56/103
3

COMMONWEALTH OF AUSTRALIA

DEPARTMENT OF NATIONAL DEVELOPMENT

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS.

RECORDS

1956, No.103

BUREAU OF MINERAL RESOURCES LIBRARY Copy 3 CANBERRA, A.C.T.

VIBRATION TESTS AT COMMONWEALTH FERTILISERS AND CHEMICALS LTD., YARRAVILLE, MELBOURNE.

by

M.J. O'CONNOR.

BUREAU OF MINERAL RESOURCES
LIBRARY
Copy 3
CANBERRA, A.C.T.

RECORDS 1956, NO. 103

VIBRATION TESTS AT COMMONWEALTH FERTILISERS AND CHEMICALS LTD., YARRAVILLE, MELBOURNE.

by

M.J. O'CONNOR.

C O N T E N T S

		PAGE
	ABSTRACT	(iii)
1.	INTRODUCTION	1
2.	METHOD	1
3.	RESULTS	2
4.	ACCURACY	2
5.	CONCLUSIONS	5

ILLUSTRATION.

PLATE 1. PLAN OF LEAD-CHAMBER PLANT.

A B S T R A C T

Tests were carried out at the lead-chamber plant of Commonwealth Fertilisers and Chemicals Ltd., Yarraville, to trace the source of vibration causing damage to the lead-chamber structure. The tests were made with a Leet 3-component portable seismograph.

The main source of vibration was found to be blower 8, although it could not be determined whether any of the vibrations were really damaging to the lead-chambers.

1. INTRODUCTION

At the request of Commonwealth Fertilisers & Chemicals Ltd., (Cuming Smith & Co. Pty. Ltd.) a series of vibration tests was carried out at the Company's factory by the Geophysical Section of the Bureau of Mineral Resources, on 7th July and 16th August, 1956.

The tests were made on the framework surrounding the lead chambers of a sulphuric acid plant. Cracks which have developed in the chamber walls may have been caused by vibration and it was desired to find out (i) the frequencies and amplitudes of vibration to which the chambers are subjected, and (ii) the source of any undesirable vibration.

There are four lead chambers, each approximately 50 ft. long, 20 ft. wide and 25 ft. high. The chamber walls are supported from wooden beams at the top. The bases of the chambers rest on a floor supported by rolled steel joists on brick columns 12 ft. high and 24 inch square cross-section (see Plate 1). The bases of the brick columns are embedded in a concrete floor at ground level. There are platforms around the base and top of the chambers, the top platform being supported by wooden pillars about 9 inches in diameter, sitting on the brick pillars.

The main sources of vibration are believed to be blowers 1, 5 and 6 (2, 3 and 4 are not in use) on the concrete floor below the 2nd chamber (Plate 1), blowers 7 and 8 also on the concrete floor, and two acid pumps on the acid tank.

The tests on 7th July were made while the plant was operating under normal conditions. On the 16th August, tests were made with the various blowers and pumps running individually, in order to investigate the vibrations caused by each unit separately.

2. METHOD

The tests were made with a Leet 3-component portable Seismograph. In most of the tests, the seismograph was set on a base of plyboard (see Table 1) because the platforms on which the tests were made consist of pieces of timber about 2 inches apart.

The seismograph was always set so that the horizontal longitudinal trace measured the component in the YOY' direction (Plate 1) and the horizontal transverse trace measured the component in the XOX' direction. The paper motor of the instrument was allowed to run for about 4 seconds for each record.

From the records, the amplitudes and frequencies of the vibrations were calculated from the formula :-

$$a = cf^2A \qquad (1)$$

where a = acceleration (inches/second^2)
f = frequency (cycles per second)
A = amplitude (inches)
c = a constant = $4\pi^2$ = 40 (approx.)

The force applied to a structure by a vibration is proportional to the acceleration produced by the vibration. Hence the accelerations shown are a measure of the stresses to which the structure is subjected by the vibrations.

..2/

3. RESULTS.

The values of the amplitudes (inches), frequencies (c.p.s.) and accelerations (inches/second^2) measured from the records of 7th July and 16th August are shown in Tables 1 and 2 respectively.

On 7th July, the plant operated normally, with all machinery working and with gas under pressure fed to the blowers. On 16th August the plant was closed down, but the pumps were left working and the blowers were turned on for short periods. The blowers were not fed with gas under pressure but with ordinary air. A comparison of readings at the same positions taken on the two days, e.g. Record 9 of Table 1 and Record 30 of Table 2, shows that the values of the amplitude and acceleration were greater on 7th July. This is assumed to be due to the blowers being under load on that date and not on 16th August.

