COMMONWEALTH OF AUSTRALIA

DEPARTMENT OF NATIONAL DEVELOPMENT

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

RECORD No. 1961-164

RINGWOOD MAIN SEWER (M.M.B.W.) VIBRATION TESTS, RINGWOOD, VICTORIA 1961

by

E.J. Polak and J.T.G. Andrew

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ILLUSTRATIONS

1. INTRODUCTION

This Record describes a vibration investigation made by the Bureau of Mineral Resources at the request of E. Balbinot and Company Pty Ltd and the Melbourne and Metropolitan Board of Works.

The Company is constructing a section of the Ringwood Main Sewer which passes under Whitehorse Road and runs under Sherbrook Street (Plate 1) where the investigation was made.

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 houses in the area and on an auction building with a plate glass front.

The investigation was made by the authors, on 14th December 1961.

2. INSTRUMENTS

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 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 for the four shots fired during the investigation.

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

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

where a = maximum acceleration (in./sec^2)

f = frequency (c/s)

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

Using this equation, the acceleration was 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 acceleration for the three components and has been calculated both in in./sec^2 and in terms of the acceleration to gravity (= 386 in./sec^2).

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 . . . . . Caution zone

" less than 0.1g . . . . . Safe zone

Table 1 shows the ground displacements and frequencies of the three components as measured on each of the four records, and the calculated resultant accelerations.

TABLE 1

Shot No.	Component	Displacement (in.)	Frequency (c/s)	Resultant Acceleration	
				in./sec^2	in terms of g.
I	L	.0008	50		
	V	.0010	60	177	.46g
	T	.00055	55		(caution zone)
II	L	.0008	50		
	V	.00095	55	151	.39g
	T	.00075	45		(caution zone)
III	L	.0007	50		
	V	.0012	55	164	.42g
	T	.0008	33		(caution zone)
IV	L	.00025	40		
	V	.00045	60	71	.18g
	T	.00035	40		(caution zone)

4. CONCLUSIONS

It is apparent from Table 1, that in each of the four cases investigated, the blasting produces vibrations within the "caution zone" as specified by the U.S. Bureau of Mines, but the vibrations are within the safe limit as imposed by other authorities (see Appendix).

APPENDIX

The following are references to and extracts from regulations and authoritative publications in the United States and Great Britain covering or recommending safe amplitudes of vibrations that may be applicable to buildings:

(Note: f = frequency in cycles per second.

A = ½ peak to trough amplitude, inches.

Reference 1.

State of New Jersey, U.S.A. Extract from rules and regulations governing Quarry Blasting and Related Operations. March 26, 1954.

"6.1. Allowable Limits. Allowable Limits of ground motion and sound pressure contained in this section shall be considered neither to produce structural damage in any structure that has been reasonably well constructed according to accepted engineering practice nor to constitute a nuisance to persons."

"6.3. Frequency - amplitude relations. When ground frequency and displacement characteristics in relation to known quantities of detonated explosives in primary blasts have been determined by approved means of instrumentation to the satisfaction of the Commissioner, the allowable limits of the maximum amplitude of ground vibrations related to frequencies of vibration shall be as indicated in the following table:

Frequency of ground motion in cycles per second.	Maximum amplitude of ground movement, in inches.
up to 10	not more than 0.0305
20	0.0153
30	0.0102
40	0.0076
50	0.0061
60	0.0051"

Reference 2.

Rules Concerning Blasting in Strip Mine Operations in the Anthracite Region, Pennsylvania, Act No. 472, June 27, 1947.

"Section 20.

..in no case shall the ground displacement be in excess of 0.03 inches at any dwelling house, public building, school, church, commercial or institutional building."

Reference 3.

Teichman, G.A. and Westwater, R.

Blasting and Associated Vibration.

Engineering, April 12, 1955, pp. 460/465.

> "Because of the variation in the types of structure it has been recommended that they should be broadly classified into four groups:
>
> (a) structures of great value and frailty. This will include certain ancient monuments, such as churches and certain badly designed properties.
>
> (b) Property, houses etc. closely congested.
>
> (c) Isolated property.
>
> (d) Civil engineering structures.
>
> Taking suitable safety factors and after the site has been investigated by a vibrograph caution limits are applied. These limits usually are 0.004, 0.008, 0.016, 0.030 inches, respectively."

Reference 4.

Crandell, working on behalf of a United States Insurance Co., suggests fA as a suitable relationship and quotes -

"fA = 0.745 as the damaging level

fA < 0.527 as safe level."

