CHAPTER XIII. BAROGRAPH OBSERVATIONS AT YUNO-TAIRA OF ASAMA-YAMA ERUPTIONS(THE ERUPTIONS AND EARTHQUAKES OF THE ASAMA-YAMA IV [Strong Asama-yama Outbursts, Dec. 1912 to May 1914])

journal or publication title	Bulletin of the Imperial Earthquake Investigation Committee
volume	7
number	1
page range	189-198
year	1914-08-23
URL	http://hdl.handle.net/2261/16058

CHAPTER XIII. BAROGRAPH OBSERVATIONS AT YUNO-TAIRA OF ASAMA-YAMA ERUPTIONS.

118. *Open Barograph records of Asama-yama eruptions.* In 1913 an attempt was made to obtain the open diagrams of the air disturbances caused by the strong Asama-yama eruptions, by means of a Richard's barograph, whose pointer was made to register with 5 times magnification on the smoked paper, just in the same way as in an Omori horizontal tromometer. (See Fig. 62.) By means of this arrangement a few of the eruptions were successfully registered at the Yuno-taira observatory and the Asama Pasture Ground,* as described below; the enlarged diagrams being reproduced in Figs. 63, 64 and 65. It may here be added that the proper vibration period of the pointer was quick and $=0.3$ sec. approximately.

119. *Observation of explosions at Yuno-taira.* The following three eruptions have been barographically registered at Yuno-taira on the quickly moving smoked paper:—

(i) Explosion of Aug. 12th, 1913; at $7^h\,45^m$ p.m.
(ii) „ „ „ „ , „ ; „ 11 20 p.m.
(iii) „ May 5th, 1914; „ 0 33 a.m.

(i.) *Explosion of Aug.* 12*th*, 1913, *at* $7^h\ 45^m$ *p.m.* (Fig. 65.) The barometric disturbance, which occurred at $7^h\ 45^m\ 14.0^s$ p.m., began with a compressional wave, composed of the 1st displacement, or rise, of 2.8 mm and the 2nd displacement, or fall, of 3.2 mm, the two making up an oscillation of $T=2.7$ sec. Then followed a rarefactional wave about 4.4 sec. in period, and of the maximum double amplitude of 0.43 mm, there being a superposi-

* Same observations were repeated at the Sakura-jima on the occasion of the recent eruptions. The barographic diagrams were similar to those obtained at the Asama-yama stations.

tion of smaller vibrations of T=1.3 sec. The whole disturbance lasted 7.1 sec., the termination being also quite abrupt.

The 1st displacement of the "initial vibration" of the corresponding earthquake motion at Yuno-taira took place at 7^h 45^m 07.6^s; the 2nd displacement appearing 0.7 sec. later on (§ 61). Consequently the time interval between the occurrence of the detonation and that of the explosive outward motion of the ground was 5.7 sec.

(ii) *Explosion of Aug. 12th,* 1913, *at* 11^h 20^m *p.m.* In the smoked paper diagram, the barometric disturbance began at 11^h 20^m 40.4^s p.m. with a sudden rise of over 11 mm, the writing index of the instrument having thereby been thrown off the recorder. The counter motion seems to have been about 2 mm greater than the preceding.

In the ordinary Richard's barogram, the rise and fall of the pressure amounted to 14.2 and 16.5 mm respectively.

The commencement at Yuno-taira of the earthquake motion was at 11^h 20^m 32.9^s p.m., the 2nd displacement of the "initial vibration" taking place 1.5 sec. later on. Thus there was a time interval of 6.0 sec. between the occurrence of the detonation and that of the explosive outward motion of the ground.

