LOS ANGELES VICINITY STRONG MOTION
ACCELEROGRAPH NETWORK

by

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ABSTRACT

A network of strong motion accelerographs has been installed in the Los Angeles basin and its vicinity. The placement of this network was motivated by the combination of several factors: (1) The existence of major faults in the region of a large metropolitan area with about seven million population, (2) the presence of apparently anomalous behavior in the strain field of the region, which could suggest stronger earthquake activity in the near future, (3) significantly frequent occurrence of intermediate and small earthquakes to generate steady recording of data in the near future. The network is intended to help to understand the distribution of strong shaking, attenuation of strong motion, and its relationship to the geological structure and near surface sediments. The purpose of this report is to describe the current status of this project.

The full network is the result of a coordinated effort between the University of Southern California and the California Division of Mines and Geology. This report focuses on the part which has been installed, and is being maintained by the University of Southern California (USC). A summary review of fifteen sites which will be instrumented by the California Division of Mines and Geology (CDMG) to constitute a sub-array of the USC network, is included.

INTRODUCTION

A network of strong motion accelerographs has been installed in the Los Angeles metropolitan area. It became operational in the Spring of 1980. This array will contribute data from future strong earthquakes which may occur near Los Angeles and will benefit both engineers and seismologists in a long term program of hazard reduction. Data from this array can be used to study, for example, the nature of wave propagation and the shallow crustal structure in the Los Angeles basin, the distribution of strong ground motion, and the relationship of these to the thickness and degree of consolidation of the Los Angeles basin sediments. Furthermore, the data from this array can be used to study the high frequency shear wave travel times and the short-period surface wave dispersion in the Los Angeles basin. This data can also be inverted for the structure and especially the shear wave structure. The S-wave arrival times and polarizations, for example, are particularly useful in a detailed study of earthquake locations and focal mechanisms.

The accelerograms recorded by the array will contribute toward answering many empirical questions on site characteristics of strong ground shaking. These include, for example, the questions how the amplitudes of various frequencies and the duration of shaking vary from place to place in the Los Angeles basin. Having examined these questions empirically it will be possible to examine whether these variations are related to the structure. Another useful question that can be examined from the engineering viewpoint is whether there are predominant periods associated with each site, and if so, if these are related to the depth,

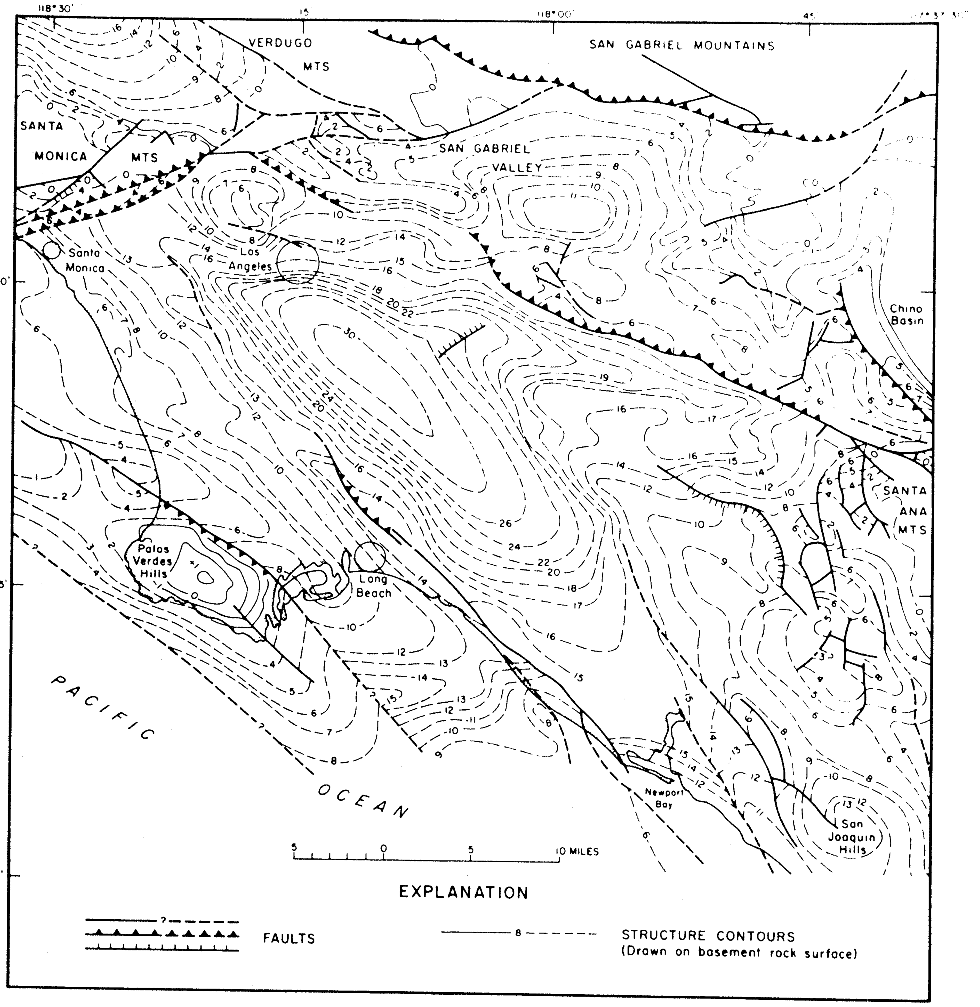


Fig. 1. Thickness of alluvium in the vicinity of Los Angeles (after Yerkes et al. 1965).

and velocity structure of the alluvium. The solution to this problem is necessary to evaluate if microzonation of the Los Angeles basin, and other metropolitan areas, is possible or desirable. The Los Angeles basin is particularly well suited for these studies because the depth of basement rocks and the basin configuration is fairly well known as a result of 70 years of oil field investigations; this allows a reduction in ambiguity when deriving shear velocity structure and a more reliable study of the effects of alluvial depth.

In the event of a strong earthquake, the array will be valuable in interpreting the distribution of damage, for it will help to demonstrate in what manner variations in the ground shaking correlate with variations in the observed damage. In some cases, this data may help explain why some structures are less damaged than others.

It should be noted that although the possibility that a large earthquake may occur in the near future in the Los Angeles area reinforces the need for an array of strong motion accelerographs there, this does not represent the only essential source of ground shaking for the array to record. Events as small as magnitude 3 can be expected to be recorded on the nearest portion of the array, and will provide data useful for study of crustal structure. About four events of that size may occur annually in the region which has been instrumented (Teng _et al_. 1975; Henyey and Teng, 1976). Thus the array will record both major and lesser seismic events.

Figure 1 after Yerkes _et al_. (1965) shows how the thickness of the sediments varies in the vicinity of Los Angeles. The depth to the basement rock as determined by oil drillings varies from zero to over 30,000 feet. In some places, e.g. south boundary of the San Gabriel Mountains, the sediments thickness changes abruptly; in other places it appears to change more smoothly but rapidly. This geometry is important to understand because shallow geologic structure is believed to have pronounced effects on near field wave propagation, especially in the relatively high frequency ground motions of engineering significance. This conclusion is supported by theoretical research by Wong and Jennings (1975) and experimental work by Hanks (1975), Anderson and Dorman (1973), Wong et al. (1976), Borchert and Gibbs (1976), Westermo and Trifunac (1976a,b, 1978, 1979) and Cerri (1976), among others. Some of these studies suggest that a sedimentary thickness may correlate with, and have important effects on, properties of the propagating near field waves. For example, Hanks (1975) has shown qualitatively that the geology along the path does have a strong effect on the development of surface waves.

It is known from the study of accelerograms that the details of geologic structure have a strong effect on some characteristics of strong shaking. Trifunac (1976a) has found a correlation between the surficial geology and the peaks of ground motion, and both Trifunac (1976b) and Seed et al. (1976) have found that different site conditions affect spectral shapes and amplitudes. Wong et al. (1976) studied the amplitudes of steady state waves recorded in crossing the boundary of an alluvial basin. Their results show clearly how the decreasing sediments thickness causes large amplitude variations to occur in relatively short horizontal distances. Westermo and Trifunac (1978, 1979) have studied how the duration of seismic waves is affected by the thickness of the sediment. They suggest that the duration of shaking increases by between 0.5 and 1.0 second for each additional thousand feet of sediment. Thus, one could expect the duration of strong shaking to depend strongly on location in Los Angeles, since sediment thicknesses vary between zero and 30,000 feet.

Better understanding of all of these phenomena is important for the development of modern codes for the design of earthquake resistant structures, but the presently existing data is inadequate, because the distribution of strong motion recordings has not been adequate and because many existing strong motion records do not have absolute timing, so that phases often cannot be correlated from one station to the next. Operating instruments include short-period seismic networks of the California Institute of Technology (Hileman _et al_. 1973) and the University of Southern California (Teng and Henyey, 1974) and strong motion accelerographs coordinated by the U.S. Geological Survey (USGS, 1976). The short-period seismic networks have a limited dynamic range, and narrow-band frequency response peaked at higher frequencies than one is primarily concerned with in earthquake engineering and most important, do not record horizontal components of motion.

The existing strong-motion accelerographs in California have been installed gradually over the past 50 years. Some of those are shown in Figures 2, 3 and 4. Figure 2 shows all the accelerographs in the Los Angeles basin which were triggered by the San Fernando, California, earthquake of 1971. Those are coordinated by the U.S. Geological Survey (USGS, 1976). Most of these accelerographs are installed in large

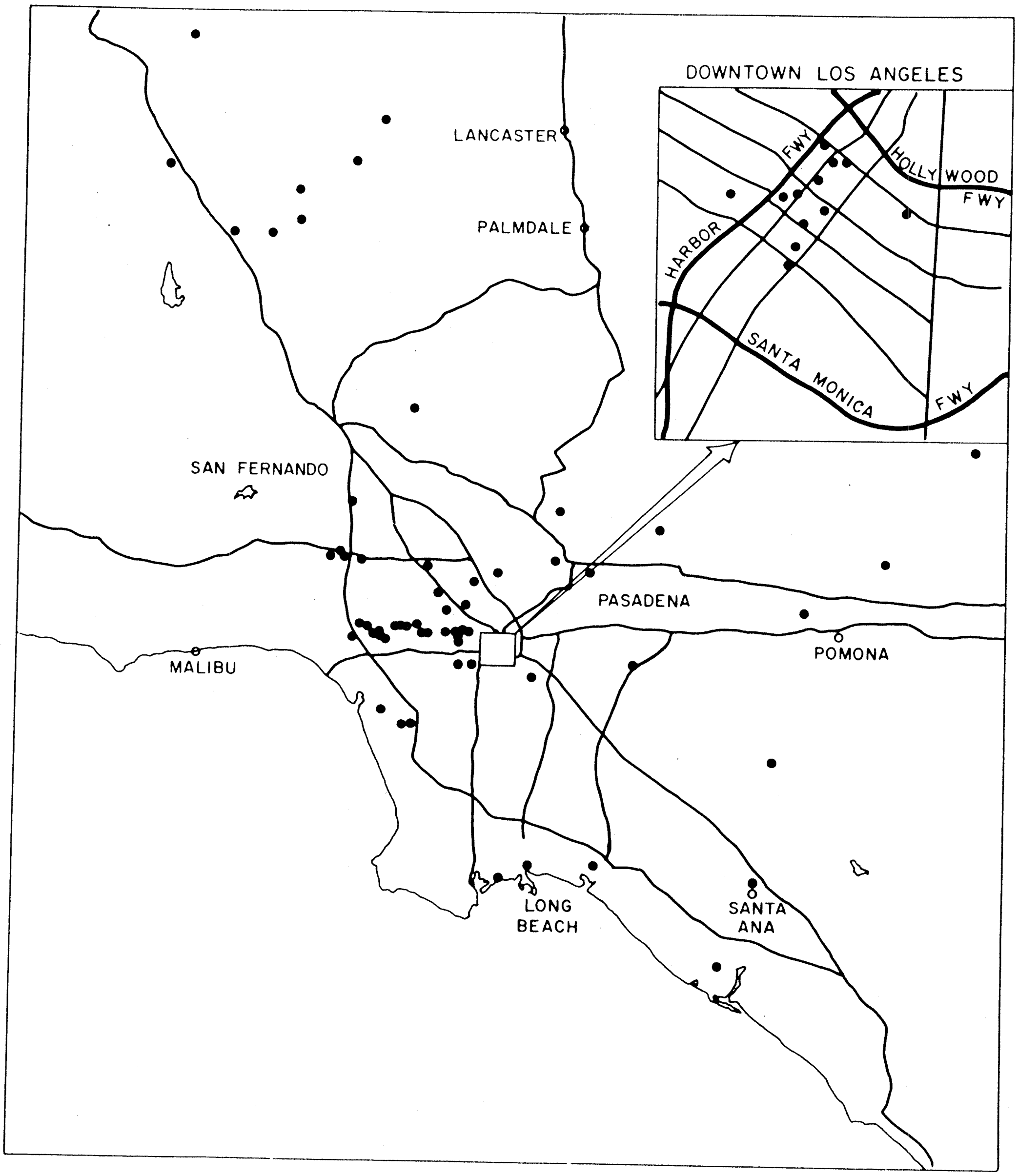


Fig. 2. Accelerographs in the Los Angeles Basin triggered by the San Fernando, California, earthquake of 1971.

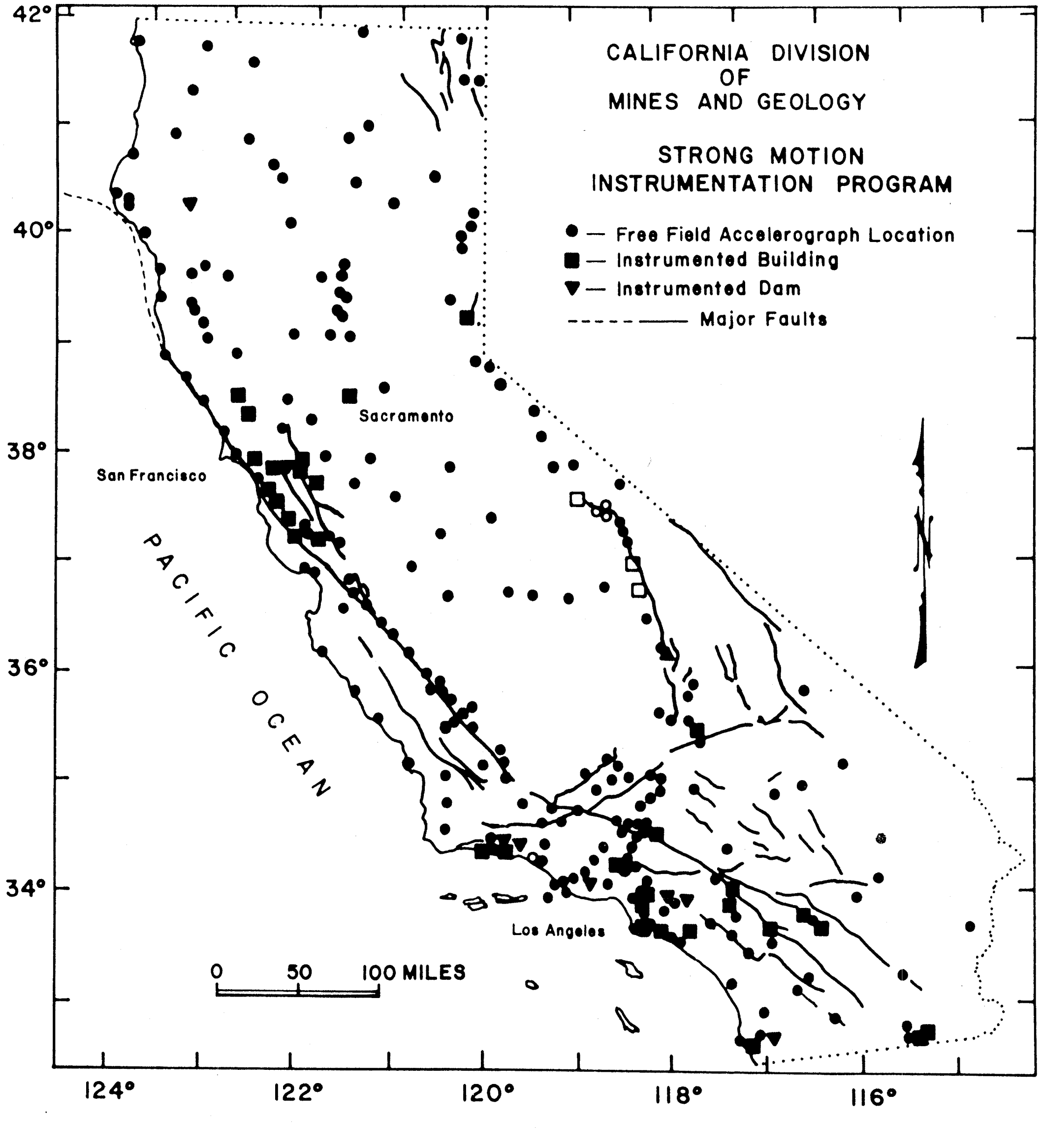


Fig. 3. California Division of Mines and Geology Strong Motion Instrumentation Program Accelerograph Sites (1976).

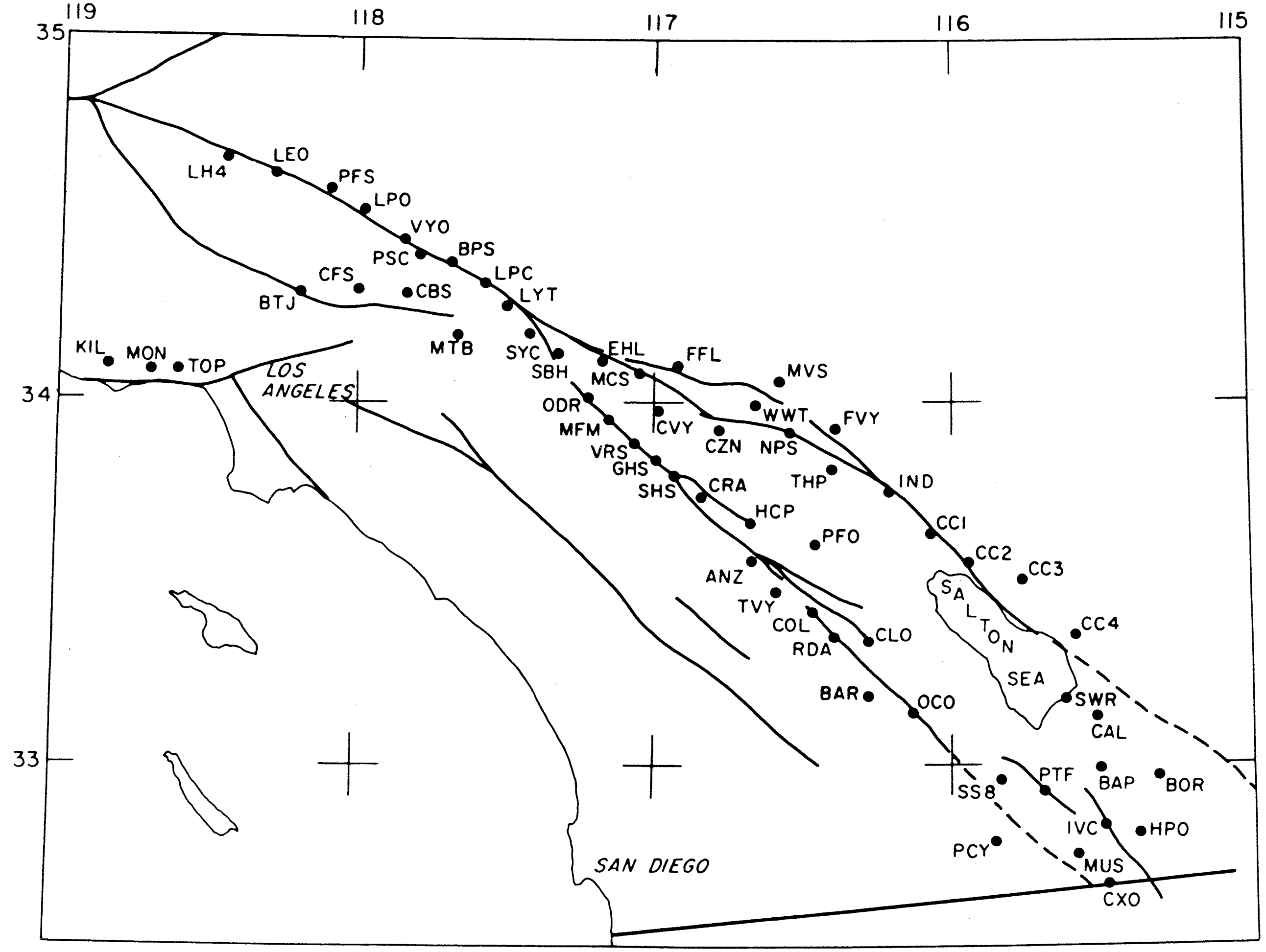


Fig. 4 San Jacinto array as installed in 1973/74.

structures. Since 1972 accelerographs have been installed in small structures and at free field locations by the California Division of Mines and Geology (CDMG) under the California Strong Motion Instrumentation Program (Gay, 1976). This program (Figure 3), which will eventually instrument a large number of structures in addition to "free field" locations, has concentrated on free field locations to date, and has completed much of that phase (Gay, 1976). Many of the additional planned instruments will be in special purpose arrays to monitor attenuation of strong shaking perpendicular to the faults and the change of shaking in vertical column. Another example of a recently installed group of accelerographs in free field locations is a linear array along the San Andreas and San Jacinto fault systems in Southern California (Figure 4). This array has been designed and deployed under direction of M. D. Trifunac and T. C. Hanks in 1973/74, while at California Institute of Technology. The geometrical characteristics of this array have been selected to study motions in the near field during large earthquakes. During the recent (October 15, 1979) earthquake in Imperial Valley this array contributed valuable recordings for source mechanism and related near field studies.

SEISMICITY OF LOS ANGELES AND VICINITY

Some aspects of the seismicity of Southern California are shown in Figures 5 and 6 (Teng and Henyey, 1974) which present the seismicity since reliable epicenter location became possible in 1932. This shows that seismic activity of low magnitude occurs throughout the Los Angeles

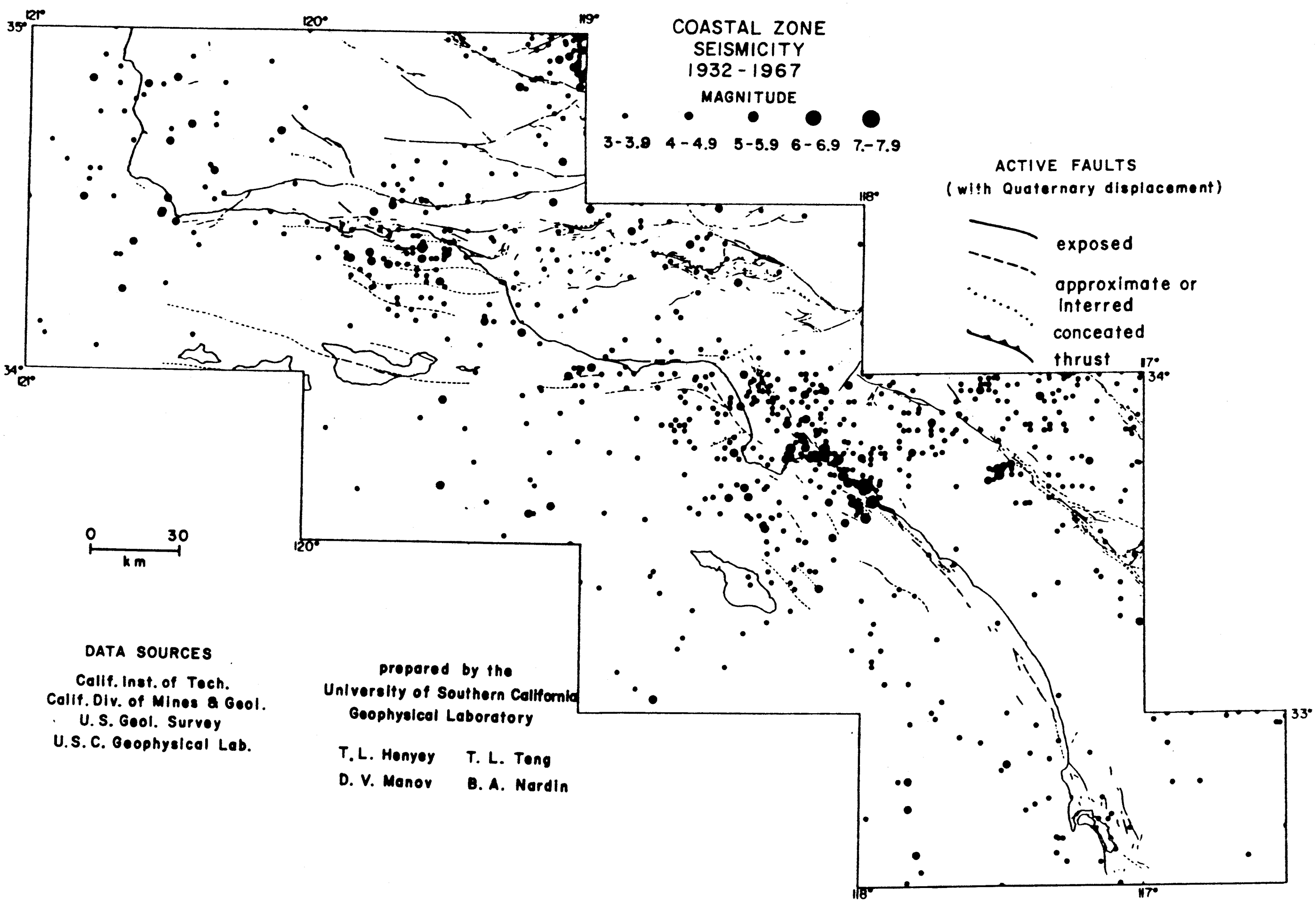

COASTAL ZONE
SEISMICITY
1932 - 1967
MAGNITUDE
3-3.9 4-4.9 5-5.9 6-6.9 7.-7.9
ACTIVE FAULTS
(with Quaternary displacement)
exposed
approximate or inferred
concealed
thrust
0 30
km
DATA SOURCES
Calif. Inst. of Tech.
Calif. Div. of Mines & Geol.
U. S. Geol. Survey
U.S.C. Geophysical Lab.
prepared by the
University of Southern California
Geophysical Laboratory
T. L. Henyey T. L. Teng
D. V. Manov B. A. Nardin
121°
120°
119°
118°
117°
35°
34°
33°

Fig. 5

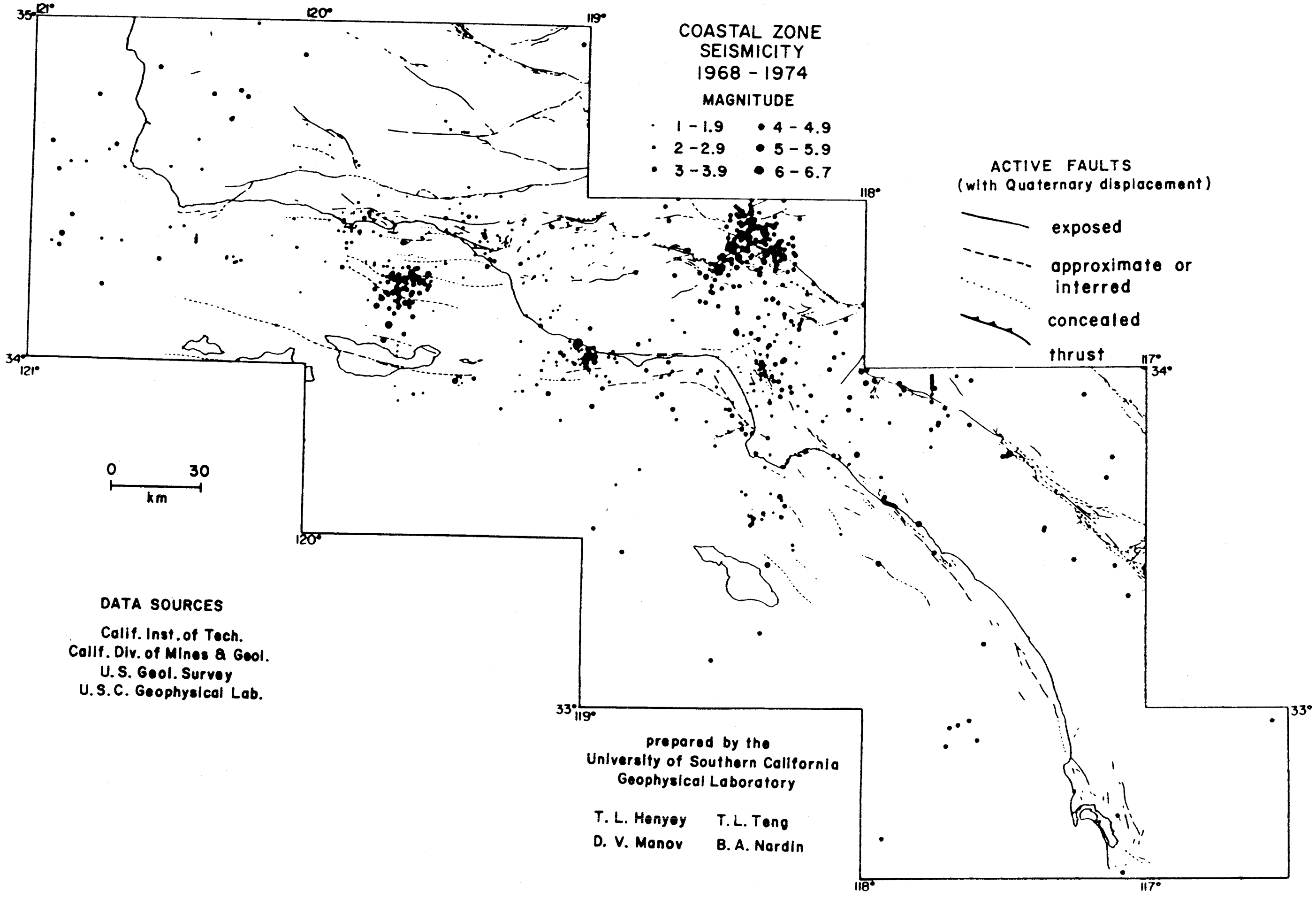

COASTAL ZONE
SEISMICITY
1968 - 1974
MAGNITUDE
· 1 - 1.9
· 2 - 2.9
• 3 - 3.9
• 4 - 4.9
● 5 - 5.9
● 6 - 6.7
ACTIVE FAULTS
(with Quaternary displacement)
exposed
approximate or inferred
concealed
thrust
0 30
km
DATA SOURCES
Calif. Inst. of Tech.
Calif. Div. of Mines & Geol.
U. S. Geol. Survey
U. S. C. Geophysical Lab.
prepared by the
University of Southern California
Geophysical Laboratory
T. L. Henyey
T. L. Teng
D. V. Manov
B. A. Nardin
35°
121°
120°
119°
118°
117°
34°
33°

Fig. 6

basin. On the basis of recurrence curves derived from this data (Hileman et al., 1973) within the approximately 2,500 km^2 area of the Los Angeles basin one should expect about four earthquakes of magnitude greater than 3 each year. This is consistent with the seismicity map by Teng and Manov (1976) shown in Figure 7. From this data it is clear that the Los Angeles basin is regularly subjected to earthquakes, and there is no evidence to suggest that this moderate to high seismicity is decreasing.

