CHAPTER VI. STRONG ASAMA-YAMA EXPLOSIONS OBSERVED AT YUNO-TAIRA.*

45. *Explosion of May 16th, 1913, at 4. 41. 00 p.m.* According to Mr. Kurosaka, this strong explosion was felt at the Yuno-taira observatory as a loud detonation like that of a gun discharge, which shook the building for 1 or 2 sec., being followed for about 8 min. by rushing sounds like that of a violent gush of wind, although it had then been almost perfectly calm. The thick snow fall at the time of the eruption prevented the condition of the mountain being ascertained. Mr. Kurosaka ascended to the mountain top on the 19th and found the Muken-dani and the slope of the central cone covered by light masses of yellow-brownish lava fragments, while there were several new solid rock pieces, 1 foot or so in diameter, which were projected as far as the lower part of the Yuno-taira plateau, charring the grasses on which they fell.

Tromometer Diagram : *Longitudinal Component.* Total duration =95 sec. [Preliminary and principal portions : duration=28.5 sec.] The preliminary displacement was 0.0051 mm (duration=0.26 sec.) away from the mountain. Then followed a large displacement of 0.070 mm toward the origin, and the counter motion of 0.102 mm away from the latter, these two forming the "initial," and at the same time, maximum vibration of T=1.52 sec. For the next 14.7 sec., the motion remained active (max. 2 a=0.059 mm), and consisted of the vibrations of T=1.47 sec. mixed with those of T=0.61 sec., and others still quicker. During the remaining 10.5 sec. of the principal portion the motion became small.

46. *Explosion of May 27th, 1913, at 5. 22. 57 a.m.* At the

* The times of occurrence of the explosions considered in this chapter are those registered by the tromometers at the Yuno-taira observatory.

Yuno-taira observatory, a loud detonation was heard at about 5. 23. 04 a.m., while the time of the earthquake occurrence indicated in the tromometer diagrams was 5. 22. 57 a.m. As it was then heavily raining and deeply misty, the condition of the mountain could not be ascertained. At Naganohara, a violent detonation like a gun discharge shook the houses strongly, causing damage to earthenwares which were thrown down from shelves. At Kusatsu, the sound was loud and produced much horizontal shakings of the houses. The sound was also heard at Komoro and Karuizawa.

(i) *Tromometer Diagram*: *Longitudinal Component.* Total duration=73 sec. [Preliminary and principal portions: duration=29.4 sec.] The 1st displacement, which was perfectly sudden, was 0.045 mm toward the monntain top, followed by the counter displacement of 0.062 mm, directed away from the latter; these two making up the slow and maximum "initial vibration" of T=1.3 sec. For the next 1.45 sec., the motion was small, being composed of 4 vibrations of T=0.36 sec., max. 2a=0.0096 mm, mixed with a slow motion. These were followed by three vibrations of T=1.3 sec., the 1st of which had the max. 2a of 0.039 mm; there being mixture of small movements of T=0.4 sec. Then, 6.0 sec. from the end of the 1st displacement of the "initial vibration," there began quick vibrations of T=0.44 sec., max. 2a=0.037 mm, which were probably due to the effect of the sound shock, and which remained active for 7.1 sec. During the remaining 15.6 sec. of the principal portion, the motion was smaller: 2a=0.0126 mm.

(ii) *Tremor-recorder Diagram*: *Transverse Component.* The principal portion lasted 21 sec. and consisted, during the first 6.7 sec., of regular vibrations of T=1.44 sec., max. 2a=0.054 mm.

Thereafter set in the mixture of quick movements which were due to the sound shock.

47. *Explosion of May 29th, 1913, at 10. 44. 12 a.m.* The eruption consisted of a strong explosion, not much inferior in intensity to those on May 8th and Oct. 22nd, 1911, and threw out a considerable amount of rock fragments around the crater to a radial distance of about 2 km; large hot pieces more than $1\frac{1}{2}$ ft. in dimension, which fell at the foot of the Maikake-yama, charring the grasses and trees struck under them. In several cases the rock fragments of the size of a fist, which fell in the upper part of the Yuno-taira plateau, produced patches of burnt area to a maximum extension of about 7 metres diameter. According to Mr. Kurosaka, the detonation was at Yuno-taira very loud and suddenly shook the building, which continued to make slight movements for about 20 sec. Simultaneously a column of black smokes rose from above the thin layer of mists shrouding the mountain, accompanied by rushing sounds. The mists cleared off after one minute or so, when smoke column was observed continuing its ascent, while the rock fragments, which had fallen on the mid-slope of the Maikake-yama were in four or five points issuing white steams for 30 to 60 minutes. The sounds ceased after 5 min., all being restored to the normal state in 10 min.

This eruption was the third among the numerous outbursts since 1909, which was attended by fatal accident. Two young men, of the town of Murota, Gumma prefecture, who ascended the mountain on the same morning from Karuizawa, met the explosion and were struck by the stone fragments projected from the crater when they reached the Kenga-mine, the remnant of the old crater wall on the E. side, or the continuation of the Maikake-yama. One of them was severely wounded yet able to run down to the Waka-

sare Cottoge, while, the other was killed on the spot in consequence of the blows received on leg and neck. There were at the time of the eruption also a party of seven gardeners, who were collecting dwarf plants at the Tengu-no-roji. No sooner had they been startled by the loud detonation, than there fell ashes and hot rock fragments as large as fist. They ran for life towards the observatory and were able to reach a place outside the limit of the stone precipitation.

Tromometer Diagram: *Longitudinal Component.* Total duration =90 sec. [Preliminary and principal portions: duration=36.3 sec.] The earthquake began with a very small preliminary motion of 0.0023 mm (duration=0.16 sec.) directed away from the mountain. Then followed two large displacements of 0.048 and 0.098 mm, directed respectively toward and away from the origin, together making up the slow and maximum "initial vibration" of T=2.65 sec., mixed with those of T=0.44 sec. (max. 2a=0.028 mm). For the next 20.0 sec., the motion gradually decreased, consisting of slow vibrations of T of about 1.6 sec. (max. 2a=0.011 mm), mixed with quick movements of T=0.34 sec. (max. 2a=0.008 mm). The occasional groups of quick vibrations which occurred during this last phase of motion, at 24.2; 26.0; 27.8; 29.0; 31.0 sec. from the commencement of the earthquake, may possibly denote a series of small eruptions which followed the principal one. The sound shock occurred 7.0 sec. from the commencement, or 5.9 sec. after the end of the 1st displacement of the initial vibration. In Fig. 52 is also reproduced the vertical motion diagram, in which the vibrations were very small.

48. *Explosion of June 13th, 1913, at 11. 01. 16 p.m.* At Yuno-taira, there were perceived first rushing sounds, followed after a short time interval by a loud detonation like a gun discharge,

the shakings of the building continuing for a few seconds. The smokes issuing from the crater threw out bright glowing lava pieces, and continued red like a distant conflagration for about 30 minutes.

Tromometer Diagram: *Longitudinal Component.* Total duration=72 sec. [Preliminary and principal portions: duration=23.2 sec.] This was a comparatively small disturbance, whose "initial vibration" was not definitely indicated. The motion was active during the 1st 13.4 sec., in which the principal period was 0.56 sec. (?), with mixture of other periods, the max. 2a of 0.020 mm having taken place 8.0 sec. after the commencement. During the remaining 9.8 sec., of the principal portion, the motion was smaller: 2a=0.0057 mm., T=0.4 sec.