(iii) *Explosion of May 5th,* 1914, *at* 0.33 *a.m.* (See Fig. 64.) The exact time of commencement of the barometric disturbance was $t=0^h$ 33^m 10.3^s a.m. or 6.9 and 5.2 sec. respectively after the moment of arrival of the 1st earthquake movement and the displacement corresponding to the actual beginning of the explosion; the time of commencement of the earthquake at Yuno-taira being 0^h 33^m 03.4^s a.m. The 1st barometric effect consisted in an abrupt increase of the pressure amounting to 6.4 mm, followed by the decrease of 7.0 mm, together composing an atmospheric vibration of T=2.3 sec. Then followed a 2nd vibration of T=1.9 sec., and composed of increase=0.3 mm, and decrease=1.5 mm; these forming, with the 2nd displacement of the 1st, a total decrease of 8.3 mm, resulting in the diminution of 1.8 mm from the original level. The next two small vibrations of T=3.4 sec. practically brought the barometric disturbance to end. Total duration=12.3 sec.

120. *Observation of non-detonative eruptions.* In 1913 the following two of the non-detonative eruptions of the Asama-yama have been observed in the same barographical manner:—

(iv)	At Yuno-taira	Eruption of	Aug. 15th, at 4.01 p.m.
(v)	„ Asama Pasture Ground	„	Nov. 20th, „ 3.40 p.m.

(iv) *Eruption of Aug. 15th*, 1913, *at about* 4^h *p.m.*, observed at Yuno-taira. (Fig. 63.) The barographic disturbance was essentially compressional and began at $4^h\ 01^m\ 16.5^s$ p.m. ($=t_b$) with pressure increase, which reached the amount of 0.31 mm in the course of 1.9 sec. For the next 7.2 sec., the pressure was gradually decreased by the amount of 0.015 mm. Then, for the next 10.4 sec., the barometric fluctuations became active, there being amongst the others, 6 vibrations of maximum range of 0.29 mm and of period of about 1.14 sec. So far the total duration was 19.5 sec. The disturbance was thereafter very small, continuing for further 8.8 sec.

The character of the barometric disturbance was in accordance with that of the eruption, which consisted, not in a single explosion, but of a powerful smoke emission of a long duration. In the diagram of the corresponding earthquake motion, there were very small introductory movements for some time interval, but the commencement of the well pronounced preliminary stage was at

4^h 01^m 05.8^s p.m. ($=t_1$), while there was a slight increase in the amplitude 3.7 sec. later on, namely, at $4^h 01^m 09.5^s$ p.m. ($=t_2$). The intervals between these times of occurrence of the earthquake movements and that of the barograph disturbance were as follows:—

$$t_b - t_1 = 10.7 \text{ sec.},$$
$$t_b - t_2 = 7.0 \text{ ,, };$$

the latter of these values being not much different from those found, in the cases of the three strong explosions considered in the preceding § for the interval between the detonation and the outward explosive motion of the ground. Thus the commencement of the barometric disturbance coincided very nearly with that of the generation of the vibrations forming the introductory part of the preliminary portion of the earthquake motion, and not with the subsequent stronger shock or larger movements.

(v) *Eruption of Nov. 20th*, 1913, *at* 3^h 40^m *p.m.*, observed at the Asama Pasture Ground. The barometric disturbance, which lasted 5.4 sec., was composed of the two slow vibrations of the average T=2.7 sec., (with trace of the superposition of very slight movements); the 1st and principal one being made up of a rise of 0.36 mm and a fall of an equal amount. The time of commencement was 3^h 40^m 58^s p.m. or 21 sec. after the arrival of the earthquake motion at the same observing place.

121. ***Remarks on barographic observations at Yuno-taira.*** In the three cases of the explosions considered in § 119, the time differences between the occurrence of the barometric disturbance and the commencements of the preliminary portion and the 2nd displacement (or the end of the 1st) of the "initial vibration" of the earthquake motion were as follows:—

Explosion.	Time difference between Barometric Disturbance and Commencement of	
	Preliminary Portion.	2nd displacement of "Initial Vibration."
(i) Aug. 12th, 1913.	6.4 sec.(1)	5.7 sec.
(ii) „ „ „	7.5	6.0
(iii) May 5th, 1914.	6.9	5.2
Mean.	**7.2**(2)	**5.6**

(1) The preliminary portion was obliterated by the tremblings of the ground which existed beforehand.
(2) (i) is excluded in taking this mean.

