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RECORDS

1959 NO. 84.

GROUND VIBRATION MEASUREMENTS AT THE WYCHEPROOF HOSPITAL, VICTORIA, 1959.

BY

E.J. POLAK AND F. JEWELL.

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PLATE

ABSTRACT.

Following some defects which appeared in walls and floors at the Wycheproof Hospital, measurements of ground vibrations were made at the Hospital to find out if the defects could be attributed to blasting operations in a nearby quarry. The amplitude of ground displacement recorded at the hospital from the greatest blast measured was only 0.002 inches.

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1. INTRODUCTION

The investigation described in this report was carried out to find out whether certain damage met with in buildings at the Wycheproof Hospital, Victoria, could be attributed to blasting operations conducted at the Wycheproof Shire Quarry at Mt. Wycheproof. This damage consisted of cracks in walls, and concrete floors.

The request for the work was made to the Bureau of Mineral Resources, Geology and Geophysics by the Secretary of the Wycheproof Hospital and the Victorian Mines Department.

Measurements of ground movements were made by E.J. Polak (party leader) and F. Jewell (Geophysicist) at the Hospital on 7th May during blasting operations at the Quarry. A Leet Vibrograph and a Mid-Western Seismograph were set up at the Hospital for the purpose according to the plan shown in Plate 1.

2. THE INSTRUMENTS

(a) Leet Vibrograph. This instrument records the three components of ground movement mutually at right angles to each other. The magnification factor of the instrument, achieved by optical means, is 50, so that a ground movement of 0.02 inches is represented by a movement of one inch of the traces on the record.

(b) Mid-Western Shallow Reflection-Refraction Seismograph. In this equipment the ground vibrations are detected by geophones (12 in this case) and then recorded photographically. The amplification is obtained electronically. Some of the geophones recorded horizontal movements; others vertical.

3. ARRANGEMENT OF BLASTING SHOTS

Four blasts were fired in the quarry at intervals of approximately fifteen minutes.

(a) The first blast consisted of ten surface charges, each of ½ or 1 plug of explosive, set off simultaneously.

(b) For the second blast, seven holes, each nine feet deep, were loaded with a total of 15 lbs. of explosive and fired simultaneously.

(c) For the third blast, fifteen holes, each 21 feet deep, were loaded with a total of 200 lbs. of explosive. The holes were 4'6" apart and were tamped for 8 to 9 feet. Delay detonators were used to fire the charges in five sets of 40 lbs. each at intervals of 20 to 25 milliseconds.

(d) The fourth blast consisted of eight surface charges, each of ½ or 1 plug of explosive, set off simultaneously.

4. THE LAY-OUT FOR THE TESTS

The general relative positions of the blast-point, hospital and recording equipment are shown on Plate 1. The distance from the blast-point to the recording equipment was 840 feet.

The Leet Vibrograph L, was placed on the concrete floor of a porch alongside the brick wall of the hospital. The record obtained from the third blast is shown on Figure 2.

The disposition of the Mid-Western geophones was as follows:-

(a) A three-component geophone, A, was buried in the ground near the gate to record the ground movements in three directions mutually at right angles.

(b) Geophones G4 to G6 were placed so as to detect vertical movement of the ground along the line from blast-point to the hospital.

(c) Geophone G7 (three separate components) was set to record three dimensional ground movements.

(d) Geophones G10 to G12 were set to record the vertical movement of the ground along a line parallel to the fence and road.

(e) Geophone G13 was placed near the charge to record the shot instant.

Records obtained on the second and third blasts are shown on Figures 3a and 3b.

5. RESULTS

(a) Leet Vibrograph. The record reproduced in Figure 2 shows a vibration with a frequency of about 15 cycles per second, and a ground movement amplitude of 0.002 inches (resultant of three components). The amplitude of 0.002 inches is about the amplitude to be expected according to the findings of the U.S. Dept. of the Interior, Bureau of Mines, as published in "Seismic Effects of Quarry Blasting" (Bulletin 442).

Table 1 of Plate 4 reproduced from the above-montioned publication, indicates that 40 lbs. of explosive produces an average overburden vibration amplitude of 0.0027 inches at a distance of 800 feet. On outcrops of solid rock the amplitude is less.