49. *Explosion of June 17th*, 1913, *at* 10. 47. 41 *p.m.* This eruption of the Asama-yama, which had been quiet during the day time of the 17th, was very strong; at Yuno-taira, the detonation being excessively loud and shaking the observatory building violently. The whole slope of the Maikake-yama was instantly covered by red hot lava fragments, while the volcanic sounds and the noises caused by the falling projectiles were almost deafening. The effects of the light scintillation caused by the air currents and the hot materials were striking, such that the observer, Mr. J. Nishizawa, believed a torrent of lava and a "volcanic avalanch" were actually descending down the Maikake-yama toward the observatory, appearing to give no chance of escape to the inmates of the latter. The luminous lava pieces projected with considerable force from the crater, which looked like groups of shooting stars, passed overhead to places beyond the observatory, on whose roof were showered small lava fragments like hails. Some of the rock blocks which fell in the vicinity of the observatory and were partially buried in earth were found to glow red for over 15

minutes. Holes, about 3 metres in diameter, were formed at Yuno-taira. (See also § 6.)

(i) Unfortunately the tromometer, which was not in a good working order, registered only the commencement of the disturbance. It began with a small but distinct outward motion of 0.004 mm, followed by the "initial vibration" composed of the inward and the outward displacements respectively of about 0.051 and 0.11 mm, the latter being mixed with quick movements.

(ii) Tremor-Recorder Diagram. Total duration=120 sec.

Longitudinal Component. [Preliminary and principal portions: duration=34.2 sec.] The preliminary outward motion was 0.004 mm (duration=0.37 sec.). The two displacements of the "initial vibration" of T=2.8 sec. were respectively 0.053 mm (duration =1.0 sec.) and 0.11 mm (duration=1.8 sec.). The disturbances (greatest 2a=0.11 mm) due to the sound shock began to occur about 7.6 sec. after the earthquake commencement, or 6.2 sec. after the end of the 1st displacement of the "initial vibration"; the superposition of quick movements becoming thereafter very pronounced. The appearance of a new maximum group of these latter 23.7 sec. after the earthquake commencement was probably due to the effect of large lava blocks falling in the vicinity of the observatory.

Transverse Component. [Principal portion: duration=38.6 sec.] During the 1st 7.8 sec., the motion was comparatively small and simple: T=1.52 sec., max. 2a=0.063 mm. The interval between the moments of appearance of the effects due to the sound-shock and of the impact of the falling lava blocks was 16.1 sec., result in a perfect accordance with the longitudinal component register. The greatest 2a was 0.093 mm. [End portion.] At first there were vibrations of T=1.45 sec., 2a=0.004 mm.

50. *Explosion of June 18th, 1913, at 6. 21. 03 a.m.* At

Yuno-taira the building was shaken, a column of black smokes, unattended by a detonation, being ejected from the crater. At Naganohara a detonation was heard.

Tromometer Diagram: *Longitudinal Component.* Total duration=113 sec. [Preliminary and principal portions: duration=24.0 sec.] The earthquake began with a slow inward displacement (duration=3.5 sec.), which were mixed with small movements of T=0.78 sec., 2a=0.0014 mm and may be taken as comprising the preliminary tremor (about 1.5 sec. in duration) and the 1st displacement of the "initial vibration." The 2nd displacement of the latter was 0.0297 mm, and followed by a third slow motion of 0.0545 mm, these two being mixed with quick movements of T=0.39 sec., and together forming an oscillation of T=4.9 sec. For the next 8.2 sec., the motion was made up of quick regular vibrations of T=0.47 sec., the max. 2a of 0.0248 mm having taken place 11.8 sec. after the commencement of the earthquake. During the remaining 7.6 sec. of the principal portion, the motion was much smaller: principal T=0.84 sec., 2a=0.0046 mm. [End portion.] Principal T=1.0 sec., 2a=0.003 mm.

51. *Explosion of June 20th, 1913, at 4. 06. 47 a.m.* This was a comparatively small eruption. At Yuno-taira a detonation was heard, red hot lava fragments having been thrown out of the crater. According to the tremor-recorder diagram, the total duration was 94 sec., while the duration of the principal portion in the longitudinal and transverse components were respectively 11 and 7.8 sec. The two displacements of the "initial vibration," preceded by no preliminary portion, were 0.01 and 0.025 mm. In the transverse component, the movements in the principal portion were regular: T=1.18 sec., max. 2a=0.02 mm.

52. *Explosion of June 24th*, 1913, *at* 11. 37. 34 *a.m.* The eruption consisted in a vertical ejection of black smokes, whose sound was, at Yuno-taira, like that of strong wind, the building being at the same time slightly shaken.

Tromometer Diagram: *Longitudinal Component.* Total duration =88 sec. [Preliminary and principal portions: duration=12.2 sec.] The preliminary motion was not shown, the earthquake beginning with the "initial vibration" of T=1.8 sec. composed of the 1st, or inward, displacement of 0.014 mm, and the 2nd, or outward, one of 0.0398 mm. The latter and the succeeding $4\frac{1}{2}$ vibrations of T=0.37 sec., 2a=0.0174 mm, form together a slow oscillation of T=2.3 sec., 2a=0.048 mm. Then took place three slower vibrations (2a=0.015 mm) lasting together about 1.4 sec., when began the conspicuous quick movements of 2a=0.029 mm. Supposing these latter to be the effect of the sound shock, the interval between the arrivals of the latter and the end of the 1st displacement of the "initial vibration" comes out to be 4.1 sec. For the remaining 6.7 sec. of the principal portion, the motion was composed of the vibrations of T=0.36 sec., 2a=0.017 mm, mixed with those of T=1.1 sec., 2a=0.023 mm. [End portion.] During the 1st 19.3 sec., the motion was composed of the vibrations of of T=1.6 sec., max. 2a=0.0025 mm, mixed with the quicker ones of T=0.77 sec., max. 2a=0.0027 mm. Thereafter the motion was much smaller: T=1.2 sec.

53. *Explosion of June 26th*, 1913, *at* 8. 09. 40 *a.m.* At Yuno-taira the detonation was very loud, and the lava fragments which were thrown down on the slope of the Maikake-yama caused temporary conflagrations among the forests. Some of the fallen rock pieces continued to issue white smokes or vapours for about 30 minutes. At the base of the Asama-yama about 2 km

to the NE of Komoro, the present author heard the detonation, composed of two sounds, which were only moderately loud and were separated by a time interval of about 0.5 sec. It is likely that the mountain slope forms a sort of shadow region, where the detonations are heard only with diminished intensity, or even not heard at all.

Tromometer Diagram: *Longitudinal Component.* Total duration=115 sec. [Preliminary and principal portions: duration=16.2 sec.] The very small preliminary motion of 0.0007 mm (duration=0.47 sec.) was followed by the "initial vibration" of T=1.74 sec., composed of the 1st, or inward, displacement of 0.021 mm, and the 2nd, or outward, one of 0.0403 mm. Then followed a smaller well defined vibration of T=1.36 sec., and 2a=0.021 mm (duration=0.86 sec.) and a slow (inward) motion of 2a=0.036 mm; these forming, together with the 2nd displacement of the "initial vibration," an oscillation of T=3.0 sec., 2a=0.045 mm. For the next 4.2 sec., the motion was nearly uniform, and composed of the vibrations of T=0.71 sec., max. 2a=0.0162 mm; the most conspicuous movement of 2a=0.0184 mm, which may denote the effect of the sound shock, occurring at the end of this interval, or 6.6 sec. after the end of the 1st displacement of the "initial vibration." During the remaining 7.5 sec. of the principal portion, the motion was smaller: T=0.63 sec., max. 2a=0.0134 mm. [End portion.] During the 1st 9.2 sec., the motion was comparatively large, and composed of the vibration of T=1.4 sec., max. 2a=0.0018 mm, mixed with small quicker ones of T=0.75 sec. Thereafter the motion was smaller.

54. *Explosion of June 26th*, 1913, *at* 11. 41. 59 *p.m.* The author, who was staying at the time in the observatory of Yunotaira, was aroused from sleep by the violent detonation, whose time moment noted from a watch near by was 8 sec. after the arrival

of the earthquake motion indicated by the tromometer, and which may be likened to a loud thunder or artillery peal of some duration, causing sharp rattlings and shakings of the building. When he rushed out of doors, after having noted the time from the watch, the Maikake-yama, which was covered by thick mists, was enveloped in a pink light, while the lava fragments projected down there were glowing like huge stars or white gas lights at a distance. The smokes became obscure rather abruptly $1^m\ 40^s$ after the arrival of the detonation, although the rushing sounds were heard for 2 minutes longer.