Reference 5.

C. Morris - Vibrations due to blasting and their effect on building structures.

The Engineer, Nov. 3, 1950. pp. 394/395, 414/418.

> "the limiting amplitude of 8.2×10^{-3} (0.0082) inches gives a conservative estimate of the limiting amplitude for conventional structures. The state of repair of the building does not seriously affect this estimate, as an old building technically less strong than a new one will have benefitted by a process of "bedding in" due to long-continued small movement."

Reference 6.

Thoenen, J.R. and S.L. Windes, 1942. Seismic Effects of Quarry Blasting.

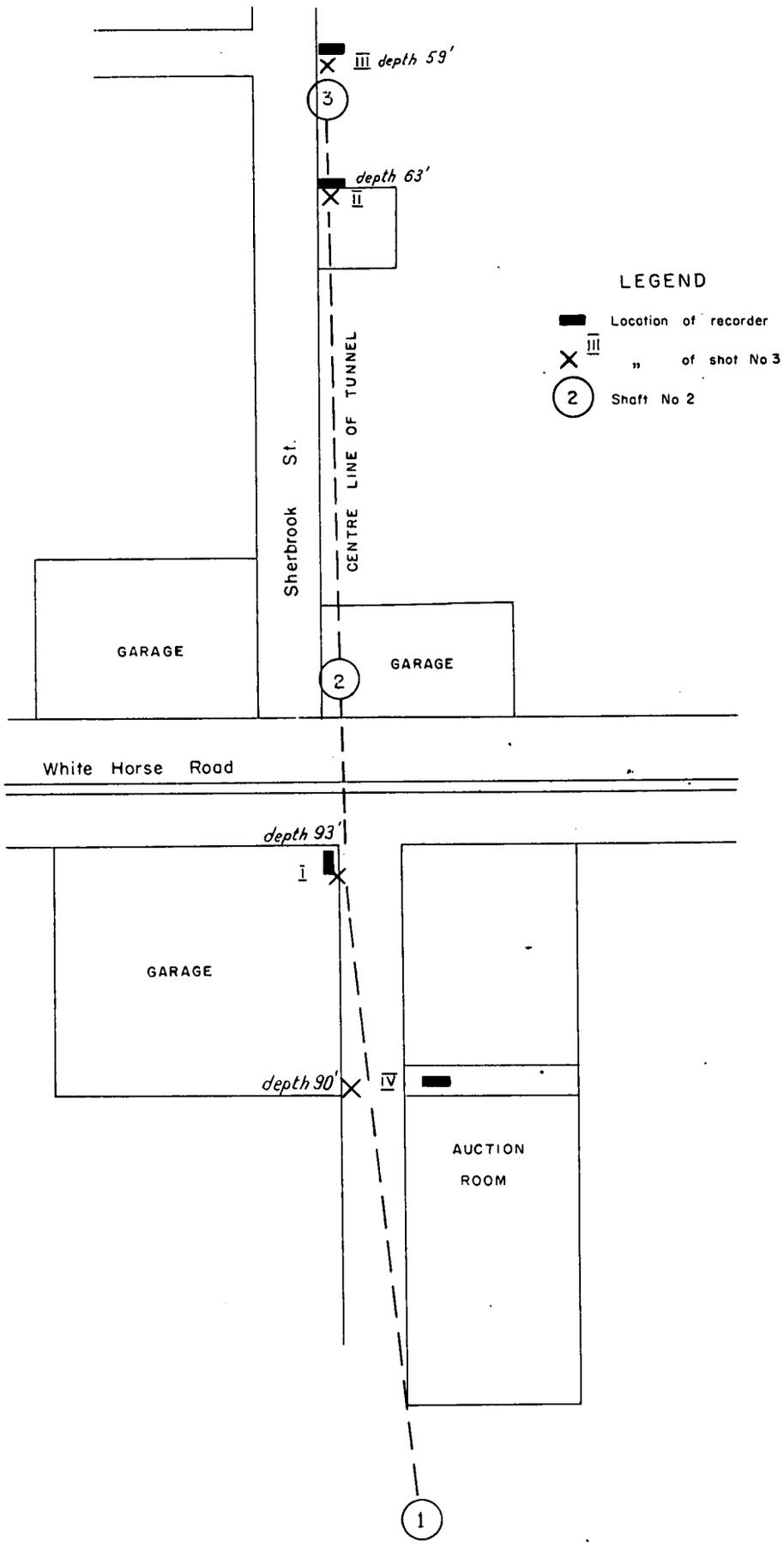
United States Bureau of Mines Bull. 442.

"$f^2 A >$ 10 Damage

$f^2 A <$ 1 Safe "

"Vibrations of very low amplitude and short duration were neglected, even though the accelerations may have been high, because these conditions were noticeable in the records of many tests that did not cause damage."

PLATE 1



RINGWOOD MAIN SEWER, SHERBROOK STREET

VIBRATION TEST, M.M.B.W., 14-12-61.

(NOT TO SCALE)

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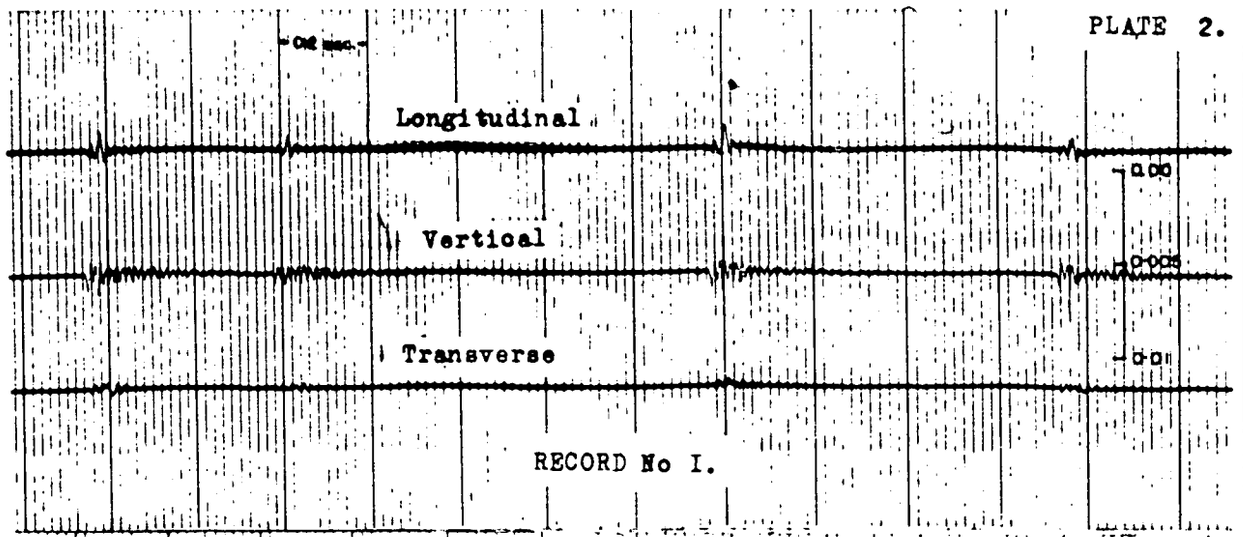

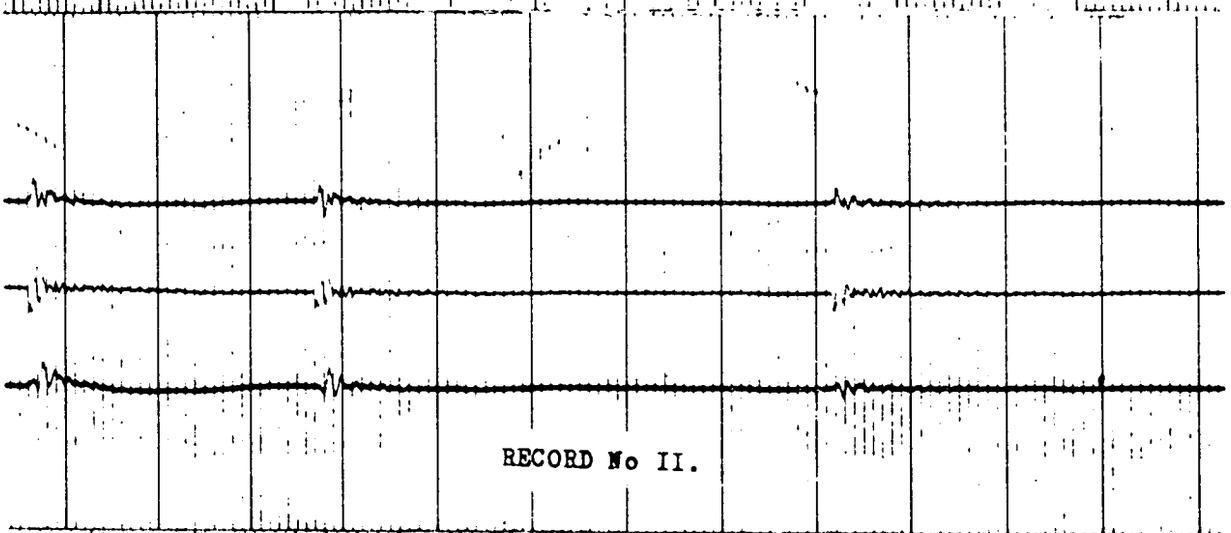

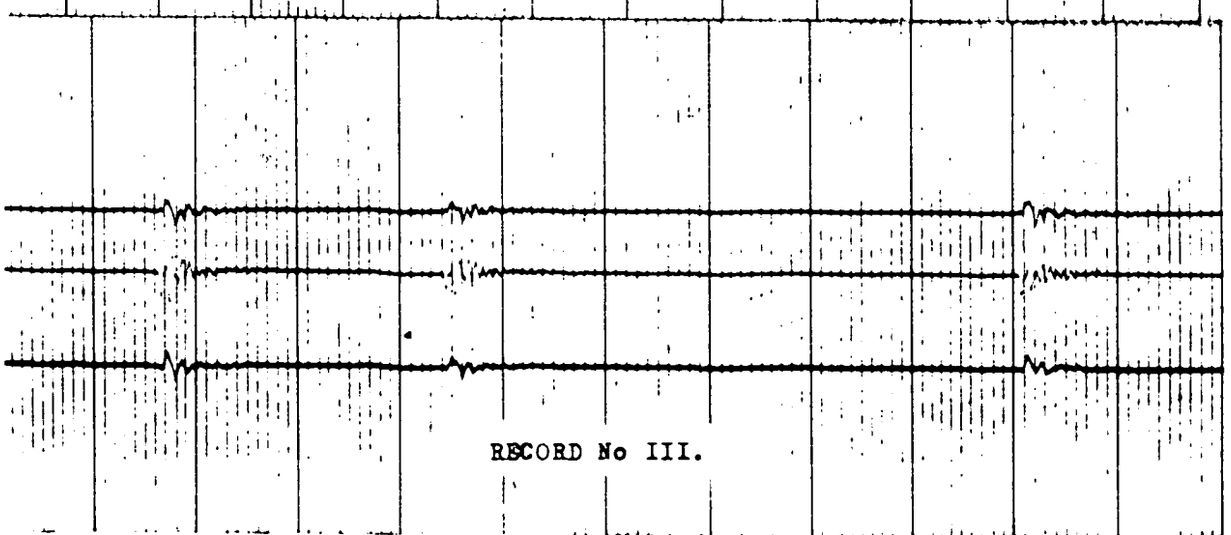

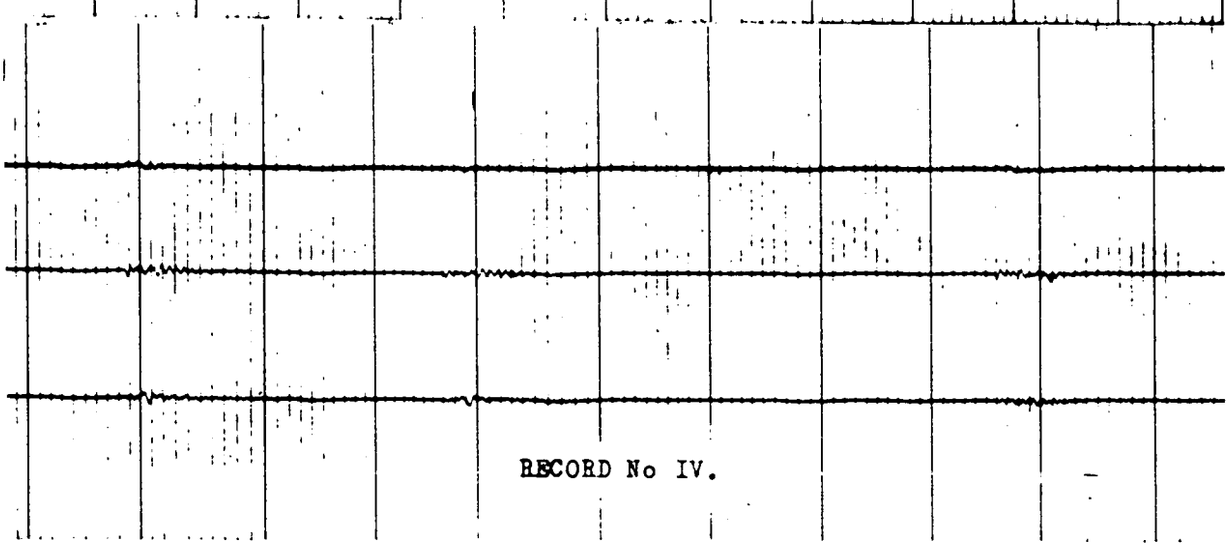

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LEGEND

1 — State of New Jersey as specified by regulation

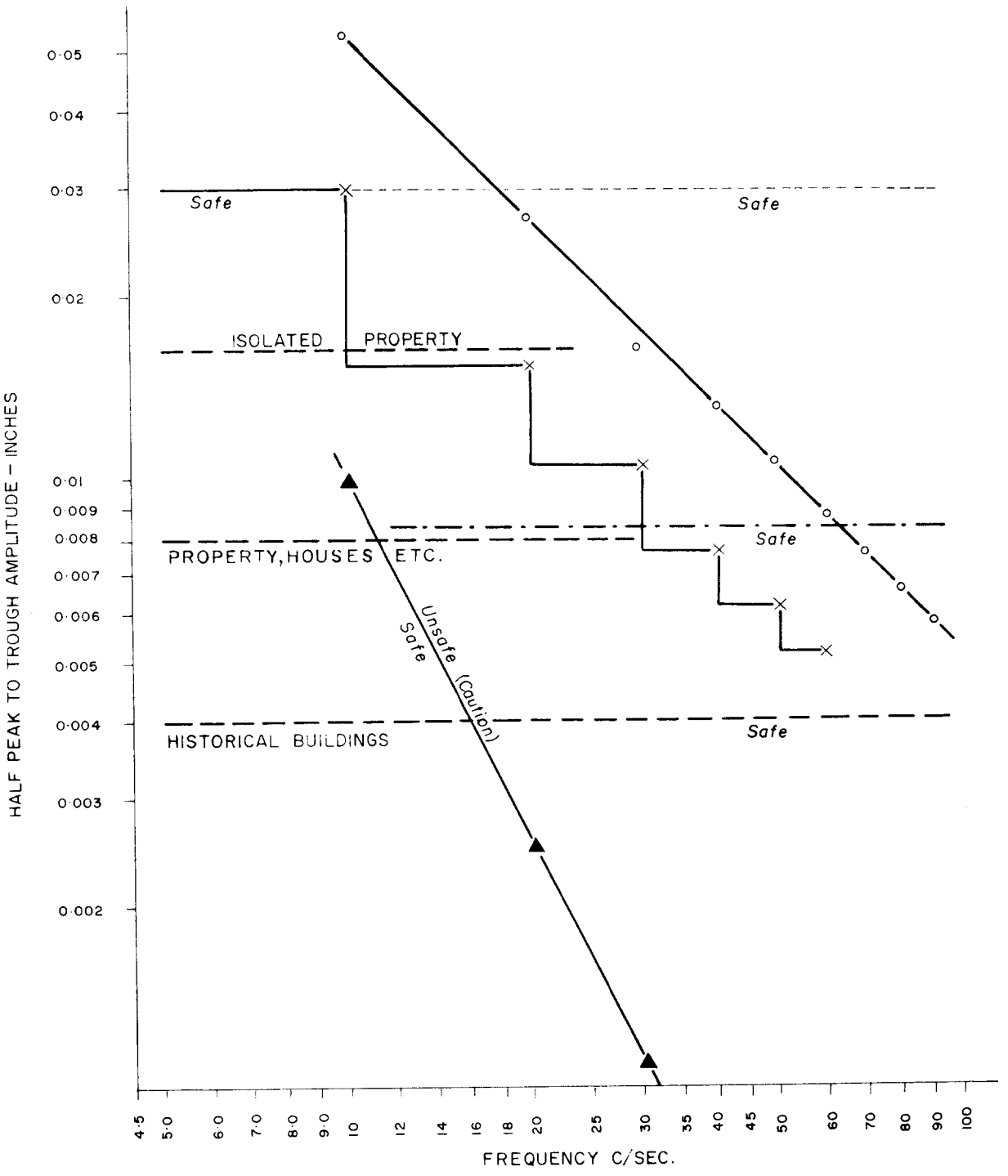
2 — State of Pennsylvania as specified by regulation for any structure

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

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