COMMONWEALTH OF AUSTRALIA

DEPARTMENT OF NATIONAL DEVELOPMENT

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS.

RECORDS

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CHEWTON, VIBRATION TESTS, VICTORIA 1960

by

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ILLUSTRATIONS.

ABSTRACT.

In the township of Chewton a trench is being excavated for a pipeline. This report describes tests made to determine how big a charge of gelignite may safely be exploded near buildings.

The survey shows that the biggest charges of AN60 gelignite which may safely be exploded are

at 200 ft. from a building - 5 ozs.

at 50 ft. from a building - 2½ ozs.

It is recommended that for distances between 200 ft. and 50 ft. from buildings, pattern shooting with delay blasting should be used; delays should be 200 milliseconds or more, and the size of individual charges should range from 5 ozs. at 200 ft. down to 2½ ozs. at 50 ft. It is recommended also that blasting should not be carried out closer than 50 ft. from buildings.

1. INTRODUCTION.

This report describes an investigation carried out by the Bureau of Mineral Resources, Geology and Geophysics at the request of the State Rivers and Water Supply Commission of Victoria, which is excavating a trench at Chewton, Victoria, for a pipeline. Explosive charges are being used to shatter the rock before it is removed by mechanical shovels. Along Hunter Street, Chewton, the pipeline will pass close to houses constructed of different materials. Two mud-brick houses are in poor condition and the Commission was concerned that blasting might damage them; they wanted to know the maximum size of charge that could safely be used for blasting.

Ground acceleration was the index used to determine the size of gelignite charge that could be used for blasting without damaging property. The acceleration was calculated from recordings of ground displacement produced by small explosive charges fired at various distances from a point close to the mud brick houses in Hunter Street.

The tests were carried out by P.E. Mann, geophysicist and P.J. Anthony, student, on 4th February 1960. The instrument used to record the ground displacement was a Sprengnether Portable Blast and Vibration Seismograph (Serial No. 1577).

The main findings of the survey have already been given verbally to the Commission, so that the work could continue without delay. The present report provides a permanent record of the survey.

2. INSTRUMENT AND METHOD.

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 time before firing the shot and stopped after the elapse of an interval of time sufficient to ensure that a complete record of the movement has been taken. Timing lines are printed on the record at 20-millisecond intervals. The magnification factor of the instrument is 100; that is, a displacement of one inch of a trace on the photographic record represents an actual ground displacement of 0.01 in.

Tests were made in the open area opposite the mud-brick houses in Hunter Street (Plates 1, 2). In this area thinly bedded Ordovician mudstone and sandstone crop out and strike approximately north. Along Hunter Street the pipeline trench is being excavated in a direction approximately perpendicular to the strike of the rocks. In order to measure at a single point the ground displacement in directions parallel and perpendicular to the bedding planes of the sedimentary rocks, tests were made using two sets of shot-holes. One set of holes was laid out parallel to the strike; the other set perpendicular to the strike (Plate 2). They were 5 ft. deep and at distances of 10, 20, 30, 40, 50, and 75 ft. from the recording point. Two sets of records were taken; one using $2\frac{1}{2}$-oz. charges, and the other using 5-oz. charges of AN60 gelignite.

In another test, a record was taken of the ground displacement produced by a "pattern shot" of the kind often used for blasting the rock. Five holes 5 ft. deep were drilled at the corners and centre of a 2-ft. square; each was loaded with $2\frac{1}{2}$ ozs. of AN60 gelignite, and the five charges fired simultaneously. The seismograph was set up at a distance of 15 ft. from the central charge, and in a direction parallel to the strike.

In still another test, records were taken with the seismograph mounted on the hearth of the dining room fireplace of a mud-brick house (Plate 2), when a fully loaded heavy truck passed in both directions along Hunter Street.

3. RESULTS.

Plates 4 and 5 show the kind of seismogram obtained in the tests. The series illustrated is for $2\frac{1}{2}$-oz. charges at distances from 10 to 75 ft.

