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COMMONWEALTH OF AUSTRALIA

DEPARTMENT OF NATIONAL DEVELOPMENT

# BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS.

RECORDS

1960 NO.5

# GTV 9 STUDIO, VIBRATION TESTS, RITCHMOND, VICTORIA, 1959.

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## ILLUSTRATIONS.

## ABSTRACT.

The attenuation of ground vibrations has been measured at the site of a proposed television studio. The attenuation co-efficient is larger over the first 25 ft. from a vibration source than it is from this distance outward.

The experimentally derived attenuation coefficient is used to calculate the ground acceleration which may be expected from a passing motor vehicle. This acceleration is compared with the acceleration to which an electron microscope may be safely subjected.

Vehicles passing along the nearest street to the site, produced no detectable movement of the seismograph ; it is concluded that they would have no effect on a television camera.

## INTRODUCTION.

This report describes an investigation carried out by the Bureau of Mineral Resources, Geology and Geophysics at the request of Mr. Peter Spier ARAIA, architect, who is designing a new sound-recording studio to be built at the General Television Corporation (GTV 9) Studios, Bendigo Street, Richmond, Victoria.

The structure will consist basically of two masonry rooms, one within the other; it is desired that the noise level within the structure, of sounds from external sources, be kept below that prescribed in a United States of America regulation governing television studio buildings. The architect was concerned about the possible influence on the television cameras of vibration due to traffic, and he wanted information about the attenuation of ground vibrations at the studio site.

The attenuation characteristic of the ground was measured by recording the ground vibrations produced by small explosive charges fired at various distances from a point located within the building site. The work was done by several geophysicists from the Engineering Group of the Bureau on the 12th November, 8th December and 10th December 1959; the data were collated by the authors. The instrument used to record the vibrations was a Sprengnether Portable Blast and Vibration Seismograph (Serial No. 1577).

## INSTRUMENT AND METHODS.

The Sprengnether seismograph records on a moving photographic strip the ground motion in three mutually perpendicular directions. The photographic paper is run for a short moment before the firing of the shot and stopped after the elapse of an interval of time sufficient to ensure that a complete record of the oscillation has been taken. Timing lines are printed on the record at 20-millisecond intervals. The magnification factor of the instrument is 100; i.e. a displacement of one inch of a trace on the photographic record represents an actual ground displacement of 0.01 inches.

In the vibration tests conducted on the 8th November, electric detonators (Nobel No.6) were used as the energy source. Two series of shots were fired; in one series two detonators were exploded at distance of 10, 15, 25 and 35 ft. from the recording point, and the second series used four detonators fired at distances of 10, 15, and 25 ft. The records were photographically enlarged ten times to enable the amplitudes of vibration to be measured. The results of the experiments using the detonators were inconsistent and it was decided to repeat the work.

The vibration tests conducted on the 8th December were marred by a technical fault and were repeated on 10th December. In this series of tests vibrations were recorded when 40-gram and 70-gram charges of AN-60 gelignite were each fired at distances of 10, 20, 30, 40, 50, and 75 ft. from the recording point. Records were taken also when a 38-lb weight was dropped through a free fall of 3ft. 6 in. at distances of 5, 10, 15 and 20 ft. from the seismograph.

## RESULTS.

Plate 1 shows the locality of the survey and the positions of the seismograph and shot points for the tests conducted on the 8th November and 10th December.

Plates 3, 4 and 5 show reproductions of some of the seismograms. The amplitudes of the recorded vibrations of tests carried out on the 8th November were quite small; to increase the amplitude, small charges of gelignite were used in the tests of the 10th December.

In order to ensure that the explosions were uniform the charges were accurately weighed. 40-gram charges were used in one series of tests, and 70-gram charges in another. For each series it will be assumed that ../2 every explosion transmitted the same amount of energy to the ground.

In the argument which follows, certain terms require definition; they are :

Instantaneous Amplitude - the amplitude of the recorded vibration from the rest position. This is measured at the same instant for each of the three recorded components of the ground motion.

Instantaneous Frequency - The frequency of the recorded vibration measured at the same instant as the instantaneous amplitudes.

Resultant Amplitude - the square root of the sum of the squares of the three instantaneous amplitudes.

Table I lists the instantaneous amplitudes and frequencies scaled from the seismograms, and the resultant amplitudes and ground accelerations calculated from the scaled figures. The time at which the scalings were made is the time at which the resultant amplitude is at its maximum value.

If the distance from the source of vibrations increases, the amplitude of the vibration decreases because -

(a) the energy from the source is spread over a larger volume, and

(b) energy is dissipated by friction ; both solid friction between adjacent particles of the soil, and fluid friction in the fluid which fills the pore spaces of the soil.

