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**BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS**



RECORD No. 1961-96

# RINGWOOD OUTFALL SEWER (M.M.B.W.) VIBRATION TESTS, NUNAWADING, VICTORIA 1961

by

E.J. Polak and E.E. Jesson

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## CONTENTS



## ILLUSTRATIONS



## ABSTRACT


Vibrations produced by blasting in a tunnel during construction of the Ringwood Outfall Sewer were measured.

The accelerations calculated from the vibration records are within the "caution zone" accepted by the United States Bureau of Mines.

## 1. INTRODUCTION

This Record describes a vibration investigation carried out by the Bureau of Mineral Resources at the request of Prentice Bros. and Minson Pty. Ltd.

The Company is constructing the Ringwood Outfall Sewer which passes below Canterbury Road, Nunawading (Plate 1), where the investigation was carried out.

The purpose of the investigation was to measure the ground vibrations produced by blasting in the tunnel, so as to determine the effect of the blasting on the timber and brick-veneer homes in the area.

The investigation was carried out by the authors who are geophysicists of the Bureau.

## 2. INSTRUMENT

The instrument used in recording the ground vibrations was a Sprengnether Portable Blast and Vibration Seismograph, Serial No. 1577. This instrument records three mutually perpendicular components of the ground vibration on a moving strip of photographic paper. The record shows the ground motion magnified 100 times and with timing lines at intervals of 20 milliseconds.

## 3. RESULTS

Plate 1 shows the positions of the seismograph, and Plate 2 shows parts of the records obtained for the three shots fired during the investigation.

The ground acceleration can be calculated, on the assumption that the vibrations are sinusoidal, from the equation :

$$a = 4 \pi^2 f^2 A \qquad \ldots\ldots\ldots\ldots\ldots (1)$$

where $a$ = maximum acceleration

$f$ = frequency

$A$ = ground displacement, which is half the peak-to-trough amplitude.

Using this equation, the acceleration is calculated for each of the three components of the wave motion, namely the longitudinal, vertical, and transverse components. The total or resultant acceleration is the vector sum of the accelerations for the three components, and is expressed both in conventional units and in terms of the acceleration due to gravity.

Various limiting standards for damaging and non-damaging effects of vibrations have been proposed by different authorities (see Appendix). The U.S. Bureau of Mines (Thoenen and Windes, 1942), using acceleration as an index of likelihood of damage, proposed the following classification applicable to buildings:

| | | |
|---|---|---|
| Acceleration | greater than 1.0g | : Damaging |
| " | between 0.1g and 1.0g | : Slightly damaging (Caution zone) |
| " | less than 0.1g | : No damage (Safe zone) |

In the case of the Ringwood Outfall Sewer being considered here, each firing was arranged so that the charges were detonated in groups, with each group delayed by an interval ranging from 0 to 4.5 seconds after firing.

The three records show the vibration caused by the detonation of the individual groups of charges comprising each firing. In many cases, the detonation of the individual charges within the groups can also be identified on the records.

The ground displacement produced by the detonation of the individual groups of charges did not vary much between groups. The greatest displacement was approximately $2\frac{1}{2}$ times the average displacement for all groups on the three records, and the smallest observed displacement was approximately 0.2 times the average displacement.

It is thought that the greatest observed ground displacement may have been caused by the simultaneous detonation of charges within a group, and the smallest displacement, by detonation of the charges in rock which has been loosened by a previous detonation of other groups of charges in the shot.

The amplitudes and frequencies of the three components of the waves were scaled from the seismograms; the scalings were taken at the same instant on each component, and the instant selected is that at which the resultant acceleration is a maximum.

Table 1 shows the ground displacements and the frequencies of the three components of the waves corresponding to the three positions of the seismograph. The accelerations shown in the table were determined by means of a graphical solution of Equation (1), as shown on Plate 3.