Thus, at Yuno-taira the barometric disturbance arrived, in the mean, 5.6 sec. after the occurrence of the 2nd vibration of the "initial vibration," or the stage corresponding to the actual moment of the explosion, and 7.2 sec. after the commencement of the earthquake motion.

Now, according to the descriptions of the seismograms given in Chapter VI, the mean time differences between the appearance of the "sound shock" and the commencements of the preliminary portion and of the 2nd displacement of the "initial vibration" were at Yuno-taira respectively 7.3 and 5.8, being equal to the above found mean intervals respecting the barometric disturbance, as follows :—

Explosion. (1913)	Time difference between "Sound Shock" and Commencement of	
	Preliminary Portion.	2nd displacement of "Initial Vibration."
May 27th.	— sec.	6.0 sec.
„ 29th.	7.0	5.9
June 17th.	7.6	6.2
„ 26th, (11 p.m.)	—	6.1

Explosion. (1913)	Time difference between "Sound Shock" and Commencement of	
	Preliminary Portion.	2nd displacement of "Initial Vibration."
July 8th.	6.9 sec.	5.7 sec.
„ 13th.	8.7	6.3
„ 18th.	6.4	5.2
„ 19th.	6.8	5.5
Aug. 12th, (11 p.m.)	7.6	6.0
May 5th, (1914).	—	5.4
Mean.	**7.3**	**5,83**

Thus the time moment of appearance of the "sound shock" on the tromometer diagram is perfectly identical with that of the air disturbance on the barogram.

The total durations of the barometric disturbance in the two explosions of Aug. 12th, 1913, (at 7 p.m.), and May 5th, 1914, were respectively 7.1 and 12.3 sec.; being in the latter case equal to the duration of the specially prominent earthquake motion.

The first and main portion of the barometric disturbance is always made up of an abrupt compressional displacement followed by a slightly greater counter motion, the two making up an oscillation of the mean period of about 2.5 sec. It is interesting that this period (T), is not at all very short, but sufficiently long and not much different from that of the "initial vibration" of the earthquake motion. Denoting the amount of the increase or decrease in the barometric height by δp, the average rate of the pressure change is $=2\delta p/T$. If, for instance, δp be 15 mm, as was nearly the case in the explosion of Aug. 12th, 1913, at 11 p.m., then the mean pressure change on 1 sq. metre area would be