The frequencies recorded range from 4.8 c.p.s. (YOY' component, Record 21) to 120 c.p.s. (XOX' component, Record 7). The maximum displacement measured was 0.0034 inches as the resultant of a 23 c.p.s. vibration (amplitude 0.0022 in.) and a 20 c.p.s. vibration (amplitude 0.0012 in.) as shown for the vertical component in Record 8.

The maximum value of the acceleration is 180 inch/second^2 (XOX' component Record 9).

Table 3 shows the vibrations recorded from blowers 7 and 8 and from blowers 1, 5 and 6 during a test on 16th August. The plant was not working at full load, i.e. the blowers were passing cold air at atmospheric pressure. These results were obtained by comparing the recorded vibrations with all the machinery working and the recorded vibrations with all the machinery working except blowers 7 and 8 and 1, 5 and 6.

The frequency of 60 c.p.s., shown in Table 3, was recorded in other places with blowers 7 and 8 off and 1, 5 and 6 on; also with all the blowers and pumps off except the pumps marked ⊙ on Plate 1. (See Table 2, Records 26, 27 and 29).

It appears that the accelerations caused when the blowers are operating under zero load are of minor importance compared with those caused by blower 8 under load (blowing hot gas under pressure).

4. ACCURACY

The acceleration may be represented by equation (1)

$$a = cf^2A \text{ .... } (1)$$

The maximum error (da) in a can be represented by

$$da = cf\ (2A\,df + f\,dA) \text{ .... } (2)$$

in which df is the maximum error in f,
and dA is the maximum error in A.

If df = ± 1 c.p.s. and dA = ± 0.0001 inch, equation (2) becomes:

$$da = cf\ (2A + .0001\ f) \text{ .... } (3)$$

In Table 4, the possible errors in the accelerations are shown for a range of amplitudes from the minimum to the maximum observed, corresponding to frequencies of 10, 30 and 60 c.p.s.

TABLE 1

FREQUENCIES, AMPLITUDES AND ACCELERATIONS MEASURED FROM RECORDS TAKEN ON 7TH JULY 1956, UNDER NORMAL PLANT OPERATION.

Rec. No.	Vertical component			YOY' component			XOX' component		
	f (cps.)	A (in.)	a (in/sec^2)	f (cps.)	A (in.)	a (in/sec^2)	f (cps.)	A (in.)	a (in.sec^2)
2A^{x}	(19 (16	.0019 .0009	26 9	15.7	.0005	5	16.2	.0005	5
3^{x}	30	.0003	10.8(1)	30	.0005	18	60	.0001	14(1)
4^{x}	-	-	-	-	-	-	-	-	-
5^{x}	15.6	.0008	8	15.9	.0008	8	15.9	.0013	13
6^{x}	19	.0018	25	(13.5 73	.0007 .0001	5 22(1)	9.6 120	.0009 <.0001	3 -
7	19	.0013	18	(19 (73	.001 .0001	14 22(1)	19 120	.0015 <.0001	21 <57(1)
8^{x}	(23 (20	.0022 .0012	47) 19)	23	.0008	17	59	.0005	69
8A^{x}	30	.0025	89	30	.0005	18	(30 (60	.001 .0005	35 70
9	29	.0012	40	16	.0008	8	68	.001	180
9A	30	.001	36	15.5	.0006	6	60	.0009	130
10^{x}	33	.0003	14(1)	16	.0003	3(1)	(16 (63	.0002 <.0001	2 <16(1)
11^{x}	19	.0005	7	11.5	.0005	3	(8.5 (63	.0005 <.0001	1 <16(1)
12^{x}	30	.0001	4(1)	16.5	.0002	2(1)	10.5	.0002	1(1)
13^{x}	-	-	-	18	.0005	6	16	.0002	2(1)
14^{x}	27	.0006	17	(12.5 (74	.0008 .0001	5 22(1)	12.5	.0008	5
15	27	.0008	23	(10 (74	.0009 .0001	4 22(1)	11 35	.001 .0001	5 5(1)
16^{x}	24.5	.0013	31	15	.0008	7	25	.0003	7(1)
17^{x}	24	.0003	7(1)	8	.0005	1	-	-	-
18^{x}	7.5	.001	2	10	.0006	2	8	.0005	1
19^{x}	-	-	-	8	.0005	1	13.5	.0002	1 (1)
20^{x}	30	.0002	7(1)	-	-	-	16	.0002	2(1)
21^{x}	23.5	.0002	4(1)	4.8	.0005	0.5	8.7	.0009	3
22^{x}	-	-	-	-	-	-	18.5	.0002	3(1)

x Seismograph on plyboard base.