The amplitude of the vibration is therefore a complex function of the distance from the source; the relation of the two is often simplified to the exponential form :

$$A_x = A_o \exp(-mx)$$

where $A_o$ is the amplitude of vibration of an arbitrary point.

$A_x$ is the amplitude of vibration at a distance X (measured in a direction away from the source) from the arbitrary point.

m is a constant which depends on the ground material and may be loosely termed the attenuation coefficient.

If the attenuation of vibration can be exactly expressed by the exponential form, the attenuation coefficient is equal to the gradient of the straight line obtained when the resultant amplitude on a logarithmic scale is plotted against distance on a linear scale, as shown on Plate 2.

Each series of tests using explosives to initiate the shock wave gave results of the same form; namely, a large attenuation coefficient (about 0.20) for a distance up to approximately 25ft. from the explosion, and a much small coefficient (about 0.019) at greater distances.

The results of tests using the weight-dropping method to initiate the shock wave confirm the larger figures at short distances; however the shock is too weak to be recorded at distances much greater than 20 ft. The high value of the attenuation coefficient for short distances agrees with the figure 0.18 derived by Polak (1959) for overburden at Clayton, Victoria.

A criterion commonly used to assess the effect of vibrations is the acceleration of the ground. On the assumption that the motion of the ground is simple harmonic, the relation between maximum acceleration (a), frequency (f) and amplitude (A) is :

$$a = 4\pi^2 f^2 A$$

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The resultant acceleration of the ground has been computed by taking the square root of the sum of the squares of the acceleration of each component. The manufacturer of an electron microscope quotes the figure of 0.4 in. per sec.$^2$ as the maximum acceleration to which the instrument should be subjected during use (Polak and Bamber, 1959).

The smallest amplitude which can be scaled from a seismogram (without enlargement) is 0.01 in. from peak to trough. If the smallest amplitude which can be scaled from the seismogram is recorded simultaneously by each component of the seismograph, a vibration of frequency 50 cycles per sec. (the highest frequency recorded in the tests of 10th December) involves a ground acceleration of 8.4 in. per sec.$^2$ This is about twenty times the maximum acceleration to which an electron microscope can be subjected.

Plate 5 shows a seismogram taken when a heavy motor truck and a sedan car travelled close together down Stawell Street about 200 ft. from the seismograph. No vibration was detected. It is probably a reasonable deduction that traffic in Stawell Street does not produce a ground acceleration greater than ten times the critical value to which an electron microscope can be subjected.

Thoenen and Windes (p.13) recorded a vibration amplitude of 0.0003 in. due to a coal truck passing 30 ft. from a recording station. If this figure is accepted as representative of heavy vehicles, the amplitude of ground motion can be calculated for greater distances by use of the attenuation coefficient 0.019 derived by experiment. For example at 100 and 200 ft. the ground amplitudes and accelerations at two selected frequencies representative of traffic (Steffens, 1952, p.14) would be as follows :

| Distance from passing truck (ft.) | Vibration amplitude (in.) | Ground acceleration (in. per sec.$^2$) | |
|---|---|---|---|
| | | 50 c/s | 25 c/s |
| 30 | 0.0003 | 30 | 7.5 |
| 100 | 0.000079 | 7.9 | 2.0 |
| 200 | 0.000023 | 2.3 | 0.6 |

The amplitude even at 100 ft. would be too small to be detected by the seismograph used for the tests.

## CONCLUSIONS.

At the site of the new studio the amplitude of ground vibrations decreases as the distance from the source increases. The attenuation coefficient for the ground tested is about 0.20 for distances up to about 25 ft. from the source but the coefficient changes to about 0.019 from this distance outwards.

The nearest road is Stawell Street about 200' from the studio site. Vehicular traffic in Stawell Street produced no detectable movement of the seismograph, which confirms the theoretical prediction that no vibration would be recorded from vehicles passing at a distance of 100 ft. from the seismograph.

It has been shown that a ground movement too weak to be recorded by the seismograph might still involve fairly large ground accelerations - as much as twenty times the maximum acceptable for a site where an electron microscope is to be used.

As the magnification of electron beams in a television camera is very much less than in an electron microscope it is a reasonable assumption that any ground vibrations too weak to be recorded by the siesmograph will not affect a television camera.

## REFERENCES


POLAK, E.J., 1959 - Vibration tests at Kirkstall-Repco Pty. Ltd., Clayton, Victoria. Bur. Min. Resour. Aust.Rec. 1959/65

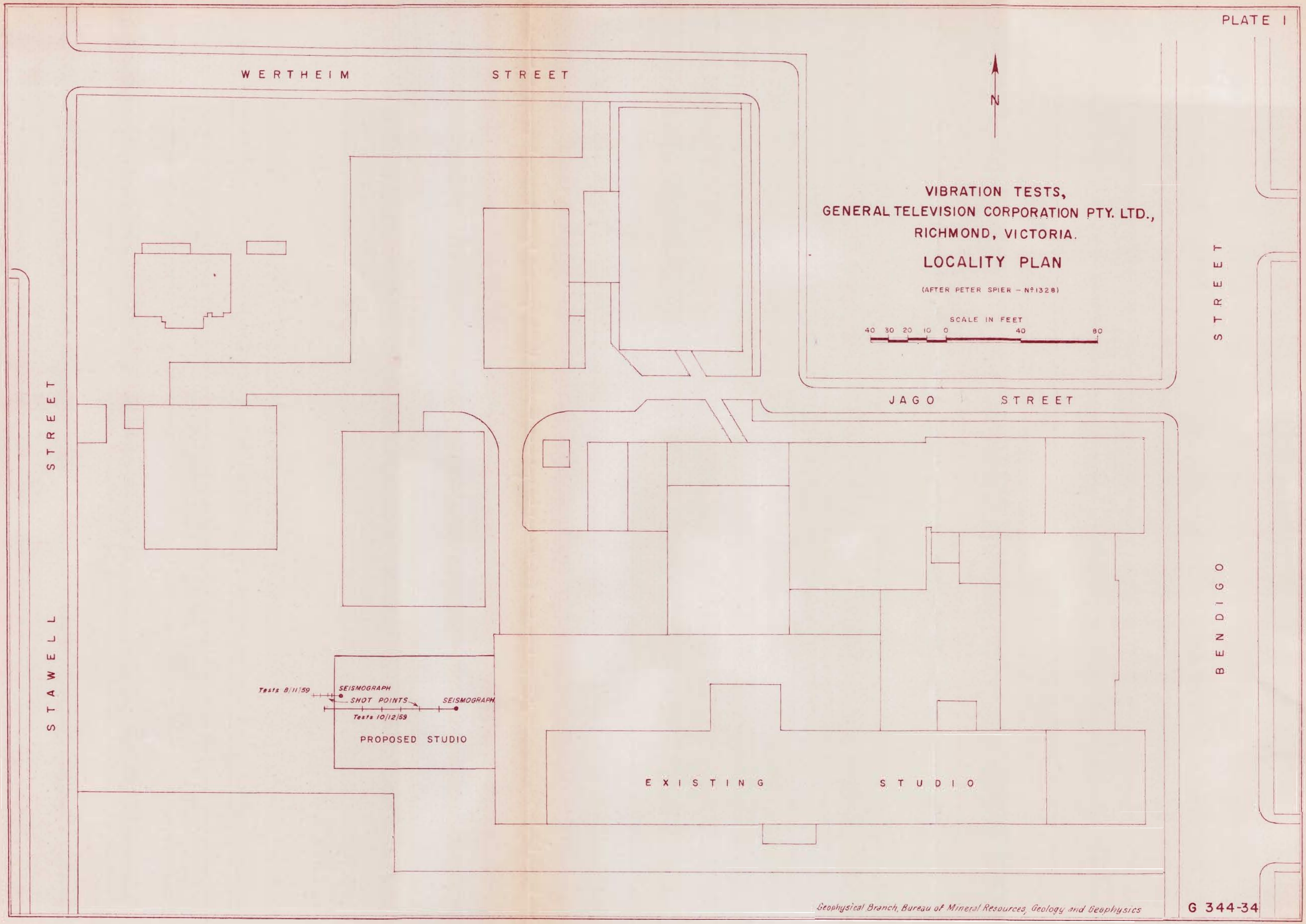
POLAK, E.J. and BAMBER, B., 1959 - Vibration tests at C.S.I.R.O. laboratory, Fishermen's Bend, Melbourne. Bur.Min.Resour.Aust. Rec. 1959/81.

STEFFENS, R.J., 1952 - The assessment of vibration intensity and its application to the study of building vibrations. Nat.Build.Stud.spec.Rep. 19 (H.M.S.O.)