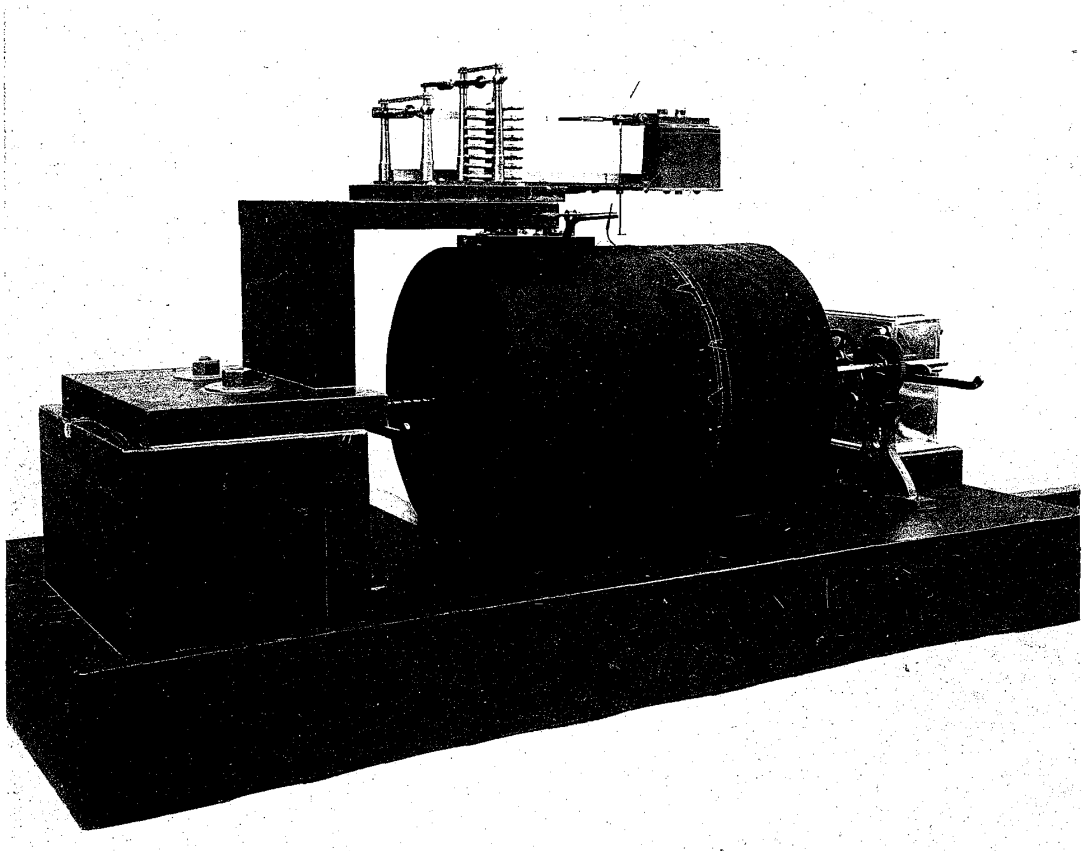


Fig. 62. **Barograph** adapted to a quick mechanical registration on smoked paper.

Fig. 63. **Yuno-taira Barogram of the non-detonative Asama-yama eruption on Aug. 15th, 1913, at 3. 58. 46 p.m.** Magnification = 44.
Time Scale: 1 minute = 192 mm.
(+)....Pressure Increase. (−) ...Pressure Decrease.

Smoked-Paper Barograms of the Asama-yama Explosions observed at Yuno-taira. (+)....Pressure Increase. (−)....Pressure Decrease.

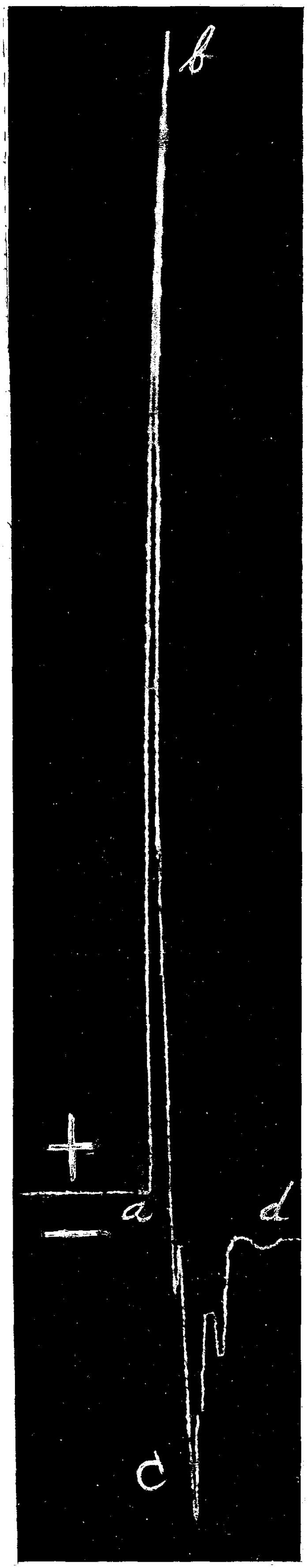


Fig. 64. May 5th, 1914.
Magnification = 23.
Time Scale: 1 min. = 79 mm.

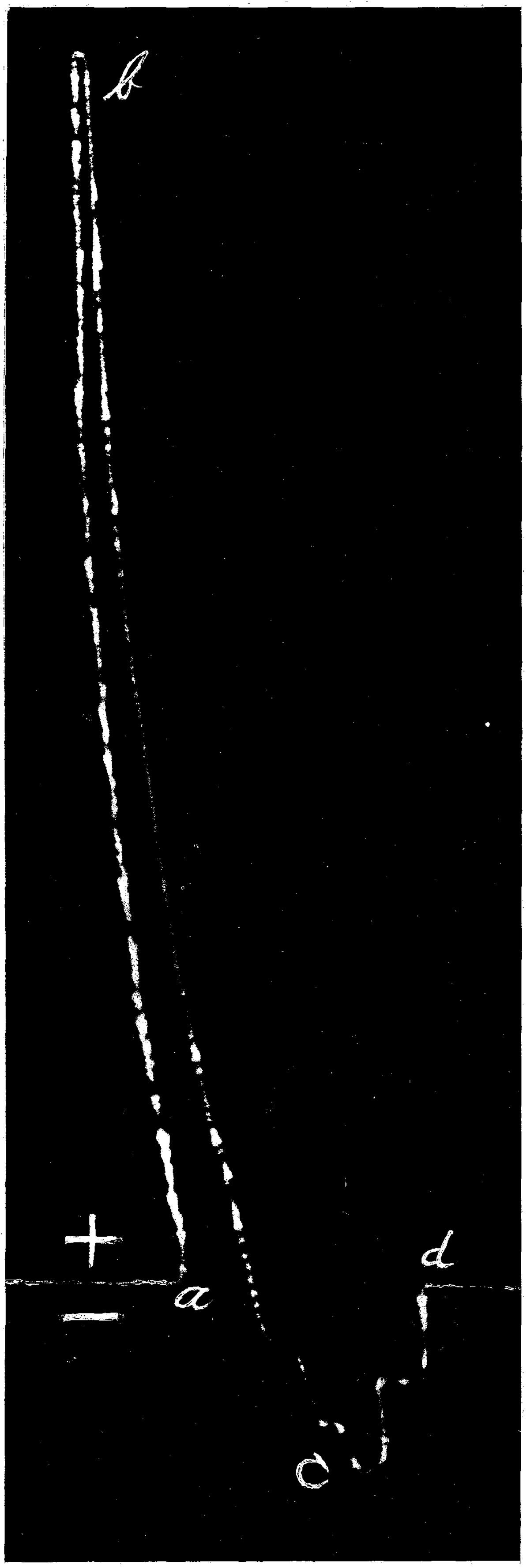


Fig. 65. Aug. 12th, 1913; $7\frac{3}{4}$ **p.m.**
Magnification = 56. Time Scale:
1 minute = 265 mm.

$100 \times 100 \times \left(\frac{2 \times 1.5}{2.5}\right) \times 13.6 = 160$ kg per sec. This may be regarded as indicating the intensity of the sound wave of the explosion which caused the shakings of the building of the Yuno-taira observatory, being a sort of measure of the destructive capacity of the air concussion. The quick minute vibrations, which are doubtless mixed up with the principal oscillation above considered, although not indicated in the diagram, are probably the cause of the audible detonative sound.

From § 120 it is seen that the two powerful non-detonative eruptions of Aug. 15th (at 4 p.m.) and Nov. 20th, 1913, produced slight barometric disturbances, which consisted of a greater or smaller number of similar vibrations; the maximum amount of the barometric change being in these two cases 0.31 (at Yuno-taira) and 0.36 mm (at the Asama Pasture Ground). There existed the periods of 1.14 and 2.7 sec.

The barometric disturbances caused by the eruptions, both explosive and non-explosive, were essentially positive, i.e., consisted in the compressive effects, the rarefactional change beyond the level of equilibrium being very slight. (See also § 122.)

122. *Explosions recorded on Richard's barograph.* An ordinary Richard's barograph to the natural scale kept in the Yuno-taira observatory has recorded the different stronger explosions, the diagram consisting in each case of only a short single line, as shown in Figs. 66 and 67.

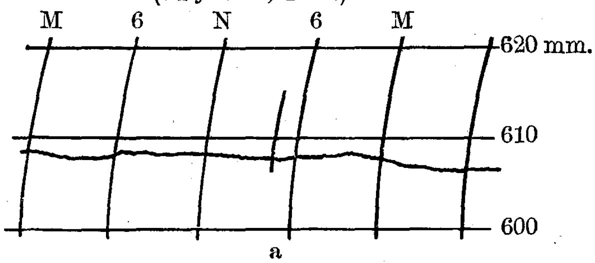
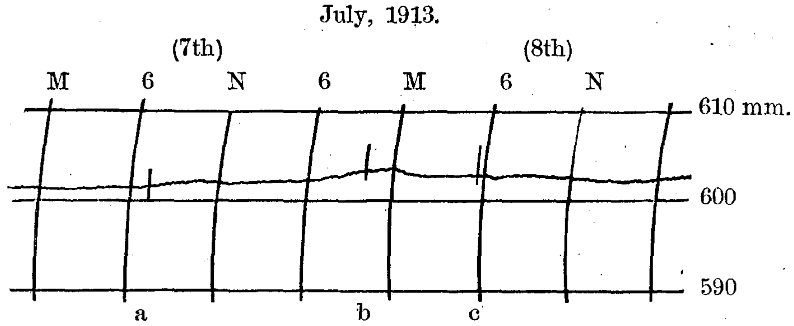


Fig. 66. (a)..Barometric disturbance caused by the explosion of the 13th, at 4.01 p.m.

Fig. 67.



(a), (b), (c).... Barometric disturbances caused by the explosions of the 7th, at 7.10 a.m. and 9.46 p.m., and of the 8th, at 5.25 a.m.

The barometric disturbance, i.e., the 1st increase and the 2nd decrease measured from the barograms, is tabulated below.

TABLE XXX. RICHARD'S BAROGRAPH RECORDS OF THE ASAMA-YAMA EXPLOSIONS. YUNO-TAIRA, 1913.

Date. (1913).	2nd displacement of the "initial vibration."	Barometric Disturbance.		
		Increase.	Decrease.	Ratio: Decrease./Increase.
May 16.	0.102 mm.	2.8 mm.	4.0 mm.	1.4
„ 27.	0.062	3.6	4.2	1.2
„ 29.	0.098	3.0	3.6	1.2
June 20.	0.025	2.3	2.6	1.1
„ 26.	0.040	3.4	4.7	1.4
„ „	0.093	6.0	7.3	1.2
July 7.	0.037	2.7	4.0	1.5
„ „	0.080	3.3	4.1	1.2
„ 8.	0.088	3.5	4.3	1.2
„ 13.	0.123	7.7	9.6	1.3
„ 18.	0.116	3.4	4.7	1.4
„ 19.	0.127	9.6	12.5	1.3
Aug. 12.	0.050	1.6	—	—
„ „	0.217	14.2	16.3	1.2
Mean.	——	——	——	**1.3**

Vibrations due to the Sound-Shock of the Asama-yama Explosion registered by the Tromometer at the Seismological Institute, Tokyo.

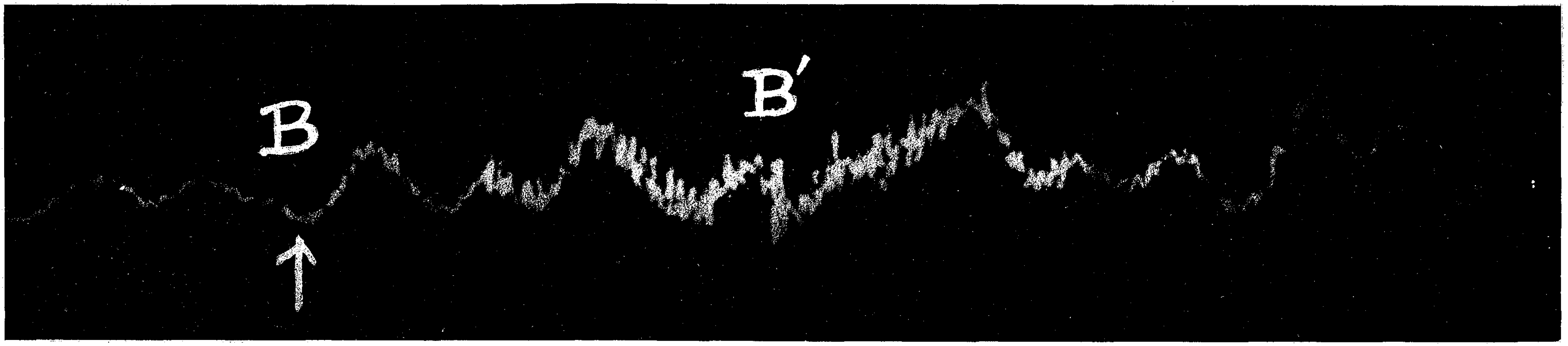


Fig. 68. Asama-yama Explosion of Dec. 7th, 1909. Magnification = 1100. Time Scale: 1 minute = 235 mm.