Tromometer Diagram: *Longitudinal Component.* Total duration=150 sec. [Preliminary and principal portions: duration= 28.9 sec.] The very small preliminary motion of 0.0008 mm (duration=0.37 sec.) was followed by the conspicuous "initial vibration," of T=2.3 sec., composed of the 1st, or inward, displacement of 0.064 mm, and the 2nd, or outward, one of 0.093 mm. The latter and the succeeding $5\frac{1}{2}$ vibrations of T=0.89 sec., and max. 2a=0.041 mm, form together a slow oscillation of T=5.8 sec. and of 2a=0.140 mm. Then set in a slow pendulum motion (T=15.2 sec.) of the steady mass of the seismograph, the quick superposed vibrations, to be supposed to be the effect of the "sound shock," becoming at the same time very conspicuous and continuing active for 8.5 sec.: T=0.59 sec., max. 2a=0.083 mm. The time interval between the end of the 1st displacement of the "initial vibration" and the appearance of the sound shock was about 6.1 sec. During the remaining 13.2 sec. of the principal portion, the motion consisted of vibrations of T=0.75 sec., 2a= 0.023 mm. [End portion.] The motion was composed of the vibrations of T=2.2 sec., 2a=0.0065 mm, mixed with the small movements of T=0.79 sec.

55. *Explosion of July 7th*, 1913, *at* 7. 10. 32 *a.m.* At Yunotaira, a detonation of short duration caused some shakings of the glass doors and of the building. The black smokes rose high up in a vertical column presenting a magnificent sight. The eruption force was, however, comparatively weak, there being apparently no precipitation of lava masses on the Maikake-yama.

Tromometer Diagram: *Longitudinal Component.* Total duration =78 sec. [Preliminary and principal portions: duration=12.4 sec.] The preliminary displacement was 0.0009 mm, directed outwards. The "initial vibration" of T=1.48 sec. was composed of the inward motion of 0.017 mm (duration=0.7 sec.) and the outward motion of 0.037 mm (duration=0.78 sec.). For the next 4.0 sec., there were 3 slow vibrations of T=1.33 sec., 2a=0.022 mm, mixed with smaller movements. For the remaining 6.7 sec. of the principal portion, the motion was composed of nearly equal vibrations of T=0.4 sec., 2 a=0.019 mm, more or less grouped into the traces of slower movements of T=1.34 sec. [End portion.] During the 1st 7.6 sec.: T=0.85 sec., max. 2a=0.009 mm. During the next 7.2 sec., the motion was smaller, T=0.72 sec., max. 2a =0.005 mm. The subsequent portion was very small.

56. *Explosion of July 7th*, 1913, *at* 9. 46. 53 *p.m.* At Yunotaira, a detonation caused shakings of the building. As the cloud layers were high, although it was raining at the time, the smokes were seen wholly ablaze. The glowing lava fragments fell only around the crater and did not reach to the slope of the Maikake-yama. For about 15 minutes, the mountain top presented a sight like a distant conflagration.

(i) *Tromometer Diagram*: *Longitudinal Component.* Total duration=126 sec. [Preliminary and principal portions: duration=15.1 sec.] The earthquake began with a preliminary motion of 0.0019

mm (duration=0.47 sec.) and the "initial vibration" of T=1.61 sec., composed of the 1st (inward) and 2nd (outward) displacements respectively of 0.036 and 0.08 mm. For the next 2.1 sec., the motion was small, comprising a vibration of T=0.93 sec., 2a=0.019 mm, and a few quick movements (2a=0.019 mm). For the next 7.6 sec. the motion became active, and was composed of the slow vibrations of T=1.12 sec., 2a=0.031 mm, mixed with those of T=0.40 sec., whose maximum (2a=0.045 mm) occurred 9.2 sec. after the earthquake commencement. For the remaining 3.3 sec. of the principal portion, the motion was much smaller: T=0.35 sec., 2a=0.021 mm. The effect of the sound shock was not clear. [End portion.] During the 1st 12.1 sec., the motion was comparatively large and consisted of slow vibrations of T=1.85 sec., 2a=0.0058 mm, divided into movements of half-period and others. Thereafter, the motion was smaller, the T being 0.81 sec. At 4.8 and 6.7 sec. from the commencement of the end portion there took place single sudden quick vibrations, each of 2a=0.010 mm. These might be due to small after-explosions.

(ii) *Tremor-recorder Diagram: Longitudinal and Transverse Components.* The preliminary motion was 0.0019 mm directed away from the crater, accompanied by a slight trace of movement toward the N20° W. The two displacements of the "initial vibration" of 0.036 and 0.08 mm, were combined respectively with those of 0.004 and 0.017 mm in the transverse component, the resultants being 0.036 mm toward the N 63° E and 0.082 mm toward the S 60° W. The maximum slow vibration in the transverse component occurred 2.9 sec. after the earthquake commencement, i.e., its beginning coincided with the end of the "initial vibration" in the longitudinal.

57. *Explosion of July 8th, 1913, at 5. 25. 25 a.m.* This ex-

plosion was a little larger than that on the preceding evening. At Yuno-taira there was heard a detonation, which caused shakings of the building, and for 5 sec. could be heard the noises arising from the fall of lava fragments on the slope of the Maikake-yama. At the time, the mountain was shrouded in thick mists.

Tromometer Diagram: *Longitudinal Component.* Total duration=50 sec. [Preliminary and principal portions: duration=22.5 sec.] The earthquake began with a very small preliminary outward movement of 0.0017 mm (duration=0.29 sec.) and the "initial vibration" of T=1.95 sec. composed of the 1st (inward) and 2nd (outward) displacements respectively of 0.046 and 0.088 mm. For the next 4.4 sec., the motion was small and consisted approximately of 4 irregular vibrations of T=1.11 sec. (max. 2a=0.03 mm) mixed with quick movements of T=0.27 sec., and 2a=0.014 mm. Then took place suddenly a large vibration (absolute maximum) of T=1.41 sec., which was composed of the 1st (inward) and the 2nd (outward) displacements respectively of 0.089 and 0.13 mm. If this maximum motion be supposed to be the effect of the sound shock, the time of its appearance was 6.9 sec. after the earthquake commencement, or 5.7 sec. after the end of the 1st displacement of the "initial vibration." Then there followed 5 others of T=1.05 sec. (max. 2a=0.105 mm), together making up a phase of greatest activity of 6.7 sec. duration. The 2a of the maximum superposed quick vibrations was 0.042 mm. For the remaining 9.1 sec. of the principal portion, the motion was much smaller but nearly uniform, consisting of well defined quick vibrations of T=0.27 sec., and 2a=0.029 mm, mixed with slow movements of T=1.14 sec., and 2a=0.017 mm. [End portion.] Duration=about 27 sec. The motion consisted of regular vibrations of T=0.82 sec., and max. 2a=0.012 mm.

58. ***Explosion of July 13th, 1913, at 4. 01. 19 p.m.*** Since the morning the weather was clear and calm, and the Asama-yama continued perfectly quiet, giving out only a slight amount of white vapours, till the occurrence of the strong explosion in question. The lava fragments projected out with considerable force caused for 20 or 30 minutes conflagrations among the vegetation at the southern slope leading down to the village of Shiono and, at Yuno-taira side, as far down as the vicinity of the observatory, where several patches of the grass-covered ground were set on fire. My assistant, Mr. T. Kato, and the police constable of Komoro, Mr. Ogawa, who were engaged at the time in the search for the rumoured cracks supposed to have been formed on the upper part of the southern side of the Asama-yama, experienced a very narrow escape, having met the explosion at a place only about $1\frac{1}{2}$ km from the top and near the upper boundary of the low tree forest zone. On hearing the detonation, they crept down at once behind a large rock block, when the lava fragments were already falling thickly around them, setting the trees and grasses on fire, while several were projected over their heads with booming noise. The precipitation of the hot stone pieces continued for some time interval, during which the two intrepid men managed alternately to run and to seek shelter behind the trees. The eruption ceased after they had thus changed the place of concealment 3 times successively into the forest. Mr. Ogawa had the good fortune of receiving no injury, although at one time a lava projectile passed between his legs, while Mr. Kato had his toe slightly hit by a small burning rock fragment. The latter gentleman recollects that the detonation was, at the spot where he found himself then, not much louder than the noon-gun in Tokyo heard at the distance of 4 or 5 km, being evidently the shade-effect of the mountain slope. After the ex-

plosion, the mountain became again quiet, but threw out large quantity of white smokes.