(1) Possible error exceeds 30%.

TABLE 2

FREQUENCIES, AMPLITUDES AND ACCELERATIONS MEASURED FROM RECORDS TAKEN ON 16TH AUGUST, 1956, UNDER ABNORMAL PLANT OPERATIONS
(The plyboard base was not used for these tests).

Rec.	Vertical component			YOY' component			XOX' component			Remarks
No.	f (cps.)	A (in.)	a (in.sec^2)	f (cps.)	A (in.)	a (in.sec^2)	f (cps.)	A (in.)	a (in.sec^2)	
23	32	.0001	$4^{(1)}$	17	.0004	$5^{(1)}$	-	-	-	Same position as for Rec. 9. Acid pumps off, all blowers off, pumps ⊙ on.
24	30	.0001	$4^{(1)}$	17	.0005	6	-	-	-	As for 23, except acid pumps on.
24A	30	.0001	$4^{(1)}$	17	.0005	6	18	.0002	$3^{(1)}$	As for 23, except acid pumps on.
25	-	-	-	17	.0004	$5^{(1)}$	-	-	-	As for 24, except pumps ⊙ off.
28	31	.0004	15	16	.0008	8	-	-	-	As for 24, except blowers 1, 5, 6 on.
30	30	.0006	21	16	.0010	10	60 16	<.0001 .0005	$<14^{(1)}$ 5	As for 28, except blowers 7, 8 on.
31	22	.0004	8	68 16	<.0001 .0007	$<18^{(1)}$ 7	65	<.0001	$<16^{(1)}$	As for 30, except blowers 1, 5, 6 off.
32	-	-	-	16	.0007	7	60 16	<.0001 .0005	$<14^{(1)}$ 5	Same position as for Rec. 10, same conditions as for Rec. 31.
26	19	.0005	7	19	.0007	10	59 19	.0001 .0003	$14^{(1)}$ $4^{(1)}$	Same position as for Rec. 2, 2A, all blowers off, acid pumps on.
27	17	.0001	$1^{(1)}$	20	.0004	$6^{(1)}$	60	.0001	$14^{(1)}$	As for 26, except acid pumps off.
29	25	.0002	$5^{(1)}$	72	.0006	120	60	.0003	$43^{(1)}$	On ground floor, behind blowers 1, 5, 6, which were on; acid pumps on.

(1) Possible error exceeds 30%.

TABLE 3.

EFFECT OF BLOWERS 7 AND 8, AND 1, 5 AND 6, AS DETERMINED BY COMPARING THE RESULTS OF RECORDS 23, 24, 25, 28, 30 AND 31 (16TH AUG).

Source of vibration	Vertical component			YOY' component			XOX' component		
	f (cps.)	A (in.)	a (in.sec2)	f (cps.)	A (in.)	a (in.sec2)	f (cps.)	A (in.)	a (in.sec2)
Blowers 7, 8	30	.0003 .0002	9	17	.0002	2	60 17	<.0001 .0005	<14 6
Blowers 1,5,6	30	.0003 .0002	9	17	.0003	3	-	-	-
Other sources	30	.0001	4	17	.0005	6	17	.0002	2

TABLE 4.