TABLE 1

| Shot No. | Component | Displacement (in.) | Frequency (c/s) | Resultant Acceleration | |
|---|---|---|---|---|---|
| | | | | in./sec$^2$ | in terms of g |
| 1 | L | 0.0004 | 50 | | |
| | V | 0.00075 | 83 | 190 | 0.5 g |
| | T | 0.00035 | 33 | | (caution zone) |
| 2 | L | 0.00035 | 40 | | |
| | V | 0.00065 | 67 | 120 | 0.3 g |
| | T | 0.0005 | 37 | | (caution zone) |
| 3 | L | 0.00115 | 40 | | |
| | V | 0.0004 | 72 | 120 | 0.3 g |
| | T | 0.0004 | 37 | | (caution zone) |

## 4. CONCLUSIONS

It is apparent from Table 1 that in each of the three cases investigated, the blasting produces vibrations within the "caution zone" as specified by the U.S. Bureau of Mines.

## 5. REFERENCES

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

## LEGEND

1 — State of New Jersey as specified by regulation

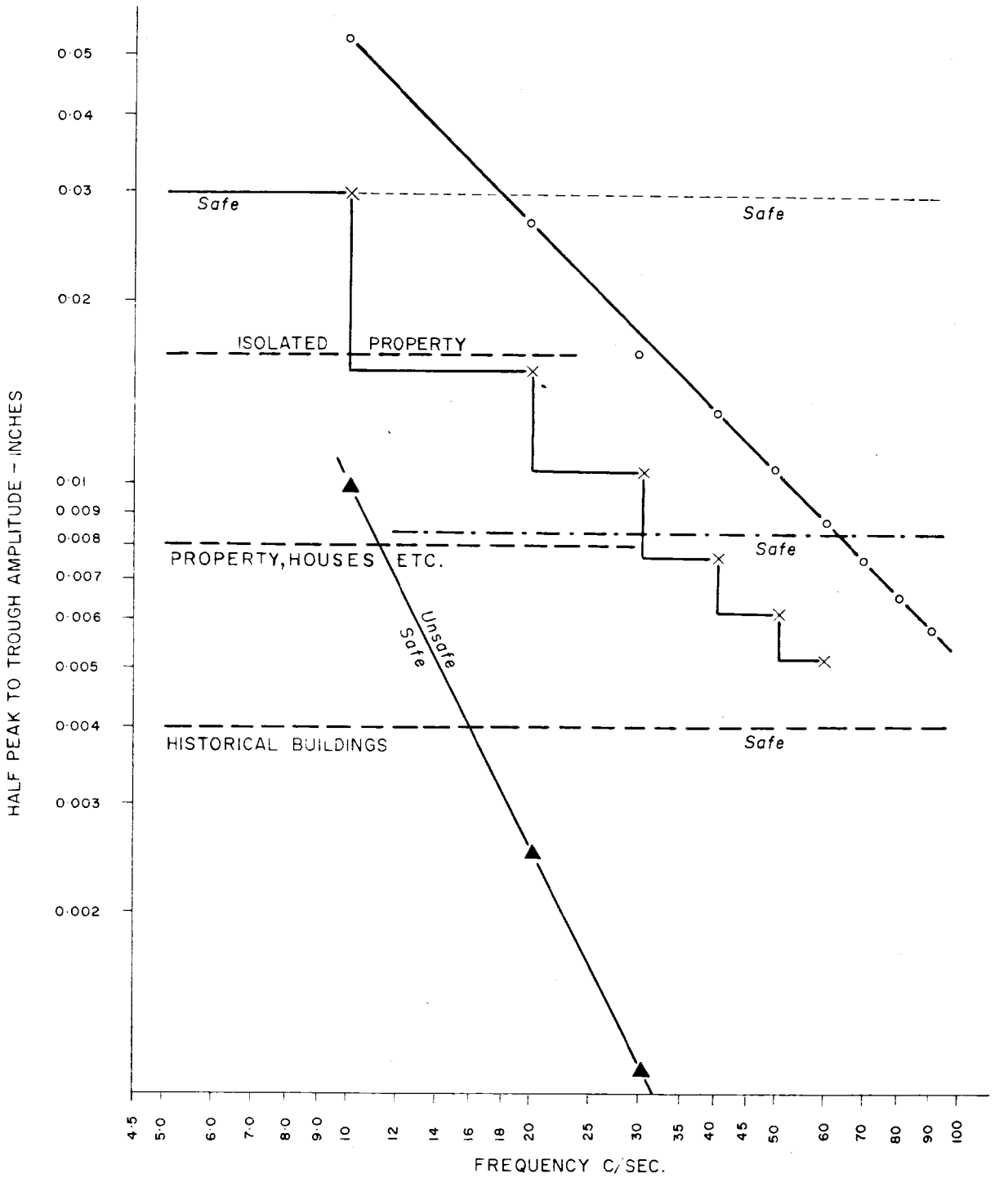
2 — State of Pennsylvania as specified by regulation for any structure

3 — As recommended by Teichman

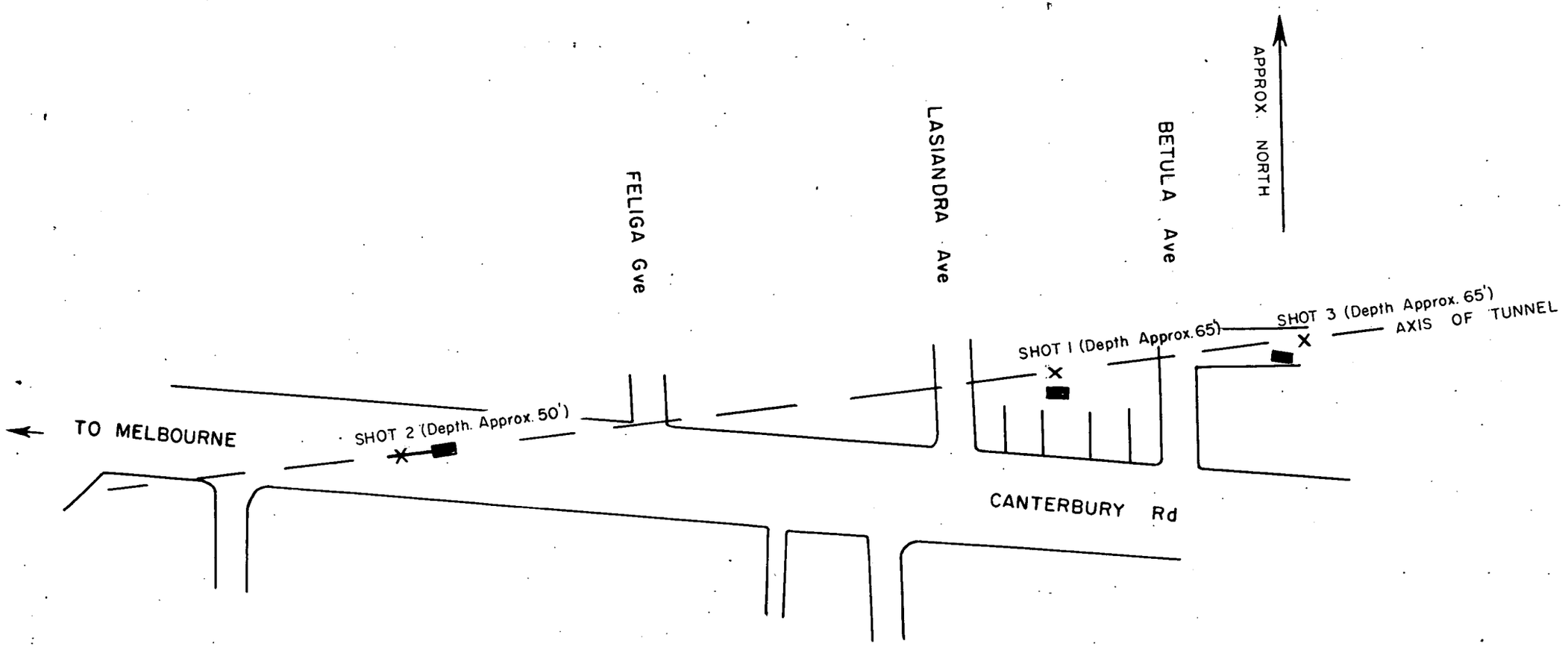
4 — As recommended by Crandell to a United States Insurance Co.

5 — As recommended by Morris

6 — As recommended by U.S. Bureau of Mines




# MAXIMUM SAFE HALF PEAK TO TROUGH AMPLITUDE OF VIBRATION PLOTTED AGAINST FREQUENCY AS SPECIFIED AND RECOMMENDED BY VARIOUS U.S. GOVERMENT AUTHORITIES AND BY INDIVIDUALS




RINGWOOD OUTFALL SEWER

M.M.B.W., NUNAWADING

# VIBRATION TEST, 19/6/1961

PLATE 1

X SHOT POSITION

POSITION OF RECORDER

SCALE IN FEET (APPROX.)

200 0 200 400

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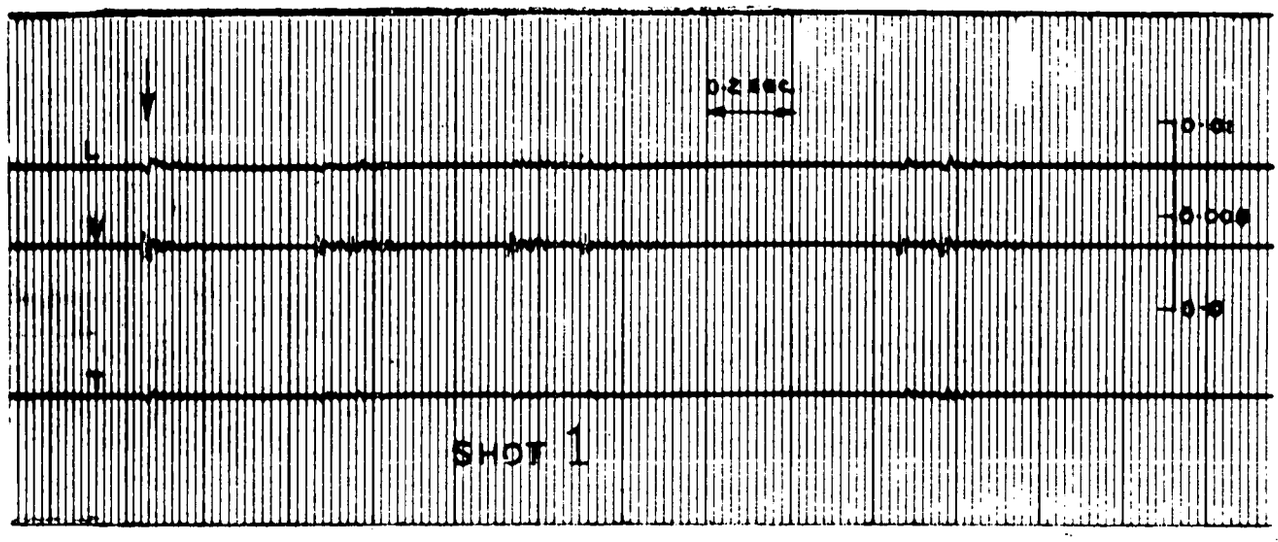


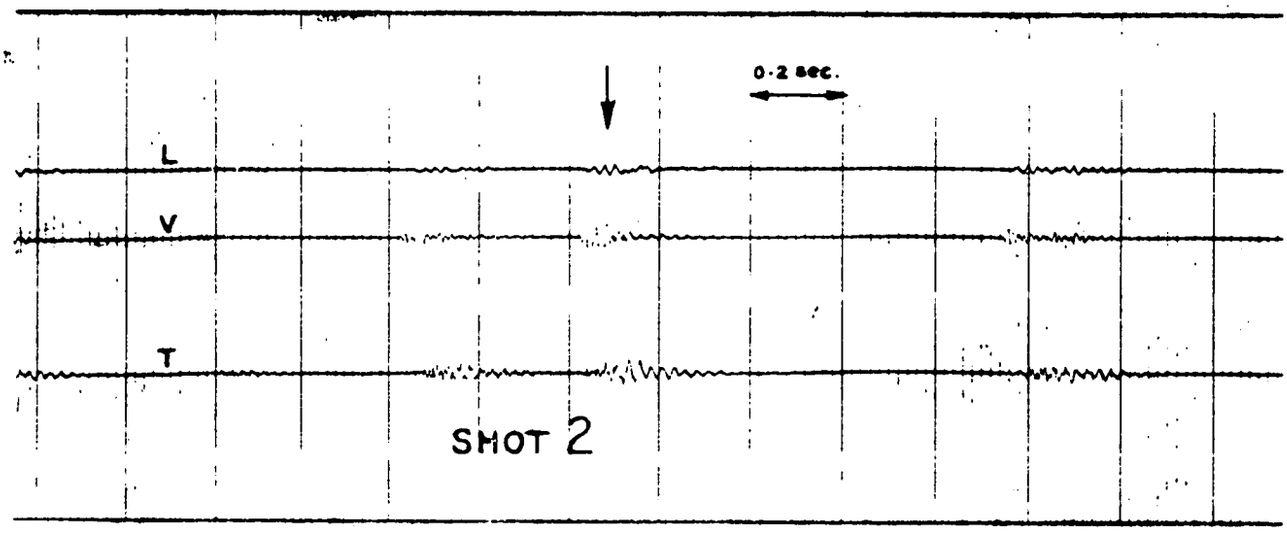


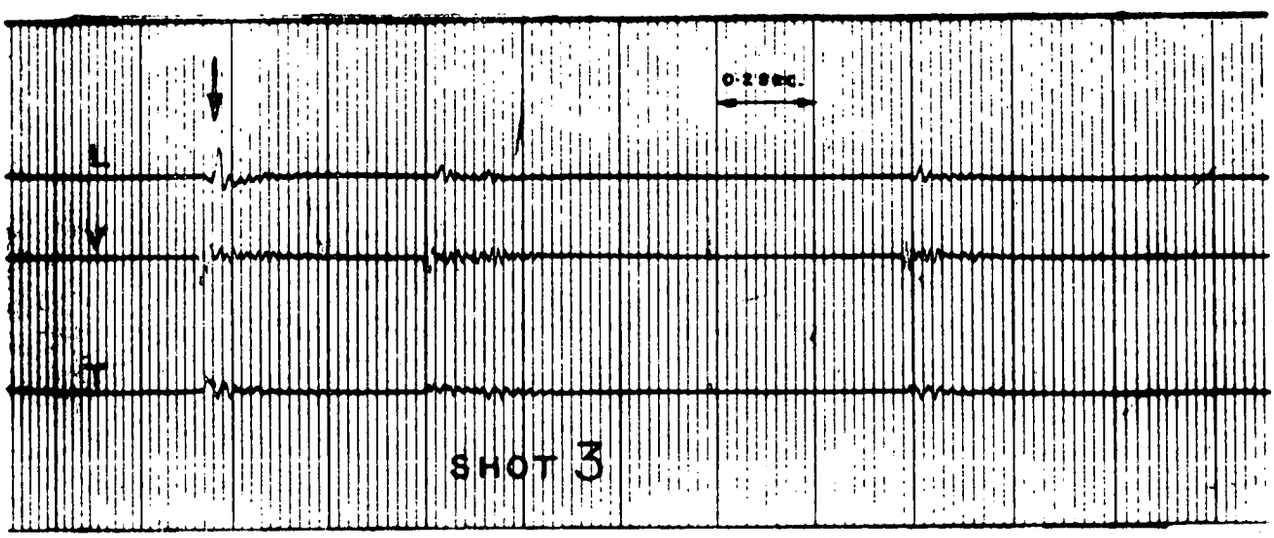


RINGWOOD OUTFALL SEWER

VIBRATION RECORDS

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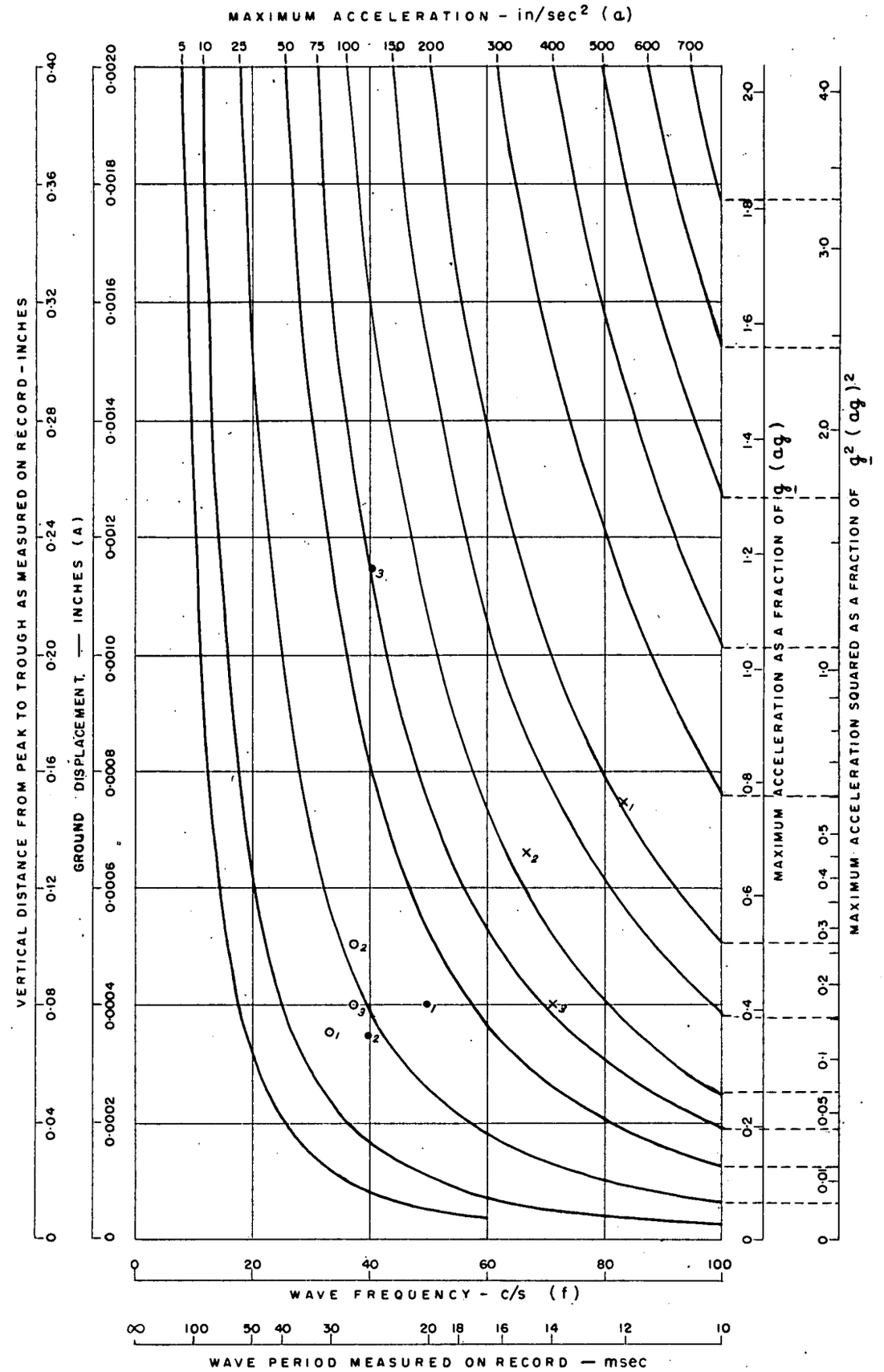


LEGEND

- • POINT REPRESENTING LONGITUDINAL WAVE (L)
- X " " VERTICAL " (V)
- o " " TRANSVERSE " (T)

NUMBER SUFFIX INDICATES RECORD NUMBER. THUS $X_2$ REPRESENTS VERTICAL WAVE, RECORD 2.

RESULTANT ACCELERATION ($a_T$) IS GIVEN BY:

$$a_T = \sqrt{(a_{gL})^2 + (a_{gV})^2 + (a_{gT})^2}$$

$a_{T1} = 0{\cdot}5\,g$ (CAUTION ZONE)

$a_{T2} = 0{\cdot}3\,g$ " "

$a_{T3} = 0{\cdot}3\,g$ " "

# GRAPHICAL SOLUTION OF $a = 4\pi^2 f^2 A$ FOR USE WITH SPRENGNETHER PORTABLE SEISMOGRAPH No.1577

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TO ACCOMPANY RECORD No 1961-96

MMBW Ringwood Outfall Sewer, Vibration Test, Nunawading, 19-6-61