(i) *Tromometer Diagram*: *Longitudinal Component.* Total duration=138 sec. [Preliminary and principal portions: duration =26.8 sec.] The preliminary outward motion was 0.002 mm, (duration=0.67 sec.). The 1st, or inward, displacement of the "initial vibration" of T=3.0 sec., was 0.053 mm (duration=1.3 sec.) and free from superposition, while the 2nd, or outward, displacement was 0.123 mm (duration=1.7 sec.) and was mixed in its later course with two small movements, which began to appear 3.4 sec. from the commencement. Then there took place a slow inward displacement of 2a=0.141 mm (duration=5.4 sec.), on which were mixed smaller vibrations of T=1.1 sec., 2a=0.031 mm; at the end there were also some quicker movements, probably denoting the effect of the sound shock which appeared first 8.7 sec. after the commencement of the earthquake, or 6.3 sec. after the end of the 1st displacement of the "initial vibration." The next slow (outward) displacement, of 2a=0.126 mm, lasted 6.3 sec., during which the superposed quick vibrations were most active: T=0.33 sec., 2a=0.053 mm. During the remaining 10.9 sec. of the principal portion the motion was smaller and consisted of quick vibrations of T=0.26 sec., 2a=0.025 mm, mixed with those of T=0.65 sec. [End portion.] The motion was throughout extremely small, consisting, during the 1st 13.1 sec., of minute vibrations of T=0.29 sec., 2a=0.0012 mm, mixed with those of T=0.53 sec., 2a=0.0028 mm, and some others. Thereafter there were also some vibrations of T=0.70 sec.

(ii) *Tremor-recorder Diagram*: *Longitudinal and Transverse Components.* The very 1st displacement was 0.0022 mm away from the crater, and 0.0018 mm toward N 20° W, giving the resultant

motion of 0.0027 mm directed toward N70° W. In the longitudinal component, the preliminary portion lasted 0.64 sec.; while in the transverse, it lasted 2.35 sec. The 1st displacement (=0.053 mm) of the "initial vibration" corresponded to a complete vibration in the transverse component, which consisted of the two movements of 0.0029 and 0.0072 mm. Again, the 2nd displacement of the "initial vibration," which was 0.123 mm, corresponded to a complete vibration in the same component consisting of the two movements of 0.0054 and 0.031 mm. In the transverse component, the maximum vibration of 0.047 mm occurred 8.5 sec. after the earthquake commencement.

59. *Explosion of July 18th, 1913, at 2. 08. 34 a.m.* At Yuno-taira, the observer, Dr. K. Aomi, was aroused from sleep by the detonation. The burning lava fragments which fell on the Maikake-yama were glowing through the mists which surrounded the latter.

Tromometer Diagram: Longitudinal Component. Total duration=148 sec. [Preliminary and Principal portions: duration=25.9 sec.] The diagram is almost perfectly identical with that of the explosion on July 13th. The preliminary motion of 0.0019 mm (duration=0.29 sec.) was followed by the "initial vibration," of T=2.2 sec., composed of the 1st, or inward, displacement of 0.054 mm, and of the 2nd, or outward, one of 0.116 mm. The latter and the succeeding $4\frac{1}{2}$ vibrations of T=0.80 sec., and max. 2a=0.062 mm, may be regarded as together forming a slow oscillation, of T=4.55 sec., and 2a=0.134 mm. Then set in a slow pendulum oscillation of the steady mass, the superposed earthquake motion being active for the next 9.4 sec., and consisting of quick vibrations of T=0.36 sec., 2a=0.050 mm, mixed with those of T=0.78 sec., 2a=0.044 mm. For the remaining

10.4 sec. of the principal portion, the motion was much smaller and composed of the vibrations of T=0.65 sec., 2a=0.026 mm, mixed with some quicker ones. The apparent "sound shock" occurred 6.4 sec. after the commencement of the earthquake, or 5.2 sec. from the end of the 1st displacement of the "initial vibration." [End portion.] At first the motion consisted of vibrations of T=0.60 sec., 2a=0.0036 mm, mixed with traces of slow movements of T=2.3 sec. Later on there were also some other periods.

60. *Explosion of July 19th, 1913, at 0. 54. 03 p.m.* The detonation of this strong explosion as heard at Yuno-taira was intensely loud, being, according to the account of the observer, Dr. K. Aomi, like that caused by the simultaneous discharge of several heavy artillery pieces at the immediate vicinity. The eruption sound continued for some 5 minutes after the explosion. The precipitation of the lava fragments was thick; one of these falling on the ground and forming by impact a hole 6 feet in diameter at a distance of 33 metres from the observatory building. Numerous projectiles came down at places several hundred feet below the observatory, which had 4 window panes broken by the shakings of the house. (See p. 13 and Fig. 10.)

(i) *Tromometer Diagram : Longitudinal Component.* Total duration=140 sec. [Preliminary and principal portions: duration=36.9 sec.] The preliminary motion, of 0.0025 mm (duration=0.48 sec.) was followed by the "initial vibration," of T=1.75 sec., composed of the 1st, or inward, displacement of 0.10 mm and the 2nd, or outward, one of 0.127 mm. The latter and the succeeding 4½ vibrations of T=1.28 sec., and max. 2a=0.041 mm, together form a slow oscillation, of T=6.5 sec., and 2a=0.171 mm. The superposed quick vibrations, which may be assumed to represent the "sound shock," began to appear at 6.8 sec. after the commence-

ment of the earthquake, or 5.5 sec. from the end of the 1st displacement of the " initial vibration." These became soon very active (2a=0.077 mm apprx.), when, at 9.9 sec. after the commencement of the earthquake, there took place a large slow displacement of 2a=0.190 mm directed toward the crater followed by a pendulum oscillation of T=14.9 sec., and 2a=0.267 mm. During the last 10.4 sec. of the principal portion, the motion was again active and consisted of extremely quick vibrations of T=0.27 sec., 2a=0.053 mm, distributed into three maximum groups probably due to the precipitation of lava fragments in the vicinity ; the last and largest of the three occurred 35.2 sec. after the earthquake commencement, being no other than the shock caused by the impact of a large lava block some 3 feet in dimension, which fell about 55 metres to the ENE of the observatory. (See § 6). [End portion.] During the 1st 18.6 sec., the motion was composed of small quick vibrations of T=0.45 sec., 2a=0.009 mm, mixed with those of T=1.1 sec. and others. Thereafter, the quick movements disappeared, and the average periods were 1.9 and 1.16 sec.

(ii) *Tremor-recorder Diagram.*

Longitudinal Component. The small preliminary motion was 0.0025 mm directed away from the crater, accompanied by that of 0.0008 mm in the latter directed toward the N20° W, giving the resultant of 0.0026 mm in the direction of S88° W. Corresponding to the 1st, or inward, displacement of 0.10 mm of the " initial vibration " there was in the transverse component a small motion of 0.008 mm directed toward the N20° W, the resultant being 0.10 mm in the direction of N 70° E. Again, corresponding to the 2nd displacement of the " initial vibration," there was a complete oscillation in the transverse component, whose two movements were respectively 0.03 and 0.097 mm.