POSSIBLE ERRORS IN ACCELERATION

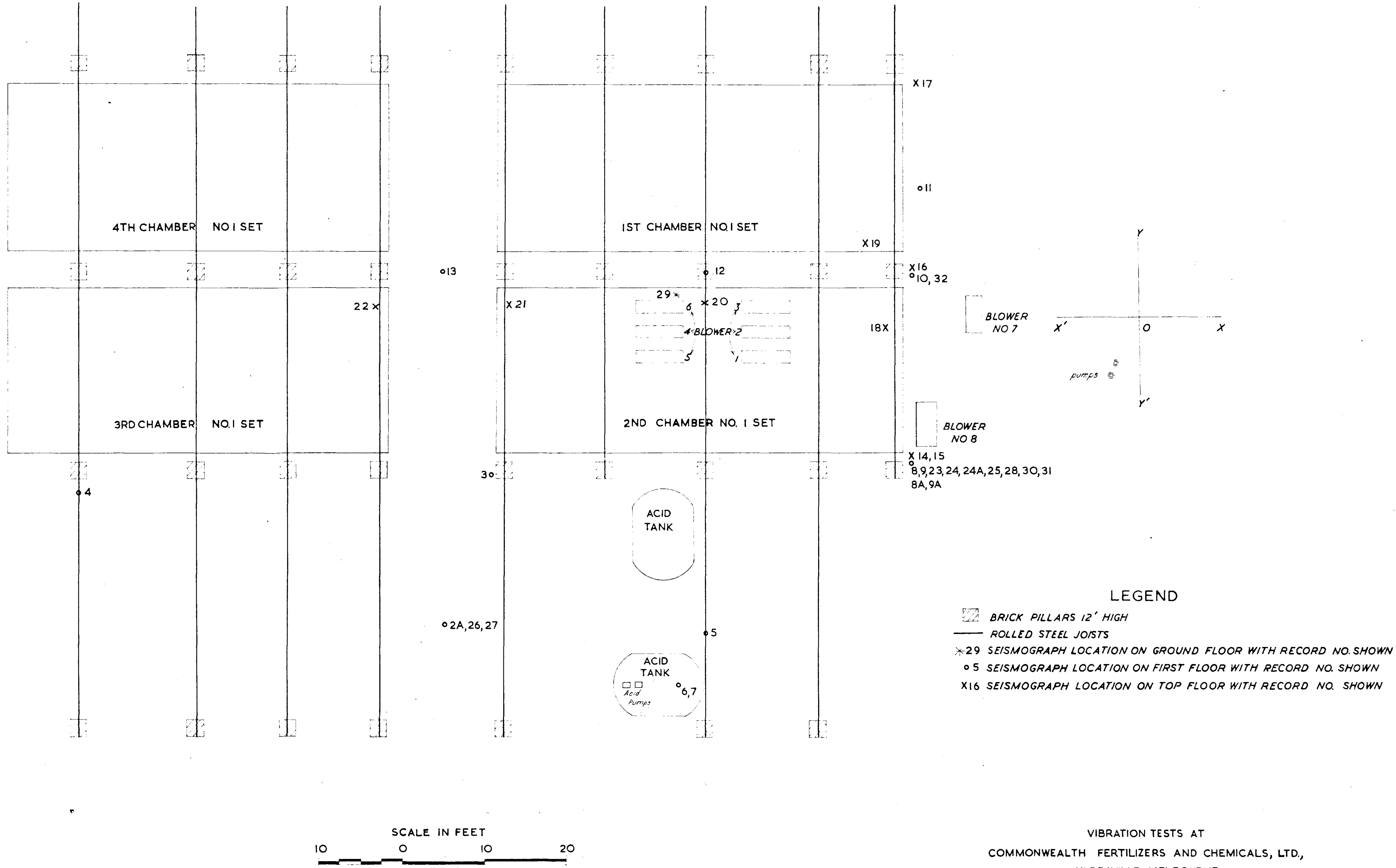
f (cps.)	A (in.)	a (in.sec2)	Maximum error in a (da) (in.sec2) da = cf(.24 + .0001 f)	Maximum percentage error in a
10	.0025	10	2.4 ✓	24
	.0010	4	1.2	30
	.0005	2	0.8	40
30	.0012	43	6.5	15
	.0005	18	5	28
	.0001	3.6	4	110
60	.0010	143	19	13
	.0005	72	17	24
	.0001	14	14	100

As expected, Table 4 indicates that the possible percentage errors in acceleration are fairly large with amplitudes smaller than 0.0005 inch.

5. CONCLUSIONS

It is not possible to indicate in this report if the vibrations recorded on the lead-chamber structure are really damaging to the chambers. The vibrations most likely to cause any damage however, are those of higher frequency. From the tests of 16th August, it appears that there are many sources of vibrations with frequencies of the order of 60 c.p.s. The greatest accelerations produced by the 60 c.p.s. vibrations were measured on 7th July on Records 9 and 9A, which were taken with the seismograph set on the first floor, almost immediately above blower 8. This indicates that the main source of vibration is blower 8, which is located quite close to one of the brick pillars supporting the lead-chamber structure.

The 60 c.p.s. vibration produced by this blower is a horizontal vibration in the direction XOX' (see Table 1, Records 9 and 9A).



VIBRATION TESTS AT
COMMONWEALTH FERTILIZERS AND CHEMICALS, LTD.,
YARRAVILLE, MELBOURNE.

PLAN OF LEAD-CHAMBER PLANT

GEOPHYSICAL SECTION BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS