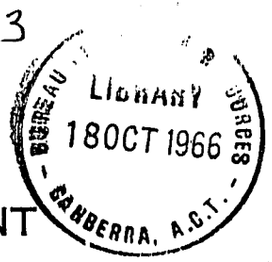

COMMONWEALTH OF AUSTRALIA

DEPARTMENT OF NATIONAL DEVELOPMENT

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

RECORD No. 1966/165

FOOTSCRAY AMMUNITION FACTORY VIBRATION TESTS, VICTORIA 1966

by

M. WAINWRIGHT

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ILLUSTRATIONS

SUMMARY

Vibration tests were carried out on a specially designed pillar in the Standards Laboratory of the Ammunition Factory, Footscray. The results are compared with those obtained immediately after construction of the pillar in April 1957. A maximum amplitude of 0.49 microns and frequencies greater than 5000 c/s were recorded. These vibrations originate from a number of sources including movement of personnel and vibration of machinery in the Standards Laboratory and in the adjacent room.

Similar tests were also carried out on the machine table and foundation of a jig-boring machine in a nearby tool room.

1. INTRODUCTION

In response to a request by the Department of Supply, measurements were made by the Geophysical Branch of the Bureau of Mineral Resources of amplitudes and frequencies of vibrations on the top of a specially constructed pillar in the Standards Laboratory, Metrology Section of the Ammunition Factory, Footscray. Similar tests were also made on a jig-boring machine located in a nearby machine shop of the factory. The measurements were made by M. Wainwright, geophysicist, on 1st February 1966.

Measurements had been made previously on the foundations of the pillar in November 1955, prior to its construction, and on the 4th and 5th April 1957 on the pillar itself (Hawkins & Stocklin, 1957). In these earlier tests, a Willmore three-component seismograph was used. During the tests of November 1955 and on the 4th April 1957 (Test A), machinery in adjacent buildings was not operative. For the test on 5th April 1957 (Test B) and in the current tests discussed, this machinery was in normal operation.

2. METHODS AND EQUIPMENT

For the tests described in this record, a Halls-Sear HS-1 omnidirectional geophone with a natural frequency of 14 c/s was used to record the vibrations. This geophone resolves components of the vibrations in three mutually perpendicular directions, vertical (green-yellow-leads), and two horizontal (red-blue, and black-white leads). The orientation of the components with respect to the pillar and jig-borer is shown in Plate 1. The HS-1 geophone is essentially a velocity recording instrument, and the amplitude of the recorded signal (displayed on the Y axis of an oscilloscope) is proportional to the maximum velocity of the measured vibration and is a function of the frequency of the signal and the frequency response characteristics of the geophone (see Curve d, Plate 3). The signals from the geophones were displayed on a Tektronix Type 564 Storage oscilloscope with a Type 2A63 differential amplifier module. The 2A63 module was chosen for its high-gain characteristics, but unfortunately it permits only one component of vibration to be displayed at a time.

Let the frequency of the displayed signal = f c/s
the amplitude of the displayed signal = S volts,
and the geophone sensitivity at frequency f = d volts/in/s (Plate 3)

The maximum velocity v of the recorded vibration = S/d in/s
$= 2.54\ S/d$ cm/s

Also, $v = 2\pi af$
where a = amplitude of motion in cm
Thus, we have $2\pi af = 2.54S/d$
or $a = 2.54\ S/(2\pi fd)$ cm

Since S in these tests is in millivolts,
$a = 4S(fd)\mu$

where $\mu = 10^{-4}$ cm

Sensitivity curves for the HS-1 geophone are supplied by the manufacturer (Plate 3). In the tests, the geophone coils were shunted by resistors of 240 ohms, giving rise to a damping of 72%. For the frequencies greater than 300 c/s, a sensitivity of 0.30 volts/inch/s was assumed, which might introduce errors in the computed amplitudes; however, these high frequency vibrations have very small amplitudes, so that the resultant computed amplitude will be very small.

The Standards Laboratory vibrations were recorded with the geophone at the centre of the pillar, and at the centre of the foundations. In the tool room, the vibrations were recorded at the centre of the jig-borer machine table (directly beneath the spindle) and at two positions on the foundations (see Plate 1, Figure 2).

3. RESULTS

The results of the vibration tests are recorded in Tables 1 and 2 and typical records are shown in Plate 2. In these tables, the amplitudes of motion in three directions are given, together with resultant amplitudes.