On Plate 4 also is shown data obtained from 160 tests, for which the amplitude of vibration is plotted against frequency. The value of the amplitude of vibration for the third blast at Wycheproof on 7th May is superimposed on the graph. The vibration from the fourth blast, was recorded on the Leet Vibrograph. It is not reproduced in this report as the amplitude of the trace displacement is too low to be read. The ground amplitude would therefore be less than 0.0002 inches. It is believed that the amplitude from the first blast, which was not recorded, would be of the same magnitude.

(b) Mid-Western Seismograph. Figure 3a shows a record obtained from the second blast, when 15 lbs. of explosive were fired as one shot. Figure 3b shows a record obtained from the third blast, when the 5 sets of 40 lbs. of explosive were fired at delays of approximately 25 milliseconds. The amplitude of the vibrations is much smaller than would be expected from the firing of 200 lbs. of explosive. It is only slightly higher than that due to a single charge of 40 lbs. of explosive, the increase being mainly in the amplitude of the transverse component of the vibrations.

On Figure 3c the distances in feet from the blast point to the geophones A and G3 to G7 are plotted against time in milliseconds for the shock wave to travel the distances. This presentation is called a time-distance-curve.

The following deductions may now be noted:-

(a) The velocity of the longitudinal wave from the time-distance-curve is 17,500 ft/sec. The velocity calculated from the distance of 840 feet divided by the time of travel of 48 milliseconds is 17,500 ft/sec., indicating that the thickness of the overburden, usually having a low seismic velocity, is negligible.

(b) The ratio of the amplitude of the ground movement from 40 lbs. of explosive (3rd blast) to that from 15 lbs. (2nd blast) is 2.0. The ratio for shots of similar sizes as indicated in Table 1 is 1.94.

(c) In figure 3b the instants of arrival of vibrations from delayed blasting are shown. The amplitude of the vibration resulting from five delayed blasts is slightly higher than the amplitude of a single shot from the group. This appears to be due mainly to the increase of the transverse component of the vibration.

