Study of the Sound emitted by the Japanese "Dōhachi"

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Study of the Sound emitted by the Japanese "Dōhachi"

By

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Abstract

Records of the sound waves emitted by the Japanese bowl-shaped gong called "Dōhochi" (or "Keisu") were obtained by a Low-Hilger audiometer. They were analysed, and compared with the results found by calculation.

The Japanese bowl-shaped gong called "Dōhachi" (or "Keisu") has a very simple nearly hemispherical form, and its thickness is almost uniform except at the margin, which is made particularly thick. It is not made by casting in a mould, but is made from a flat plate of metal curved gradually by repeated beating with a hammer on an anvil, until it became nearly hemispherical.

Four Dōhachis (A), (B), (C), (D) of different size, used in this investigation, are shown in Pls. I and II. (B), (C), (D) are composed of copper and zinc in the ratio of 2 : 1. The composition of (A) is uncertain. This Dōhachi (A) has already been studied by H. Muraoka[1]. We ring them by striking with one of the wooden strikers shown in Pl. II, Fig. 3 at the margin from the outside. The total lengths of these strikers are 35 and 23 cms., and the diameters are 5.2 and 2.8 cms. respectively.

The "Dōhachi" is now used in various ceremonies in temples.

The sound waves of these four Dōhachis were obtained by using a Low-Hilger audiometer, and the curves obtained were analysed by

1. 村岡範爲馳, 實驗音響學, 396—398 (1917).

means of periodogram-analysis. The method of investigation was nearly the same as that previously reported by the present writer in these memoirs[1].

In Pls. III, IV, V. VI are shown the records of the sounds of Dōhachis (A), (B), (C), (D) respectively. To obtain all of these except Figs. 5 and 6 in Pl. IV, (A) and (B) were struck by the larger striker and (C) and (D) by the smaller one shown in Pl. II, Fig. 3. Figs. 5 and 6 in Pl. III are the records of the sounds of (A) when it was struck by the smaller striker.

The marked portions in these Plates were analysed, and the diagrams affixed to the end of this paper were obtained. In order to compare the results, the frequency of the fundamental tone of the different Dōhachis was put at 10, and the following table was obtained, representing the ratios of the frequencies of their partial tones.

(A)	10	29	50	80	100	130
(B)	10	28	50	82		
(C)	10	28	50			
(D)	10	28	50	80		

Lord Rayleigh calculated the frequencies of the sound emitted by a hemispherical shell of uniform thickness under the condition of no extension, and obtained the following numbers[2]:

10	28.1	54.3

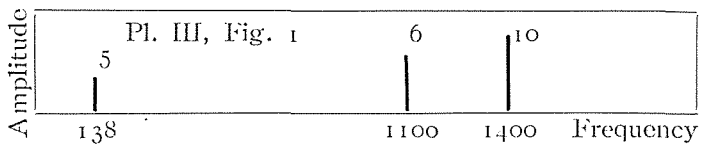
In form, the Dōhachi is rather a combination of a hemisphere and a cylinder than a simple hemisphere. (A) is the best example of this combined form. Putting 20 cms. for the radius of the hemisphere, 12 cms. for the length of the cylinder and $\frac{1}{3}$ for the Poisson's ratio into Yamashita's formula[3], we get the frequencies,

1. I. Aoki, Memoirs, Coll. of Sci. Kyoto, **14**, 213—218 (1931).
   I. Aoki, lot, cit. **15**, 311—313 (1932).
   K. Yamashita and I. Aoki, lot, cit. **15**, 323—326 (1932).
2. Lord Rayleigh, Scientific Papers, vol. I, pp. 551—562.
3. K. Yamashita, Memoirs, Coll. Sci. Kyoto, **15**, 315—322 (1932).

10	26.7	49.2

We see that there are some deviations between the experimental data and the calculated results, but these are probably caused by the conditions of uniform thickness and no extension.

In conclusion the writer wishes to express his gratitude to Prof. K. Tamaki for his kind guidance.


Amplitude
Pl. III, Fig. 1
5
6
10
138
1100
1400
Frequency

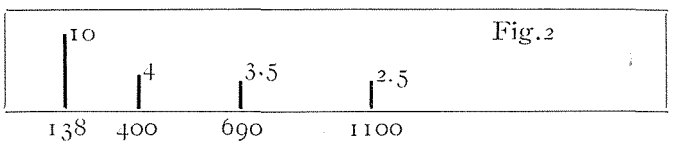


Fig.2
10
4
3.5
2.5
138
400
690
1100

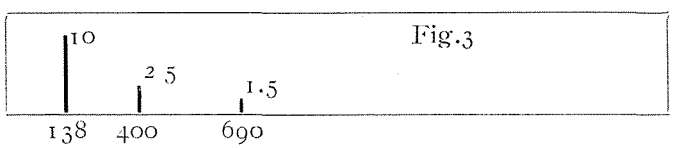


Fig.3
10
2.5
1.5
138
400
690

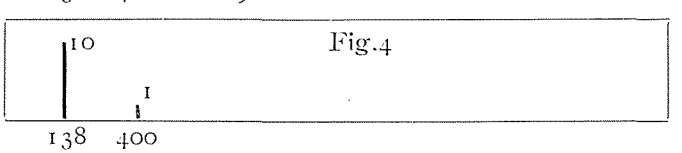


Fig.4
10
1
138
400

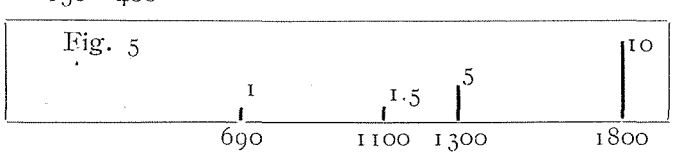


Fig. 5
1
1.5
5
10
690
1100
1300
1800

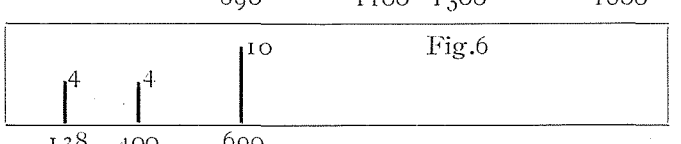
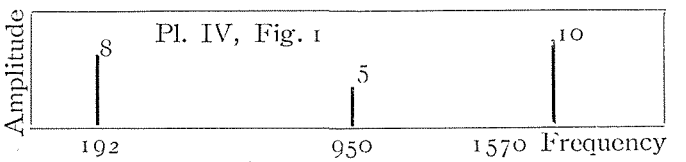


Fig.6
4
4
10
138
400
690


Amplitude
Pl. IV, Fig. 1
8
5
10
192
950
1570
Frequency

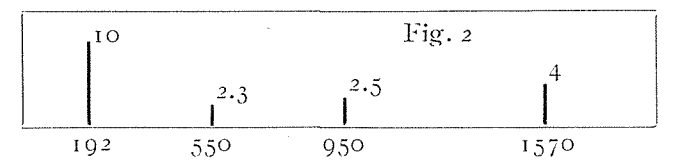


Fig. 2
10
2.3
2.5
4
192
550
950
1570

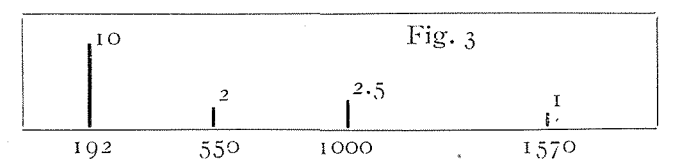


Fig. 3
10
2
2.5
1
192
550
1000
1570

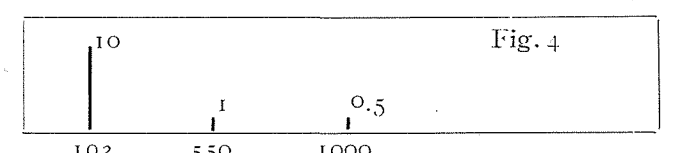


Fig. 4
10
1
0.5
192
550
1000

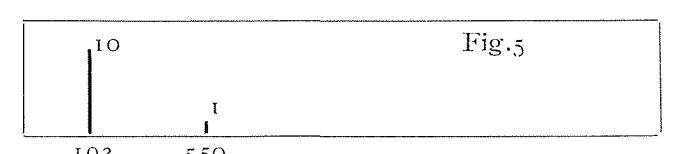
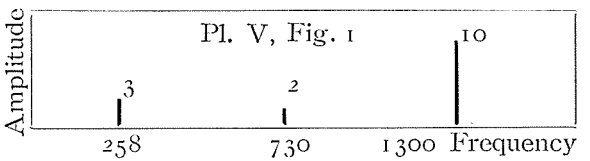


Fig.5
10
1
192
550


Amplitude
Pl. V, Fig. 1
3
2
10
258
730
1300 Frequency

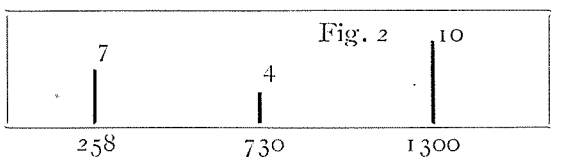


Fig. 2
7
4
10
258
730
1300

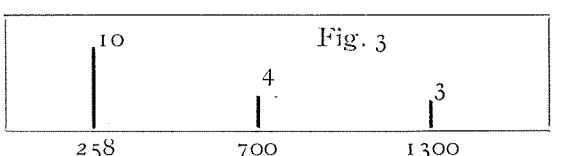


Fig. 3
10
4
3
258
700
1300

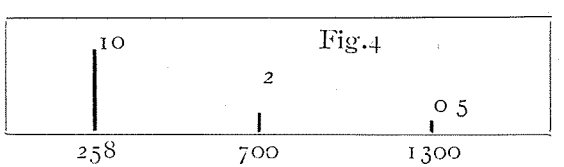


Fig.4
10
2
0 5
258
700
1300

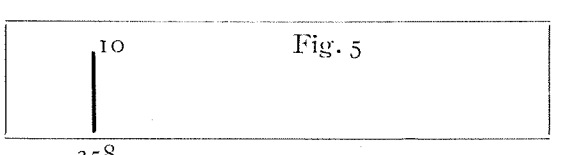
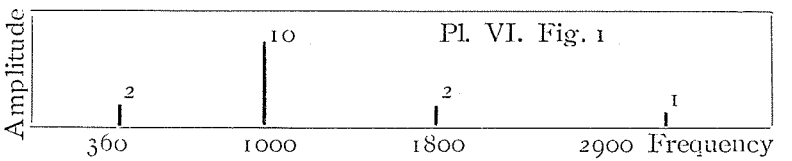


Fig. 5
10
258


Amplitude
Pl. VI. Fig. 1
10
2
2
1
360
1000
1800
2900 Frequency

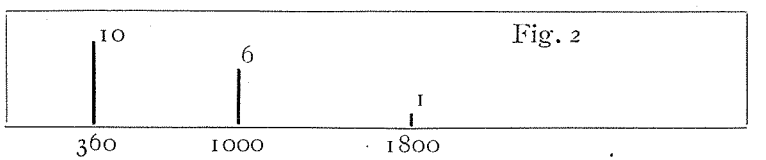


Fig. 2
10
6
1
360
1000
1800

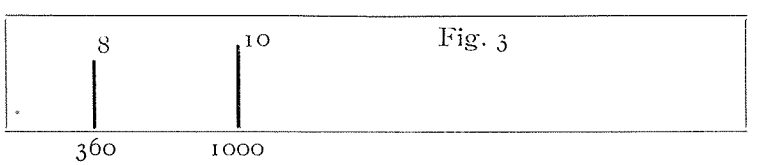


Fig. 3
8
10
360
1000

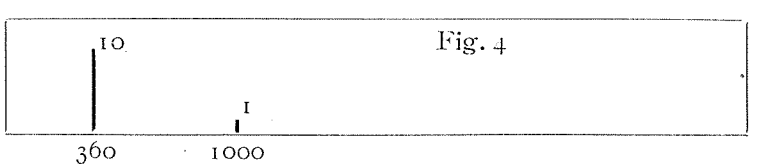


Fig. 4
10
1
360
1000

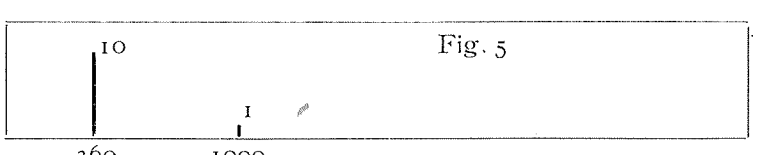


Fig. 5
10
1
360
1000

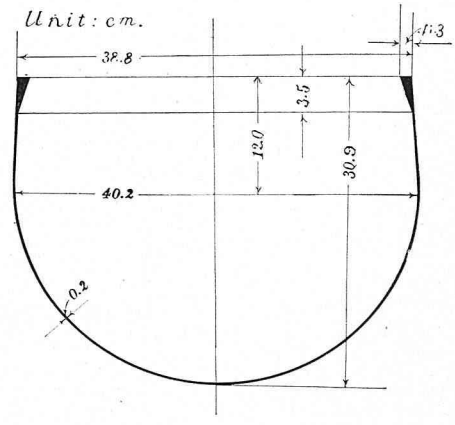
Ichiro Aoki

Plate I

(A)

Fig. 1

Fig. 1′



(B)

Fig. 2

Fig. 2′

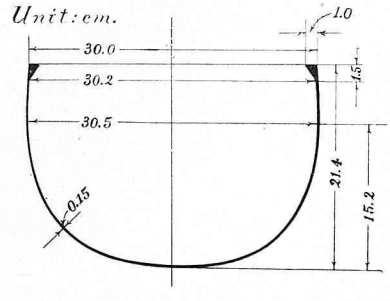
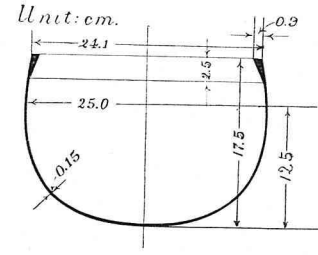


Plate II

(C)

Fig. 1

Fig. 1′



(D)

Fig. 2

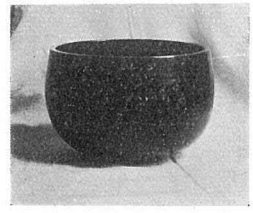


Fig. 2′

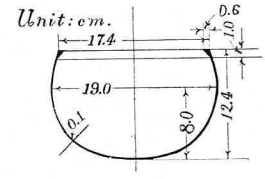


Fig. 3

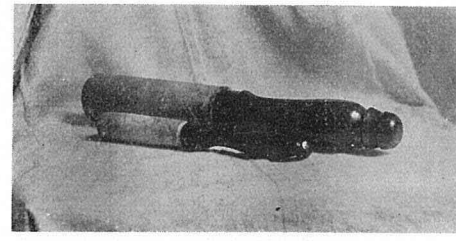


Plate III

Fig. 1 ← 1/50 s. →

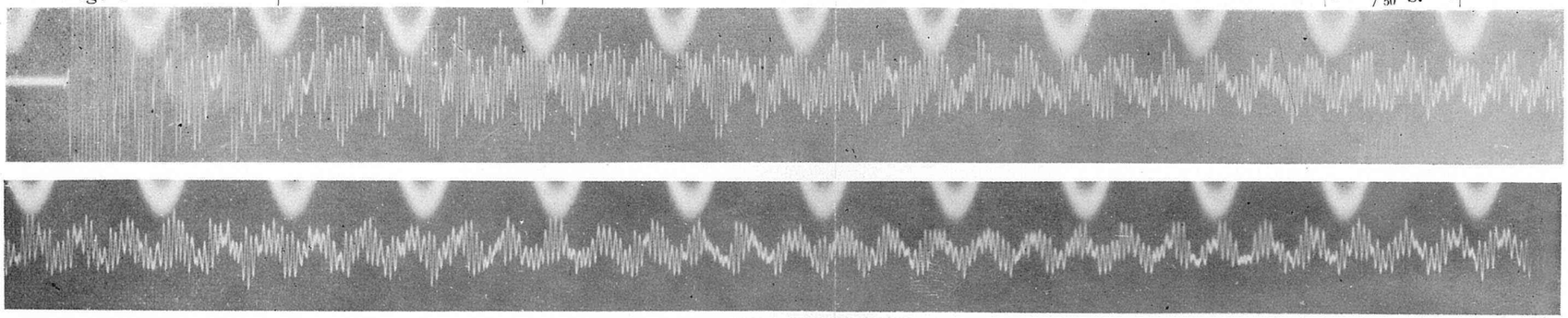


Fig. 2 1.5 secs. after it is struck.

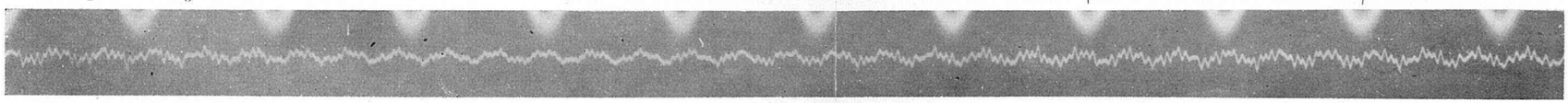


Fig. 3 6 secs.

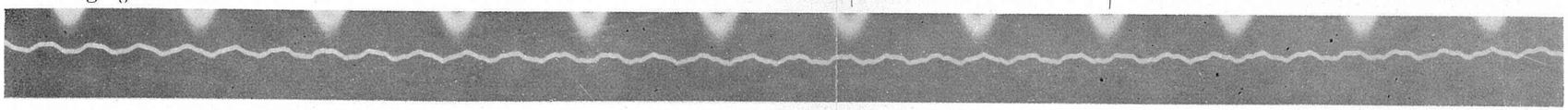


Fig. 4 10 secs.

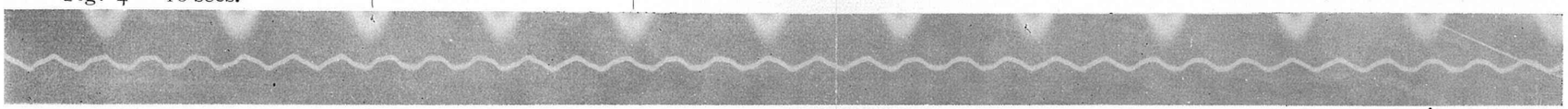


Fig. 5 (with smaller clapper)

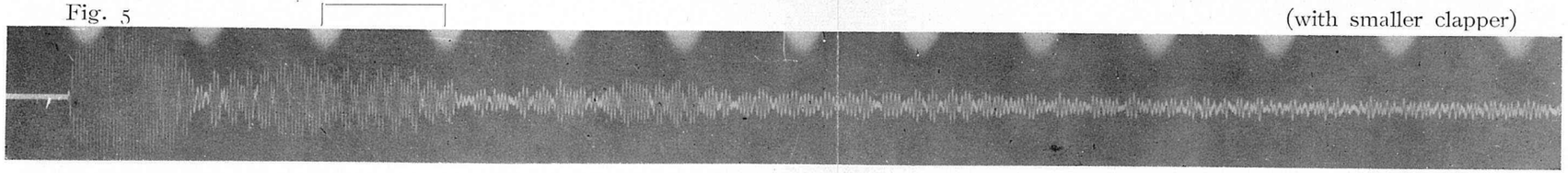


Fig. 6 1 sec. (with smaller clapper)

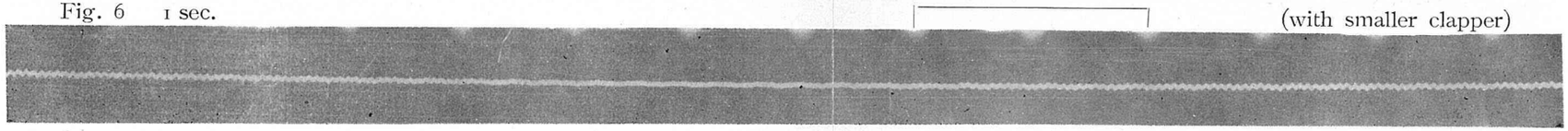


Plate IV

Fig. 1

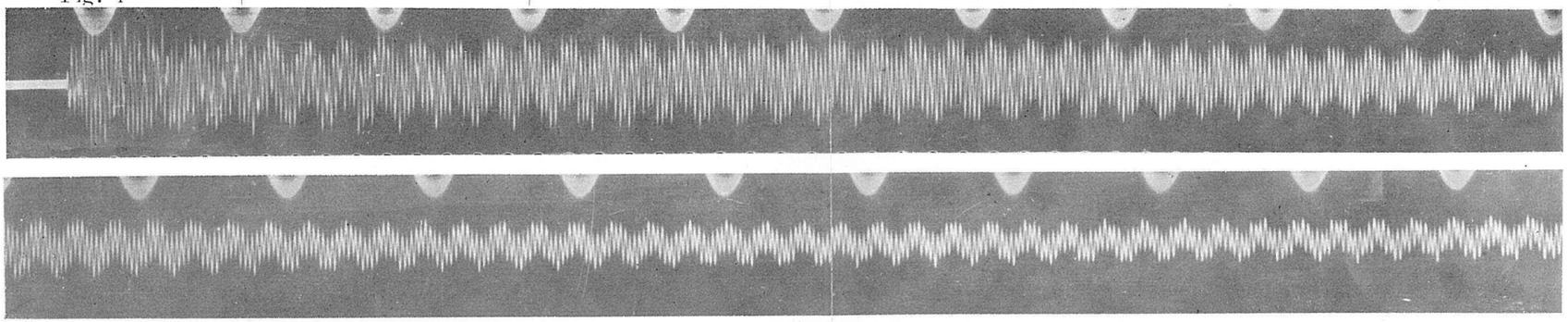


Fig. 2 1 sec. after it is struck.

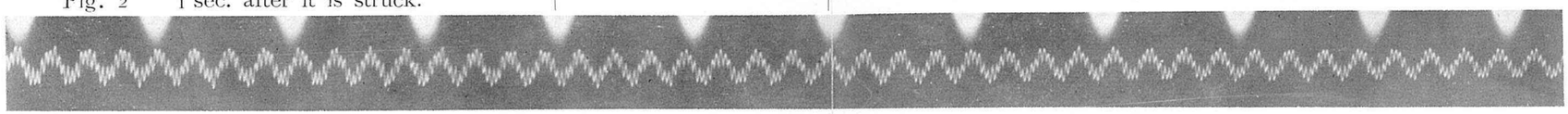


Fig. 3 3 secs.

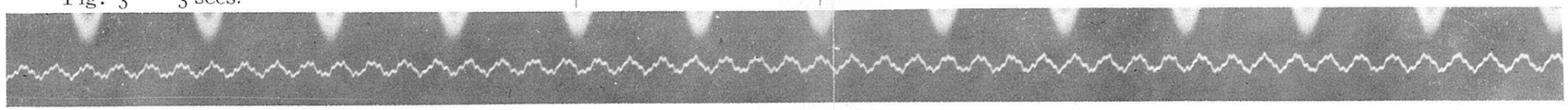


Fig. 4 6 secs.

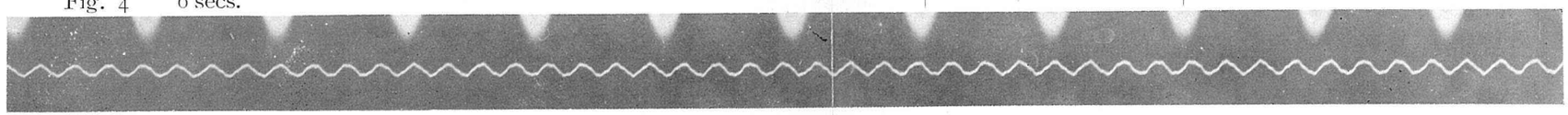


Fig. 5 10 secs.

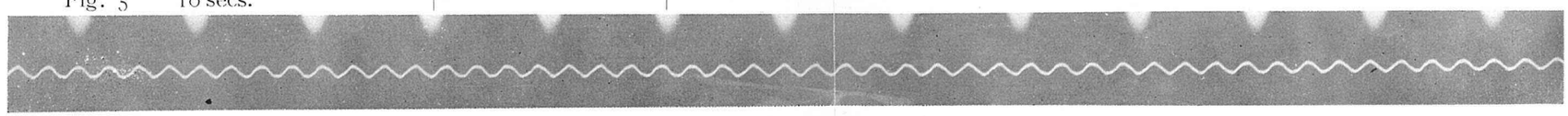


Plate V

Fig. 1

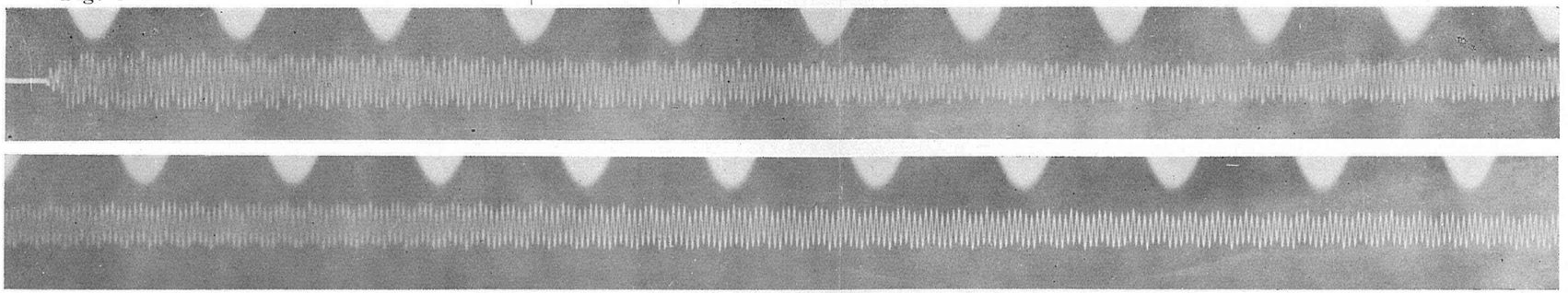


Fig. 2 1.5 secs. after it is struck.

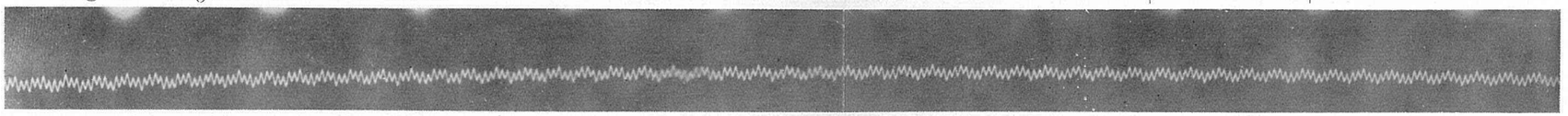


Fig. 3 3 secs.

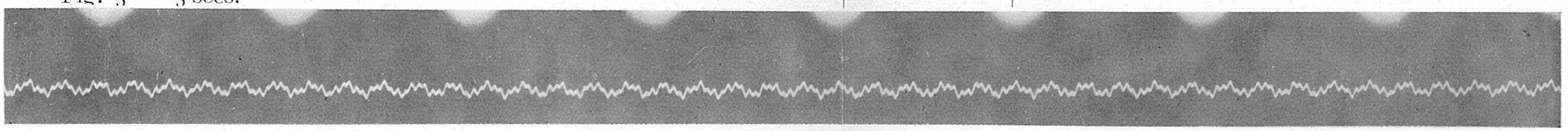


Fig. 4 5 secs.

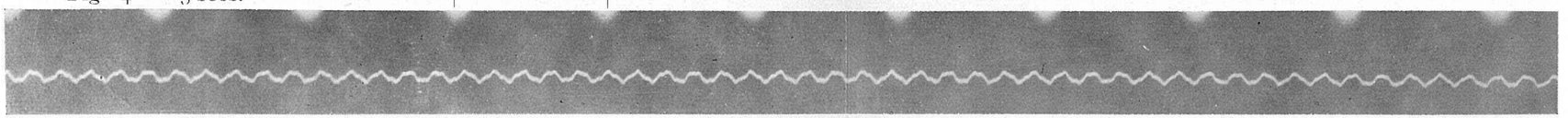


Fig. 5 8 secs.

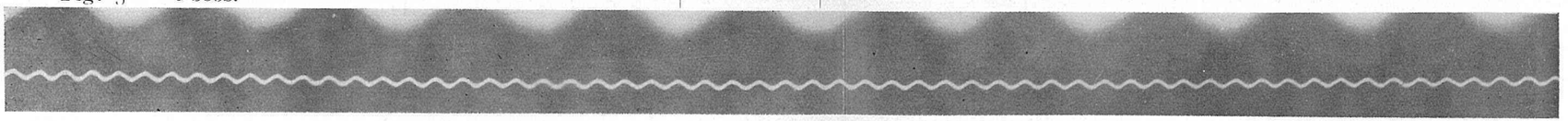


Plate VI

Fig. 1

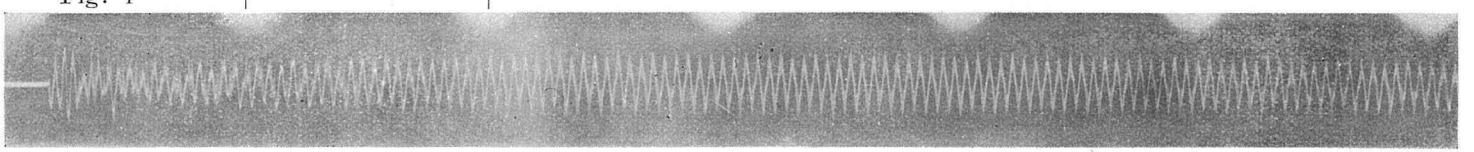


Fig. 2 1 sec. after it is struck.

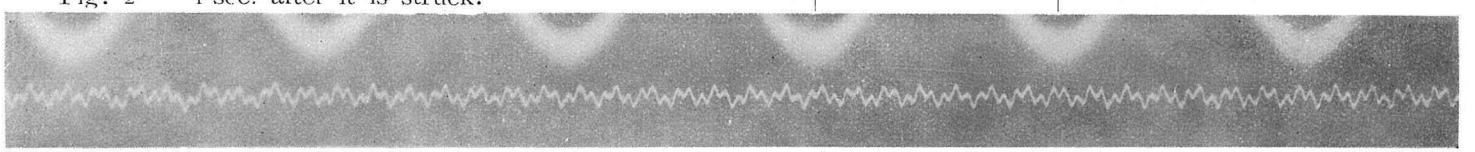


Fig. 3 3 secs.

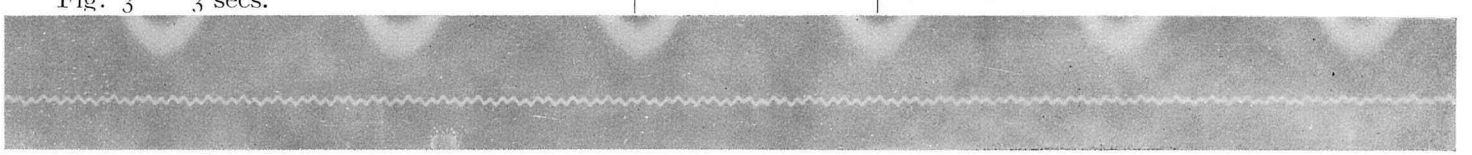


Fig. 4 5 secs.

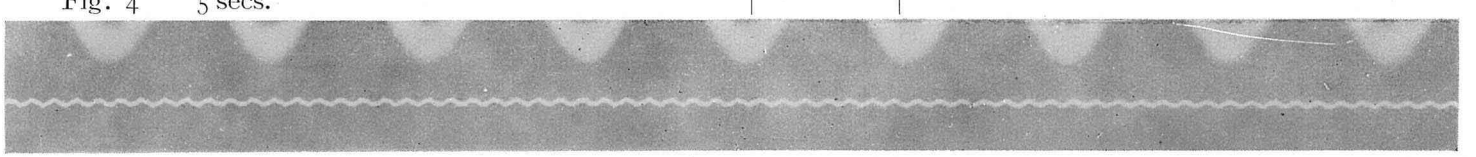


Fig. 5 8 secs.