Comparison of results with Test B (5th April 1957)

It should be noted that in previous tests in the Standards Laboratory, all recorded vibrations were 10 c/s or less (Hawkins & Stocklin, 1957). In the current vibration tests, the lowest recorded frequency was 18 c/s and most of the remaining frequencies lay in the range of 30-50 c/s. It should be noted that the Willmore seismograph records vibrations on a moving chart, the low speed of which prohibits measurements of frequencies greater than 10 c/s. The geophone-oscilloscope combination was capable of recording frequencies of 10 c/s or less, but if present these are probably overshadowed by the much higher frequencies and amplitudes presented in Table 1. Further, the effect of electromagnetic pick-up from stray power supplies by the oscilloscope is uncertain. Most of the vertical components of vibration, e.g. records 2 (a), 2 (b), 2(c), 3 (a), 5 (a), 6 (e), and 7 (a), show a frequency of 50 c/s, which suggests interference from power supplies. This is always an inherent possibility with amplification equipment, and it is difficult to arrange effective screening.

Background vibrations were due to a number of contributory factors such as noise from a compressor station about 350 ft away, machine shops opposite the Metrology Section, air conditioning, minor movements in adjacent rooms, and passing traffic along Gordon Street. The amplitudes of vibrations measured in the current tests are smaller than those of the 1957 tests. For example, in Test B, the greatest amplitude was 1.89μ for the N-S horizontal component. In the current tests on the pillar the greatest amplitude of a horizontal component was 0.127μ, on record 5 (b) due to personnel moving in an adjacent room, and on record 7 (b) due to a tram passing along Gordon Street. The greatest vertical component measured on the pillar was 0.27μ, on record 1 (f) due to personnel walking in the standards room; this compares with a maximum amplitude of 0.685μ due to some unidentified source in Test B. It should be noted, however, that with the recording system used in the current tests, the period of observation was very short. For an oscilloscope with a time sweep across the Y scale (10 cm in length) varying between 5 millisec/cm, such as on record 1 (c), and 20 millisec/cm, such as on record 1 (a), the period of observation varies between 50 and 200 millisec. Therefore, to be certain of recording the maximum velocity of an event, several records were made, and the maximum recorded velocity was chosen for computation. When personnel move inside the laboratory itself, the amplitude could rise an order one in magnitude : compare records 1 (e) and 1 (f). Trams passing along Gordon Street increase the resultant amplitude by about 50%, as can be seen by comparing records 1 (b), 1 (d), and 1 (e) with 7 (a), 7 (b), and 7 (c).

Vibrations measured on the foundations are much greater than the background vibrations on the pillar, i.e. 0.58μ on records 6 (a), 6 (b), and 6 (c) as against 0.106μ on records 1 (b), 1 (d), and 1 (e). In part of the tests, thin linoleum was used to cover the pillar; without this cover, the background vibrations are smaller, as can be seen by comparing records 5 (a) and 5 (c) with records 1 (e) and 1 (b); 5 (b) cannot be considered in this context because of significant movement in the adjacent room.

Tool room annexe

The results of vibrations measured on the hydroptic B size 5 jig-borer fixture are presented in Table 2 and records 8 and 9. The geophone was placed at the centre of the machine table directly beneath the centre-line of the spindle (see Plate 1, Figure 2). With the spindle rotating at 1250 r.p.m., the resultant amplitude on the table was 0.8μ, as compared with 0.5μ recorded at position 2 on the foundations. It is clear from records 8 (a), 8 (d), 8 (e), and 8 (f) that the amplitude does not change much whatever the speed of the spindle. The lowest amplitudes were recorded with the geophone at foundation position 3, which is farthest away from the drive motor, the major source of vibration - see records 9 (d) and (e).

4. CONCLUSIONS

Tests carried out on the Standards Laboratory pillar demonstrate the presence of vibrations with frequencies much higher than any previously recorded. Trams passing along Gordon Street affect the vibration level on the pillar, but movement of personnel and vibration of machinery in the laboratory itself, and in the adjacent room, cause vibrations of at least the same level. It has not been possible to attribute the general background vibrations to any particular source. The air conditioning does not appear to cause significant vibrations. However, there appears to have been a decrease in the level of background vibration compared with that of Test B on 5th April 1957. Even allowing for different methods of observation, it does not seem that the efficiency of the pillar foundations to isolate vibrations has deteriorated since construction.

Tests carried out on the jig-borer indicate that the vibrations originate from the drive motor, the speed of rotation of the spindle being of no great influence. The maximum amplitudes were recorded on the machine table: those on the foundations were considerably lower, with the minimum amplitudes at foundation position 3.

5. REFERENCES

HAWKINS, L. V. and STOCKLIN, A. 1957 Vibration tests on a specially constructed pillar in the Standard Laboratory of the Munitions Factory, Footscray, Bur. Min. Resour. Aust. Rec. 1957/81.

TABLE 1

Details of vibrations in Standards Laboratory

TABLE 1

Location and Conditions (See notes)	Record number	Component measured	Amplitude displayed (cms) Major	Amplitude displayed (cms) Minor	Vertical scale Y (millivolts/cm)	Magnitude of signal (millivolts) Major	Magnitude of signal (millivolts) Minor	Hor. scale X (msecs/cm)	Frequency 'f' of signal (c/s) Major	Frequency 'f' of signal (c/s) Minor	Amplitude of motion (μ) Major	Amplitude of motion (μ) Minor	Maximum resultant amplitude (μ)	Remarks
A, B, C	1 (a)	-	0.125		1	0.125		20	50		0.032			Open circuit - 50 c/s pick-up
A, B, C	(b)	H1	0.160		1	0.160		20	30		0.067x			Background noises only
A, B, C	(c)	H1	0.05	0.04	1	0.05	0.04	5	120	5000	0.005	0.0002	0.106	" " " (poor record)
A, B, C	(d)	H2	0.17		1	0.17		20	30		0.077x			" " "
A, B, C	(e)	V	0.10		1	0.10		20	42		0.030x			" " "
A, B, C	(f)	V	0.48	0.05	1	0.48	0.05	20	23	135	0.27	0.005		Persons walking in Standards Laboratory
A, B, C,	2 (a)	V	0.09		1	0.09		20	50		0.023			People moving in adjacent room (20 ft)
A, B, C	(b)	V	0.20	0.10	1	0.20		20	50		0.051			"
A, B, C	(c)	V	0.15	0.05	1	0.15		20	50		0.038			"
A, B, C	3 (a)	V	0.19	0.10	1	0.19	0.10	20	50	250	0.048x	0.005		Standards laboratory door closing
A, B, C	(b)	H1	0.10	0.09	1	0.10	0.09	20	30	250	0.038x	0.005	0.14	"
A, B, C	(c)	H2	0.27	0.10	1	0.27	0.10	20	30	250	0.114x	0.005		"
B, C	4 (a)	V	0.25		1	0.25		20	30		0.102			Background noise only
B, C	(b)	H2	0.13		1	0.13		20	30		0.055			"
B	5 (a)	V	0.11		1	0.11		10	50		0.026x			"
B	(b)	H2	0.30		1	0.30		10	30		0.127x		0.14	People moving in adjacent room
B	(c)	H1	0.11		1	0.11		10	30		0.051x			Background noise only
D	6 (a)	H1	0.70		1	0.70		10	18		0.49x			"
D	(b)	H2	0.62		1	0.62		10	27		0.29x		0.58	"
D	(c)	V	0.17		1	0.17		10	50		0.043x			"
B	7 (a)	V	0.20		1	0.20		10	50		0.051x			Tram passing on Gordon St.
B	(b)	H2	0.34		1	0.34		10	33-36		0.127x		0.157	"
B	(c)	H1	0.19		1	0.19		10	30-36		0.077x			"

Notes : A - Air conditioning in operation
B - Geophone at centre of pillar
C - Linoleum cover on pillar
D - Geophone at centre of foundation
x - Used to calculate resultant amplitude
H1 - Horizontal component with black and white leads of geophone
H2 - Horizontal component with red and blue leads of geophone

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TABLE 2

Details of vibrations on hydroptic jig-borer

TABLE 2

Location and Conditions (See notes)	Record number	Component measured	Amplitude displayed (cms) Major	Amplitude displayed (cms) Minor	Vertical scale Y (millivolts/cm)	Magnitude of signal (millivolts) Major	Magnitude of signal (millivolts) Minor	Hor. scale x (msecs/cm)	Frequency 'f' of signal (c/s) Major	Frequency 'f' of signal (c/s) Minor	Amplitude of motion (μ) Major	Amplitude of motion (μ) Minor	Maximum resultant amplitude (μ)	Remarks
A, E	3 (a)	H1	0.16	0.05	20	3.2	1.0	5	200 ±	V.H.F.	0.20	0.057		Also high-frequency, low-amplitude signal
A, D1	(b)	V	0.17	0.40	20	3.4	8.0	5	75	660	0.57x	0.152	0.80	"
A, D1	(c)	H2	0.36	0.07	20	7.2	1.4	5	250	540	0.36x	0.033		"
A, D1	(e)	H1	0.19	0.06	20	3.8	1.2	5	250	540	0.19x	0.028		"
A, D2	(e)	H1	0.16	0.07	20	3.2	1.4	5	250	660 +	0.17	0.027		
A, D3	(f)	H1	0.14		20	2.8		5	130		0.20			
B, D1	2 (a)	V	0.09	≪0.05	20	1.8	≪1.0	20	78	>550	0.29x	<0.0013	0.50	Also high-frequency, low-amplitude signal
B, D1	(b)	H1	0.04	≪0.05	20	0.80	≪1.0	20	37?	>600	0.27x	<0.0019		"
B, D1	(c)	H2	0.04	≪0.05	20	0.80	≪1.0	20	37?	>600	0.27x	<0.0019		"
C, D1	(d)	H2	0.13	0.06	5	0.65	0.30	20	78	>150	0.10x	<0.025	0.23	Assumed H1 amplitude of 0.125μ
C, D1	(c)	V	0.13	0.07	5	0.65	0.35	10	60	620	0.14x	<0.007		

Notes : A - Centre machine table position 1 beneath spindle
B - Foundation position 2
C - Foundation position 3
D1 - Spindle rotating at 1250 r.p.m
D2 - 680 r.p.m
D3 - 40 r.p.m
E - Only the motor operative
x - Used to calculate resultant amplitude
H1 - Horizontal component with black and white leads of geophonee
H2 - Horizontal component with red and blue leads of geophone

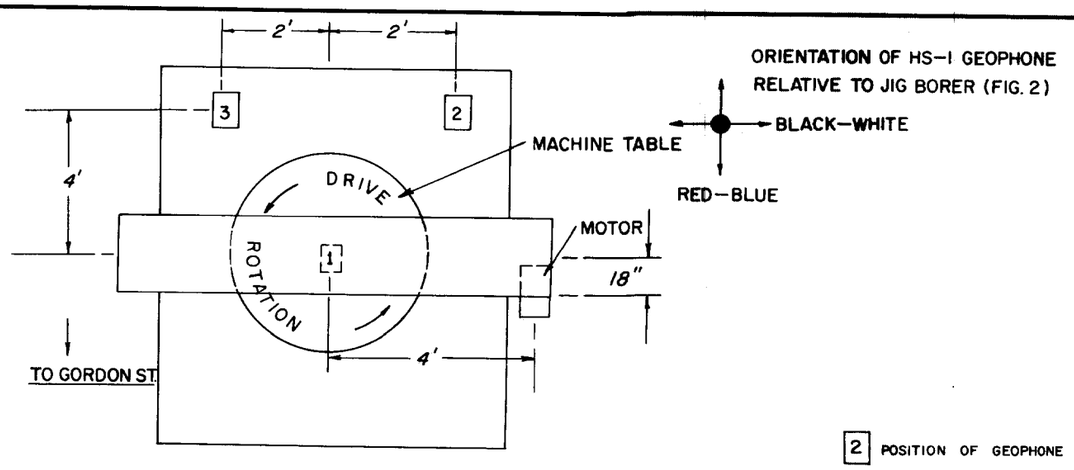


Fig.2 JIG BORER, HYDROPTIC B, SIZE —5 DETAILED PLAN

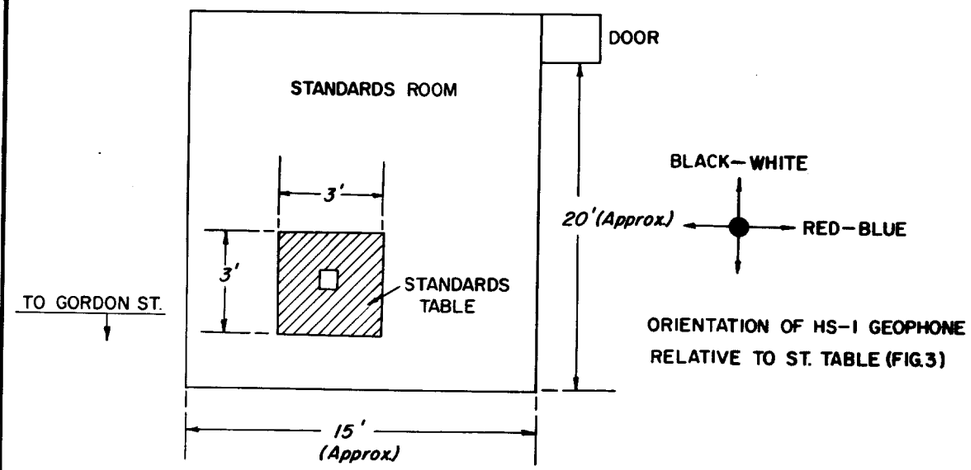


Fig.3 STANDARDS ROOM—PLAN

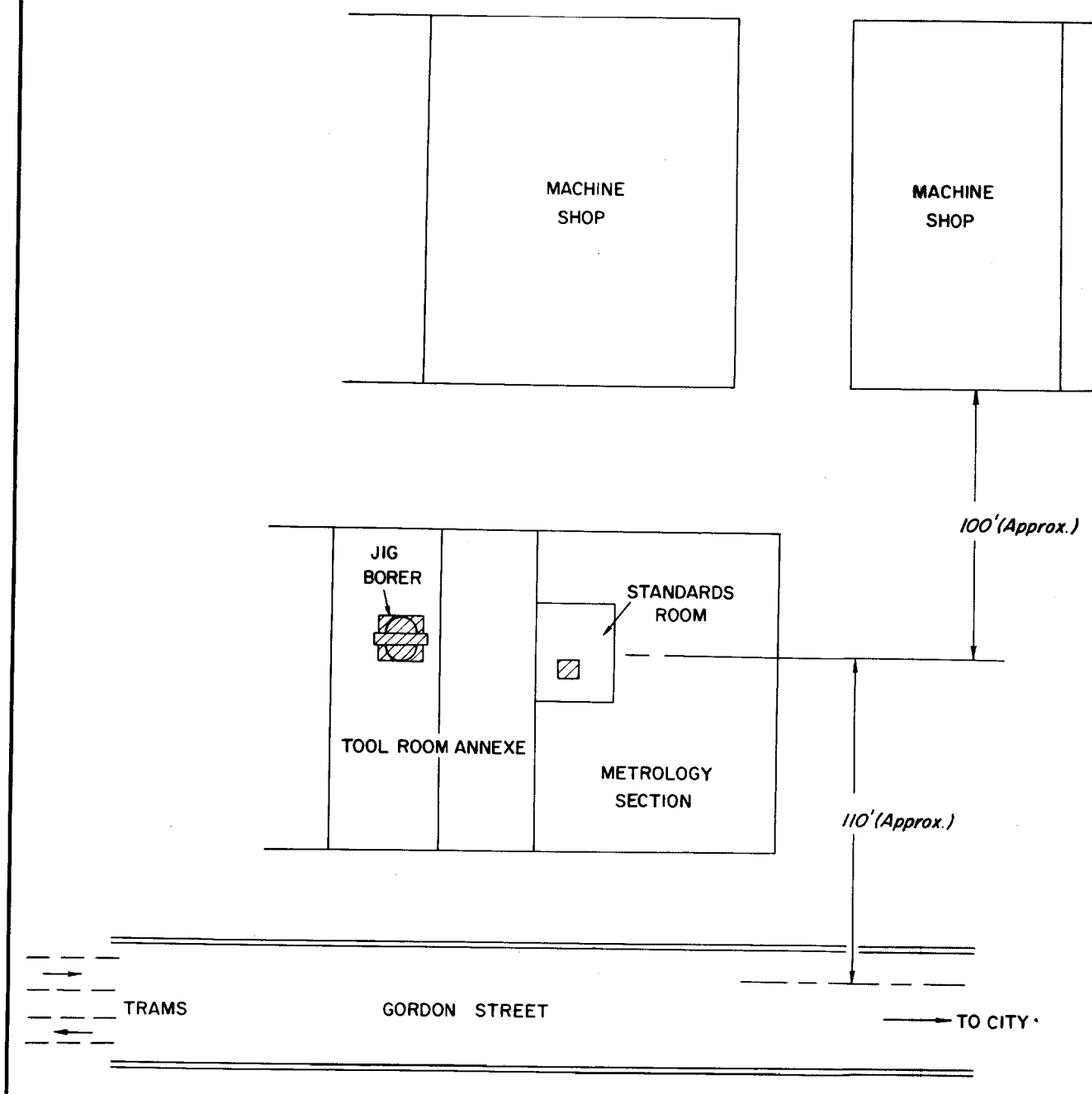
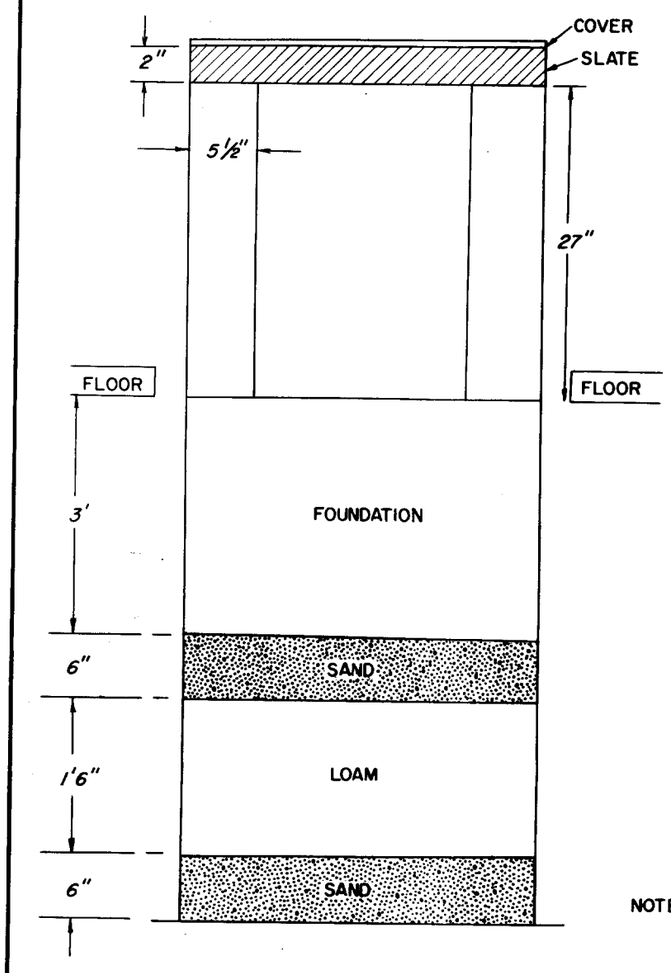


Fig. 1 LOCATION PLAN, AMMUNITION FACTORY, DEPARTMENT OF SUPPLY
GORDON ST., FOOTSCRAY, VICTORIA.



NOTE: FIGS. NOT DRAWN TO SCALE

Fig.4 STANDARDS TABLE—ELEVATION

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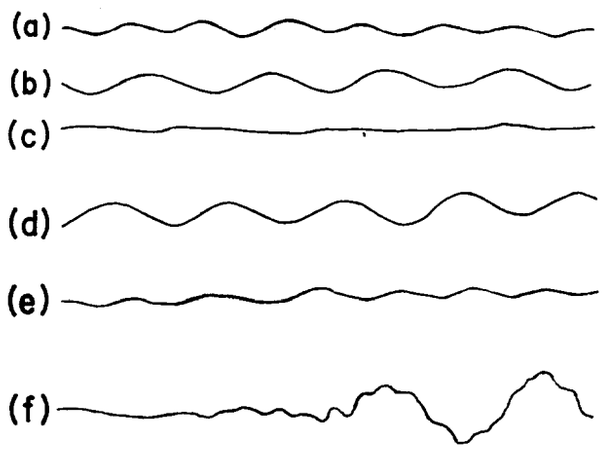

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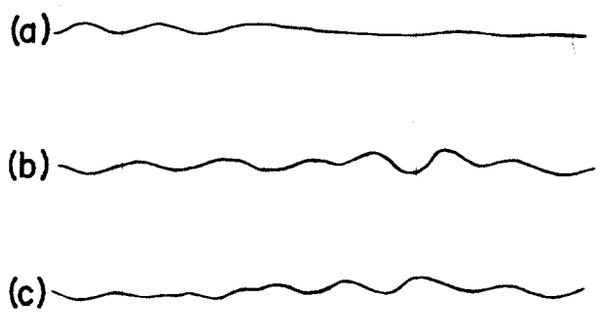

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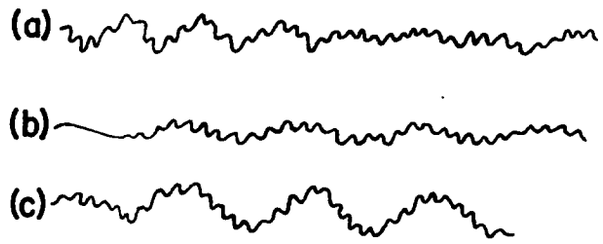

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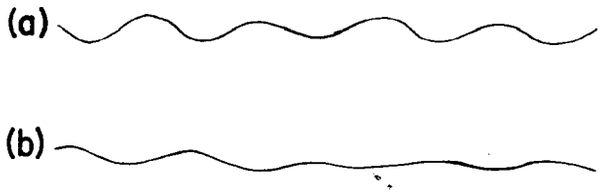

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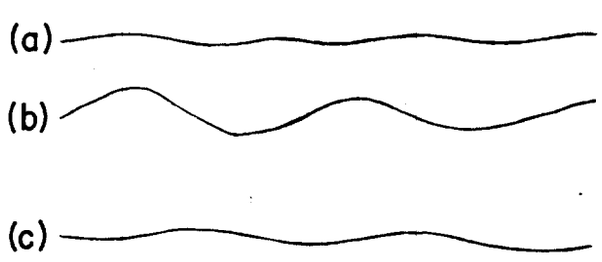

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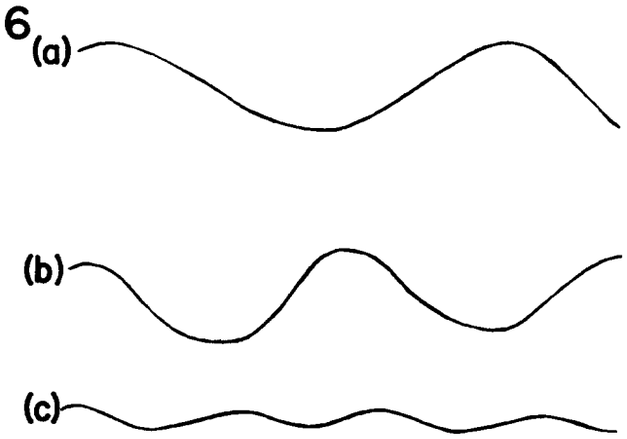

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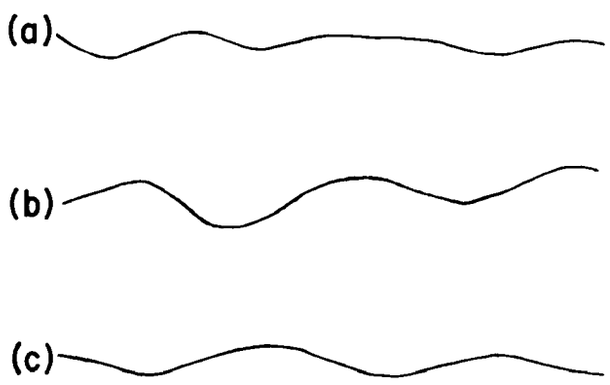

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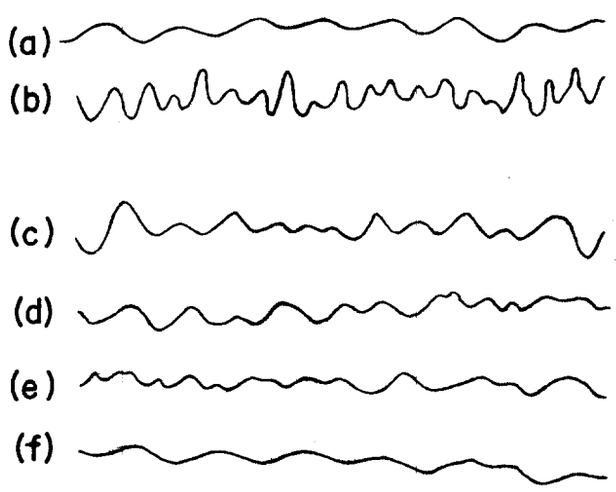

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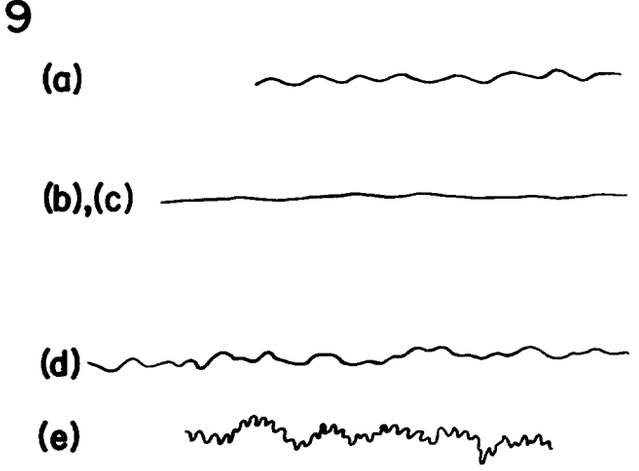
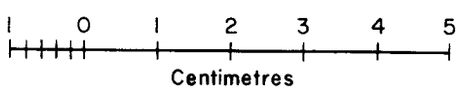


SCALES



Horizontal (X) and vertical (Y)

Note For explanation of records refer to tables 1 and 2

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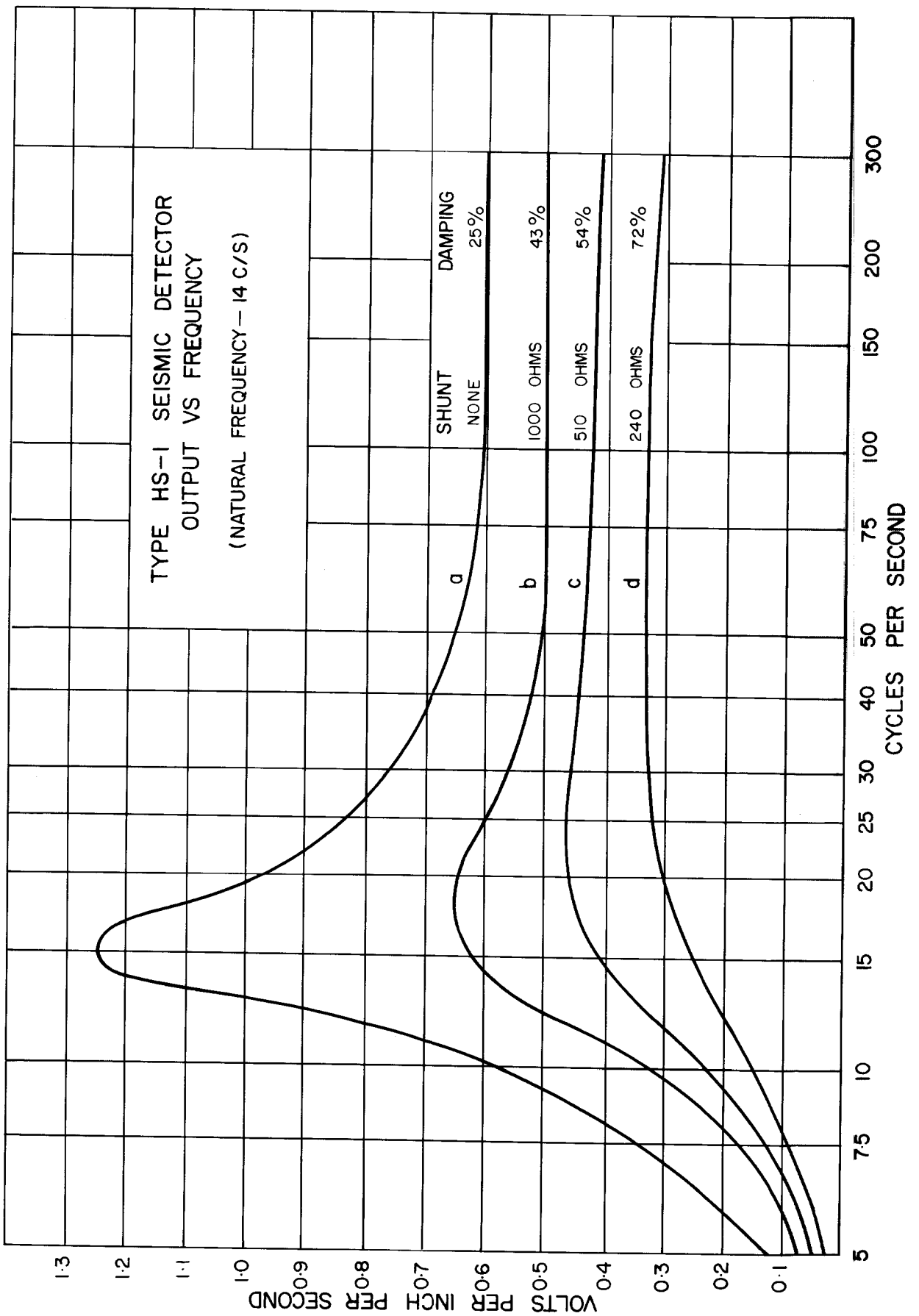
PLATE 3



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FREQUENCY RESPONSE CURVES, HS-I GEOPHONE

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