B = Approximate Commencement.
B′ = Maximum Phase.

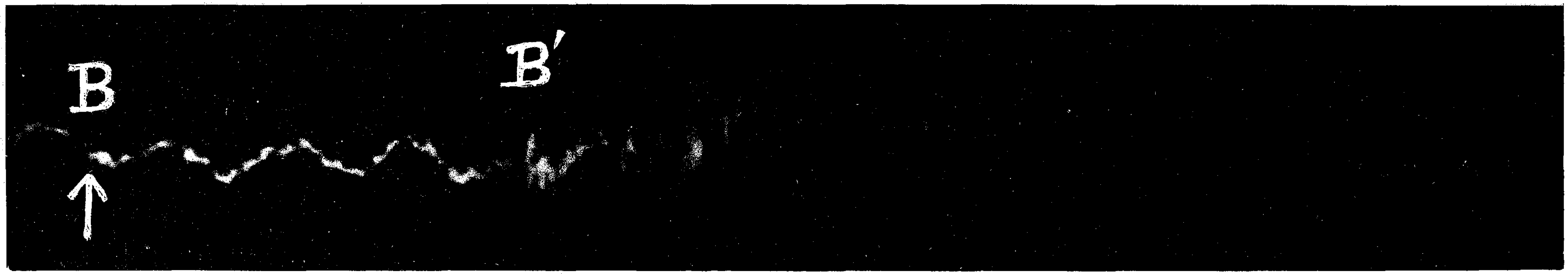


Fig. 69. Asama-yama Explosion of May 8th, 1911. Magnification = 1450. Time Scale: 1 minute = 287 mm.

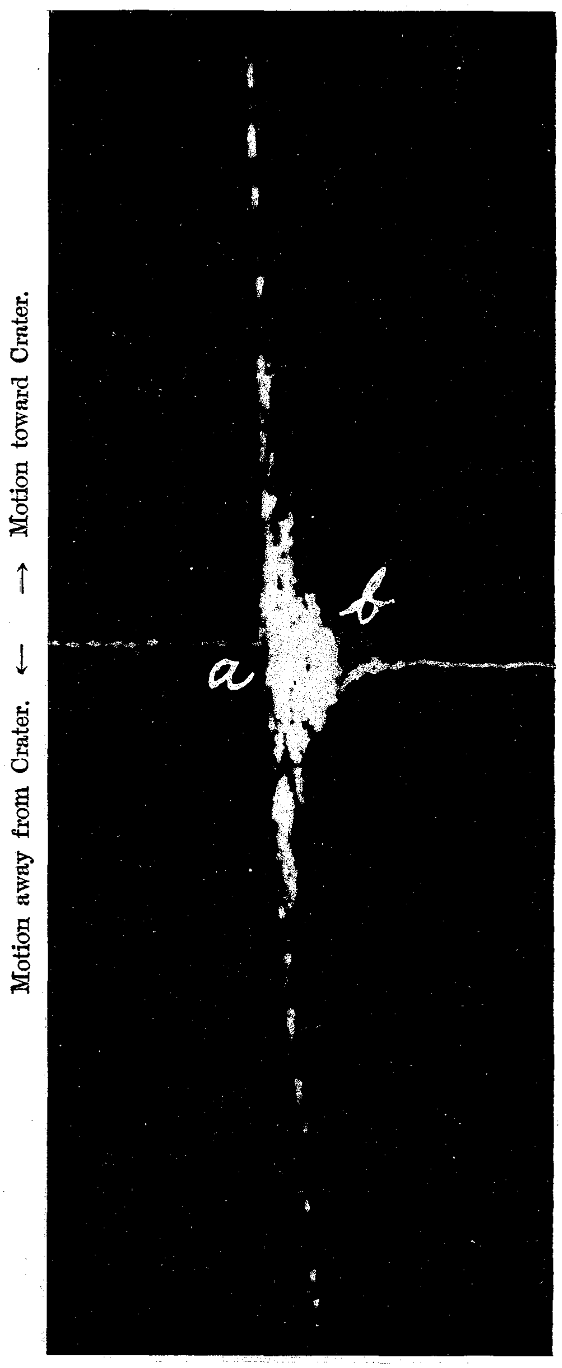
Non-Eruptive Volcanic Eqkes observed at Yuno-taira.