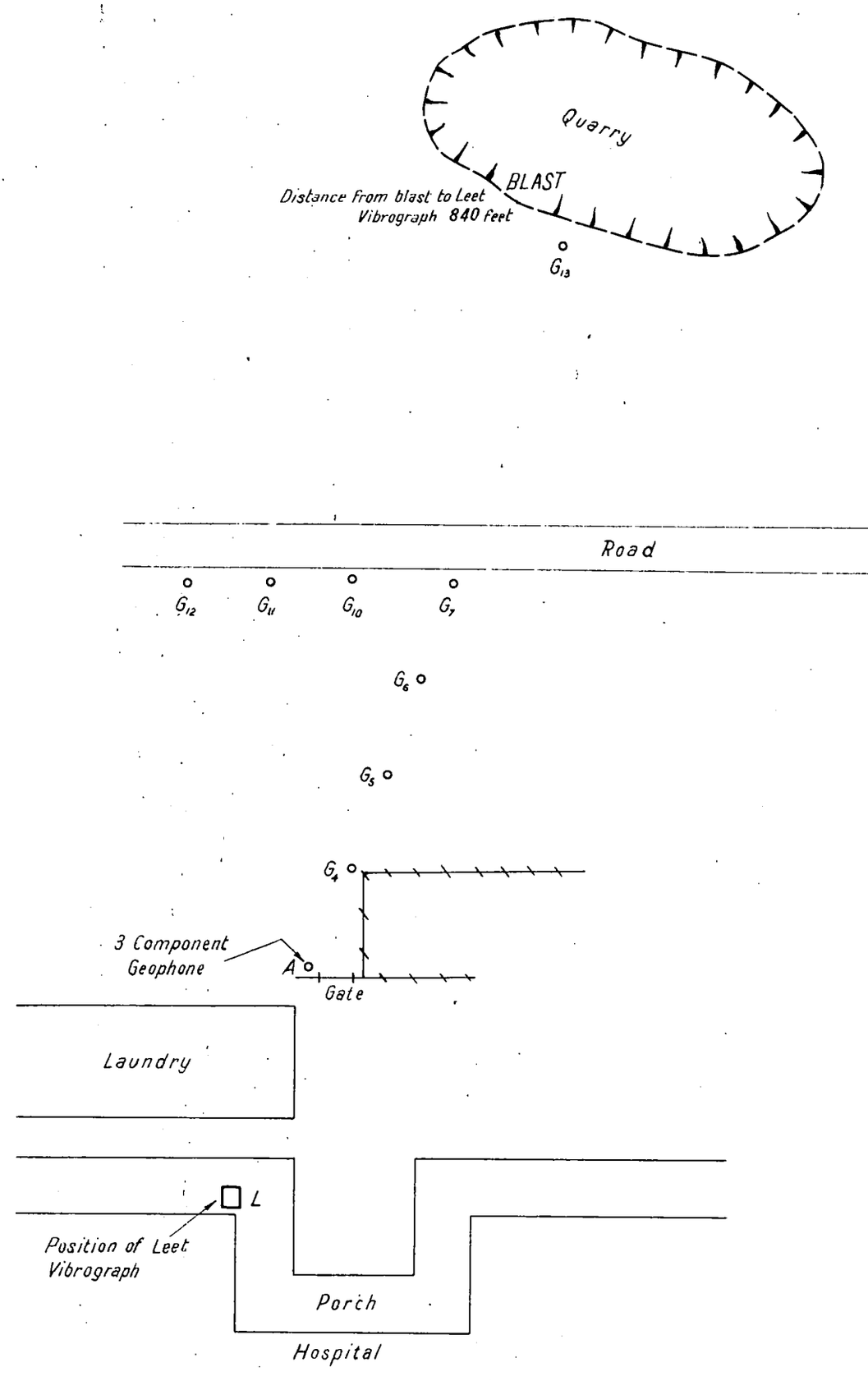
6. CONCLUSIONS

(a) The amplitude of the displacement recorded at the hospital from the greatest blast measured was only 0.002 inches at a frequency of about 15 c.p.s. Tests made by the U.S. Bureau of Mines to determine the effect of quarry blasting on buildings indicated that amplitudes of about 10 times that extent at that frequency could be applied to the test building before even cracks developed in the plaster.

(b) It is emphasised, however, that the ground amplitudes measured apply only to the specific charges fired during the tests. It is to be expected that larger charges or a number of charges fired simultaneously would produce larger ground displacements.

(c) The amplitudes of the vibrations measured at the Wycheproof Hospital are less than average as determined experimentally in USA., and as shown in Table 1. Table 1 therefore can be used to estimate the safe maximum charge for a single shot, but the charge decided on as the safe maximum should be checked by a vibration test. The safe maximum charge may be greatly increased by the use of delay firing techniques.

PLATE 1



VIBRATION TESTS AT WYCHEPROOF HOSPITAL, VIC.

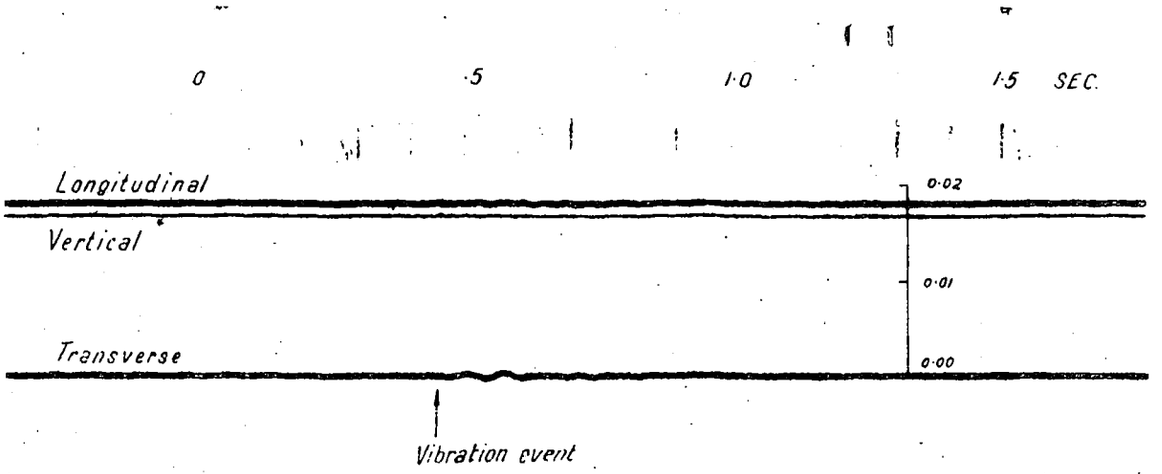
TEST LAYOUT

(NOT TO SCALE)

Geophysical Section, Bureau of Mineral Resources, Geology and Geophysics. 800

To accompany Records 1959, No 84

PLATE 2



WYCHEPROOF SHIRE QUARRY
7·5·1959
Record of vibration taken with
LEET 3-Component Vibrograph
at WYCHEPROOF Hospital (840
ft. from the shot)

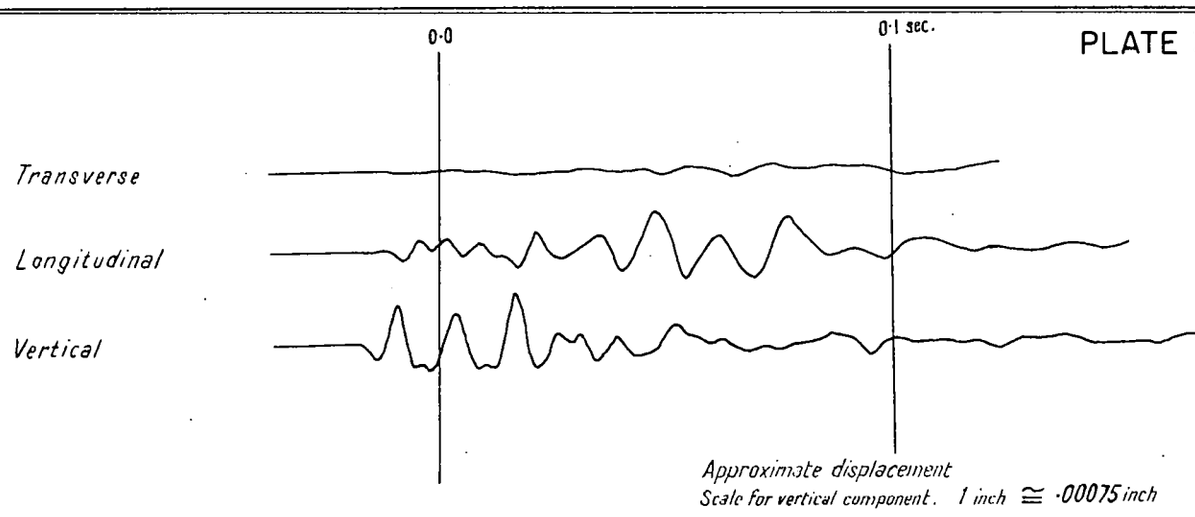
VIBRATION TESTS AT WYCHEPROOF HOSPITAL, VIC.

VIBROGRAPH RECORD

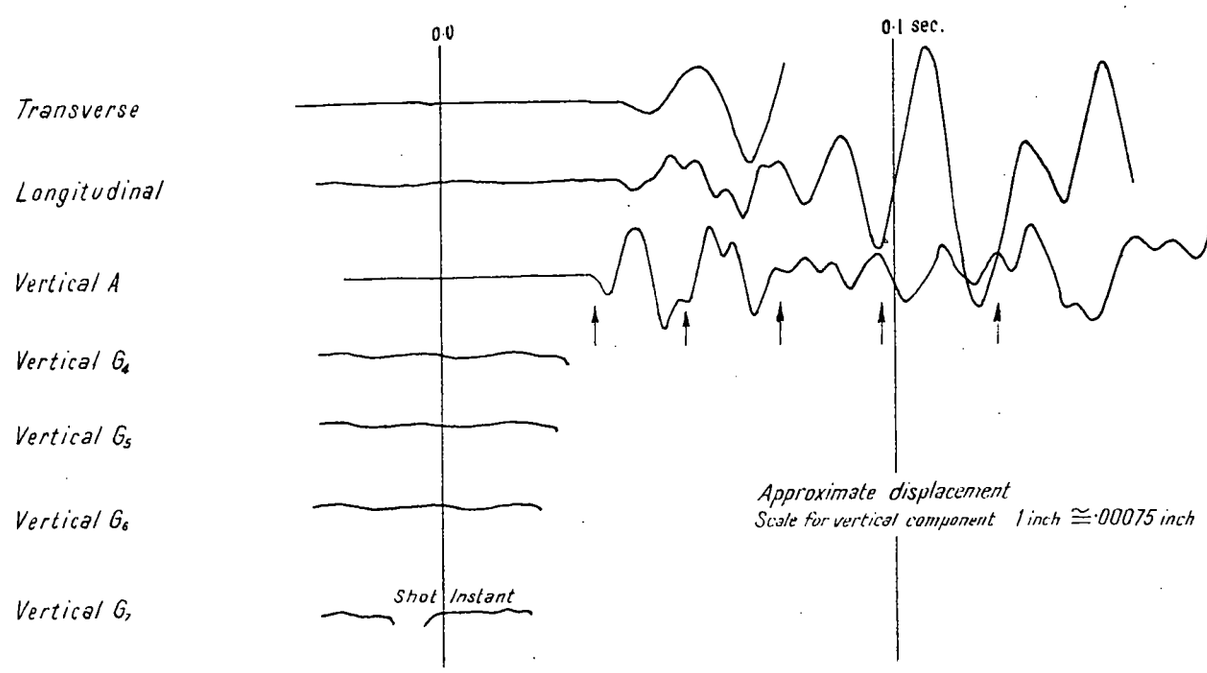
THIRD SHOT, 40 LBS. EXPLOSIVES, 5 DELAYS

To accompany Records 1959, N°84

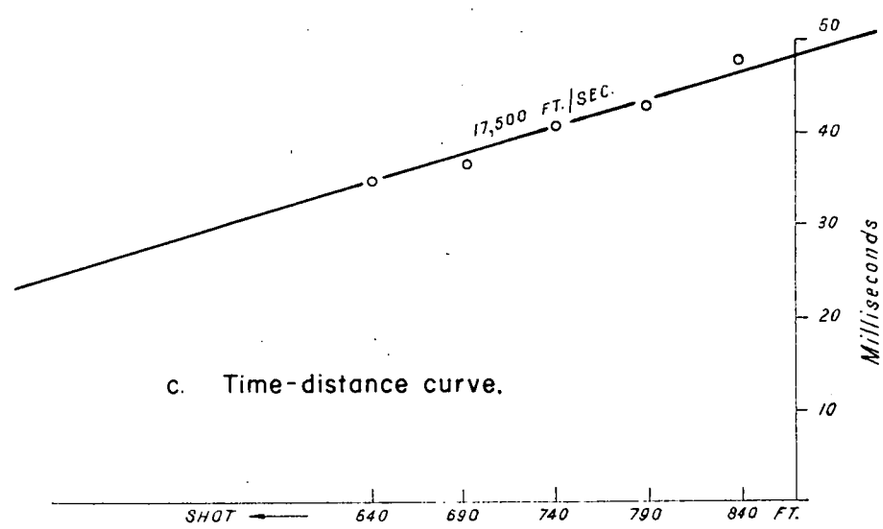
PLATE 3



a. Second shot, 15 lbs. explosives.



b. Third shot, 40 lbs. explosives, 5 delays.



c. Time-distance curve.

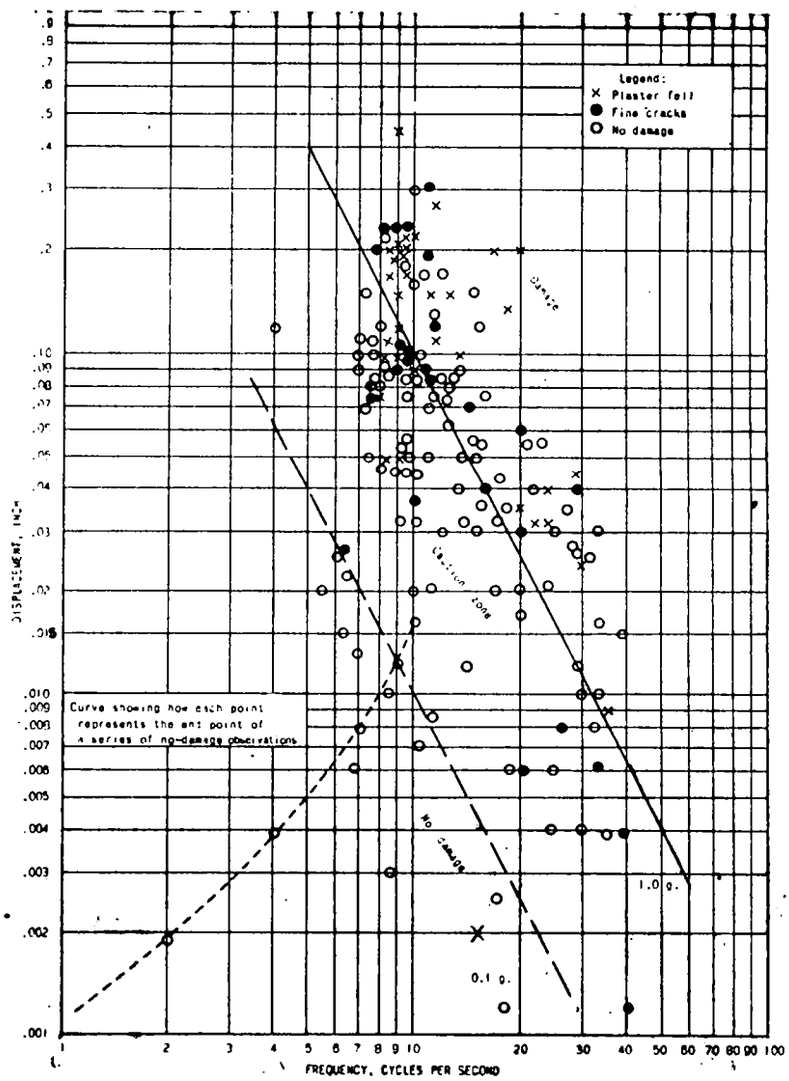
VIBRATION TESTS AT WYCHEPROOF HOSPITAL, VIC.

