigación de Operaciones. Ambos proyectos estan encuadrados en la Unidad de Estudios Profesionales y de Postgrado del Colegio de Ciencias y Humanidades

## TRABAJOS DE INVESTIGACION PUBLICADOS (1975-1976) 90

| | |
|---|---|
| Comunicaciones técnicas | 60 |
| Artículos en revistas científicas | 30 |

ESTACION TT

APPENDIX 5

Descripción del control para un sensor.
Velocidad de muestreo

La velocidad límite de muestreo queda determinada por la velocidad de transmisión y el formato de palabra. Suponiendo que:

a) La velocidad es de 1200 ó 2400 bauds.

y b) Cada muestra estará formada por dos caracteres con 11 bits por carácter

Cada carácter tiene 1 bit de start, 2 bits de stop, (supuesta una transmisión asíncrona) y 8 bits de información. El formato es el que se indica en la figura 1.

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| 1er. carácter | Stop | D6 | D5 | D4 | D3 | D2 | D1 | D0 | 1 | Start |
| 2°. carácter | Stop | EXP1 | EXP0 | D11 | D10 | D9 | D8 | D7 | 0 | Start |

Figura 1. Formato de caracteres

Con el primer bit de los ocho de información se identifica si se trata del primer o segundo carácter de la muestra, y en el caso de que haya multiplexaje, más de un sensor, solo será "1" en el caso del primer bit del primer carácter de un ciclo pre-establecido El dato estará contenido en los siete bits restantes del primer carácter y cinco del segundo tal como se ve en el diagrama reservandose los últimos dos bits del segundo carácter para el exponente. Una vez establecidas estas características podemos definir las velocidades máximas de muestreo, estas son:

109 muestras/segundo para 2400 bauds
54 muestras/segundo para 1200 bauds

Dado que es de capital importancia el que la velocidad de transmisión sea exácta se escoge como base de tiempo, para todo el sistema, un oscilador de cristal cuya frecuencia es un múltiplo de la velocidad de transmisión; para la estación TT será de 240000 Hz.

## POSIBLES VELOCIDADES DE TRANSMISION

Si tomamos como base una frecuencia de 24 000, se tiene una descomposición en factores primos de

$$2^6 \times 5^3 \times 3$$

Teniendose los siguientes divisores de interés

| | 1 | 5 | 5.5 | 3 | 3.5 | $3.5^2$ |
|---|---|---|---|---|---|---|
| 1 | 1 | 5 | 50 | 3 | 15 | 75 |
| 2 | 2 | 10 | 100 | 6 | 30 | |
| 4 | 4 | 20 | | 12 | 60 | |
| 8 | 8 | 40 | | 24 | | |
| 16 | 16 | 80 | | 48 | | |
| 32 | 32 | | | 90 | | |
| 64 | 64 | | | | | |

Para nuestra aplicación son de interés
32,40,48,50,60,64,75,80,96 y 100
Siendo utilizables para el caso de una transmisión de 1200 bauds; 32,40,48,50. Teniendose una libertad en bits por muestra de:

| | Divisor | #muestras por segundo | Libertad (bits/muestra) |
|---|---|---|---|
| 2400 | 75 | 32 | 15.5 |
| | 60 | 40 | 8 |
| | 50 | 48 | 3 |
| | 48 | 50 | 2 |

Para el prototipo, con fines de investigación, se tendrán las siguientes características:

## • CARACTERISTICAS

1.- Velocidad de Transmisión de 1200 bauds.

2.- Muestreo de 40 ó 48 muestras/segundo

3.- Dos escalas de amplificación (1)

4.- Pulso de calibración condicionado (2) a la escala en función. 3 hrs, 24 hrs

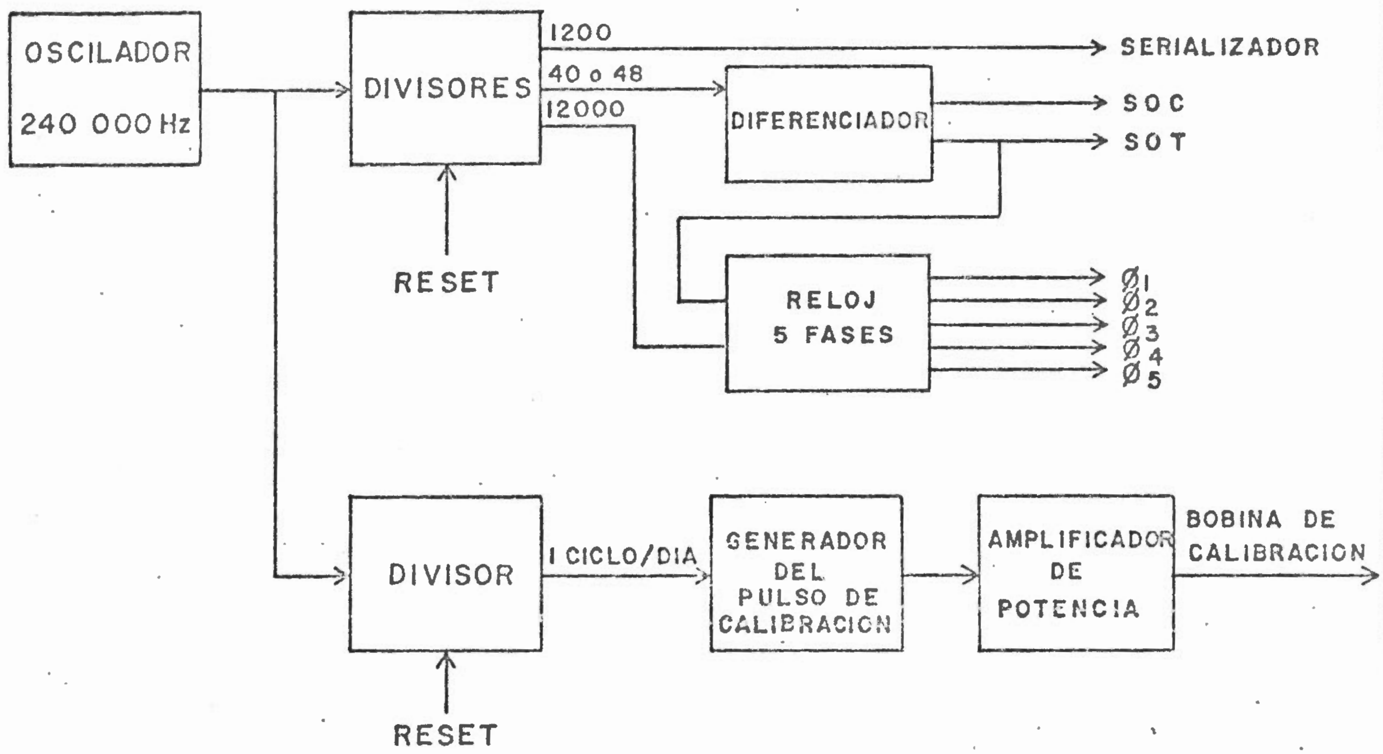
5.- Reset general al circuito. (3)

El diagrama de bloques del control del prototipo, sin incluir el control de las escalas de ganancia sería como se muestra en la siguiente figura: (hoja 4)

(1) Explicación aparte

(2) Aún en desarrollo

(3) Funciona este reset al momento de poner en funcionamiento el sistema.



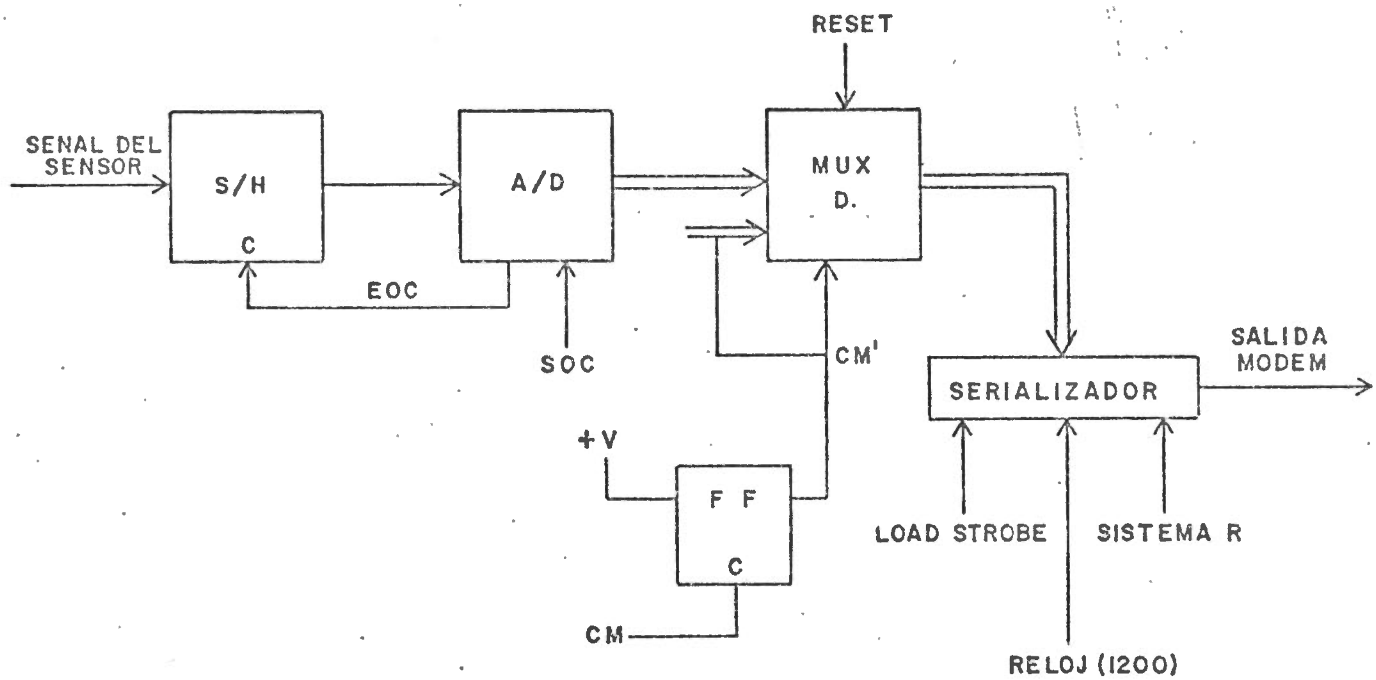

Ø - Ø son 5 fases que se generan por cada frente en la señal de 40-48 Hz son utilizadas para realizar las funciones de control de transferencia en forma síncrona.

SOC Start of convert

SOT Start of transmission

| | | | | |
|---|---|---|---|---|
| CIMAS-UNAM<br>CENTRO DE INVESTIGACION EN MATEMATICAS APLICADAS Y EN SISTEMAS. | PROYECTO: RESMAC | RESPONSABLE: ING. J. GIL | DISEÑO JAIME H. RUBI | HOJA 4 DE 7 |
| | SISTEMA: TT | COORDINADOR DR. LOMNITZ | | FECHA: 27/VII/75 REVISION |

Para establecer un diagrama de Flujo se presenta un diagrama ilustrativo del sistema a bloques incluyendo sus señales de control.




Al tomarse una muestra se sigue la siguiente secuencia

SOC al proveer esta señal se levanta la bandera EOC (END OF CONVERSION) lo que produce que el S/H se mantenga en modo Hold y el A/D inicie la conversión.

SOT al producirse esta señal se generan las cinco fases

$\emptyset_1$ Se provee CM para obtener un cambio en el multiplexor

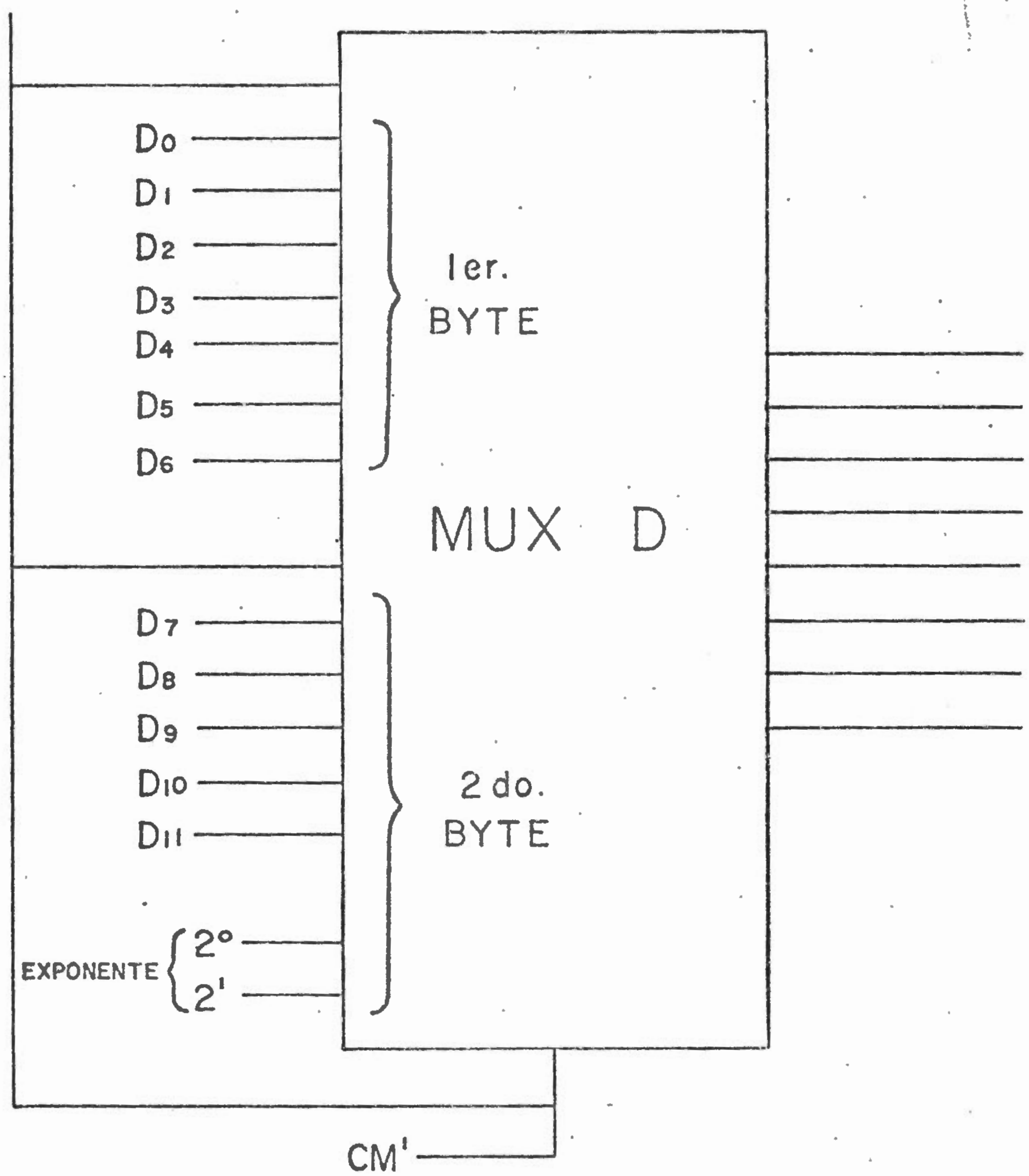
$\emptyset_2$ LS (Load Strobe) se carga del primer byte del dato

$\emptyset_3$ SR en esta fase se inicia la transmisión

$\emptyset_4$, $\emptyset_5$ } Utilizables para la terminal T en desarrollo

Una vez que se ha terminado de transmitir el primer byte, el SOT vuelve a generar el reloj de 5 fases y el 2° byte se transmite bajo la misma secuencia.

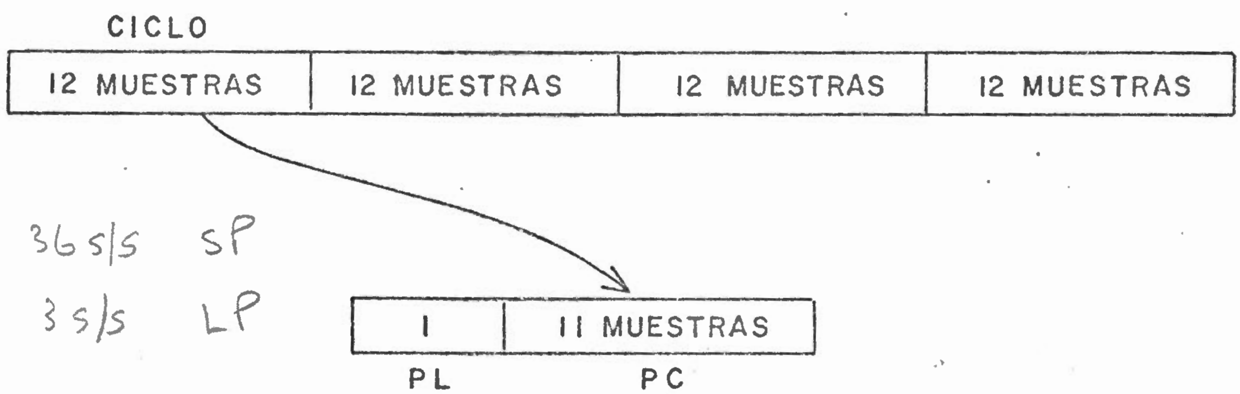
En el caso de la terminal TT el mismo control CM' nos sirve para el bit de identificación de cada byte, quedando las entradas al multiplexor como se muestra




$D_{10}$ - $D_{11}$ 12 bits provenientes del A/D (convertidor análogo-digital)

| | | | | | |
|---|---|---|---|---|---|
| CIMAS-UNAM CENTRO DE INVESTIGACION EN MATEMATICAS APLICADAS Y EN SISTEMAS. | PROYECTO: RESMAC | RESPONSABLE ING. J. GIL | DISEÑO JAIME H. RUBI | HOJA 6 DE 7 | |
| | SISTEMA: TT | COORDINADOR DR. LOMNITZ | | FECHA: 27/VI/75 | REVISION |

En el caso de dos o más sensores el muestreo se hará en forma cíclica, por ejemplo; si tenemos dos sensores uno de período corto y el otro de período largo de las 48 muestras 4 corresponderan al período largo y 44 al período corto teniéndose el siguiente diagrama




ie 36 s/s SP
3 s/s LP

CM' estará condicionado por el autómata de direccionamiento que controla al multiplexor analógico, el que a su vez alimenta al "sample/hold", siendo "1" sólo el primer bit del primer byte de la primera muestra de las 12 que forman un ciclo.

36 muestras/seg. período corto

48 muestras/seg. p.c. + 3 período largo

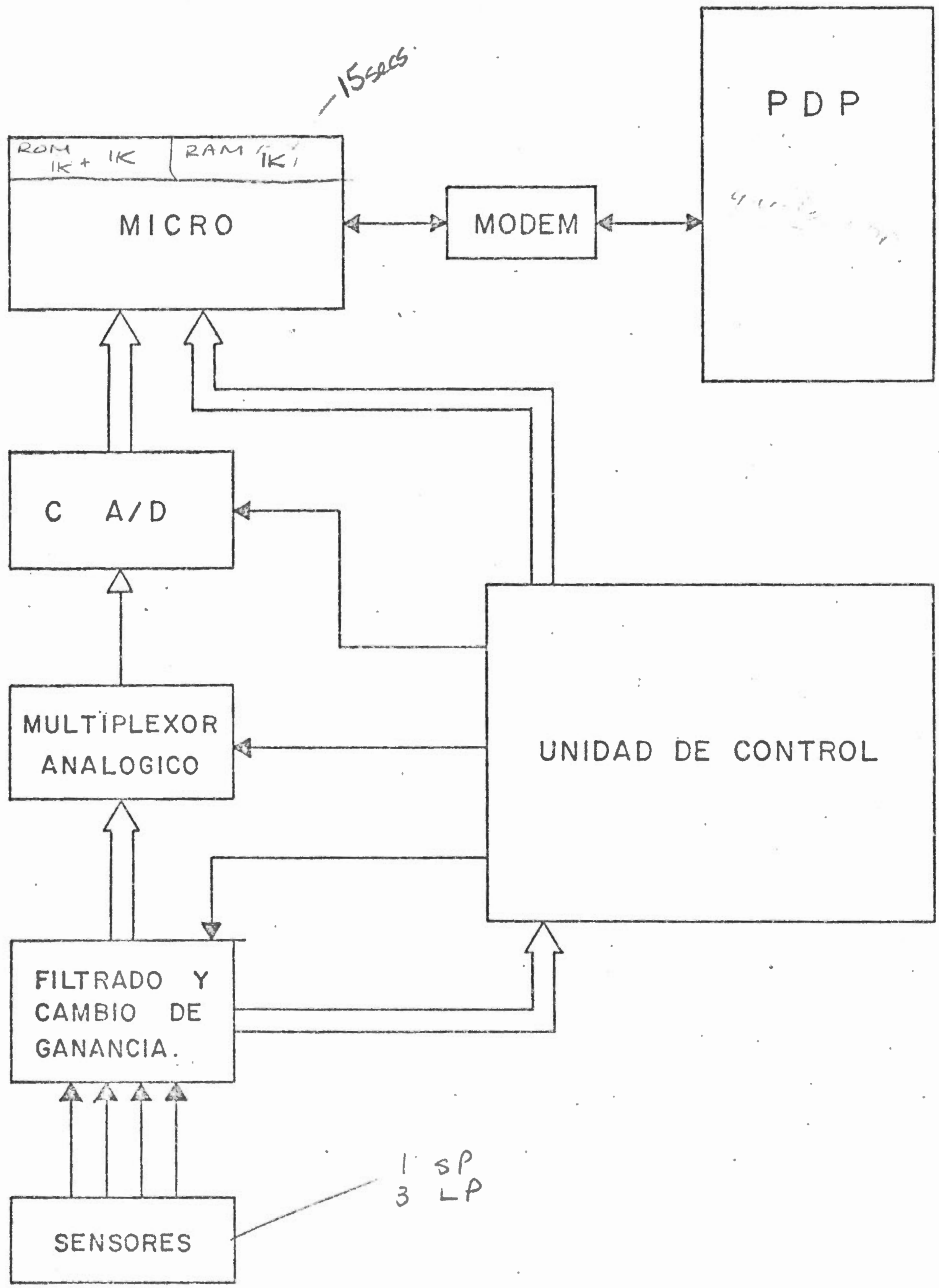
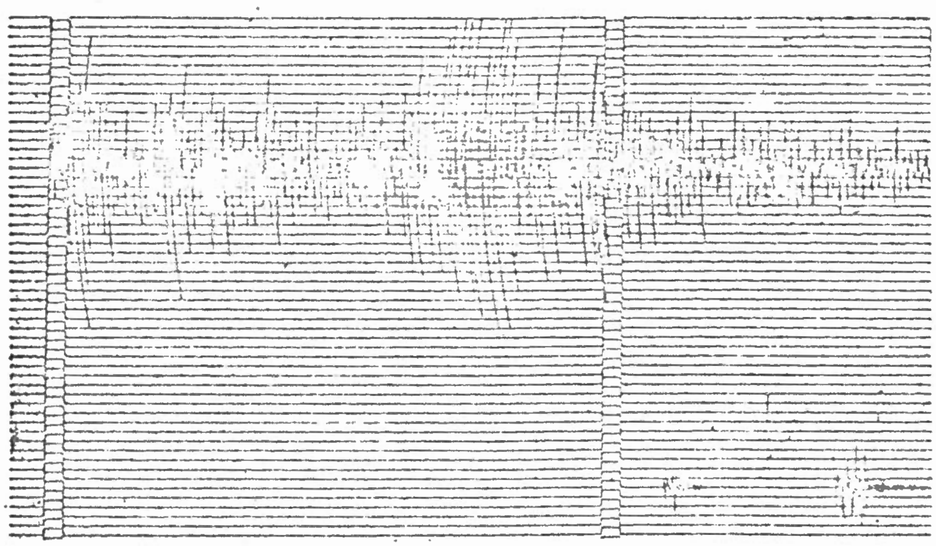



FIGURA (I).- ORGANIZACION ESTACION I

UNIVERSIDAD NACIONAL AUTONOMA DE MEXICO

APPENDIX 7

# información sísmica preliminar



INSTITUTO DE INGENIERIA

año 1 núm 5 sep-oct 1976

## ACTIVIDAD SISMICA

Los datos sísmicos que se dan a conocer a partir de enero de 1976 en el Instituto de Ingeniería de la UNAM son provisionales y se basan en el análisis preliminar de sismogramas obtenidos en el propio Instituto mediante la operación del Sistema de Información Sismotelemétrica de México (SISMEX) y en la estación sismográfica de Chicoasén, Chiapas, de la Comisión Federal de Electricidad (CFE).

Los datos, en algunos casos, son comparados con los de estaciones del Servicio Sismológico del Instituto de Geofísica de la UNAM.

La información corresponde a movimientos de magnitud ⩾ 4, y se limita a día del mes, tiempo de origen referido a TMG, coordenadas epicentrales, región y comentarios, profundidad del foco, magnitud calculada y número de estaciones registradoras.

Tanto los movimientos con magnitud ⩾ 4 que se listan, como de cualquiera de los otros que se glosan en el resumen final de cada informe, se encuentran catalogados y, a solicitud, se proporcionarán mayores datos o se harán estudios especiales.

**NOTA:** Las coordenadas epicentrales de movimientos considerados en solo dos estaciones son tentativas, a menos que aparezcan datos de intensidad.

### CARACTERISTICAS DE LAS ESTACIONES

| Sistema | Lugar | Clave | Coordenadas N | Coordenadas W | Altitud, en m | Componente | Periodo, en seg | Amplificación, veces |
|---|---|---|---|---|---|---|---|---|
| SISMEX | Sta. Rita Coyotepec, Méx. | IIC | 19.767° | 99.258° | 2 725 | Z | 1 | 56 000 |
| SISMEX | Inst. de Ing, UNAM, D. F. | IIM | 19.326° | 99.182° | 2 275 | Z | 1 | 3 000 |
| SISMEX | El Fino, Texcoco, Méx | IIP | 19.347° | 98.917° | 2 650 | Z | 1 | 15 000 |
| SISMEX | Tonantzintla, Pue. | IIT | 19.021° | 98.308° | 2 205 | Z | 1 | 30 000 |
| SISMEX | Cerro de Tuxpan, Iguala, Gro. | III | 18.376° | 99.463° | 1 750 | Z | 1 | 15 000 |
| CFE | Chicoasén, Chis. | CSN | 16.969° | 93.103° | 320 | Z | 1 | 6 000 y 12 000 |
| Geof. | Tacubaya, D F. | TAC | 19.270° | 99.116° | 2 297 | Z, NS-EW | varios | varias |
| Geof. | Comitán, Chis. | COM | 16.151° | 92.238° | 1 528 | Z, NS-EW | 1 y 4 | 35 000 y 200 |
| Geof. | Presa Benito Juárez, Oax. | PBJ | 16.437° | 95.406° | 213 | Z, NS-EW | 1 | 48 000 |
| Geof. | Observatorio, Oaxaca, Oax. | VHO | 17.069° | 96.732° | 1 685 | Z | 1 | 67 000 |

DATOS PROVISIONALES CORRESPONDIENTES AL MES DE SEPTIEMBRE DE 1976

| Día | Tiempo de Origen | | | Coordenadas epicentrales | | Región y comentarios | Prof en km | Magnitud | Núm. de estaciones |
|---|---|---|---|---|---|---|---|---|---|
| | h | m | s | N | W | | | | |
| 1 | 03 | 50 | 54 | 15 150 | 94 440 | Golfo de Tehuantepec.Frente costas Oaxaca Chiapas | Nor | 4 | 3 |
| 1 | 05 | 46 | 05 | 15 500 | 93 300 | Costas de Chiapas Pijijiapan IV° | Nor | 4 | 3 |
| 1 | 06 | 13 | 5.5 | 17 410 | 94 360 | Edo. de Veracruz.Istmo de Tehuantepec | Nor | 4 | 3 |
| 1 | 12 | 45 | 45 | 14 339 | 93 083 | Frente costas de Chiapas | Nor | 3 | 2 |
| 1 | 13 | 00 | 23 | 17 250 | 94 950 | Limites Oaxaca y Veracruz | 50 | 5 | 7 |
| 1 | 15 | 46 | 24 | 16 357 | 96 924 | Edo. de Oaxaca | Nor | 4.5 | 5 |
| 1 | 22 | 53 | 04 | 19 380 | 103 190 | Edo. de Jalisco | Nor | 3 | 2 |
| 2 | 04 | 14 | 35 | | | P041600(COM);P041611(CSN);P041640(PBJ); P041705(VHO);P041751(IIC,IIP) | | 5.5 | 6 |
| 2 | 10 | 20 | 14 | 13 259 | 69 989 | Próximo costas Guatemala.Sentido II°en - San Salvador, El Salvador Según PDE H=10 20 25.9 | 80 | 5 | 7 |
| 3 | 02 | 45 | 40 | 15 450 | 94 160 | Golfo de Tehuantepec.Frente costas Oaxaca y Chiapas | Nor | 3 | 2 |
| 3 | 07 | 13 | 36 | 15 571 | 94 000 | Golfo de Tehuantepec.Frente costas Oaxaca Chiapas | Nor | 4 | 3 |
| 3 | 07 | 34 | 25 | 16 060 | 93 420 | Costas de Chiapas | Nor | 4 | 3 |
| 4 | 05 | 13 | 20.5 | 20 600 | 99 250 | Próximo a Cardonal, Hidalgo | Nor | 3 | 2 |
| 4 | 17 | 24 | 59 | 14 875 | 92 490 | Costas de Chiapas, Región Soconusco | Nor | 3 | 2 |
| 5 | 01 | 28 | 21 | 16 911 | 92 755 | Chiapas Región próxima a Larrainzar | Nor | 3 | 2 |
| 5 | 09 | 52 | 01 | 13 250 | 91 660 | Frente a las costas de Guatemala | Nor | 4 | 2 |
| 5 | 20 | 11 | 37 | 18 742 | 101 118 | Localización según PDE: Edo. de Guerrero IV°D.F. - Fuerte en Zihuatanejo | 85 | 5.3 | 7 |
| 6 | 05 | 09 | 19 | 15 000 | 93 000 | Frente costas de Chiapas | Nor | 3 | 2 |
| 6 | 12 | 14 | 06 | 13 292 | 93 566 | Fuera costas de Chiapas | Nor | 3 | 2 |
| 6 | 17 | 38 | 03 | 14 980 | 93 230 | Frente costas de Chiapas | Nor | 3 | 2 |
| 7 | 04 | 31 | 37 | 14 895 | 94 870 | Golfo de Tehuantepec Frente costas deOxac | Nor | 3 | 2 |
| 7 | 05 | 12 | 19 | 15 714 | 93 660 | Frente costas de Chiapas | Nor | 4 | 3 |
| 7 | 11 | 22 | 07 | 15 482 | 92 075 | Frontera México Guatemala | Nor | 3 | 2 |
| 7 | 12 | 12 | 54 | 17 000 | 94 860 | Edo. de OaxacaIstmo de Tehuantepec | Nor | 4 | 3 |
| 7 | 15 | 26 | 36.5 | 14 830 | 93 868 | Frente costas de Chiapas | Nor | 3 | 2 |
| 7 | 23 | 11 | 56 | 16 000 | 94 798 | Golfo de Tehuantepec Frente costas Oaxaca | Nor | 5 | 6 |
| 8 | 03 | 19 | 46 | 13 608 | 92 075 | Frente a las costas de Guatemala | Nor | 3 | 2 |
| 8 | 07 | 19 | 33 | 18 000 | 103 367 | Frente a las costas de Michoacan | Nor | 4 | 3 |
| 8 | 07 | 47 | 04 | 18 000 | 102 905 | Frente a las costas de Michoacan | Nor | 4 | 3 |
| 8 | 21 | 51 | 12 | 15 821 | 93 775 | Frente a las costas de Chiapas | Nor | 3 | 2 |
| 9 | 00 | 02 | 49.5 | 18 446 | 100 160 | Edo. de Guerrero, limites con Edo.de Méx. | Nor | 3 | 2 |
| 9 | 04 | 58 | 21.5 | 14 235 | 94 000 | Frente Costas de Chiapas | Nor | 3 | 2 |
| 10 | 04 | 42 | 30.5 | 15 950 | 94 360 | Frente costas de Oaxaca | Nor | 3 | 2 |
| 10 | 07 | 46 | 50 | 17 378 | 92 125 | Distrito de Alvaro Obregón Chis. | 100 | 4 | 3 |
| 10 | 07 | 55 | 07 | 15 145 | 94 190 | Frente costas de Oaxaca | Nor | 4 | 3 |
| 10 | 11 | 53 | 39 | 17 250 | 95 000 | Estado de OaxacaRegión Istmo deTehuantepe | 40 | 4 | 3 |
| 10 | 12 | 09 | 21.5 | 17 661 | 91 094 | Límites Chiapas Campeche Guatemala | Nor | 3 | 2 |
| 10 | 15 | 08 | 40 | 14 536 | 93 283 | Frente costas de Chiapas | 40 | 4 | 3 |
| 10 | 23 | 36 | 50 | 16 113 | 98 660 | Frente costas de Guerrero Oaxaca | Nor | 4 | 4 |
| 11 | 00 | 13 | 43 | 13 232 | 92 510 | Frente costas a Guatemala | 50 | 5.5 | 7 |
| 11 | 00 | 23 | 07 | 14 464 | 94 550 | Fuera costas de Chiapas | Nor | 3 | 3 |
| 11 | | | | | | P024258(COM);P024313(CSN);P024330(PBJ,e02 4530(VHO). | | 4 | 4 |
| 11 | 08 | 16 | 23 | 16 839 | 92 330 | Distrito de Alvaro Obregón,Chiapas | Nor | 3 | 3 |

DATOS PROVISIONALES CORRESPONDIENTES AL MES DE SEPTIEMBRE DE 1976

| Día | Tiempo de Origen | | | Coordenadas epicentrales | | Región y comentarios | Prof en km | Magnitud | Núm. de estaciones |
|---|---|---|---|---|---|---|---|---|---|
| | h | m | s | N | W | | | | |
| 11 | 08 | 49 | 40 | 16 839 | 92 330 | Repetición del anterior | Nor | 4 | 3 |
| 11 | 17 | 01 | 23 | 15 630 | 93 792 | Frente a las costas de Chiapas | Nor | 4 | 3 |
| 11 | 19 | 47 | 18 | 15 446 | 98 190 | Frente a las costas de Oaxaca | Nor | 4 | 3 |
| 11 | 19 | 47 | 43.5 | 15 884 | 99 700 | Fuera costas de Guerrero | Nor | 3 | 2 |
| 12 | 00 | 01 | 37 | 15 571 | 93 472 | Frente a las costas de Chiapas | Nor | 4 | 3 |
| 12 | 03 | 02 | 34.5 | 16 245 | 97 196 | Costas de Oaxaca Juquila IV° | Nor | 4 | 3 |
| 12 | 10 | 13 | 30 | 13 732 | 91 924 | Frente a las costas de Guatemala | Nor | 4.5 | 3 |
| 12 | 16 | 14 | 11 | 15 518 | 91 434 | Guatemala,próximo frontera con Chiapas | Nor | 4 | 3 |
| 12 | 16 | 41 | 25 | 16 125 | 99 150 | Frente a las costas de Guerrero | Nor | 4 | 4 |
| 12 | 18 | 03 | 12 | 14 110 | 94 700 | Fuera costas de Chiapas | Nor | 3 | 2 |
| 13 | 01 | 18 | 00 | 14 000 | 91 860 | Frente a las costas de Guatemala | Nor | 4 | 3 |
| 13 | 05 | 06 | 28 | 16 000 | 94 000 | Costas de Chiapas Puerto Arista IV° | Nor | 4 | 3 |
| 13 | 06 | 42 | 08 | 15 950 | 94 245 | Frente costas de Oaxaca | Nor | 4 | 3 |
| 13 | 10 | 36 | 30.5 | 17 000 | 96 283 | Oaxaca, región Central | Nor | 4 | 3 |
| 13 | 12 | 49 | 53.5 | 17 268 | 101 680 | Frente costas de Guerrero | Nor | 3 | 2 |
| 13 | 16 | 57 | 32 | 16 755 | 94 981 | Estado de Oaxaca | Nor | 4 | 3 |
| 13 | 20 | 47 | 20 | 16 000 | 97 160 | Costas de Oaxaca.-Mixtepec V° Juquila IV° | Nor | 5 | 7 |
| 13 | 22 | 04 | 42 | 18 000 | 103 143 | Frente a las costas de Michoacan | Nor | 5 | 5 |
| 14 | 02 | 02 | 34 | 18 000 | 103 000 | Frente a las costas de Michoacan | Nor | 3 | 2 |
| 14 | 03 | 33 | 56 | 15 240 | 90 340 | Guatemala | Nor | 3 | 2 |
| 14 | 06 | 33 | 52.5 | 16 500 | 92 604 | Región Central de Chiapas | Nor | 3 | 2 |
| 14 | 09 | 33 | 17 | 18 161 | 92 094 | Limites Tabasco y Campeche | Nor | 3 | 2 |
| 14 | 15 | 46 | 03 | 26 432.5 | 115 067 | Cordillera Es la de Pascua-Según EDR.P15 54 38 (VHO); P155450 (IIC,IIP) | Nor | 5.5 | 3 |
| 14 | 17 | 45 | 31 | 15 714 | 93 910 | Frente costas de Chiapas | Nor | 4 | 3 |
| 14 | 18 | 38 | 31 | 16 518 | 92 622 | Región Central de Chiapas | Nor | 3 | 2 |
| 14 | 23 | 47 | 22 | 13 060 | 91 717 | Frente a las costas de Guatemala | Nor | 5.5 | 7 |
| 15 | 04 | 42 | 02 | 15 821 | 100 755 | Frente a las costas de Guerrero | Nor | 3 | 2 |
| 15 | 16 | 07 | 36 | 15 143 | 93 584 | Frente a costas de Chiapas | Nor | 4 | 4 |
| 15 | 17 | 31 | 51 | 15 571 | 93 773 | Frente a las de Chiapas | Nor | 4.5 | 4 |
| 15 | 20 | 43 | 33 | 16 500 | 91 850 | Edo. de Chiapas | Nor | 3 | 2 |
| 15 | 20 | 52 | 56.8 | 12 544 | 87 797 | P20 54 22 (COM); P20 54 37 (CSM); P20 54 54 (PBJ); P20 55 20(VHO)Situación SegúnPDE | 86 | 4.9 | 4 |
| 16 | 03 | 24 | 03.5 | 16 557 | 100 396 | Frente costas de Guerrero | Nor | 3 | 2 |
| 16 | | | | | | P03 38 IV (IIC); P03 38 18 (IIP) | ? | ? | 2 |
| 16 | 07 | 22 | 34 | 18 090 | 102 130 | Desembocadura Rio Balsas Limites de Guerrero y Michoacan | Nor | 3 | 2 |
| 16 | 15 | 03 | 08 | 13 822 | 92 434 | Frente costas de Guatemala | Nor | 4 | 4 |
| 16 | 19 | 04 | 31.5 | 16 910 | 94 530 | Edo de Oaxaca. Región Istmo de Tehuantepec. | 50 | 4 | 4 |
| 16 | 19 | 10 | 26 | 14 160 | 95 830 | Fuera costas de Oaxaca | Nor | 4 | 4 |
| 17 | 02 | 57 | 13 | 14 540 | 93 245 | Frente costas de Chiapas | Nor | 3 | 2 |
| 17 | 09 | 16 | 56.5 | 19 500 | 94 000 | Golfo de México | Nor | 3 | 2 |
| 17 | 12 | 04 | 33 | 18 070 | 92 510 | Estado de Tabasco | Nor | 3 | 2 |
| 17 | 12 | 27 | 54 | 18 160 | 92 890 | Estado de Tabasco | Nor | 3 | 2 |
| 17 | 13 | 32 | 53 | 18 339 | 103 000 | Costas de Michoacan | Nor | 4 | 3 |
| 17 | 22 | 55 | 04 | 13 455 | 91 566 | Frente a las costas de Guatemala | Nor | 4 | 3 |
| 17 | 23 | 55 | 19 | 14 570 | 93,050 | Frente a las costas de Chiapas | Nor | 4 | 3 |
| 18 | 00 | 01 | 42 | 17 950 | 92 550 | Estado de Tabasco | Nor | 3 | 2 |
| 18 | 04 | 09 | 56.5 | 14 150 | 93 558 | Fuera costas de Chiapas | Nor | 4 | 4 |

DATOS PROVISIONALES CORRESPONDIENTES AL MES DE SEPTIEMBRE DE 1976

| Día | Tiempo de Origen | | | Coordenadas epicentrales | | Región y comentarios | Prof en km | Magnitud | Núm. de estaciones |
|---|---|---|---|---|---|---|---|---|---|
| | h | m | s | N | W | | | | |
| 18 | 11 | 51 | 53 | 16 232 | 99 320 | Frente a las costas de Guerrero | Nor | 5 | 6 |
| 18 | 20 | 16 | 45 | 15 214 | 91 840 | Guatemala. Próximo frontera de México | Nor | 3 | 2 |
| 18 | 22 | 48 | 51 | 12 446 | 91 270 | Fuera costas de Guatemala | Nor | 4 | 3 |
| 19 | 02 | 16 | 06 | 16 860 | 100 132 | Frente costas de Guerrero. III°Acapulco | Nor | 3 | 2 |
| 19 | 02 | 47 | 07 | 17 200 | 95 075 | Estado de Oaxaca. Istmo de Tehuantepec | Nor | 4 | 3 |
| 19 | 07 | 03 | 31 | 12 770 | 92 075 | Fuera costas de Guatemala | Nor | 4 | 3 |
| 19 | 08 | 39 | 08 | 16 515 | 96 755 | Estado de Oaxaca | Nor | 4.2 | 5 |
| 19 | 11 | 52 | 20 | 13 770 | 90 584 | Frente costas de Guatemala | Nor | 4 | 4 |
| 19 | 12 | 23 | 30.7 | 7 294 | 82 239 | P12 26 53 (CSN); P12 27 28 (PBJ); P12 27 34 (VHO); P12 28 10 (IIP); P12 25 16(IIC | 5.3 Seg. | 5.2 PDE | 5 |
| 19 | 16 | 55 | 00 | | | P 16 55 38 (CSN) inscripción prominente | | | |
| 19 | 20 | 58 | 07 | 18 034 | 100 766 | IV-V°D.F. Fuerte en Chilpancingo y otros lugares en los estados de Michoacan, Jalisco y México.H=205805=18.22/N100.469 Seg. PDE. | 100 | 6 | 7 |
| 19 | 23 | 06 | 20 | 16 000 | 99 000 | Frente a las costas de Guerrero | Nor | 4 | 3 |
| 19 | 23 | 10 | 05 | 19 560 | 98 430 | Estado de Hidalgo | Nor | 3 | 2 |
| 20 | 04 | 20 | 28 | 15 290 | 93 584 | Frente alas costas de Chiapas | Nor | 3 | 2 |
| 20 | 05 | 11 | 20 | 14 625 | 91 780 | Guatemala Proximo frontera con México | Nor | 3 | 2 |
| 20 | 06 | 22 | 27 | 14 810 | 92 000 | Guatemala Próximo a frontera con México | Nor | 3 | 2 |
| 20 | 18 | 04 | 53 | 19 434 | 97 000 | Estado de Veracruz. Región de Coatepec | Nor | 4 | 5 |
| 20 | 18 | 33 | 51 | 15 053 | 93 264 | Frente alas costas de Chiapas | Nor | 3 | 2 |
| 21 | 02 | 51 | 29.5 | 14 625 | 93 377 | Frente a las costas de Chiapas | Nor | 4 | 3 |
| 21 | 03 | 34 | 43 | 18 268 | 91 339 | Estado de Campeche ?- Localización dudosa | Nor | 4 | 3 |
| 21 | 15 | 52 | 51 | 16 518 | 93 120 | Chiapas Región Central | Nor | 4 | 3 |
| 21 | 19 | 21 | 18 | 15 180 | 90 200 | Guatemala | Nor | 4 | 3 |
| 21 | 19 | 44 | 10 | 14 071 | 92 905 | Frente desembocadura rio Suchiate | Nor | 4.5 | 3 |
| 22 | 03 | 11 | 20 | 16 964 | 92 830 | Unos 37 km al oriente de Chicoasen | Nor | 3 | 2 |
| 22 | 20 | 10 | 46.5 | 15 536 | 93 849 | Frente a las costas de Chiapas | Nor | 3 | 2 |
| 23 | 00 | 59 | 49 | 18 132 | 104 800 | Frente a las costas de Colima | Nor | 4.5 | 4 |
| 24 | 01 | 12 | 12 | 16 000 | 98 482 | Frente a las costas de Oaxaca | Nor | 4 | 5 |
| 24 | 03 | 15 | 48 | 17 360 | 95 810 | V°Choapan Oax.17 277N95.558WMag.4.5Seg. | 50 | 5 | 6 |
| 24 | 14 | 12 | 02 | 18 070 | 94 415 | Edo. de Veracruz PDE | Nor | 4.5 | 6 |
| 24 | 17 | 32 | 12.5 | 18 285 | 93 283 | Estado de Tabasco ? | Nor | 3.5 | 2 |
| 24 | 21 | 40 | 10 | 14 607 | 94 604 | Fuera Golfo de Tehuantepec | Nor | 3 | 2 |
| 25 | 11 | 49 | 12 | 13 643 | 92 509 | Frente costas de Guatemala | Nor | 3 | 2 |
| 26 | 03 | 57 | 21 | 21 360 | 104 190 | Estado de Nayarit | Nor | 3 | 2 |
| 26 | 05 | 21 | 14.5 | 15 714 | 93 792 | Frente a las costas de Chiapás | Nor | 3 | 2 |
| 27 | 04 | 19 | 54 | 16 036 | 94 339 | Frente a las costas de Oaxaca | Nor | 3 | 2 |
| 27 | 11 | 42 | 42 | 18 700 | 102 467 | Región Agnililla Mich. | Nor | 3 | 2 |
| 28 | 00 | 34 | 44 | 14 893 | 94 000 | Frente a las costas de Chíapas | Nor | 3 | 2 |
| 28 | 05 | 23 | 18 | 15 178 | 93 094 | Frente a las costas de Chíapas | Nor | 3 | 2 |
| 28 | 09 | 01 | 46 | 13 196 | 91 453 | Frente a las costas de Guatemala | Nor | 3 | 2 |
| 28 | 18 | 54 | 16 | 15 450 | 93 450 | Frente a las costas de Chíapas | Nor | 3 | 2 |
| 28 | | | | | | P19 48 13 (COM); P194627 (CSN) | | | 2 |
| 29 | | | | | | P095521.5(CSN); P095609(VHO);P095636(IIP) P095637(IIC); e095639 (IIM) | | | 5 |
| 29 | 11 | 53 | 30 | 15 000 | 90 905 | Guatemala | Nor | 3 | 2 |
| 30 | 06 | 47 | 54.5 | 16 820 | 95 150 | Estado de Oaxaca | Nor | 3 | 2 |
| 30 | | | | | | P234714 (IIC);P234717(IIP);P234719(VHO). | | | 3 |

RESUMEN FINAL DE SEPTIEMBRE DE 1976

REGISTROS CATALOGADOS

| Estación | 0 a 10 km | 11 a 50 km | 51 a 100 km | 101 a 200 km | 201 a 500 km | 501 a 1000 km | >1000 km | ? km | Explosiones | SUMA |
|---|---|---|---|---|---|---|---|---|---|---|
| IIC | 2 | 8 | 9 | 3 | 27 | 6 | 4 | 21 | | 80 |
| IIM | | | 1 | | 11 | 2 | 3 | 1 | 13 | 31 |
| IIP | 2 | 4 | 1 | 4 | 26 | 4 | 4 | 11 | | 56 |
| III | | | | | | 1 | | | | 1 |
| CSN | 1 | 15 | 9 | 52 | 65 | 10 | 1 | 18 | 10 | 181 |
| TAC | | | | | 3 | | | | | 3 |
| COM | | | 7 | 27 | 51 | 5 | 1 | | | 91 |
| PBJ | | 1 | 2 | 20 | 29 | 9 | | 5 | | 66 |
| VHO | | 1 | 3 | 4 | 13 | 10 | 1 | 6 | | 38 |
| TOTAL | 5 | 29 | 32 | 110 | 225 | 47 | 14 | 62 | 23 | 547 |

DATOS PROVISIONALES CORRESPONDIENTES AL MES DE OCTUBRE DE 1976



| Día | Tiempo de Origen | | | Coordenadas epicentrales | | Región y comentarios | Prof en km | Magnitud | Núm. de estaciones |
|---|---|---|---|---|---|---|---|---|---|
| | h | m | s | N | W | | | | |
| 1 | 02 | 37 | 38 | 15 536 | 92 962 | Chiapas | Nor | 3 | 2 |
| 1 | 08 | 09 | 43 | 15 410 | 91 300 | Guatemala | Nor | 3 | 2 |
| 1 | 10 | 31 | 51 | 17 768 | 95 207 | Estado de Veracruz | 100 | 5 | 6 |
| 2 | 05 | 25 | 36 | 15 000 | 90 829 | Guatemala | Nor | 3 | 2 |
| 2 | 11 | 15 | 55 | 15 786 | 92 910 | Chiapas.- Angel A. Corzo III° | | 3 | 3 |
| 2 | 12 | 22 | 28 | 16 570 | 99 850 | Frente a las costas de Guerrero | Nor | 5 | 5 |
| 2 | 20 | 56 | 20 | 14 500 | 92 740 | Frente a las costas de Chiapas | Nor | 4 | 3 |
| 3 | 00 | 25 | 22 | 15 964 | 92 850 | Chiapas | Nor | 3 | 3 |
| 3 | 07 | 24 | 56 | 14 621 | 92 360 | Frente costas Guatemala | Nor | 4 | 3 |
| 3 | 10 | 27 | 42 | 17 786 | 102 210 | Frente a la desembocadura del Rio Balsas | Nor | 3 | 2 |
| 3 | 10 | 52 | 40 | 15 300 | 95 00 | Golfo de Tehuantepec.Frente costas Oax. | Nor | 3 | 3 |
| 3 | 11 | 54 | 54 | 16 893 | 95 320 | Oaxaca. Istmo de Tehunatepec | Nor | 3 | 3 |
| 3 | 22 | 05 | 17 | 14 190 | 94 370 | Fuera costas de Chiapas | Nor | 4.5 | 5 |
| 4 | 01 | 02 | 32 | 14 540 | 94 280 | Fuera costas de Oaxaca | Nor | 3.5 | 3 |
| 4 | 06 | 21 | 15 | 14 803 | 93 132 | Frente costas de Chiapas | Nor | 4 | 3 |
| 4 | 06 | 42 | 42 | 20 513 | 98 333 | Estado de Hidaldo | Nor | 4 | 3 |
| 4 | 06 | 59 | 15 | 20 607 | 98 887 | Hidalgo. V°en Pachuca,Zacualtipán, El Cardonal y otros lugares.-Distrito Federal III y IV°.- Entre esta fecha y el 19 de octubre se inscribieron 81 debiles >III°; 6 medianos >V°; y el fuerte con grados del III al V.- Todos estos movimientos se registraron en IIC e IIP | Nor | 4.8 | 7 |
| 4 | 09 | 00 | 10.5 | 14 415 | 95 415 | Fuera de las costas de Oaxaca | Nor | 4 | 3 |
| 5 | 07 | 04 | 50 | 16 110 | 94 207 | Costas de Oaxaca | Nor | 3 | 2 |
| 5 | 09 | 47 | 01 | 15 962 | 94 377 | Frente a las costas de Oaxaca | Nor | 3 | 2 |
| 6 | 05 | 37 | 29 | 15 214 | 93 132 | Frente a las costas de Chiapas | Nor | 3 | 3 |
| 6 | 06 | 46 | 39.2 | 18 428 | 92 811 | Costas de Tabasco | Nor | 4 | 3 |
| 6 | | | | | | e 091740 (CSN). P09 1749 (PBJ); e091833 (IIP); e 091839 (IIC). | ? | 6 | 3 |
| 7 | 17 | 07 | 54 | 15 786 | 93 641 | Costas de Chiapas | Nor | 3 | 2 |
| 8 | 10 | 43 | 08 | 15 696 | 93 698 | Frente costas de Chiapas | Nor | 3 | 3 |
| 8 | 12 | 31 | 15.8 | 10 837 | 85 756 | P123447 (IIP); P123448.5 (IIM): P12 3732 (COM).P123451 (IIC).-Según PDE Costa Rica | 85 | 5.3 | 4 |
| 8 | 15 | 50 | 02.5 | 16 893 | 92 207 | Chiapas Distrito A. Obregón | Nor | 3 | 3 |
| 8 | 22 | 02 | 36 | 15 090 | 92 962 | Frente a las costas de Chiapas | Nor | 3 | 3 |
| 9 | 10 | 16 | 33 | 14 180 | 94 000 | Fuera costas de Chiapas | Nor | 3 | 3 |
| 9 | 21 | 09 | 11 | 18 928 | 102 226 | Estado de Michoacán | Nor | 3 | 2 |
| 9 | 23 | 42 | 07 | 15 550 | 97 450 | Frente a las costas de Oaxaca | Nor | 3.5 | 3 |
| 10 | 01 | 01 | 17 | 15 630 | 92 905 | Chiapas | Nor | 3 | 2 |
| 10 | 06 | 32 | 30 | 20 665 | 99 604 | Estado de Hidalgo | Nor | 3 | 2 |
| 10 | 06 | 34 | 10 | 15 770 | 94 226 | Frente a las costas de Oaxaca | Nor | 3 | 2 |
| 10 | 07 | 07 | 59 | 16 428 | 95 075 | Proximo a Tehuantepec? Oaxaca | Nor | 3 | 2 |
| 10 | 07. | 03 | 15 | 16 321 | 98 905 | Frente a las Costas de Guerrero | Nor | 3 | 2 |
| 10 | 12 | 15 | 30 | 15 732 | 94 622 | Frente costas de Oaxaca Golfo de Tehuantepec. | Nor | 3 | 3 |
| 10 | 15 | 03 | 42 | 17 107 | 94 679 | Estado de Oaxaca.Istmo de Tehuantepec | Nor | 4 | 3 |
| 10 | 17 | 07 | 08 | 14 981 | 93 792 | Frente a las costas de Chiapas | Nor | 3 | 2 |
| 10 | 19 | 55 | 33 | 15 714 | 94 320 | Frente a las costas de Chiapas | Nor | 4 | 3 |
| 10 | 21 | 26 | 31 | 13 821 | 91 837 | Frente a las costas de Guatemala | 50 | 4 | 3 |
| 10 | 22 | 37 | [illegible] | 15 643 | 94 622 | Golfo de Tehuantepec Frente costas Oaxaca. | Nor | 4 | 3 |

DATOS PROVISIONALES CORRESPONDIENTES AL MES DE OCTUBRE DE 1976

| Día | Tiempo de Origen | | | Coordenadas epicentrales | | Región y comentarios | Prof en km | Magnitud | Núm. de estaciones |
|---|---|---|---|---|---|---|---|---|---|
| | h | m | s | N | W | | | | |
| 10 | 23 | 12 | 00 | 20 730 | 99 622 | Queretaro. Proximo a Codereyta | Nor | 3 | 2 |
| 11 | 03 | 02 | 09 | 14 857 | 95 358 | Frente a las costas de Oaxaca | Nor | 4 | 3 |
| 11 | 07 | 53 | 02 | 20 830 | 99 245 | Hidalgo | Nor | 3 | 2 |
| 11 | 08 | 05 | 55.5 | 17 464 | 92 132 | Chiapas Distrito A. Obregón | Nor | 3.5 | 3 |
| 11 | 08 | 06 | 13 | 15 786 | 93 330 | Costas de Chiapas | Nor | 3 | 2 |
| 11 | 14 | 50 | 19 | 16 270 | 94 320 | Costas de Oaxaca | Nor | 4 | 3 |
| 12 | 03 | 14 | 42 | 16 375 | 100 320 | Frente a las costas de Guerrero | Nor | 3 | 2 |
| 12 | 19 | 38 | 40 | 14 893 | 95 050 | Fuera de las costas de Oaxaca | Nor | 4 | 3 |
| 12 | 21 | 24 | 02 | 16 075 | 92 590 | Chiapas | Nor | 3.5 | 3 |
| 12 | 23 | 48 | 47 | 17 553 | 93 226 | Chiapas Pichucalco III° | Nor | 4 | 2 |
| 13 | 05 | 10 | 36 | 15 300 | 98 717 | Frente a las costas de Guerrero y Oaxaca | Nor | 4.5 | 5 |
| 13 | 05 | 32 | 56 | 14 000 ? | 93 400 ? | Po5 3340 (CSN); P05 33 43 (COM); P053349 (PBJ) | Nor | 4 | 3 |
| 13 | 15 | 23 | 41.5 | 20 768 | 99 100 | Hidalgo | Nor | 3 | 2 |
| 13 | 15 | 26 | 17 | 15 448 | 99 189 | Fuera costas de Guerrero Epicentro aprox. | Nor | 4.5 | 4 |
| 13 | 23 | 07 | 34 | 15 893 | 94 360 | Frente a las costas de Oaxaca Golfo de Tehuantepec | Nor | 3 | 3 |
| 14 | 16 | 31 | 54 | 16 178 | 92 698 | Chiapas Embalse presa Angostura | Nor | 3 | 2 |
| 14 | 22 | 20 | 13 | 15 645 | 93 453 | Costas de Chiapas | Nor | 3 | 2 |
| 15 | 04 | 26 | 36.5 | 17 303 | 92 610 | Próximo a Amatan Chiapas | Nor | 3 | 2 |
| 15 | 11 | 29 | 26 | 16 703 | 100 500 | Frente a las costas de Guerrero | Nor | 3 | 2 |
| 15 | 20 | 14 | 37 | 16 625 | 94 680 | Oaxaca Istmo de Tehuantepec | Nor | 3 | 2 |
| 16 | 04 | 09 | 39 | 15 800 | 93 660 | Costas de Chiapas | Nor | 3 | 2 |
| 16 | 11 | 10 | 02.5 | 16 000 | 94 428 | Frente a las costas de Oaxaca Golfo de Tehuantepec | Nor | 3 | 2 |
| 17 | 08 | 39 | 15 | 11 770 | 91 887 | Fuera costas de Guatemala | Nor | 4 | 2 |
| 17 | 23 | 38 | 02.5 | 16 107 | 94 470 | Frente a las costas de Oaxaca Golfo de Tehuantepec | Nor | 3 | 2 |
| 18 | 01 | 53 | 19 | 16 888 | 100 333 | Frente a las costas de Guerrero | Nor | 4 | 3 |
| 20 | 03 | 19 | 47 | 14 303 | 92 264 | Frente a las costas de ChiapasyGuatemala | 80 | 4 | 3 |
| 20 | 09 | 13 | 49 | 15 000? | 89 590? | Guatemala? | Nor | 4 | 3 |
| 20 | 10 | 40 | 31 | 16 214 | 98 830 | Frente a las costas de Guerrero | Nor | 5 | 8 |
| 20 | 11 | 09 | 54 | 16 178 | 98 755 | Frente a las costas de Guerrero | Nor | 4 | 4 |
| 20 | 12 | 36 | 37? | | | P124242(IIC);P124250.5(IIP);P124307(COM) P124316(VHO). P124324(PBJ). | ? | ? | 5 |
| 20 | 18 | 53 | 4.5 | 17 200 | 93 160 | Próximo a Ocotepec, Chiapas | Nor | 3 | 2 |
| 20 | 19 | 10 | 55 | 13 000 | 90 232 | Frente a las costas de El Salvador | Nor | 5 | 4 |
| 21 | 00 | 26 | 30 | 14 800 | 93 190 | Frente a las costas de Chiapas | Nor | 3.5 | 3 |
| 21 | 04 | 59 | 06 | 19 533 | 105 150 | Frente a làs costas de Jalisco Manzanillo IV°- V° Guadalajara III°-IV° | Nor | 6 | 8 |
| 22 | 04 | 04 | 24 | 12 270 | 88 250 | P040548(COM);P040604(CSN);P040623(PBJ); P040648(VHO)P040724(IIM);P040726(III);P0407275(IIP);P040732.5(IIC). Frente a las costas de Nicaragua. | Nor | 6.4 | 8 |
| 22 | 05 | 53 | 49. | 13 075 | 88 397 | P05 5502(COM);P05 5516 (CSN) P05 5535(PBJ P05 5637.5 (III); P055640 (IIP); P05 5644(IIC).Frente a las costas de El Salvador | 82 Segú | 4.8 PDE | 7 |
| 22 | 12 | 40 | 38.5 | 14 000 | 91 127 | Probablemente costas de Guatemala | Nor | 3.5 | 2 |
| 22 | 14 | 33 | 51 | 15 143 | 92 000 | Limites Chiapas Guatemala | Nor | 3 | 2 |
| 22 | 17 | 34 | 05 | 19 836 | 99 099 | Hidalgo Próximo a El Cardonal | Nor | 3 | 2 |
| 23 | 00 | 45 | 35 | 15 857 | 101 000 | Fuera de las costas de Guerrero | Nor | 3 | 2 |

DATOS PROVISIONALES CORRESPONDIENTES AL MES DE OCTUBRE DE 1976

| Día | Tiempo de Origen | | | Coordenadas epicentrales | | Región y comentarios | Prof en km | Magnitud | Núm. de estaciones |
|---|---|---|---|---|---|---|---|---|---|
| | h | m | s | N | W | | | | |
| 23 | 02 | 44 | 57 | 17 430 | 94 000 | Veracruz próximo limites con OaxacayChiapas | Nor | 3 | 2 |
| 23 | 08 | 45 | 42.5 | 16 285 | 95 152 | Muy próximo a Tehuantepec Oax. | Nor | 4 | 2 |
| 23 | 16 | 15 | 01 | 19 380 | 98 884 | Estado de Hidalgo | Nor | 3 | 2 |
| 23 | 20 | 14 | 46 | 15 161 | 94 160 | Golfo de Tehuantepec Frente costas Oaxaca Chiapas | Nor | 4 | 3 |
| 24 | 05 | 40 | 05 | 19 480 | 91 464 | Frente a las costas de Campeche | Nor | 4 | 3 |
| 24 | 20 | 00 | 54.5 | 19 340 | 92 924 | Frente a las costas de Tabasco | Nor | 4 | 3 |
| 24 | 20 | 25 | 12 | 15 786 | 93 810 | Frente a las costas de Chiapas | Nor | 4 | 3 |
| 24 | 21 | 03 | 17 | 16 000 | 98 302 | Frente a las costas de Oaxaca | Nor | 5 | 7 |
| 24 | 21 | 51 | 19 | 17 375 | 94 380 | Veracruz Jesús Carranza III° | 80 | 3 | 2 |
| 25 | 04 | 41 | 00 | 14 880 | 93 360 | Frente a las costas de Chiapas | | 3.5 | 3 |
| 25 | 07 | 13 | 06 | 19 836 | 99 099 | Estado de Hidalgo Próximo a el Cardonal | Nor | 4 | 4 |
| 25 | 08 | 16 | 24 | 15 790 | 92 415 | Chiapas | Nor | 3.5 | 3 |
| 25 | 20 | 02 | 05 | 15 360? | 94 000? | Frente a las costas de Chiapas | Nor | 3 | 3 |
| 25 | 22 | 56 | 16 | 17 446 | 93 210 | Chiapas Próximo a Chapultenango | | 3.5 | 3 |
| 26 | | | | | | P005102(CSN);P005104?(VHO);P005105(PBJ);P005112(COM);P005203(III,IIP,IIM);P005209(IIC). | ? | ? | 8 |
| 26 | 10 | 39 | 21 | 15 964 | 94 415 | Golfo de Tehuantepec.Frente costas de Oax | Nor | 3 | 3 |
| 26 | | | | | | P131030(IIC);P131031.5(IIP);P131036(PBJ);P131038(VHO);P131046?(CSN) | ? | ? | 5 |
| 26 | 21 | 17 | 04 | 15 607 | 94 584 | Frente a las costas de Oaxaca | | 3 | 2 |
| 27 | 19 | 20 | 22.5 | 17 000 | 101 000 | Frente a las costas de Guerrero | Nor | 4 | 3 |
| 27 | 23 | 17 | 48 | 16 000 | 90 411 | Limites Guatemala Chiapas | Nor | 4 | 3 |
| 27 | 23 | 28 | 10.5 | 15 820 | 92 924 | Chiapas | Nor | 3 | 3 |
| 28 | 05 | 22 | 57.7 | 17 268 | 94 472 | Istmo Tehuantepec LímitesVeracruz-Oaxaca | 70 | 3 | 3 |
| 28 | 09 | 07 | 02 | 20 462 | 98 653 | Hidalgo | Nor | 3 | 2 |
| 28 | 17 | 30 | 44 | 15 553 | 94 000 | Frente a las Costas de Chiapas | Nor | 3 | 3 |
| 28 | 23 | 34 | 28 | 13 928 | 93 113 | Frente a las costas de Chiapas | 80 | 4 | 3 |
| 29 | | | | | | P031001(IIC,IIP);P031002 (III);P031005(PBJ,VHO); P031011(CSN) | ? | ? | 6 |
| 29 | 04 | 48 | 56 | 14 395 | 92 622 | Frente a las costas de Chiapas Tapachula Suchiate V° | 60 | 6 | 8 |
| 29 | 06 | 38 | 30 | 16 732 | 101 434 | Frente a las costas de Guerrero | Nor | 4 | 4 |
| 29 | 07 | 39 | 20 | 17 090 | 101 924 | Frente a las costas de Guerrero | | 4.5 | 4 |
| 29 | | | | | | (PBJ);e095404(CSN);e095406(VHO);e0954275(III);e095438(IIP);e095443(IIC).e095354 | ? | ? | 6 |
| 30 | 07 | 53 | 48 | 17 000 | 101 815 | Frente a las costas de Guerrero | Nor | 4.5 | 6 |
| 30 | 10 | 23 | 11 | 14 592 | 92 810 | Frente a las costas de Chiapas | Nor | 3 | 3 |
| 30 | 11 | 46 | 59 | 15 645 | 97 740 | Frente a las costas de Oaxaca | Nor | 3 | 2 |
| 30 | 11 | 47 | 09 | 15 436 | 99 000 | Frente a las costas de Guerrero | Nor | 3 | 2 |
| 30 | 23 | 29 | 58 | 15 518 | 92 415 | Chiapas Próximo limites con Guatemala | Nor | 3.5 | 3 |
| 31 | 04 | 47 | 44.5 | 16 000 | 97 215 | Costas de Oaxaca | | 4 | 6 |
| 31 | 12 | 20 | 13 | 20 851 | 103 156 | Estado de Jalisco | | 3 | 2 |
| 31 | 18 | 40 | 54 | 15 464 | 98 943 | Frente costas Guerrero Oaxaca | | 4 | 4 |
| 31 | 23 | 30 | 51 | 15 411 | 94 509 | Frente a las costas de Oaxaca | | 4 | 3 |

RESUMEN FINAL DE OCTUBRE DE 1976

Registros Catalogados

| Estación | 0 a 10 km. | 11 a 50 km. | 51 a 100 km. | 101 a 200 km. | 201 a 500 km. | 501 a 1000 km. | >1000 km. | ? | Explosiones | Suma |
|---|---|---|---|---|---|---|---|---|---|---|
| IIC | 2 | 4 | 90 | 25 | 21 | 4 | 3 | 13 | | 162 |
| IIM | 1 | 2 | | 7 | 8 | 2 | 1 | 1 | 12 | 34 |
| IIP | | 1 | 6 | 72 | 26 | 3 | 3 | 5 | | 116 |
| III | | | 1 | 2 | 11 | 2 | 3 | 1 | | 20 |
| CSN | | 4 | 7 | 47 | 40 | 8 | 2 | 6 | 5 | 119 |
| COM | | 2 | 6 | 18 | 46 | 5 | 2 | | | 79 |
| PBJ | | 1 | 3 | 20 | 37 | 9 | 2 | | | 72 |
| VHO | | | | 2 | 8 | 6 | 2 | | | 18 |
| SUMA | 3 | 14 | 113 | 193 | 197 | 39 | 18 | 26 | 17 | 620 |

APPENDIX 8

UNIVERSIDAD NACIONAL AUTONOMA DE MEXICO

# BOLETIN SISMOLOGICO

VOLUMEN 58 NUM. 1

SERVICIO SISMOLOGICO NACIONAL

INSTITUTO DE GEOFISICA

MEXICO

ENERO - MARZO 1974

UNIVERSIDAD NACIONAL AUTONOMA DE MEXICO
INSTITUTO DE GEOFISICA
Director: Dr. Julián Adem
Servicio Sismológico Nacional

Torre de Ciencias 4° Piso
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Sr. Salvador Landín
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**Encargados de las Estaciones:**

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LCG: Mons. Daniel Castillo C.
LNM: Mons. Daniel Castillo C.
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MER: Sr. José Sansores
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OAX: Sra. Carmen de Ortega
OXG: Sr. Rafael Velázquez
PBJ: Sr. Aarón Ríos
PIM: Sr. Eustacio Núñez
PMM: Ing. Andrés Pintor
PPM: Sr. Melchor de Jesús y Sr. Salomón Ramírez
TAC: Sr. Alonso Ibarra T. y Sr. Virginio Contreras
TMM: Ing. Edgar Beckley
TPM: Sr. Wenceslao Rivera
UNM: Sra. Guadalupe T. de Cedeño
VCM: Sr. César Luna
VHM: Sr. Manuel Ortega

Editor del Boletín Sismológico
Casiano Jiménez

C O N T E N I D O

# INTRODUCCION

Este Boletín tiene por objeto dar a conocer principalmente la actividad sísmica de México, que es seguramente de interés para el lector en general, así como de los profesionales.

La parte principal de este boletín contiene las observaciones hechas en las estaciones de la Red Sismológica Mexicana que fueron suceptibles de localizarse.

Al final se consigna una lista sumario de los sismos ocurridos dentro del Territorio Nacional y otras de telesismos.

Información sobre daños producidos por sismos, con todo el detalle posible, también es consignada.

Los datos fueron procesados en el sistema B-6700 del CENTRO DE SERVICIOS DE COMPUTO (CSC).

Agradecemos la colaboración de la Comisión Federal de Electricidad, por el apoyo material en el establecimiento de las estaciones OXM y PPM, y por su cooperación en el mantenimiento de las estaciones PIM y PMM. La U. S. GEOLOGICAL SURVEY ha continuado prestando su colaboración en la mantención de los equipos originalmente prestados por esa Institución.

La información macrosísmica fué recabada con los reportes enviados por el personal de Telégrafos Nacionales y el Servicio Meteorológico de la Secretaría de Agricultura y Ganadería.

RED SISMOLOGICA MEXICANA

| ESTACION | LATITUD ° ' " | LONGITUD ° ' " | ALTURA S/N DEL MAR | LOCALIDAD |
|---|---|---|---|---|
| CHH | 28 38 12.0N | 106 04 42.0W | 1430 m | Chihuahua, Chih. |
| COM | 16 15 12.0 | 92 07 41.0 | 1528 | Comitán, Chis. |
| GUM | 20 40 46.0 | 103 19 27.0 | 1567 | Guadalajara, Jal. |
| LCG | 21 C8 42.0 | 101 43 30.0 | 2200 | León, Gto. (Cerro Gordo) |
| LNM | 21 07 00.0 | 101 40 03.0 | 1800 | León, Gto. |
| MAZ | 23 11 17.0 | 106 24 22.0 | 65 | Mazatlán, Sin. |
| MER | 20 56 51.0 | 89 36 59.0 | 7 | Mérida, Yuc. |
| MNZ | 19 03 15.0 | 104 19 50.0 | 60 | Manzanillo, Col. |
| OAX | 17 01 13.0 | 96 45 46.0 | 1570 | Oaxaca, Oax. |
| OXM | 19 17 49.8 | 99 41 18.0 | 2700 | Oxtotitlán, Méx. |
| PBJ | 16 26 12.0 | 95 24 24.0 | 213 | Presa Benito Juárez, Oax. |
| PIM | 18 16 30.0 | 101 52 54.0 | 81 | Presa Infiernillo, Mich. |
| PMM | 17 10 12.0 | 93 36 10.0 | 215 | Presa Malpaso, Chis. |
| PPM | 19 04 00.0 | 98 37 36.0 | 4000 | Volcán Popocatépetl, Tlamacas, Pue. |
| TAC | 19 24 18.0 | 99 11 37.0 | 2297 | Tacubaya, Méx. |
| TMM | 25 45 01.8 | 100 12 10.3 | 585 | Tecnológico de Monterrey, Monterrey, N.L. |
| TPM | 18 59 00.0 | 99 03 42.0 | 1500 | Tepoztlán, Mor. |
| UNM | 19 19 54.0 | 99 11 00.0 | 2275 | Ciudad Universitaria, México. |
| VCM | 19 12 02.0 | 96 08 16.0 | 3 | Veracruz, Ver. |
| VHM | 17 10 36.0 | 96 44 43.0 | 1829 | Vista Hermosa, Oax. |

# EXPLICACION DE LOS DATOS

1.- Todas las localizaciones epicentrales de sismos regionales están hechas con datos de nuestra red. Cuando se trata de telesismos y algunos sismos regionales, nuestros datos son estudiados tomando como base las localizaciones hecha por USGS, haciéndose notar esto en los comentarios.

Cuando la letra "R" aparece en algunos de los parámetros calculados significa que dicho parámetro permaneció fijo durante la computación.

2.- FECHA Todas las fechas están reportadas en Tiempo Medio de Greenwich (TMG).

H Hora origen en horas, minutos y segundos (TMG), para reducir a hora de México reste 6 horas.

LAT Latitud Geográfica del epicentro en grados y décimos de grado.

LONG Longitud Geográfica " " " " " "

NO Número de referencia del sismo.

PROF Profundidad del foco en Km.

ERR Error "Standard" en la localización obtenida usando la fórmula $ES = \sum_{i=1}^{n} \frac{r_i^2}{(n-m)}$ donde ri es el i - ésimo resíduo (sólamente P) n el número de lecturas y m el número de parámetros determinados.

MAG Magnitud del sismo MB calculada con ondas P, MS - con ondas superficiales y ML Magnitud Local Calculada con sismógrafos Wood Anderson (Generalmente - MB y MS son tomados del USGS).

3.- EST Código de la estación que registró el evento.

4.- FASE Una "I" o "E" precede al nombre de la fase para indicar el carácter del arribo.

a) E (emersio), indica un comienzo gradual en el cual la dirección del movimiento es dudoso.

b) I (ímpetu), indica que el primer arribo fué impulsivo y la dirección del primer movimiento es claro.

c) ( ) (paréntesis), indica incertidumbre.

d) El símbolo *P significa pP

e) El símbolo $P " sP

5.- INS Designa la componente (N,E o Z) del sismógrafo de la cual el tiempo de arribo o amplitud y el período fueron medidos.

6.- TIEMPO El tiempo de arribo de la fase está dado en Horas, minutos y segundos en TMG.

7.- DIR Para las fases designadas como ímpetu una C ó D representa un movimiento de compresión o dilatación respectivamente.

8.- PER Período en segundos de la fase correspondiente.

9.- AMP Contiene la amplitud en (mm) de la fase correspondiente, medida de pico a pico sobre el sismograma. Para obtener el desplazamiento del suelo es necesario corregir estos valores usando la curva de amplificación del equipo correspondiente.

10.- DIST Contiene la distancia en grados entre el observatorio y el epicentro.

11.- AZ Contiene el azimut en grados, medido a partir del NORTE a través del ESTE, entre el meridiano que pasa por el epicentro y el arco que une el epicentro y la estación.

12.- O - C Contiene las diferencias de tiempo para las ondas P, PKP ó S entre los tiempos observados y los calculados según las tablas de Jeffreys - Bullen.

13.- Los grados de intensidad consignados en " Información Macrosísmica " están medidos en la escala de Mercalli Modificada (MM).

**ENÉ 2** H= 10 42 29.9R LAT=22.50RS LONG= 68.40RW — NO.74/ 1
PROF= 105R KM NORTE DE CHILE **USGS**
MAG= 6.4(MB) (RICHTER)

| EST | FASE | INS | TIEMPO | DIR | PER | AMP | DIST | AZ | O-C |
|---|---|---|---|---|---|---|---|---|---|
| COM | IP | Z | 10 50 38.4 | D | | | 44.98 | 326.8 | 1.9 |
| TAC | IP | NEZ | 10 51 25.5 | D | | | 51.38 | 321.8 | -0.7 |
| | IS | NZ | 58 24.5 | | | | | | |
| UNM | IP | Z | 10 51 26.4 | | | | 51.32 | 321.8 | 0.7 |
| LCG | IP | E | 10 51 48.0 | | | | 54.21 | 320.8 | 0.8 |

**ENÉ 4** H= 01 33 19.7R LAT=19.50RN LONG=108.00RW — NO.74/ 2
PROF= 33R KM FRENTE A COSTA DE JALISCO **USGS**
MAG= 4.3(MB) (RICHTER)

| EST | FASE | INS | TIEMPO | DIR | PER | AMP | DIST | AZ | O-C |
|---|---|---|---|---|---|---|---|---|---|
| LCG | EP | Z | 01 35 08.0 | | | | 6.11 | 73.3 | 17.7 |
| TAC | EP | Z | 01 35 08.0 | | | | 8.30 | 89.2 | -13.0 |

**ENÉ 4** H= 17 54 57.7R LAT=14.50RN LONG= 93.80RW — NO.74/ 3
PROF= 51R KM GOLFO DE TEHUANTEPEC **USGS**
MAG= 4.8(MB) (RICHTER)

| EST | FASE | INS | TIEMPO | DIR | PER | AMP | DIST | AZ | O-C |
|---|---|---|---|---|---|---|---|---|---|
| COM | IP | Z | 17 55 35.5 | | | | 2.37 | 42.4 | 0.1 |
| | IS | Z | 56 00.5 | | | | | | -3.3 |
| VHM | IP | Z | 17 55 55.5 | | | | 3.90 | 313.6 | -1.5 |
| | I | Z | 56 55.0 | | | | | | |

**ENÉ 5** H= 08 33 50.7R LAT=12.30RS LONG= 76.40RW — NO.74/ 4
PROF= 98R KM CERCA DE LA COSTA DE PERU **USGS**
MAG= 6.3(MB) (RICHTER)

| EST | FASE | INS | TIEMPO | DIR | PER | AMP | DIST | AZ | O-C |
|---|---|---|---|---|---|---|---|---|---|
| COM | IP | Z | 08 40 14.2 | D | | | 32.36 | 330.9 | 1.2 |
| VHM | IP | Z | 08 40 43.0 | D | | | 35.53 | 325.1 | 2.8 |
| UNM | IP | Z | 08 41 09.6 | D | | | 38.63 | 324.1 | 3.4 |
| | *P | | 41 41.6 | | | | | | |
| TAC | IP | NEZ | 08 41 06.5 | D | | | 38.69 | 324.2 | -0.2 |
| | IS | N | 47 05.0 | | | | | | |
| LCG | IP | Z | 08 41 32.8 | | | | 41.53 | 323.0 | 2.7 |

**ENÉ 5** H= 11 00 15.8R LAT= 8.40RN LONG=104.00RW — NO.74/ 5
PROF= 33R KM FUERA DE LA COSTA DE MEXICO **USGS**
MAG= 4.8(MB),MAG= 4.5(MS) (RICHTER)

| EST | FASE | INS | TIEMPO | DIR | PER | AMP | DIST | AZ | O-C |
|---|---|---|---|---|---|---|---|---|---|
| VHM | EP | Z | 11 02 58.0 | | | | 11.23 | 38.3 | 0.8 |
| | E(S) | Z | 51 12.0 | | | | | | |
| TAC | EP | Z | 11 03 06.0 | C | | | 11.89 | 22.5 | -0.2 |
| UNM | E(P) | Z | 11 03 10.3 | | | | 11.84 | 22.7 | 4.8 |
| LCG | IP | Z | 11 03 22.0 | | | | 12.87 | 9.6 | 2.7 |
| COM | EP | Z | 11 03 38.0 | | | | 13.97 | 54.9 | 4.3 |

FECHA EST FASE INS TIEMPO DIR PER AMP DIST AZ O-C

ENE 5 H= 11 45 31.3R LAT= 8.30RN LONG=104.00RW NO.74/ 6
PROF= 33R KM FUERA DE LA COSTA DE MEXICO **USGS**
MAG= 5.0(MB),MAG= 4.9(MS) (RICHTER)

| EST | FASE | INS | TIEMPO | DIR | PER | AMP | DIST | AZ | O-C |
|---|---|---|---|---|---|---|---|---|---|
| UNM | IP | Z | 11 48 25.8 | | | | 11.93 | 22.6 | 3.6 |
| VHM | EP | Z | 11 48 15.0 | | | | 11.31 | 38.0 | 1.2 |
| TAC | IP | NZ | 11 48 26.0 | C | | | 11.98 | 22.4 | 3.0 |
| | I | | 49 49.6 | | | | | | |
| LCG | IP | Z | 11 48 41.2 | | | | 12.96 | 9.5 | 5.1 |
| COM | IP | Z | 11 48 52.0 | | | | 14.03 | 54.6 | 2.0 |

ENE 5 H= 12 38 25.7R LAT=13.96RN LONG= 92.51RW NO.74/ 7
PROF= 33R KM FRENTE COSTA MEXICO-GUATEMALA **USGS**
MAG= 4.3(MB),MAG= 3.6(MS) (RICHTER)

| EST | FASE | INS | TIEMPO | DIR | PER | AMP | DIST | AZ | O-C |
|---|---|---|---|---|---|---|---|---|---|
| COM | IP | Z | 12 39 06.0 | | | | 2.31 | 9.0 | 3.7 |
| | I(S) | Z | 39 43.0 | | | | | | |
| VHM | IP | Z | 12 39 45.0 | | | | 5.19 | 308.6 | 1.6 |
| UNM | I(P) | Z | 12 40 35.1 | | | | 8.34 | 310.8 | 7.7 |

ENE 5 H= 14 00 56.8R LAT=52.20RN LONG=171.40RW NO.74/ 8
PROF= 41R KM ISLAS FOX **USGS**
MAG= 5.4(MB),MAG= 4.7(MS) (RICHTER)

| EST | FASE | INS | TIEMPO | DIR | PER | AMP | DIST | AZ | O-C |
|---|---|---|---|---|---|---|---|---|---|
| VHM | EP | Z | 14 11 38.5 | | | | 67.22 | 91.2 | -10.7 |

ENE 5 H= 23 29 18.6R LAT=42.60RN LONG=126.60RW NO.74/ 9
PROF= 22R KM FUERA DE LAS COSTA DE OREGON **USGS**
MAG= 5.0(MB),MAG= 4.6(MS) (RICHTER)

| EST | FASE | INS | TIEMPO | DIR | PER | AMP | DIST | AZ | O-C |
|---|---|---|---|---|---|---|---|---|---|
| VHM | EP | Z | 23 36 20.0 | | | | 35.88 | 125.7 | 0.7 |

ENE 7 H= 02 18 50.1R LAT= 0.00RN LONG= 91.50RW NO.74/ 10
PROF= 33R KM ISLAS GALAPAGOS **USGS**
MAG= 5.4(MB),MAG= 5.5(MS) (RICHTER)

| EST | FASE | INS | TIEMPO | DIR | PER | AMP | DIST | AZ | O-C |
|---|---|---|---|---|---|---|---|---|---|
| COM | IP | Z | 02 22 41.5 | D | | | 16.16 | 357.8 | 5.0 |
| TAC | IP | Z | 02 23 33.0 | D | | | 20.71 | 339.0 | 2.7 |
| | I | N | 27 40.0 | | | | | | |
| UNM | IP | Z | 02 23 31.7 | | | | 20.64 | 339.0 | 2.1 |
| LCG | IP | N | 02 23 59.2 | | | | 23.28 | 335.2 | 3.3 |

ENE 7 H= 16 35 57.8R LAT=26.90RS LONG= 65.70RW NO.74/ 11
PROF= 33R KM PROVINCIA DE TUCUMAN, ARG. **USGS**
MAG= 5.8(MB) (RICHTER)

| EST | FASE | INS | TIEMPO | DIR | PER | AMP | DIST | AZ | O-C |
|---|---|---|---|---|---|---|---|---|---|
| COM | IP | Z | 16 44 51.0 | | | | 49.99 | 326.1 | -0.0 |
| VHM | EP | Z | 16 45 17.0 | | | | 53.19 | 322.0 | 1.9 |

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CHA  EST  FASE INS     TIEMPO   DIR   PER     AMP        DIST     AZ     O-C

          I     Z         45 53.0
     LCG  I(P)  Z      16 46 02.0                        59.16  320.2    4.0

ENE  8 H= 21 47 21.6R  LAT=39.00RS   LONG= 46.20RE             NO.74/  12
     PROF= 33R KM      CORDILLERA ATLANTICO-INDICA     **USGS**
     MAG= 6.0(MB),MAG= 6.1(MS) (RICHTER)

     VHM  EPKP  Z      22 06 45.0                       141.13  246.6   =4.0
          E     Z         07 57.0
     TAC  IPKP  Z      22 06 54.0                       144.33  246.8   =0.6
          E     Z         08 14.0
     UNM  IPKP  Z      22 06 55.2                       144.28  246.7    0.7

ENE  9 H= 09 59 02.9R  LAT=32.33RN   LONG=116.32RW             NO.74/  13
     PROF=   8R KM     CERCA DE TIJUANA ,BAJA CALIF    **USGS**

      *REGISTRADO EN LA RED EXPERIMENTAL DE B.C.*

ENE  9 H= 22 27 24.1R  LAT=11.00RN   LONG= 85.80RW             NO.74/  14
     PROF= 144R KM     NICARAGUA                       **USGS**
     MAG= 4.9(MB) (RICHTER)

     COM  IP    Z      22 29 12.0  C                      8.07  311.0   =7.8

ENE 10 H= 08 51 13.3R  LAT=14.40RS   LONG=166.90RE             NO.74/  15
     PROF=  34R KM     ISLAS NUEVAS HEBRIDAS           **USGS**
     MAG= 6.7(MB),MAG= 7.2(MS) (RICHTER)

     TAC  IP    EZ     09 04 51.0  C                     98.27   72.1    2.3
          I               07 38.5
     LCG  IP    Z      09 04 54.0                        96.33   69.9   14.1

ENE 10 H= 14 35 40.0R  LAT=17.58RN   LONG=103.11RW             NO.74/  16
     PROF=  33R KM     FRENTE A COSTA DE MICHOACAN     **TAC **

     UNM  IP    Z      14 36 42.3                         4.12   64.2   =0.2
          IS    Z         37 30.4                                       =0.0
     TAC  IP    E      14 36 42.0                         4.13   63.3   =0.7
          IS    E         37 20.0                                       =2.8
     VHM  IP    Z      14 37 10.0                         6.08   92.8   =0.1
     COM  IP    Z      14 38 14.0                        10.59   95.5    1.3
          I               40 21.0

ENE 10 H= 22 31 47.8R  LAT=57.30RN   LONG= 33.60RW             NO.74/  17
     PROF=  33R KM     NORTE DEL OCEANO ATLANTICO      **USGS**
     MAG= 5.1(MB),MAG= 4.6(MS) (RICHTER)
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| FECHA | HORA | EPICENTRO | | REGION | PROF | MAG | NO |
|---|---|---|---|---|---|---|---|
| ENE | | | | | | | |
| 4 | 01 33 19.7 | 19.50N | 108.00W | FRENTE A COSTA DE JALISCO | 33 | 4.3 | 2 |
| 4 | 17 54 57.7 | 14.50N | 93.80W | GOLFO DE TEHUANTEPEC | 51 | 4.8 | 3 |
| 5 | 12 38 25.7 | 13.96N | 92.51W | FRENTE COSTA MEXICO-GUATEMALA | 33 | 4.3 | 7 |
| 9 | 09 59 02.9 | 32.33N | 116.32W | CERCA DE TIJUANA ,BAJA CALIF | 8 | | 13 |
| 13 | 14 35 40.0 | 17.58N | 103.11W | FRENTE A COSTA DE MICHOACAN | 33 | | 16 |
| 15 | 02 29 53.8 | 17.92N | 94.67W | ISTMO DE TEHUANTEPEC | 33 | | 22 |
| 19 | 16 32 49.6 | 13.55N | 94.03W | GOLFO DE TEHUANTEPEC | 33 | | 26 |
| 20 | 07 46 24.7 | 15.92N | 94.67W | GOLFO DE TEHUANTEPEC | 54 | 4.5 | 27 |
| 21 | 07 54 01.5 | 17.80N | 94.90W | ISTMO DE TEHUANTEPEC | 33 | | 28 |
| 21 | 22 48 52.1 | 14.90N | 93.60W | GOLFO DE TEHUANTEPEC | 33 | 5.0 | 29 |
| 22 | 22 39 15.4 | 15.41N | 94.64W | GOLFO DE TEHUANTEPEC | 33 | | 30 |
| 23 | 06 15 25.6 | 32.13N | 115.80W | CERCA DE MEXICALI,BAJA CALIF | 8 | | 31 |
| 24 | 11 29 24.4 | 13.59N | 92.32W | FRENTE COSTA MEXICO-GUATEMALA | 33 | | 34 |
| 25 | 13 43 57.5 | 14.10N | 92.62W | CERCA COSTA MEXICO-GUATEMALA | 33 | | 35 |
| 25 | 23 14 56.1 | 16.57N | 98.75W | CERCA COSTA GUERRERO-OAXACA | 33 | | 37 |
| 26 | 05 35 33.6 | 18.26N | 103.41W | COSTA DE MICHOACAN | 33 | 5.1 | 38 |
| 27 | 01 02 44.5 | 15.53N | 98.06W | FRENTE A COSTA DE OAXACA | 33 | | 39 |
| 29 | 03 35 25.8 | 31.30N | 115.92W | PENINSULA BAJA CALIF NORTE. | 8 | | 40 |
| 30 | 00 38 41.1 | 32.65N | 115.82W | CERCA DE MEXICALI,BAJA CALIF | 8 | | 41 |
| 30 | 09 06 26.6 | 14.82N | 92.65W | CERCA COSTA MEXICO-GUATEMALA | 33 | | 42 |
| 30 | 10 26 44.4 | 16.26N | 95.36W | OAXACA | 60 | | 44 |
| 30 | 12 51 01.2 | 16.79N | 100.00W | COSTA DE GUERRERO | 33 | | 45 |
| FEB | | | | | | | |
| 1 | 01 37 09.4 | 32.30N | 115.23W | CERCA DE MEXICALI,BAJA CALIF | 8 | | 48 |
| 1 | 01 55 12.7 | 32.38N | 115.12W | CERCA DE MEXICALI,BAJA CALIF | 8 | | 49 |
| 1 | 10 24 31.1 | 18.13N | 92.07W | COSTA DE TABASCO. | 33 | | 51 |
| 2 | 07 07 37.7 | 13.80N | 92.78W | FRENTE COSTA MEXICO-GUATEMALA | 75 | | 53 |
| 2 | 08 29 03.6 | 17.00N | 99.50W | GUERRERO | 33 | 4.6 | 54 |
| 3 | 01 48 29.7 | 14.28N | 94.16W | GOLFO DE TEHUANTEPEC | 33 | | 55 |
| 4 | 16 56 20.0 | 13.75N | 93.06W | FRENTE COSTA MEXICO-GUATEMALA | 33 | | 59 |
| 6 | 14 38 53.0 | 14.20N | 92.05W | CERCA COSTA MEXICO-GUATEMALA | 33 | | 63 |
| 7 | 22 39 27.6 | 17.50N | 94.01W | ISTMO DE TEHUANTEPEC | 33 | | 65 |
| 8 | 02 21 27.4 | 18.60N | 104.30W | FRENTE COSTA COLIMA | 33 | | 66 |
| 8 | 17 19 59.1 | 30.30N | 113.30W | GOLFO DE CALIFORNIA NORTE | 33 | 4.4 | 68 |
| 8 | 21 29 55.7 | 15.83N | 93.82W | COSTA DE CHIAPAS | 63 | | 69 |
| 9 | 16 17 09.3 | 18.26N | 103.42W | COSTA DE MICHOACAN | 33 | | 70 |
| 9 | 18 36 07.9 | 14.97N | 92.74W | CERCA COSTA MEXICO-GUATEMALA | 109 | 4.8 | 71 |
| 10 | 05 07 36.0 | 17.56N | 93.98W | ISTMO DE TEHUANTEPEC | 33 | | 72 |
| 10 | 05 50 04.7 | 17.05N | 94.43W | ISTMO DE TEHUANTEPEC | 33 | | 73 |
| 10 | 12 05 33.8 | 15.73N | 98.29W | FRENTE A COSTA DE OAXACA | 33 | | 74 |
| 10 | 18 23 47.6 | 14.84N | 92.53W | CERCA COSTA MEXICO-GUATEMALA | 33 | | 75 |
| 10 | 22 10 34.0 | 18.05N | 96.07W | LIMITE VERACRUZ-OAXACA | 33 | | 76 |
| 21 | 08 18 19.5 | 17.32N | 94.78W | ISTMO DE TEHUANTEPEC | 100 | | 88 |
| 22 | 00 57 00.1 | 16.07N | 95.09W | OAXACA | 33 | | 91 |
| 22 | 04 29 44.0 | 14.76N | 92.76W | CERCA COSTA MEXICO-GUATEMALA | 33 | | 92 |
| 22 | 09 54 16.6 | 13.86N | 93.10W | FRENTE COSTA MEXICO-GUATEMALA | 33 | | 93 |
| 23 | 06 02 53.3 | 16.08N | 98.12W | CERCA COSTA GUERRERO-OAXACA | 33 | 5.1 | 94 |
| 23 | 06 21 34.0 | 15.65N | 98.28W | FRENTE A COSTA DE OAXACA | 33 | 5.3 | 95 |
| 28 | 04 23 00.2 | 15.50N | 94.45W | GOLFO DE TEHUANTEPEC | 33 | | 99 |
| MAR | | | | | | | |
| 2 | 20 37 41.1 | 19.50N | 109.00W | FRENTE A COSTA DE JALISCO | 33 | 4.3 | 103 |
| 6 | 10 52 11.4 | 16.30N | 94.14W | ISTMO DE TEHUANTEPEC | 33 | | 107 |

| FECHA | HORA | EPICENTRO | | REGION | PROF | MAG | NO |
|---|---|---|---|---|---|---|---|
| MAR | | | | | | | |
| 6 | 14 14 26.2 | 15.70N | 94.75W | GOLFO DE TEHUANTEPEC | 45 | 4.5 | 108 |
| 6 | 18 03 42.4 | 15.79N | 98.90W | FRENTE A COSTA DE OAXACA | 33 | | 109 |
| 20 | 03 19 48.5 | 18.63N | 91.75W | CERCA LAGUNA DE TERMINOS,CAMP | 33 | | 119 |
| 21 | 09 32 26.3 | 17.40N | 105.60W | FRENTE A COSTA DE MICHOACAN | 33 | 4.4 | 120 |
| 23 | 17 36 47.0 | 30.30N | 113.80W | GOLFO DE CALIFORNIA NORTE | 33 | 4.5 | 125 |
| 25 | 07 37 12.3 | 18.10N | 103.24W | COSTA DE MICHOACAN | 57 | 4.7 | 127 |
| 28 | 12 37 56.7 | 17.70N | 105.90W | FRENTE A COSTA DE MICHOACAN | 33 | 4.4 | 129 |
| 29 | 00 42 30.0 | 17.08N | 95.32W | LIMITE VERACRUZ-OAXACA | 33 | | 130 |
| 29 | 17 33 59.5 | 16.78N | 94.03W | ISTMO DE TEHUANTEPEC | 33 | | 131 |

| FECHA | HORA | EPICENTRO | | REGION | PROP | MAG | NO |
|---|---|---|---|---|---|---|---|
| ENE | | | | | | | |
| 2 | 10 42 29.9 | 22.50S | 68.40W | NORTE DE CHILE | 105 | 6.4 | 1 |
| 5 | 08 33 50.7 | 12.30S | 76.40W | CERCA DE LA COSTA DE PERU | 98 | 6.3 | 4 |
| 5 | 11 00 15.8 | 8.40N | 104.00W | FUERA DE LA COSTA DE MEXICO | 33 | 4.8 | 5 |
| 5 | 11 45 31.3 | 8.30N | 104.00W | FUERA DE LA COSTA DE MEXICO | 33 | 5.0 | 6 |
| 5 | 14 00 56.8 | 52.20N | 171.40W | ISLAS FOX | 41 | 5.4 | 8 |
| 5 | 23 29 18.6 | 42.60N | 126.60W | FUERA DE LAS COSTA DE OREGON | 22 | 5.0 | 9 |
| 7 | 02 18 50.1 | 0.00N | 91.50W | ISLAS GALAPAGOS | 33 | 5.4 | 10 |
| 7 | 16 35 57.8 | 26.90S | 65.70W | PROVINCIA DE TUCUMAN, ARG. | 33 | 5.8 | 11 |
| 8 | 21 47 21.6 | 39.00S | 46.20E | CORDILLERA ATLANTICO-INDICA | 33 | 6.0 | 12 |
| 9 | 22 27 24.1 | 11.00N | 85.80W | NICARAGUA | 144 | 4.9 | 14 |
| 10 | 08 51 13.3 | 16.40S | 166.90E | ISLAS NUEVAS HEBRIDAS | 34 | 6.7 | 15 |
| 10 | 22 31 47.0 | 57.30N | 33.60W | NORTE DEL OCEANO ATLANTICO | 33 | 5.1 | 17 |
| 11 | 01 59 17.5 | 57.30N | 33.50W | NORTE DEL OCEANO ATLANTICO. | 33 | 4.7 | 18 |
| 11 | 05 18 02.4 | 31.80S | 68.40W | PROVINCIA DE SAN JUAN, ARG. | 122 | 5.4 | 19 |
| 12 | 04 47 59.3 | 13.70N | 91.00W | FRENTE A COSTA GUATEMALA | 64 | 4.4 | 20 |
| 14 | 15 52 47.3 | 8.60S | 77.60W | PERU | 4 | 5.2 | 21 |
| 17 | 09 14 11.5 | 28.10S | 70.90W | CHILE CENTRAL | 83 | 5.3 | 23 |
| 17 | 11 16 02.9 | 13.20N | 88.30W | EL SALVADOR | 103 | 4.6 | 24 |
| 19 | 06 07 52.3 | 8.40N | 82.40W | R FRONTERIZA PANAMA-COSTA RICA | 33 | 4.8 | 25 |
| 23 | 13 51 08.8 | 22.90S | 179.10W | SUR DE LAS ISLAS FIJI | 449 | 5.4 | 32 |
| 23 | 21 43 51.3 | 32.20S | 69.80W | PROV.DE MENDOZA, ARGENTINA | 115 | 5.2 | 33 |
| 25 | 22 40 16.1 | 16.40S | 172.50W | REGION DE LAS ISLAS SAMOA | 9 | 5.2 | 36 |
| 30 | 09 53 12.0 | 5.20S | 134.10E | REGION ISLAS AROE | 33 | 5.9 | 43 |
| 31 | 19 55 26.2 | 52.40N | 168.70W | ISLAS FOX, ISLAS ALEUTIANAS | 36 | 5.6 | 46 |
| 31 | 23 30 05.3 | 7.50S | 155.90E | ISLAS SOLOMON | 34 | 6.0 | 47 |
| FEB | | | | | | | |
| 1 | 03 12 33.1 | 7.40S | 155.60E | ISLAS SALOMON | 40 | 6.2 | 50 |
| 1 | 13 06 17.7 | 15.70S | 75.00W | CERCA COSTA DE PERU | 47 | 5.2 | 52 |
| 3 | 10 08 40.4 | 18.90N | 120.10E | LUZON, I. FILIPINAS | 30 | 5.9 | 56 |
| 3 | 18 45 45.7 | 5.10S | 133.80E | REGION I. AROE | 33 | 5.7 | 57 |
| 4 | 09 09 41.4 | 35.60S | 104.80W | SUR DE OCEANO PACIFICO | 33 | 5.1 | 58 |
| 4 | 20 10 42.0 | 7.30S | 155.80E | ISLAS SALOMON | 54 | 5.4 | 60 |
| 6 | 04 04 07.2 | 53.80N | 164.70W | REGION I. UNIMAK | 2 | 5.9 | 61 |
| 6 | 08 14 27.2 | 6.80N | 73.00W | NORTE DE COLOMBIA | 159 | 5.1 | 62 |
| 7 | 09 41 51.0 | 3.00S | 134.00E | R OCCIDENTAL DE NUEVA GUINEA | 30 | 5.8 | 64 |
| 8 | 06 22 11.5 | 8.30S | 77.20W | PERU | 81 | 4.6 | 67 |
| 11 | 01 40 46.2 | 6.10S | 104.10E | ESTRECHO DE SUNDA | 33 | 5.5 | 77 |
| 13 | 23 37 52.9 | 0.00N | 122.70E | NORTE DE CELEBES | 11 | 5.8 | 78 |
| 14 | 06 19 55.8 | 26.20S | 66.50W | CATAMARCA, ARGENTINA | 33 | 5.0 | 79 |
| 14 | 07 49 40.3 | 19.70N | 70.00W | REGION REPUBLICA DOMINICANA | 6 | 5.1 | 80 |
| 16 | 01 26 59.8 | 21.30S | 69.90W | NORTE DE CHILE | 74 | 5.3 | 81 |
| 16 | 01 51 10.8 | 11.40N | 92.30E | REGION ISLAS ANDAMAN | 25 | 5.5 | 82 |
| 16 | 01 53 06.6 | 11.40N | 92.40E | REGION ISLAS ANDAMAN | 33 | 5.7 | 83 |
| 19 | 03 30 21.8 | 13.90N | 122.10E | LUZON, ISLAS FILIPINAS | 16 | 5.7 | 84 |
| 20 | 03 02 53.5 | 30.00S | 68.60W | S.JUAN, ARGENTINA | 115 | 5.5 | 85 |
| 20 | 04 56 58.7 | 7.20N | 82.30W | SUR DE PANAMA | 33 | 4.8 | 86 |
| 20 | 16 11 26.8 | 19.60N | 70.00W | REGION REPUBLICA DOMINICANA | 18 | 4.9 | 87 |
| 21 | 14 27 05.2 | 35.20S | 71.00W | CENTRO DE CHILE | 87 | 5.1 | 89 |
| 22 | 00 35 53.8 | 33.20N | 136.90E | SUR DE HONSHU, JAPON | 385 | 6.0 | 90 |
| 23 | 18 31 26.5 | 14.25N | 91.89W | GUATEMALA | 33 | | 96 |
| 27 | 17 00 00.1 | 37.10N | 116.05W | SUR DE NEVADA | 0 | 5.8 | 97 |
| 27 | 18 01 48.7 | 1.30N | 97.70E | NORTE DE SUMATRA | 33 | 5.9 | 98 |