The amplitudes and frequencies of the three components of ground displacement 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. (The amplitude of the recorded vibration on a single component is the displacement of the trace from its position of rest).

Assuming that the motion of the ground is simple harmonic, the maximum acceleration (a) may be calculated from the scaled values of frequency (f) and amplitude (A) by the use of the equation

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

Expressed as a fraction of the acceleration due to gravity (g) this acceleration is equal to

$$(4\pi^2 f^2 A)/12\,g \qquad \text{where } g = 32.2 \text{ ft/sec}^2$$

The resultant ground acceleration has been computed from the accelerations of the three components by means of the equation

$$a = \sqrt{a_L^{\,2} + a_V^{\,2} + a_T^{\,2}}$$

The maximum error in the acceleration is, from (1)

$$a = 4\pi^2 f\,(2A\,\partial f + f\,\partial A)$$

where ∂f is the maximum error in f

∂A is the maximum error in A

and the maximum error in the resultant ground acceleration is

$$\partial a = \frac{a_L}{a}\cdot\partial a_L + \frac{a_V}{a}\cdot\partial a_V + \frac{a_T}{a}\cdot\partial a_T$$

where ∂a_L is the maximum error in the longitudinal acceleration

∂a_V " " " " " " vertical "

∂a_T " " " " " " transverse "

and the percentage error in the resultant acceleration is

$$\frac{a_L^{\,2}}{a^2}\cdot\frac{\partial a_L}{a_L} + \frac{a_V^{\,2}}{a^2}\cdot\frac{\partial a_V}{a_V} + \frac{a_T^{\,2}}{a^2}\cdot\frac{\partial a_T}{a_T}$$

Table 1 lists the amplitudes and frequencies scaled from the seismogram, the resultant ground acceleration, the ratio of the resultant ground acceleration to the acceleration due to gravity, and the maximum percentage error in the resultant ground acceleration.

Thoenen and Windes (1942) made extensive investigations using a mechanical shaker on ceiling panels of buildings to determine the border line between damage and no damage; they adopted acceleration as a workable index to measure the likelihood of damage. In terms of acceleration they defined three zones which they named "safe", "caution" and "damage" (Plate 3). The lines dividing these zones were at 0.1 and 1.0 times the acceleration due to gravity. Damage generally occurred at accelerations greater than 1.0g, slight damage or preliminary phases of damage at accelerations between 0.1g and 1.0g, and no damage at accelerations less than 0.1g. In other tests a structure was damaged by blasting; recordings indicated accelerations of approximately 1.0g at the damage point, further confirming the adequacy of the index derived from the shaker tests.

The zones defined by Thoenen and Windes are adopted in this present report. They are marked on Plate 3, which is a graph of resultant ground acceleration (as a fraction of the acceleration due to gravity) against distance of the charge from the recording point. Curves B and C (2½-oz. charges) show that there is no great difference between the energies transmitted along the strike and perpendicular to the strike. Curves B and C pass from the "caution" to the "safe" zone at approximately 50 ft., and curve A (5-oz. charges) by extrapolation will pass from the "caution" to the "safe" zone at approximately 200 ft.

The "pattern shot" of five 2½-oz. charges 15 ft. from the recorder, lies in the "caution" zone but very near the "damage" zone; it falls almost exactly on the curve for a single 5-oz. charge. On the seismograms for distances greater than 50 ft., the complete recorded vibrations occupy an interval of about 200 milliseconds. A "pattern shot" using 200 millisecond delays would therefore produce no greater vibration than a single shot at distances over 50 ft.

As a guide to the level of vibration to which the houses have often been subjected, the seismograph was set up on the hearth of the dining room fireplace in the mud brick house B3 (Plate 2). Recordings were taken while a heavily loaded truck drove in both directions along Hunter Street, 25 ft. from the seismograph. However, no vibration was recorded, and it may be concluded that the ground accelerations due to passing traffic are too small to cause damage.

4. CONCLUSIONS.

In order to keep ground accelerations within the "safe" limit adopted by Thoenen and Windes (1942) it has been shown that :

(a) not more than 5-ozs. of AN60 gelignite should be detonated at any instant at a distance of 200 ft. from a building.

(b) not more than 2½-ozs. of AN60 gelignite should be detonated at any instant at a distance of 50 ft. from a building.

It is recommended that wherever the pipeline trench is less than 50 ft. from a building, another method be used to break up the rock.

Pattern shooting using delay techniques can be used for blasting the rock wherever the trench is farther than 50 ft. from a building; the delay between detonation of the individual shots should be 200 milliseconds or more, and the maximum size of individual charges should range from 2½-ozs. at 50 ft. to 5-ozs. at 200 ft.

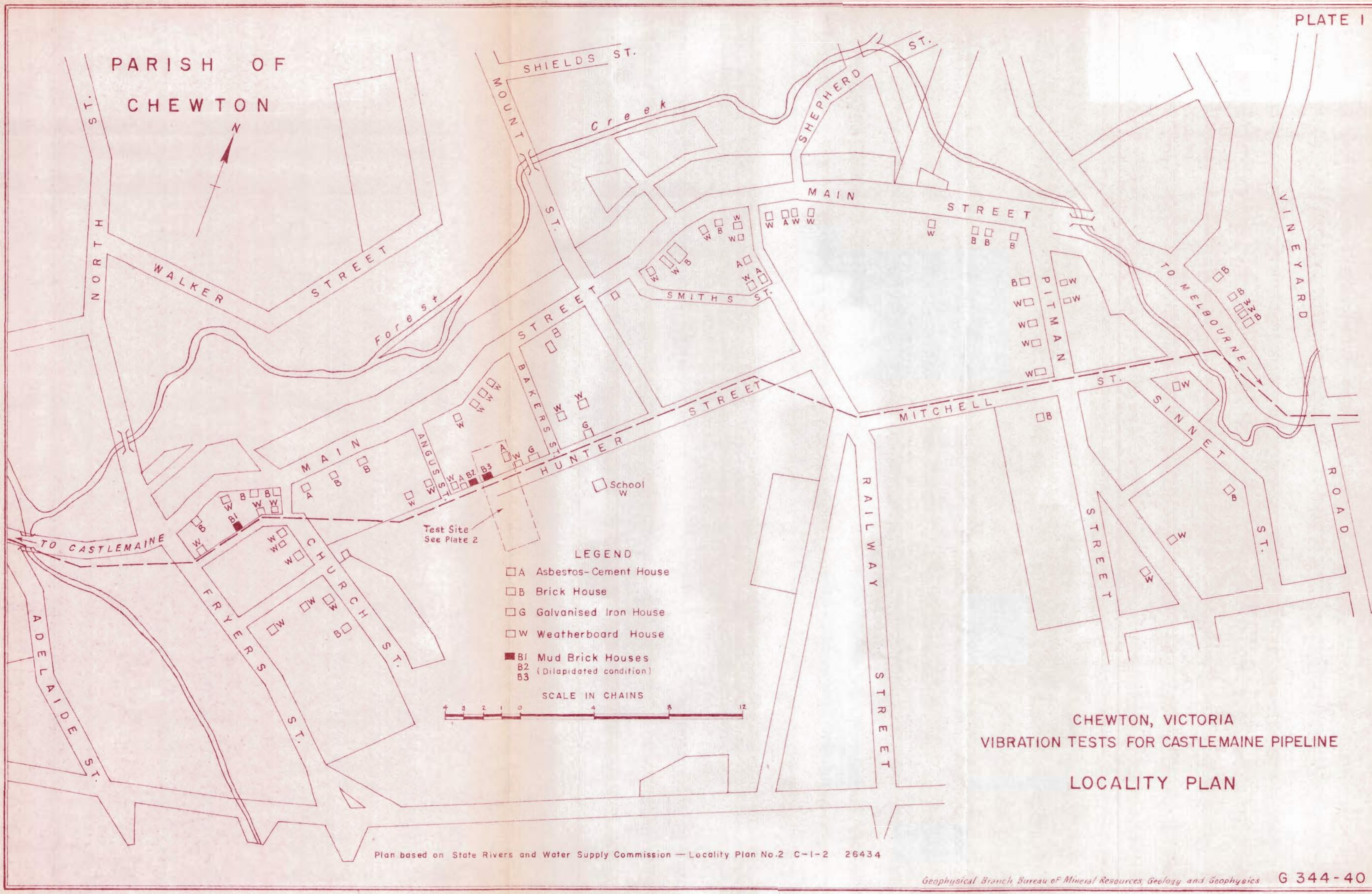
5. REFERENCES.

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

TABLE I

Wt of ANGO gelignite charg. oz	Shot Dist. ft	Amplitude, Frequency and Calculated Acceleration of Ground Displacement									Result. Accel.	Ratio Result. Accel. to Gravity	% error in Result. Accel.
		Longitudinal			Vertical			Transverse					
		A in x 10^{-3}	f c/s	a in/sec²	A in x 10^{-3}	f c/s	a in/sec²	A in x 10^{-3}	f c/s	a in/sec²	in/sec²	(g)	
5	10	5·2	20	82	5·6	50	554	1·6	37	87	564	1·46	25
5	10	20·2	14	156	4·7	59	645	3·4	18	44	665	1·72	29
5	20	0·8	30	28	1·3	67	230	0·5	77	117	259	0·67	55
5	30	0·4	77	94	1·0	77	234	0·1	100	39	255	0·66	53
5	40	0·4	77	94	0·6	77	141	0·5	100	197	259	0·67	53
5	50	0·5	59	69	0·8	59	110	-	-	-	124	0·32	34
5	75	0·3	50	30	0·7	77	164	0·3	100	118	201	0·52	57
2½	10	4·8	23	100	0·3	77	70	1·3	25	32	124	0·32	2[illegible]
2½	20	0·4	30	14	0·6	59	82	0·2	100	79	112	0·29	63
2½	30	0·4	59	55	0·3	77	70	-	-	-	81	0·21	53
2½	40	0·3	55	36	0·3	84	84	-	-	-	93	0·24	64
2½	50	0·3	37	16	0·1	100	39	0·2	55	24	46	0·12	117
2½	75	0·2	33	9	-	-	-	0·1	77	23	25	0·06	150
2½	10	5·6	23	117	1·8	63	282	0·3	39	18	310	0·80	28
2½	20	0·6	46	50	0·6	56	74	-	-	-	89	0·23	32
2½	30	0·2	59	28	0·8	59	110	-	-	-	112	0·29	43
2½	40	0·3	33	13	0·2	71	40	-	-	-	42	0·10	74
2½	50	0·2	31	8	0·1	56	12	-	-	-	15	0·04	[illegible]2
2½	75	0·2	35	10	-	-	-	-	-	-	14	0·03	70
12½	15	4·1	21	71	5·3	40	335	1·8	37	97	356	0·[illegible]2	[illegible]

G344 –



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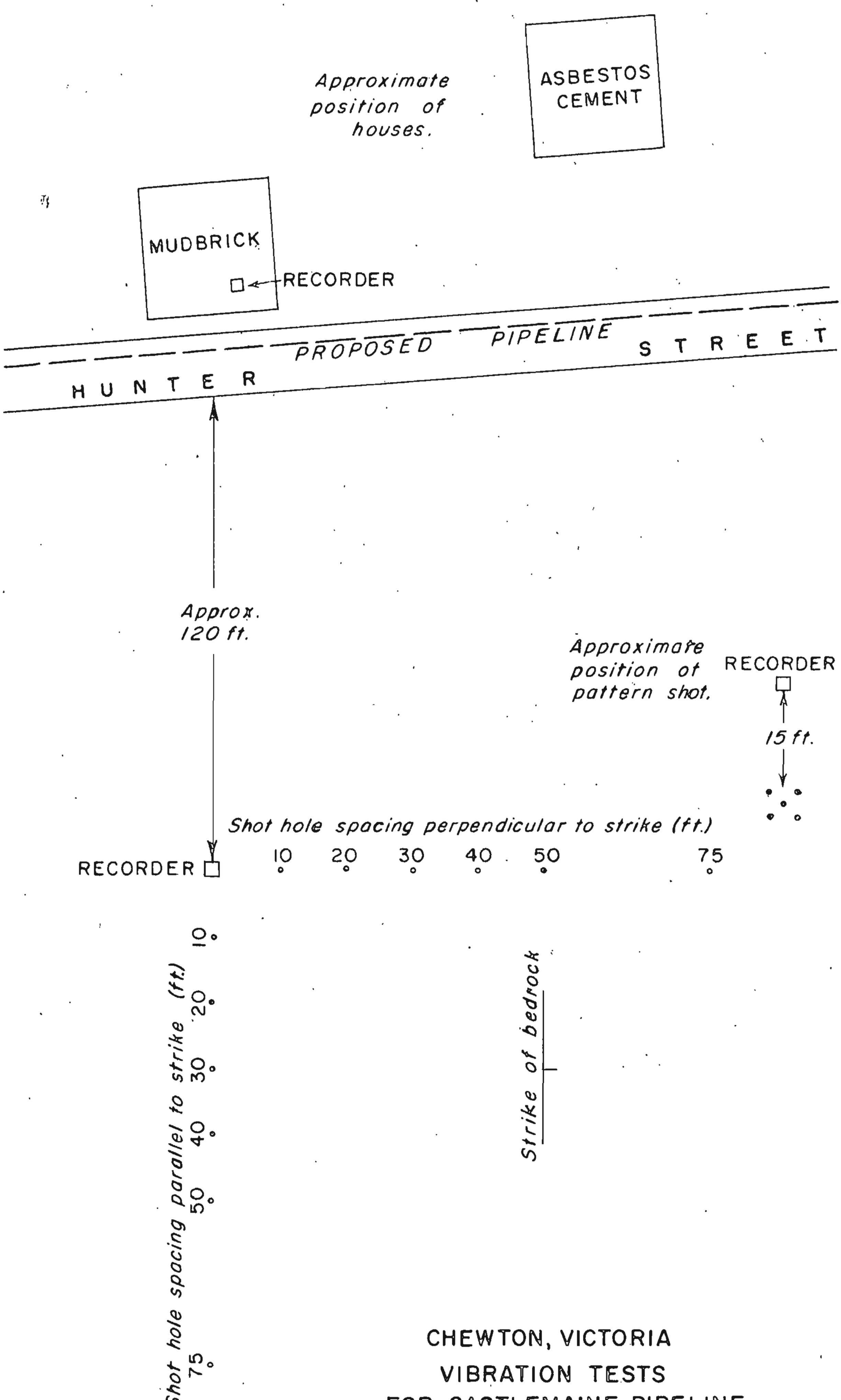
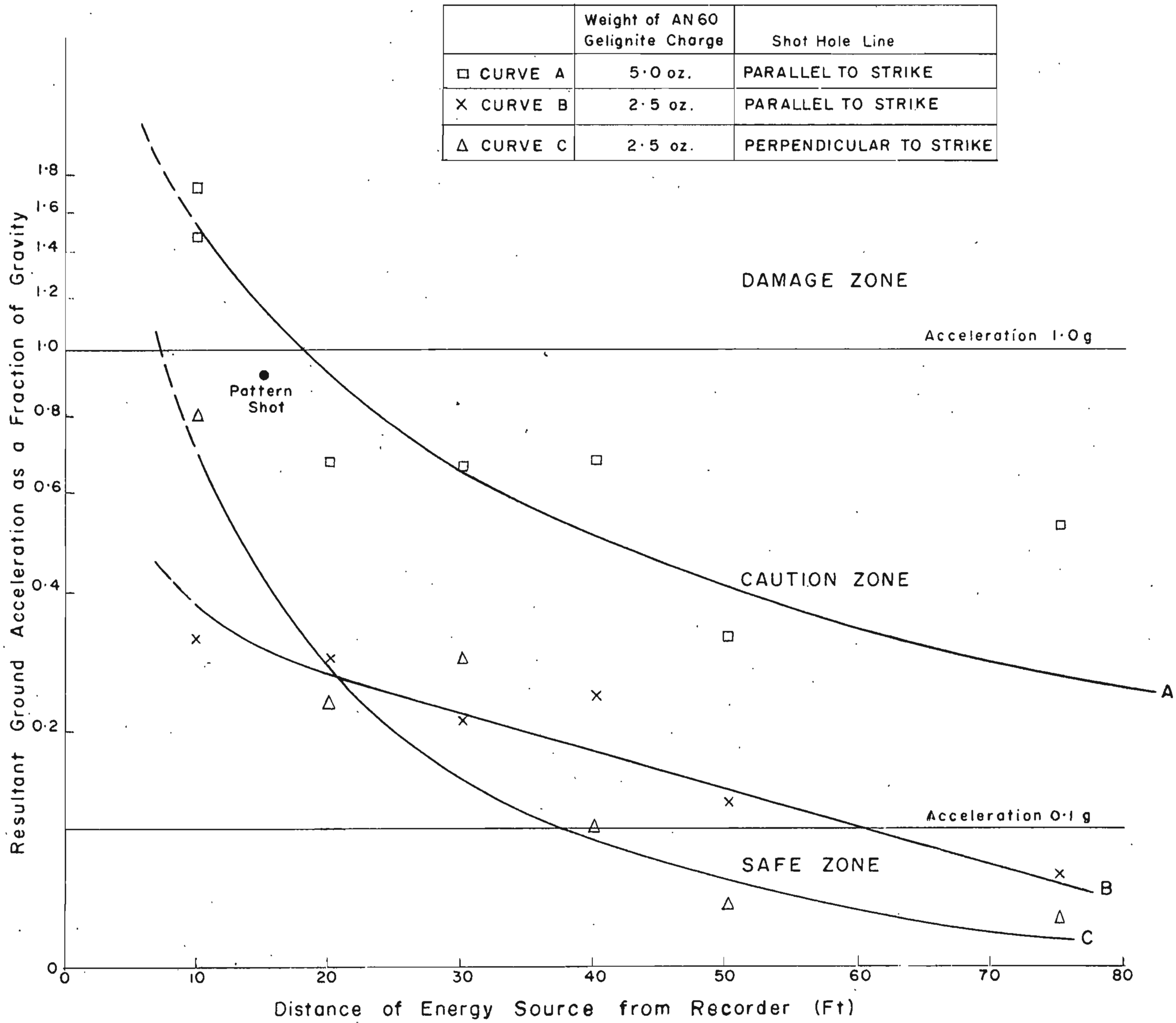


CHEWTON, VICTORIA
VIBRATION TESTS
FOR CASTLEMAINE PIPELINE

LAYOUT OF SHOT POINTS

Geophysical Branch, Bureau of Mineral Resources, Geology & Geophysics. G344-41

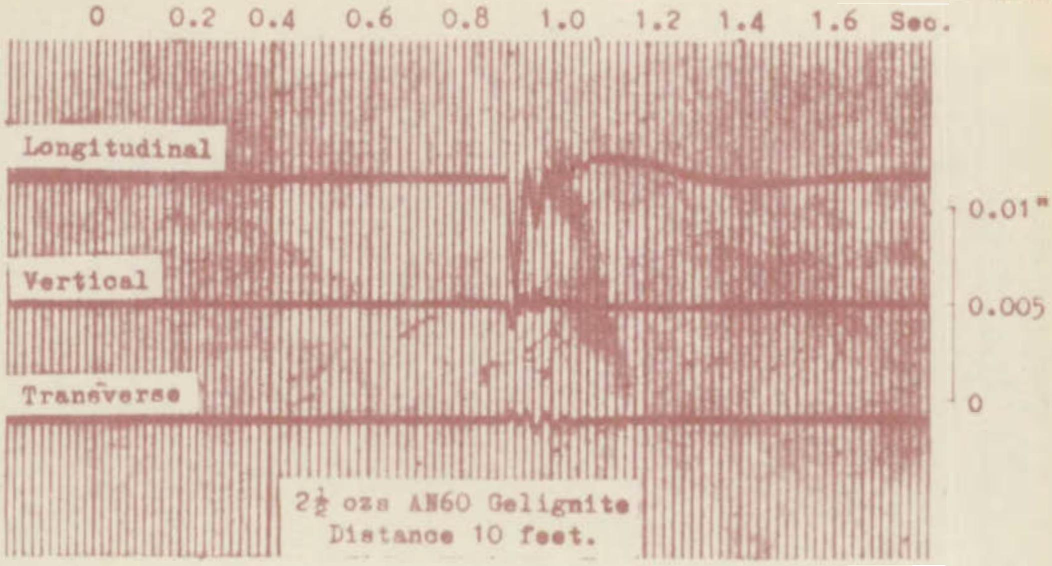
PLATE 3

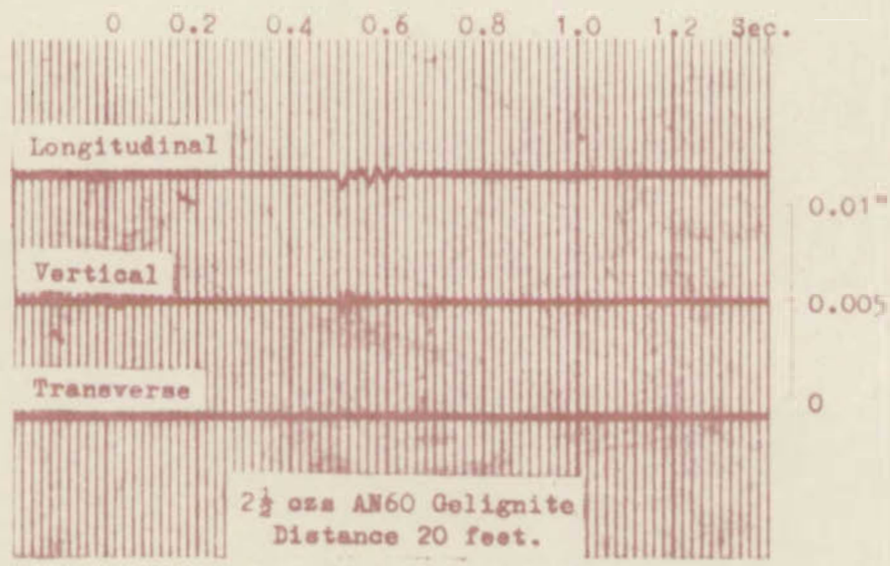


CHEWTON, VICTORIA
VIBRATION TESTS FOR CASTLEMAINE PIPELINE

GRAPH SHOWING RELATION OF GROUND ACCELERATION TO DISTANCE OF ENERGY SOURCE FROM RECORDER

PLATE 4





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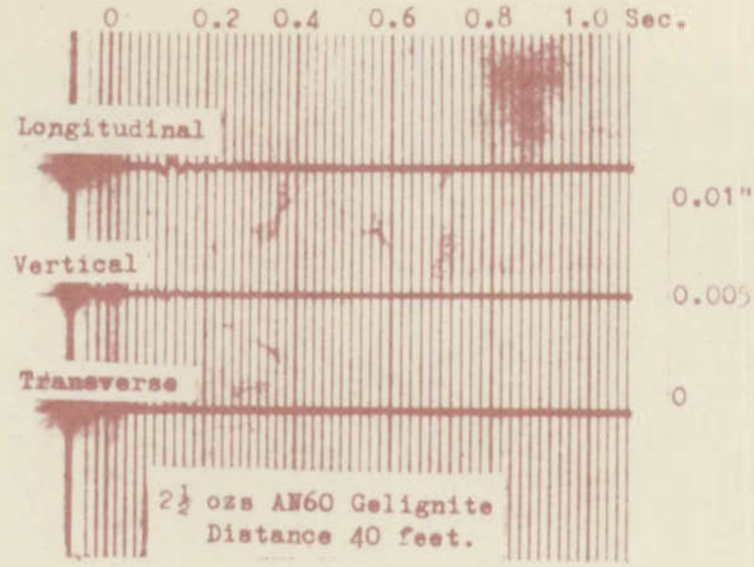
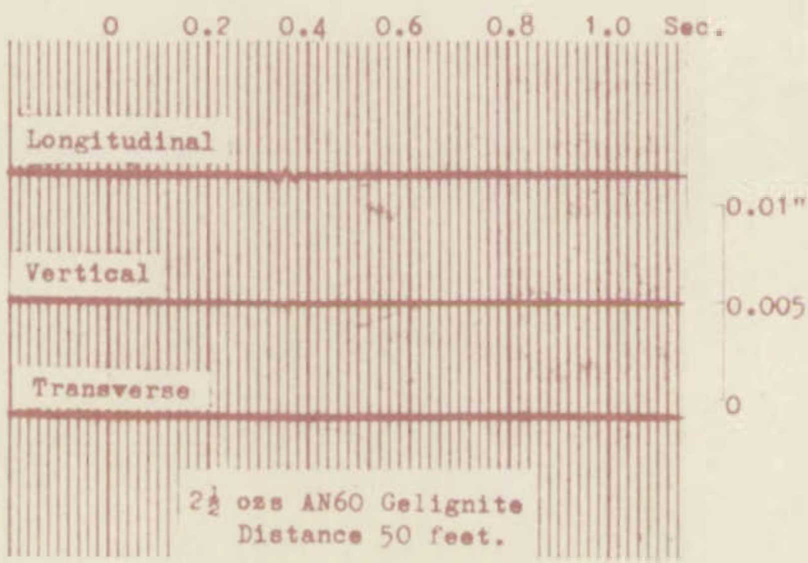
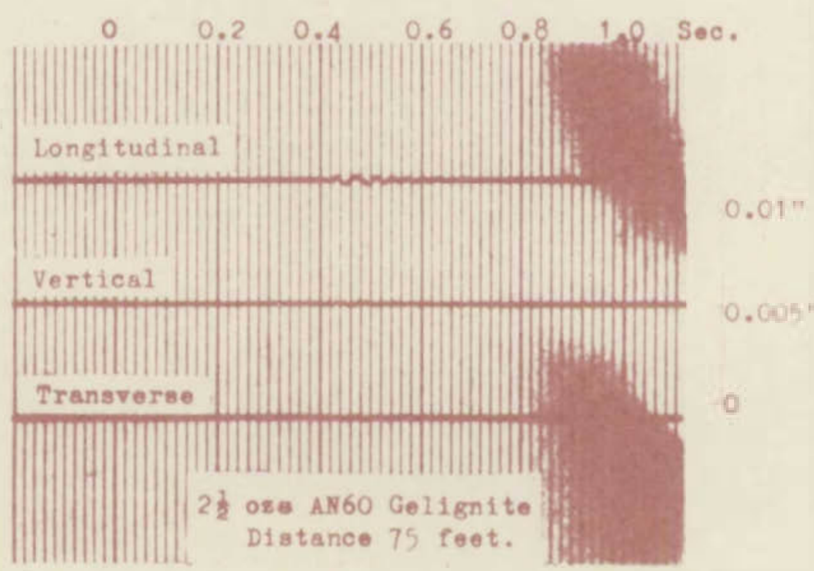
VIBRATION RECORDS







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