MIDWESTERN SEISMOGRAPH RECORDS AND TIME-DISTANCE CURVE OBTAINED ON 3-COMPONENT GEOPHONE AT "A"

To accompany Records 1959, N° 84

TABLE I.—*Displacement for various weights of explosive, inch*

Weight of explosive, pounds	Distance, feet										
	100	200	300	400	500	600	700	800	900	1,000	2,000
10	0.0029	0.0025	0.0022	0.0019	0.0016	0.0014	0.0013	0.0011	0.0010	.....	.....
20	.0045	.0039	.0034	.0030	.0026	.0023	.0020	.0017	.0015	.....	.....
30	.0059	.0052	.0045	.0039	.0034	.0030	.0026	.0022	.0020	.....	.....
40	.0072	.0063	.0054	.0047	.0041	.0036	.0032	.0027	.0024	.....	.....
50	.0084	.0073	.0063	.0055	.0048	.0042	.0037	.0032	.0028	.....	.....
60	.0095	.0082	.0072	.0063	.0054	.0047	.0042	.0036	.0031	.....	.....
70	.010	.0091	.0079	.0069	.0060	.0052	.0047	.0039	.0035	.....	.....
80	.011	.0099	.0086	.0075	.0065	.0057	.0051	.0043	.0038	.....	.....
90	.012	.011	.0093	.0081	.0070	.0061	.0055	.0046	.0041	.....	.....
100	.013	.012	.010	.0087	.0076	.0066	.0059	.0050	.0044	0.0038	0.0011
200	.021	.018	.016	.014	.012	.010	.0094	.0079	.0069	.0060	.0017
300	.028	.024	.021	.018	.016	.014	.012	.010	.0091	.0079	.0022
400	.033	.029	.025	.022	.019	.017	.015	.013	.011	.0096	.0027
500	.039	.034	.029	.026	.022	.019	.017	.015	.013	.011	.0032
600	.044	.038	.033	.029	.025	.022	.019	.016	.014	.013	.0036
700	.049	.042	.037	.032	.028	.024	.022	.018	.016	.014	.0039
800	.053	.046	.040	.035	.030	.026	.024	.020	.017	.015	.0043
900	.057	.050	.043	.038	.033	.029	.026	.022	.019	.016	.0047
1,000	.....	.....	.....	.....	.035	.031	.027	.023	.020	.018	.0050
2,000	.....	.....	.....	.....	.056	.049	.044	.037	.032	.028	.0080
3,000	.....	.....	.....	.....	.073	.064	.057	.048	.042	.037	.010
4,000	.....	.....	.....	.....	.089	.078	.069	.059	.051	.045	.013
5,000	.....	.....	.....	.....	.10	.090	.080	.068	.059	.052	.015
6,000	.....	.....	.....	.....	.12	.10	.090	.076	.067	.058	.016
7,000	.....	.....	.....	.....	.13	.11	.10	.085	.074	.065	.018
8,000	.....	.....	.....	.....	.14	.12	.11	.093	.081	.071	.020
9,000	.....	.....	.....	.....	.15	.13	.12	.10	.088	.076	.022
10,000	.....	.....	.....	.....	.16	.14	.13	.11	.094	.082	.023



GRAPH SHOWING FREQUENCY PLOTTED AGAINST DISPLACEMENT.

X - *amplitude of vibration of 3rd shot at Wycheproof.*

VIBRATION TESTS AT WYCHEPROOF HOSPITAL, VIC.

(Table and graph after U.S. Bureau of Mines Bulletin 442 "Seismic Effects of Quarry Blasting").