Transverse Component. The vibrations were comparatively small during the 1st 6.5 sec., with the period of 1.5 sec.; in other words, the maximum phase of motion occurred 6.5 sec. after the commencement of the earthquake. The sudden violent shakings, of max. 2a=0.258 and 0.192 mm respectively in the longitudinal and transverse components, which occurred 34.6 sec. after the earthquake commencement, was probably the effect due to the fall of a large lava block referred to before.

61. *Explosion of Aug. 12th, 1913, at 7. 45. 08 a.m.* The detonation was heard at Yuno-taira, the mountain top being at the time covered by thick mists.

Tromometer Diagram: *Longitudinal Component.* Total duration =120 sec.

The ground was in a trembling condition already from 38.5 sec. before the earthquake: the micro-tremors being composed of the mixture of the vibrations of T=0.57 sec. (max. 2a=0.0015 mm), T=0.26 sec. (max. 2a=0.0096 mm), and some others. [Principal portion: duration=28.8 sec.] The "initial vibration," whose commencement was at $7^h\ 45^m\ 07^s.6$ p.m., and whose period was 1.6 sec., was composed of the 1st, or inward, displacement of 0.029 mm, and the 2nd, or outward, displacement of 0.050 mm. The latter and the succeeding $4\frac{1}{2}$ vibrations (with some superpositions) of T=0.8 sec. together formed a slow oscillation of T=4.5 sec. and of the two displacements of 0.089 and 0.114 mm. This was followed by an outward motion of 0.046 mm (duration=0.48 sec.) mixed with 4 small movements. Then took place a conspicuous vibration of T=1.5 sec., and of the inward and outward displacements of 0.067 and 0.085 mm respectively; there being at the end a well defined superposition of quick movement of 2a= 0.028 mm. For the next 4.55 sec., the motion may be regarded as

being made up of slow movements of T=1.14 sec. (max. 2a= 0.046 mm), mixed with the quick ones of T=0.38 sec. (max. 2a= 0.026 mm). For the next 8.5 sec., the vibrations were regular: T=0.58 sec., max. 2a=0.028 mm. During the remaining 9.1 sec., the motion was much smaller: T=0.7 sec., 2a=0.0113 mm.

62. *Explosion of Aug. 12th. 1913, at 11. 20. 33 p.m.* This was a strong explosion, whose detonation was at Yuno-taira like that of a tremendous thunder peal. The upper part of the mountain was at the time invisible, being enclosed in thick mists. But the glowing lava pieces falling in the vicinity of the observatory looked like groups of shooting stars; one small lava block of the size of a fist falling to within 2 metres distance at the front of the building. (See also p. 14.) In Tokyo, the present author, who was at the time sitting quietly in his house at Koishikawa, by his writing desk, heard the detonation, whose time of occurrence was accurately noted by means of a pocket chronometer to be 11. 26. 58 p.m., (§ 115).

Tromometer Diagram: *Longitudinal Component.* (See Fig. 54, Pl. XXIII.) Total duration=260 sec.

The preliminary outward motion of 0.0044 mm (duration=0.42 sec.) was followed by the "initial vibration," of T=3.2 sec., which was made up of the 1st, or inward, displacement of 0.125 mm (duration=1.15 sec.), and of the 2nd, or outward, displacement of 0.217 mm (duration=2.0 sec.); the superposition of the small movements appearing first 2.3 sec. from the commencement. For the next 3.8 sec., there were three small vibrations of T=1.2 sec., max. 2a= 0.084 mm, (with some superpositions of smaller movements). Then, at 7.6 sec. from the earthquake commencement, or 6.0 sec. from the end of the 1st displacement of the "initial vibration," the writing index of the pointer began for a few seconds to jump up over the

smoked paper so that there was left only an imperfect dotted trace of the maximum range of 0.119 mm apprx. The motion for the next 3.5 sec. probably marks the effect of the sound waves, giving the interval of 6.0 sec. for the time difference between the moments of arrival of the explosive earth motion and the detonation, in perfect accordance with the result obtained from a comparison of the barograph and the tromometer diagrams. The inward motion reached a limit 11.1 sec. after the earthquake commencement, the pointer being thence thrown into the counter displacement of 0.473 mm. Then the pointer was thrown into a large pendulum oscillation, 17.6 sec. in period, composed of the two movements of 0.71 and 0.54 mm respectively. Immediately thereafter, namely, 32.8 sec. from the earthquake commencement, there took place a conspicuous quick vibration of $2a=0.108$ mm, due probably to the impact of a lava mass about $\frac{1}{2}$ metre in dimension, which fell at a distance of only 19 metres to the ENE of the observatory, causing the pointer to deviate again into a large oscillation of $2a=0.46$ mm. The disturbance came practically to end at $11^h\ 21^m\ 12^s$.

Micro-tremors. The explosion was followed for 19 min. by small micro-tremors, whose max. 2a was 0.0047 mm and whose average period was principally 1.5 sec. apprx. These indicated sudden amplitude increase at irregular intervals and was apparently the results of strong smoke emissions which continued after the outburst.

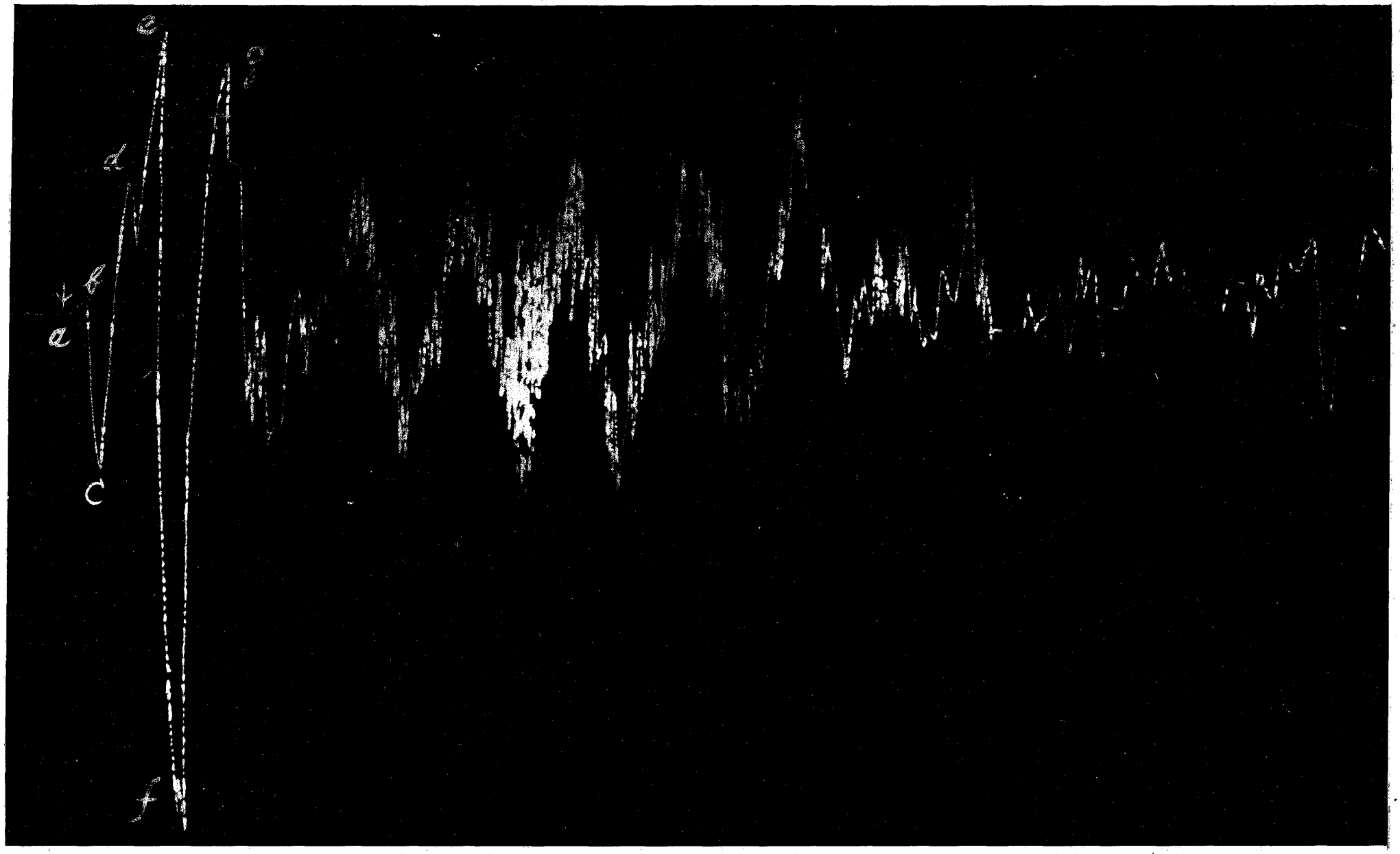
63. *Explosion of May 5th*, 1914, *at* 0. 33. 03 *a.m.* According to the report by Mr. Kurosaka, who was in charge of the observatory at Yuno-taira during the 1st half of May, the mountain had been previously quiet, there having been since the beginning of the month neither volcanic earthquakes and tremors nor powerful

smoke emissions. Thus the explosion on the 5th occurred abruptly, attended by a tremendous detonation. The noise of the lava fragments striking the slope of the Maikake-yama could be heard for about 5 minutes, although its upper part was at the time shrouded in thick mists; those fallen at the base of the somma sparkling like stars. Ten minutes after, when the sky became clear, white smokes, slightly tinged red, were observed to be thrown out at intervals. On subsequent examination, there was found to be no large lava pieces projected on the Yuno-taira plain.

In Tokyo, the author, who was at the time sitting quietly by a desk with a pocket chronometer before him, in his house (in the Koishikawa district), perceived the detonation at $0^h\,39^m\,38^s$ a.m. as a sound like distant gun discharge which shook the *shoji* on the N. side for about $1\frac{1}{2}$ sec. The noise, which, occurring in the depth of night, had a peculiar disturbing effect, was immediately followed by the barking of the dogs and the screaming of the pheasants.

(i) *Tromometer Diagram*: *Longitudinal Component.* (See Fig. 53.) Total duration=171 sec. [Preliminary and principal portions: duration=40.6 sec.] The preliminary portion consisted of an outward displacement of 0.004 mm (0.55 sec. in duration). Then followed the "initial vibration," of T=2.16 sec., which was composed of the 1st, or inward, displacement of 0.081 mm, and the 2nd, or outward, displacement of 0.143 mm; there being a superposition of three small oscillations of T=0.7 sec. For the next 10.5 sec., the motion was made up of $8\frac{1}{2}$ nearly equal and well defined vibrations of T=1.24 sec., max. 2a=0.118 mm; the apparent sound effect, accompanied by the superposition of quick movements of T=0.4 sec., appearing 5.4 sec. after the end of the 1st displacement of the "initial vibration." During the remaining 27.5 sec. of the principal portion, the motion was gra-

Fig. 51. Asama-yama Explosion of Sept. 21st, 1913, observed at Asama Pasture Ground.



(Tremor-recorder Diagram.) **Longitudinal Component.** Magnification = 1100. Time Scale: 1 min. = 255 mm.

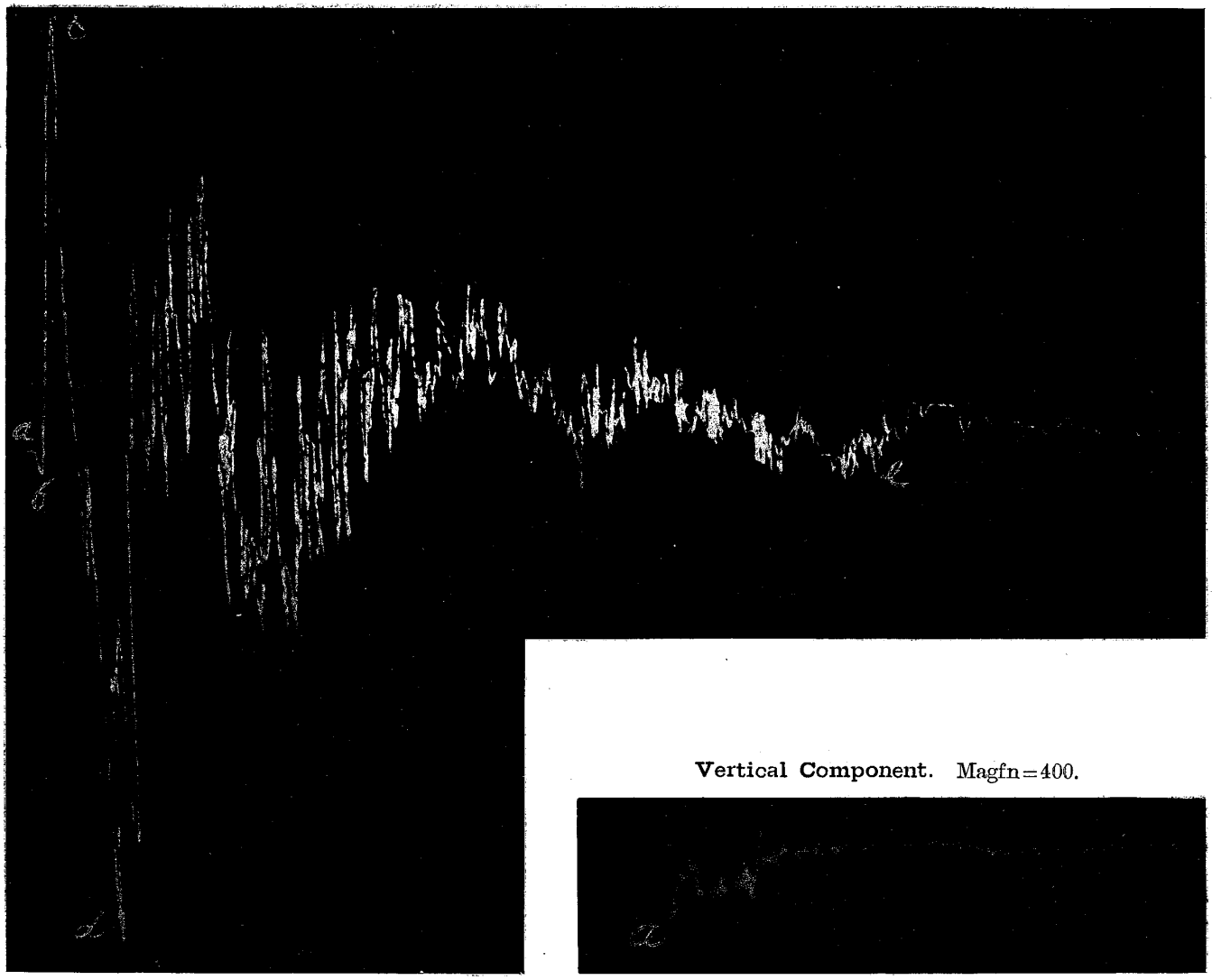
a....Comm't. **bcd...."Initial Vibration."** **S....Sound Shock.**

Fig. 52. Asama-yama Explosion of May 29th, 1913, observed at Yuno-taira: Longitudinal and Vertical Components.

a.... Commencement.

Longitudinal Component.
ab....Preliminary portion.
bcd...."Initial Vibration."

Magnification=1160.
Time Scale: 1 minute=174 mm.

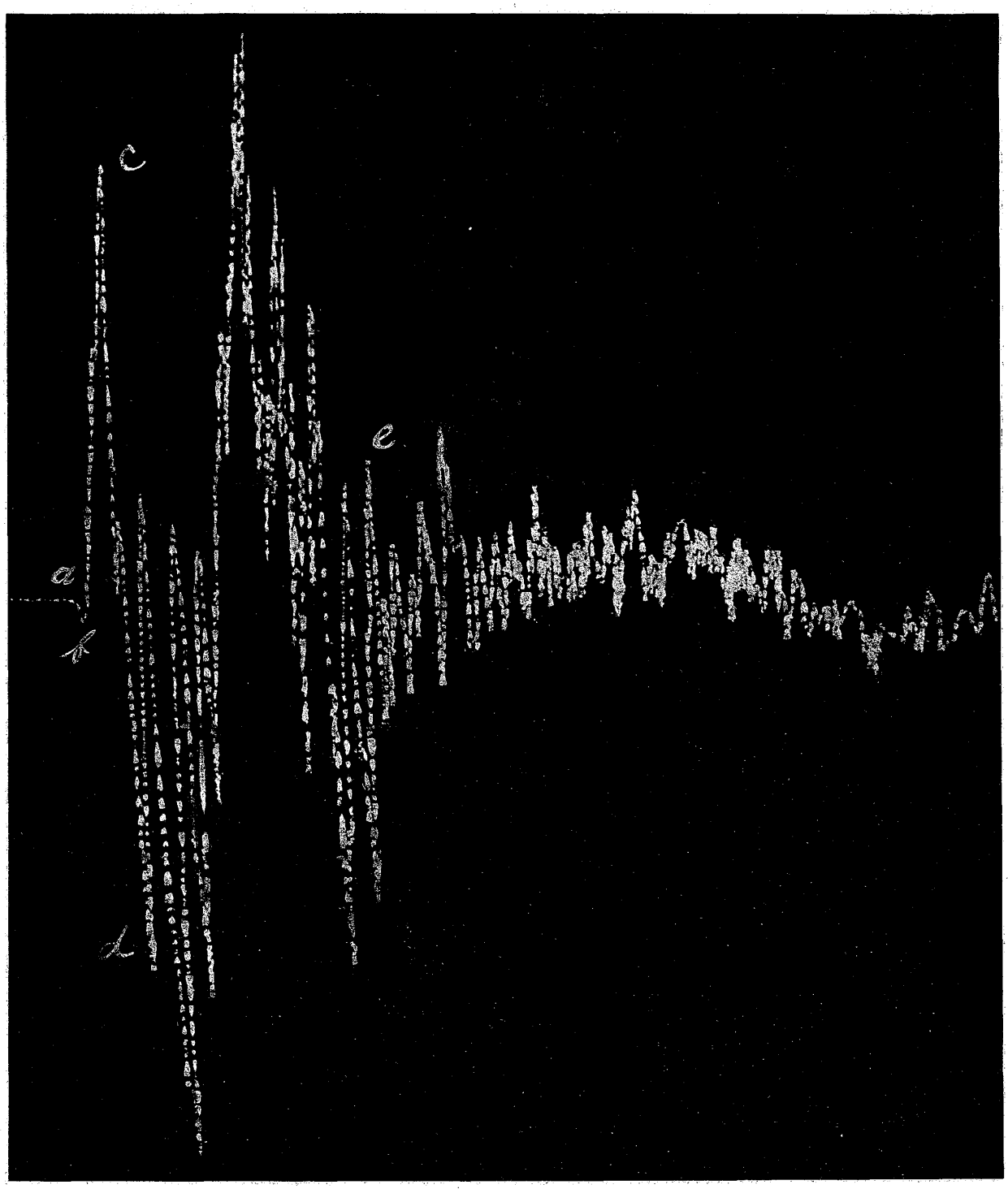


Vertical Component. Magfn=400.

bc....Motion toward Crater.
cd....Motion away from Crater.

Time Scale: 1 min.=98 mm.

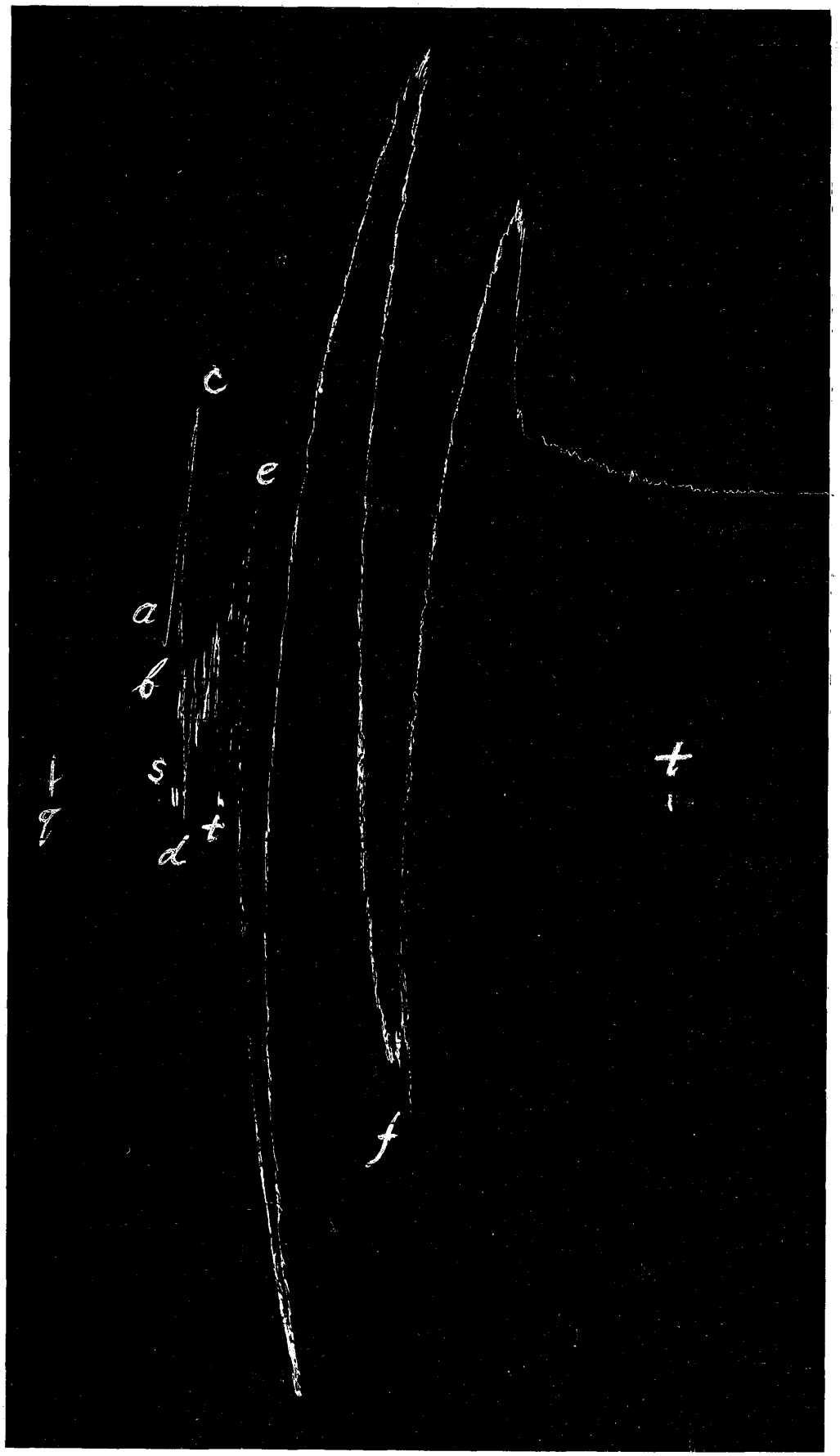
Fig. 53. Asama-yama Explosion of May 5th, 1914, observed at Yuno-taira; Longitudinal Component.



Tromometer Diagram. Magnification = 780. Time Scale: 1 minute = 194 mm.
a....Commencement. bcd . "Initial Vibration." bc....Most active part.

Fig. 54. Asama-yama Explosion of Aug. 12th, 1913, at 11.20.33 p.m., observed at Yuno-taira. Longitudinal Component.