A recurrence curve for the Los Angeles vicinity derived by Teng and Henyey (1974) is shown in Figure 8. Like the one by Hileman et al. (1973) it suggests that at least a few events with magnitude 3 or greater would occur inside the metropolitan area. Thus the array is expected to record about four to five earthquakes inside the array per year. Some of these earthquakes may not generate useful surface wave data, but will contribute to the study of S-wave velocities. Recorded accelerograms will certainly contribute to location and source mechanism studies. The array will also record larger events which occur in the mountains surrounding the Los Angeles basin. These, as well as larger events inside the array ($M > 4$) may be strong enough to generate the short period surface waves.

Any earthquake with local magnitude over 3 which occurs within the array will probably trigger several accelerographs. This can be seen from Figure 9 which shows the magnitude plotted against the epicentral distance for many of the accelerograms recorded in the United States. From this figure, it appears that one could expect to recover records from earthquakes of magnitude 3 at 10 km, from magnitude 4 earthquakes at 20 km, from magnitude 5 earthquakes at 40 km, and from magnitude 6 earthquakes over 100 km away. By considering this and the seismicity of

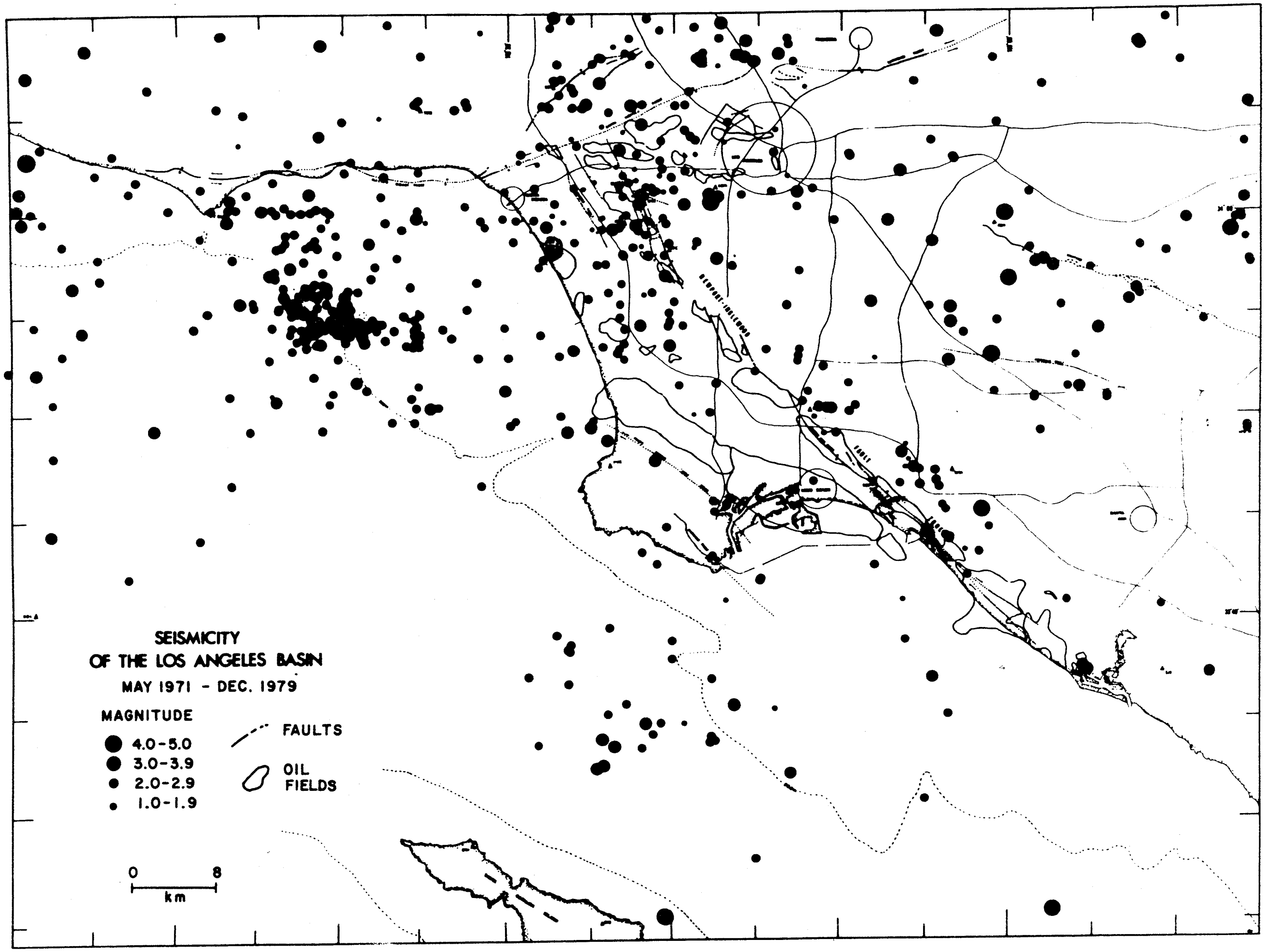
SEISMICITY
OF THE LOS ANGELES BASIN
MAY 1971 - DEC. 1979
MAGNITUDE
4.0-5.0
3.0-3.9
2.0-2.9
1.0-1.9
FAULTS
OIL FIELDS
0
8
km
NEWPORT-INGLEWOOD
FAULT

Fig. 7

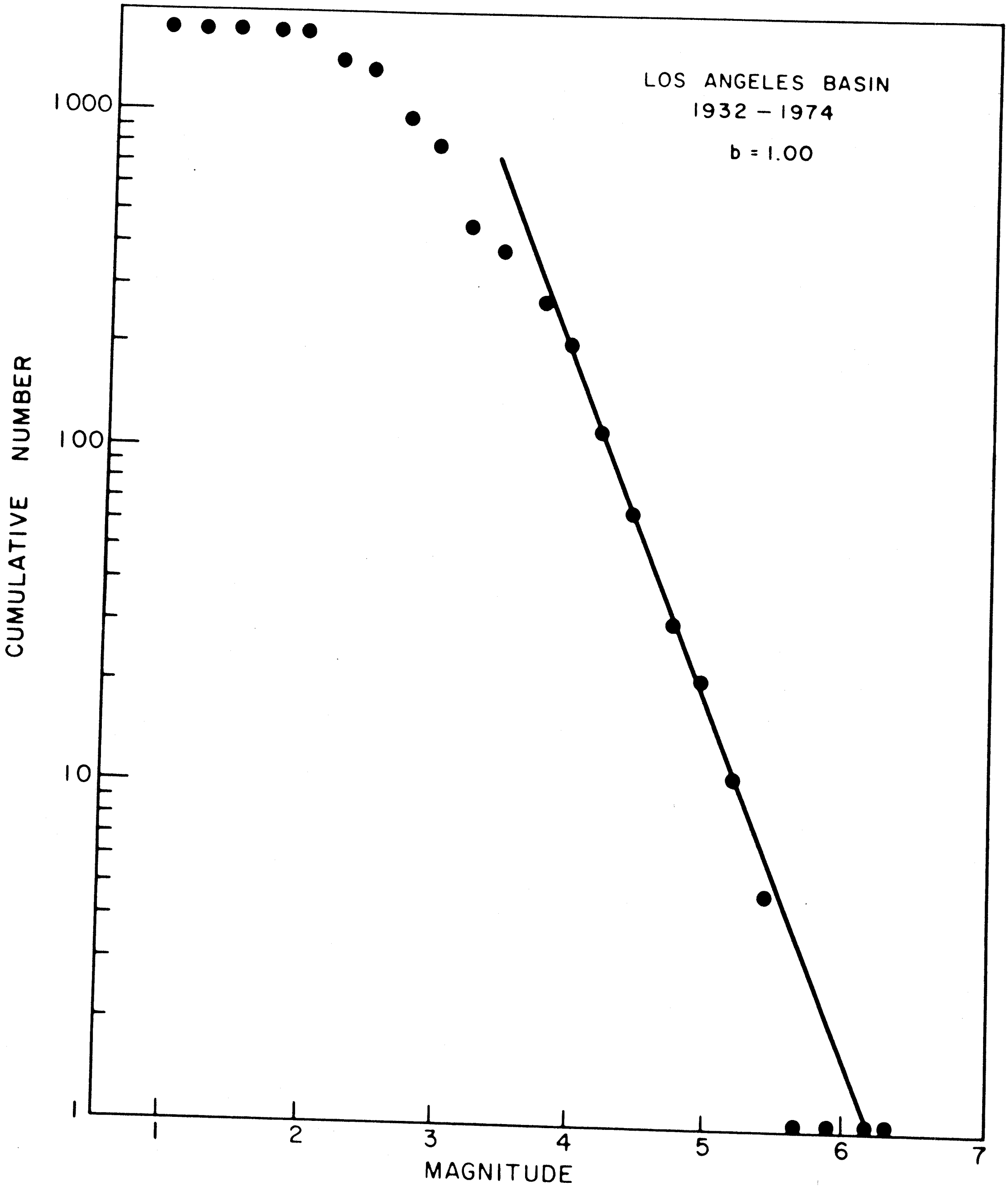

LOS ANGELES BASIN
1932 – 1974
b = 1.00
CUMULATIVE NUMBER
1000
100
10
1
1
2
3
4
5
6
7
MAGNITUDE

Fig. 8

the Los Angeles area one can estimate the rate at which the Los Angeles strong motion array will produce data.

Of course, one of the important functions of the Los Angeles accelerograph array is to record large earthquakes and their aftershocks. If a major event ($M \sim 8$) were to occur, one would expect that the aftershock zone might extend for 200 km or more, thus providing the array with numerous shaking sources with a broad range of azimuthal approach.

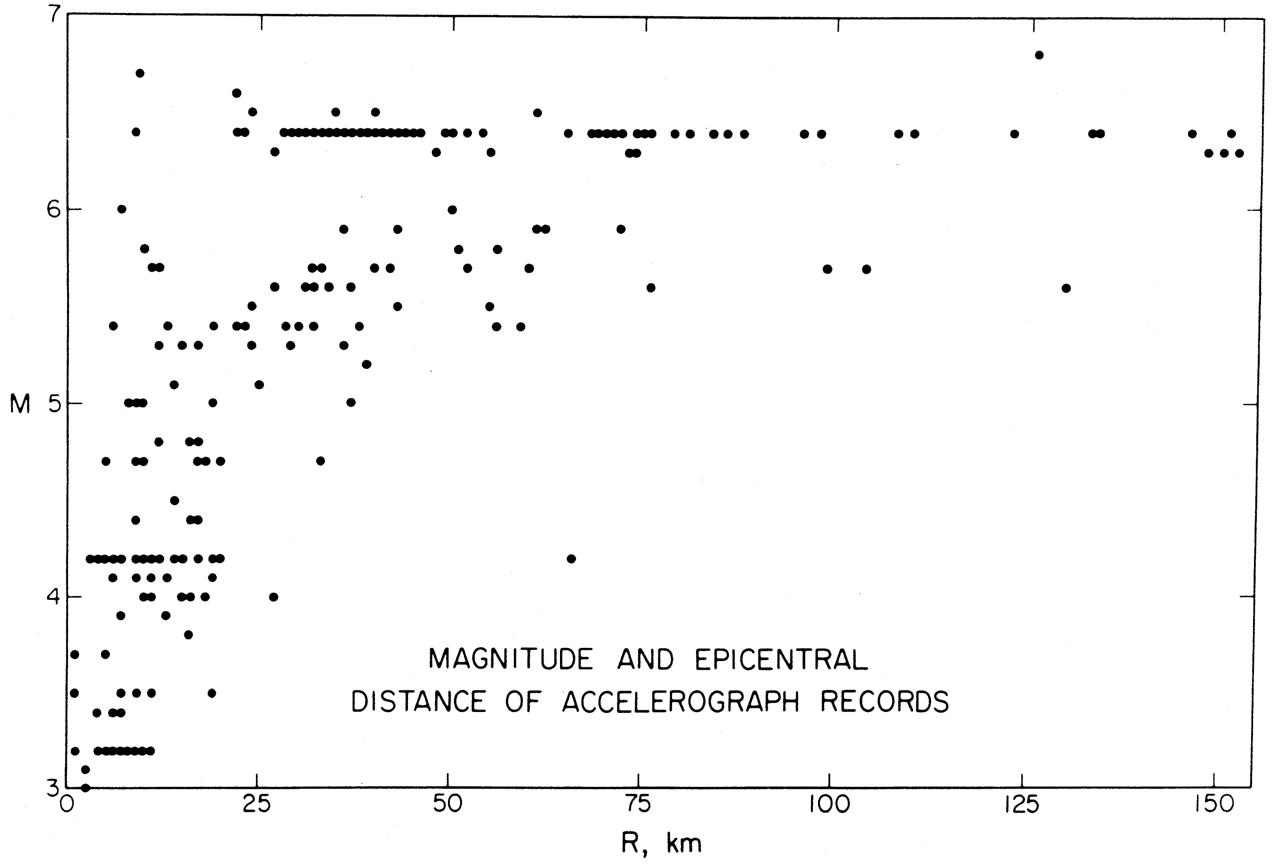

MAGNITUDE AND EPICENTRAL
DISTANCE OF ACCELEROGRAPH RECORDS
M
7
6
5
4
3
0
25
50
75
100
125
150
R, km

Fig. 9

LOS ANGELES STRONG MOTION ACCELEROGRAPH NETWORK

Geological Framework

The geology of the Los Angeles vicinity is fairly complex, but has been studied in considerable detail. Figure 10 shows a generalized map of the surficial geology. The trend of faults including the Santa Monica, Raymond Hill, and San Gabriel - Sierra Madre thrust faults mark the boundary between the Transverse Ranges and Peninsular Ranges physiographic provinces. As can be seen from Figure 10, these faults and others in the region also mark sharp discontinuities in the depth of sedimentary deposits of the region. Elsewhere, the depth to geological basement changes rapidly but apparently continuously.

Since this structure has strong lateral variations, interpretation of the wave propagation through it is not possible without broad regional coverage on a common time base. It is only then that various records can be correlated and the waves accurately identified.

Network Layout

Figure 11 shows the target locations of all accelerographs installed by the University of Southern California, and other existing or planned installations in the Los Angeles vicinity. The layout in this figure attempted to avoid a preoccupation with fault locations in the selection of accelerograph sites. An array of this size and density will inevitably provide excellent coverage to study the source properties of earthquakes which occur on any of the several faults within its boundaries. Therefore, we concentrated more on locations which would help to interpret how wave propagation is affected by geological structural features and topography.

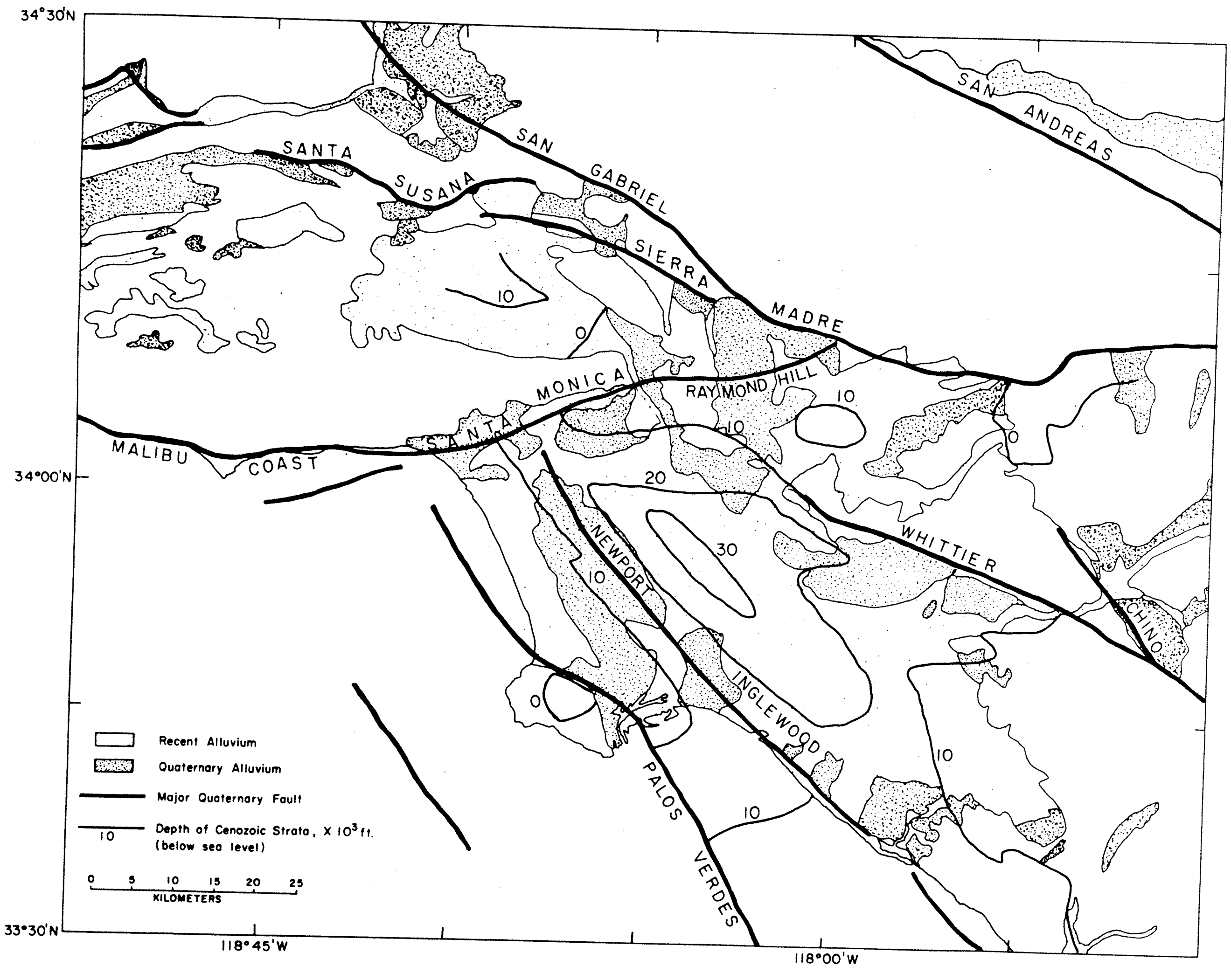


Fig. 10 Generalized map of surficial geology in the vicinity of Los Angeles.

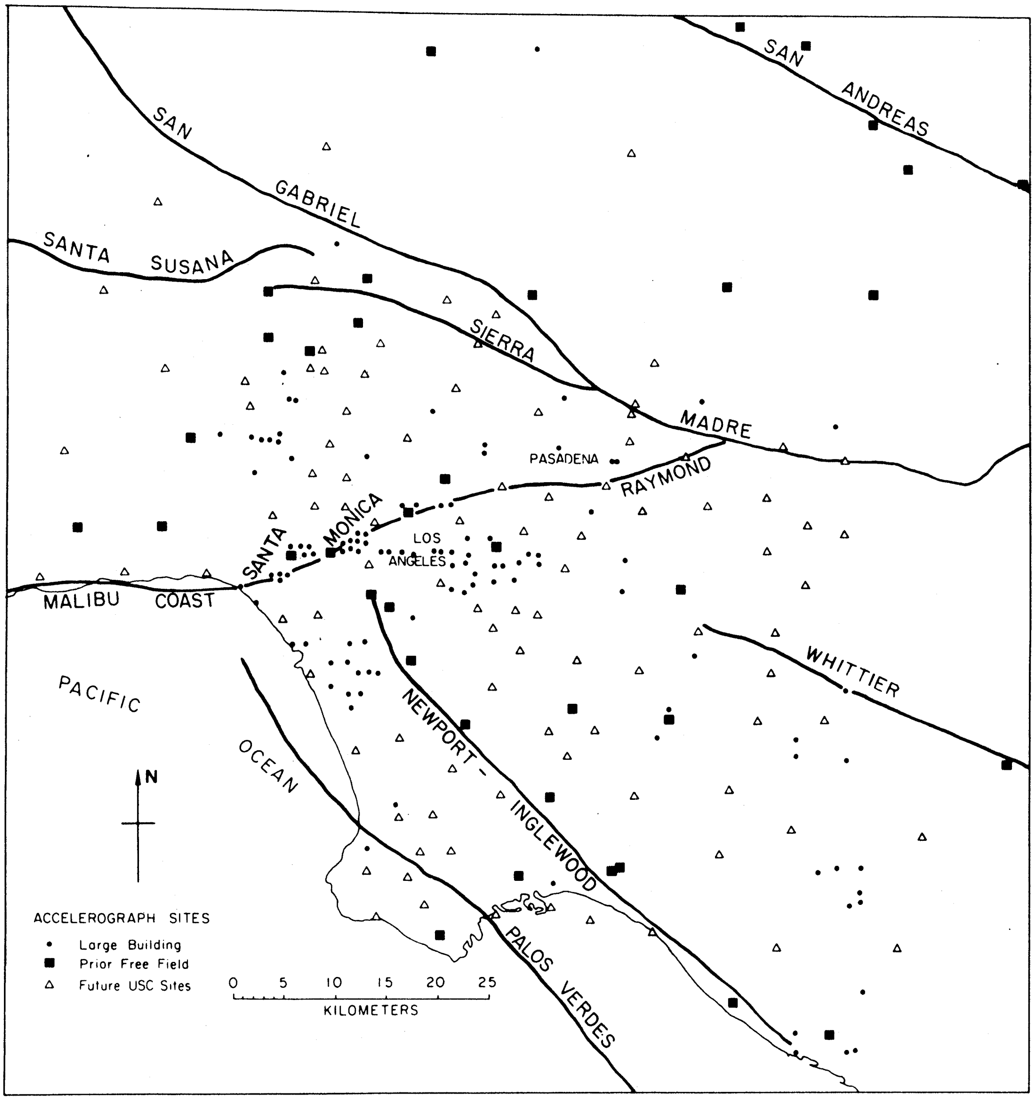


Fig. 11 Target locations for Los Angeles Array.

Optimization schemes for instrument locations, such as Udwadia and Miura (1980), thus did not seem directly relevant to the problem of laying out this network.

From the beginning, this project has been coordinated with the California Division of Mines and Geology (CDMG). They proposed to contribute 15 accelerographs to the Los Angeles array to complement the 80 network stations installed by USC. Their site selection will yield a self-contained experiment of stations in a profile across the structure of the San Gabriel valley and Los Angeles basins.

Installations

Figure 12A shows the locations of only the accelerographs installed by USC. These stations are also listed in Appendix I which gives detailed information on each site. The accelerographs have all been installed in small structures. In size, these range from a wood frame garage to a two-story church or school building, with a one-story church, fire station, or school being most typical. While an effort was made to select small buildings to minimize the effect of man-made structures on the recording of strong shaking, it must be recognized that within the metropolitan region, there is probably no location where seismic waves are strictly unaffected by man-made structures, and the wave motion is truly "free field".

We estimate that in a typical suburb, homes (on concrete slab foundations) cover about 25% to 30% of the land area; paved streets cover about 15% of the land area. Considering sidewalks, driveways, and garages, it appears that at least 40% of the land surface is capped by at least a few inches of concrete which may act like a rigid body over dimensions on the order of 25 to 50 meters. There is also an extensive network of underground pipes and sewers. In this environment, it is not clear that "free field" acceleration can exist in its strictest definition.

Wong and Luco (1978) and Luco and Wong (1977) have studied the response of a flat rigid foundation to several types of incident seismic waves. Their results show that for wavelengths less than about three times a typical dimension of the foundation, the transverse amplitudes of ground motion of the foundation may be significantly reduced compared to the amplitude of an adjacent site unaffected by the foundation. Since our sites are on concrete slabs, with dimensions of 5 to 50 m, and inevitably near concrete slabs with dimensions of 25 to 50 m, this suggests that waves with wavelengths less than 75 to 150 m may be affected by these structures. This is probably an upper-limit estimate on the effect, since a 0.1 m thick concrete slab of 25 to 50 m dimensions is hardly a rigid body.

California Division of Mines and Geology Stations

The Strong Motion Instrumentation Program (SMIP) of CDMG is participating in the USC strong-motion Los Angeles array by instrumenting and maintaining fifteen of the network stations. The general locations of the fifteen sites were determined by configuration of the proposed network. Specific locations for the CDMG instruments, within USC constraints, were selected to meet siting criteria of the SMIP when placing accelerographs in pre-existing structures. These criteria restrict stations to single-story structures with slab foundations that have the smallest possible dimensions and that are free from being situated over major underground

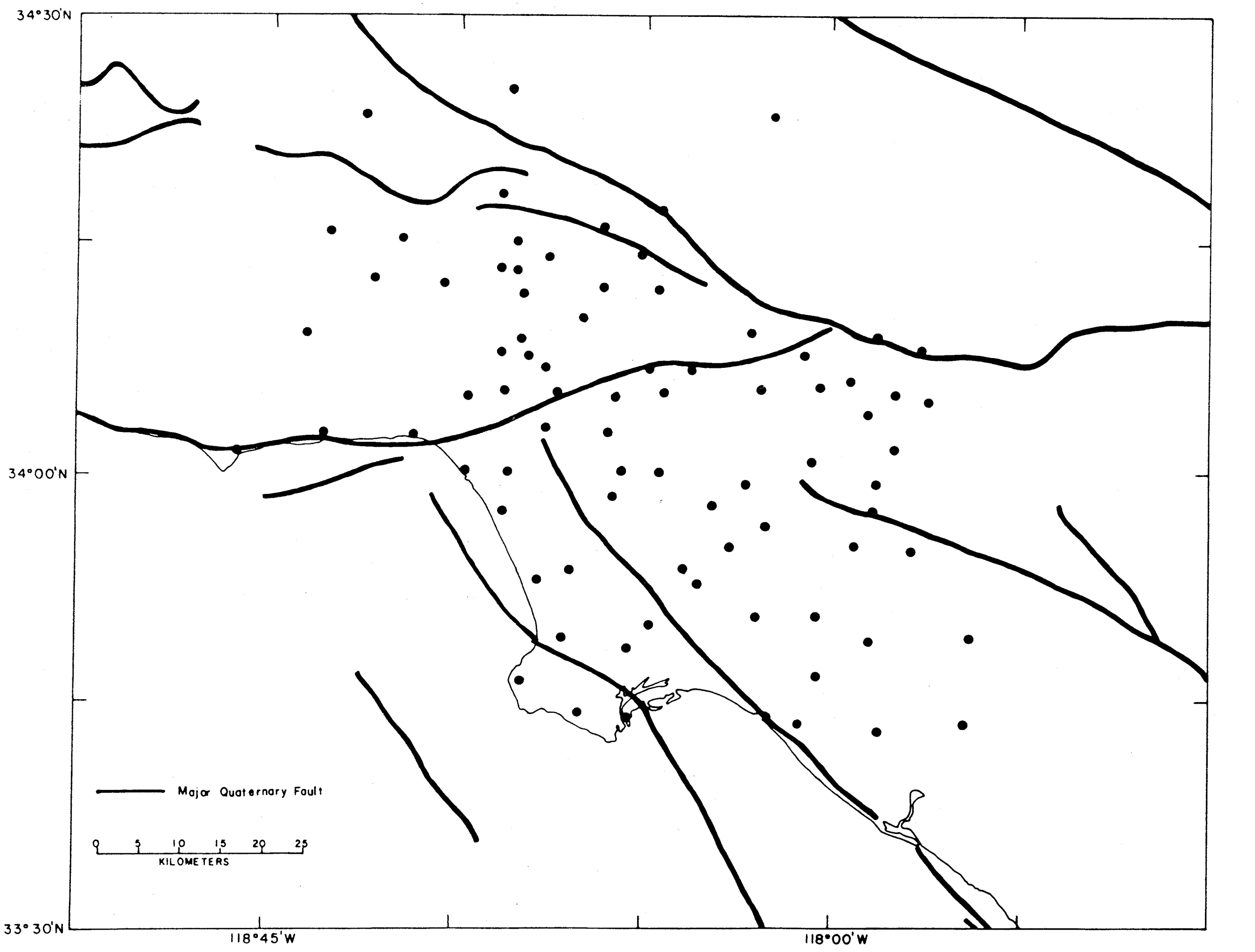


Fig. 12A. Accelerograph stations installed by USC.

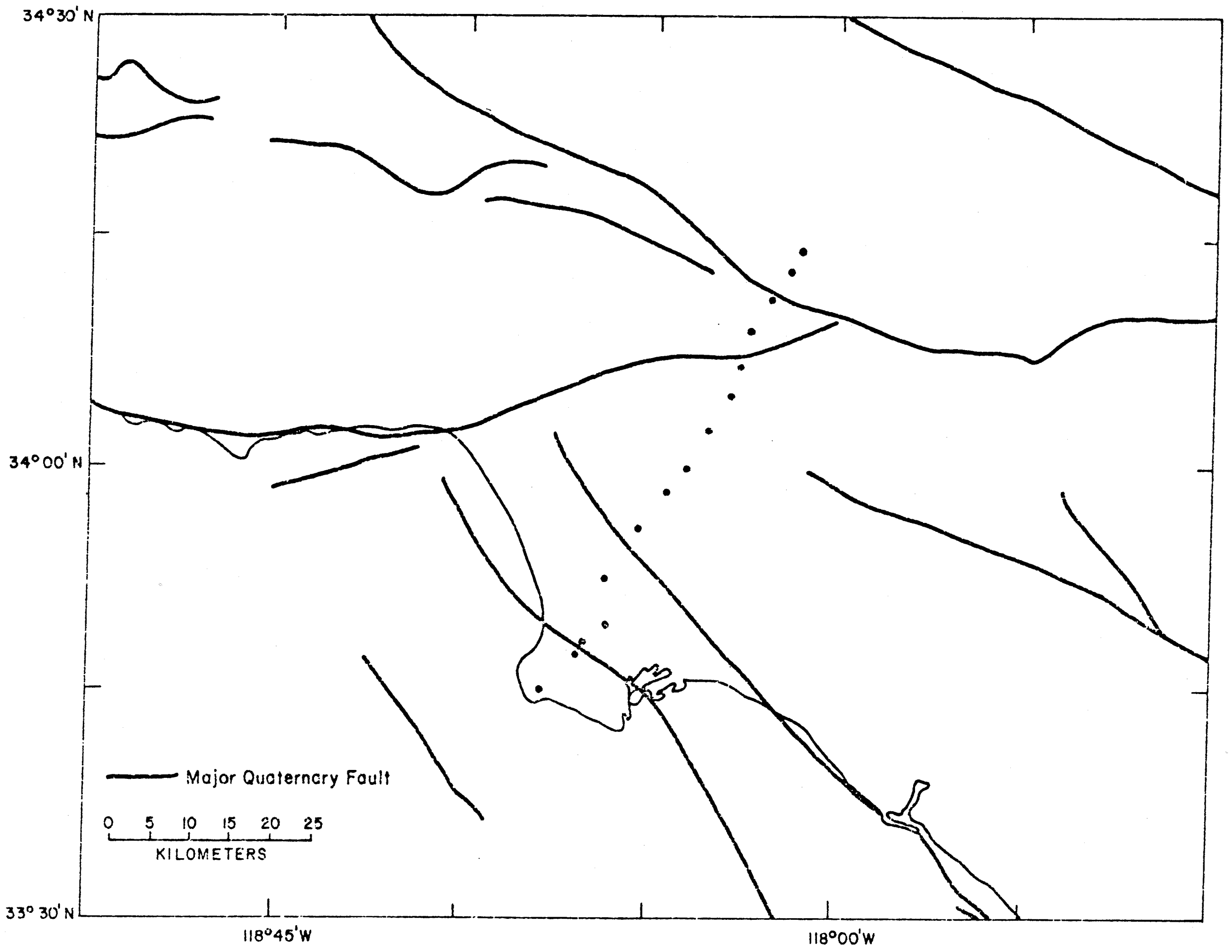


Fig. 12B. Proposed accelerograph stations to be installed by CDMG.

utilities and drains. Buildings selected include a seismic vault, schools and their out buildings, fire station utility buildings, and small storage buildings in parks. Slab dimensions for these structures vary from approximately 2 m x 3 m to 10 m x 50 m with smaller sizes the more common.

The fifteen USC network stations selected by CDMG to instrument define a linear sub-array of instruments, as shown on Figure 12B, the northernmost of which is in a California Institute of Technology (CIT) seismic vault on Mt. Wilson. From the CIT seismic vault, the sub-array trends south-southwest across the Los Angeles basin to the southernmost station on the Palos Verdes peninsula. Stations in the sub-array maintain a spacing that is close (1 km - 4 km) where they cross the Sierra Madre, Raymond Hill, Newport-Inglewood, and Palos Verdes fault zones; spacing is greater (4 km - 5.5 km) away from major fault zones.

CDMG operates three linear arrays in this general portion of southern California. These are the northeast-southwest trending Lake Hughes and San Jacinto arrays and the northwest-southwest trending Newport-Inglewood fault zone array. The north-northeast - south-southwest trend of sites selected by CDMG to instrument from the USC network is sub-parallel and nearly perpendicular to existing CDMG arrays. The addition of another linear array from proposed USC stations builds a more regional network of coordinated CDMG instruments in this portion of the State. In addition, several seismological criteria are involved in making the CDMG station selection. This station selection will facilitate the evaluation of: (1) attenuation characteristics from the San Andreas fault and other faults in the Los Angeles basin; (2) variations in seismic response resulting from the modification of seismic waves upon passing through a variety of geologic structure and complex substrata of the Los Angeles basin; and (3) background data for dynamic analysis of faulting and associated near-field effects in the Los Angeles basin.

Instrumentation

The installed accelerographs are Kinemetrics SMA-1 models (Figure 13). These record three components of acceleration on 70mm film, in the amplitude range of less than 0.01g to 1g, and in the frequency band up to about 25 Hz.

A sample sequence of a record from the accelerograph is illustrated in Figure 14. This sequence begins with a section of film which was exposed to room lights at the time the accelerograph was serviced. This is followed by a calibration record which is put onto the accelerograph at the end of the service procedure. Next in the sequence is any number of earthquake records, consisting of a main shock followed by aftershocks. These are followed by another calibration record which is put onto the film when the record is recovered. Finally, there follows the section of the film which was exposed to room light when the film is removed from the accelerograph. Various features of this sequence will be referred to in the following discussion.

Figure 15 shows a sample main shock accelerogram recorded by one of these instruments. At the top and bottom are time traces. The top time trace is coded to give the day, hour, minute, and second of the record; this code is explained in Appendix II. The lower time trace gives two pulses per second. The record shows two fixed traces, and three traces with data. Of the three data traces, the center one is the vertical component, while the two outer traces are horizontal components.

Figure 13A. SMA-1 strong motion accelerograph. White ruler shown on table in front of accelerograph is 15 inches long.

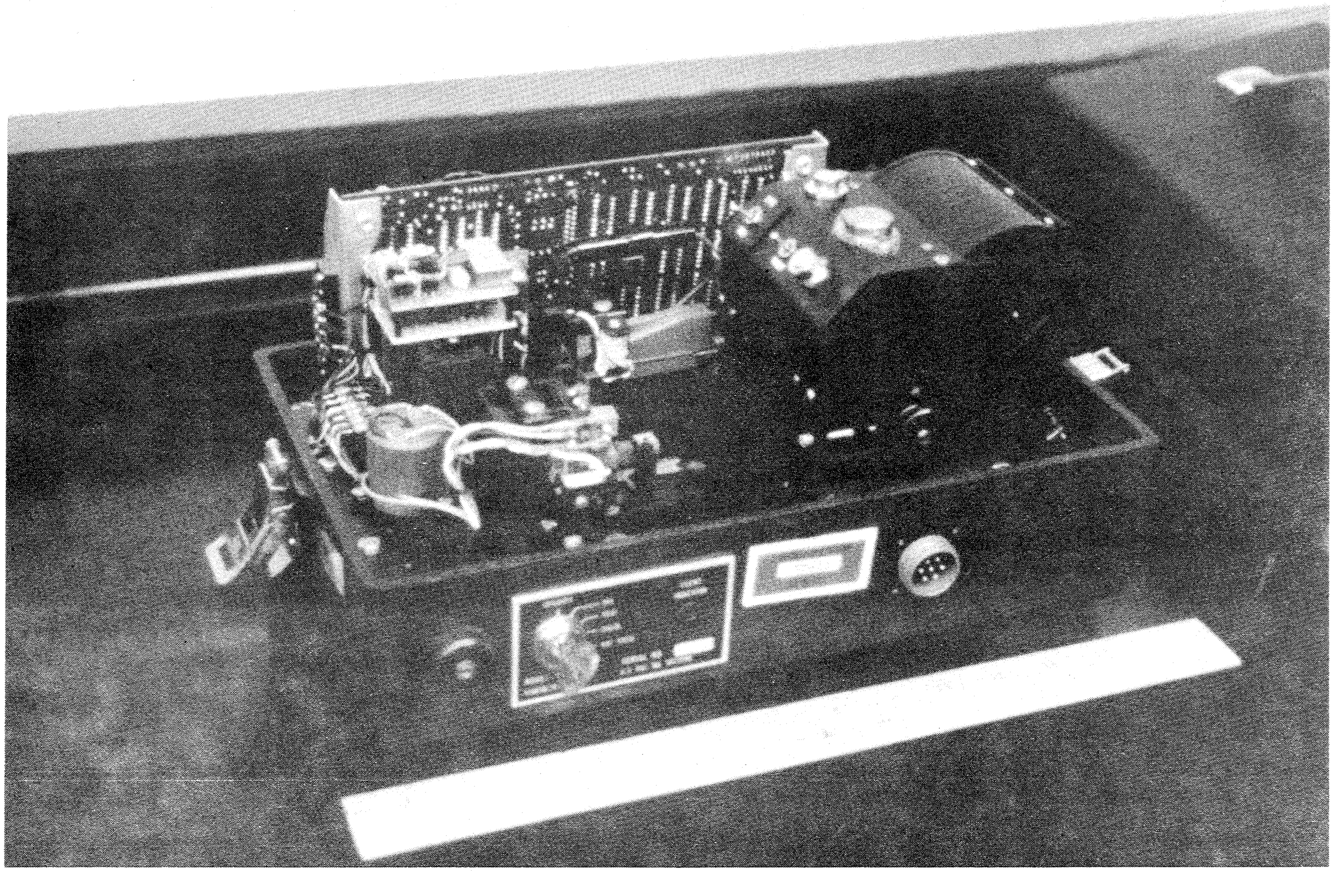


Fig. 13B. SMA-1 accelerograph without the lid. On outside bottom side of housing are seen (from right to left) (a) 7 pin plug used for battery charger, (b) key control panel with positions OPERATE, OFF, TEST, CALIB., NAT., FREQ., and the EVENT INDICATOR , and (c) connector for outside time code input (extreme left). Inside, on right, are seen the film supply and intake magazines, crystal time board (back) and vertical trigger (left).

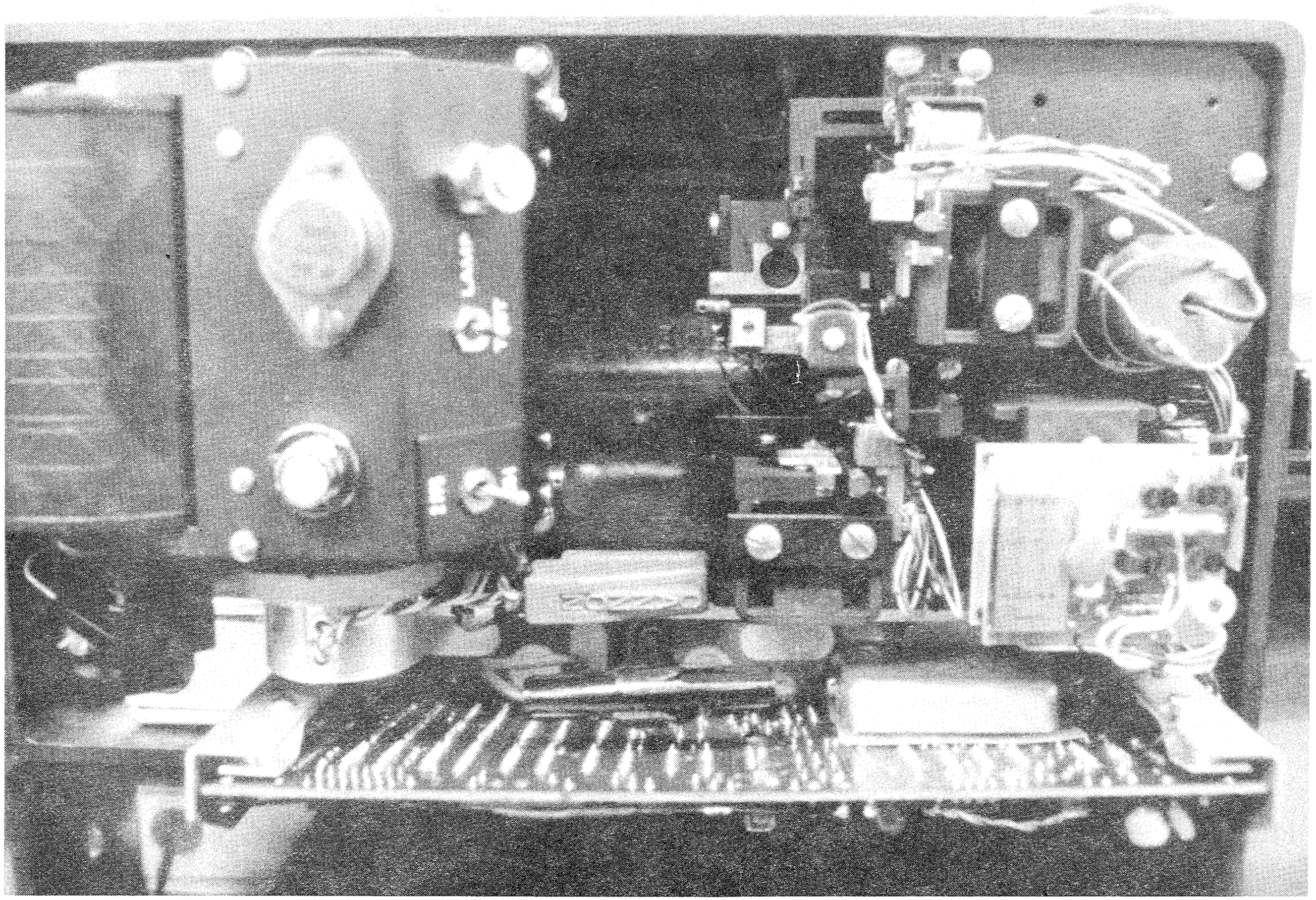


Fig. 13C. Top view of SMA-1 accelerograph without the lid.

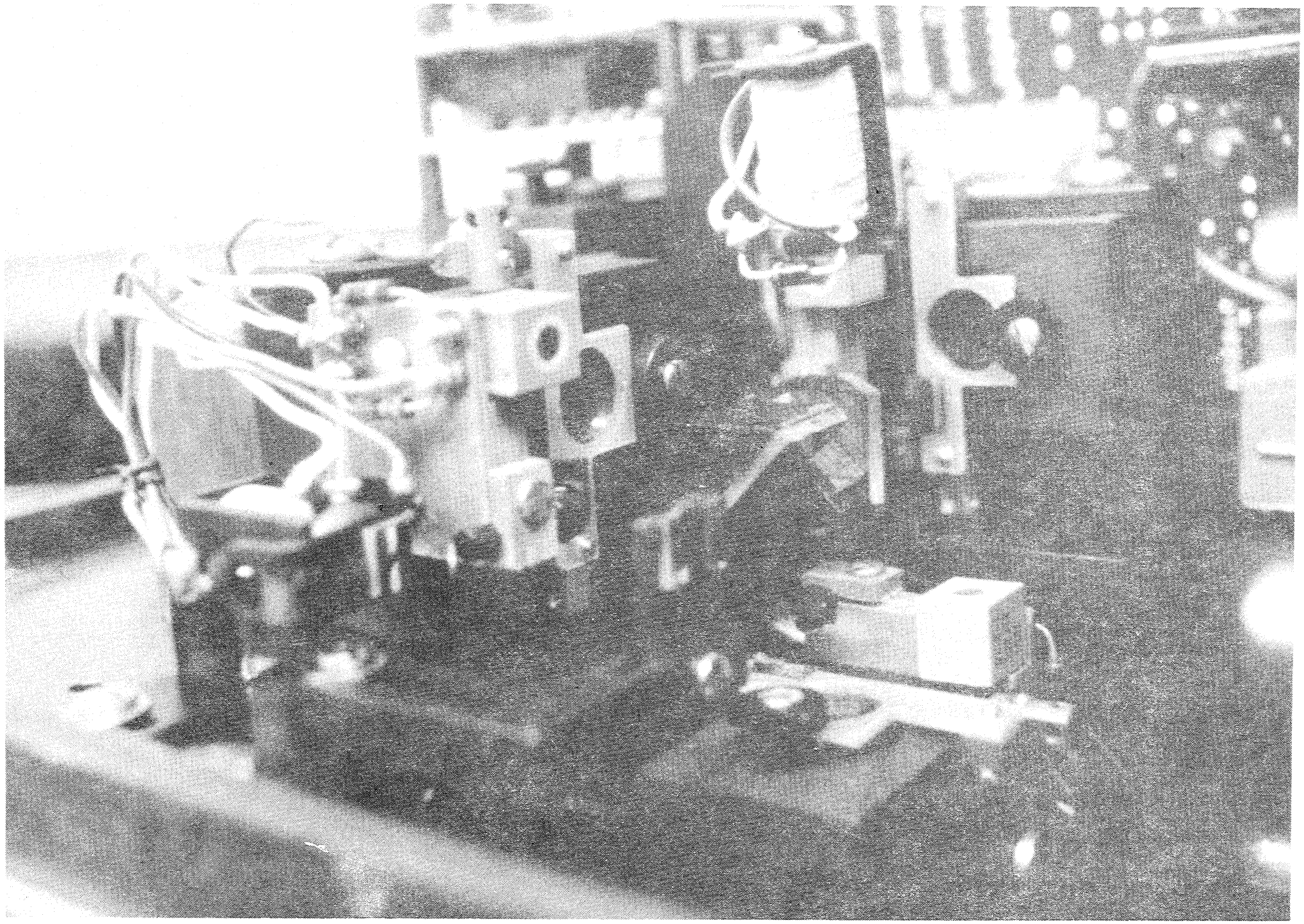


Fig. 13D. Acceleration transducers (viewed from 11 o'clock position in Figure 13C). Longitudinal acceleration transducer is seen at left. Transverse and vertical transducers are seen at right and bottom right respectively.

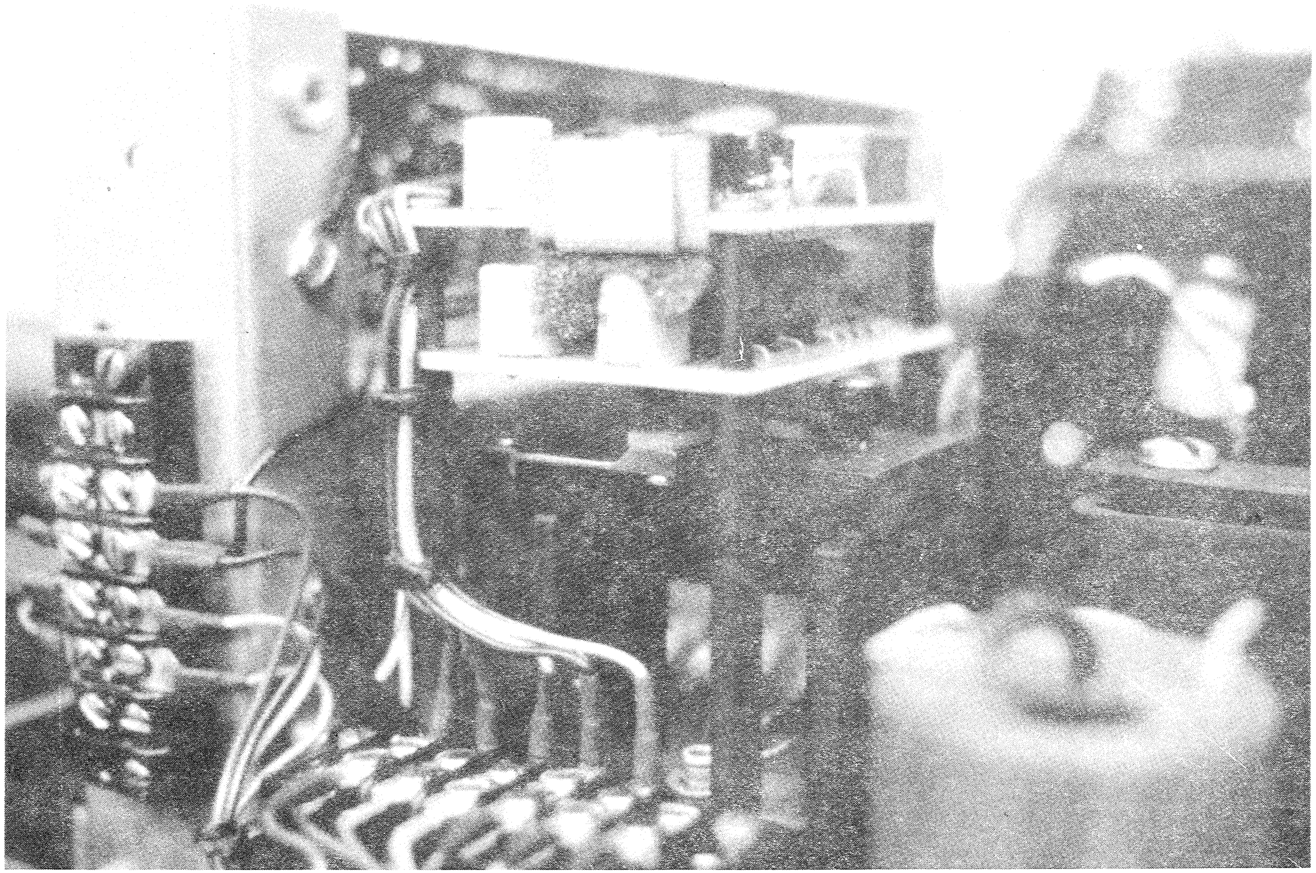


Fig. 13E. Vertical electromagnetic starter in SMA-1 accelerograph (viewed from 2 o'clock position in Figure 13C).

It will be noticed that because this is an analog accelerograph, the first motions which trigger the accelerograph are lost. We have tested some of the accelerographs, and found that after trigger, less than 100 msec of data is usually lost, consistent with the specifications of the manufacturer. Nevertheless, the data on first P-wave arrival time and polarity is lost. We considered the digital accelerographs as an alternative which would avoid this data loss. Some of the considerations which led us to select the analog accelerographs follow: The digitals are considerably more expensive; this would have decreased the number of accelerographs in the array by a factor of probably 2 to 3. The digitals are relatively unproven. Many current analyses are based on peaks of ground motion, which will be recorded in any case. Seismologist's attempts to model strong motion are usually weighted toward matching the S-wave and surface waves, and primarily the longer period ($T > 0.5$ sec) components of these records. For these studies, loss of 0.1 sec of the P-wave is not important, but accurate timing which helps tell how much is lost is important. Finally, maintenance of a digital system would have required the continuous employment of a more highly trained technician than the analog instruments require.

The basic features of the SMA-1 accelerograph employed in this array remain same as those described by Trifunac and Hudson (1970), Dielman et al. (1975) and Wong and Trifunac (1977) and need not be repeated here. The new application involves the use of crystal clock in each instrument. Since in principle this time-keeping method offers important advantages in a city environment, considerable effort in maintaining the accelerograph array in Los Angeles will be devoted to the critical testing and evaluation of this approach for providing the absolute time to each record. With

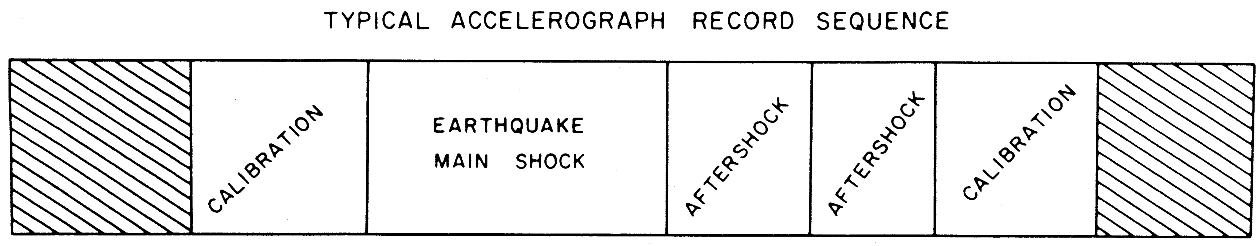
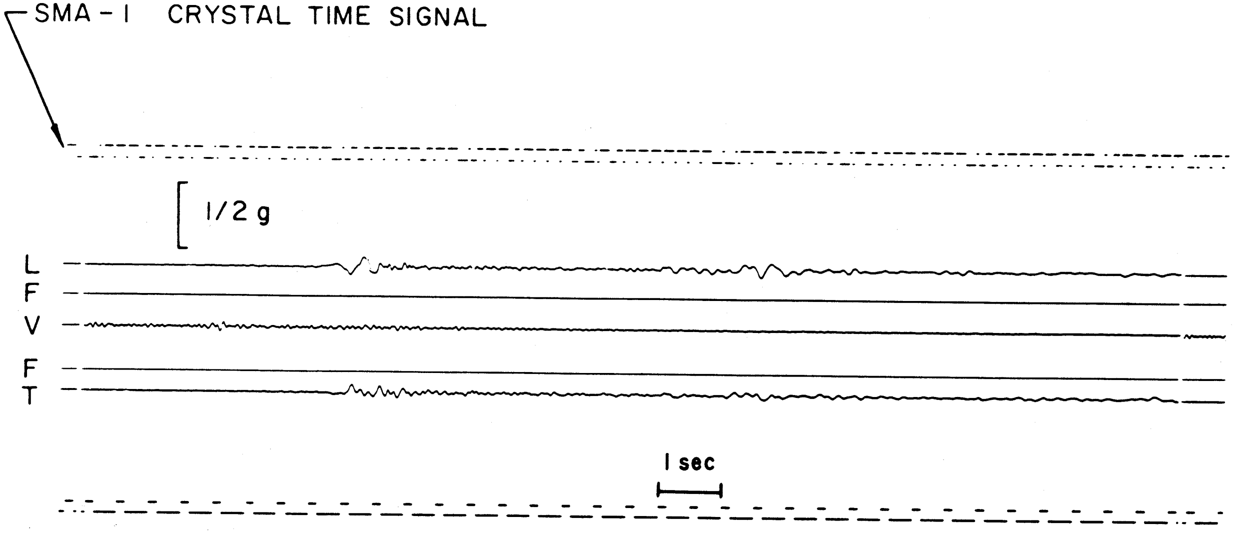


Fig. 14. A sample sequence of a record from the SMA-1 accelerogaph.



L – LONGITUDINAL ACCELERATION

V – VERTICAL ACCELERATION

T – TRANSVERSE ACCELERATION

F – FIXED MIRROR TRACE

Fig. 15. An example of a main shock accelerogram

this in mind, the following discussion will focus primarily on different aspects of crystal clock time-keeping, its evaluation and methods of use as we know it today. A reader not familiar with the basic features of strong motion accelerographs in general may find that the paper by Hudson (1970) offers an excellent overview of the subject.

Each instrument has an internal clock which generates the time code to be recorded on the film. The clock is shown in Figure 16. It has a high accuracy temperature compensated crystal oscillator with frequency stability of ± 3 x 10^{-7} in the temperature range 0°C to 50°C, implying daily drift of less than 0.025 sec, provided the crystal frequency is properly set. The aging rate for the crystal is ± 5 x 10^{-7} per year, implying that a crystal which has zero drift at constant temperature when installed will have at most a drift rate of 0.043 sec/day at the end of the first year. With long use, the aging rate of crystals asymptotically approaches zero.

Several reasons lead to selecting crystal clocks rather than the WWVB radio receivers (Dielman et al. 1975). Reception of WWVB in California has been irregular, with about 50% of the records obtained to date occurring at times when reception was too poor to give time marks at all. Second, WWVB requires a 60 sec recording for the entire radio signal time frame to be completed; the internal crystal clocks employ only 10 sec time frame. With the 70mm recording film 50 ft. (15.2 m) long and running at 1 cm/sec, a maximum of about 25 records with WWVB receiver, and of 150 records with the internal crystal clocks may be recorded before the film supply is exhausted. In reality, this maximum will never be achieved because records are longer than the minimum time required, depending on the duration of shaking, and because some of the film is used for testing. However, the

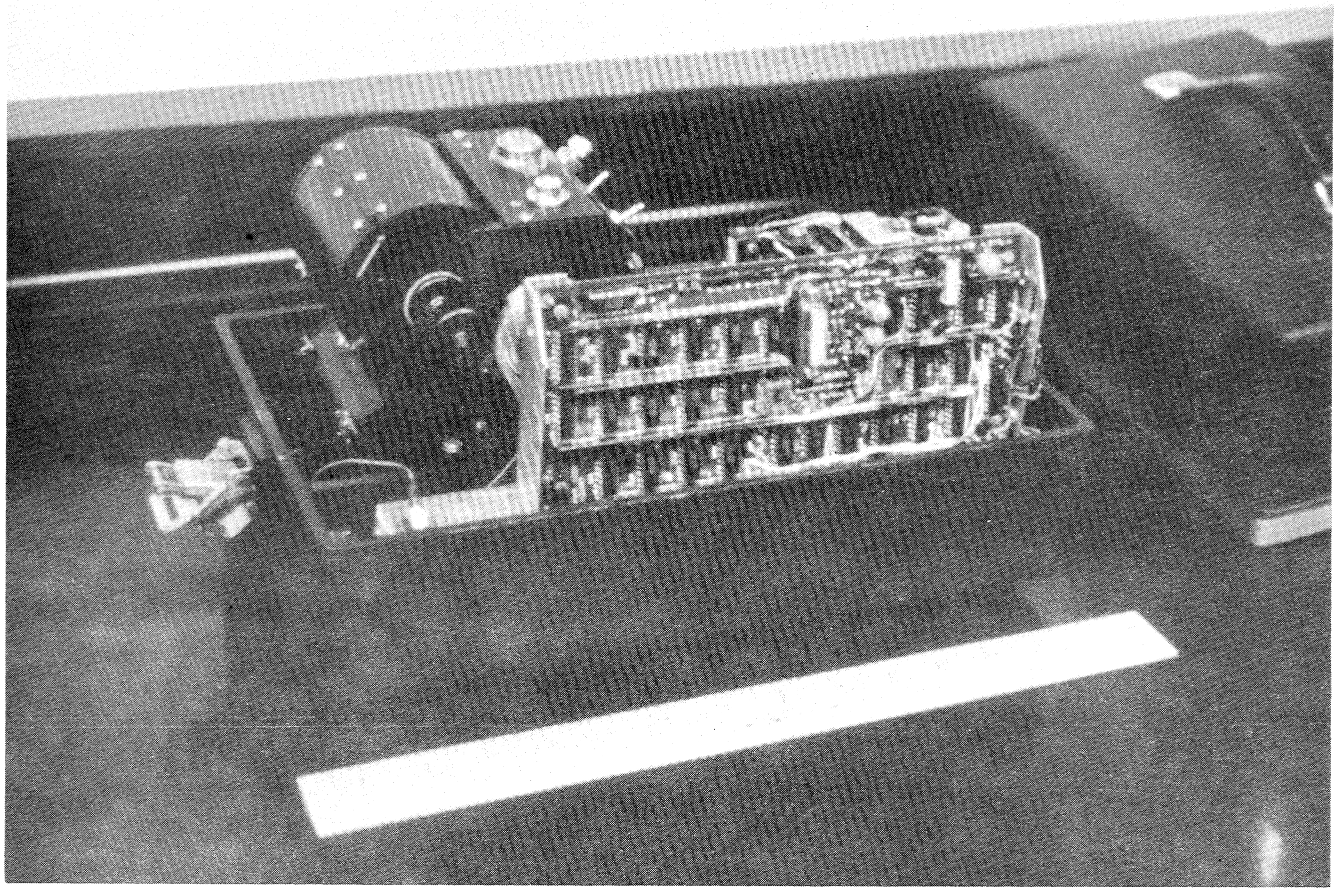


Fig. 16a. SMA-1 strong motion accelerograph without the lid showing crystal time board mounted along and over the batteries.

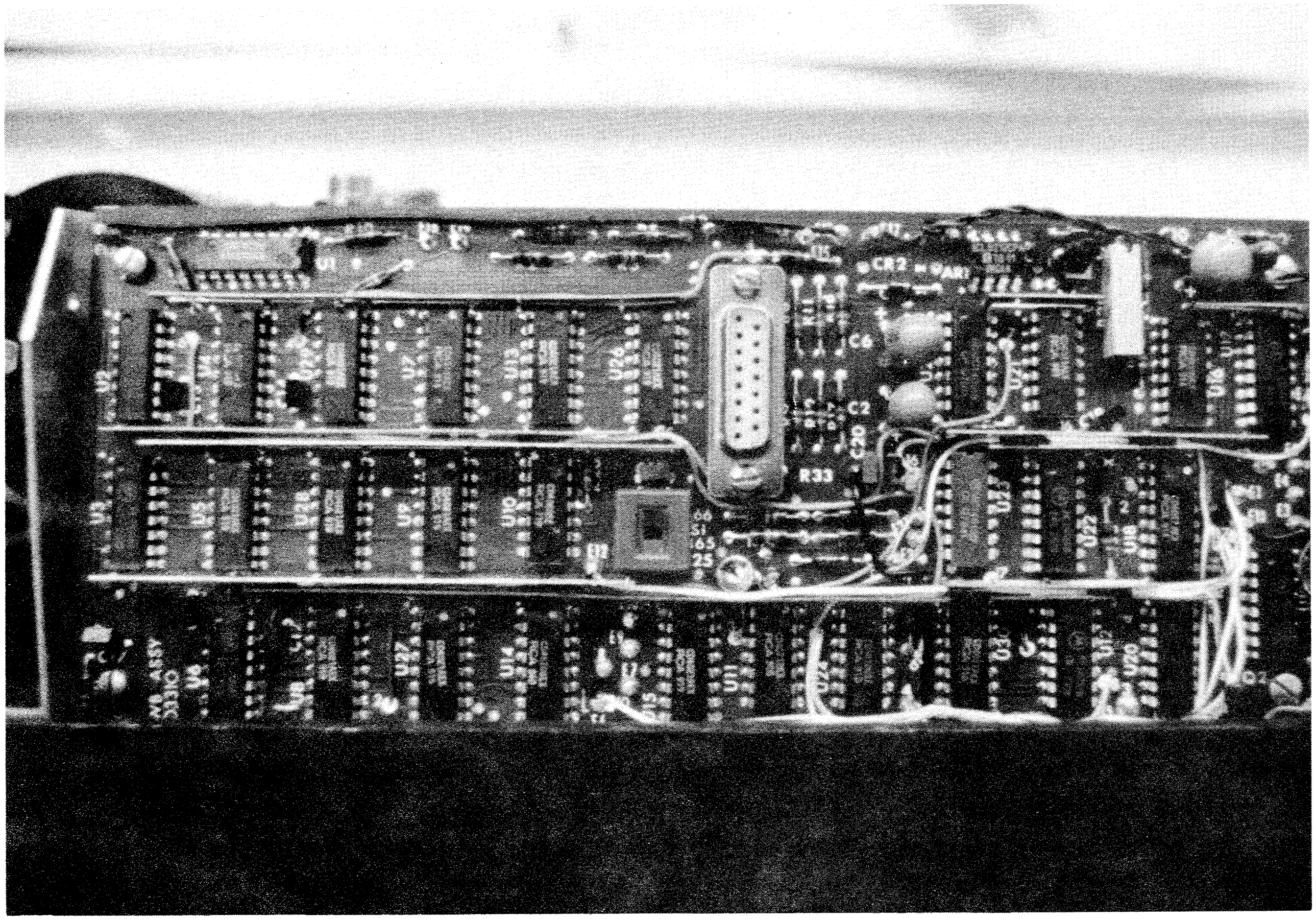


Fig. 16b. Closeup of crytal time board.

six times greater number of possible records from the accelerographs with clocks is an advantage in situations when large number of aftershocks follow a major earthquake, and it is impossible to service all of the sites within the first few hours. The internal clock also offers practical advantages for a network in an urban environment, as erecting an antenna for WWVB radio receiver creates additional installation, maintenance and security problems.

The temperature compensated crystal oscillators draw somewhat more power (∿ 6 mA) than the WWVB receiver, so that the internal batteries on the accelerograph would only last about 1 week without charging. However, AC power, easy to obtain in metropolitan Los Angeles, is used to trickle-charge the internal batteries which, in turn, supply power to the instrument. The capacity of the internal batteries is such that they would keep the instrument going for at least several days in case of AC power interruption.

In normal operations, these clocks are not reset, unless they have very large clock corrections. Rather, one can obtain clock corrections as a means of achieving the timing accuracy which is desired. Those corrections are obtained by means of a portable clock (Kinemetrics model TDC-2 Figure 17) which is calibrated in the laboratory against the WWV radio time before and after field maintenance trips.

If WWV time and the portable clock time are sampled at a given instant, one can write:

$$T_{WWV} = T_{PC} + (T_{WWV} - T_{PC}) \qquad (1)$$

where T_{WWV} and T_{PC} are the times of these two clocks read at the instant of sampling. Similarly,

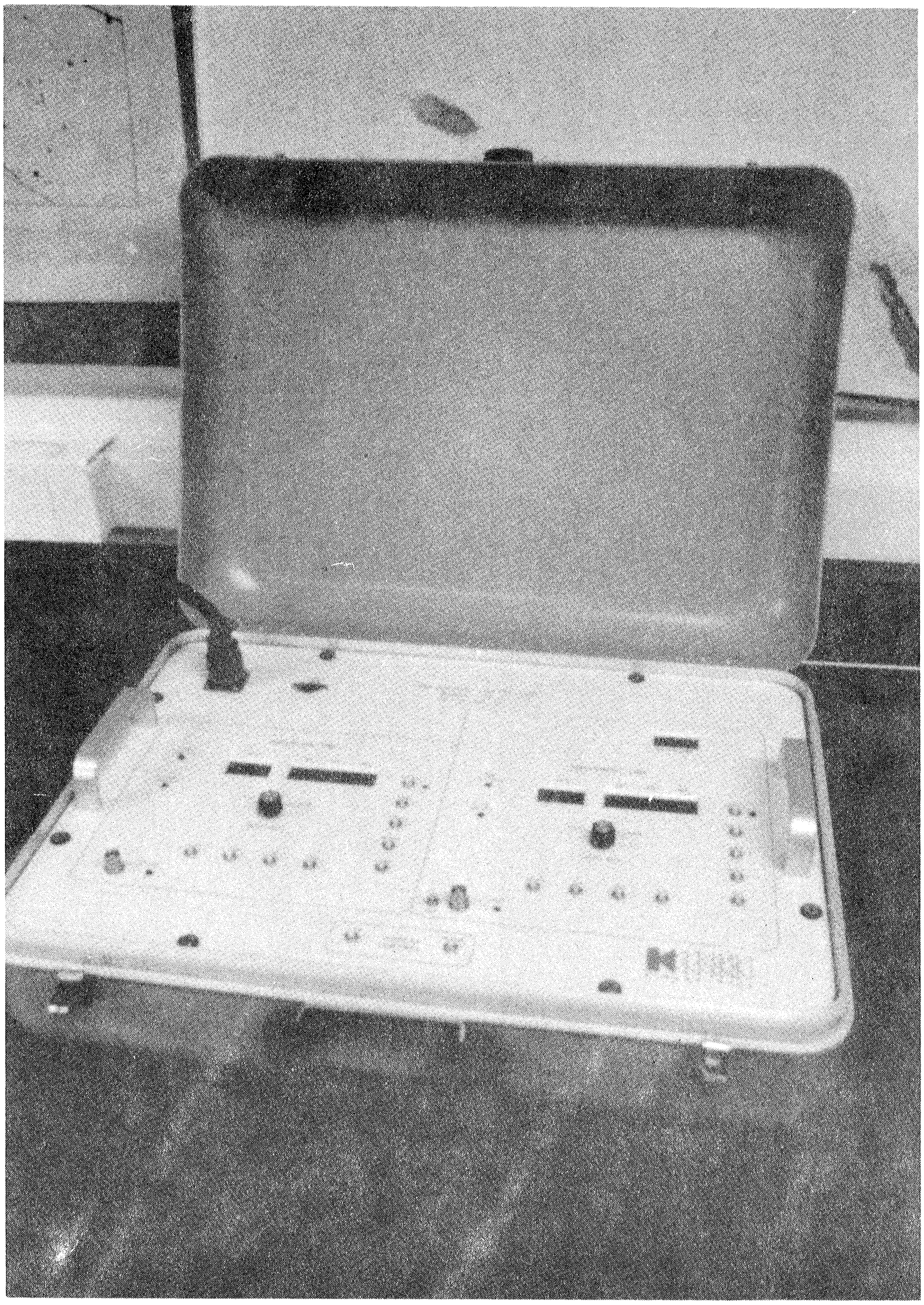


Fig. 17a. Portable crystal clock: Time Display Controller (Model TDC-2).

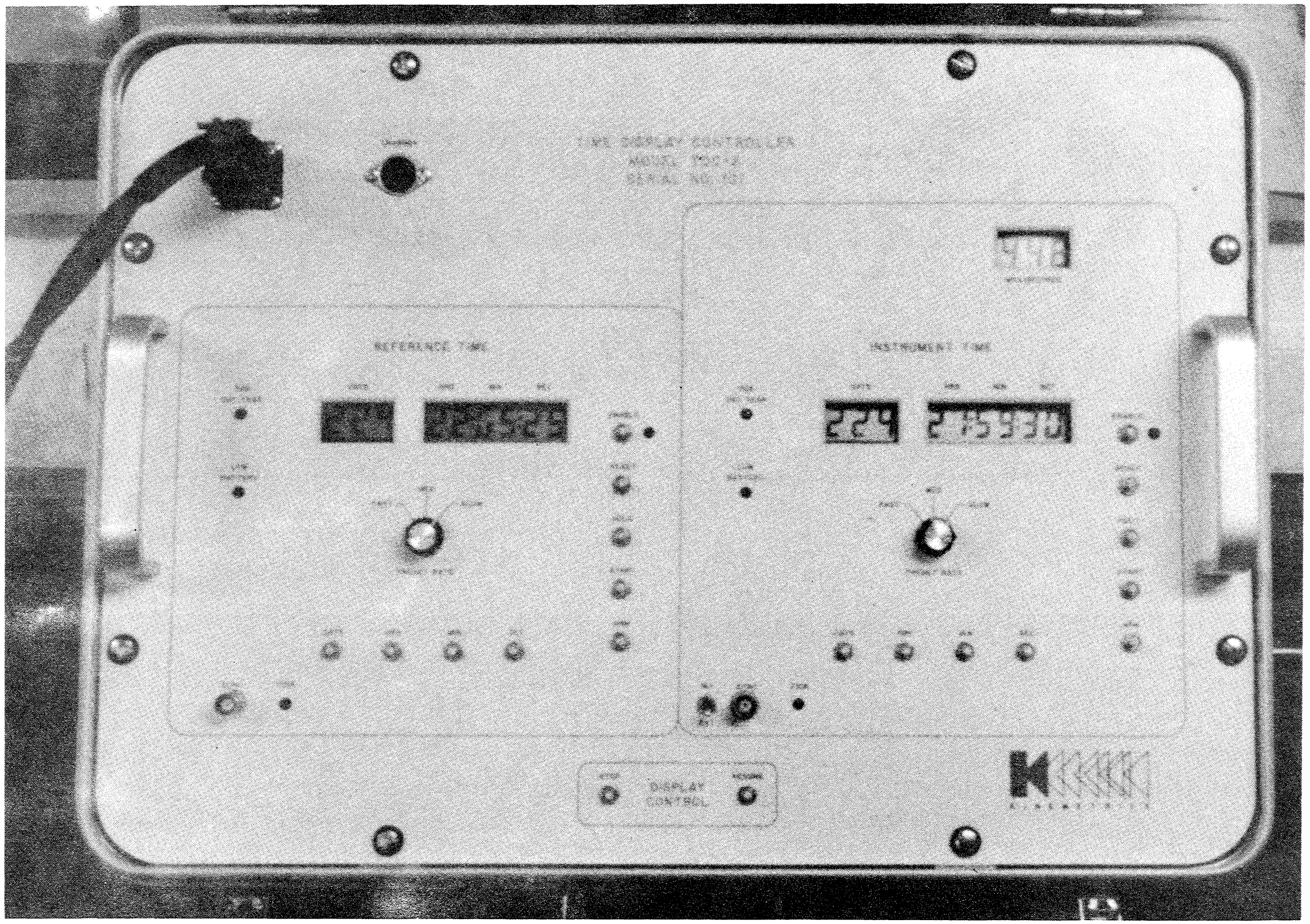


Fig. 17b. Control panel of TDC-2. On left is the reference time of portable clock. On right is the display of external SMA-1 crystal time which is calibrated with display accuracy of one msec.

$$T_{PC} = T_{SMA} + (T_{PC} - T_{SMA}) \qquad (2)$$

defines the relative difference between the portable clock and the accelerograph clock. Finally, one obtains

$$T_{WWV} = T_{SMA} + (T_{PC} - T_{SMA}) + (T_{WWV} - T_{PC}) = T_{SMA} + C_{SMA} \qquad (3)$$

where $C_{SMA} = T_{WWV} - T_{SMA}$ is the clock correction for the accelerograph. In practice, one assumes that $(T_{WWV} - T_{PC})$ is a linear function of time between two consecutive corrections, and thus estimates it by interpolation at the time the accelerograph is being serviced. $T_{WWV} - T_{PC}$ can be measured in the laboratory by recording the radio signal and the output of the portable clock on a two-channel chart recorder (Gould model 210) operating at 125 mm/sec. This procedure is illustrated in Figures 18 and 19. Time differences are thus translated into distance differences as shown on the sample chart in Figure 18. These distances can be measured to 0.1 mm under a 7 x hand lupe. Clock correction accuracy in this case thus depends on the clarity of second-tick arrivals from WWV, which are usually repeatable to within 1 or 2 msec.

To understand the clock correction on the accelerograph, it is necessary to refer back to the description of a typical record sequence (Figure 14). The difference between the portable clock and the accelerograph clock $(T_{PC} - T_{SMA})$ is measured in two ways at the time the instrument is being serviced.

As mentioned previously, the internal SMA-1 clock writes a code onto the upper time trace of the accelerograph at all times. During an earthquake, the lower time trace receives the usual 2 pulse per second time marker. However, a non-standard external connector (Figure 13b) has been added to each instrument so that when the accelerograph is operated in

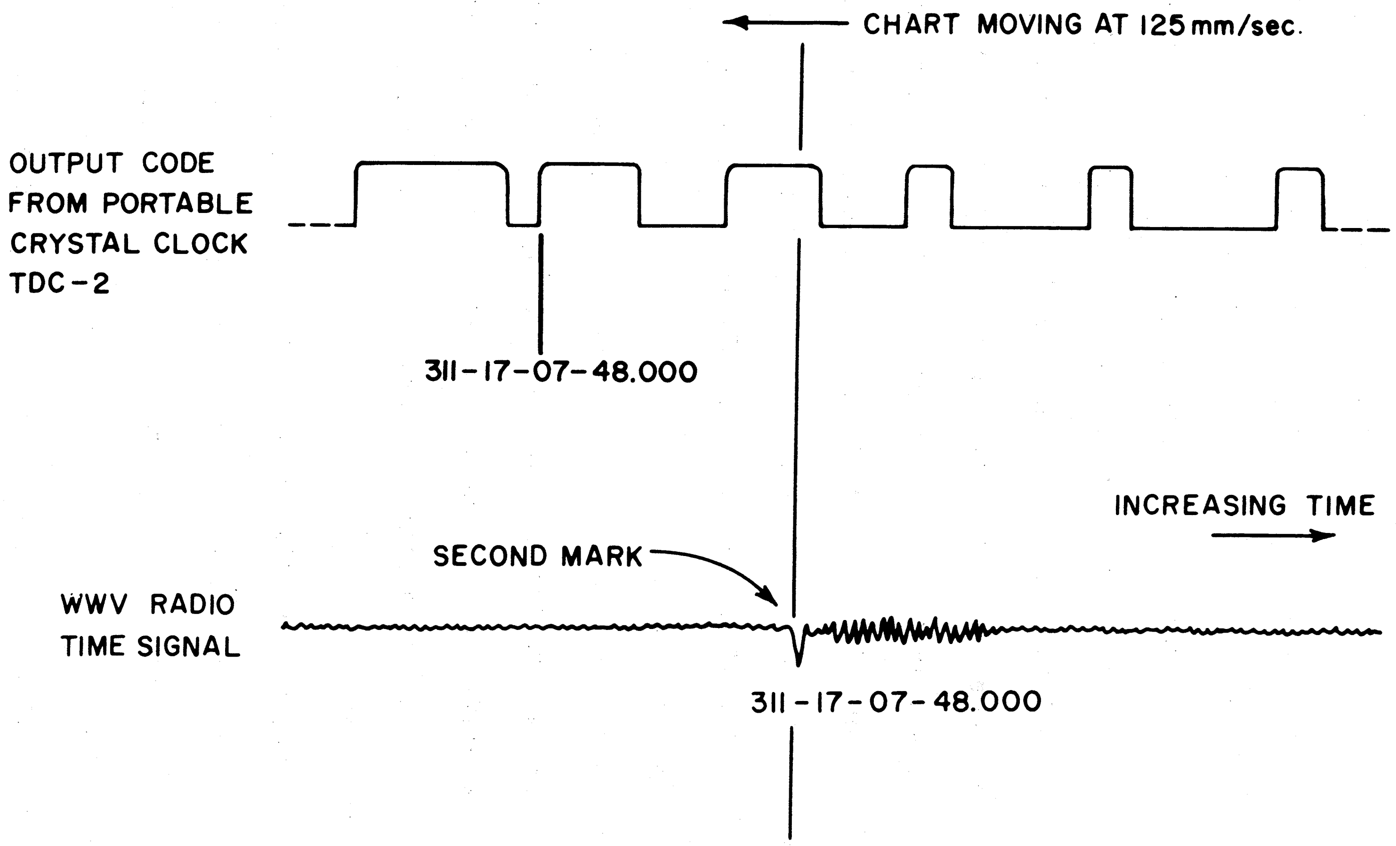


Fig. 18. An example of simultaneous brush recording of TDC-2 and WWV Radio signals (showing only a short segment containing the second mark).

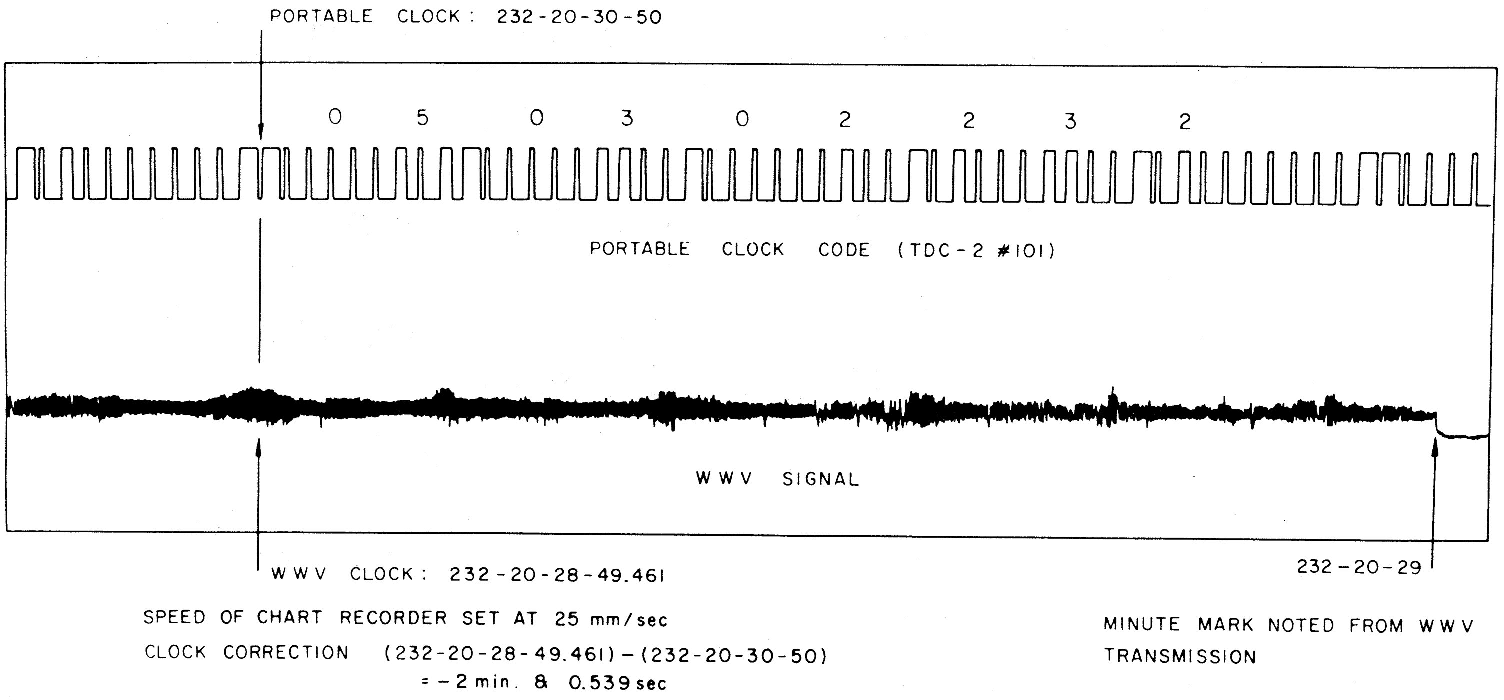


Fig. 19. An example of simultaneous brush recording of TDC-2 portable clock and of WWV radio signals.

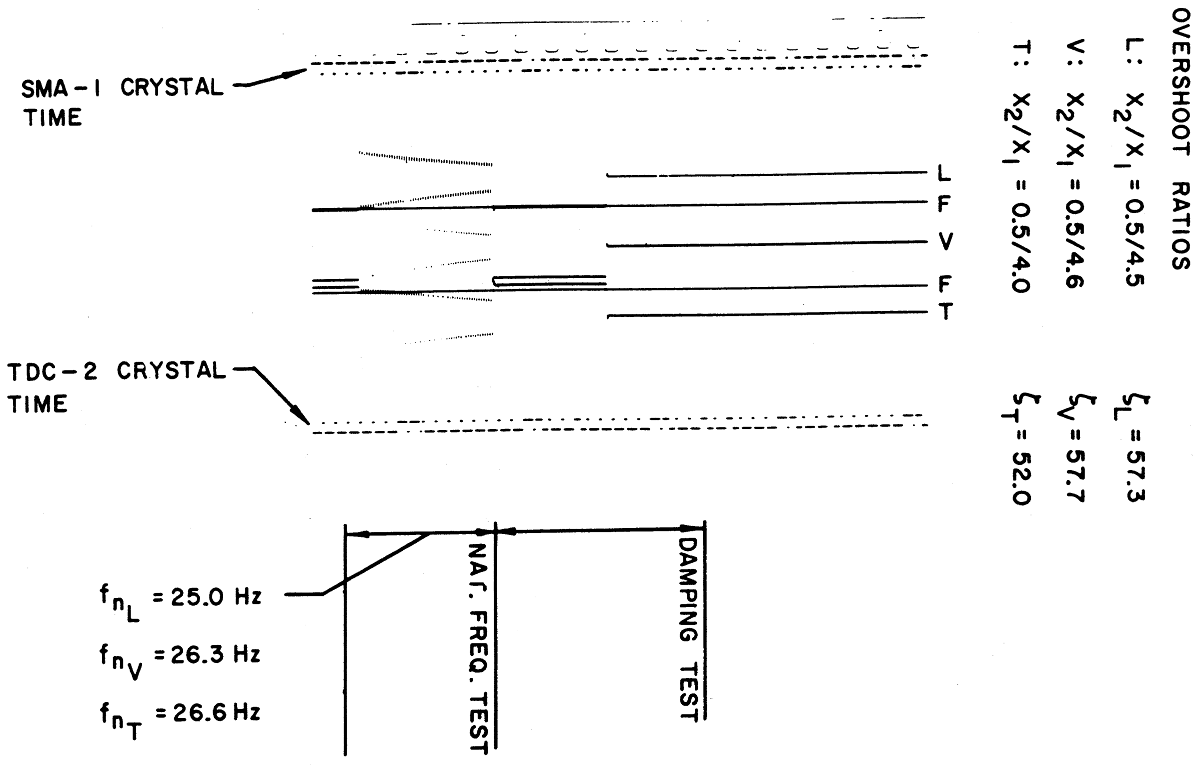


Fig. 20. A segment of 70mm film recorded during field calibration and showing SMA-1 crystal time, TDC-2 crystal time, as well as the natural frequency and damping tests.

the test mode, the portable clock may be used to suppress the 2 pulse per second time marker, and replace it with the time code from the portable clock. While the TDC-2 is designed to do this conveniently, any portable clock can be used in this step. When the film is developed, the time difference between the two clocks can be read to ± 10 msec. A sample record, run in this manner, is shown in Figure 20.

The second method of obtaining ($T_{PC} - T_{SMA}$) is used after the light-proof case of the SMA-1 accelerograph has been opened. At this time, the TDC-2 is connected to the SMA-1 clock through a 15 pin connector (Fig. 16b), and the TDC-2 displays show the times which are read by both clocks. Then the TDC-2 displays may both be sampled and frozen at the same instant. The person servicing the accelerograph then can write down both times to the nearest ± 1 msec; the difference giving ($T_{PC} - T_{SMA}$). The process of writing down both times insures that the field notes record when the clock correction was made, as well as what the difference between the clocks was. Thus, none of the data which is essential for estimating the clock correction at the time of events between field checks is omitted. Figure 21 shows a sample clock correction data sheet with several entries.

Figure 22 shows an idealized curve for the clock corrections of an accelerograph. The heavy line represents the actual difference between the accelerograph clock and radio station WWV. The average drift rate is defined in Figure 22 as the slope of the straight line connecting clock corrections over the time interval. Clearly the drift rate is a function of the selected time interval.

Between clock correction measurements, the clock correction may depart from a linear interpolation, leading to an error in the estimate, as indicated on Figure 22. The probable magnitude of this error is particularly

TDC-2 CLOCK CORRECTION DATA SHEET

Date	Ser. #	WWV Time	TDC-2 Time	Time Corr.
4-14-80	102	105-22-19-52.014	105-22-19-51.798	+0.216
5-5-80	102	126-16-22-48.012	126-16-22-47.726	+0.286
6-3-80	102	156-02-09-50.056	156-02-09-50.000	+0.056
6-3-80	102	156-02-11-47.029	156-02-11-46.971	+0.058
6-6-80	102	158-14-59-50.052	158-14-59-50.000	+0.052
6-7-80	102	159-15-44-50.052	159-15-44-50.000	+0.052
6-25-80	102	177-14-33-56.0056	177-14-33-56.6712	+0.3344
6-27-80	102	179-16-11-50.000	179-16-11-49.6712	+0.3288
7-2-80	102	184-14-36-52.000	184-14-36-51.689	+0.311
7-9-80	102	191-16-46-51.292	191-16-46-51.000	+0.292
7-17-80	102	AT THIS POINT TDC-2 TIME HAD TO BE RESET		
7-17-80	102	199-21-20-50.000	199-21-20-49.977	+0.023
7-23-80	102	205-15-43-50.000	205-15-43-49.998	+0.002
7-29-80	102	211-14-01-51.000	211-14-01-51.018	-0.018
8-15-80	102	228-14-11-54.000	228-14-11-54.113	-0.113
8-21-80	102	234-14-33-54.000	234-14-33-54.123	-0.123
9-2-80	102	246-14-31-49.000	246-14-31-49.137	-0.137
9-11-80	102	255-22-26-50.000	255-22-26-50.133	-0.133

Fig. 21. A sample of the clock correction data sheet.

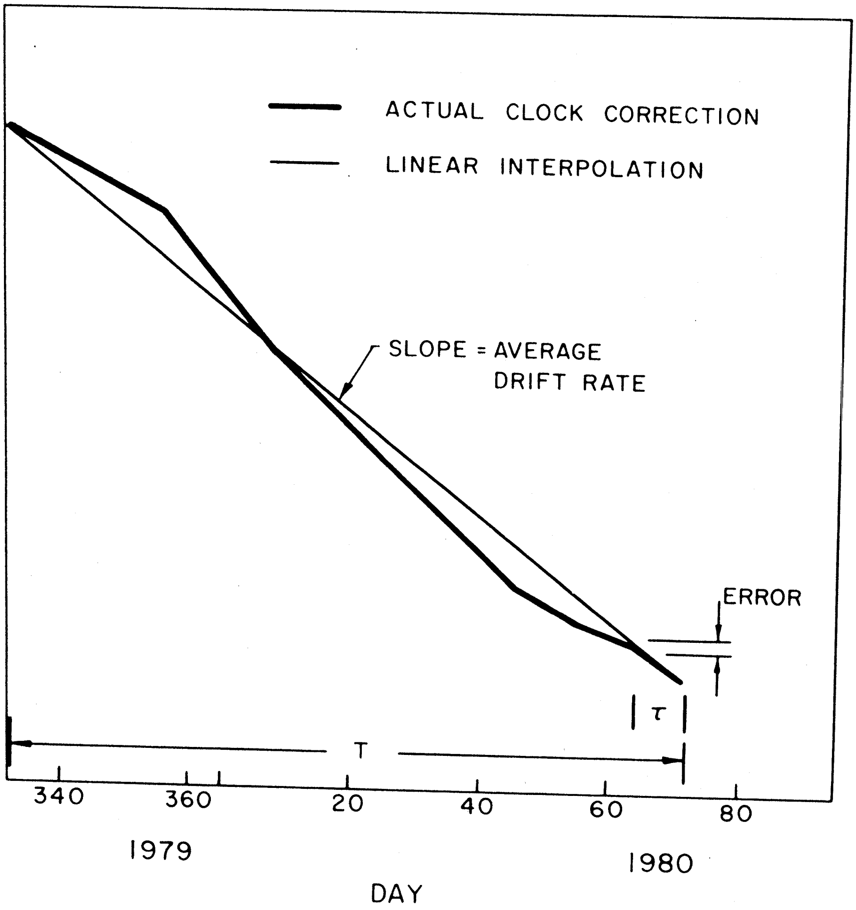


Fig. 22. Idealized curve for the clock correction.

important to understand at times shortly before a clock correction measurement. This is the circumstance which is involved when records are rapidly recovered in the first days following an earthquake.

Figure 23 shows a set of actual clock corrections for one of the accelerograph clocks. The leap seconds which may occur from time to time, as on December 31, 1979, obviously have to be removed before interpolating between corrections.

Figure 24 shows a sequence of reduced clock corrections which was obtained for one of the portable clocks: TDC-2 No. 101. This crystal showed a drift rate and an aging rate which were both considerably worse than the specifications, and the crystal was eventually returned and replaced. This figure shows a long, closely spaced sequence of clock corrections, and because of this large drift, some of the features which can be expected to appear over a longer time scale on other clocks. The drift rate, which started out slow, accelerated rapidly. For example in the first 20 days, the drift rate was less than 10 ms/day; by early 1980, it had accelerated to an average close to 50 msec/day. At later times there was a suggestion that the drift rate was leveling off to a more nearly constant rate, as the aging rate decreased.

Figure 25 shows a collection of average drift rates for clocks obtained in the laboratory, as a function of the time interval. It can be seen that for the majority of the clocks, the drift rate was well within the specifications.

Figure 26 attempts to answer a more critical question of what errors are likely at time τ (Figure 22) before a correction measurement. Each

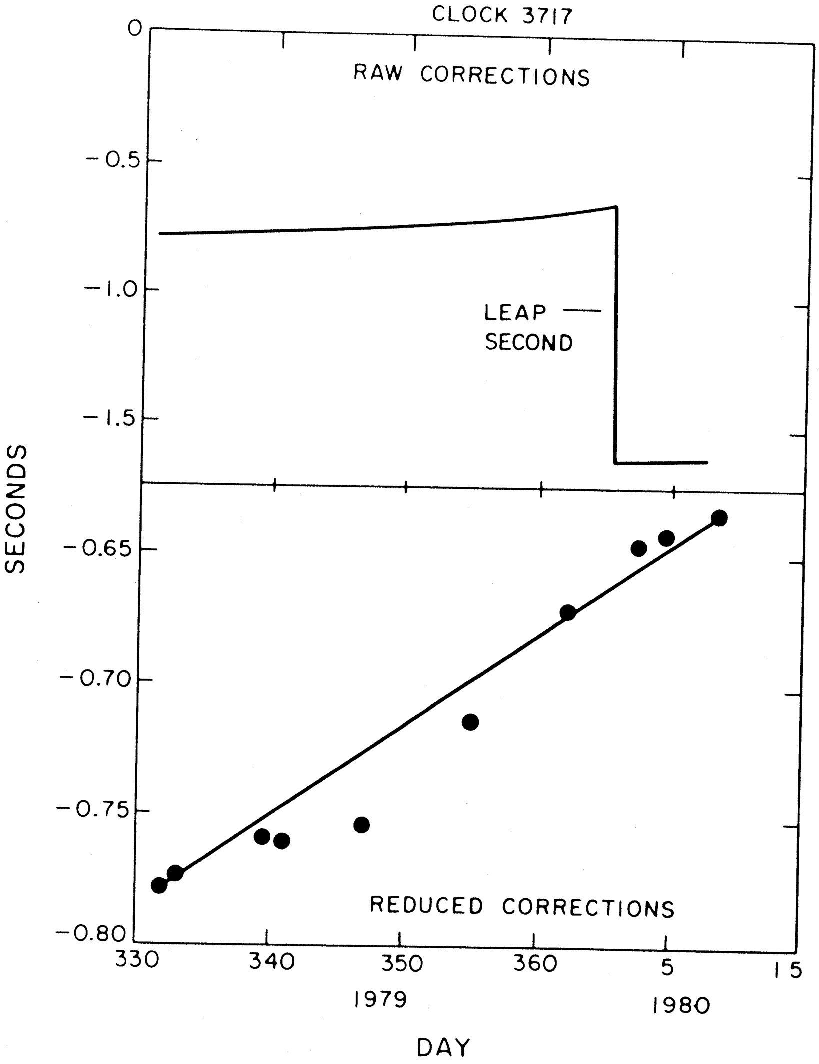


Fig. 23. Actual clock corrections.

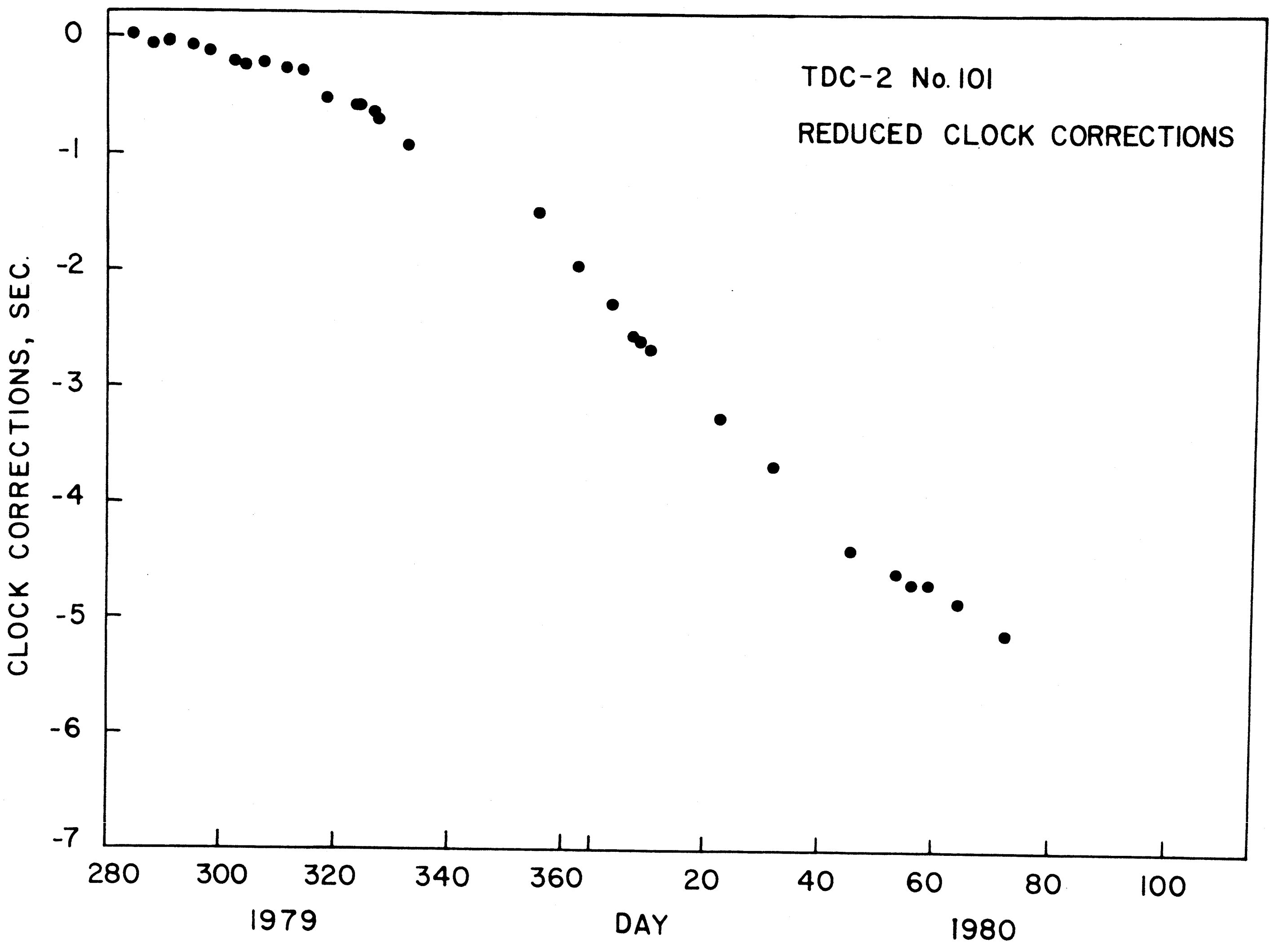


Fig. 24. A sequence of reduced clock corrections.

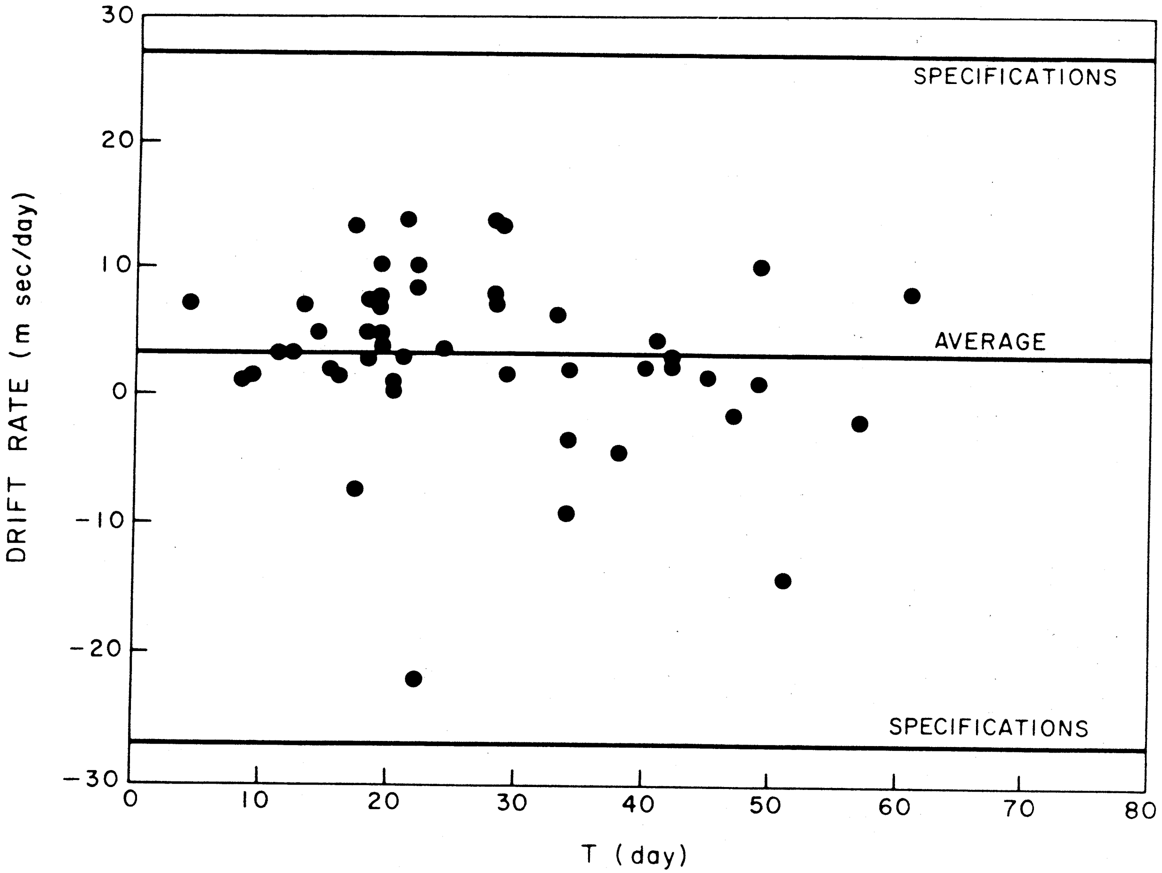


Fig. 25. A collection of average drift rates for clocks as measured in the laboratory.

discrete point in Figure 26 is based on a laboratory measurement where a sequence of several corrections was obtained. The first and last correction were used to define the linear interpolation and the error was found at intermediate correction measurements, provided $\tau < T/2$.

The data in Figure 26 do not represent actual field data in three ways. First, T for the laboratory measurements is generally shorter. Typical values of T can be seen on Figure 25. Second, the laboratory has a better controlled temperature range than some of the sites. Third, these readings were taken shortly after the clocks were started, when the aging rate is theoretically highest. The first and second factors will tend to reduce the spread of errors in Figure 26, and the third to increase it, compared with actual field data.

On the basis of the data in Figure 26, the following conclusions are possible:

If a site is reached within 4 days after an earthquake, 80% of the time the clock correction error will be less than 10 msec; 100% of the time it will be less than 30 msec. If the site is reached within 14 days, 10% of the time, the clock errors may be greater than 50 msec, 30% of the time, errors will be between 10 msec and 30 msec, and 60% of the time they will be less than 10 msec. Obviously, it is desirable to visit the site as quickly as possible, so that the timing accuracy does not degrade.

The envelope of the errors does not converge to zero at $\tau = 0.0$. The intercept is perhaps a measure of the overall uncertainty in any isolated correction determination. This limit appears to be less than 10 msec for most cases, but occasionally up to 20 msec.

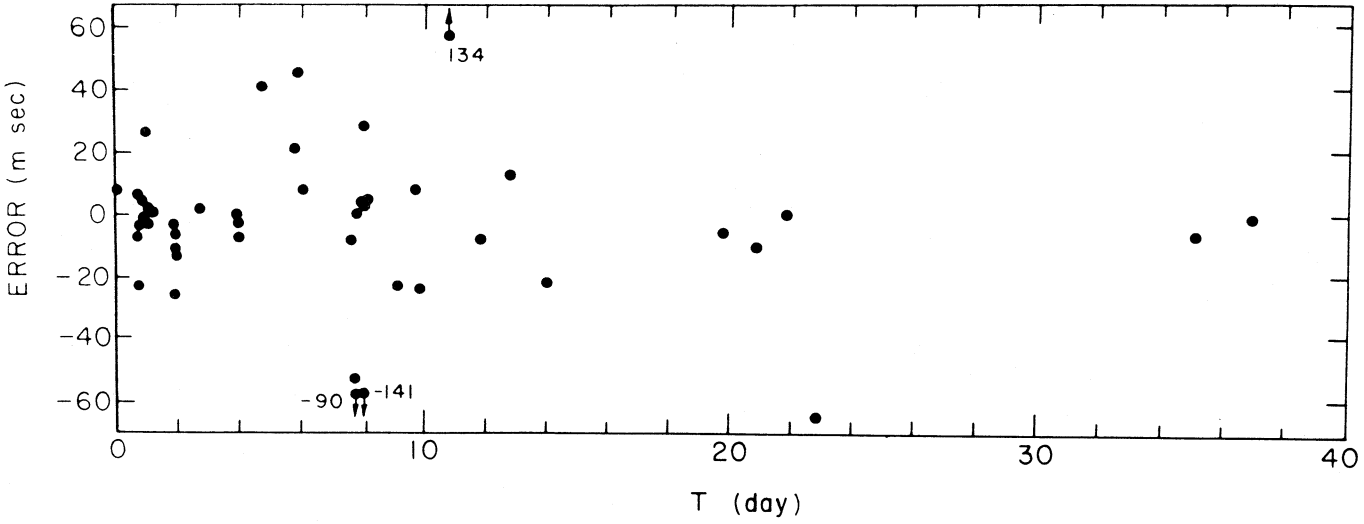


Fig. 26. Errors in reading absolute time T days before a calibration.

The clock circuitry is the most complex part of the accelerographs, and we found that operation of the clocks was not completely trouble free. In addition to a few cases where the clock drift rate was excessive, we found some cases where the clock would "jump", i.e. the clock correction would differ from its expected value by a large amount (e.g. 1 sec, 1 min, 1 hour, 1 day). At present we have identified three general causes for these problems:

1. Defects in manufacture or subsequent handling (e.g. defective parts, cracks in the printed circuit board). To prevent cracking of the printed circuits on the board, which is broad and flat, it ought to be reinforced with a cross bar in its mounting.
2. The back side of the printed circuit board was exposed when the instruments were deliverd, and easily brushed by test tools. This could cause temporary short circuits which disrupted the counter within the clocks.
3. Rough handling: The portable clocks (TDC-2) would occasionally jump in time as a result of a rough ride in a truck, for example.

Site Selection

Two methods for site selection have been used. One was to approach the leadership of widespread organizations and seek their cooperation and blanket approval for using their sites. This procedure was very successful with the Church of Jesus Christ of Latter Day Saints, as we received prompt and full permission to install accelerographs in their church buildings where space permitted. With the City of Los Angeles Fire Department, the approach was less successful as full approval required City Council action, which came very slowly, setting back our installation schedule.

The second approach was to go to the vicinity of a target site, and drive around in search of small structures where an installation might be made. One looked for buildings such as churches, schools, fire stations, or public parks service buildings to avoid the problems associated with frequent changes of ownership of private homes.

On approaching the people who locally controlled a promising looking building (e.g., principal, pastor) we would explain our project and if he(she) thought it might be possible, looked around for a suitable site. If one was found, the building owners (e.g., school board, church administration) were contacted by letter for formal approval. This letter was followed by a phone call to see if the people involved understood our request, and if any problems had arisen.

This second approach required more work for each site than the first, but it was uniformly successful. If the building had a suitable room, we did not encounter a single refusal at the site. Of perhaps 70 sites which were eventually contacted in this manner, only two did not approve the installation; one by not replying to our letter, while promising that they would; the other refusing directly. We are grateful for the immense generosity which the people of the Los Angeles region extended to us.

The network layout (Fig. 11) was prepared without any consideration of the possibility of finding a site at each target location. When we received preliminary approval from the Los Angeles Fire Department and the Church of Jesus Christ of Latter Day Saints to use their facilities, these facilities were plotted on a map of the target sites, and the grid was deformed slightly to take advantage of the facilities. After this, all the site information was transferred to 7 1/2' x 7 1/2' U.S. Geological Survey Topographic Quadrangles. On these maps most churches, fire stations, and parks are shown. Thus, before leaving for site visits, we were able to select first and second choice locations for each tentative accelerograph site. During the field visits, for perhaps 5 sites, we were forced to look more than 1 kilometer from the targets on the topographic maps, and to make consequent readjustments of the locations of nearby accelerographs.

Data Digitization and Dissemination

Recorded accelerograms will be digitized by the recently developed automatic digitzation technique (Trifunac and Lee, 1979) which uses a photodensitometer coupled to a minicomputer to convert analog records on 70mm film to digital data. This facility is available in the Civil Engineering Department at USC and is operating on a routine basis. Its throughput rate is an order of magnitude faster than the hand digitization described by Trifunac *et al*. (1973) and by Trifunac and Lee (1973). The data will be available through U.S. Geological Survey and California Division of Mines and Geology.

ACKNOWLEDGEMENTS

Many individuals have contributed to the successful completion of the first phase of this project. Its launching would not have been possible without invaluable help and enthusiasm by S. C. Liu of the National Science Foundation. His contributions are much appreciated.

We are grateful to the California Division of Mines and Geology; close cooperation and coordination with the technical staff of this agency has made the Los Angeles strong motion accelerograph network one of much better coverage. In particular, Richard McJunkin was responsible for selection of the California Division of Mines and Geology sites which complement ours, and worked closely with us to simultaneously accomplish their objectives while satisfying the constraints of our grid. He also contributed the section of this report entitled "California Division of Mines and Geology Stations", and Figures 12b and 27b.

Numerous organizations listed in Table I, and individuals associated with each have contributed generously their time and space in their facilities to help launch this project. The Church of Latter Day Saints, the Los Angeles Fire Department, and the Los Angeles School District, in particular, have contributed many sites, and deserve special recognition for their cooperation and their interest in this project. For the hospitality, good will and unselfish support of all who helped, we are most grateful.

We are also grateful for the cooperation provided by Kinemetrics Inc. of Pasadena, California. Technical personnel there worked closely with us on the design of the TDC-2 clock controller and the modifications to the SMA-1 which we required to obtain redundancy in clock corrections. The staff there also cooperated closely with us to promptly resolve the instrumental problems which inevitably result from a project of this size. Without their teamwork, the instrumental aspects of this network project would have been much more complicated.

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APPENDIX I

Accelerograph sites maintained by USC.

Figure 27 shows the USC sites, with each site numbered. Table I lists each site ordered according to its site number.

The site name/address is of the form:

Newport Beach (Mile Square Regional Park)
16801 Euclid Street
Foundtain Valley, California

In this, the first line consists of

Topographic quadrangle (detailed name). Thus, by knowing the U.S. Geological Survey 7 1/2' topographic quadrangle names for a part of the basin (e.g. near an earthquake epicenter), one can quickly determine from the site name which stations are nearby.

Figure 28 shows the topographic quadrangles covering the network region. Table II lists their names and locations in Figure 28.

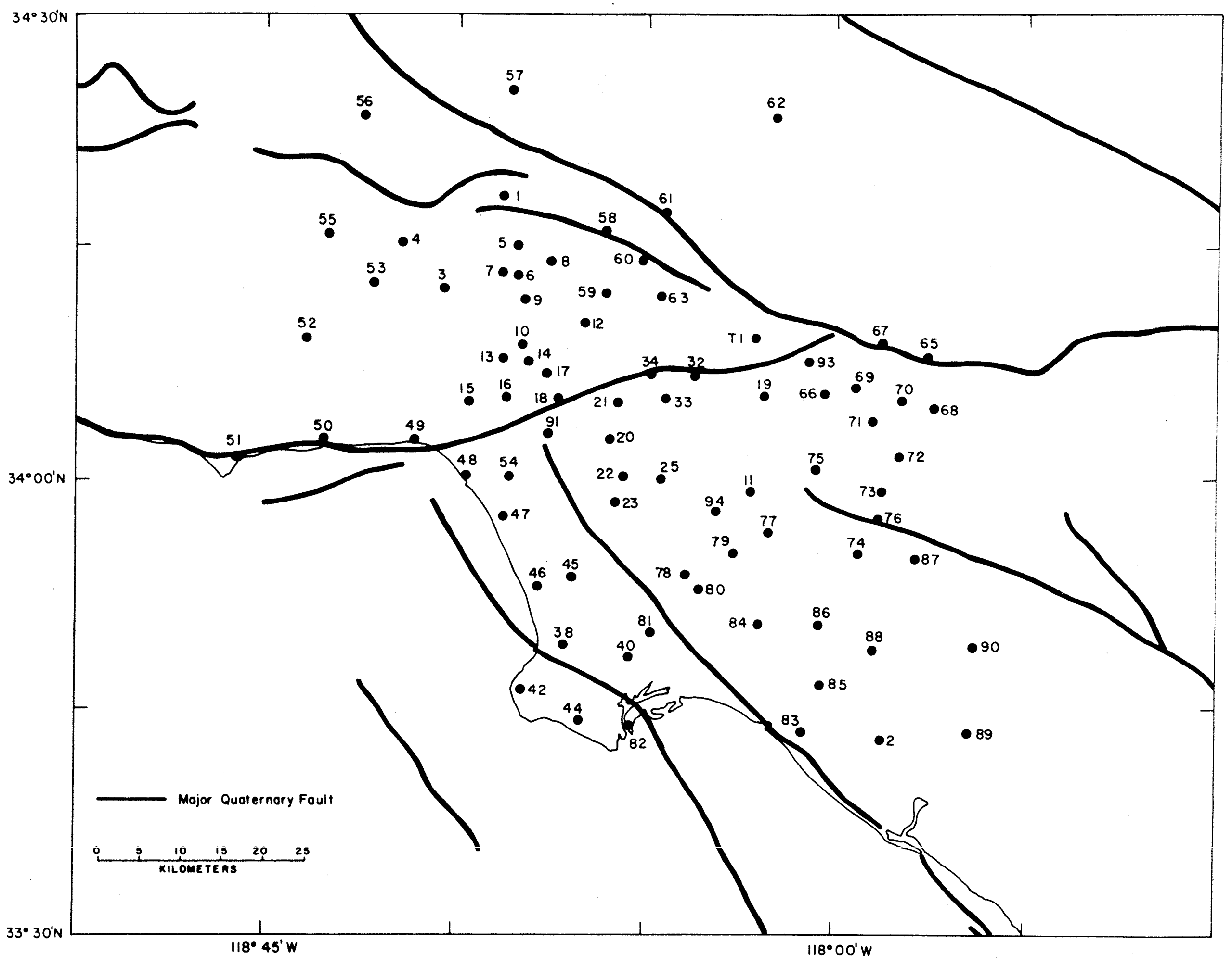

Fig. 27a. USC stations as installed in the Spring of 1980. CDMG sites are not shown.

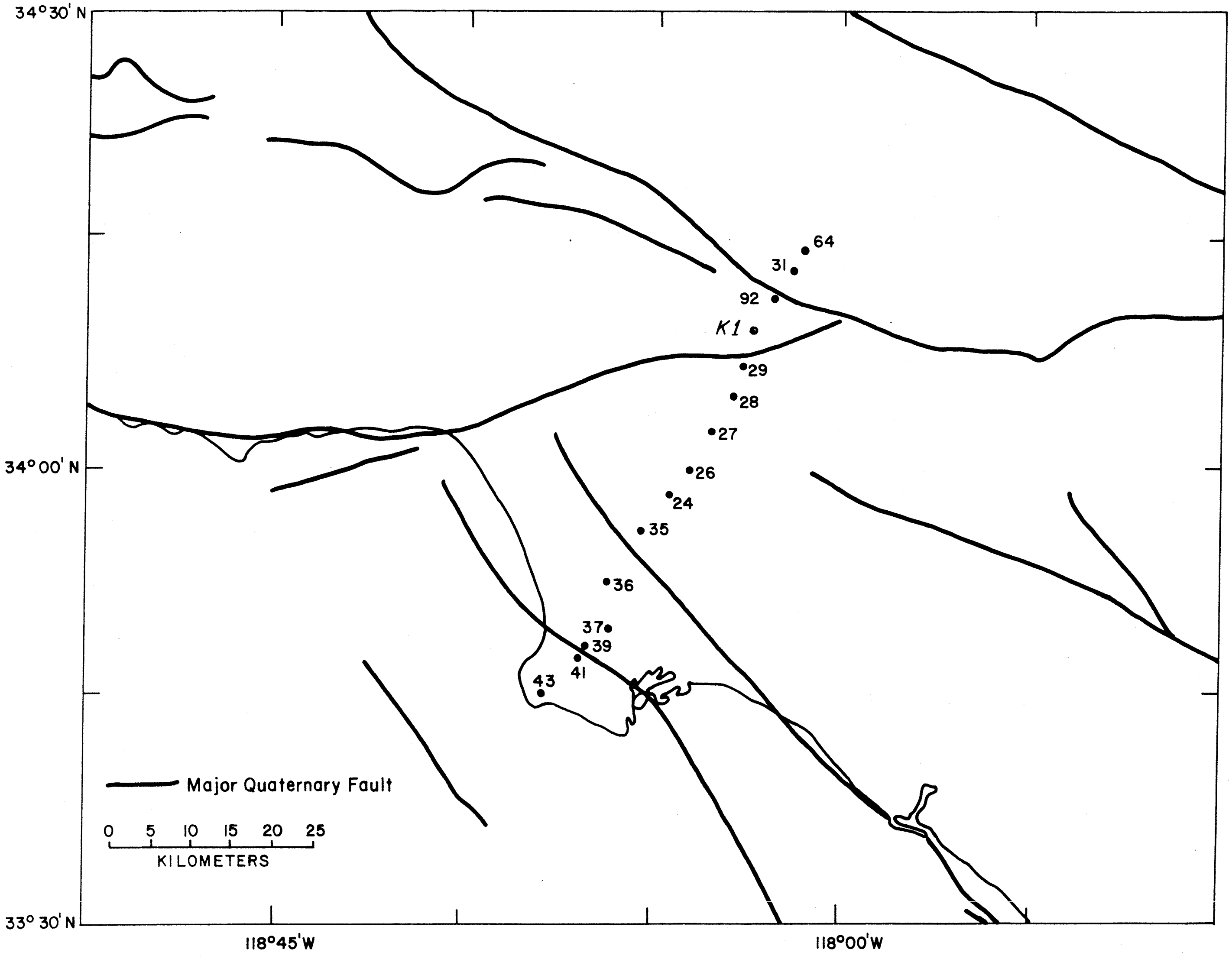

Fig. 27b. Locations of fourteen accelerograph stations located and instrumented by CDMG as part of the USC-Los Angeles strong motion array. Station numbers correspond to those in Table I. Station K1 is an accelerograph sited, owned and operated by Kinemetrics Inc. in Pasadena.

Table I

USC Site No. (See Fig. 27)	Site Name/Address	Topo. Map Loc. (See Fig. 28)	Coordinates Elevation	Building Type/Size	Brief Geol. Descrip.	Instr. Ser. #	Comp.	Nat. Freq.	Orien-tation	Sensi-tivity	Damping % Crit.
1	San Fernando (Light &	E4	34.3064°N	Storage	Alluvium	3689	L	25.9	45°	18.6	57.3
	Life Christian School)		118.4374°W	1 Story			V	25.7		20.0	51.4
	14019 Sayre Strees		1240'	Small			T	26.3	315°	18.7	53.1
	Sylmar, CA 91342										
2	Newport Beach (Mile	I9	33.7191°N	Office	Alluvium	3698	L	25.9	22°	18.9	58.4
	Square Regional Park		117.9374°W	1 Story			V	25.8		18.8	54.1
	16801 Euclid Street		39'	Small			T	25.9	292°	18.3	55.2
	Fountain Valley, CA 92708										
3	Canoga Park (White Oak	D5	34.2088°N	Church	Alluvium	3688	L	24.3	180°	19.5	58.0
	Covenant Church		118.5172°W	2 Story			V	25.7		17.6	54.6
	17645 Saticoy Street		752'	Medium			T	27.2	90°	17.0	54.9
	Northridge, CA 91325										
4	Oat Mountain (Saint	D4	34.25850°N	Church	Alluvium	3747	L	24.9	90°	19.4	58.2
	Stephen Presby. Church)		118.57125°W	1 Story			V	26.1		17.5	56.9
	20121 Devonshire Street		970′	Medium			T	27.1	0°	16.9	54.0
	Chatsworth, CA 91311										
5	San Fernando (Evangelical	E4	34.2506°N	Church	Alluvium	3704	L	25.45	45°	19.0	57.7
	Methodist Church)		118.4200°W	1 Story			V	25.		19.4	53.9
	13232 Kagel Canyon Road		940'	Medium			T	26.86	315°	17.2	57.5
	Pacoima, CA 91331										
6	Van Nuys (Grace Community	E5	34.2213°N	Church	Alluvium	3733	L	24.45	90°	18.9	57.7
	Church)		118.4215°W	2 Story			V			18.0	54.6
	13248 Roscoe Blvd.		800'	Big			T	24.45	0°	18.0	57.9
	Sun Valley, CA 91352										
7	Van Nuys (Panorama Presbyterian Church)	E5	34.2220°N	Church	Alluvium	3693	L	24.4	180°	19.6	57.3
			118.4416°W	2 Story			V	25.86		18.0	58.3
	14201 Roscoe Blvd.		803'	Medium			T	25.	90°	19.3	59.0
	Panorama City, CA 91402										

Table I

USC Site No. (See Fig. 27	Site Name/Address	Topo. Map Loc. (See Fig. 28)	Coordinates Elevation	Building Type/Size	Brief Geol. Descrip.	Instr. Ser. #	Comp.	Nat. Freq.	Orien- tation	Sensi- tivity	Damping % Crit.
8	Burbank (Sun Valley Church of the Nazarene) 9210 Sunland Blvd. Sun Valley, CA 91252	F5	34.2353°N 118.3669°W 878'	Church 1 Story Medium	Alluvium	3710	L	25.65	310°	18.5	58.3
							V	25.25		18.2	55.6
							T	24.86	220°	19.3	57.3
9	Van Nuys (Coldwater Canyon Avenue School 6850 Coldwater Canyon Ave. North Hollywood, CA 91605	E5	34.1941°N 118.4116°W 743'	House 1 Story Small	Alluvium	3722	L	25.	270°	19.3	60.8
							V	26.4		17.7	54.6
							T	25.4	180°	18.5	56.5
10	Van Nuys (Los Angeles City Fire Station 78) 4230 Coldwater Canyon Ave. Studio City, CA 91604	E5	34.1460°N 118.4125°W 634'	Fire Stat. 1 Story Medium	Alluvium	3813	L	26.6	182°	16.8	58.7
							V	26.34		16.7	54.0
							T	25.2	92°	20.0	56.9
11	Whittier (St. Vincent's Seminary High School) 1105 Bluff Road Montebello, CA 90640	H7	33.9901°N 118.1139°W 185'	Reg. Bldg. 2 Story Medium	Pleist. nonmarine	3703	L	24.8	285°	19.2	57.3
							V	24.4		19.4	56.9
							T	26.	195°	17.7	53.6
12	Burbank (Westminster Presbyterian Church) 542 N. Buena Vista Street Burbank, CA 91505	F5	34.1683°N 118.3318°W 561'	Church 1 Story Medium	Alluvium	3706	L	25.7	340°	18.9	57.3
							V	25.45		19.1	56.9
							T	25.	250°	19.1	61.7
13	Van Nuys (Los Angeles City Fire Station #99) 14145 Mulholland Drive Beverly Hills, CA 91210	E5	34.1317°N 118.4395°W 1150'	Fire Stat. 2 Story Medium	Upper Miocene Marine	3709	L	25.	9°	19.6	59.1
							V	25.5		18.9	58.3
							T	26.25	279°	18.4	59.8
14	Van Nuys (Los Angeles City Fire Station #108 12520 Mulholland Drive Beverly Hills, CA 90210	E5	34.1269°N 118.4053°W 1100'	Fire Stat. 1 Story Big	Middle Miocene Marine	3811	L	26.28	122°	18.3	59.1
							V	26.		18.8	54.6
							T	26.5	32°	19.5	58.2

Table I

USC Site No. (See Fig. 27	Site Name/Address	Topo. Map Loc. (See Fig. 28)	Coordinates Elevation	Building Type/Size	Brief Geol. Descrip.	Instr. Ser. #	Comp.	Nat. Freq.	Orien- tation	Sensi- tivity	Damping % Crit.
15	Beverly Hills (Mount St. Mary's College) 12001 Chalon Road Los Angeles, CA 90049	E6	34.0857°N 118.4815°W 1000'	School 1 Story Medium	Upper Jurasic Marine	3714	L	25.	120°	19.0	55.8
							V	26.5		17.8	54.0
							T	26.	30°	17.9	56.1
16	Beverly Hills (Westlake School) 700 N. Faring Road Los Angeles, CA 90024	E6	34.0895°N 118.4347°W 550'	School 2 Story Big	Upper Jurasic Marine	3720	L	26.	90°	17.5	55.8
							V	25.45		18.7	60.8
							T	25.89	0°	18.4	57.9
17	Beverly Hills (Wonderland Avenue Elementary School) 8510 Wonderland Ave. Los Angeles, CA 90046	E6	34.1145°N 118.3797°W 1000'	School 2 Story Medium	Mesozoic Granitic Rocks	3721	L	27.17	165°	16.9	56.8
							V	26.78		16.8	54.0
							T	27.	75°	17.0	57.3
18	Hollywood (Laurel Child- ren's Center 8023 Willoughby Hollywood, CA 90046	F6	34.0875°N 118.3653°W 240'	House 1 Story Medium	Alluvium	3726	L	26.6	180°	17.0	57.3
							V	24.75		19.2	58.9
							T	25.74	90°	18.1	57.7
19	El Monte (Lincoln School) 600 E. Grand Avenue San Gabriel, CA 91776	H6	34.0915°N 118.0927°W 200'	School 1 Story Medium	Pleis. Non- marine	3692	L	25.	270°	18.5	52.4
							V	25.86		18.5	56.0
							T	26.9	180°	17.4	55.1
20	Hollywood (St. Thomas School) 2628 West 15th Street Los Angeles, CA 90006	F6	34.045°N 118.298 W 200'	School 1 Story Small	Pleis. Non- marine	3737	L	25.89	345°	18.2	57.2
							V	26.4		17.2	54.0
							T	26.4	255°	17.5	57.9
21	Hollywood (Dayton Heights Elementary School) 607 N. Westmoreland Ave. Los Angeles, CA 90004	F6	34.0820°N 118.298 °W 299'	Regular 1 Story Medium	Pleis. Non- marine		L	26.6	0°	17.2	54.0
						3715	V	25.45		19.1	57.9
							T	26.	270°	18.1	57.7

Table I

USC Site No. (See Fig. 27)	Site Name/Address	Topo. Map Loc. (See Fig. 28)	Coordinates Elevation	Building Type/Size	Brief Geol. Descrip.	Instr. Ser. #	Comp.	Nat. Freq.	Orien- tation	Sensi- tivity	Damping % Crit.
22	Hollywood (West Vernon Avenue School) 4312 South Grand Ave. Los Angeles, CA 90037	F6	34.0050°N 118.2791°W 170'	School 2 Story Big	Alluvium	3746	L	26.4	180°	18.4	56.0
							V	26.1		17.4	57.7
							T	27.	90°	17.3	57.9
23	Inglewood (St. Raphael School) 924 W. 70th St. Los Angeles, CA 90044	F7	33.9762°N 118.2894°W 140'	School 2 Story Medium	Quaternary Nonmarine Terrace Deposits	3748	L	25.74	0°	18.6	54.9
							V	25.23		17.7	54.0
							T	25.74	270°	18.3	56.7
24	*Los Angeles (Washington Park) 8708 S. Maie Ave. Los Angeles, CA 90002	G7	33.9545°N 118.2430°W 125'	Storage 1 Story Small	Alluvium						
25	(Vernon City School) 2369 E. Vernon Ave. Los Angeles, CA 90058	G6	34.0035°N 118.2303°W 199'	Medium Size Bldg. in Basement	Alluvium	3732	L	26.4	173°	17.8	54.6
							V	25.74		18.4	57.5
							T	25.74	83°	17.5	55.8
26	*Vernon (Vernon-Water Well #9) On Fruitland - 1 Block W. of Downey Rd. Vernon, CA	G7	34.9967°N 118.2066°W 180'	Storage 1 Story Small	Alluvium						
27	*Los Angeles (Obregon Park) 4021 E. First St. Los Angeles, CA 90063	G6	34.0368°N 118.1777°W 250'	Storage 1 Story Small	Alluvium						
28	*Alhambra (Fremont School) 2001 Elm St. Alhambra, CA 91803	G6	34.0699°N 118.1496°W 420'	School 1 Story Medium	Alluvium						

Table I

USC Site No. (See Fig. 27)	Site Name/Address	Topo. Map Loc. (See Fig. 28)	Coordinates Elevation	Building Type/Size	Brief Geol. Descrip.	Instr. Ser. #	Comp.	Nat. Freq.	Orientation	Sensitivity	Damping % Crit.
29	*San Marino (Southwestern Academy 2800 Monterey Rd. San Marino, CA 91108	G6	34.1153°N 118.1303°W 570'	Storage 1 Story Small	Alluvium						
30	*Pasadena (Kinemetrics, Inc.) 222 Vista Ave. Pasadena, CA 91107	H5	34.1498°N 118.0839°W 775'	Office 1 Story Medium	Alluvium						
31	*Henniger Flats (L.A. Co. Fire Station) 2260 Pine Crest Dr. Altadena, CA 91001	H5	34.1930°N 118.0871°W 2640'	Home 1 Story Small	Colluvium over Basement Metamorphic						
32	Los Angeles (Los Angeles City Fire Station #12) 5921 N. Figueroa St. Los Angeles, CA 90042	G6	34.1113°N 118.1893°W 540'	Fire Stat. Medium	Pleistocene Nonmarine	3740	L	27.1	58°	16.9	54.8
							V	25.8		17.6	56.2
							T	26.4	328°	18.0	58.1
33	Los Angeles (Divine Savior School) 624 Cypress Avenue Los Angeles, CA 90065	G6	34.0884°N 118.2221°W 370'	School 1 Story Medium	Alluvium	3731	L	25.9	143°	16.8	58.7
							V	26.76		16.9	57.7
							T	27.1	53°	17.4	57.5
34	Los Angeles (Los Angeles City Fire Station #50) 3036 Fletcher Drive Los Angeles, CA 90065	G6	34.1153°N 118.2437°W 390'	Brick Construction 2 Story Medium	Pleistocene Nonmarine	3745	L	27.2	234°	17.1	54.0
							V	24.75		19.8	58.1
							T	25.46	144°	18.5	57.7
35	*Los Angeles (116th Street School) 11610 Stanford Ave. Los Angeles, CA 90059	F7	33.9289°N 118.2603° 105'	School 1 Story Medium	Alluvium						

Table I

USC Site No. (See Fig. 27)	Site Name/Address	Topo. Map Loc. (See Fig. 28)	Coordinates Elevation	Building Type/Size	Brief Geol. Descrip.	Instr. Ser. #	Comp.	Nat. Freq.	Orien- tation	Sensi- tivity	Damping % Crit.
36	*Gardena (186th Street School) 1581 W. 186th St. Gardena, CA 90248	F8	33.3209°N 118.8623°W 50'	Storage 1 Story Small	Alluvium						
37	*Torrance (Torrance Elementary School) 2125 Lincoln Avenue Torrance, CA 90501	F8	33.8241°N 118.3204°W 85'	School 1 Story Medium	Alluvium						
38	Torrance (Redondo First Ward LDS Church) 4110 West 226th Street Torrance, CA 90505	F8	33.8228°N 118.3561°W 75'	Church 1 Story Big	Dune Sand	3680	L V T	25. 26.3 26.66	180° 90°	19.5 18.3 17.7	57.3 57.7 52.0
39	*Torrance (Walteria Elementary School) 24456 Madison Avenue Torrance, CA 90505	F8	33.8004°N 118.3461°W 135'	School 1 Story Medium	Alluvium						
40	Torrance (Catskill Avenue School) 23536 Catskill Avenue Carson, CA 90745	F8	33.8117°N 118.2701°W 36'	School 2 Story Big	Quaternary Nonmarine Terrace Deposits	3812	L V T	26.6 26.53 26.3	180° 90°	17.9 17.3 17.7	57.5 57.3 59.5
41	*Rolling Hills Estates (Rancho Vista School) 4323 Palos Verdes Drive-No. Rolling Hills Estates, California 90274	F8	33.7871°N 118.3560°W 440'	School 1 Story Medium	Miocene Sedimentary Rocks						
42	Redondo Beach (Margate School) 2161 Via Olivera Palos Verdes Estates, California 90274	E8	33.7760°N 118.4112°W 460'	School 1 Story Big	Middle Miocene Marine	3711	L V T	25.88 25.3 25.7	238° 148°	18.4 19.3 18.8	58.4 54.2 56.2

Table I

USC Site No. (See Fig. 27)	Site Name/Address	Topo. Map Loc. (See Fig. 28)	Coordinates Elevation	Building Type/Size	Brief Geol. Descrip.	Instr. Ser. #	Comp.	Nat. Freq.	Orien-tation	Sensi-tivity	Damping % Crit.
43	*Rancho Palos Verdes (Crestmont College) 30840 Hawthorne Blvd. Rancho Palos Verdes, California 90274	E8	33.7455°N 118.3758°W 370'	Storage 1 Story Small	Miocene Sedimentary Rocks						
44	San Pedro (Mira Catalina School) 30511 Luconia Drive Rancho Palos Verdes, California 90274	F9	33.7403°N 118.3341°W 1060'	Brick Building 1 Story Medium	Middle Miocene Marine	3744	L	25.74	276°	18.0	58.1
							V	25.2		18.6	58.0
							T	24.75	186°	20.3	57.2
45	Inglewood (Hawthorne Ward LDS Church) 14801 Osage Ave. Lawndale, CA 90260	F7	33.8970°N 118.3457°W 57'	Church Big High Ceiling	Quaternary Nonmarine Terrace Deposits	3712	L	25.	90°	18.2	58.8
							V	25.		19.3	54.2
							T	26.6	0°	17.4	56.2
46	Venice (Fire Station #2) 1400 Manhattan Beach Blvd. Manhattan Beach, CA 90266	E7	33.8869°N 118.3885°W 150'	Garage 1 Story Small	Dune Sand	3723	L	25.	90°	18.6	57.3
							V	25.		18.9	57.3
							T	26.2	0°	18.3	57.7
47	Venice (Del Rey Hills Evangelical Free Church) 8505 Saran Drive Playa del Rey, CA 90291	E7	33.9602°N 118.4321°W 100'	Church 1 Story Medium	Pleistocene Marine and Marine ter- race deposits	3686	L	25	0°	18.8	55.6
							V	25.6		19.2	58.0
							T	27.	270°	17.4	57.7
48	Beverly Hills (Santa Monica 1st Ward LDS Church) 2302 Second Street Santa Monica, CA 90405	E6	34.005°N 118.485°W 40'	Church 2 Story Medium	Pleistocene Marine and Marine ter- race deposits	3691	L	26.	295°	18.4	54.8
							V	27.5		17.1	55.8
							T	26.6	205°	18.0°	58.0

Table I

USC Site No. (See Fig. 27)	Site Name/Address	Topo. Map Loc. (See Fig. 28)	Coordinates Elevation	Building Type/Size	Brief Geol. Descrip.	Instr. Ser. #	Comp.	Nat. Freq.	Orien- tation	Sensi- tivity	Damping % Crit.
49	Topanga (Los Angeles City Fire Station #23) 17281 Sunset Blvd. Pacific Palisades, California 90272	D6	34.0419°N 118.5535°W 90'	Brick Structure 1 Story Medium	Oligocene Nonmarine	3678	L	26.4	280°	18.1	57.7
							V	26.6		18.7	54.0
							T	26.1	190°	18.4	52.0
50	Malibu Beach (Carden Malibu C6 School) 3504 Las Flores Canyon Malibu, CA 90265	C6	34.0457°N 118.6377°W 150'	House 1 Story Small	Miocene Volcanic	3741	L	26.25	250°	17.9	56.0
							V	27.87		17.2	56.9
							T	26.76	160°	19.6	54.6
51	Point Dume (St. Aidans Episcopal Church) 28211 W. Pacific Coast Hwy. Malibu, CA 90265	B6	34.0240°N 118.7874°W 30'	Church 1 Story	Pleistocene Marine and Marine Terrace deposits	3725	L	26.6	150°	17.1	57.9
							V	26.2		17.4	58.0
							T	26.	60°	17.7	54.6
52	Calabasas (L.A. County Fire Station #125) 5215 North Las Virgines Rd. Calabasas, CA 91302	C5	34.1509°N 118.6968°W 800'	Brick Construc. 1 Story Medium	Middle Miocene Nonmarine	3738	L	25.3	290°	18.3	53.8
							V	26.86		16.8	53.6
							T	25.45	200°	19.2	54.6
53	Canoga Park (Epiphany Luthern Church) 7769 Topanga Canyon Blvd. Canoga Park, CA 91304	D5	34.2120°N 118.6055°W 815'	Church 1 Story Medium	Alluvium	3729	L	25.7	196°	17.8	55.0
							V	25.		18.7	57.1
							T	24.6	106°	20.1	54.6
54	Beverly Hills (McBride School) 3960 Centinela Street Los Angeles, CA 90066	E6	34.0014°N 118.4306°W 200'	Power Panelroom 1 Story Small	Alluvium	3753	L	26.78	245°	17.7	58.5
							V	26.1		19.1	59.8
							T	25.58	155°	18.4	57.7
55	Santa Susana (Knolls Elementary School) 6334 Katherine Road Simi Valley, CA 93063	C4	34.2637°N 118.6663°W 1050'	House 1 Story Small	Alluvium	3750	L	26.2	0°	17.3	56.0
							V	26.		17.1	57.0
							T	25.45	270°	17.5	52.8

Table I

USC Site No. (See Fig. 27)	Site Name/Address	Topo. Map Loc. (See Fig. 28)	Coordinates Elevation	Building Type/Size	Brief Geol. Descrip.	Instr. Ser. #	Comp.	Nat. Freq.	Orien- tation	Sensi- tivity	Damping % Crit.
56	Newhall (Sun Oil Company Rancho San Francisco Lease) 26835 West Pico Canyon Blvd. Newhall, CA 91321	D3	34.3911°N 118.6219°W 1297'	Wood Constr. 1 Story Medium	Upper Pliocene Nonmarine	3728	L	27.5	46°	17.1	56.0
							V	25.		19.0	57.7
							T	26.6	316°	16.7	58.3
57	Mint Canyon (Sulphur Springs School) 16628 West Lost Canyon Rd. Canyon Country, CA 91351	C3	34.4193°N 118.4261°W 1540'	School 1 Story Medium	Alluvium	3717	L	25.6	0°	18.6	57.7
							V	24.7		18.9	57.4
							T	26.26	270°	17.6	55.0
58	Sunland (Mt. Gleason Jr. High School) 10965 Mt Gleason Avenue Sunland, CA 91040	F4	34.2689°N 118.3031°W 1460'	School 1 Story Big	Alluvium	3814	L	26.	270°	17.9	54.6
							V	25.		18.5	55.8
							T	25.45	180°	18.8	55.4
59	Burbank (Castaway Restaurant) 1250 Howard Road Burbank, CA 91501	F5	34.2035°N 118.3018°W 1220'	Restaurant 1 Story Medium	Pleistocene Nonmarine	3742	L	24.37	230°	20.1	57.7
							V	25.		18.0	54.8
							T	25.2	140°	18.0	57.8
60	Burbank (Anderson W. Clark Junior High School) 4747 New York Avenue La Crescenta, CA 91214	F5	34.2377°N 118.2536°W 1800'	Brick Constr. 2 Story Big	Alluvium	3705	L	24.6	180°	20.2	60.7
							V	26.6		17.3	57.5
							T	26.6	90°	17.2	57.3
61	Condor Peak (Big Tujunga Station) U.S. Forest Station	G4	34.2863°N 118.2254°W 1840'	Garage 1 Story Medium	Mesozoic Granitic Rocks	3716	L	25.8	352°	19.1	55.0
							V	26.8		16.8	57.1
							T	26.6	262°	16.6	53.6
62	Pacifico Mountain (Mill Creek Station) U.S. Forest Service Angeles National Forest	H3	34.3897°N 118.0799°W 4980'	Garage 1 Story Small	Mesozoic Granitic Rocks	3694	L	25.7	115°	17.5	55.7
							V	27.		17.3	55.7
							T	26.	25°	18.5	57.0

Table I

USC Site No. (See Fig. 27)	Site Name/Address	Topo. Map Loc. (See Fig. 28)	Coordinates Elevation	Building Type/Size	Brief Geol. Descrip.	Instr. Ser. #	Comp.	Nat. Freq.	Orien- tation	Sensi- tivity	Damping % Crit.
63	Pasadena (Fremont Elementary School) 3320 Las Palmas Avenue Glendale, CA 91208	G5	34.2000°N 118.2312°W 1100'	Dining Rm. 1 Story Medium	Alluvium	3751	L	25.36	267°	19.5	59.3
							V	25.2		19.2	57.3
							T	27.36	177°	17.4	56.6
64	*Mt. Wilson California Institute of Technology Seismic Vault	H5	34.0574°N 118.2237°W 5680'	Seismic Vault 1 Story Small	Mesozoic Granitic Rocks						
65	Azusa (Azusa Ward LDS Church) 120 North Oakbank Glendora, CA 91740	I5	34.1367°N 117.8824°W 670'	Church High Ceiling Big	Alluvium	3682	L	25.58	170°	18.5	57.3
							V	25.7		18.1	57.3
							T	26.47	80°	17.9	57.7
66	El Monte (El Monte First Ward LDS Church) 11338 Fairview Avenue El Monte, CA 92021	H6	34.0928°N 118.0186°W 318'	Church 2 Story Medium	Alluvium	3752	L	25.4	270°	19.3	57.4
							V	24.87		18.5	58.1
							T	27.4	0°	16.4	55.2
67	Azusa (Valley View Elementary School) 237 Mel Canyon Road Duarte, CA 91010	I5	34.1499°N 117.9395°W 635'	School High Ceiling 1 Story Medium	Alluvium	3739	L	26.	174°	17.1	56.6
							V	26.6		17.8	57.9
							T	25.75	84°	18.1	54.8
68	San Dimas (Covina State LDS Church) 656 South Grand Avenue Covina, CA 91724	J6	34.0779°N 117.8706°W 580'	Church 1 Story Big	Pleistocene Nonmarine	3699	L	25.86	105°	17.9	58.0
							V	26.		17.7	54.0
							T	26.	15°	17.8	57.5
69	Baldwin Park (Olive Jr. High School) 3699 North Holly Avenue Baldwin Park, CA 91706	I6	34.1004°N 117.9741°W 380'	Brick Building 1 Story Medium	Alluvium	3702	L	26.	270°	18.3	53.4
							V	26.25		17.1	54.7
							T	25.35	180°	18.4	54.0