Time Scale: 1 min. = 82 mm.

Fig. 70. Tremor-recorder Transverse Component Diagram of a sensible Shock on July 1st, 1912, at 10. 09. 07 a.m.

Magnification = 585

[a....Commencement.]



Time Scale: 1 min. = 190mm.

Fig. 71. Tromometer Longitudinal Component Diagram of a shock on Sept. 13th, 1911, at 8.43.09 p.m.

Magnification = 1190.

The largest barometric disturbances of about, or over, 10 mm were indicated in the three cases of July 13th and 19th, and Aug. 12th, 1913. The barographic record of the strong explosion of June 17th was unfortunately not taken at all. The 2nd or decrease change is on the average 1.3 times larger than the 1st or increase change.

Comparison with "Initial Vibration." From Table XXX it will be seen that the amount of the barometric disturbance varies with the range of the "initial vibration." Comparing the 2nd displacement of the latter, which accompanies the actual explosion, with the direct effect on the air disturbance, namely, the 1st barometric rise, we have :—

Barometric Disturbance. (1st Pressure Increase.)	"Initial Vibration." (2nd Displacement.)
14.2 mm.	0.217 mm.
9.6	0.127
7.7	0.123
6.0	0.093
3.0*	0.070*

* Meaned from the 10 cases in which the barometric increase was less than 4 mm.

The "initial vibration," the range of whose 2nd (or 1st) displacement increases with the amount of the barometric disturbance, may thus probably be taken as being proportional to the intensity of the explosive effect. Seismically, the "initial vibration" seems to possess no necessary, or at least, no simple, relation to the intensity of the subsequent earthquake motion.

123. ***Barometric disturbance and extension of sound area.*** In the following table I give a comparison of the extension of the total sound area and the 1st displacement of the barometric disturbance recorded by the Richard's barograph (Table XXX), arranged in order of magnitude of the latter.

Group.	Explosion.	Barometric Disturbance. (1st Displacement, or Increase).	Total Sound Area.
i	Aug. 12th (11 p.m.)	14.2 mm.	35,940 sq. km.
	July 19th	9.6	19,050
	„ 13th	7.7	18,250
	June 26th (11 p.m.)	6.0	15,750
ii	June 26th (8 a.m.)	3.4	12,610
	May 29th	3.0	19,370
	„ 16th	2.8	7,240
	June 20th	2.3	19,560

Thus, of the group (i) explosions, with the larger barometric disturbance, that on Aug. 12th had very extensive sound area. On the other hand, the explosions of the (ii) group, with the smaller barometric disturbance, had the sound areas of about the same extension as the rest of the (i) group. This seems to show that the extent of the sound area does not depend simply on the intensity of the detonation at the origin.

CHAPTER XIV. PROPAGATION VELOCITIES OF VOLCANIC DETONATION AND EARTHQUAKE MOTION.

124. *Propagation velocity* (= *V*) *of Asama-yama detonation between Yuno-taira and Tokyo.* In the two explosions of Aug. 12th, 1913, at 11.20 p.m. (§§ 62 and 117) and of May 5th, 1914, at 0.33 a.m. (§§ 63 and 117), the times of occurrence of the barometric disturbance at Yuno-taira and of the "sound shock" in Tokyo have been accurately determined; the barometric disturbance and the "sound shock" being identical with