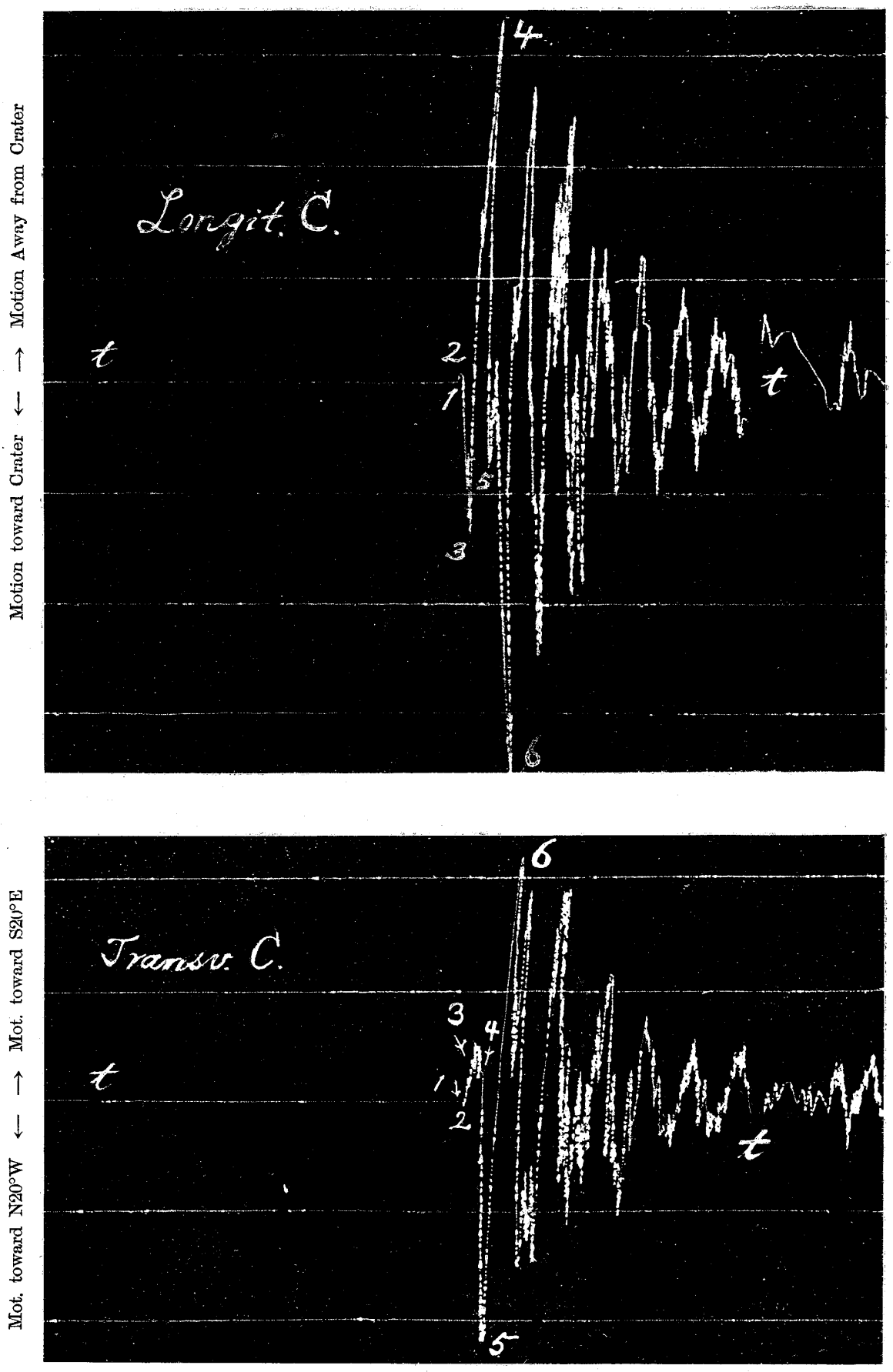
Magnification = 264. Time Scale : 1 minute = 62 mm.



Motion away from Crater. ← → Motion toward Crater

ab....Preliminary Portion. bcd...."Initial Vibration." tt ....Minute Time Marks.
f ....Shakings caused by falling stones. s ....Mark made by the observer by pushing electric key when he was aroused from sleep by the detonation. q ....Time corresponding to Commencement.

Fig. 55. Asama-yama Explosion of May 5th, 1914, observed at Yuno-taira.



(Tremor-recorder Diagram.) Magnification = 365. Time Scale : 1 minute = 96 mm.
t, t . . . Successive Minute Cuttings. 1 . . . . Commencement.
1, 2, 3, 4, 5, ... Corresponding parts in the two components.

dually reduced from 0.046 to 0.011 mm, the quick vibrations being mixed with those of T=1.26 sec.: Duration of the specially active part=12.7 sec. In the later part of the *end portion* the vibrations were regular, T=1.12 sec.

(ii) *Tremor-recorder Diagram.* In Fig. 55 are reproduced the longitudinal and transverse component tremor-recorder diagrams, with the resultant magnification of 365, and the time scale of 96 mm for 1 minute. As the writing indices of the pointers were simultaneously lifted every minute, a given time moment can be identified with perfect accuracy in the two different directions. The preliminary motion, of duration of 0.6 sec., was composed of the following displacements:—0.0035 mm, away from the crater; 0.0009 mm, towards N 20 W; resultant motion=0.0036 mm, toward S 85° W. The 1st displacement of the "initial vibration" in the longitudinal component was 0.063 mm, toward the crater, accompanied by a displacement of 0.018 mm toward S20° E, giving the resultant motion of 0.065 mm directed toward the N86° E. The 2nd displacement of the "initial vibration" was 0.203 mm, directed away from the crater and was accompanied by a small complete oscillation of 2a=0.012 mm, being thus almost perfectly radial in direction. In the transverse component, there followed the maximum slow oscillation of T=2.2 sec., composed of the two displacements corresponding to the largest well defined ones in the longitudinal component, as follows:—

1st displacement .. 0.108 mm, toward N 20° W,
0.176 „ , „ Crater;
Resultant motion= 0.206 mm, directed toward N40° E.

2nd displacement.. 0.192 mm, toward S 20° E.
0.162 „ , toward Crater.
Resultant motion= 0.251 mm, directed toward S 20° W

The maximum and 1st well-defined transverse vibration occurred 1.8 sec. later than the longitudinal "initial vibration."

CHAPTER VII. NON-EXPLOSIVE ERUPTIONS OBSERVED AT YUNO-TAIRA AND THE ASAMA PASTURE GROUND.*

64. *Eruption of June 24th*, 1913, *at* 11. 34. 17 *p.m.* At Yuno-taira, there was perceived some sound, accompanied by the slight shakings of the building. As the mountain was shrouded in thick mists, the condition of the crater could not be ascertained.

Yuno-taira Tromometer Diagram: *Longitudinal Component.* Total duration=88 sec.

[Preliminary and principal portion: duration=21.1 sec.] Unlike the diagrams in the usual cases, the motion began with a very small "initial vibration," of T=2.7 sec., composed of the 1st, or inward, displacement of 0.001 mm, and the 2nd, or outward, one of 0.0034 mm. For the next 6.2 sec., the motion was largest, being composed of the 4 nearly equal vibrations of the average T=1.55 sec., max. 2a=0.0305 mm, mixed with the quick movements of T=0.30 sec., 2a=0.0164 mm; the quivering of the writing pointer due to the sound shock, occurring 5.5 sec. after the end of the 1st displacement of the "initial vibration." During the next 4.5 sec., the motion was smaller and consisted of vibrations of T=1.0 sec., 2a=0.016 mm, mixed with those of T=0.45 sec., 2a=0.0085 mm. During the remaining 7.6 sec. of the principal portion, the vibrations were small: T=0.9 sec., max. 2a=0.0077 mm. [End portion.] The motion was regular: T=0.64 sec., max. 2a=0.0039 mm.

65. *Eruption of July 1st*, 1913, *at* 0. 17. 01 *p.m.* At Yuno-

* The times of occurrence of the eruptions considered in this chapter are those registered at Yuno-taira, with the exception of the last case, for which the observation was made only at the Asama Pasture Ground.