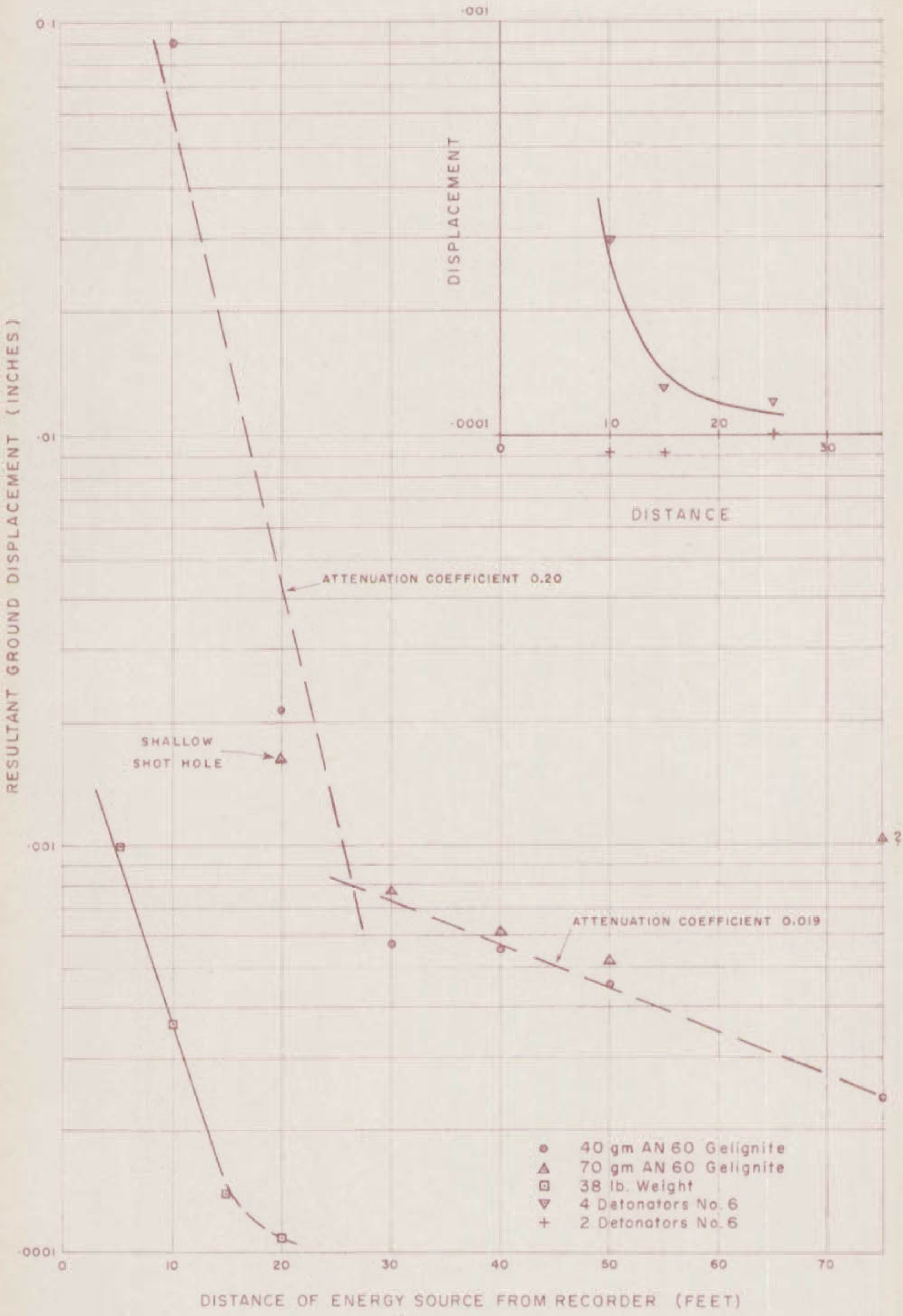
THOENEN, J.R. and WINDES, S.L., 1942 - Seismic effects of quarry blasting. Bull. U.S. Bur.Min. 442.

TABLE I.

| | Distance | Longitudinal | | Vertical | | Transverse | | Resultant | Ground |
|---|---|---|---|---|---|---|---|---|---|
| | | $A_L$ | $f_L$ | $A_V$ | $f_V$ | $A_T$ | $f_T$ | A | Accel/n |
| | | in. | c/s | in. | c/s | in. | c/s | in. | in/sec.$^2$ |
| | 10' | 0.0188 | 10 | .0025 | 20 | .0019 | 10 | .0191 | 84.1 |
| 10/12/59 | 20' | .0020 | 25 | .0001 | 25 | .0007 | 25 | .0021 | 53.7 |
| 40 gram | 30' | .0005 | 30 | .0002 | 50 | .0002 | 25 | .00057 | 26.9 |
| AN 60 | 40' | .0005 | 30 | .0001 | 50 | .0002 | 25 | .00055 | 21.0 |
| gelignite | 50' | .0004 | 30 | .0001 | 50 | .0002 | 30 | .00046 | 18.5 |
| | 75' | .0002 | 30 | .0001 | 30 | .0001 | 25 | .00024 | 1.8 |
| | 10' | (Motion too fast to record satisfactorily) | | | | | | | |
| 10/12/59 | 20' | .0013 | 20 | .008 | 20 | .0005 | 25 | .0016 | 27.4 |
| 70 gram | 30' | .0007 | 25 | .0003 | 50 | .0001 | - | .00077 | 34.6 |
| AN 60 | 40' | .0006 | 25 | 0 | 30 | .0001 | 25 | .00061 | 15.0 |
| gelignite | 50' | .0005 | 25 | .0001 | 30 | .0001 | 25 | .00052 | 16.0 |
| | 75' | .0009 | 25 | .0005 | 25 | .0001 | 25 | .0010 | 25.8 |
| | 5' | .0009 | 25 | .0004 | 50 | .0001 | 25 | .00099 | 46.0 |
| 10/12/59 | 10' | .0002 | 25 | 0 | 50 | .0003 | 25 | .00036 | 89 |
| 38 lb. | 15' | .0001 | 25 | .0001 | 50 | 0 | 25 | .00014 | 10.3 |
| weight | 20' | .0001 | 25 | 0 | - | .0001 | 25 | .00014 | 36 |
| | 10' | .00007 | 50 | .00005 | 100 | .00003 | 50 | .00009 | 21.4 |
| 8/11/59 | 15' | .00007 | 50 | .00006 | 100 | .00002 | 50 | .00009 | 25.0 |
| 2 | 25' | .00009 | 50 | .00004 | 100 | .00002 | 50 | .00010 | 18.3 |
| Detonators | 35' | Motion too small to be read accurately | | | | | | | |
| | 10' | .00026 | 50 | .00013 | 100 | .00003 | 50 | .00029 | 67.0 |
| 8/11/59 | 15' | .00010 | 50 | .00008 | 100 | .00003 | 100 | .00013 | 34.6 |
| 4 Detonators | 25' | .00010 | 50 | .00006 | 100 | .00001 | 100 | .00012 | 27.2 |




To Accompany Records 1960-5

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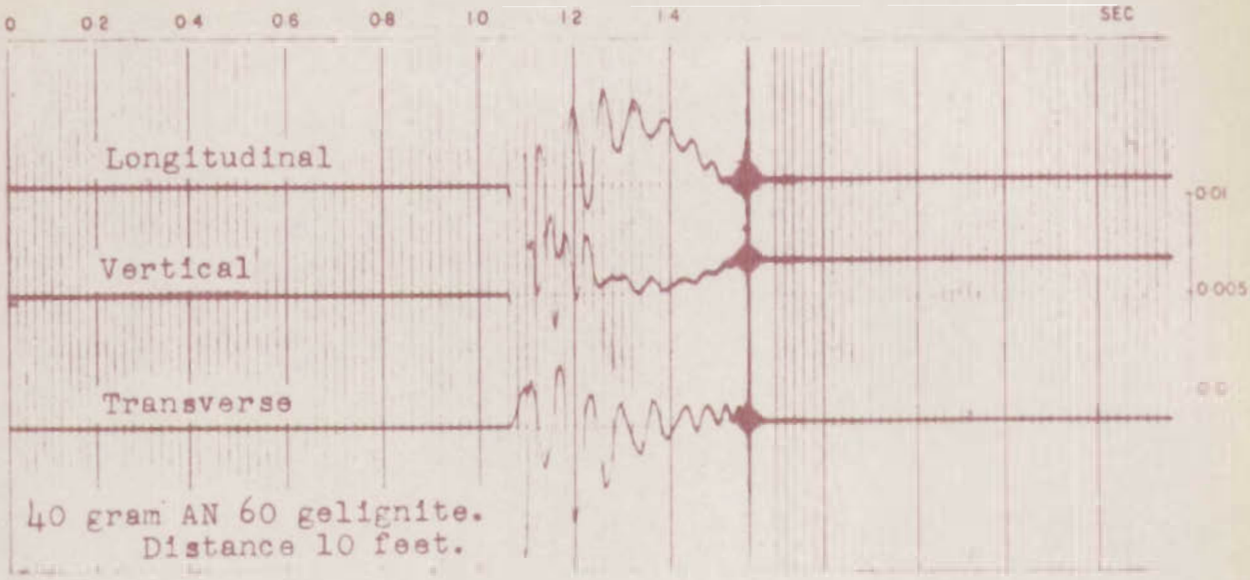


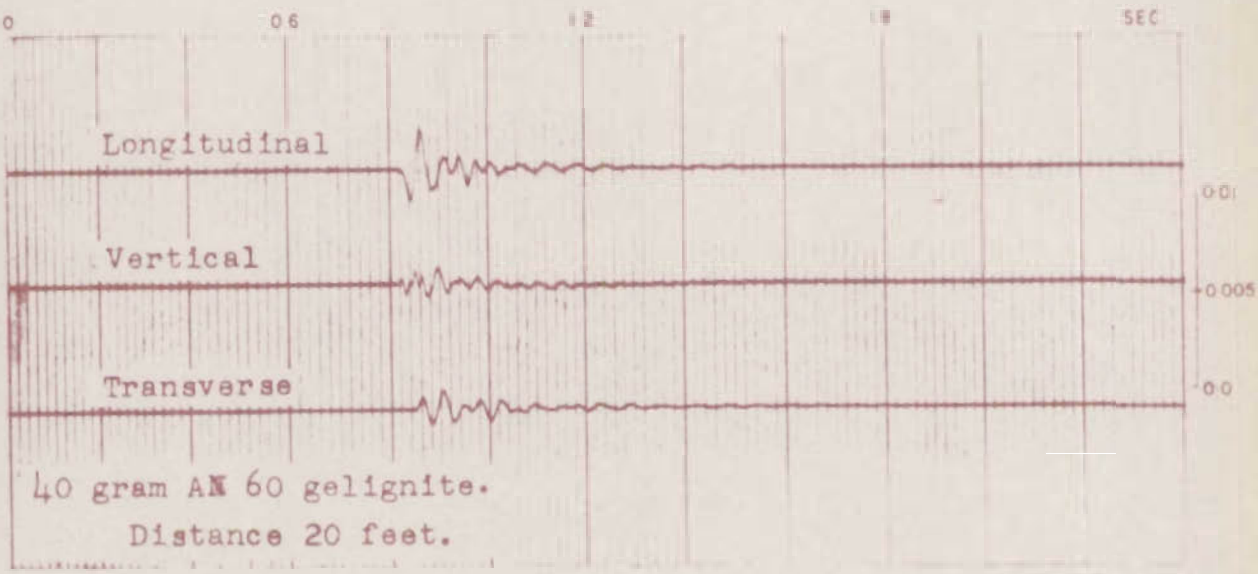


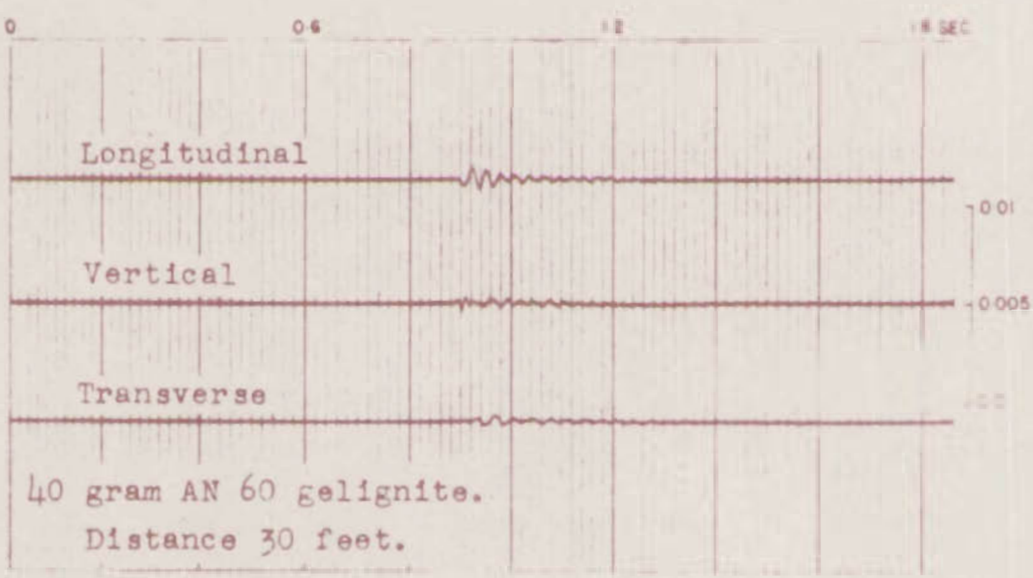


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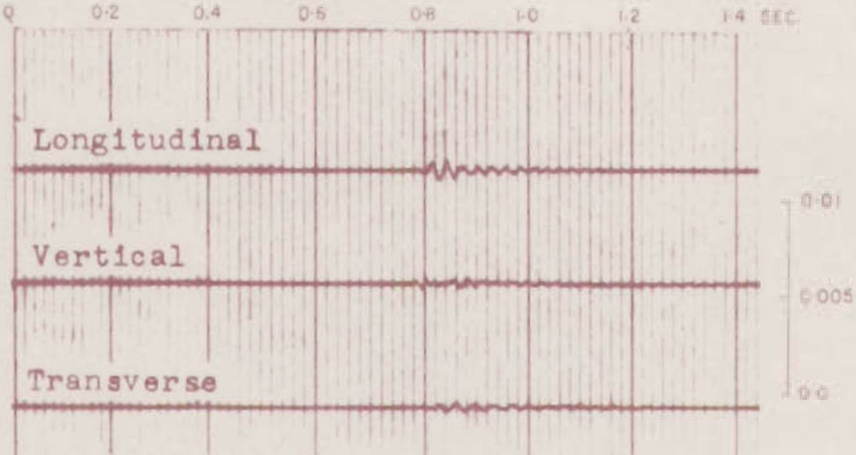
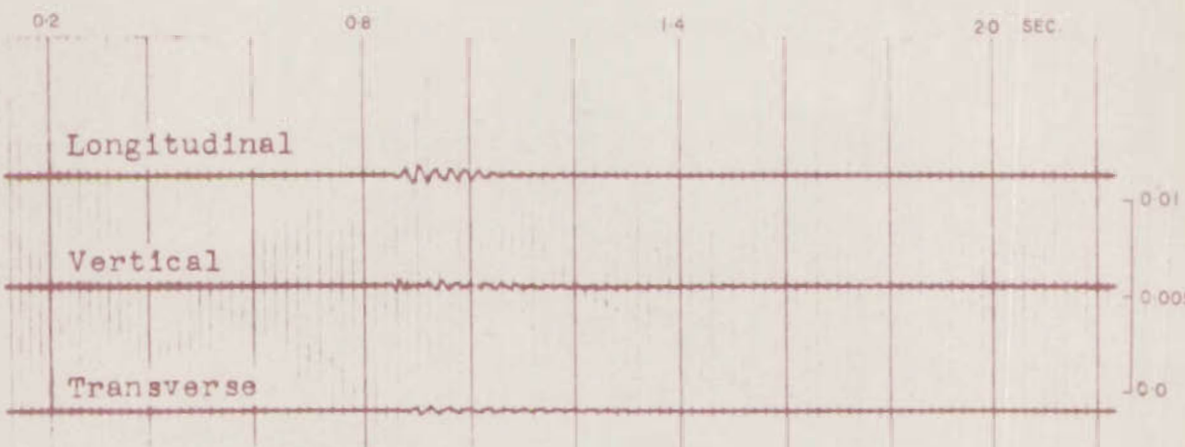
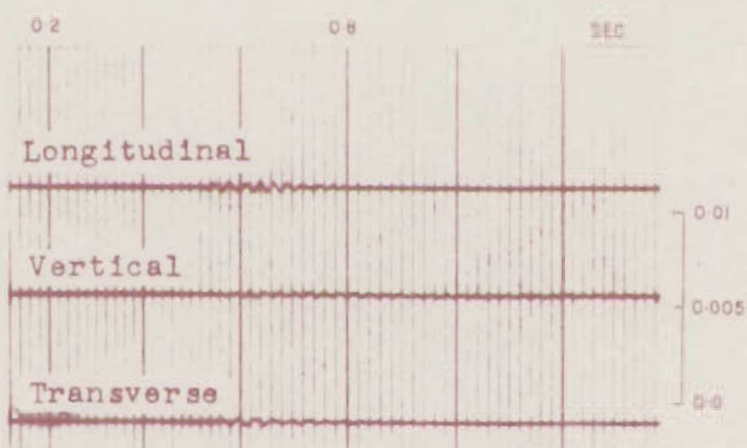
(Using Sprengnether Vibration Seismograph).




40 gram AN 60 gelignite.
Distance 40 feet.




40 gram AN 60 gelignite.
Distance 50 feet.




40 gram AN 60 gelignite.
Distance 75 feet.

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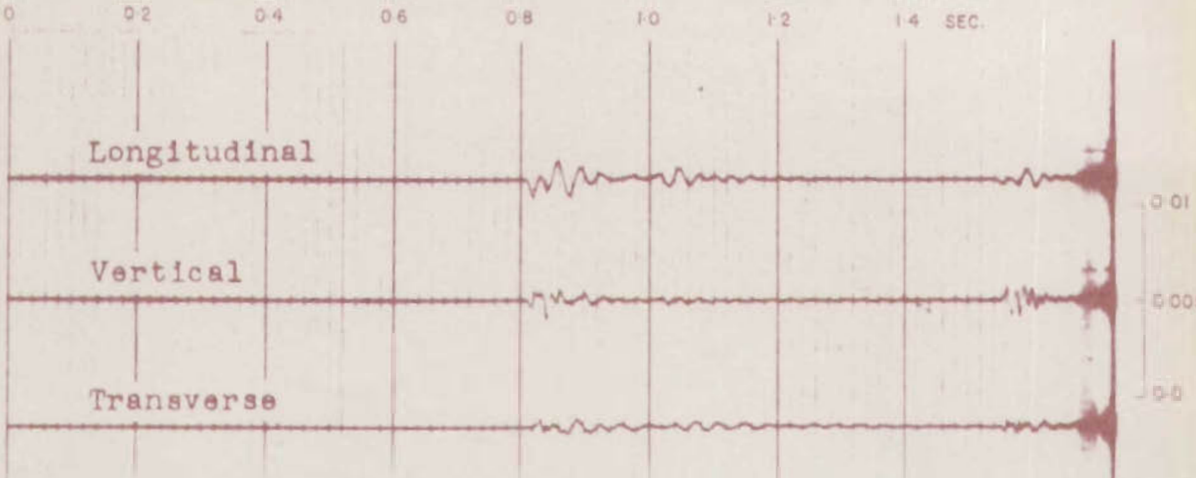
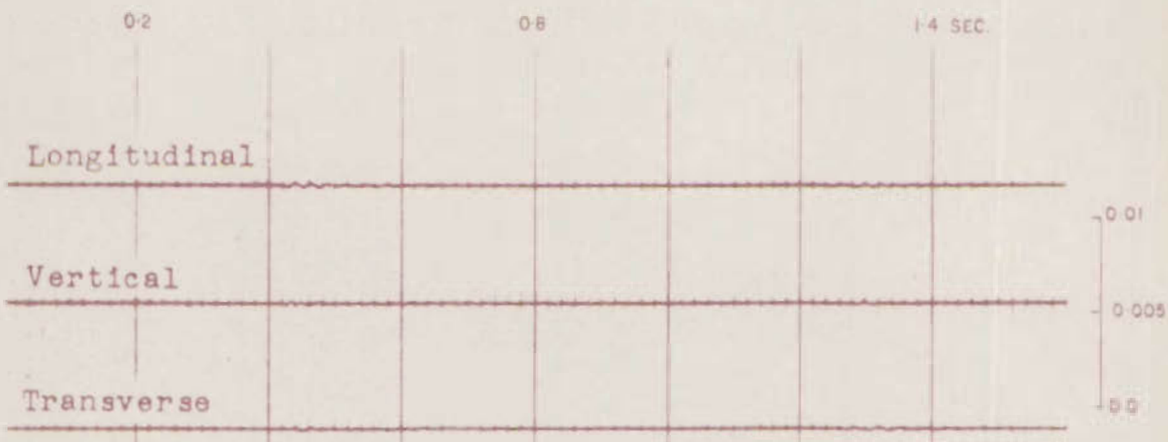
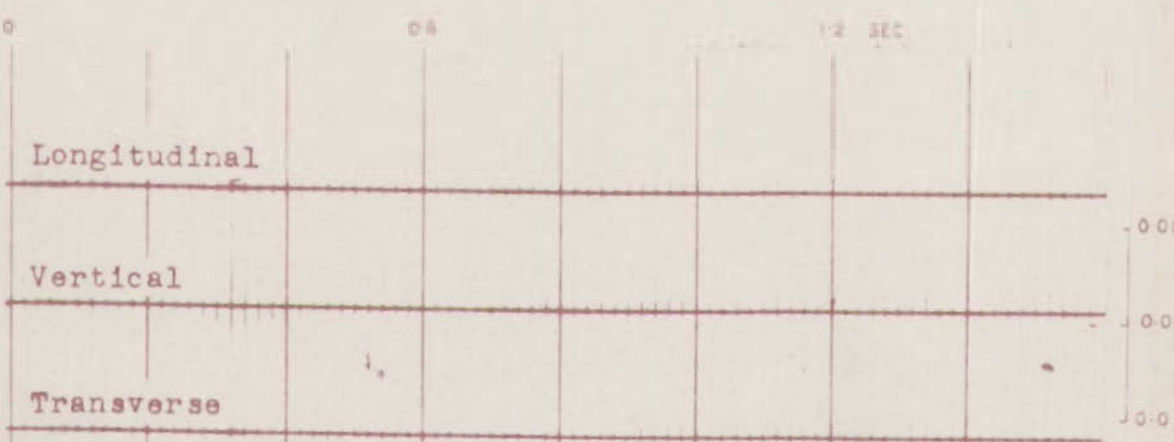



38 lb. weight. Distance 5 feet.




38 lb. weight. Distance 15 feet.




Vehicular traffic Stawell Street.
1 truck followed immediately by 1 car.

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RICHMOND, VICTORIA, 10/12/59.
(Using Sprengnether Vibration Seismograph).