Table I

USC Site No. (See Fig. 27)	Site Name/Address	Topo. Map Loc. (See Fig. 28)	Coordinates Elevation	Building Type/Size	Brief Geol. Descrip.	Instr. Ser. #	Comp.	Nat. Freq.	Orien- tation	Sensi- tivity	Damping % Crit.
70	Baldwin Park (Baldwin Park Ward LDS Church) 1271 West Badillo Covina, CA 91722	I6	34.0870°N 117.9154°W 460'	Church 1 Story Medium	Alluvium	3701	L	25.65	0°	18.5	58.3
							V	25.25		18.2	55.6
							T	24.86	270°	19.3	57.3
71	Baldwin Park (Baldwin Park 1st Ward LDS Church) 1307 South Orange West Covina, CA 91722	I6	34.0641°N 117.9522°W 357'	Church 1 Story Medium	Alluvium	3685	L	25.7	315°	18.6	55.4
							V	26.8		17.0	54.6
							T	27.	225°	17.4	54.6
72	La Puente (West Covina 3rd Ward LDS Church) 504 Rimgrove Avenue La Puente, CA 91706	I6	34.0260°N 117.9180°W 400'	Church 1 Story Medium	Alluvium	3684	L	24.0	105°	19.7	56.7
							V	25.58		18.2	55.6
							T	26.4	15°	17.5	54.8
73	La Habra (Hacienda Hts. 1st Ward LDS Church) 16750 Colma Road Hacienda Heights, CA 91745	I7	33.9899°N 117.9426°W 520'	Church 2 Story Medium	Upper Miocene Marine	3708	L	25.7	230°	17.8	57.1
							V	25.0		18.3	55.6
							T	26.0	140°	17.9	56.4
74	La Habra (Olita School) 950 Briarcliff Drive La Habra, CA 90631	I7	33.9211°N 117.9727°W 280'	Cafeteria 2 Story Medium	Pleistocene Nonmarine	3690	L	25.4	90°	19.0	54.0
							V	26.9		16.5	56.6
							T	26.6	0°	18.1	58.0
75	Whittier (Lou Henry Hoover School) 6302 South Alta Drive Whittier, CA 90601	H7	34.0152°N 118.0287°W 460'	School 1 Story Medium	Alluvium	3736	L	26.5	90°	17.6	57.7
							V	25.3		19.2	57.0
							T	25.3	0°	18.5	57.7
76	La Habra (Hacienda Golf Club 718 East Road La Habra, CA 90631	I7	33.9597°N 117.9459°W 700'	Golf Club Big	Upper Miocene Marine	3695	L	26.6	273°	18.1	58.8
							V	25.7		18.7	61.0
							T	25.58	183°	19.3	57.3

Table I

USC Site No. (See Fig. 27)	Site Name/Address	Topo. Map Loc. (See Fig. 28)	Coordinates Elevation	Building Type/Size	Brief Geol. Descrip.	Instr. Ser. #	Comp.	Nat. Freq.	Orien-tation	Sensi-tivity	Damping % Crit.
77	Whittier (Lakeview School) 11500 E. Joslin Street Santa Fe Springs, CA 90670	H7	33.9442°N 118.0873°W 128'	Supply Rm. (Brick) 1 Story Small	Alluvium	3743	L	25.74	48°	17.7	58.2
							V	26.4		17.2	57.7
							T	26.4	318°	17.7	57.8
78	South Gate (Compton First LDS Church) 14637 Castlegate Street Compton, CA 90221	G7	33.8991°N 118.1964°W 69'	Church 2 Story Medium	Alluvium	3713	L	25.	0°	19.7	57.3
							V	24.28		20.0	58.0
							T	25.	270°	19.8	57.7
79	South Gate (South Middle School) 12500 Brichdale Downey, CA 90241	G7	33.9202°N 118.7372°W 97'	Cafeteria 1 Story (High Ceiling) Big	Alluvium	3735	L	23.25	180°	16.6	55.4
							V	25.4		18.4	59.1
							T	26.	90°	17.1	57.3
80	South Gate (Long Beach 6th Ward LDS Church) 6979 Orange Avenue Long Beach, CA 90805	G7	33.8813°N 118.1768°W 58'	Church High Ceiling Big	Alluvium	3719	L	25.	10°	18.4	56.9
							V	26.1		18.0	57.7
							T	24.4	280°	20.4	57.1
81	Long Beach (Del Amo Elementary School) 21288 Water Street Carson, CA 90745	G8	33.8363°N 118.2397°W 24'	School 2 Story Medium	Alluvium	3810	L	27.1	270°	16.7	56.9
							V	26.3		17.8	53.8
							T	26.6	180°	17.2	57.1
82	San Pedro (Los Angeles City Fire Station 111) 954 South Seaside Avenue Berth #260 Terminal Island, CA 90731	F9	33.7359°N 118.2690°W 12'	Fire Station 1 Story Medium	Alluvium	3718	L	24.75	342°	19.5	54.6
							V	26.8		17.7	54.5
							T	25.1	252°	18.3	57.7
83	Seal Beach (Haven View School) 16081 Waikiki Lane Huntington Beach, CA 92649	H9	33.72733°N 118.0435°W 9'	House 1 Story Small	Alluvium	3700	L	26.1	290°	17.3	54.4
							V	25.4		18.3	57.1
							T	27.2	200°	17.1	54.1

Table I

USC Site No. (See Fig. 27)	Site Name/Address	Topo. Map Loc. (See Fig. 28)	Coordinates Elevation	Building Type/Size	Brief Geol. Descrip.	Instr. Ser. #	Comp.	Nat. Freq.	Orien- tation	Sensi- tivity	Damping % Crit.
84	Los Alamitos (Mae Bayer Park) 6701 Del Amo Blvd. Lakewood, CA 90713	H8	33.8456°N 118.0991°W 43'	House 1 Story Small	Alluvium	3727	L	25.5	90°	18.1	56.5
							V	26.1		16.6	55.6
							T	25.	0°	17.6	54.6
85	Los Alamitos (Patton School) 6861 Santa Rita Garden Grove, CA 92645	H8	33.7900°N 118.0122°W 43'	School 1 Story Medium	Alluvium	3724	L	24.6	0°	20.1	61.0
							V	24.6		19.1	57.5
							T	24.4	270°	19.2	61.3
86	Los Alamitos (Centralia School District Administrative Offices) 6625 La Palma Avenue Buena Park, CA 90620	H8	33.8470°N 118.0176°W 57'	Medium Size Building L Story	Alluvium	3734	L	26.1	180°	18.3	55.8
							V	25.45		18.4	57.7
							T	26.4	90°	17.7	59.5
87	La Habra (Brea Laurel School) 200 South Flower Brea, CA 92621	I7	33.9164°N 117.8963°W	School 1 Story Medium	Pleistocene Nonmarine	3681	L	24.	20°	19.7	56.7
							V	25.58		18.2	55.6
							T	26.4	290°	17.5	54.8
88	Anaheim (Francis Scott Key School) 2000 W. Ball Road Anaheim, CA 92805	I8	33.8172°N 117.9510°W 104'	Big Education Building 1 Story	Alluvium	3707	L	25.5	90°	18.2	56.5
							V	24.4		19.5	54.6
							T	26.9	0°	16.4	57.3
89	Tustin (St. Cecilia's School) 13014 E. Sycamore Tustin, CA 92680	J9	33.7278°N 117.8244°W 92'	Big Education Building	Alluvium	3697	L	25.	130°	18.9	58.3
							V	25.4		19.4	59.1
							T	26.6	40°	17.6	53.7
90	Orange (Cerro Villa Junior High School) 17852 Serrano Avenue	J8	33.8209°N 117.8182°W 335'	Small Room 1 Story	Pleistocene Nonmarine	3696	L	26.6	0°	17.8	56.5
							V	26.		18.2	57.9
							T	26.9	270°	17.1	55.2

Table I

USC Site No. (See Fig. 27)	Site Name/Address	Topo. Map Loc. (See Fig. 28)	Coordinates Elevation	Building Type/Size	Brief Geol. Descrip.	Instr. Ser. #	Comp.	Nat. Freq.	Orien- tation	Sensi- tivity	Damping % Crit.
91	Hollywood (Saturn Street School) 5360 Saturn Street Los Angeles, CA 90019	F6	34.0465°N 118.3554°W 115'	School 2 Story Medium	Alluvium	3730	L V T	26.1 26.97 26.	110° 20°	17.5 17.5 18.2	58.0 54.0 54.6
92	*Altadena (Eaton Canyon Park) 1750 N. Altadena Drive Pasadena, CA 91107	H5	34.1771°N 118.0962°W 970'	Park 1 Story Small	Alluvium						
93	Mt. Wilson (Arcadia High School) 180 Campus Drive Arcadia, CA 91006	H5	34.1297°N 118.0364°W 430'	House 1 Story Small	Alluvium	3749	L V T	27.5 25.5 25.	9° 279°	17.3 18.0 19.2	55.6 56.4 58.0
94	South Gate (Grant Ward LDS Church) 7420 Jaboneria Bell Gardens, CA 90201	G7	33.9649°N 118.1582°W 117'	Church 1 Story Medium	Alluvium	3677	L V T	26.15 25.97 25.	297° 207°	18.6 18.4 19.9	57.9 57.7 57.7

Small	<50'
Medium	50' - 150'
Large	>150'

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*Future CDMG sites scheduled to be completed in autumn of 1981.
Data such as natural frequency, orientation, sensitivity and damping will be provided by CDMG.

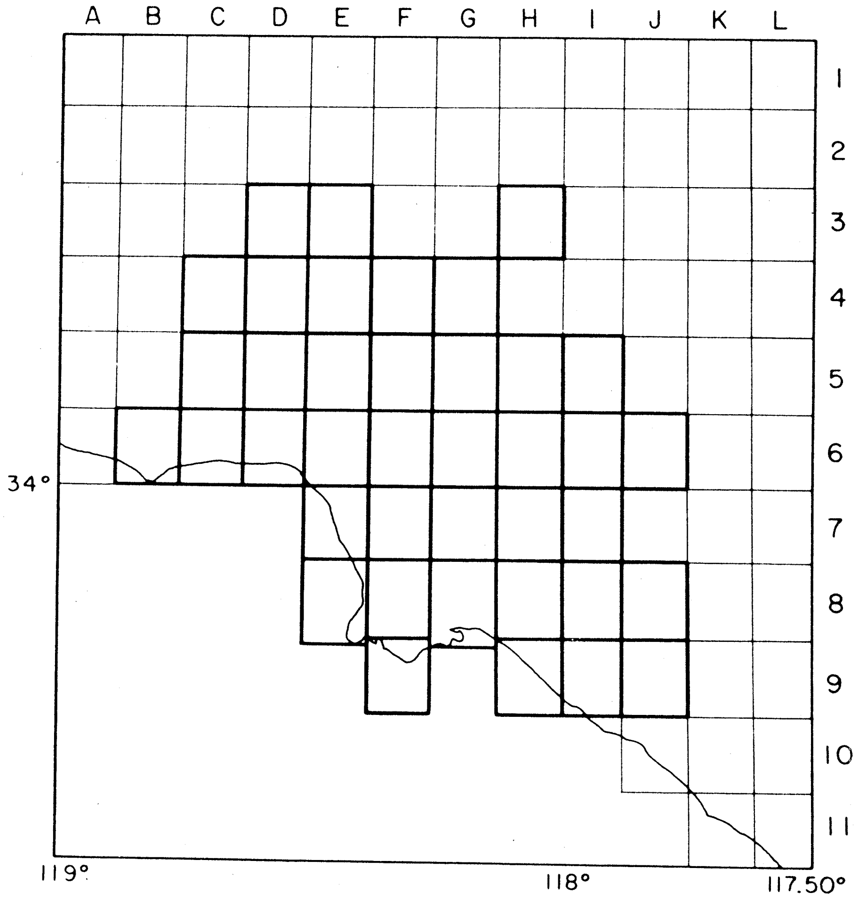


Fig. 28. Topographic quadrangles (Table II) covering the network.

TABLE IIa

Topographic Sheet	Map Location (Figure 28)
Anaheim	I-8
Azusa	I-5
Baldwin Park	I-6
Beverly Hills	E-6
Burbank	F-5
Calabasas	C-5
Canoga Park	D-5
Condor Peak	G-4
El Monte	H-6
Hollywood	F-6
Inglewood	F-7
La Habra	I-7
Long Beach	G-8
Los Alamitos	H-8
Los Angeles	G-6
Malibu Beach	C-6
Mint Canyon	E-3
Mount Wilson	H-5
Newhall	D-3
Newport Beach	I-9
Oat Mountain	D-4
Orange	J-8
Pacifico Mountain	H-3
Pasadena	G-5
Point Dume	B-6
Redondo Beach	E-8
San Dimas	J-6
San Fernando	E-4
San Pedro	F-9
Santa Suzana	C-4
Seal Beach	H-9
South Gate	G-7
Sunland	F-4
Topanga	D-6
Torrance	F-8
Tustin	J-9
Van Nuys	E-5
Venice	E-7
Whittier	H-7

TABLE IIb

Map Location (Figure 28)	Topographic Sheet
B-6	Point Dume
C-4	Santa Susana
C-5	Calabasas
C-6	Malibu Beach
D-3	Newhall
D-4	Oat Mountain
D-5	Canoga Park
D-6	Topanga
E-3	Mint Canyon
E-4	San Fernando
E-5	Van Nuys
E-6	Beverly Hills
E-7	Venice
E-8	Redondo Beach
F-4	Sunland
F-5	Burbank
F-6	Hollywood
F-7	Inglewood
F-8	Torrance
F-9	San Pedro
G-4	Canoga Park
G-5	Pasadena
G-6	Los Angeles
G-7	South Gate
G-8	Long Beach
H-3	Pacific Mountain
H-5	Mount Wilson
H-6	El Monte
H-7	Whittier
H-8	Los Alamitos
H-9	Seal Beach
I-5	Azusa
I-6	Baldwin Park
I-7	La Habra
I-8	Anaheim
I-9	Newport Beach
J-6	San Dimas
J-8	Orange
J-9	Tustin

APPENDIX II

Interpretation of the time code

Figure 29 demonstrates the format of the time code which is recorded on the 70 mm film, and also some interpreted examples of this time code. The code consists of a number of ticks, of varying widths. In Figure 29, the base line is the upper edge of one of the strings of time codes, so that the ticks are pointing downward. Ticks begin every 0.2 sec, and there are 50 ticks per time frame, giving the time frame a duration of 10.0 sec.

These timing ticks come in three widths: short (0.04 sec; 20% of time interval between start of successive ticks), medium (0.10 sec; 50% of time interval between start of successive ticks), and long (0.16 sec; 80% of time interval between successive ticks). Long ticks occur at six specific places in the time frame, and are used for position markers. Short and medium ticks are used to encode the time information.

Figure 29A shows an example of a time code in which all of the ticks are either short or long. One long tick occurs every two secons (ticks #10, 20, 30, 40 and 50), and in addition the first tick is long. Thus two long ticks in a row mark the start of the time frame. In line A, the short ticks which are coded are blackened in; these may be either short or medium length while the other short ticks are always short. The code is broken into a number of sequences of two to four coded ticks separated by short or long ticks. Within each sequence, the ticks are interpreted to give a value of a digit from 0 to 9; these digits are combined to interpret the day, hour, minute, and second of the start of the time frame. The headings above line A show the meaning which is assigned to each

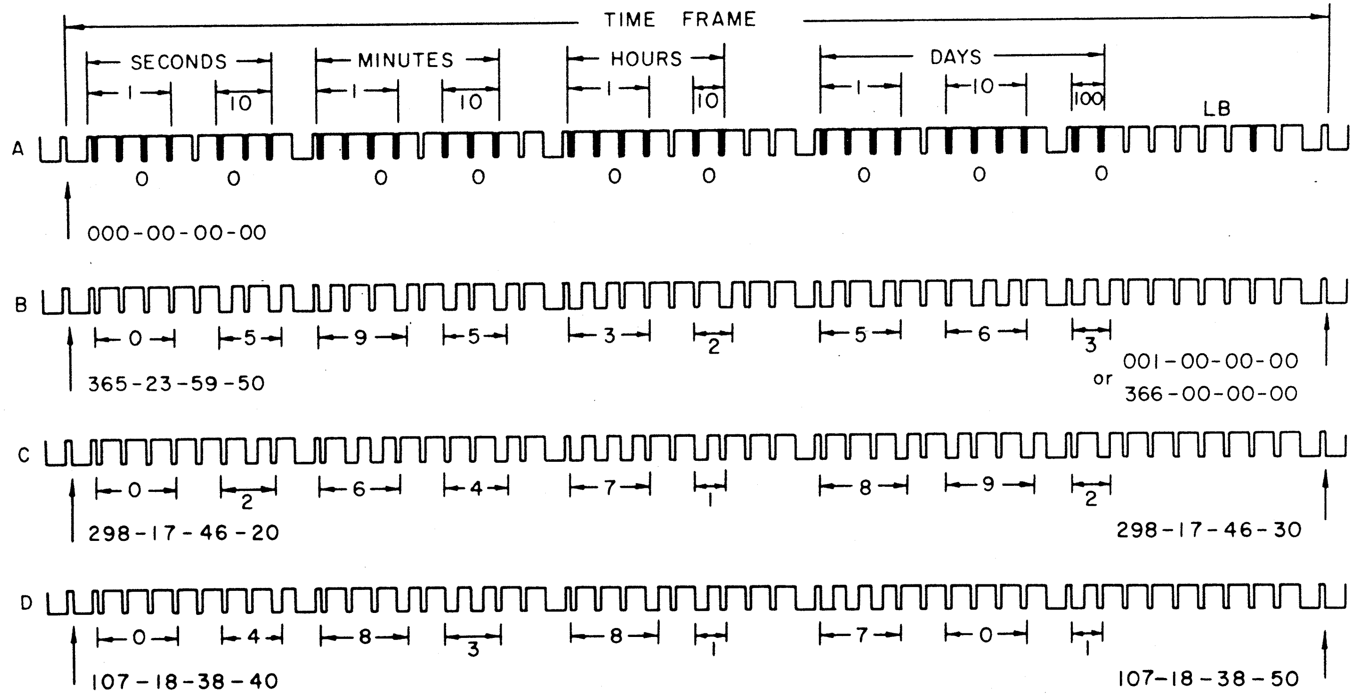


Fig. 29. An example of the crystal time code.

sequence of coded ticks.

In interpreting the coded sequences, a short tick is interpreted as a "0" and a medium tick as a "1". These combine to give the binary representation of the digit from 0 to 9. Within each coded sequence, reading from right to left, the first tick is the least significant. Thus the sequence short-long-short-short corresponds to binary 0010, or decimal 2. Figure 29 (B, C, and D) shows three examples of the interpretation of this code.

The bit marked "LB" is always set to zero when the clock-accelerograph system is operating properly. If the internal batteries are ever completely discharged, due to failure of the external battery charger, and then power is restored, the clock restarts at time 0, and the "LB" bit is set to 1.

APPENDIX III

This appendix contains a copy of the paperwork which has been used in the process of selecting sites and receiving site approval. These are listed below:

A. Information Sheet: Given to owners at a potential site to explain the project, and what would be required of them if they agree to allow the installation of an accelerograph.

B. Permit: We asked the owners of each site to give us written permission for the installation. This permit, modeled after the permit used by the California Division of Mines and Geology, was supplied for their convenience, but a letter in their own format was accepted.

C. Indemnification and Hold-Harmless Agreement: When owners of a site requested a hold-harmless agreement, one was provided. The text is modeled after the agreement requested by the Church of Jesus Christ, Latter Day Saints. When this was supplied, lawyers who reviewed both this and the permit struck out clause 2 of the permit before returning it to us.

UNIVERSITY OF SOUTHERN CALIFORNIA
STRONG MOTION ACCELEROGRAPH NETWORK

INFORMATION SHEET

The project is being funded by the National Science Foundation, and is being carried out jointly by the Departments of Civil Engineering and Geological Sciences at the University of Southern California. The responsible personnel at USC are Professor Ta-liang Teng (Geological Sciences; 743-6124), Professor Mihailo D. Trifunac (Civil Engineering; 743-2987 or 743-6745). We are all engaged in research on seismology and earthquake engineering, with the object of understanding, predicting and reducing earthquake hazards.

The object of our project is to obtain vital information on the nature of strong ground shaking in the Los Angeles metropolitan area. This information is needed for the design of earthquake resistant structures and for the reduction of hazards from future earthquakes.

We plan to obtain this information by installing a grid of strong motion instruments throughout the metropolitan region with a grid spacing of about 8 to 10 km (5 to 6 miles). The grid will not be perfectly regular; it will be adjusted so that we can study the effects that various geologic structures (above and below the surface) have on the strong shaking. Coverage will include metropolitan regions in Los Angeles, Orange and San Bernardino counties. The array will extend to the mountains north of the San Fernando and San Gabriel Valleys. The eastern limits will be in the vicinity of the eastern boundary of Los Angeles County, and the southern limit will be south of Santa Ana. The enclosed figure illustrates the target sites for our network of instruments, as well as the distribution of other accelerographs in the region.

The instruments are known as strong motion accelerographs; they begin recording when they first sense strong ground shaking, and stop recording when the shaking has ended. The specific instrument which we install will be a Kinemetrics SMA-1 strong motion accelerograph. The Kinemetrics SMA-1 is a rugged instrument contained in a lightproof and waterproof cast aluminum box. The box has dimensions of about 8" x 14", and 8" high. It has internal batteries which are kept ready by a trickle charger. The power requirement is negligible -- about a tenth of a watt. The instrument records on photographic film.

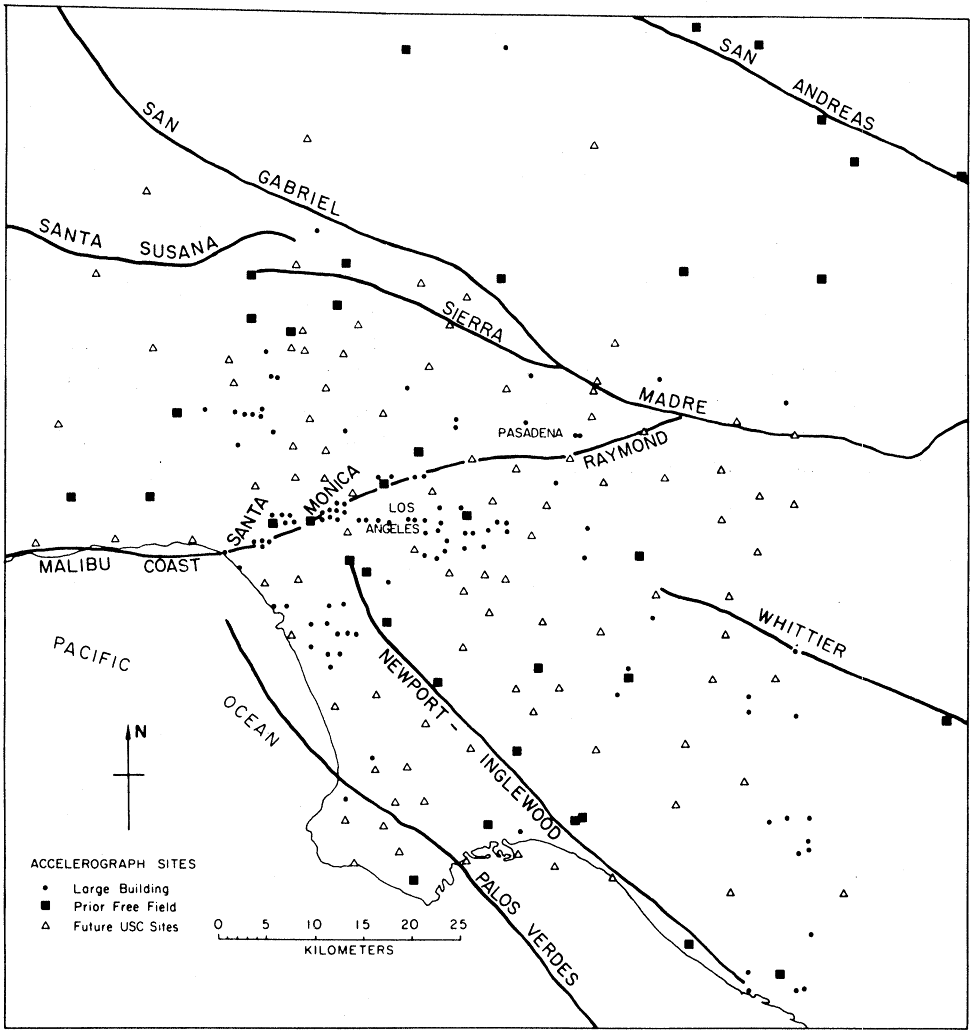
An ideal installation is in the basement or ground floor of a small building (one or two stories), on a concrete foundation poured directly onto the ground. Buildings such as fire stations, police stations, churches and schools are good for several reasons. Two important ones are that it is not likely that these buildings will change ownership and access to the building is controlled. The ideal installation will be in a quiet corner of the building where it is not likely to be bumped, since bumping an accelerograph may cause it to start to record in the same was as an earthquake. Thus, it is as important to us as to the owner of the building that

Strong Motion Accelerograph Network
Information Sheet

Page Two

the instrument be in a location which is out of the way and will not interfere with the daily operations. We would like a connection to AC power, but will be prepared to install as long an extension cord as is needed. The installation requires drilling one small hole in the concrete (about 1 1/2" deep, 3/4" in diameter) so that the instrument cannot slide during an earthquake.

Beyond providing the out of the way site and the tiny amount of power, we require very little. A small amount of time would be needed mainly from building maintenance personnel to help us examine and select a site and to let our technicians install the instrument. We will also need access to maintain the instrument with visits 2 or 3 times each year. The maintenance checkout usually requires about one-half hour at a site. It will also be important to us to have access to the instruments so that we can retrieve the records within a week after any earthquake. Aside from these time requirements on building personnel to give us access to the instruments, we will incur all the costs. All responsibility for the installation will be ours.


SAN ANDREAS
SAN GABRIEL
SANTA SUSANA
SIERRA MADRE
PASADENA
RAYMOND
SANTA MONICA
LOS ANGELES
MALIBU COAST
WHITTIER
PACIFIC OCEAN
NEWPORT - INGLEWOOD
PALOS VERDES
N
ACCELEROGRAPH SITES
• Large Building
■ Prior Free Field
△ Future USC Sites
0 5 10 15 20 25
KILOMETERS

PERMIT FOR INSTALLATION OF STRONG MOTION SEISMOGRAPH INSTRUMENTATION

Station:__________________________

Location:_________________________

City:_____________________________

County:___________________________

Permission is hereby granted the University of Southern California, Department of Civil Engineering, its officers, employees, agents and contractors, to enter with all necessary men and equipment upon our property in the County of ______________________________, State of California, described as:

____

____

for the purpose of installing and servicing Strong Motion Seismograph Instruments for earthquake recording. This work may require the installation of brackets for mounting of the instruments and in some case, the installation of a protective instrument housing.

This permission is given subject to the following conditions:

1. Reasonable precautions will be exercised to avoid damage to person or property.
2. The University of Southern California agrees to indemnify Permitter(s) for any injury or damage to persons or property which may result from the uses authorized by this permit, unless such injury or damage is caused by circumstances over which the University, its officers and employees, have no control.
3. Any instruments or fixtures installed by the University shall remain the property of the University. Upon removal of instruments, the property will be restored to its original condition.
4. This permit may be terminated by Permitter(s) giving written notice of termination to the Department of Civil Engineering, University of Southern California, Los Angeles, California, 90007, at least 30 days prior to the date of termination.

____
(Signature of Permitter)

____
(Address)

____

____

INDEMNIFICATION AND HOLD-HARMLESS AGREEMENT

The UNIVERSITY OF SOUTHERN CALIFORNIA, in consideration of being allowed to install and maintain certain strong motion accelerographs, such as the Kinemetrics SMA-1, or its equivalent, in selected buildings belonging to ____

____

____

(the building owner) does agree and covenant as follows:

1) To install such instrument only in thos locations specifically designated by the building owners.

2) To enter onto the premises of the buildings only with the approval of and in company with a representative of the building owner.

3) To indemnify and hold-harmless, the building owner, its organizations, subdivision, officers, agents and employees from and against any and all claims or damages resulting from injury to persons or damage to property, arising in any manner whatsoever from the installation, maintenance or occupancy of strong motion accelerographs on the property of the building cwner, or from the removal thereof from such property.

4) To excuse and indemnify the building owner, its organizations, subdivisions, officers, agents, members and employees from any and all responsibility, financial or otherwise, for any loss, damage, resulting inconvenience or loss of information occurring as a consequence of any and all injury to, disappearance, disconnection or theft of, any such strong motion accelerograph while such instrument is on the premises of the building owner.

IN WITNESS WHEREOF, the University of Southern California has executed this indemnification and hold-harmless agreement this ______________ day of ____________________.

WITNESS: UNIVERSITY OF SOUTHERN CALIFORNIA

________________________ BY: ____________________________

APPENDIX IV

The following forms were used to coordinate the laboratory checkout of the accelerographs. By following them, the checkout procedure is described completely:

A. Coordination Sheet

B. Reception Sheet

C. Initial Lab Checkout

D. Tilt Test Procedure and Interpretation

E. Clock Correction Data Sheet. We kept the frequent clock corrections for at least two to three weeks before installation to be sure the clock performed properly. This sheet was then assigned to the accelerograph site folder for continuous updating.

S/N 3811

STEPS TO APPROVE SMA-1 FOR FIELD INSTALLATION

	DATE COMPLETE	BY
1. Unpack box. Set up folder by serial number Fill out reception form.	12-27-79	JA
2. Carry out initial lab checkout Fill out form.	12-27-79	JA
3. Deliver battery chargers and connectors to Ray Galvin for assembly.	✓	JA
4. Tilt Test. Complete form.	12-27-79	JA
5. Set clock. Begin daily clock corrections. Perform corrections as specified by J.G. Anderson. Write data onto clock correction data sheet. After 7 days or more, find drift rate. If low enough, this test is complete.	✓	JA
6. Just prior to installation, run 30 sec record and be sure clock writes correct time code onto the record.	✓	JA

Approved for installation by JA

Date 2-27-79

SMA-1 ACCELEROGRAPH S/N 3811

Reception & checkout

Received with accelerograph?	Yes	No
KINEMETRICS CALIBRATION	✓	
MANUAL + SUPPLEMENT	✓	
BATTERY CHARGER	✓	
AMPHENOL CONNECTOR FOR BATTERY CHARGER	✓	
INSTALLATION KIT	✓	
ACCELEROGRAPH	✓	
CHARGER CONNECTOR COVER	✓	

VISUAL CHECKOUT - Note any questions or comments:

Looks ok.

Signed: JA

Date: 12-27-79

Date 12-27-79

S/N 3811

INITIAL LAB CHECKOUT

1. Adjust the following

   A. Lamp voltage (2.55v to 2.65v) 2.60
   B. Trace alignment ✓
   C. Set time switch to TCG-1 ✓

2. Measure:

   A. Battery voltage (no load) 13 V
   B. Current drawn by SMA-1 with clock (should be less than 6ma without charger) 5.5 mA

3. Set clock from TDC-2 and get first clock correction. (3.1 mA w/charger)

4. Put on lid.
   Insert connector from portable clock. ✓
   Run SMA-1 for 10 seconds.

   At 10 second before minute mark on portable clock: ✓
   turn key to: Test (2 sec)
   Calib. (2 sec)
   Nat. Freq. (2 sec)
   Calib. (2 sec)
   Test (2 sec)
   Off

5. Remove film.
   Scratch inst. serial number into exposed end of emulsion.
   Place film cartridge into light-tight box.
   Tape box closed.
   Write inst. serial number on tape.

6. Wind film back out of sprockets so it will not be used on next tests.

7. Starter actuates? [✓ Yes] / No
   Re-insert foam trigger protectors.

8. Run duration after triggering (11 - 13 sec) 11.5 Sec.

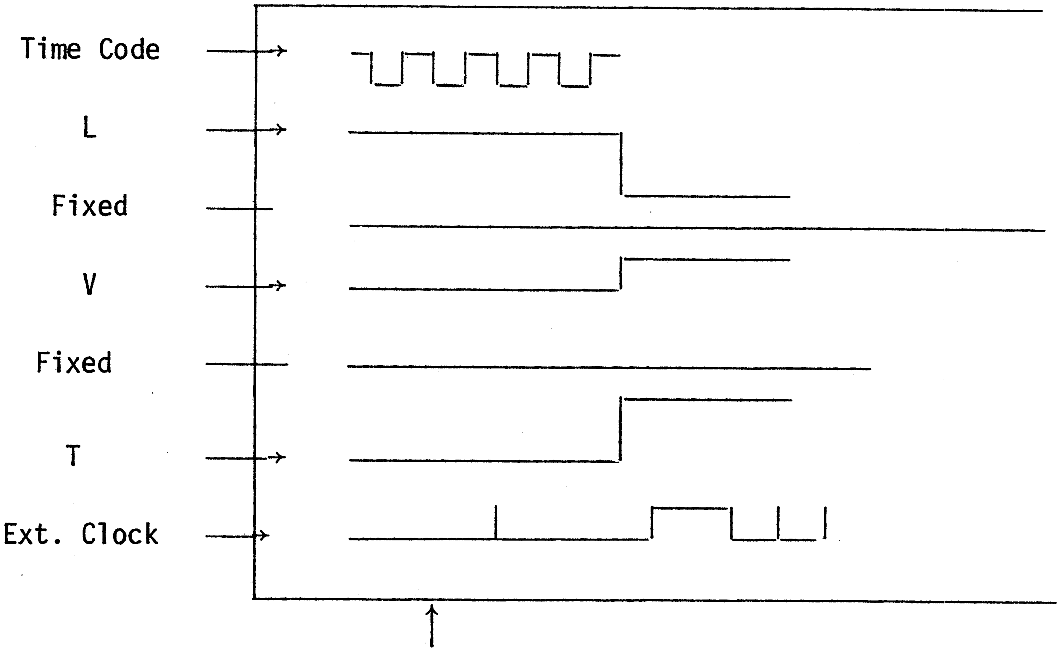
9. Initial clock checkout:

   A. Disconnect and connect TDC-2 several times (at least 10) to see if clock re-sets. Did it re-set? Yes / [✓ No]

Initial Lab Checkout
Page Two

10. Process film. Check for:

    A. All traces in focus (width <0.2mm)
    B. Traces aligned
    C. Time code generator gives time code on film OK.
    D. External clock impresses minute mark on film
    E. Time code from time code generator matches time code from external clock. OK.



Proper direction of calibration pulse

11. If traces are not in focus, re-set and repeat step 8.

12. Be sure screws holding accelerogrometers are tight. ✓

S/N 3811

Checked by JA

Date 12-27-79

TILT TEST PROCEDURE

1. Thread film. Attach cover.
2. Attach SMA-1 to tilt table.
3. Insert connector with switch into plug.
4. Run the following records in exactly this order:
    - A. Normal operation position. USE KEY.

      TEST (2 sec)

      CAL (2 sec)

      NAT. FREQ. (2 sec)

      CAL (2 sec)

      TEST (2 sec)
    - B. Rotated 90° about long axis. Key side down. Switch (1 sec).
    - C. Upside down.
    - D. Rotated 90° about long axis. Key side up.
    - E. Normal position.
    - F. Rotate base plate - normal position.
    - G. Rotate 90° about transverse axis. Key up in air.
    - H. Rotate 90° about transverse axis. Key in lower position.
    - I. Normal position (base plate rotated).
5. Repeat steps 4B, D - I. But this time all rotations are 30° from horizontal.
6. Run. TEST (2 sec)

   CAL (2 sec)

   NAT. FREQ. (2 sec)

   CAL (2 sec)

   TEST (2 sec)

   OFF.

7. Remove film. Scratch in serial number.
8. Process film.

Serial No. 3680

Date ______________

TILT TEST ANALYSIS

1. Key calibration.

A. Distance on film between time markers:

Top 2 sec = — mm. Rate = — mm/sec.

Bottom 2 sec = 20 mm. Rate = 10 mm/sec.

B. Offset of trace in CALIB position. Overshoot.

	OFFSET		OVERSHOOT	
Long.	4.5	mm	.5	mm
Vert.	4.6	mm	.5	mm
Trans.	4.0	mm	.59	mm

	OVERSHOOT RATIO	DAMPING	SENSITIVITY
L	.111	57.3	19.2
V	.109	57.7	18.3
T	.147	52.0	17.7

C. Natural Frequency

	Cycles	in	mm	Frequency
L	10		4	25.
V	20		7.6	26.3
T	8		3	26.6

2. Tilt Test.

A. Key to accelerations

Interval	1	2	3	4	5	6	7	8	9	10
L	0	0	0	0	0	0	0	1g	-1g	0
V	0	0	-1g	-2g	-1g	0	0	-1g	-1g	0
T	0	0	-1g	0	1g	0	0	0	0	0

B. Displacements (mm)

	1	2	3	4	5	6	7	8	9	10
L								19.2	19.3	
V			17.9	N.A.	18.7			18.1	18.4	
T			17.6		17.7					

A. Key to accelerations

Interval	11	12	13	14	15	16	17	18
L	0	0	0	0	0	+0.5g	-0.5g	0
V	0	-0.134g	-0.134g	0	0	-0.134g	-0.134g	0
T	0	-0.5g	+0.5g	0	0	0	0	0

B. Displacements (mm)

	11	12	13	14	15	16	17	18
L						9.7	9.5	
V		2.6	2.4			2.4	2.5	
T		8.8	8.8					

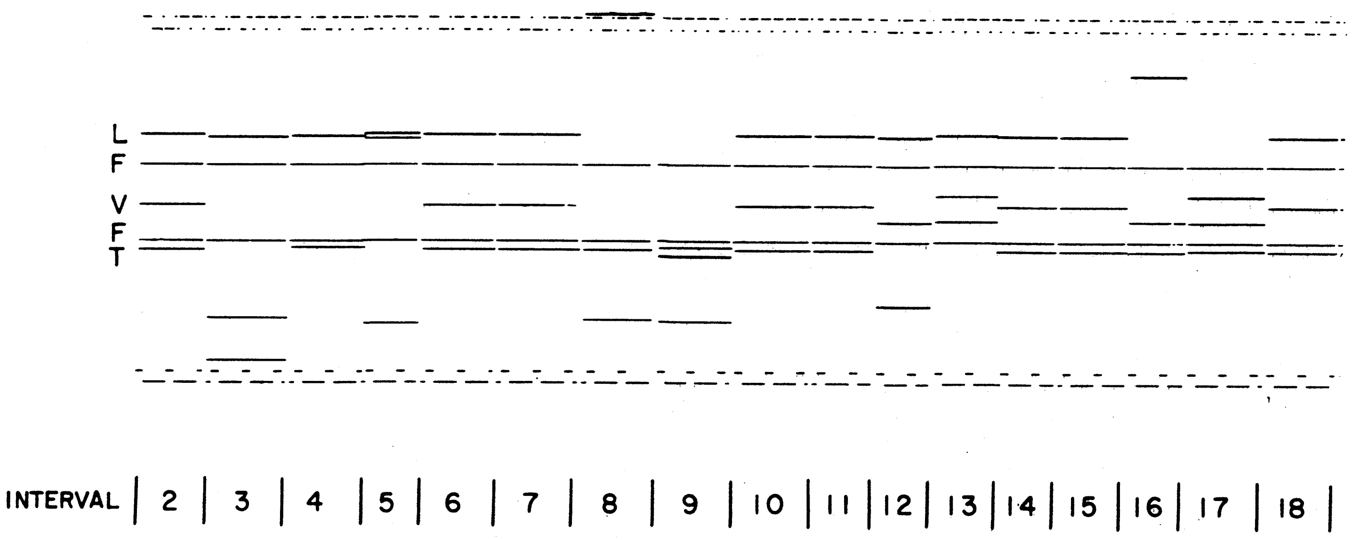


Fig. 30. Sample record from a tilt test. Interval corresponds to the tilt test analysis sheet.

SERIAL NO. 3811

CLOCK CORRECTION DATA SHEET

Date	Portable Reference Cloc		Reference Time	SMA Instrument Time	Total Cor.
	Ser.#	Cor.			
3/4/80	102	.108	065-00-43-04	065-00-43-04.000	.108
3/12/80	102	.130	072-21-47-01	072-21-47-00.980	.150
3/18/80	102	.116	078-19-04-57	078-19-04-56.964	.152
4/3/80	102	.213	094-19-13-05	094-19-13-04.983	.230
4/18/80	102	.229	109-19-03-24	109-19-03-23.978	.251
7/9/80	101	-2 min. -.333	191-16-37-49	191-16-35-48.212	.455

APPENDIX V

The following sheets were used for station description:

A. Station Data Summary.

B. Station Data Sheets: These have not been filled out completely for all the sites, and much of the information requested on them is unknown. It suggests what a complete site documentation might look like. Parts of this form are adopted from data sheets in use by the California Division of Mines and Geology.

USC ACCELEROGRAPH STATION DATA SHEET

USC Site No.: 14

Site Name: Van Nuys (Los Angeles City Fire Station #108)

Address: 12520 Mulholland Drive
Beverly Hills, Ca. 90210

Station Data:

Topographic Quadrangle: Van Nuys

Coordinates: 34.1269 °N 118.4053 °W

Elevation: 1100 FT. SMA-1 Serial No.: 3811

Orientation: Longitudinal 122 Transverse 32

****

For maintenance contact:

Position: Captain on duty

Address if different:

Telephone: Work ( ) ; Home ( )

Phone ahead? Yes ____ No ____ Normal Hours:

Local permission contact: Mike Nares / Judy Bisetti / Peter R. Lucarelli

Position: Administrative Assistant / Battalion Chief

Address if different: Los Angeles City Fire Department
200 North Main Street
Los Angeles, Ca. 90012

Telephone: Work (213) 485-5961 ; Home ( )

Formal permission contact: Don Gamble

Position: Building Maintenance Superintendent

Address if different: Department of General Services
200 North Main Street
Los Angeles, Ca. 90012

Telephone: Work (213) 485-5858 ; Home ( )

****

Notes:

USC No. ____________

STATION LOCATION SHEET

Department of Civil Engineering
University of Southern California

Station ______________________ Installation Date ____________
Address ______________________ County ____________________
____
Contact ______________________ Phone ____________________
Position ______________________ Phone ahead: Yes ___ No ___
Keys ______________________ Service Hours ______________
Topo Quad. ______________________ Coordinates ______°N ______°W
Cross Streets (nearest) __________________________________
Parking ____
Recorder Location _______________________________________
Housing Type ______________________ Charger Type ____________
Instrument __________ S/N ____________
Orientation of Axis ____________ (Motion of case for positive acceleration trace).
Notes: ____
____

ATTACH MAP
HERE

University of Southern California USC No.__________

STRUCTURAL DATA

Building Name ______________________________

Address ______________________________

____

General Description ______________________________

____

Construction Details

Number of Levels: Basement? yes / no

Foundation:

Outside Walls: Material Outside __________

Material Inside __________ Total Thickness __________

	Ave. height	%doors & Windows	Shape
Wall 1			
2			
3			
4			

Comments

Roof: Material outside __________ inside __________

Shape:

Comments:

Interior walls: Construction

Amt. of open space:

Comments:

Interior floors:

Comments:

General Comments:

Sketch building to scale and attach to this report. Sketch room containing accelerograph to scale and attach to this report.

GEOLOGICAL DATA SUMMARY SHEET

Station Name ____________________ Site Geology Completed (date)________

Location ____________________ Photographed__________;__________

____________________ __________;__________;__________

County ____________________ Geol. Map, CA__________________Sheet

Topo Quad ____________________ GOORD: Lat ________N Long__________W

REGIONAL GEOLOGY Geomorphic Province ____________________

Discussion ____

____

SITE GEOLOGY Geology of Foundation Materials ____________________

____

____

____

Possible Geologic Hazards ____________________H_2O Table Depth_____

Comments____

____

Geophysical Data____

Estimated Max. Cred. Bedrock Acc. at Site__________Source__________

FAULTS

Name	Dist. from Site at Closest Point	Fault Length	Sense of Movement	Class.	Max Cred	Max Prp

Discussion____

____

____

SEISMICITY Severity Zone: Low___ Moderate___ High___(from CDMG Bu. #113

Location and Date	Magnitude (M) Intensity (I)	Related to Which Fault	Remarks

Discussion ____

____

____

USC No. ________________

GEOLOGICAL DATA SUMMARY SHEET (page 2)

Stratigraphic column at site

Formation/unit	Brief description	Thickness, V_p, V_s, Density

Elevation
Topography at site

Describe briefly how geology and topography change in all directions.

APPENDIX VI

The following are field checklists:

A. Installation Checklist.

B. Accelerograph Inspection Report.

C. Rapid Accelerogram Recovery Report.

LAB PREPARATION FOR INSTALLATION TRIP

1. Material for each site:

   Accelerograph (bring one spare)
   Two locks
   Installation kit
   Empty film cassette
   Battery charger
   Folder
   Topographic map

2. Other equipment from lab:

   TDC-2 portable clock
   Camera
   Compass

3. Lab Preparation:

   Clock correction on SMA
   Clock correction on TDC-2
   Call sites in advance

Site #14

FIELD INSTALLATION PROCEDURE

A. In Lab:

a) Set clock, get clock correction.
b) Be sure all lab checks are complete. ✓

B. Drill hole, install, carefully level SMA-1. ✓

C. Install and attach battery charger. ✓

D. Accelerograph Installation Inspection:

(1) Timing switch: should be TCG1 : 2PPS / [✓ TCG1] ✓
Film supply (< 1/3, replace): ✓
Lamp voltage (2.55 - 2.65): 2.59
Trace alignment: ✓

Battery charger: [✓ Yes] / No Voltage: 17.60

(2) Put on lid.
Is trace alignment screen out of SMA-1? [✓ Yes] / No ✓
Insert connector from portable clock. ✓
Run SMA 15 seconds. ✓

At 15 sec before minute mark on portable clock: ✓
Turn key to: Test (2 sec)
Calib. (2 sec)
Nat. Freq. (2 sec)
Calib. (2 sec)
Test (2 sec)
Off

Note here time of minute mark on portable clock: 109-18-50

(3) Remove film.
Scratch inst. serial number into exposed end of emulsion. ✓
Place film cannister in light-tight box.
Tape box closed.
Write inst. serial number onto tape.
Bring to lab for processing.

(4) Wind film back out of sprockets so it will not be used in next tests. ✓

(5) Battery voltage: 12.79 V Load: 12.35 V
Starter actuates: [✓ Yes] / No
Trigger sensitivity: + 157 - 55
(for +, red lead is toward the close end of SMA-1)

Nominal trigger sensitivity is 70 to 90 (x 10^{-4} g)

Field Installation Procedure
Page Two

Site # 14

D. (5) (Continued)

If re-set trigger: + 72 - 74
+ ______ - ______
+ ______ - ______

(6) Duration of run after triggering (sec): 13 Sec.

(7) Put alignment screen into SMA.
Run test-calibrate-natural frequency.
Do both timing relays move? [✓ Yes] / No
Do all three accelerometer traces move? [✓ Yes] / No

(8) Clock: Days in year: 365 / [✓ 366]

Clock correction data:

(used TDC-2 #102)

Trial	SMA-1 Time	Portable Clock	Lab(+ .229)
1	109-19-02-41.978	109-19-02-42	+ .022
2	109-19-03-23.978	109-19-03-24	+ .022
total	clock correction	= Portable clock Corr.	+ SMA-1 Clock Corr.

= (+ .229) + (+ .022) = .251

(9) Was clock re-set? Yes / [✓ No]
Indicate trial where it was re-set.

(10) Load film.
Be sure it runs smoothly. ✓
Replace cover.

(11) Is alignment screen out of the SMA-1? [✓ Yes] / No

(12) Is timing switch on TCG-1? [✓ Yes] / No

(13) Repeat Step 2. Time of minute mark: 109-19-09

(14) Turn key to "Operate" ✓
Remove key.

(15) Event indicator ([✓ Black] / White)

Field Installation Procedure
Page Three

Site *# 14*

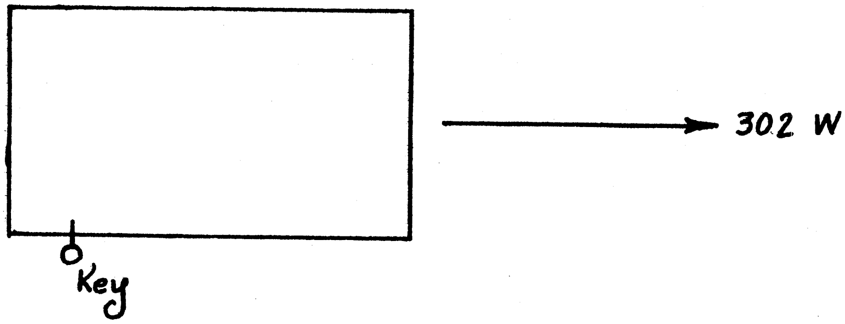
(16) Is the instrument locked? [✓ Yes] / No

(17) Film, battery, parts replaced: *No*

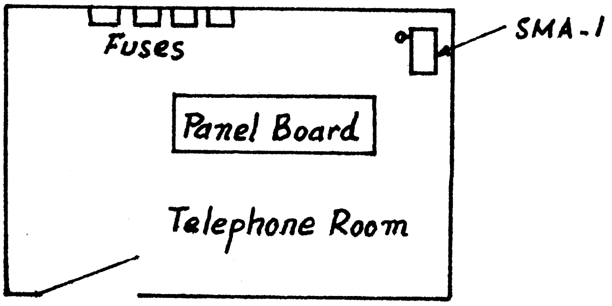
(18) Other comments:

None

E. Determine SMA-1 orientation. Sketch here:



F. Draw plan of building, and show SMA-1 location:
(See also next page)



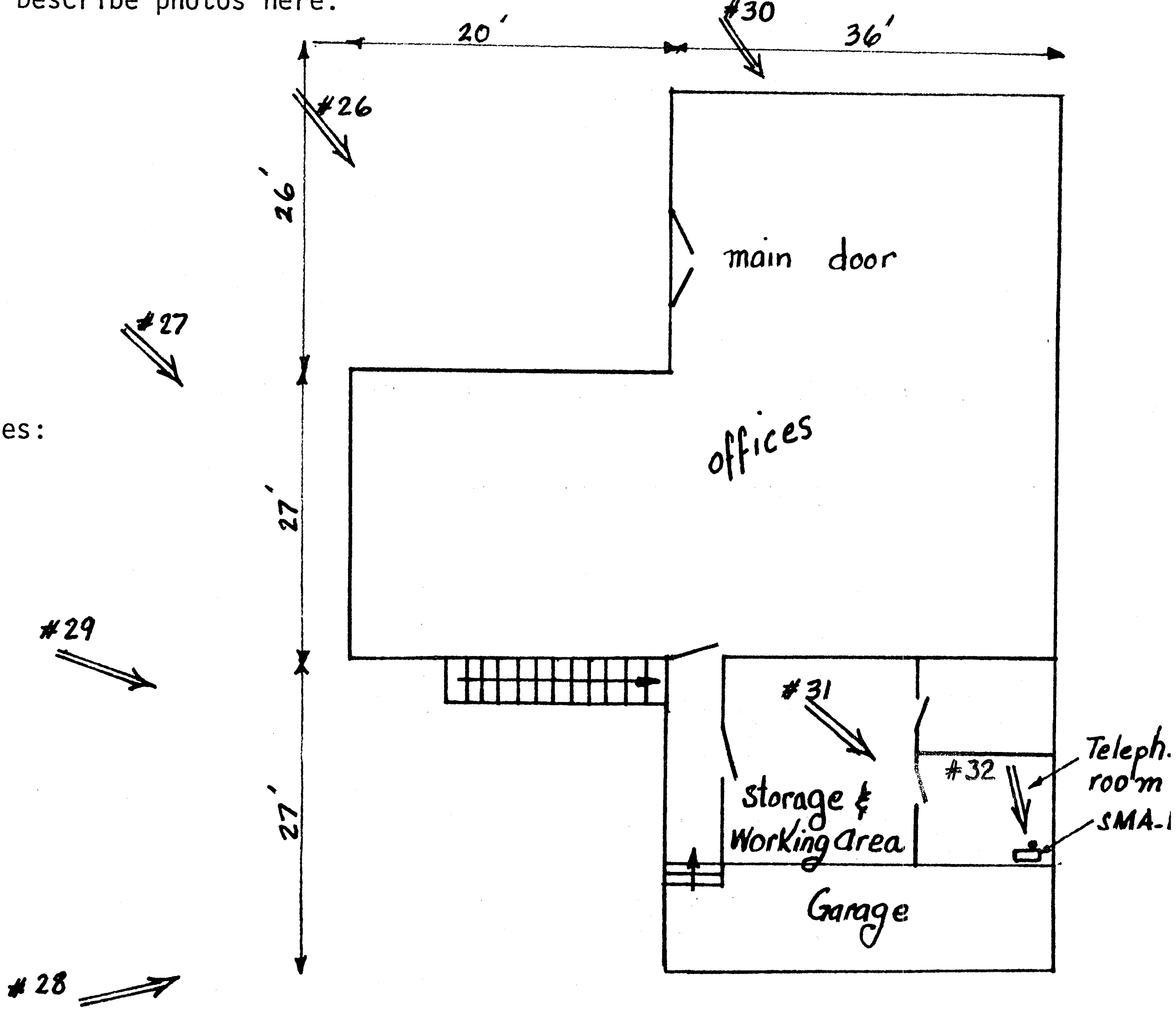
G. Complete station location sheets as much as possible. ✓

Field Installation Procedure
Page Four

Site # 14

H. Mark exact SMA-1 location on topo sheet. ✓

I. Photograph site from all angles. Several shots.
Describe photos here.



Notes:

SMA-1 Serial Number: 3811

Installed by A. Amini & R. Galvin

Date 4/18/80

LAB PROCEDURE AFTER INSTALLATION TRIP

1. Clock correction on TDC-2.
2. Compute and log clock correction of SMA at installation.
3. Mark site locations on Lab Copy of topo map.
4. Measure latitude and longitude.
5. Develop film record.
6. Check film record for:
    a) All accelerometers working
    b) Time traces working
    c) Time codes on film give proper clock correction
7. Mark installation date on wall chart.
8. Label slides of site and put in folder.

ACCELEROGRAPH INSPECTION REPORT

Date 7/9/80	SMA-1
Station #14	S/N 3811

1. Event indicator: [✓ Black] / White

2. Insert connector from portable clock into SMA-1. Turn key to:

TEST (2 sec)
CALIBRATE (2 sec)
NATURAL FREQUENCY (2 sec)
CALIBRATE (2 sec)
TEST (2 sec)
OFF

Time of portable clock: 191-16-22

3. Repeat Step 2. 191-16-23

4. Remove film; scratch instrument serial number and site number into exposed end of emulsion; place film in light-proof box; bring to lab for processing. ✓

5. Wind film back out of sprockets.

6. Timing switch position: [✓ TCG-1]/2PPS

Film supply (<1/2, replace): >1/2

Lamp voltage: 2.75 V

Battery Charger: 15 V

Battery voltage: No Load: 13 V

Load: 12.8 V

7. Insert alignment screen.
Check trace alignment, adjust if needed
Was the alignment adjusted? Yes / [✓ No]

8. Turn key to Test-Cal-Natural frequency.
Do both timing relays move? [✓ Yes] / No
Do all three accelerometer traces move? [✓ Yes] / No
Remove alignment screen.

9. Starter activates: [✓ Yes] / No
Trigger sensitivity: + 86 - 86

10. Duration of run after triggering: 13 Sec.
Clock: Days in year: 365 / [✓ 366]

Accelerograph Inspection Report
Page Two

Station # 14
S/N 3811

11. Clock Correction Data:

Date	Portable Reference Clock Ser. #	Cor.	Reference Time	SMA Instrument Time	Total Cor.
7/9/80	TDC-2 # 101	-2 min -.333 Sec.	191-16-33-25	191-16-31-24.212	+ .455
7/9/80	TDC-2 # 101	-2 min. -.333 Sec	191-16-37-49	191-16-35-48.212	+ .455

12. Load film. Be sure it runs smoothly. Replace cover. ✓

13. Is the alignment screen out of the SMA-1? [✓ Yes] / No

14. Is timing switch set to TCG-1? [✓ Yes] / No

15. Run SMA for 10 seconds. ✓

16. Repeat Step 2. Time of minute mark: 191-16-40

17. Turn key to operate; remove key. ✓

18. Event indicator: [✓ Black] / White

19. Is the instrument locked? [✓ Yes] / No

20. Film, batteries, parts replaced: None

Accelerograph Inspection Report
Page Three

Station # 14
S/N 3811

21. Other Comments:

None

Serviced by: K. Moslem

In Lab

22. Process record, attach here:

See Figure ____ in text

23. Clock correction for reference clock at time of service: -2 min & -.333 Sec
Clock correction for SMA-1 clock: +.455
(Write this time and clock correction onto clock correction summary sheet)

Completed By: Bobby Chang

RAPID
ACCELEROGRAM
RECOVERY
REPORT

Date

Station

SMA-1

S/N

1. Event indicator: Black / White

2. Insert connector from portable clock into SMA-1. Turn key to:

   TEST (2 sec)
   CALIBRATE (2 sec)
   NATURAL FREQUENCY (2 sec)
   CALIBRATE (2 sec)
   TEST (2 sec)
   OFF

   Time of portable clock: ______________________

3. Repeat Step 2. ____________

4. Remove film; scratch instrument serial number and site number into exposed end of emulsion; place film in light-proof box; bring to lab for processing.

5. Timing switch position: TCG-1/2PPS

   Film Supply (<1/2, replace):

6. Insert alignment screen.
   Check trace alignment, adjust if needed.
   Was the alignment adjusted: Yes / No

7. Turn key to Test-Cal-Natural frequency.
   Do both timing relays move? Yes / No
   Do all three accelerometer traces move? Yes / No
   Remove alignment screen.

8. Starter: Yes / No

9. Clock Correction Data:

Date	Portable Reference Clock Ser. #	Cor.	Reference Time	SMA Instrument Time	Total Cor.

Accelerogram Recovery Report
Page Two

Station ______________
S/N ______________

12. Load film. Be sure it runs smoothly.
Replace cover. ______________

13. Is the alignment screen out of the SMA-1? Yes / No

14. Is timing switch set to TCG-1? Yes / No

15. Run SMA for 10 seconds. ______________

16. Repeat Step 2. Time of minute mark: ______________

17. Turn to operate; remove key.

18. Event indicator: Black / White

19. Is the instrument locked? Yes / No

20. Film, batteries, part replaced:

21. Other comments:

Serviced by: ______________________________

In Lab

22. Process record, attach here:

23. Clock correction for reference clock at time of service: ______________
Clock correction for SMA-1 clock: ______________
(Write this time and clock correction onto clock correction summary sheet).

Complted by: ______________________________

ACCELEROGRAPH FIELD VISIT REPORT

Date________________

Mileage: Start: ____________

End: ____________

Miles Driven: ____________ Expense @ 17¢/mi:____________

Expenses:

TOTAL OTHER EXPENSES: ____________

TOTAL REFUND: ____________

Sites visited and summary of results:

Signature: ________________________

Attach receipts.